BACKGROUND

Ecosystem analysis at the watershed scale is intended as a way to develop and document a scientifically-based understanding of the processes and interactions that occur within a watershed. A goal of ecosystem management is to promote long-term sustainability of natural systems. In order to protect and sustain these systems, we must understand the interactions between our management activities and the physical and biological environment in which we operate. Understanding these interactions is essential for making sound management decisions.

Using the Federal Guide for Watershed Analysis 1995 (version 2.2) as guidance, the Forest Service has prepared this analysis of relevant ecosystem elements within the upper South Santiam watershed to enhance understanding of the area and to help guide the general type, location and sequence of appropriate management activities there. By understanding the interactions between land-use activities and the environment, the ecosystem can be better managed for all of its intrinsic values.

In addition, the analysis helps estimate direct, indirect and cumulative effects of management activities so that appropriate courses of action can be determined to sustain the health and productivity of various natural resources.

The understanding gained through the analysis also aids in setting and refining boundaries of riparian and other reserves, setting restoration strategies and priorities and revealing the most useful indicators for monitoring environmental changes in the watershed. This is an ongoing, dynamic process intended to be revised and updated as conditions, assumptions, or resource plans change and new information becomes available.

This analysis is not a decision-making process, but rather a stage-setting process to establish the context for subsequent planning, project development and regulatory compliance. Decisions have not been made about implementing any of the recommendations made in this document; those must be further analyzed in the NEPA process.

Document Structure

This document is organized in four sections as outlined below:

- ***Introduction:*** This part of the document identifies where the watershed is located in relationship to the larger river basin and describes ownership patterns, how the land is used and what rules and regulations landowners operate under that influence the management of the natural resources in the watershed. It also discusses climate and various natural processes at work in the watershed.

- ***Physical Domain:*** This section *characterizes* the geologic and hydrologic processes and conditions within the upper South Santiam watershed. Then it identifies *issues* which highlight specific areas of concern with respect to the physical resources here. From these issues, *key questions* are asked to help focus the analysis on the relevant elements of the physical environment as they relate to management questions and human values. Following that is a description of the *current condition* of the physical resources followed by a comparative description of *past conditions.* This helps in understanding how conditions have changed over time as a result of either human influences and/or natural disturbances. Next, through *synthesis and interpretation*, attempts are made to explain differences and similarities between current and past conditions, the causes of the changed conditions and the impacts those changed conditions have on other resource values. Finally*, recommendations* are made to address changes that have occurred which require management action such as restoration, maintenance, protection, etc.

- ***Biological Domain:*** This portion of the document describes the pattern and habitat character of plants and animals in and watershed and is organized similarly to the Physical Domain section starting with characterization of the resources, issues and key questions, current and past conditions, synthesis and interpretation and recommendations.

- ***Social Domain:*** This section describes human uses and interactions within the watershed and is also organized similarly to the Physical Domain section starting with characterization of the uses and interactions, issues and key questions, current and past conditions, synthesis and interpretation and recommendations.

1 INTRODUCTION

This section describes where the watershed is located in relationship to the larger river basin and describes ownership patterns, how the land is used and what rules and regulations landowners operate under that influence the management of the natural resources in the watershed. It also discusses climate and various natural processes at work on the landscape.

1.1 Location of watershed in relationship to the larger river basin

The upper *South Santiam Watershed* encompasses about 160 square miles of Sweet Home Ranger District on the Willamette National Forest in eastern Linn County, near Sweet Home, Oregon. The western and northern edges of the watershed lie just outside the National Forest boundary.

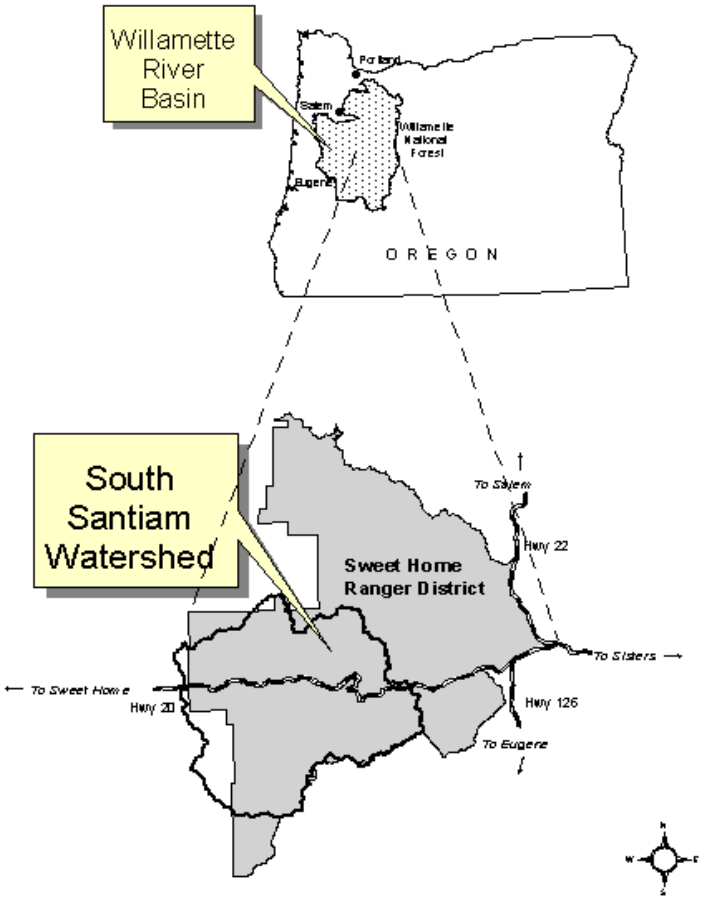


Figure 1: Vicinity Map

The watershed was carved out by Moose, Soda Fork, Trout, Sheep, Sevenmile, Upper Canyon, Owl, and Canyon Creeks which originate in the Cascade Mountains. These streams form the headwaters of the South Santiam River. See figure 2 below.

Fifth and Sixth-Field Watersheds

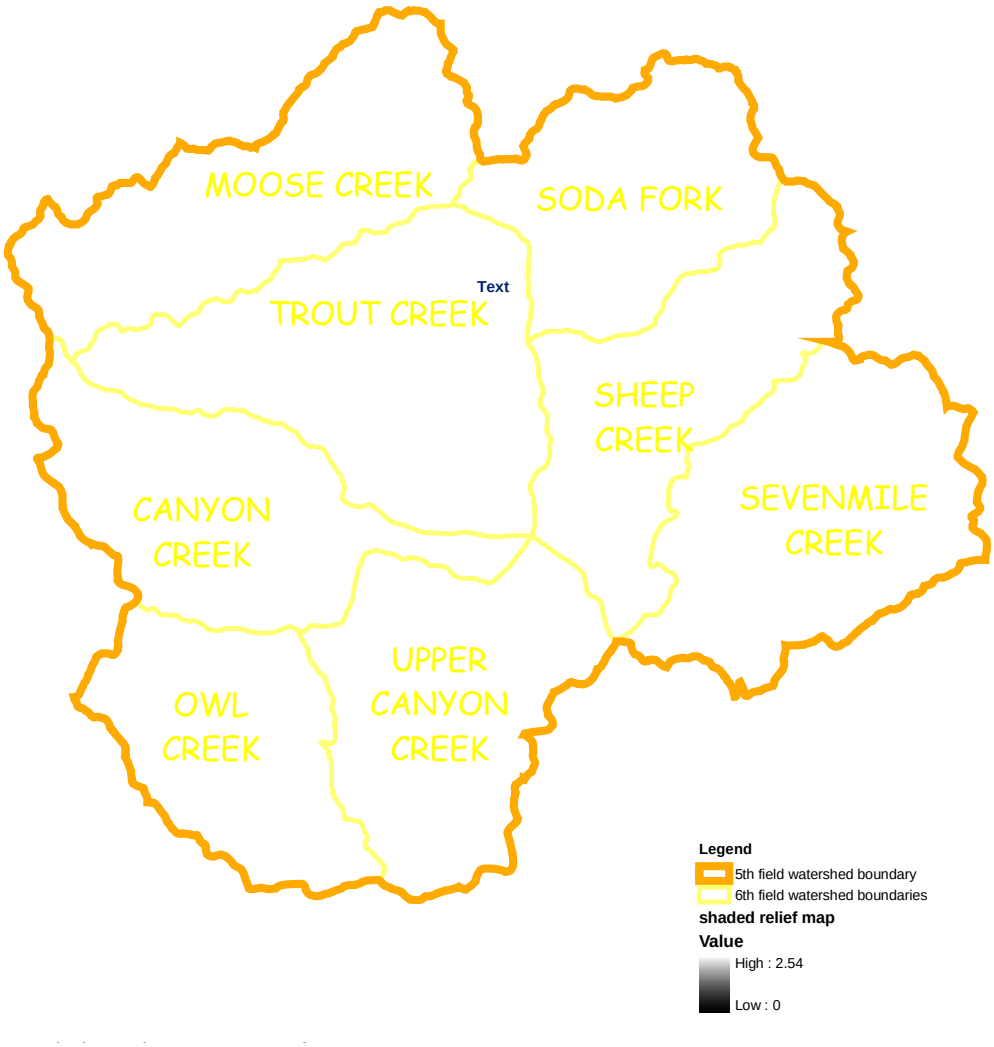


Figure 2: Fifth and Sixth Field Watersheds

The upper South Santiam watershed is highlighted in red on this map to show its relationship to the larger South Santiam River watershed. The South Santiam River joins the North Santiam about 15 miles northeast of Lebanon, Oregon to become the Santiam River.

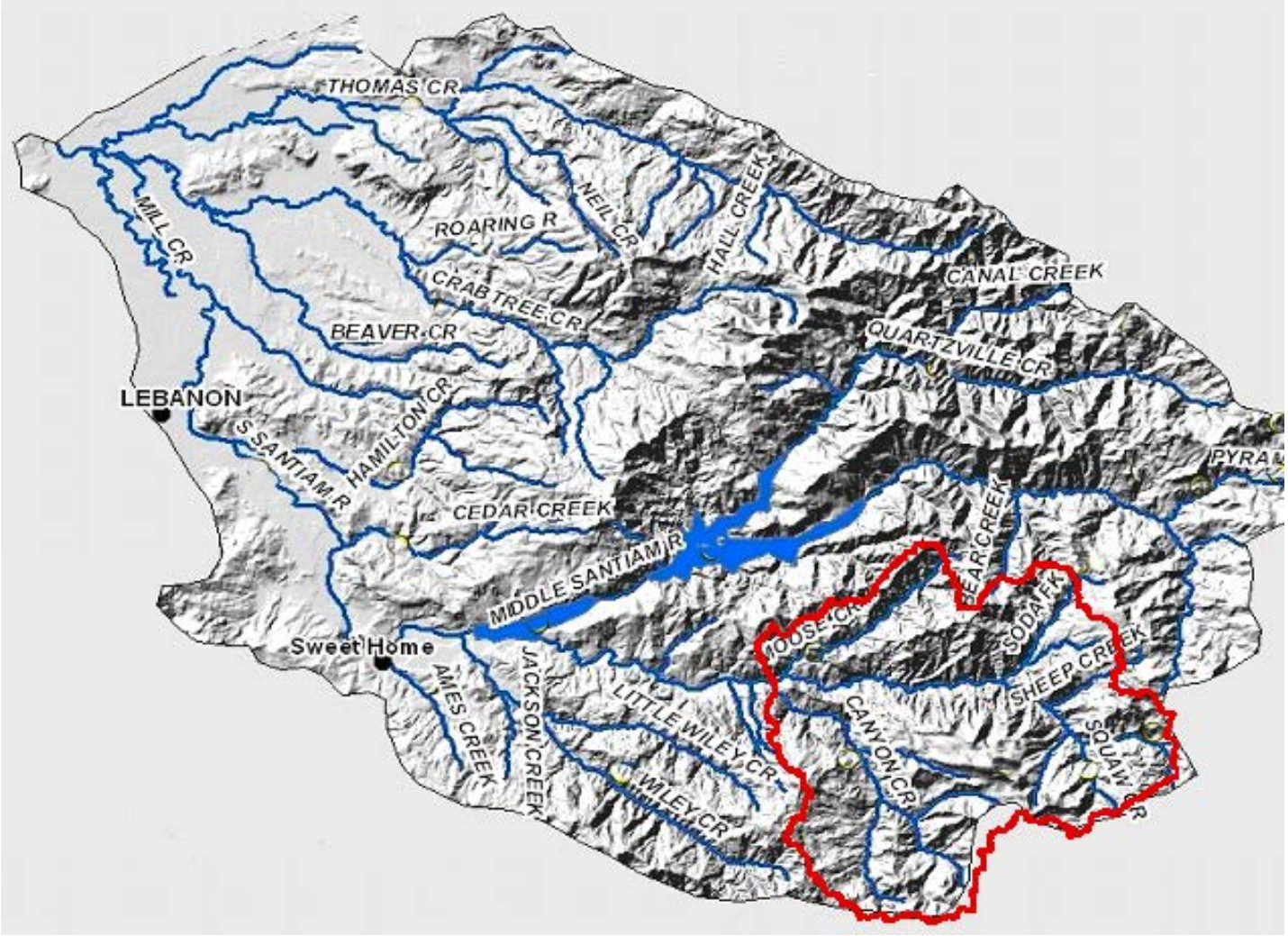


Figure 3: Upper South Santiam Boundary within larger South Santiam River Watershed

Figure 4: The Willamette River System

The Santiam River empties into the Willamette River between Albany and Salem, Oregon. The Willamette watershed drains an area of about 12,000 square miles.

It is divided into three physiographic provinces which incorporate physical, biological and environmental factors that helped shape the broad-scale landscapes:

1) the ***Coast Range*** which constitutes the western boundary of the basin and is comprised of marine sedimentary and volcanic rocks,
2) the ***Cascade Range*** which forms the eastern basin boundary and is comprised mainly of volcanic rocks. The upper South Santiam watershed is located in the Western Cascades physiographic province in the Cascade Range.

3) the ***Willamette Valley***, an elongated lowland which lies between these mountain ranges and is filled with flows of Columbia River basalt and younger unconsolidated sediment. The Willamette Valley contains Oregon's three largest cities (Portland, Eugene and Salem) and is home to about 70 percent of the State's population.

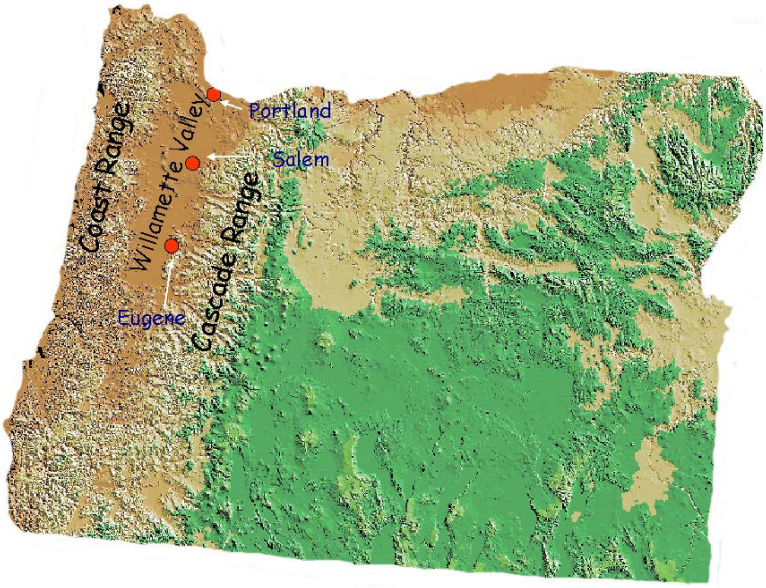


Figure 5: Physiographic Provinces

The Willamette is tributary to the Columbia River which is the largest river in the Pacific Northwest and drains into the Pacific Ocean. The Columbia River drains 259,000 square miles in Oregon, Washington, Idaho, Montana, Nevada, Wyoming, Utah and a province in Canada.

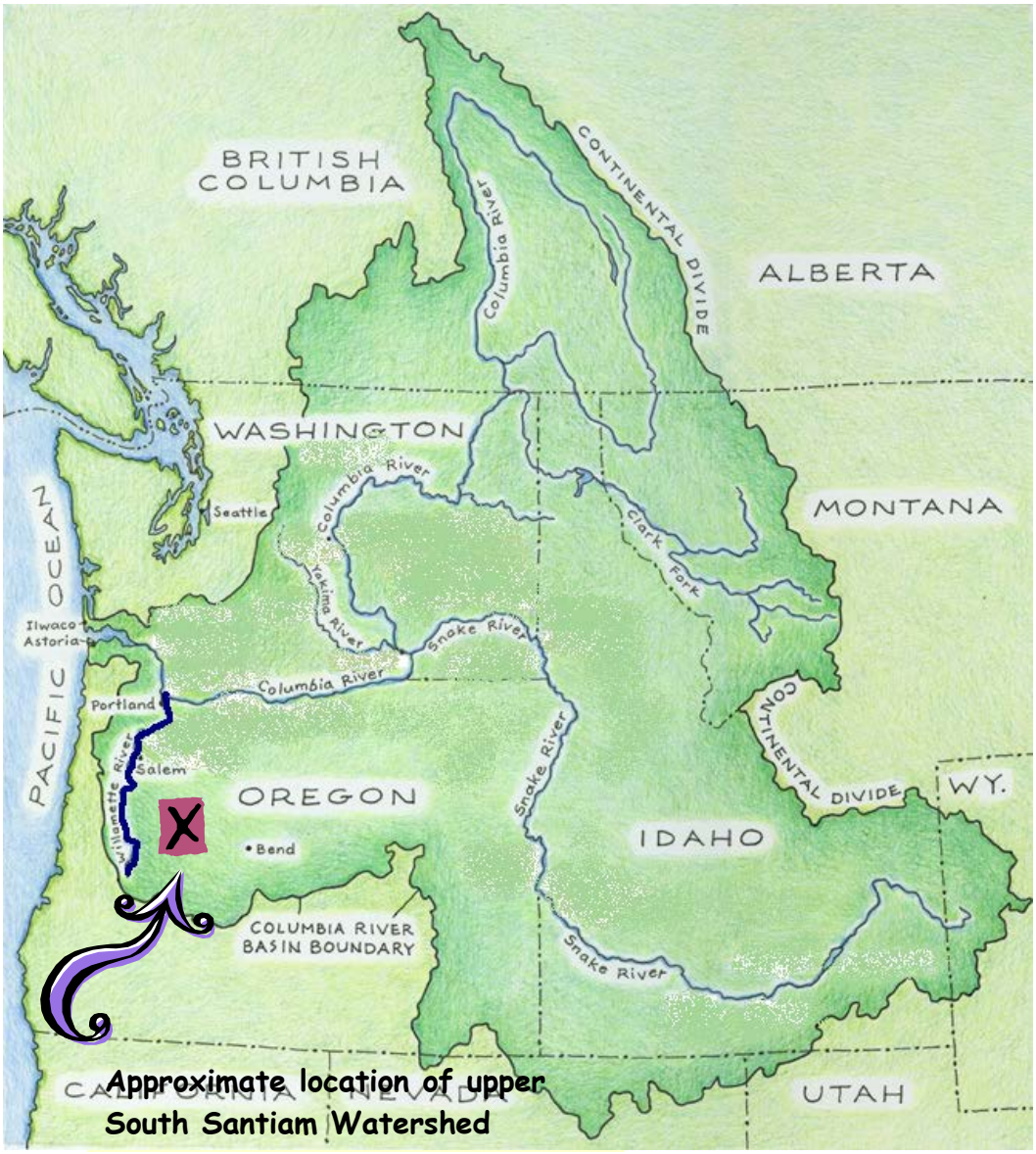


Figure 6 shows the relationship of South Santiam Watershed and the Willamette River Basin with the entire Columbia River Basin, which is the darker shaded area on the map.

1.2 Current Ownership Patterns in the Watershed

Approximately 67% of the watershed is on the Willamette National Forest and the majority of the remainder is owned by private, industrial timber companies. Much of the industrial ownership is interspersed with Forest Service land and generally occurs in the northern portion and across the southern one-third of the watershed. The State of Oregon and numerous private individuals own small parcels located mainly along the Highway 20 corridor. The chart below shows how many acres and what percent of the watershed that each owner occupies.

Table 1: **Watershed Ownership**

Ownership	Ownership Acres	Percent of Watershed
Willamette National Forest	68,294	67
Private	33,453	33
State	5	>.005
Total	101,752	100

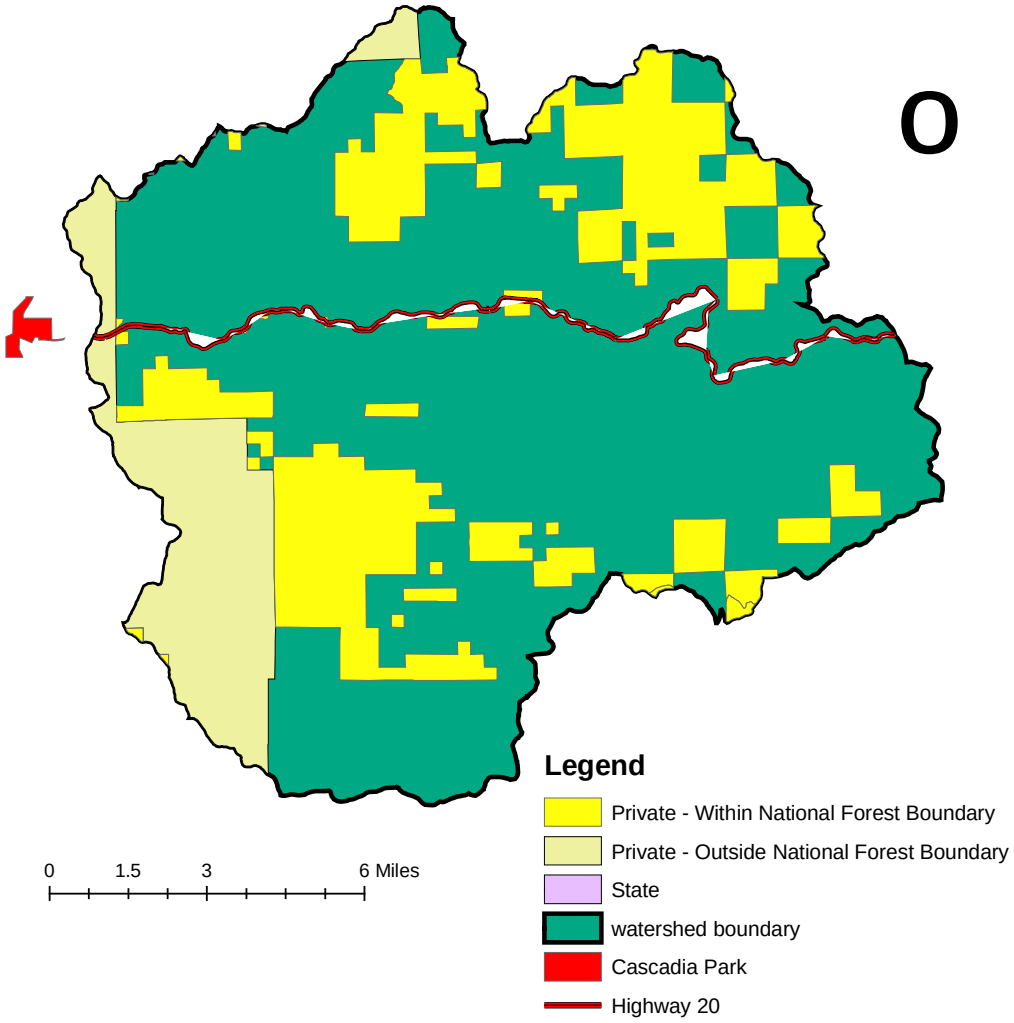


Figure 7 shows the pattern of ownership in the watershed

1.3 How the Land is Currently Used:

The chart below shows the 1994 Northwest Forest Plan land allocations for the Willamette National Forest Service portion of the watershed. Each land allocation designation is followed by a short description of how the land is managed within the allocation, the size of each allocation and the percent of the watershed that each land allocation occupies. The map that follows shows the spatial arrangement of these land allocations within the watershed.

Table 2: **NW Forest Plan Land Allocations**

Land Allocations by Ownership	Description of how land is managed within each allocation	Acres	Percent of Watershed
Ownership:	**US Forest Service: Willamette National Forest**		
• Central Cascades Adaptive Management Area	Lands designated in the NW Forest Plan to encourage the development and testing of technical and social approaches to achieving desired ecological, economic and other social objectives on the landscape.	25,924	26
• Late-Successional Reserve	Lands allocated to protect and enhance conditions of late-success ional and old-growth forest ecosystems, which serve as habitat for late-successional and old-growth related species including the northern spotted owl	27,637	27
• Late-Successional Reserve – 100 acre	Protection buffers around known spotted owl activity centers	853	<1
• Riparian Reserves	Areas along stream networks and other water bodies designed to maintain hydrologic, geomorphic, and ecologic processes, confer benefits to riparian-dependent species, improve travel and dispersal corridors for terrestrial animals and plants and provide connectivity among Late Successional Reserves.	Exact acres unknown because not all class IV streams have been surveyed	Estimated to range between 45 – 70% of National Forest system lands
• Matrix	Lands where most timber harvest, silvicultural and other resource activities are conducted in accordance with standards and guidelines.	4,464	4

Note: The percent of the watershed occupied by each land allocation exceeds 100% because of overlap.

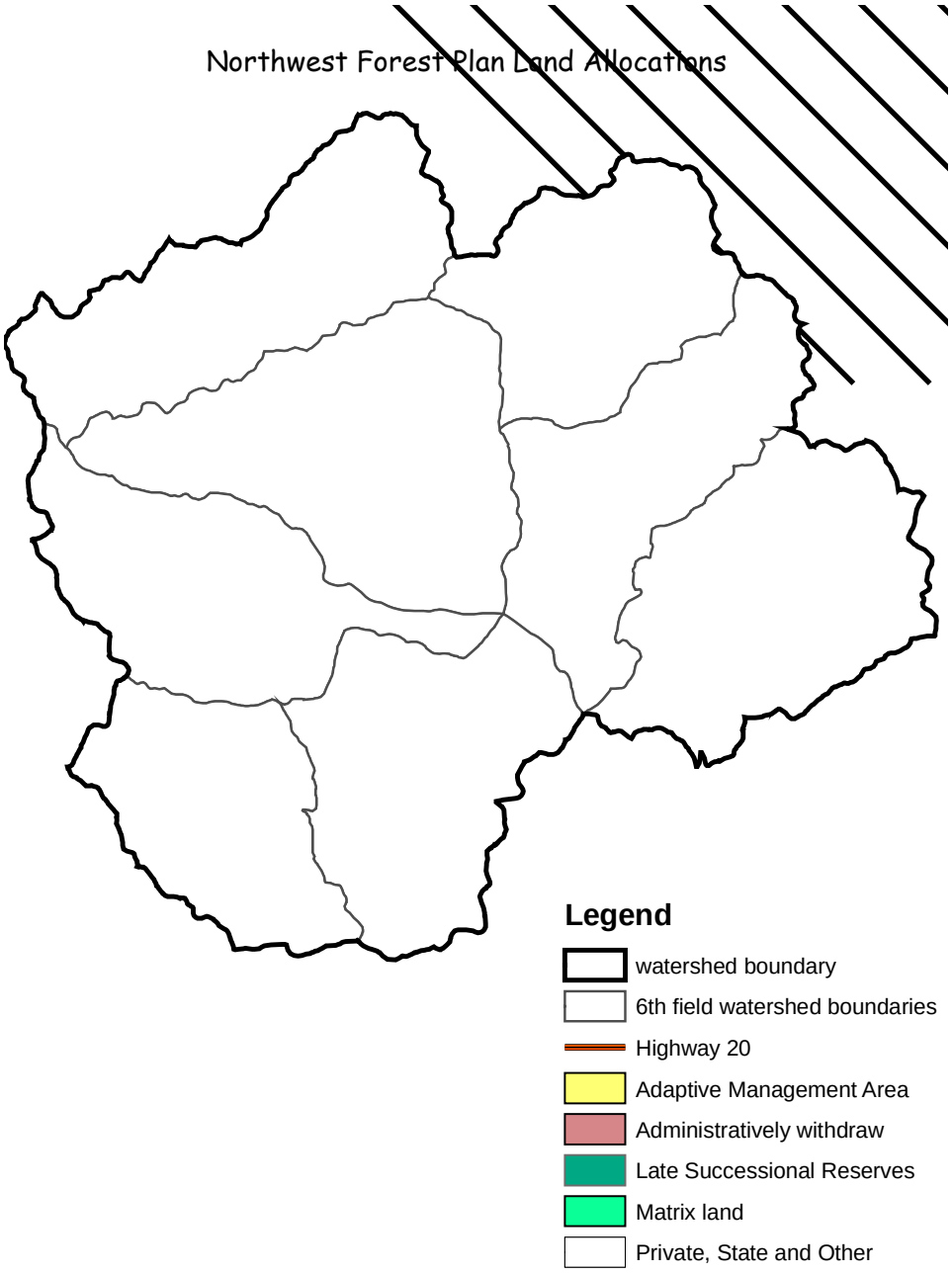


Figure 8: Northwest Forest Plan land allocations

The chart below shows the 1990 Willamette National Forest Plan land allocations followed by a map showing the spatial arrangement of the land allocations within the watershed. The 1994 Northwest Forest Plan amended the 1990 Willamette National Forest Plan and added the land allocations outlined in Table 2 *(page 9)* and displayed on the map above (*figure 8, page 10).* Along with these new land allocations were standards and guidelines for managing the allocations. If standards and guidelines in the 1990 Forest Plan were in conflict with those in the 1994 Northwest Forest Plan, they were replaced by the 1994 standards and guidelines. If the 1990 Forest Plan standards and guidelines were more restrictive or provided greater benefits to late-successional species, then the existing standards and guidelines remained in effect. **Note:** *When the Willamette National Forest Plan is revised later in the decade, land allocations within the national forest will likely change, except those designated by congressional action such as wilderness.*

Table 3: **Willamette National Forest Plan Land Allocations**

Land Allocations by Ownership	Description of how land is managed within each allocation	Acres	Percent of Watershed
Ownership:	**US Forest Service: Willamette National Forest (continued)**		
• Menagerie Wilderness	Lands set aside for preservation and protection in a natural condition.	4,914	4.8
• Scenic- modification middle ground	Maintains scenic quality in middleground areas of moderate sensitivity in conjunction with timber harvests and other management activities.	1,910	1.9
• Scenic-partial retention middle ground	Maintains scenic quality in middleground areas of high sensitivity in conjunction with timber harvests and other management activities	777	0.8
• Scenic-partial retention foreground	Maintains scenic quality in foreground area of very high sensitivity in conjunction with timber harvests and other management activities	1,109	1.1
• Special Interest Areas (*Santiam Wagon Road and Cougar Rock*)	Protects sites with unique geologic, biological, cultural or scenic characteristics and provides opportunities for interpretation and education.	131	0.1
• Research Natural Area *(Three Creeks*)	Protects representative physical and biological system in a natural condition for scientific study	2	0.001
• Special wildlife habitat area *(marten)*	Protects stands of mature forest habitat necessary for a viable population of martens and species with similar habitat needs.	111	0.1
• Special wildlife habitat area *(Pileated Woodpecker)*	Protects stands of mature forest habitat necessary for a viable population of pileated woodpeckers and species with similar habitat needs	84	0.08
• Dispersed Recreation – Semiprimitive Nonmotorized	Semiprimitive nonmotorized – maintains the opportunities for semiprimitve recreation without motor vehicles and restricts some resource activities	381	0.4

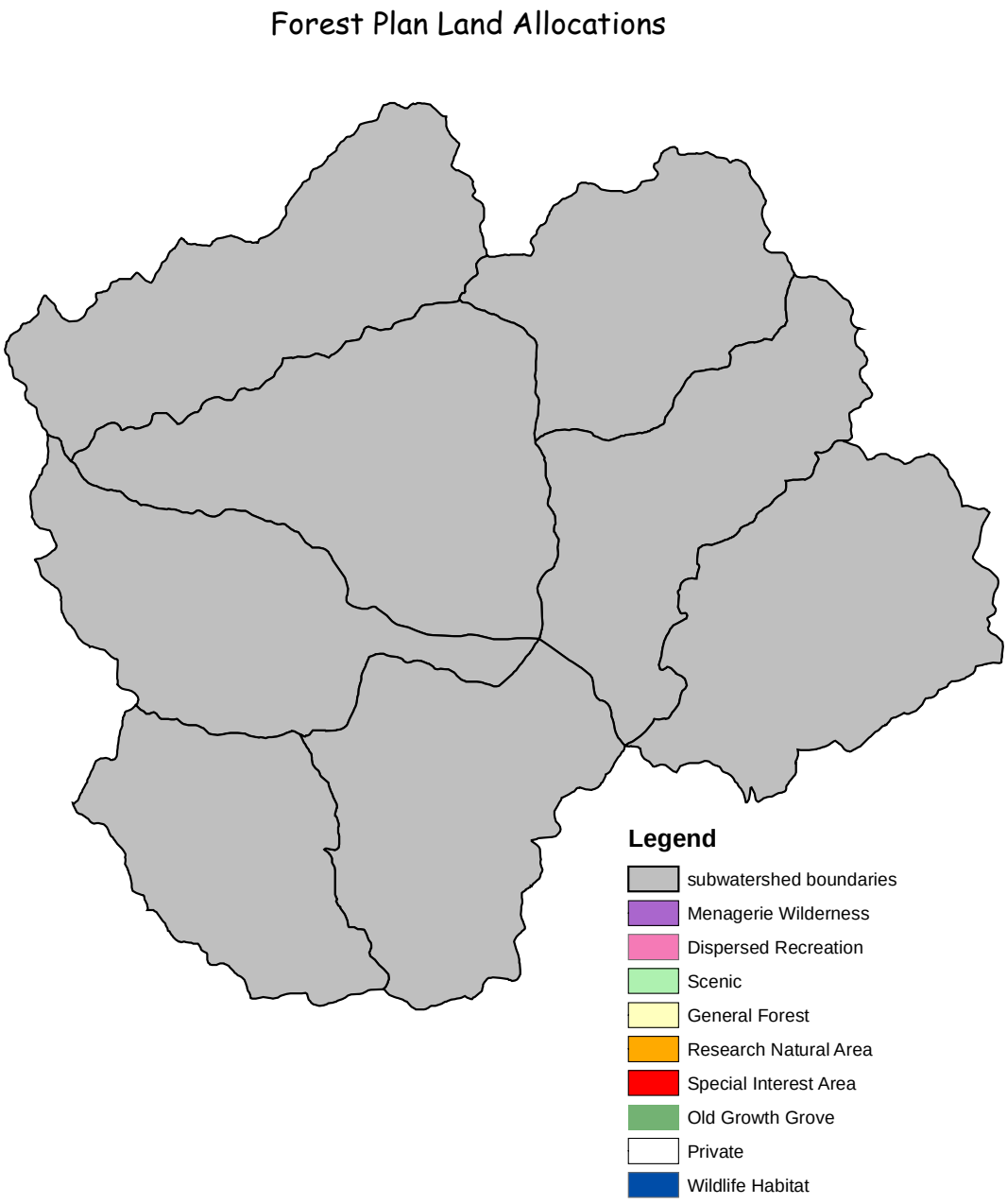


Figure 9: Willamette National Forest Plan land allocations

The chart below shows State and private land uses followed by a map showing the spatial arrangement of those uses within the watershed.

Table 4: **Private and State Land Uses**

Land Allocations by Ownership	Description of how land is managed within each allocation	Acres	Percent of Watershed
Ownership:	**Private**		
• Industrial timber • Other	• Lands managed under the Oregon State Forest Practices Act which encourages economically efficient forest management and the continuous growing and harvesting of trees and maintenance of forestlands consistent with the protection of forest resources through the sound management of soil, air, water, fish and wildlife resources. • Generally home sites, etc.	33,453	32.9
Ownership:	**State of Oregon**		
• Highway right of way	Generally highway 20 right of way, used for maintenance and management of the road resource.	5	0.005
	Total Acres in Watershed for all owners	**101,752**	

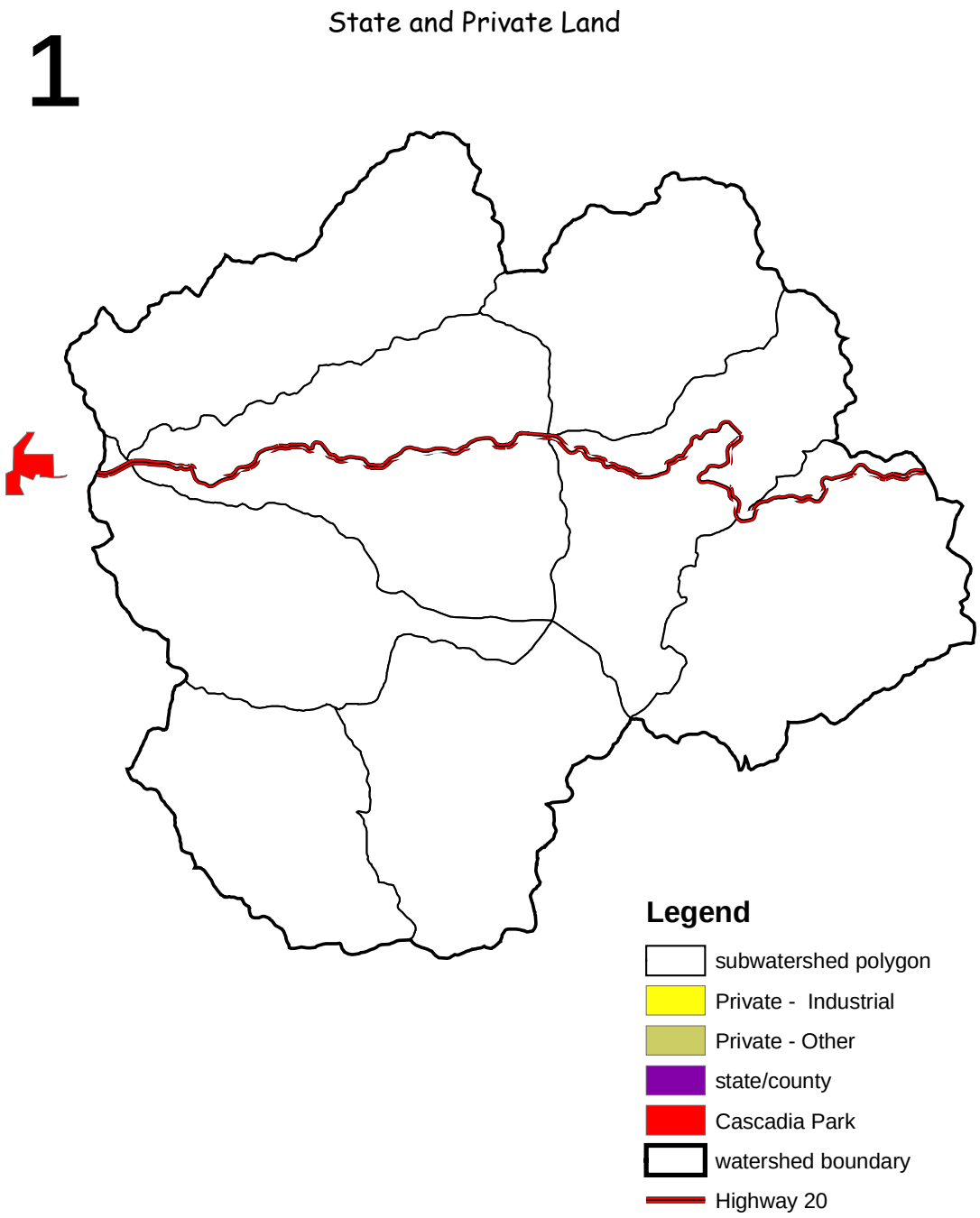


Figure 10: State and Private Lands

1.4 Primary Rules and Regulations Influencing Management of Natural Resources in the Watershed:

The following is a list of some of the primary rules and regulations that the major landowners in the watershed operate under. It is not an exhaustive list but includes the most common rules and regulations.

Willamette National Forest

- Willamette National Forest Land and Resource Management Plan 1990 as amended by the NW Forest Plan in 1994
- National Forest Management Act of 1976
- National Environmental Policy Act of 1969
- Federal Noxious Weed Act of 1974
- Endangered Species Act of 1973
- Mid-Willamette LSR Assessment of 1998
- Wild and Scenic Rivers Act of 1968
- National Historic Preservation Act of 1966
- Wilderness Act of 1964
- Multiple Use-Sustained Yield Act of 1960
- Clean Water Act of 1977
- Knutson-Vandenberg Act of 1930
- Migratory Bird Conservation Act of 1929
- Us Mining Laws 1872

In addition to existing management plans, the following agreements have been made with other parities that would be applicable in this watershed:

- Memorandum of Understandings with Confederated Tribes of Grand Ronde Community Confederated Tribes of Siletz Indians and Confederated Tribes of Warm Springs.

Private Industrial Landowners

- State Forest Practices Act
- Endangered Species Act of 1973
- Clean Water Act of 1977

1.5 Natural Processes at Work in the Watershed

Climate and microclimate are important physical determinants of ecological patterns and processes on the landscape. Temperature and precipitation affect ecosystem productivity while extreme wind events, fires and floods are important factors in the disturbance ecology of the forest landscape.

The upper South Santiam watershed falls under the influence of the temperate maritime climate which is dominated by winter Pacific frontal systems moving eastward across the State. As storms move from west to east, they encounter first the Coast Range and then the Cascade Range. As these storm systems rise over these mountain ranges, they release large amounts of terrain-induced precipitation on the western slopes. As a result the upper South Santiam receives approximately 60 to 120 inches of rainfall per year depending on elevation. Below 2,000 feet most of the precipitation occurs as rain. The proportion of the precipitation that occurs as snowfall increases with elevation. Winter snow accumulations are substantial in much of the Cascades where they are an important source of summer streamflows. Precipitation generally occurs during the winter months, with November through March accounting for more than 75 percent of the total precipitation. Summers are typically warm and dry.

Climatic Trends - In the Pacific Northwest, both temperature and precipitation have increased over the 20th Century. According to the *Climate Impacts Group*, on average, the region warmed about 1.5°F in the last 100 years with the warmest decade being the 1990's. Predictions are that the trend of increased average temperatures will continue over the 21st Century on the order of 0.3°F – 1°F per decade.

Future changes in precipitation are less certain but are projected to increase in most of the Pacific Northwest. These projected climatic changes could have significant implications for natural resources, as well as the human systems that depend on them. As temperatures rise they will likely cause snowpacks to diminish, and rivers that derive their flow from snowmelt will likely see increased winter flows and reduced summer flows. If this comes about, in the summer, many competing uses such as hydropower, irrigation, fish, and recreation could be negatively impacted by the lower flows. In addition, snowmelt is a primary source of summer moisture for high elevation forests since they don't start growing until late spring or early summer. If there is less snow to provide moisture to these forests, they are likely to experience increased drought stress and insect problems. Low-elevation forests may expand upward as the growing seasons lengthen and the risk of forest fires may increase.

Snowfall – Precipitation in this mountainous area tends to increase with increasing elevation. At the highest elevations the precipitation generally falls as snow. In most areas above 4,500 feet, snow cover lasts from early December until the latter part of April. Heavy, wet snows can contribute to tree breakage particularly in dense pole to small, sawlog-sized stands.

Snowfall trends in the Pacific Northwest point toward a decline in snowpack, especially at lower elevations, since the 1950's. In addition, peak spring runoff in snowmelt-dominated streams has moved 10-30 days earlier into the spring season in 2000 compared to 1948.*

Wind – Generally winds in the upper South Santiam are light and result from differential heating and cooling in the mountainous terrain or from prevailing wind patterns. Strong winds occur occasionally.

The majority of destructive surface winds come from the south or southwest and are associated with storms moving onto the coast from the Pacific Ocean. The Columbus Day Storm of 1962 was a classic example of this. Winds of nearly 116 mph caused about 25 million board feet (MMBF) of timber to blow down on the Sweet Home Ranger District. Windstorms of this magnitude occur about every 100 years.

In the fall this area occasionally receives strong winds from the east which generally are not powerful enough to topple trees, but are more of a concern with respect to fire behavior.

Table 5: **Major Windstorms in Oregon**

Date	Affected Area	Characteristics
Apr. 1931	Western OR	Wind 78 mph
Nov. 1951	Statewide	Wind 40-60 mph with gusts 75-80 mph
Dec. 1951	Statewide	Wind 60 mph with gusts to 75
Dec 1955	Statewide	Wind 55-65 with gusts to 69
Nov 1958	Statewide	Wind speed 51 with gusts to 71
Oct 1962	Statewide	Columbus Day Storm; winds 116
Mar., 1971	Most of OR	Wind 54 mph with gusts to 70 mph
Nov. 1981	Most of OR	Winds 71
Jan 1990	Statewide	Heavy rain with winds exceeding 75 mph
Dec 1995	Statewide	Followed path of Columbus Day Storm. Winds 62
Nov 1997	Western OR	Winds 52
Feb 2002	Western OR	Strongest storm in several years

Source: Taylor, George H. and Ray Hatton, 1999, The Oregon Weather Book, p 151-157.

Floods – Most serious flooding experienced in this area usually occurs during a rain-on-snow event between December and February. Floods are often associated with La Nina conditions, where prolonged rain rapidly melts snow on saturated or frozen ground. High flows that occur during flood events trigger other processes such as landslides that provide sediment and wood to stream channels. Flood frequency and magnitude vary. The last major flood event that occurred here was in 1996 and the largest one prior to that was in 1964.

**(Stewart, I.T., D.R. Cayan and M.D. Dettinger, 2004: Changes in snowmelt runoff timing in western North America under a 'Business as Usual' climate change scenario. Climatic Change 62: 217-232.)*

Floods have the potential to drastically alter habitat elements by removing and depositing sediments or changing the course of a stream, which may disconnect a wetland from its water source. Likewise, it can introduce water to new areas, creating swamps, bogs, and marshes under certain conditions. It can create new habitats for plants or remove them in a single event. For noxious weeds, the newly disturbed floodplain substrate resulting from a flood can provide expansion room if a seed source is nearby.

Table 6: **Major Flood Events in Oregon**

Date	Location	Characteristics	Type of Flood
Dec, 1861	Willamette Basin and Coastal Rivers	Preceded by two weeks of heavy rain.	Rain-on-snow, snow melt
Feb. 1890	Willamette Basin and Coastal Rivers	Second largest known flood in Willamette Basin.	Rain-on-snow
Dec. 1937	West. Oregon	Flooding following heavy rains.	Rain-on-snow
Jan. 1963	West. Or	Widespread flooding accompanied by windstorm	Rain-on-snow
Dec. 1964 – Jan 1965	Willamette Basin	Record flooding. Two intense storms. Near-record early season snow.	Rain-on-snow
Jan. 1974	West. OR	Flooding, followed by heavy wet snow and freezing rain	Rain-on-snow
Dec. 1978	West OR	Intense heavy rain, snowmelt, saturated ground.	Rain-on-snow
Feb. 1986	Entire State	Severe statewide flooding. Rain and melting snow	Snowmelt
Feb. 1987	Western OR	Willamette River and tributaries.	Rain-on-snow
Feb. 1996	Entire State	Deep snow pack, warm temperatures, record-breaking rains.	Rain-on-snow
Nov. 1996	Entire State	Record-breaking precipitation, local flooding	Rain-on-snow

Source: Taylor, George, and Raymon Hatton, 1999, The Oregon Weather Book, p. 77-103

Drought is another common natural "disturbance" process here. Although the area receives an abundance of rainfall, it generally does not fall during summer months and plants have adapted to summertime droughts. Besides the short-duration summer drought periods, there are also major, prolonged droughts. These occur with varying frequency, severity and duration.

Table 7: **Significant Droughts in Oregon**

Date	Description
1904-1905	Statewide drought of about 18 months
1917-1931	Very dry period in Oregon, punctuated by brief wet spells in 1920-21 and 1927.
1939-1941	A three-year intense drought in Oregon
1985-1997	Generally a dry period, capped by statewide drought in 1992 and 1994
2000-2001	Low snow pack in mountains worsens drought conditions

Source: Taylor, George H., and Ray Hatton, 1999, The Oregon Weather Book

Fire – Historically, fire played a major role as a renewal agent in the upper South Santiam watershed and has helped to shape the ecological patterns on the landscape.

Wildfires in this watershed are often associated with lightning strikes from thunderstorms during the dry season, but often-overlooked and also important, are human-caused fires. This area has been occupied by humans for at least 8,000 years and they have used fire here both intentionally and accidentally throughout much of that time. In addition, climate, topography and fuels all contribute to the timing, severity and size of fires across the landscape.

Many species have adapted to the natural fire regime here (*see figure 11 Fire Regime Map*). The natural fire regime is defined as the role that fire plays on the landscape without modern human intervention. It does include the influence of burning by indigenous people however. Natural fire regimes are described by the average number of years between fires and how severe those fires are on the dominant vegetation. For this subwatershed the natural fire regime is defined as follows:

- IIIB (50 – 100 year frequency with mixed severity). This regime occurs mostly on south and west-facing slopes
- IIIC (100-200 year frequency with mixed severity). This regime occurs mostly in valley bottoms, north and east-facing slopes
- IVB (100+ year frequency with stand replacement). This regime occurs mostly on ridgetops.

Lightening-caused fires in the eastern headwaters and higher elevations of the watershed were often associated with precipitation, tended to stay small and leave behind elements of the pre-fire forest structure. Stand-replacing fires were less frequent than underburns here. The partial or underburns created a variable pattern on the landscape which included not only gaps but also areas that were left intact.

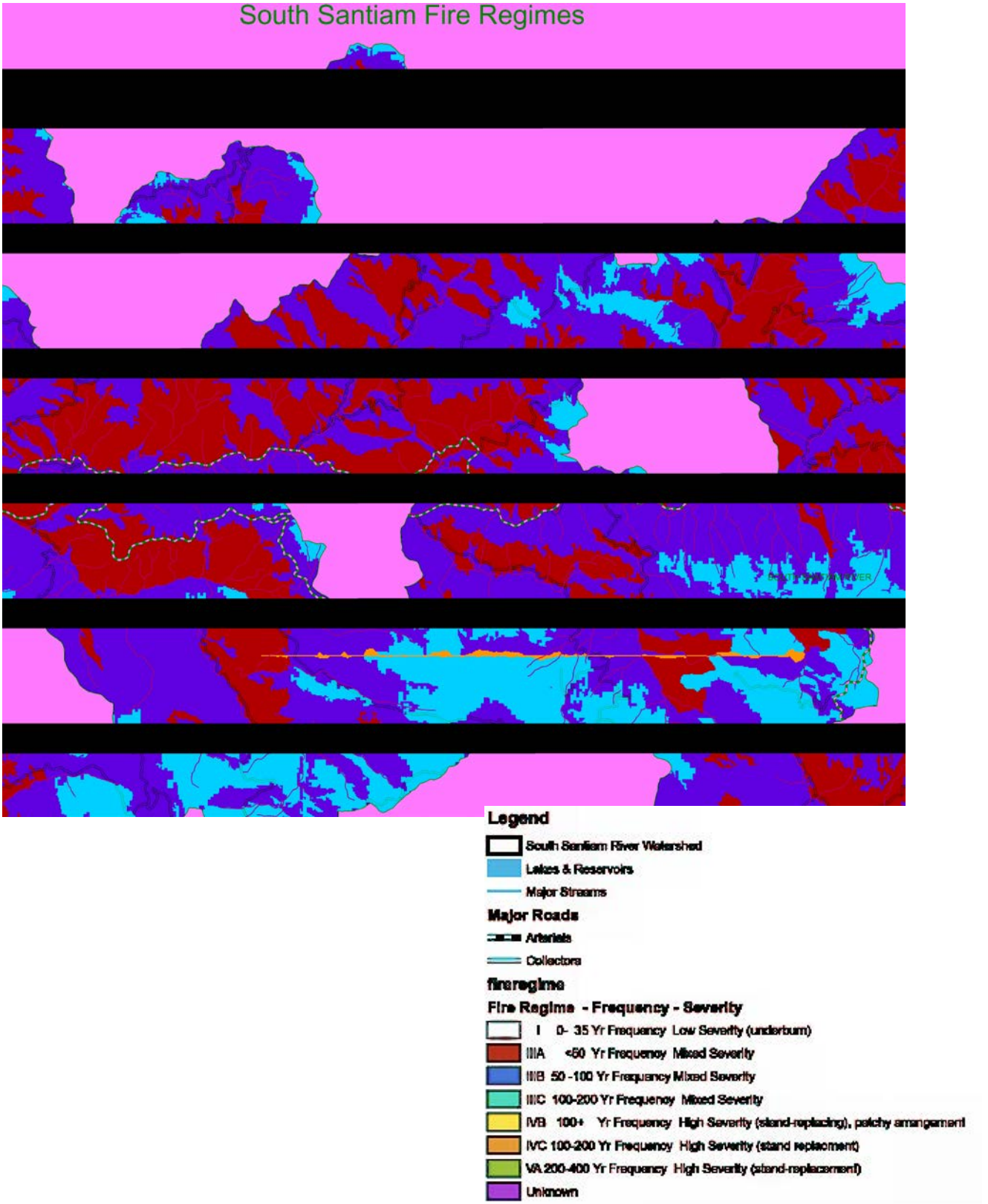


Figure 11: Fire Regimes

In the western and lower elevation areas of the watershed, catastrophic stand-replacing fire events have occurred in Moose, Trout and Sevenmile subwatersheds. Fires of this type are known to have occurred in this watershed in 1911, 1867, 1856 and 1500 *(see Figure 12: Fire History map).*

These fires were either lightning and/or human-caused and appear to have occurred during drought conditions which led to large, high-intensity burns. The main canyon here has a strong east-west orientation and a steep 'V'-shape. This geography creates a chimney effect that intensifies normal fire-season winds and probably contributed to high burning intensities and rapid fire spread over larger areas once fires ignited. These infrequent fires created large blocks of early seral stands across the landscape.

The lack of residual large wood in the stream channels and channelbanks, where it would have been predicted to survive the known fire events of the last 100 years, suggests that repeated large fires affected these areas even before Europeans settled here.

The lack of a well-developed duff layer on some north-facing slopes in Moose, Trout and Sevenmile subwatersheds also suggests that fire intensities were high and/or frequent for a period of time. In a more typical Western Cascades situation, the moister climate of north-facing slopes results in more duff accumulation as compared to south-facing slopes in a particular area. A probable scenario is that a stand-replacing fire burned through an area creating lots of snags and, over time, a large amount of fuels on the forest floor. Later a second fire came through that was carried by these heavy fuel loads and burned up snags, down wood and the duff layer even more thoroughly than the first fire.

Unlike much of the rest of the watershed, the Three Creeks Research Natural Area has not experienced a stand-replacing fire in the last 800 years. This seems to be a consequence of geographic location, landform, weather patterns, and random chance.

Fire effects – The dominant early seral species that regenerate here after a stand- replacing disturbance are generally Douglas-fir. Stand-replacing fires can kill the fire-intolerant western hemlock and Pacific silver fir, while only slightly affecting the more fire-tolerant Douglas-fir thereby leaving it as the dominant seed source for establishment of a new stand. Since not all fire-intolerant trees may be killed, western hemlock and western redcedar may also be early seral stand components in the western hemlock plant associations and Pacific silver fir and noble fir may be components in the Pacific silver fir plant associations.

Post-fire seedbeds in partial or underburns vary, with western hemlock and Pacific silver fir able to regenerate under more shady conditions than Douglas-fir. These intermediate disturbances serve to increase the within, as well as, between stand heterogeneity.

Most stands in the natural fire regimes for this area reach classic old-growth conditions of multiple layers, large snags and down wood.

Fire Suppression: Well-intentioned fire suppression activities have excluded fire or minimized its effects on the landscape in this watershed for the last 70 – 100 years. The last large, stand-replacing fires in the upper South Santiam drainage were in 1856, 1867, 1911 and 1936.

Since these last large fires, the size of smaller patch fires has been kept artificially low, and the opportunity for these fires to become large stand-replacing fires under certain environmental conditions (high temperatures, east winds, etc.) has been greatly reduced by fire suppression efforts.

Road building that occurred over the years in the watershed has increased accessibility for fire suppression efforts, and even though many local roads have been closed in the last 15 to 20 years, accessibility is still good. In addition, both roads and harvest units, especially those that were clearcut and broadcast burned, have provided fuel breaks throughout much of the area to keep fires small.

Fire exclusion has resulted in accumulations of surface fuels and understory vegetation in many areas. Without fire, the increased fuel build up eventually will affect the intensities of fires that do burn here. Thus, the irony of fire exclusion through fire suppression is that, when a fire does get started, it often burns more intensely and gets larger than it would under natural conditions in areas that are beyond the natural fire interval.

The overall effect is a decrease in the probability of large, low-intensity fires, an increase in the probability of high-intensity fires, and a divergence from the natural fire pattern which existed in this area prior to management. This decrease in the types of fires that occur leads to a decrease in the types of vegetation that respond differentially to fire. The resulting condition probably reflects an alteration in the distribution, composition and extent of plant communities that had adapted to the pre-management fire regime.

It is clear that fire, predominantly stand-replacing fire, has been the major disturbance factor creating current natural stands. With the inception of forest fire protection measures, fire has become a decreasingly important disturbance mechanism in the watershed. Where natural underburning was prevalent, lack of fire generally has resulted in increasing stocking levels of understory trees and fuel loadings.

Fire History

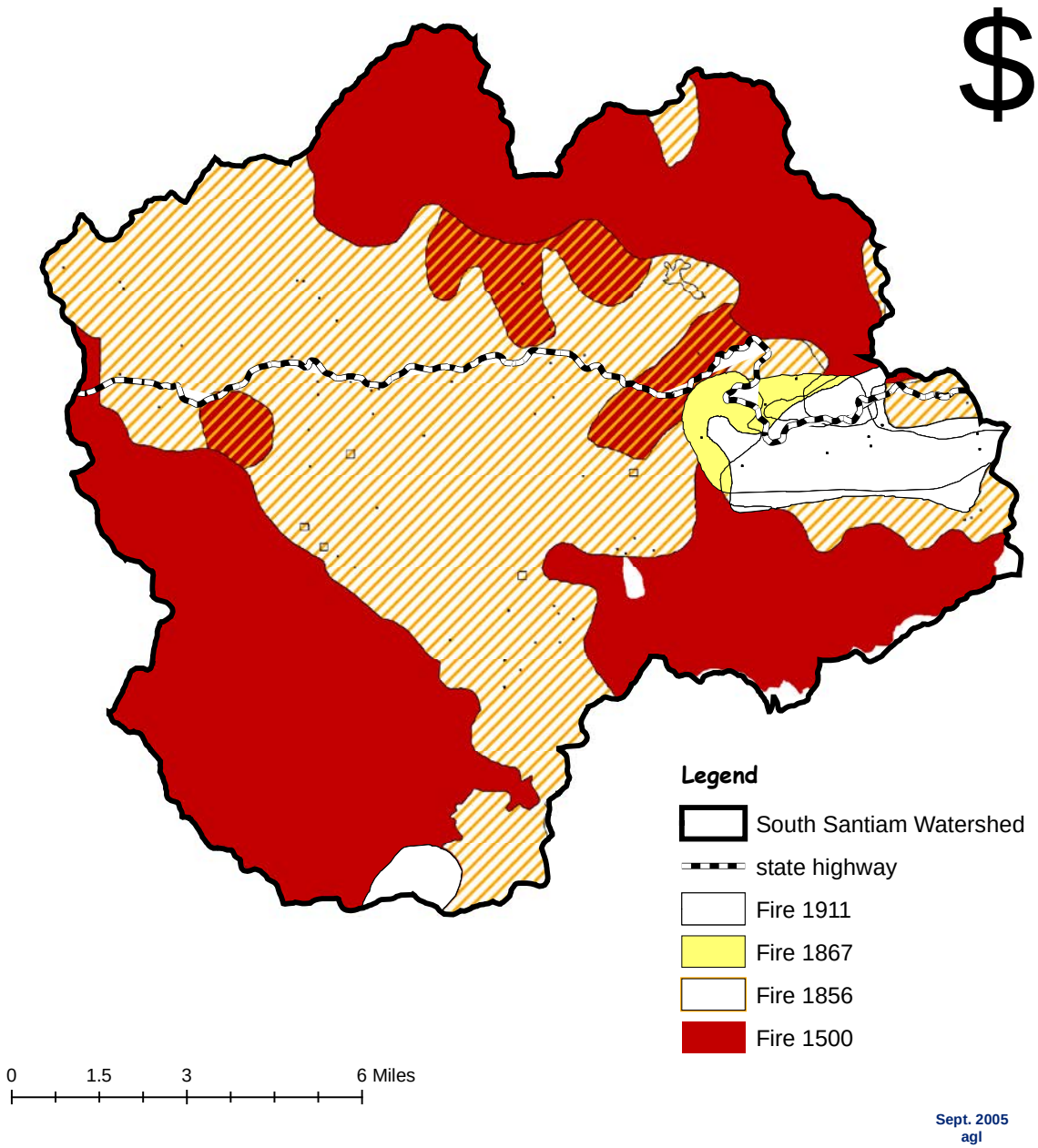


Figure 12: Fire History

Insects and Diseases are natural and important components of the evolutionary history, biological diversity and disturbance ecology and overall sustainability of forest ecosystems.

Root diseases: Laminated root rot is caused by the fungus *Phellinus weirii* and is most destructive in pure Douglas-fir stands. It affects trees of all sizes and ages and is a perennial inhabitant of the site. The disease occurs in patches or infection centers that are sporadically distributed. Since early mortality is scattered and trees are small, the problem is often not conspicuous before a stand reaches 40 years of age. Persistence from one rotation to the next and the gradual spread of the fungus can maintain the disease on the site indefinitely. *Phellius weirii* as can substantially reduce site productivity.

Pocket of laminated root rot

Another root disease, *Fomes annosus*, is also normal part of the forest ecosystem and may increase as a result of intensive management activities (*Schmitt at al 2000*). This root disease contributes to structural and compositional diversity in the forest. Infected trees suffer decay in both roots and the lower portion of the tree, as well as root mortality. This results in reduced tree vigor, increased windthrow, susceptibility to bark beetles and mortality.

Insects: Commonly, insects and pathogens work in tandem to cause tree mortality.

For instance, Douglas-fir beetles often attack trees that have been weakened by some kind of stress such as drought, competition, diseases, etc.

Larger beetle outbreaks usually occur after a large-scale disturbance such as a major fire, windstorm, or snow breakage. Beetle populations build up in downed or injured trees and then infest nearby green trees. Usually elevated beetle populations last for two to three years and then subside.

These beetles help accelerate the decomposition of downed trees by introducing other agents such as decay. In an ecological sense, they contribute by creating gaps in the forest which contribute to stand structure and species composition changes.

Douglas-fir beetle damage

Photo by: William M. Ciesla, Forest Health Management International www.forestryimages.org

White pine blister rust is an introduced fungus affecting five-needled pines such as western white pine, found in this watershed. Blister rust causes significant mortality plus top kill in all ages of this pine. For many years, white pine replanting has been done with rust-resistant trees.

White pine blister rust

Dwarf mistletoe affects many western hemlock, Pacific silver fir and to a lesser extent noble fir in this watershed. Dwarf mistletoe is more prevalent in mature stands with multiple canopy layers which facilitate spread from the overstory to the understory. Past even-aged management practices helped to reduce the distribution of dwarf mistletoe, but current harvest practices and fire suppression tend to promote conditions conducive to its spread.

Dwarf mistletoe in western hemlock

Photo taken by Kenelm Russell, Washington State Department of Natural Resources.

Bear, deer, elk, beaver, mountain beaver and *pocket gophers* can cause significant damage to stands in several ways: they can strip bark from the trees to feed on the sapwood, trample or pull out seedlings, browse seedling stems, prune the roots of young trees, cut the trees down, etc.

Bear damage to tree

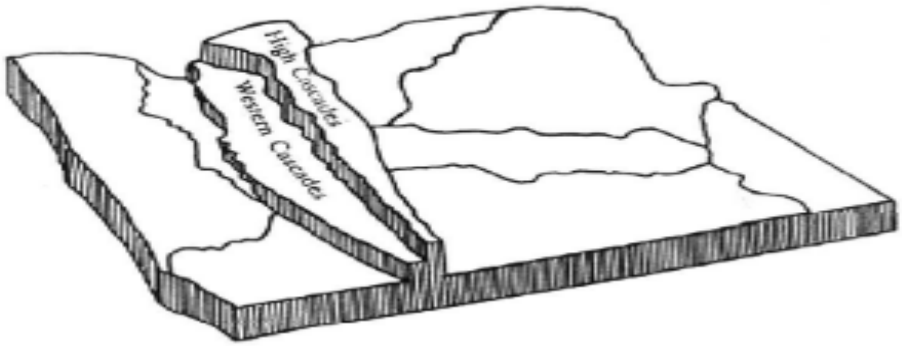
Deer

Pocket gopher

Mountain beaver

2.1.1 Characterization of Erosion Processes: *What erosion processes are dominant within the watershed? Where have they occurred or are they likely to occur?*

Understanding the basic geology of the watershed helps in understanding the dominant erosion processes here. The Cascades are composed of two parallel mountain chains -- an older, deeply eroded region called the Western Cascades and a younger region further to the east called the High Cascades. The Western Cascade Range was formed by a series of volcanic episodes beginning about 40 million years ago and the High Cascades started about 5 to 10 million years ago.



The upper South Santiam watershed is located entirely within the Western Cascades physiographic province and receives 60 to 120 inches of precipitation annually supplying the headwaters of the South Santiam River and its tributaries and contributing to deep weathering of geologic features here. The topography of the area is generally rugged with ridge crests averaging 4,500 – 5,000 feet in elevation. As elevations decline, the watershed gradually becomes less steep.

The geologic foundation of the watershed is older Tertiary basalt lava flows, tuffs and tuffaceous sedimentary rocks which date back 17 to 32 million years. Overlying this formation, flows and flow breccias ranging in age from 10-17 million years, form broad caps on the higher elevation main ridges in the Gordon Lakes/Soapgrass area and throughout the Harter Mountain area. Resting on these broad upland deposits are even younger, ridge-capping flows and flow breccias from 4 to 10 million years old, some of which are similar to flows found in the High Cascade volcanic sequence. (Walker and Duncan 1989)

These volcanic rock formations have been extensively modified by erosion through mountain glaciation, slope instability and stream downcutting since late Miocene time.

Geologic Foundation of the Watershed

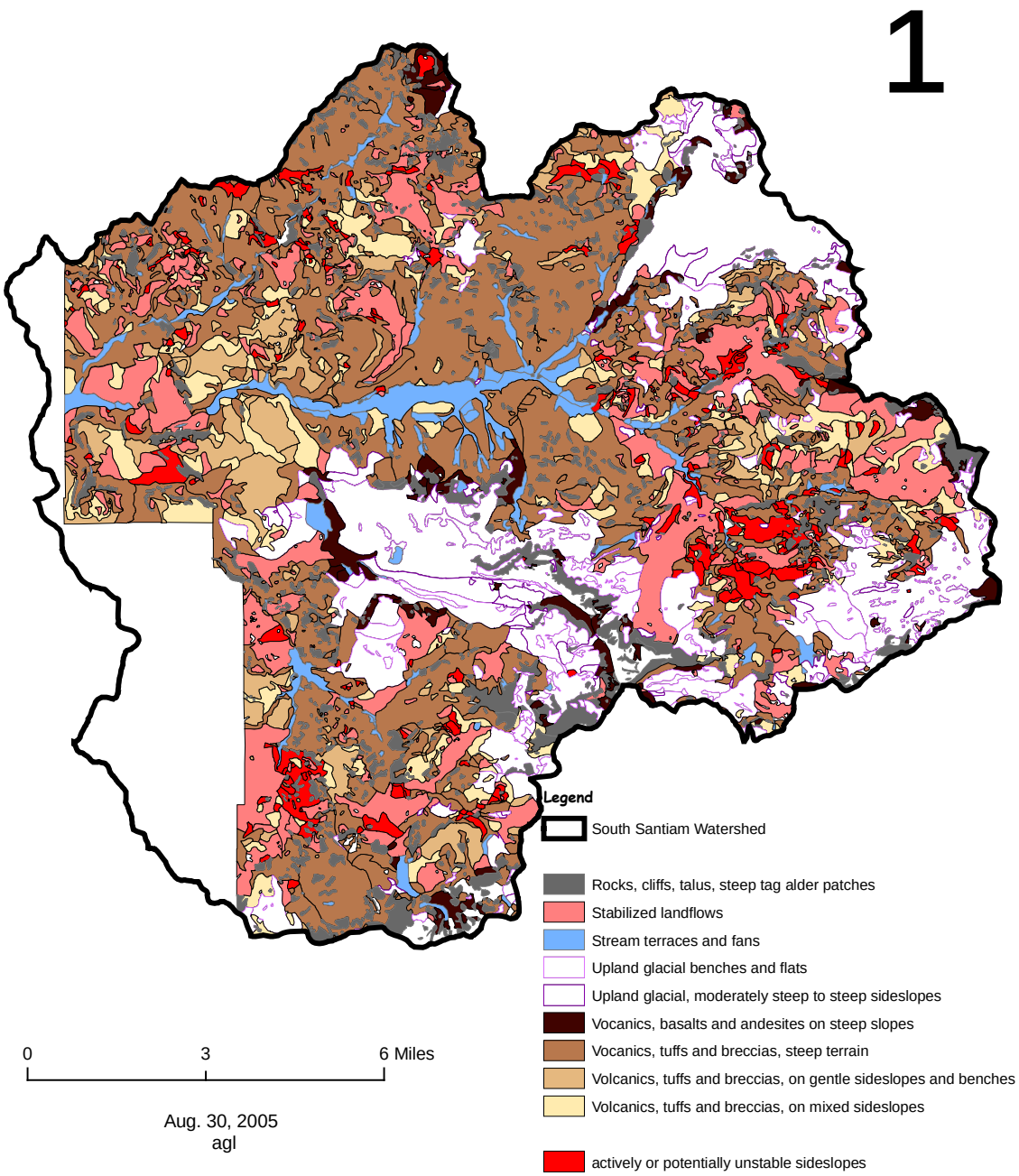
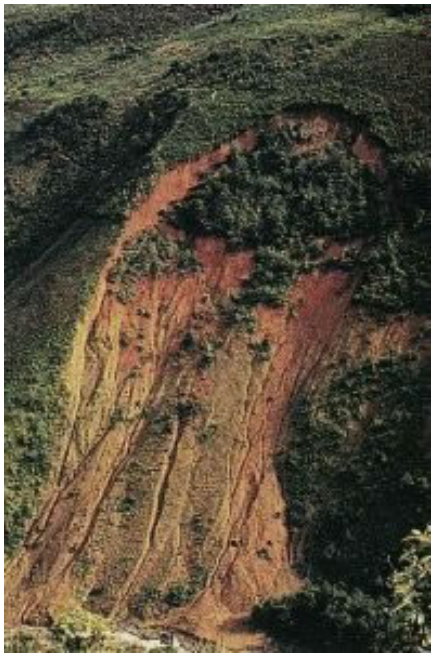


Figure 13: Geologic Foundation of Watershed

Mountain glaciation: At one time mountain glaciation was the primary erosion agent as evidenced by glacial landforms and glacially-derived soils that are common in parts of the watershed. During the earliest glacial periods about one to two million years ago, valley glaciers probably traveled down the South Santiam canyon and some of its tributaries. With the more recent glaciations, in the last 100,000 years, smaller glaciers carved cirques on the north and east aspects of higher peaks. Examples of glacial cirques can be found at the headwaters of Sevenmile and Latiwi Creeks as well as on Soapgrass, Tidbits, Twin Buttes and Two Girls Mountains. In addition to cirques, other glacial features such as hanging valleys and assorted morainal deposits can be found in the watershed but most have been extensively altered by stream erosion and slope instability over time. Due to climatic changes glaciation is no longer an erosion agent in the watershed.

Example of a Mountain Glacier in Canada
(*Natural Resources Canada - Terrain Sciences Division Canadian Landscapes*)

Slope instability: Large scale slump/landflow instability has been a significant factor in slope development and stream channel morphology since the glacial period ended about 10,000 years ago. The volcanic materials of the Little Butte Series weather to form deep colluvial and residual soils that create conditions where both rotational and translational failures are common, such as the very large debris chute which occurred in Sheep Creek in 1998. In many areas, actively unstable remnants of these larger landflows can still be found. Most still manipulate and control stream channel morphology to a high degree. Stabilized slump/landflow features such as sag ponds, bench and scarp topography, and disrupted drainages are common in Sheep, Sevenmile, Latiwi and Canyon Creeks.



Example of a slump not in this watershed

Photo from ***www.earthsci.org/Flooding/ unit3/u3-02-03a.html***

Stream downcutting: The terrain in this watershed has been extensively altered by stream downcutting over time. With 60-120 inches of precipitation annually, there is an extensive stream network working to transform the landscape. Currently downcutting is prevalent in many stream reaches where deep colluvial and alluvial materials are present. Many channels have been scoured to volcanic bedrock and downcutting occurs more slowly in the hard rocky layers.

Due to past fires, many stream channels lack adequate large wood to control stream energies and store sediments. High stream energies can result in scoured or undercut streambanks and can trigger streamside channelbank instability. Much of the sediment introduced to streams from scour, landslides, etc. washes through the system relatively quickly except in lower gradient areas, behind geologic nick points, and in isolated areas where large wood has accumulated to store the sediments.

In summary, the complex geologic history of this area has produced a diverse landscape with landforms that include highly glaciated upland benches and flats with extensive ground moraines, large scale stabilized slump/earthflow complexes and associated glacial deposits, and flat stable river terraces and outwash plains.

Three primary erosional agents mountain glaciation, slump/earthflows and stream downcutting, have created a variety of productive soils that include colluvial and residual soils on the volcanics, glacial morainal deposits and stream terraces and often times, the slump/earthflow terrain contains all three.

Stream downcutting (Soda Fork area)

Table: 8 Dominant Erosion Processes by Subwatershed

Subwater-shed	History	Basic Geology of Area	Dominant erosion processes
Moose	• About 900-1,000 years ago, a major slope failure blocked Moose creek to form Moose Lake. • About 1855 a stand replacing fire, and subsequent fires, removed almost all of the old growth in the basin. Fire caused extensive soil ravel and slough on steeper sideslopes and considerable nutrient loss on a variety of aspects in the drainage. • After the fires, large amounts of soil and debris were transported to streams by debris chute slope failures, especially during the major storms of 1861. • Because of rugged terrain, little road development or timber management has occurred here since the 1980's. Much of the area is still undeveloped and inaccessible. A lot of road building was done using end-haul techniques so road-related failures are rare here.	• Steep rocky canyons and crags • Bedrock – primarily tuffs, breccias, and ash flows. • Highly-dissected valleys. • Steep, shallow-soiled, rocky side slopes with numerous V-shaped draws. Rock outcrops and cliffs are common.	• In the past there was extensive erosion from mountain glaciers, earth failures and stream downcutting. • Then there was extensive soil ravel and slough after the large fires. Debris chutes were common, especially after floods that followed the large fires. • Now soil ravel, slough and soil creep are the principal agents providing material to the draws. Some localized areas of slope instability (both slumps and debris chutes are still active). • Road-generated sediment is not now a major factor on public land. • Private land – lots of harvest in 60-70's, many sidecast roads = debris chute scars. Now offsite sediment movement has reduced considerably. However, the storm of 1966 resulted in numerous road sidecast failures in the headwaters. • Human-caused sediment now only a token amount when compared to extensive sediment inputs from fire, flood and slope failure in last 300 years.

Subwater-sheds	History	Basic Geology of Area	Dominant erosion processes
Sevenmile Sheep Soda Fork	• Stand replacing fire 140 years ago and again 80 years ago removed almost all of the old growth in this areas, except in Sheep Creek	• Bedrock – primarily tuffs, breccias, and ash flows. • Highly dissected valleys. • Landforms – highly-glaciated upland benches and headwalls to large scale, stabilized slump/earthflow complexes to steep highly dissected v-shaped draws and headlands	• Extensive erosion from glaciations, earth failures and stream downcutting. • Numerous major slope failures (300 yrs old) that have at times blocked and still control base levels for parts of the S. Santiam River and its tributaries. Numerous active slump/earthflows move thousands of cubic yards of rock and soil downslope into drainages. Dozens of highly debris-chute prone terrain periodically fails into streams. • Soil ravel and slough following fires on steeper sideslopes. Large amounts of soil and debris were transported to streams by colluvial activity. Considerable reduction in nutrient availability and organic matter from severe fire intensity. • Sheep and Soda Fork Creeks are well-roaded. Latiwi is relatively unroaded due to steep terrain. Older roads were sidecast and some road failures have adversely affected streams. Most areas are finally beginning to stabilize. • Slumps and debris chutes. Soil and ravel slough after fires. Sheep Creek had a very large debris chute in 1998.

Subwater-shed	History	Basic Geology of Area	Dominant erosion processes
Upper Canyon Owl Canyon	• Stand replacing fire removed almost all old growth in Moe Creek (a tributary to Canyon Creek) 140 years ago.	• Bedrock – primarily tuffs, breccias, and ash flows. • Highly-dissected valleys. • Landforms = highly glaciated upland benches and headwalls to large scale, stabilized slump/earthflow complexes to steep highly dissected v-shaped draws and headlands • Large scale stabilized slump/earthflow complexes and associated glacial deposits	• Extensive erosion from glaciations, earth failures and stream downcutting. • Fire caused extensive soil ravel and slough on steeper sideslopes and considerable reduction in nutrient availability and organic matter in areas of severe fire intensity on south and west aspects. Stabilized slump/landflows features such as sag ponds, end and scarp topography and disrupted drainages • Most sediment to the streams, in the natural system, is supplied by the more gradual activities of soil creep when vegetative cover is common and ravel/slough when vegetation is removed, primarily after catastrophic fire events. • In the 1996 flood, Owl creek was impacted by series of debris chutes. • Many older roads constructed with sidecast techniques and road-related failures still contribute a considerable amount of sediment to streams.
Trout		• Older Western Cascades with highly dissected, steep to very steep side slopes. • Mostly dissected volcanics with shallow, rocky soils. Fluvio-glacial outwash terraces at lower elevations.	• Stream downcutting and colluvial movement predominate across the landscape. • Steep sideslopes have had considerable debris chute history, but very little debris chute potential remains, as little is left to fail.

2.1.2 Erosional Process Issues and Key Questions: *The issues and key questions help focus the analysis on the relevant elements of the ecosystem as they relate to management questions, human values or resource conditions within the watershed.*

Issue: The watershed contains many active landflows, primarily in Sheep and Latiwi Creek that contribute pulses of sediment through the stream network. These landflows move, almost independently of weather, but may be exacerbated by some storm events. Earthflows move downslope and constrict stream channels, then a storm event cuts through the constriction and mobilizes sediments within the stream network. This is when the major influx of sediments occurs in the stream system. This is especially true with storm events, following large fires.

Human-caused erosion processes have added to these natural processes. During construction of many of the early roads in the area, excess excavation material was sidecast, or put over the side of the hill. This material often became saturated and triggered landslides that took the roads with them. In addition, road grades were limited to 8%, because loaded log trucks could not negotiate steeper grades, so this limited flexibility in fitting roads to the lay of the land. This coupled with other road construction techniques used at the time, road densities, and the fact that some of these roads crossed segments of unstable ground, made them more prone to road failures. Before a lot of work was done to actively stabilize many of these roads, they produced a similar amount of sediment to natural systems. Some of this sediment input occurred during summer months when the stream systems were not geared for this amount of input, negatively affecting both fish and wildlife.

Although minor, when compared to old road construction techniques and natural processes, current management practices such as sub-optimal maintenance of road surfacing and drainage areas and recreational traffic (ATV's) on storm-proofed roads, also contribute to sediment production.

In addition, by precluding fires, we have allowed vegetation to stabilize some of these areas, but at the cost of increased fuel buildup. If a large-scale, stand-replacing fire event were to occur in an area of high fuel buildup, it could result in a massive influx of sediment into the system following the fire.

Even though this subwatershed has a history of natural erosion processes that its systems have adapted to, human activities, such as road construction, etc. may affect the spatial distribution of erosion processes on a minor scale, but to a larger extent they may have changed the frequency or timing of erosion processes such that they are not in sync with natural-system adaptations.

- ***Indicators for measuring or interpreting conditions:*** changes in natural range of variability in the frequency, timing and/or spatial distribution of erosion processes in the watershed
- ***Key Question***: What is the natural range of variability of disturbance processes that contribute to erosion within the watershed both in time and space? Where do management-induced erosion processes fall along this continuum? How does

sediment move through the system and in what time frames do these processes operate? How does the timing and frequency of human-cause sediment impact the natural system?

Issue: Soil compaction from old tractor skid roads and landings reduces soil infiltration causing water to pool on the surface, some of these areas have become wetlands providing habitat and contributing to species diversity and others have contributed to surface erosion. This has occurred mainly in lower elevation areas and older harvest units in Canyon, Owl and Sheep creeks. Where appropriate, when we have reentered these previously logged areas for additional harvest activities such as commercial thinning, we have tried to reuse the existing skid road system, where possible. Re-used skid roads are often subsoiled and returned to a more natural condition following harvest operations; however, compacted areas that have turned into wetland areas are protected from disturbance. These human-caused wet areas often preclude access to previously used landings or skid roads, making it necessary to disturb more ground to access the stands.

- ***Indicators for measuring or interpreting conditions:*** Acres of new skid roads or landings creating human-caused wetlands
- ***Key Question:*** What role do management-created wetlands play in this ecosystem? How important are management-induced wetlands to species habitat and diversity? How should these human-caused wetlands be managed?

2.1.3 Current Erosion Process Conditions: *What are the current conditions and trends of the dominant erosion processes prevalent in the watershed?*

Currently the dominant erosion processes prevalent in the watershed are debris chutes, slump/earthflows, colluvial processes, and stream bank erosion. To a lesser extent, timber harvest and roading also contribute to erosion in the watershed.

The Upper South Santiam is a sediment-rich system with numerous areas of active slope instability. Both slumps and debris chutes are principal sediment delivery mechanisms with soil ravel and slough a distant second, in the last century, followed by timber harvest activities in a distant third place.

Debris chutes are rapid, downhill mass movements of clay-to-boulder size material on fairly steep slopes. They are numerous in parts of the watershed and a principal-erosion agent affecting stream channel and drainage morphology here.

Debris chutes in this watershed have typically been the result of natural processes, road-side cast failures and to a lesser extent, timber management activities.

Trends: Debris chutes caused by natural processes have slowed down since the large stand-replacing fires of 1867 and 1911. Most of this can be attributed to vegetative growth and fire suppression. Debris chutes are still associated with significant storm events, but they tend to be isolated incidences now as compared to the past. In addition, occasional debris chutes just occur, such as the very large one in Sheep Creek that was not associated with a major storm event or timber management activities.

The frequency of road-sidecast debris chutes are trending downward as well. Many of these areas are being stabilized by vegetation, pullback of sidecast materials on old roads, improved drainage structures, road decommissioning and storm proofing. In the 1996 flood there were fewer road-sidecast debris chutes than in the 1964 flood, even though there were more roads in 1996 than in 1964.

Debris chutes associated with timber harvest are also trending downward. This can be partially attributed to the following three factors: 1) less timber harvest on public lands now than in the past, 2) harvest on public lands has gone from mostly clearcutting to mostly thinning, and 3) geological input on harvest unit locations to ensure that cutting areas are not placed on debris-chute prone areas.

Slumps/Earthflows are large, deep-seated, slow-moving mass movements of soil and are primary sediment delivery systems in this watershed. Actively unstable, slump/earthflow terrain is considered unsuited for timber management. These areas have been avoided in timber sale planning for almost 30 years now.

Trends: Based on personal observation by the district geologist, Doug Shank, it appears that slump/earthflows are reactivating in increasing frequency in the last 20 years or so, even in areas without management.

Colluvial processes: Creep and colluvial deposition from slope ravel and slough play a considerable role in more steady-state sediment delivery mechanisms in the watershed, at least on steep slopes. Management activities that resulted in vegetation removal and intensive, large scale fire activity undoubtedly accelerated these rates.

Trends: Vegetative growth, as a result of fire suppression, and changes in the amount and type of timber harvest on federal lands have likely reduced colluvial processes over past conditions. In addition, logging suspension and duff retention requirements have helped to minimize colluvial processes as well.

On the other hand, fire suppression has led to the accumulation of fuels that could eventually result in a large-scale, stand replacing fire. If this were to occur, colluvial processes would increase over current conditions.

Stream bank erosion: Another sediment delivery mechanism is stream bank erosion along mainstem and tributary channels, especially during high flow events. This may include erosion of earthflow toes, colluvial buildup adjacent to streams, and previously deposited alluvium in terraces and floodplains. The magnitude of the erosion is related to the magnitude of the flow, i.e., the greater the flow the more bank erosion is likely. It is also tied to the availability of large woody material in the stream channels, which is lacking in many stream channels because of past fires in the watershed.

Trends: When compared to the last 100 years, the trend is less erosion of stream banks now than in the past. Stream channels are becoming more stable because of vegetative growth, riparian buffer protection requirements, fire suppression efforts that have maintained vegetation on the landscape, and recent, drier weather patterns that have affected stream flows.

The trend toward more stabilized stream banks could reverse given a 30-100 year storm event. A significant increase in stream flows could mobilize stabilized areas in, and adjacent to stream channels, because there is not enough large, woody material to retain these areas. This could set the channels back to more unstable conditions.

Management Activities

Roading: Slope failures along the segment of highway 20 between Mountain House and Tombstone Summit are common because the highway is built across several actively moving slump/earthflows and other areas of unstable ground. These slope failures contribute varying amounts of sediment to stream channels especially during storm events.

In addition, surface erosion from forest roads and bare soil areas is another mechanism that can contribute sediment to stream channels in the watershed. Unsurfaced roads constructed next to streams can be chronic contributors of fine sediment, particularly if they are used in winter months. Winter logging exacerbates this problem because the truck wheels pump fines from within the road bed to the surface. Fine sediment from roads can then enter stream channels. Best Management Practices (BMP's) are implemented to reduce this type of erosion.

The frequency and extent of road maintenance can affect the amount of sedimentation coming from roads. In the past, roads on federal lands were often maintained to a higher

standard than described in road maintenance standards for individual roads. For instance, *Maintenance Level II* roads, which are intended for incidental traffic by high-clearance vehicles, were often maintained to higher standards allowing passenger car access.

Now there is insufficient funding to maintain all of these roads, which can lead to more sediment production as surfacing is lost or if culverts washout, etc. If roads are decommissioned and storm proofed, this is less of a concern. So road managers have spent considerable energy analyzing the road system to determine which roads were essential to keep open and which should be decommissioned.

Trends: Fewer roads are open to access the watershed, on public lands, than in the recent past. Many roads have been decommissioned and stored for future use and road maintenance levels have been downgraded on many other roads, especially from Maintenance Level III to Maintenance Level II. Road access for management activities, fire suppression, and recreation is reduced and so is sediment associated with roads.

Road Use: ATV use on forest roads has been on the rise in recent years. These vehicles are able to use roads that many other vehicles can no longer traverse because they have been decommissioned and may be blocked by berms, etc. There is a concern when ATV's are used on decommissioned roads, as they may contribute to increased erosion on roads that are not currently intended for vehicular use, and usually there isn't enough money to continually fix these roads.

Trends: ATV use will likely increase over current conditions and use of decommissioned roads will become more of a concern in the future. Sediment production from roads, previously storm-proofed and stored, will likely increase on roads used by ATV's.

Timber harvest has the potential to increase erosion in the short term, especially on steep slopes with a high inherent risk of landslides. In recent years harvest levels have been reduced and harvest practices have changed from mostly clearcutting to mostly thinning.

Trends: The inherent risk of landslides associated with harvest practices is decreasing as vegetation recovers and as harvest units are located away from landslide-prone areas as a result of geologic input on unit location.

2.1.4 Reference Erosion Process Conditions: *What are the historical erosion processes in the watershed? Where have they occurred?*

The primary historical erosion processes in this watershed were mountain glaciation, slope instability, stream downcutting and roading.

Mountain glaciation– Evidence of mountain glaciation is common in this watershed. From the appearance of the landscape, it appears that valley glaciers probably traveled down the South Santiam canyon and some of its tributaries during the earliest and most extensive glacial periods one to two million years ago. Glacial features in the watershed can still be found, but have been extensively altered by stream erosion and slope instability.

Slope instability - Slump/landflow instability has been a significant factor in slope development and channel morphology here for centuries in areas of deep colluvial and residual soils where both rotational and translational failures are common. Stabilized slump/landflow features such as sag ponds, bench and scarp topography, and disrupted drainages are common in many parts of the watershed.

This area has had a fairly extensive fire history in which large stand replacing fires have removed large areas of vegetation. After the large fire and storm events of the mid-1800's and early 1900's, slope instability was very prominent in this watershed for many years.

Stream downcutting – Since stream erosion and deposition are controlled by water volume and velocity, the 60-120 inches of precipitation annually provides ample water volume, and the relatively steep topography provides plenty of velocity, for significant stream downcutting to take place here to shape the landscape. The terrain in this watershed has been extensively altered by stream downcutting and erosion, over time, as evidenced by the extensive stream network here. Because of the high-energy stream system, and lack of large wood to moderate stream energies in many stream channels, some channels have been scoured to bedrock.

Land Management Activities – In the period between the late 1940's and 1975, many miles of roads were constructed in the upper South Santiam watershed. Road location and construction techniques during this time period differed from techniques used today. Roads used for log hauling and recreational use contributed significantly to stream sediment prior to current road construction techniques. Accumulated road failures in large storm events exacerbated the situation. During this time, it is estimated that human-caused erosion rates were approximately equal to natural processes in the amount of sediment produced, but there were some major differences in the timing of sediment input and the location where the sediment came from within the watershed.

In the last 1970's geologists and transportation planners were hired. At that time there were major advances in transportation planning and road construction techniques to help minimize this management-induced erosion.

2.1.5 Synthesis and Interpretation of Erosion Processes: *What are the natural and human causes of change between historical and current erosion processes? What are the influences and relationships between erosion processes and other ecosystem processes?*

Table 9: Natural and Human Causes of Change between Historical and Current Erosion Processes

Changes between historical and current erosion processes	Natural Causes of Change	Human causes of change
Mountain glaciation is not longer a major player in shaping the landscape in this watershed	• Climate changes. It is warmer now than it was when mountain glaciation occurred here.	
Timing, frequency and spatial distribution of erosion processes in the watershed may have changed	• Vegetative growth stabilizing areas where previous erosional activities occurred.	• Side-cast road construction discontinued. On many of these roads sidecast material pulled back and vegetation reestablished to stabilize roads • Less road construction and roads that are constructed are located with geologic input to avoid unstable areas. • Fewer miles of open roads as more roads are decommissioned or obliterated. • Less timber harvest on public lands and harvest type changed from mostly clearcutting to mostly thinning. Also because of geologic input, harvest units are located away from unstable areas. • Fire suppression has minimized input of sediment from landflows because there are fewer stand-replacing fires

Changes between historical and current erosion processes	Natural Causes of Change	Human causes of change
Stream downcutting to bedrock	• Fires and storm events in the mid-1800's and early 1900's removed a significant amount of large wood from streams to moderate stream energies	• Stream cleanout and salvaging practices in riparian areas limited the amount of large woody material available to streams to moderate stream energies
Debris chutes have slowed since the fires in mid-1800's and early 1900's	• Vegetative re-growth	• Fire suppression • Fewer sidecast roads • Improved road drainage structures • Less clearcutting and more thinning • Geotechnical input into road locations
Slump/earthflows reactivating with increasing frequency	• As landscapes age, soils are developed and water tables established that promote re-activation. This process involves the "loading" of the mass and then a casual mechanism to trigger movement. Through the years the system has been loading itself for eventual failure *(Benda)*	• Incidental removal of toe areas of slopes through road construction

Changes between historical and current erosion processes	Natural Causes of Change	Human causes of change
Colluvial processes such as soil creep, ravel and slough are less extensive now that after fires and floods in mid-1800's and early 1900's	• Passive recovery is happening as natural growth of vegetation is slowing colluvial movement.	• Less harvest and road construction so there is less bare soil subject to this type of erosion • Changes in timber harvest activities from mostly clearcutting to mostly thinning leave more vegetation on the site to moderate colluvial processes • Logging suspension and duff retention requirements protect from this type of erosion • Vegetation growth along road cuts – causing to stabilize more • Fire suppression lead to more vegetation re-growth but more fuel buildup that could result in stand replacing fire and much more colluvial activity.
The influence of roads and timber harvest on erosion rates have decreased and is now more like a background level than in the past	• Re-vegetation has helped to stabilize roads and harvest units	• Sidecast pullback on old side-cast roads • Put bigger culverts in roads to accommodate more flow – after 1996 flood • Less clearcutting and more thinning • Less road construction, more road decommissioning (fewer open roads) • Hired staff with geological expertise in locating roads and harvest units to minimize erosion
Increasing duff layer development, soil nutrient and water storage capacity	• Leaf-fall and other organic debris building up duff layer and soil nutrients.	• Changes in logging practices duff retention and suspension requirements • Fire suppression

Changes between historical and current erosion processes	Natural Causes of Change	Human causes of change
Soil compaction from logging is less now than in the past	• Fracturing by roots • Freeze-thaw on old skid roads	• Changes in logging practices, designated skid roads, log suspension requirements, ripping and seeding skid roads, etc.
Slope failures and addition of sediment to streams less now than in the past	• Vegetative re-growth stabilizing areas	• Placement of roads and harvest units outside of unstable areas based on geologic input
Streambank erosion is less than it was in the past, especially after the fires and floods	• Vegetative re-growth • Drier weather patterns recently so there is less water to erode the streambanks	• Riparian buffers on streams maintains vegetation that helps minimize streambank erosion • Fire suppression has kept vegetation on the landscape which helps minimize streambank erosion
After fires and flood of 1861, lots of sediment was being input into the stream system, now we are moving to the other end of that spectrum, we are beginning to collect sediments in the streams	• Starting to see more mortality in stands because of competition. Some of this mortality is contributing wood into the streams	• Put structure in streams in Moose and Soda Fork • Less salvage in riparian areas

Table 10: Influences and Relationships between Erosion Processes and Other Ecosystem Processes.

Erosion Processes	Influences and Relationships between erosion processes and other ecosystem processes
• Slumps/earthflows	• Introduces sediment into stream channels. If collected behind large woody debris, sediments can create quality fish habitat. • Too much sediment in stream can adversely affect fish habitat. • Sediment can affect domestic water treatment, especially from clays associated with persistent turbidity. • Can affect traffic safety and vegetation.
• Stream downcutting	• Can result in downcutting to bedrock which can affect stream temperatures and can remove substrate for fish habitat.
• Debris flows	• Can block roads, remove vegetation and conversely add sediment and structure to stream channels
• Colluvial processes	• Can rapidly increase in rate with stand-replacing fires.
• Soil compaction	• In some areas can create wetland habitat. • Affects plant growth and ability to establish vegetation • Can increase surface erosion
• Streambank erosion	• Can undercut trees and topple them, adding structure to stream channels • Add sediment to stream channels

2.1.6 Recommendations: *Which of the changes in ecosystem condition and function require management action to achieve management objectives?*

Changes requiring management action	Management objective	Recommended management actions to achieve management objectives	General Location	Indicator used to measure success	Recommended Monitoring or Research and Data Gaps
Duff layer development	• Maintain duff layer	• Require appropriate log suspension during harvest operations • If burned, require burning conditions conducive to retaining duff layer • Encourage development of duff layer in areas where it is lacking • Follow Forest Plan standards and guidelines and Best Management Practices	• Entire watershed	• *Indicators:* Amount of duff retained • *Expected outcome*: retain existing duff layer and encourage duff development in areas that are deficient • *Duration:* long-term • *Certainty:* moderate to high	• Monitor amount of duff retained after management activities • Areas deficient in duff
Soil compaction and/or displacement from old tractor skid roads and landings	• Minimize soil compaction and displacement	• Select appropriate equipment and time of year for harvest operations based on soil conditions • Implement appropriate log suspension requirements for soil conditions • Restore area of soil compaction and/or displacement as appropriate, using techniques such as subsoiling skid roads and landings following harvest operations, etc.	• Entire watershed	• *Indicators:* amount of soil compaction or displacement • *Expected outcome*: little or no soil compaction or displacement • *Duration:* long-term, decades • *Certainty:* moderate to high where work is performed	• Monitor soil compaction and/or displacemen t following management activities

Changes requiring management action	Management objective	Recommended management actions to achieve management objectives	General Location	Indicator used to measure success	Recommended Monitoring or Research and Data Gaps
Old side-cast roads and/or drainage structures contributing to slope failures and adding sediment to streams	• Minimize turbidity and regulate timing of sediment input	• Fix unstable culvert fills • Replace damaged, undersized or otherwise inappropriate drainage structures in roads, especially where they contribute to sediment in stream channels • Implement side-cast pullback on old roads as needed • Use Best Management Practices in road construction	• In areas of old side-cast roads or inappropriate drainage structures	• *Indicators:* Increased road stability as evidenced by lack of tension cracks inroad fills or lack of eroding ditchlines. Appropriate size culverts. • *Expected outcome*: Stable roads • *Duration:* long-term • *Certainty:* Moderate to high where work is performed	

Changes requiring management action	**Management objective**	**Recommended management actions to achieve management objectives**	**General Location**	**Indicator used to measure success**	**Recommended Monitoring or Research and Data Gaps**
Continued slope instability	• Maintain slope stability	• Continue obtaining geologic input for harvest unit and road locations. • Implement log suspension requirements as necessary to ensure slope stability • Retain duff layer • Continue surfacing roads with rock to minimize surface erosion. • Continue to expand existing and develop new weed-free rock sources to make it cost effective to surface roads • Implement Best Management Practices	• Entire watershed	• *Indicators:* slope failures • *Expected outcome*: maintain slope stability • *Duration:* long-term • *Certainty:* moderate	
Fire suppression has caused fuel build up such that if there is a large scale stand replacing fire, soil damage will be greater than it would be under natural fuel conditions.	• Protect soil resource	• Return fire condition class to more natural condition. • Treat unnaturally high accumulations of fuel build up as appropriate	• In areas of high fuel build up	• *Indicators:* fire severity • *Expected outcome*: fire condition class closer to natural condition • *Duration:* long-term • *Certainty:* moderate	• Identify areas of high fuel build up needing treatment

2.2 HYDROLOGY

2.2.1 Hydrologic Characterization: *What are the dominant hydrologic characteristics and other notable hydrologic features and processes in the watershed?*

Peak flows - The dominant hydrologic characteristics for this watershed are peak flows, especially those that occur following rain-on-snow events. Several distinct processes generate peak flows here including rainstorms, winter and spring rain-on-snow events, and spring snowmelt. They are all produced by a combination of climatic variables such as precipitation, temperature, snow pack, wind and solar radiation, etc. Winter peak flows generally result from rainfall or rain-on-snow events. Spring peak flows are produced during the snowmelt period initiated by increased solar radiation and occur over a sustained period of time (up to several weeks). The spring rain-on-snow process can cause quick spikes in peak flows on top of the already elevated high flow during this season.

Rain-on-snow events in the transient snow zone or the part of the watershed where snow accumulates and melts on a seasonal basis, are important mechanisms during which significant snow melt and large-scale flooding can occur. They are the dominant processes that create extreme peak flows. These rain-on-snow events can influence the amount and timing of runoff and sediment delivery. When soils are frozen, the combination of rainfall and melted snow cannot infiltrate the soil, so the water runs over the surface and into streams greatly increasing the volume of water in the stream channels. This increased volume of water results in increased stream velocities that erode stream banks and cause downcutting. The biggest rain-on-snow events in this watershed usually occur between November and February.

Minimum flows - Water flow from streams varies throughout the year. It is affected by a number of factors including precipitation, infiltration rates, groundwater discharge, evapotranspiration, etc. At the other end of the spectrum from peak flow are minimum flows which result from long periods during which water being discharged is not replenished by rain or snowmelt. Because of the relatively dry summers in this watershed, the lowest flows normally occur here in the late summer. Minimum flows are significant to both human use and aquatic habitat. In late summer, the demands for a variety of needs increase at a time when the supply is limited.

Other notable hydrologic features: Besides stream flows and rain-on-snow events, notable hydrologic features in this watershed are groundwater recharge areas and cold water seeps. Although limited in this watershed, groundwater recharge areas occur in the glacial deposits in the northeastern and southeastern portions of the drainage, at stream junctions, around Gordon Meadows and behind the natural dam (Moose Lake) on Moose Creek. Cold water seeps, generally less than ½ acre in size are scattered throughout the watershed. Many seeps and small wet areas adjacent to, or within plantations are being lost because of increased transpiration of the growing trees.

2.2.2 Hydrologic Issues and Key Questions: *The issues and key questions help focus the analysis on the relevant elements of the ecosystem as they relate to management questions, human values or resource conditions within the watershed.*

Issue: The forest canopy affects both accumulation and melting of snow packs. While snow tends to accumulate in clearcuts, road openings, etc, it tends to be intercepted by forest canopies. A variety of factors affect snowmelt including: incoming solar radiation, heat from the air (snow melts faster in windy conditions than calm conditions), heat transfer from the ground, latent heat transfer and heat transfer by falling rain. Many of these factors result in faster snow melt in open areas than forested ones. Studies have shown that on the scale of a small watershed or subwatershed, management activities that create openings in the forest canopy can increase smaller peak flows (Adams, 1994)

- ***Indicators for measuring or interpreting conditions***: Changes in peak flows tied to percent of openings in watershed.
- ***Key Questions***: Does the pattern, extent and type of timber harvest and other management activities that have occurred in this watershed affect the magnitude and frequency of peak flows and how does that compare to the range of natural conditions? How long do these effects last?

Issue: High flows resulting from rain-on-snow storm events transport tremendous amounts of sediment through the system. Increases in the frequency of peak flows can cause channel instability and increased sediment downstream. Timing of the sediment transport can adversely affect the aquatic and biological and social use of water from the watershed.

- ***Indicators for measuring or interpreting conditions***: Rain-on-snow storm frequency return interval. Stream flows associated with storm events.
- ***Key Question***: How does the magnitude and frequency of peak flow compare to the range of natural conditions?

Issue: In the past, this watershed has experienced large stand-replacing fires which resulted in high peak flows. Stream channels became resistant to these flows. Fire suppression in the last 70-100 years has allowed vegetation to become re-established resulting in more complexity within stream channels but also making them more susceptible to peak flow effects. Past timber management activities, stream cleanout practices, fires and torrential flows have removed large woody debris from the system. This deficiency limits the ability of the watershed to dissipate streamflow energy and prevent erosion, retain spawning gravel and nutrients or to create and maintain instream habitat complexity.

- ***Indicators for measuring or interpreting conditions:*** Utilization of Regional Stream Survey Protocols; pool/riffle ratios; gradient; channel type, etc.
- ***Key Question:*** In what way has fire suppression altered peak flow effects on stream channels and aquatic habitat? Are these effects outside the range of natural conditions?

Issue: When the inevitable wildfire starts, after 80-100 years of fire suppression, the fire can be unnaturally intense and cause greater damage to soil and water than might have occurred naturally without fire suppression. Severe fires can create water repellent conditions could lead to increased runoff and contribute to peak flows.

- ***Indicators for measuring or interpreting conditions***: peak flows measured in cubic feet per second
- ***Key Question***: After years of fire suppression, how can management moderate the potential effects of unnaturally intense wildfires on the soil which could lead to increased runoff and contribute to peak flows in this watershed?

Issue: During the dry summer months when flows are at their lowest, there is the most competition for water by beneficial users.

- ***Indicators for measuring or interpreting conditions:*** Social, water rights and uses, biological instream flow requirements
- ***Key Question***: How can management moderate the conflicts and potential effects of minimum flows on downstream users?

Issue: As it typical of many western Cascades watersheds, there are not a lot of water storage areas here. There are fewer storage areas now than in the past because natural and management activities have altered the mechanism for storing water within the watershed. Water storage mechanisms regulate the volume of water available in the system during dryer periods of the year. Without appropriate water storage capacity, increases in stream temperature and detrimental affects to downstream water quality can occur. This occurs throughout the watershed, but primarily in the earth-flow dominated areas, related to sag ponds.

- ***Indicators for measuring or interpreting conditions***: Acres of change from existing to post treatment.
- ***Key Question***: Where and how can historic-levels of water storage be reestablished in the watershed?

2.2.3 Current Hydrologic Conditions: *What are the current conditions and trends of the dominant hydrologic characteristics and features prevalent in the watershed?*

Peak flows in the upper South Santiam watershed vary from year to year and from season to season. Overall the climate that dominates this area and impacts peak flows is a temperate maritime climate with cool, wet winters and warm, dry summers. Although this is the dominant pattern, the weather tends to run in cycles of warm, dry years and cool, wet years based on conditions in the Pacific Ocean. During warm years there tends to be less rainfall and light snowpacks as well as lower spring streamflows. In contrast, during cool years there tends to be more rainfall and heavier snowpacks with higher streamflows.

The upper South Santiam watershed is accustomed to, and has formed as a result of variations in both annual and seasonal streamflows. Both floods and drought are also part of the natural range of variability here.

Trends: In the near term, the seasonal variability and wet and dry cycles in weather patterns will continue to influence streamflows, both peak and low flows. In the longer-term, temperature increases that the Pacific Northwest has already experienced and predictions for continued increases as a result of climate changes will likely have an influence on both the seasonal distribution of streamflows and peak and low flows.

Rain-on-snow events – As described in the characterization section, rain-on-snow events are important mechanisms during which significant snow melt and large-scale flooding can occur. The last major rain-on-snow event in this watershed was in February 1996. This storm event was the result of a combination of a very wet winter which saturated soils, warm temperatures from a subtropical storm, record rainfall and a deep snowpack which quickly began to melt when hit by the warm rains and warm air temperatures. Streams rose quickly with the increase in water and many overflowed their banks. With increased water volume also came higher stream velocities and accelerated streambank and channel erosion.

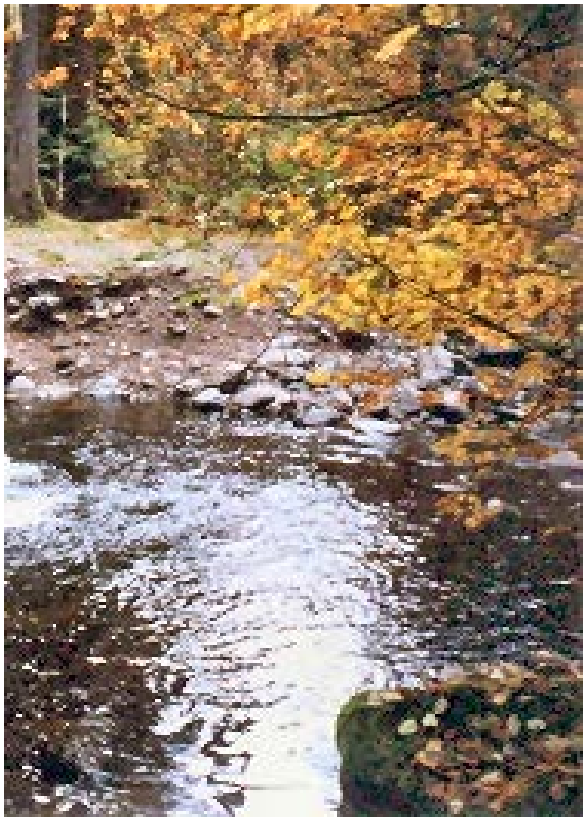
Trends - Rain-on-snow events appear to be continuing as a dominant process in the future. As the climatic warms, the frequency of rain-on-snow events may increase, but with less snow, the area affected may be smaller. In addition, there appears to be a pattern of 20-year wet and dry cycles, and we appear to be in a drier cycle. If we are entering a drier cycle, and vegetation changes seem to suggest that we are, there is literature on both sides of the fence with regard to frequency of rain-on-snow events.

Minimum Flows generally occur in this watershed in July though October after a relatively long period of little or no rainfall.

Trends – The timing of minimum flows is similar to the past but flows may actually be lower. After the large stand-replacing fires of the mid-1800's and early 1900's combined with significant timber harvest in the past, many young stands are scattered throughout the watershed. In a study by Julia Jones, et. al. on the H.J. Andrews it was determined that young stands may actually be using more water than older ones. Transpiration from the number of young, rapidly growing stands in this watershed may have an impact on water availability during very low flows in late summer.

Other notable hydrologic features – groundwater recharge areas occur in the glacial deposits in the northeastern, central and southeastern portions of the drainage and at tributary junctions. These are the only water storage mechanisms in the watershed.

Trends – The trend is a net loss of seeps and small wet areas associated with plantations due to increased transpiration of larger trees and loss of alder stands.



Sheep Creek in fall

2.2.4 Reference Hydrologic Conditions: *What are the historic hydrologic characteristics (discharge, peak flows, minimum flows) and features (cold water seeps, etc.) in the watershed?*

Discharge: Stream discharge is a measure of the amount of water that flows through a stream in one second. It is calculated using measurements of stream width, depth and velocity. Discharge fluctuates with the seasons and with storm events and is important for a variety of reasons including the types of aquatic organisms that can live in the stream.

Annual Mean Streamflow on South Santiam River at Cascadia from 1936-2003

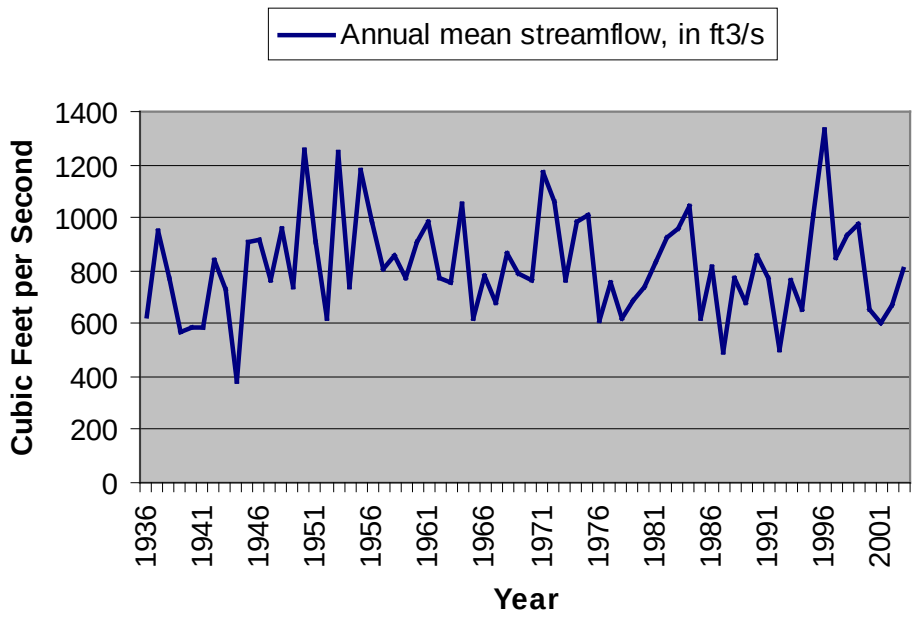


Figure 14

The *range of conditions* for annual mean streamflow for the South Santiam River at Cascadia during the time period from 1936 until 2003 was 378 ft3/sec in 1944 to 1,329 ft3/sec in 1996.

Peak Flow information for this area dates back to the 1930's. Prior to that time information is less certain. Historically peak flows were probably high in stage and frequency as reflected by the drainage densities across the landscape and the abundance of runoff that would have created these drainage patterns. The chart below illustrates peak streamflows in the South Santiam River near Cascadia for various storm events between 1936 and 2003. The range of peak flows over that time period varies from 2,690 ft3/second in 1977 to 31,700 ft3/second in 1996.

Peak Flows on the South Santiam River near Cascadia from 1936-2003

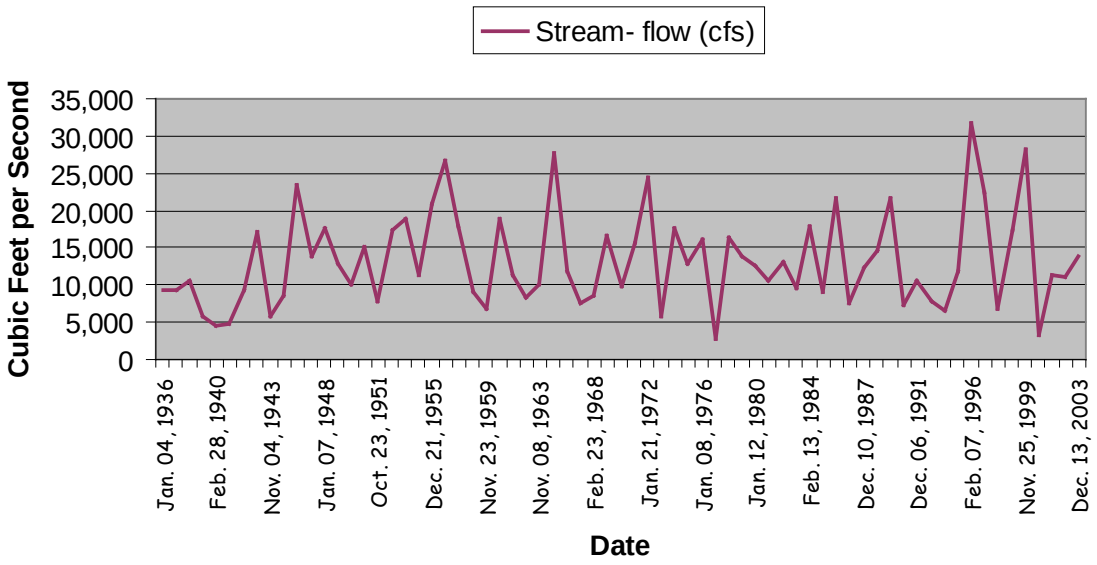


Figure 15

Rain-on-snow events contribute significantly to peak flows in this watershed. The table below shows some of the historically significant rain-on-snow events since 1861.

Table 11: **Significant Rain-on-Snow Events**

Date	Location	Characteristics	Type of Flood
Dec, 1861	Willamette Basin and Coastal Rivers	This event was preceded by two weeks of heavy rain.	Rain-on-snow, snow melt
Feb. 1890	Willamette Basin and Coastal Rivers	Second largest known flood in the Willamette Basin.	Rain-on-snow
Dec. 1937	West. Oregon	Flooding following heavy rains.	Rain-on-snow
Jan. 1963	West. Or	Widespread flooding accompanied by a windstorm	Rain-on-snow
Dec. 1964 – Jan 1965	Willamette Basin	Record flooding. Two intense storms. Near-record, early-season snow.	Rain-on-snow
Jan. 1974	West. OR	Flooding, followed by heavy wet snow and freezing rain	Rain-on-snow
Dec. 1978	West OR	Intense heavy rain, snowmelt, saturated ground.	Rain-on-snow
Feb. 1987	Western OR	Affected Willamette River and tributaries.	Rain-on-snow
Feb. 1996	Entire State	Deep snow pack, warm temperatures, record-breaking rains.	Rain-on-snow
Nov. 1996	Entire State	Record-breaking precipitation, local flooding	Rain-on-snow

Minimum flows – Minimum flows are important to those resources, such as fish, which are dependent upon water for their survival. When water flows are the lowest, competition among users is the greatest. The chart below illustrates the historic average minimum flows for each month of the year, based on about 70 years worth of data. The range is 69.8 ft^3/second in August to 1,227 ft^3/second in December.

Mean Monthly Minimum Streamflows in the South Santiam River at Cascadia from 1935-2003

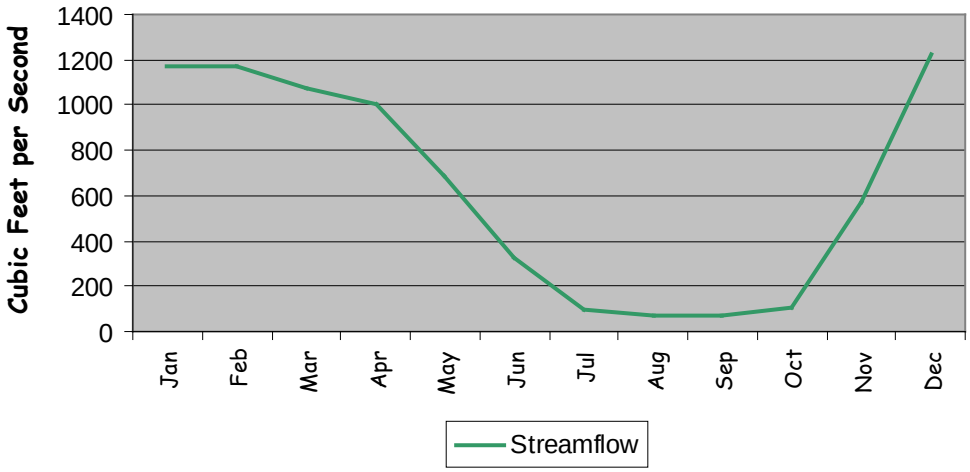


Figure 16

Other notable hydrologic features – The locations of cold water seeps and ground water recharge areas are determined by the underlying geology and stream morphology and haven't really changed over time. Vegetation in the vicinity of these features can affect the water availability here. In addition, natural and management activities can affect the mechanism for storing water in the watershed.

2.2.5 Synthesis and Interpretation of Hydrologic Conditions: *What are the natural and human causes of change between historical and current hydrologic conditions? What are the influences and relationships between hydrologic processes and other ecosystem processes?*

It is difficult to assess changes between historical and current hydrologic conditions because both streamflows, and the climate that contributes to those streamflows, are extremely variable over time. It is hard to separate out natural variations in streamflow with human-caused variations.

Table 12: Natural and Human Causes of Change between Historical and Current Hydrologic Conditions

Hydrologic condition	Natural Contribution to Hydrologic Condition	Human Contribution to Hydrologic Condition
Peak flows and high stream energies	• Climate changes may contribute to an increase in the frequency of rain-on-snow events that contribute to peak flows, but with less snow, the area affected may be smaller. • Fires and floods removed large woody structure	• Timber harvesting increases stream flow by reducing water losses from interception and evapotranspiration • Road construction • Lack of large woody structure in stream channels to moderate energies because of salvaging in riparian areas and stream clean out practices
Rain-on-snow events	• Weather patterns • Climatic changes	• Greater amounts of snow accumulate in clearcuts than in forested areas; then, during the rainstorm, more rain reaches the snow and melts it faster in open areas than in forested areas
Minimum flows- The timing of minimum flows is similar to the past but flows may actually be lower.	• Drought • Regeneration of old fire-created stands and increase demand on water through transpiration	• Dams • Transpiration from young, fast-growing stands of timber
Other notable hydrologic features – losing seeps and small wet areas	• Geology • Stream Morphology • Vegetation	• Compaction caused by past logging activities, especially on tractor skid roads and landings, has resulted in less water percolating through the soils and more water stored as surface water resulting in human-created wetlands on the landscape.

Table 13: Influences and Relationships between Hydrologic Processes and Other Ecosystem Processes.

Hydrological Processes	Influences and Relationships between hydrological processes and other ecosystem processes
High energy stream flows and Peak Flows	• Juvenile fish at greater risk, less able to occupy habitat and can be washed out of streams along with essential nutrients during high winter flows • Downcutting as a result of high energy flows can result in the main channel being at a different grade than side channels which can affect fish migration. • Can result in lack of spawning gravels, hiding cover and winter refugia in main channels of some tributaries • Alteration and loss of stream habitat • Degradation of water quality from sediments • Decreased nutrient availability • Decreased fish abundance, size, and condition
Minimum Flow	• Insufficient flows can cause stream temperatures to rise to levels that are lethal or detrimental to some species of fish • Summer low flows are significant to both human use and fish habitat. During late summer, water demands for irrigation and domestic use tend to be high and supply limited. • Reducing amount of available fish habitat- which can result in decreased abundance, size and condition of fish • Higher oxygen needs of fish and lower dissolved oxygen concentrations when the water is warmer. • During the winter, low flows cause less oxygen stress, but over wintering eggs can be damaged by freezing or ice movement. • High water temperature, low levels of dissolved oxygen, and deleterious levels of toxins can all be exacerbated by low stream flow. Moreover, the quantity, quality and connectivity (e.g. fish migration) of aquatic habitats are also influenced by flow. • Decreased hiding cover available to adult fish especially during low flows • Decreased stream flow can contribute to direct mortality if fish eggs are exposed, covered with silt, or left without sufficient, oxygenated water • Anadromous or resident species may not move to appropriate spawning sites if attractant flows are lost or stream passage is inadequate • Concentrate eggs and young in smaller area because of lack of water, encouraging increased predation • Water storage mechanisms regulate the volume of water available in the system during dryer periods of the year. Without appropriate water storage capacity, increases in stream temperature and detrimental affects to downstream water quality can occur.

2.2.6 Recommendations: *Which of the changes in ecosystem condition and function require management action to achieve management objectives?*

Changes requiring management action	Management objectives	**Recommended management actions to achieve management objectives**	**General Locations**	**Indicator used to measure success**	**Recommended Monitoring or Research and Data Gaps**
Peak flows	Maintain peak flows within the historic range of conditions	• Minimize human-caused contributions to changes in peak flows that lie outside the range of natural conditions *(i.e. type and amount of harvest, soil compaction, contributions toward climate changes such as greenhouse gasses, etc.)* • Continue to encourage large wood recruitment into stream systems • Reconnect floodplains to their stream channels where appropriate.	Entire watershed	• *Indicators:* peak flow measurements over time • *Expected outcome:* peak flows within historic range of conditions • *Duration:* long-term	• Thinning effects on peak flows • Solid evidence of effects of thinning on peak flows
High stream energies and sediment movement	Retain sediments within the system as long as possible, metering sediments downstream	• Continue to encourage large wood recruitment into stream systems to moderate stream energies and meter sediment movement through stream system • Reconnect flood plains to channels where appropriate	1st - 5th order streams	• *Indicators:* pool/riffle ratios • *Expected outcome:* increase in pools and complexity • *Duration:* 50 years • *Certainty:* High	• Conflict between need to provide woody material in stream reaches where developments such as Hwy. 20 need to be protected.
Minimum flows	Return minimum flow to more natural conditions	• Actively manage timber stands to mimic historic fire cycles throughout the watershed	Managed stands	• *Indicators:* timber stand acres managed • *Expected outcome: simulation of natural flow regimes* • Duration: >50 years • Certainty: High	

2.3 STREAM CHANNELS

2.3.1 Characterization of Stream Channels: *What are the basic morphological characteristics of stream valleys or segments and the general sediment transport and depositional processes in the watershed?*

Many streams in the upper South Santiam watershed originate in glacial terraces found along the northeastern and southeastern boundaries of the watershed. These relatively flat streams increase in gradient dramatically as they progress downslope, becoming very steep, high-energy streams with deeply incised channels and steep valley walls. These high-energy streams form a relatively narrow, geologically constricted, valley river system.

Other streams originate on steep colluvial slopes with a dendritic drainage patterns and exhibit gulley or simplistic channel characteristics.

The major tributaries of the upper South Santiam contain natural constriction points, resulting from either earthflows or resistant rock outcrops. These constriction points pinch the river valley creating two very distinct valley characters. Above the constriction points, valley bottoms have aggraded with alluvial material and are aquatically very productive. Below the constriction points, channels are transport reaches with very high-energies. In this watershed, valley constrictions that resulted from earthflows occur on Moose, Canyon, and Latiwi Creeks as well as the upper South Santiam above House Rock Campground. Valley constrictions from geologic outcrops of resistant basalts occur on Soda Fork, Falls and Sevenmile Creeks. The influence of these features on the river valley creates a diverse and complex stream channel morphology.

This high-energy stream system has limited sediment storage capacity except in areas of geologic constrictions or behind accumulations of large wood in stream channels. Large wood accumulations are not common, however, because most of the woody component of the stream system was consumed by fires. Historic records reveal a large stand-replacing fire around the mid 1850's and a 100-year storm event in 1861. As a result of these two events the channel system was inundated with massive amounts of organic debris and

sediments. Subsequent fires in the 1910's and 1930's removed the organic component of this debris in a large portion of the watershed. Storms that followed mobilized the stored sediments and flushed them downstream.

In addition, Highway 20, forest roads and campgrounds, have added to the high-energy nature of the upper South Santiam system by disconnecting the river with its floodplain. As these facilities encroached on the lower gradient stretches of the river, it was less able to moderate its energies by spreading out onto it's floodplains during storm events, as it once did. Instead, the river had to carry that energy downstream, downcutting the stream channel as it went, until it encountered bedrock. In a recent survey about 30 percent of the channel lengths surveyed in the watershed were bedrock and 48 percent were boulder, cobble substrate. During large storm events, the boulder, cobble and finer particles get flushed downstream, causing disruption of benthic organisms and resulting in short-lived nutrient cycling within the stream.

This complex history of fires and floods, when combined with timber management, has created a very efficient sediment transportation system that is highly resistant to increases in peak flows.

Since the adoption of the standards and guidelines for riparian areas in the Northwest Forest Plan (NW Forest Plan) in 1994, the amount, size, and distribution of large wood has begun to increase in this watershed. As a result, more alluvial material is being stored in areas that prior to the NW Forest Plan had such high energies that they were unable to accumulate this material. This, when coupled with fire suppression, has resulted in the development of vegetative cover in the upper watershed and along tributary streams that will eventually result in greater accumulations of large woody material and increased storage capacity for sediments which hasn't been seen in these streams since the 1850's. As these channels develop sediment storage characteristics, peak flows become critical in determining the residual time these characteristics can be retained. The longer they remain in the system the more they influence the amount and effectiveness of the habitats they create.

In 1996 a flood event widened stream channels that had not been widened since the last significant flood event in 1964. In addition, this flood mobilized large wood which amassed in some stream channels to form nick points for sediment to accumulate behind. This resulted in sediment deposition on top of bedrock, which hasn't been seen here for awhile. On the flip side, this wood accumulation poses potential risks to facilities such as roads and campgrounds, because failure of the wood dams would suddenly release all of the sediments behind them and that could cause significant damage to downstream facilities.

Since 1996, there have been drought conditions so there has been a lack of maintenance flows through stream channels in the watershed. This has allowed vegetation to encroach onto gravel bars, etc., stabilizing the normally mobile gravel bars and making them immobile. In the next normal stream flow, it will look like a flood event because a lot of this vegetation will be incorporated in the flow so there will be a lot of channel scour caused by this organic debris in the stream's bedload.

2.3.2 Stream Channel Issues and Key Questions: *The issues and key questions help focus the analysis on the relevant elements of the ecosystem as they relate to management questions, human values or resource conditions within the watershed.*

Issue: Streams are disconnected from their floodplains. The encroachment of urban and rural development *(such as campgrounds, home sites, and Highway 20*) on the floodplain has constrained the natural meandering pattern of the river and its tributaries and resulted in increased channelization, streambank erosion, increased peak flows, reduced base flows, and reduced habitat complexity and diversity. Disconnection of stream channels from their flood plains hampers fish migration, places more energy on channel banks and reduces the cross sectional area of the channel during peak flow events. This increases the potential for sedimentation and reduces the amount of water stored within the channel system. The greatest affects occur in 3-5th order streams

- ***Indicators for measuring or interpreting conditions:*** area of floodplains utilized compared to area of entire floodplain
- ***Key Question:*** Where, how and in what priority would it be appropriate to reestablish the link between stream channels and their floodplains?

Issue: Many of the streams in the watershed are steep, high-energy streams which transport tremendous amounts of sediment but have little sediment storage capacity due to lack of large wood accumulations. Past timber management activities, steam cleanout practices, fires and torrential flows have removed large woody debris from the system. Since implementation of the NW Forest Plan, combined with decades of fire suppression and more recent changes in harvest practices, there is an increasing large woody structure component in upper South Santiam stream channels. Even though the situation is improving, there is still a deficit of wood here. This deficiency limits the ability of streams to dissipate streamflow energy and prevent erosion, retain spawning gravel and nutrients or to create and maintain instream habitat complexity. On the other hand, in critical areas wood accumulation can be a risk to facilities such as Highway 20.

- ***Indicators for measuring or interpreting conditions***: pieces of large wood per mile of stream channel
- ***Key Question***: Given the wide range of natural variability in the amount of large woody material available to stream channels in this watershed, how much structure is enough to facilitate stream channel processes and associated aquatic habitat? Which streams are deficient in instream and/or riparian large wood? How much large wood recruitment can be expected from riparian areas over time? Where, how and in what priority should large wood, or other channel structure, be introduced back into stream channels.

Issue: Recent drier weather patterns and lack of maintenance flows in stream channels have allowed vegetation encroachment and reduced stream channel cross-sectional areas. When a storm event occurs, these currently stabilized channels will erode and produce considerable sedimentation.

- ***Indicators for measuring or interpreting conditions***: Miles of unstable channel after a flood event. Frequency of failures.

- ***Key Question***: Where would it be appropriate to reconnect stream channels to their historic flood plains and not impose a risk to facilities?

2.3.3 Current Stream Channel Conditions: *What are the current conditions and trends of stream channel types, and sediment transport and depositional processes prevalent in the watershed?*

Stream channel types: The Rosgen stream classification system was used to describe stream channel types for this watershed. The table below defines that basic stream channel types represented in this watershed.

Table 14: Rosgen Stream Channel Types in Watershed

Stream Channel Type	General Description	Landform/soils/features
Aa+	Very steep, deeply entrenched, debris transport streams	Very steep streams generally in headwater areas. Erosional, bedrock or depositional features; debris flow potential. Vertical steps with deep scour pools; waterfalls.
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	High relief but lower gradient that A+ channels. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step-pool bed morphology.
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks	Moderate relief, colluvial deposition and/or residual soils. Narrow, gently sloping valleys. Rapids predominate with occasional pools
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains	Broad valleys with terraces, in association with floodplains, alluvial soils. Well-defined, meandering channel. These occur above nick-point channel constrictions.
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	Broad valley/meadows. Alluvial materials with floodplain. Highly sinuous with stable, well-vegetated banks. Occurs in meadows like Gordon Meadows
G	Entrenched "gulley" step/pool and low width/depth ratio on moderate gradients	Steep, narrow valleys, or deeply incised in alluvial and colluvial material; i.e. fans or deltas. Unstable, with grade control problems and high bank erosion rates.

The majority of the stream channels in the watershed are A+, A, B of G channels. The A+ and A channels tend to flow through steep, V-shaped valleys, do not have well-defined floodplains and are fairly straight. Progressing through the classification system, generally stream channels become less steep, more complex with a higher degree of sinuosity, have more riffle and pool sequences and wider floodplains.

Trends – Some of the "A" channels in this area are transitioning into "B" channels as they recover from the stand-replacing fires of the mid-1800's and early 1900's. Years of fire suppression, tree growth and mortality have resulted in some wood accumulations which are contributing to this transition.

Sediment Transport: For the most part, streams in this watershed have high energies and transport a considerable amount of sediment, especially during storm events. Sediment is added to these streams through a variety of mechanisms including erosion of the surrounding landscape, streambanks or streambed and is transported by the streams in solution, suspension or as bedload. The particle size that a stream can transport is primarily a function of the stream's velocity which is dependent on a variety of factors including channel gradient, width, roughness and the amount of flow going through the channel. Since channel gradient, width and roughness don't vary a lot, the amount of flow is the biggest factor influencing stream velocities and the amount of sediment transported. In this area, streamflows peak during episodic rain-on-snow events. For this reason, sediment transport in this watershed is also episodic and dependent on these storm events.

Trends – As woody structure begins to build up in stream channels, it increases channel roughness and slows down stream velocities and their ability to transport sediments. During normal flows, some of these sediments are deposited behind the woody structure, so there is a reduction in sediments transported by streams. During storm events, stream velocities and streamflows increase and some of these stored sediments are picked up and transported by the streams thus increasing the amount of sediments transported.

Depositional Processes are controlled by stream energies generated from valley widths and stream gradients. The major tributaries of the upper South Santiam contain natural constriction points, resulting from either earthflows or resistant rock outcrops. These constriction points pinch the river valleys, reducing upstream energies and forming catch points for accumulations of woody material, above which deposition occurs. Valley bottoms in these areas have aggraded with alluvial material and are aquatically very productive. In this watershed, valley constrictions that resulted from earthflows occur on Moose, Canyon, and Latiwi Creeks as well as the upper South Santiam above House Rock Campground. Valley constrictions from geologic outcrops of resistant basalts occur on Soda Fork, Falls and Sevenmile Creeks.

Deposition occurs anywhere stream velocities decrease such as in areas where stream gradients decrease or where wood accumulations increase channel roughness and slowing water velocities.

Trends: As more wood accumulates in stream channels, more deposition will occur over time. As sediments are stored, floodplains begin to develop.

Stream Classes

1

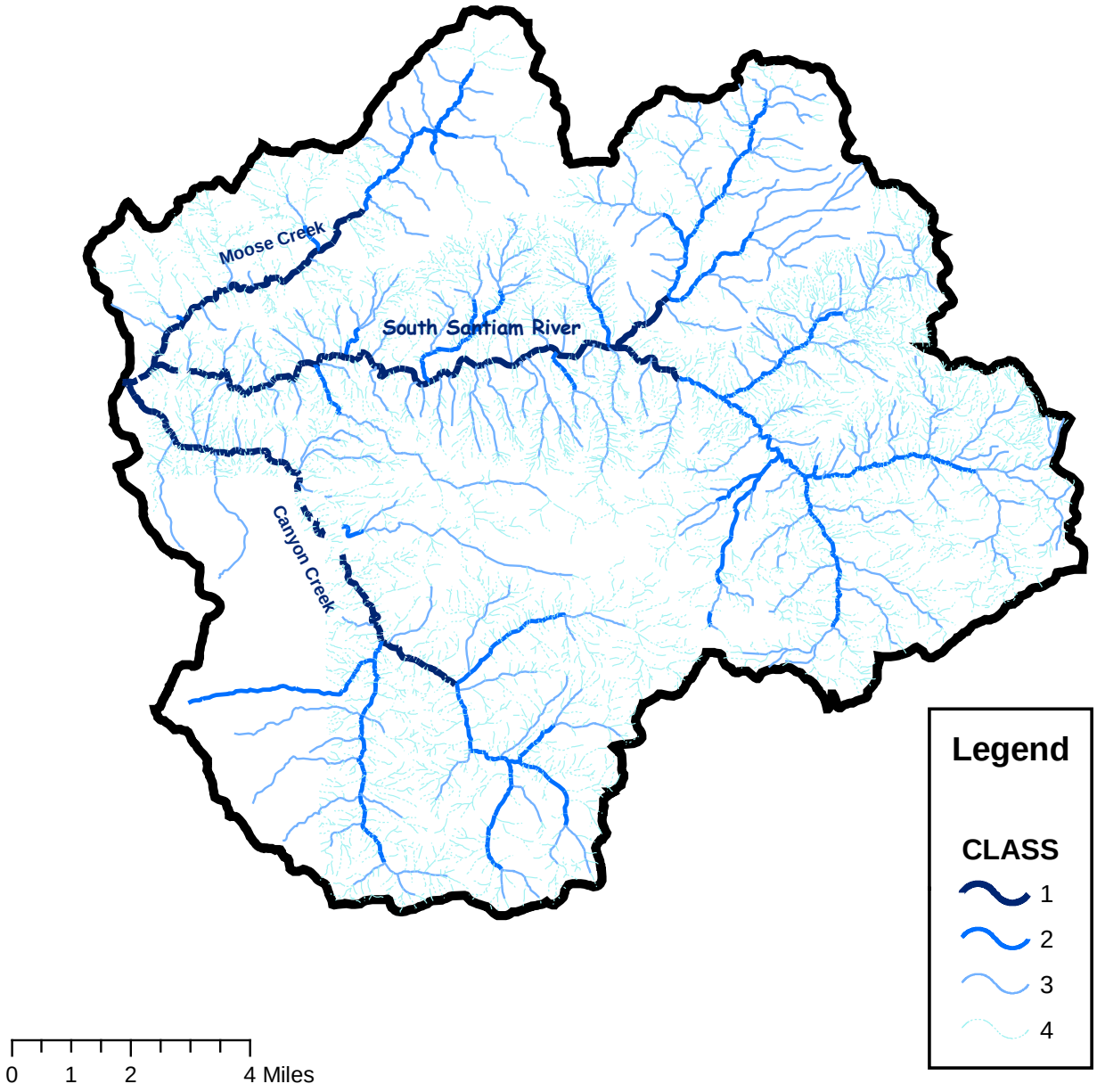


Figure 17: Stream classes within the South Santiam Watershed

2.3.4 Reference Condition of Stream Channels: *What are the historic morphological characteristic of stream valleys and the general sediment transport and depositional processes in the watershed?*

Historic morphological characteristics of stream valleys for **Moose Subwatershed**	General Sediment transport	General depositional processes
• About 1/3 of the way down from the headwaters of Moose Creek, a old debris slide blocked the channel and backed up water to form Moose Lake which now controls the peak flows and the sediment output from the upper part of the drainage. • In Moose Creek itself, channel banks are well-vegetated and currently resistant to channel scour. Channel bottom material varies depending on stream reach, but generally consists of bedrock or boulder, cobble composite, gravel and sand. • Tributary channels are generally steeper in gradient than the main channel. They range from 5 to 50 percent slope and are composed of bedrock, cobble, and fines. The headwall areas associated with tributary streams can be critical to the amount of sediment input into the system. • Outcrops of bedrock form numerous nick points or points that are resistant the steam's downcutting, along main channels. • Typically these channels vary from large boulders to silt and have steep side slopes with bedrock, boulder, or large woody debris controlling the channel. Fine silt sediments accumulate behind the large woody debris and channels are typically lush with vegetation. Shallow debris slides, dating back to the last large fires that burned here, are often associated with stream channels. These debris slides illustrate the importance of vegetative cover and root strength in holding the soil on the slopes. • There is a moderate amount of large woody debris in Moose Creek and future recruitment potential is high. Riparian canopy is in good condition on the public lands. A mainline access road is located in close proximity to the stream and does affect canopy closure here. • Some wetlands are associated with the riverine system and a pond is located on an unnamed tributary watershed. Flood plains occur along the lower reaches of the channel, and are typically associated with past landform activities.	Primary sediment transport is the result of peak flow events. High peaks result from rain-on-snow events that occur annually.	Valley constrictions and large wood accumulations slow velocities creating depositional areas. Bedrock outcrops create nick points which tend to have lower gradient reaches behind them. These are the areas that sediment is deposited until peak flows mobilize the material and continue its migration downstream

Historic morphological characteristics of stream valleys for **Soda Fork, Sheep and Sevenmile Subwatersheds**	General Sediment transport	General depositional processes
• Main-channel aggradation occurs with cobble and small boulders due changes in gradient and the backwater effects of the confluence the South Santiam. The South Santiam banks are bedrock and show little effect of increased stream flows. The banks are well vegetated and moss is prevalent. Undercutting occurs where flow is directed towards unprotected banks. There are sand bars and fine substrate filling pools. • Tributaries flowing into Sevenmile from the south (under Jump Off Joe), are primarily class IV's flowing during winter and spring rains. Rock outcrops are common and the soil is generally shallow. Tributaries which flow from thick glacial and colluvial soils to the east and north are generally class III and intermittent class III/IV. • Hillslopes range from rolling benches to steep (greater than 60%) slopes. Density of vegetation depends on the hillslope aspect. Along the channels, hardwoods predominate. The uneven terrain provides for a diversity of habitats including small seasonally-wet depressions and perennial springs. • The main channel of Sevenmile is a mix of bedrock chutes and aggraded cobble reaches. Bedrock occurs where the gradient is steep and large woody material is lacking. Wood dams store sediment and aggrade the stream bed resulting in intergravel flows during the summer months. Much of the existing channel wood is from past fires and harvest upstream. Currently this woody structure is stable, but old, and stream flow is beginning to work around the ends or bottom of the logs.	Primary sediment transport is the result of peak flow events. High peaks result from rain-on-snow events that occur annually.	Valley constrictions and large wood accumulations slow velocities creating depositional areas. Bedrock outcrops create nick points which tend to have lower gradient reaches behind them. These are the areas that sediment is deposited until peak flows mobilize the material and continue its migration downstream

Historic morphological characteristics of stream valleys for **Soda Fork, Sheep and Sevenmile Subwatersheds** (continued)	General Sediment transport	General depositional processes
• Tributary substrate size is primarily cobble and boulder. Fine sand and gravel is common in storage sites and originates from surface erosion on rocky steep slopes and actively-incising channels. • The amount of large down wood within the channel depends on the fire and harvest history. In harvested areas greater than 15 to 20 years old, woody material (standing and down) and streamside shade is generally lacking. Stand growth will continue to improve this situation. These systems are unstable to moderately stable and show signs of bank erosion due to high flows. A change in unit and channel prescriptions in the last 15 to 20 years has resulted in the maintenance of more down woody material within the channel. Streamside shading is often spotty provided primarily by brush and hardwoods. These channels are moderately stable with some signs of increased bank erosion. In channels flowing through unmanaged stands, there is a strong component of moss and little evidence of bank erosion. Most of these unmanaged channels have an adequate supply of existing and future down wood.	Primary sediment transport is the result of peak flow events. High peaks result from rain-on-snow events that occur annually.	Valley constrictions and large wood accumulations slow velocities creating depositional areas. Bedrock outcrops create nick points which tend to have lower gradient reaches behind them. These are the areas that sediment is deposited until peak flows mobilize the material and continue its migration downstream

Historic morphological characteristics of stream valleys for **Upper Canyon, Owl and Canyon Subwatersheds**	General Sediment transport	General depositional processes
• The main channel of Canyon Creek is a mix of bedrock chutes and aggraded cobble reaches. Bedrock occurs where the gradient is steep and large woody material is lacking. The lower portion of the channel is predominantly bedrock with very steep sideslopes. The middle portion, near Owl Creek confluence, is alluvial in nature due to the widening of the valley floor within this section. The headwater area consists of steeply dissected high gradient reaches. Tributary streams exhibit some of these same characteristics. • The stream energy within the Canyon Creek drainage is high due to peak flows. Vegetative conditions are such that rain-on-snow events play an important role in the channel shaping processes. High flows from streams within harvest units, both public and private, have worked the lower banks at localized points, primarily at constrictions and bends. Evidence of peak flows working the banks includes moderately frequent landsliding and undercutting of the banks. Where adequate channel shading exists, moss buffers the bank material from the high flows.	Primary sediment transport is the result of peak flow events. High peaks result from rain-on-snow events that occur annually.	Valley constrictions and large wood accumulations slow velocities creating depositional areas. Bedrock outcrops create nick points which tend to have lower gradient reaches behind them. These are the areas that sediment is deposited until peak flows mobilize the material and continue its migration downstream
Historic morphological characteristics of stream valleys for Trout Subwatershed	**General Sediment transport**	**General depositional processes**
Trout Creek tributaries are primarily class IV's flowing during winter and spring rains. Rock outcrops are common and the soil is generally shallow. Tributaries which flow from colluvial soils are generally class III and intermittent class III/IV.	Peak flows	Confluences and wood and nick points

2.3.5 Synthesis and Interpretation of Stream Channels: *What are the natural and human causes of change between historical and current species distribution and habitat quality for species of concern? What are the influences and relationships between species and their habitats and other ecosystem processes?*

Table 15: Natural and Human Causes of Change between Historical and Current Stream Channel Conditions

Changes between historical and current channel conditions	Natural Causes of Change	Human causes of change
Lack of large woody material in many stream channels	• Stand-replacing fires and floods	• Timber management and fire suppression • Stream cleanout
Stream channels less resistant to peak flows	• Stand-replacing fires – high peak flows – channels resistant to flows • Stabilization of deposition by vegetative growth decreasing cross-sectional areas of stream channels.	• Fire suppression has causes vegetation reestablishment – channels less resistant to peak flows
Stream downcutting – many channels run mostly over bedrock	• High energy streams with little woody structure to moderate flows (this is beginning to change with vegetative growth after stand-replacing fires.	• Stream cleanout and riparian salvage practices contributed to reduction in woody structure in stream channels • Infrastructure such as roads and buildings have restricted streams use of floodplains to moderate energies in lower reaches of streams
In some areas large woody material is beginning to accumulate and collect sediments	• Tree growth and natural mortality	• Not removing wood from stream channels • Placement of woody structure in stream channels • Maintenance of Riparian Reserves adjacent to stream channels – also, not salvaging here • Exploiting any opportunities to get wood into the stream channels in the future by riparian vegetation management • Fire suppression

Changes between historical and current channel conditions	Natural Causes of Change	Human causes of change
Changing stream flow from snow-dominated to rain-dominated provides a shorter season of snow melt and soil saturation	• Climatic changes	
More evapotranspiration – less runoff	• Stands very actively growing so use more water for transpiration • Water interception into soils	• Timber stand improvement practices to increase tree growth
Timing of flows	• Climate • Vegetative growth	• Management activities
Streams separated from floodplains	• Loss of woody structure in fires and floods • Sediments that could be helping to reconnect streams to their floodplains are being washed through the system by high energy streams.	• Stream cleanout and riparian salvage practices removed woody structure • The encroachment of urban and rural development on the floodplain has constrained the natural meandering pattern of the river and its tributaries, and resulted in increased channelization, streambank erosion, increased peak flows and reduced base flows, and reduced habitat complexity and diversity. •
Lack of water storage areas	• Basic geology of much of watershed • Vegetation encroachment • Stream channel downcutting causing dewatering of some of these areas	

Table 16: Influences and Relationships between Stream Channel Conditions and Other Ecosystem Processes

Channel Conditions	Influences and Relationships between channel conditions and other ecosystem processes
Beginning to accumulate large woody material in some stream channels	• Residence time of the wood and sediments is a longer duration than a decade ago because wood is holding the material, so streams are able to create micro climates for benthic organisms, etc. Historically they would be scoured out every year.
Disassociation of streams with their floodplains	• Loss of wetland habitat due to dewatering caused by channel downcutting. • Loss of tributary connectedness due to downcutting of main channels, and loss of refugia areas. This can create migration barriers to some aquatic species
High energy streams	• Greater mobility of sediments during storm events can move and/or cover spawning gravels • Can wash aquatic organisms out of the system along with the flows
Lack of water storage areas	• Reduced habitat for dependent species • Water is not stored to be metered out over drier periods of the year so water flows are less then. Lower flows can affect stream temperatures and health and well-being of aquatic organisms. • Reduced water availability for all beneficial uses during driest part of the year

2.3.6 Recommendations: *Which of the changes in ecosystem condition and function require management action (restoration, maintenance, protection, alteration) to achieve management objectives?*

Changes requiring management action	Management objective	Recommended management actions to achieve management objectives	General Locations for management actions	Indicator used to measure success	Recommended Monitoring or Research and Data Gaps
Streams are disconnected from their floodplains placing more energy on channel banks and reducing the cross-sectional area of the channel during peak flow events. This increases the potential for sedimentation and reduces the amount of water stored within the channel system.	Reestablish link with floodplains	• Vegetation management within Riparian Reserves to encourage development of large trees that will eventually provide woody structure for stream channels • Placement of structure in stream channels • Minimize and/or reduce encroachment of infrastructure into floodplains so streams can utilize their floodplains	• Greatest affects occur within 3-5th order streams, wide valley bottoms and stream confluences • Canyon Creek and the • South Santiam River is high priority because of vital fish habitat and then Soda Fork *(if stream energies can be modified first*), then Moose Ck. because it has few floodplains.	• Woody structure meeting Standard and Guidelines requirements per mile of stream • Beneficial uses met and abundance of aquatic organisms	
Bank erosion during high flows – high stream energy and lack of large wood to dissipate the energy	Reduce stream energies through recruitment of wood and establishment of vegetation to reduce magnitude of effect	• Same as above	• 3rd – 5th order stream channels	• Same as above	

Changes requiring management action	Management objective	Recommended management actions to achieve management objectives	General Locations	Indicator used to measure success	Recommended Monitoring or Research and Data Gaps
Stream channel complexity – lack of large woody sturucture in some streams	• Meet Aquatic Conservation Strategy Objectives (ACSO) • Enhance species diversity, diameter growth for future large wood recruitment and development of late successional/old growth structure	• Use various silvicultural treatments to accelerate development or to achieve Aquatic Conservation Strategy Objectives for vegetation in Riparian Reserves • Take advantage of opportunities to increase tree sizes for future instream and riparian woody structure and to increase stream shade	Riparian Reserves	Large woody structure per mile of stream	

2.4 WATER QUALITY

2.4.1 Characterization of Water Quality- *What beneficial uses dependent on aquatic resources occur in the watershed? Which water quality parameters are critical to these uses?*

image from www.clubrunner.ca/zonedata/22/Story/57/water.jpg

Beneficial uses: The following beneficial uses occur in the upper South Santiam watershed: a) domestic water, b) fisheries, c) recreation, d) hydropower, e) agricultural and f) industrial use. Each designated use has a unique set of water quality requirements or criteria that must be met for the use to be supported. A water body is considered impaired when it does not attain the water quality standards needed to support its designated uses.

Domestic – Water in the South Santiam is used for both public and private domestic water supplies. The City of Sweet Home, various small landowners, and campgrounds primarily along Highway 20, use water from this area for drinking and other domestic uses. To protect public health, high standards are set for domestic water quality by the federal Safe Drinking Water Act (1974). The amount of water needed for domestic supplies is a very small amount in comparison to the overall supply in the watershed.

Fisheries: Both resident and anadromous fisheries are dependent on water in the South Santiam for their survival. In fact, three species of fish which inhabit this area are listed as threatened by the Endangered Species Act including: spring Chinook salmon, winter steelhead and northern lamprey. Important water quality parameters for fisheries include temperature, dissolved oxygen, pH, turbidity and pollution levels.

Recreation use includes activities where there is contact with water and ingestion of water is reasonably possible such as swimming, wading, and fishing, as well as uses involving proximity to water, where water ingestion is not likely, such as camping, picnicking, or hiking. Here water quality concerns might include fecal contamination, algae and other toxins, etc.

Hydropower –Falls Creek hydroelectric facility is a small electric-generating facility located about 25 miles east of Sweet Home. The facility is a 4.3 megawatt plant that uses about 26 cubic feet per second of water and water pressure from a 2,831 elevation drop,

rather than water quantity to turn a turbine to produce power. The plant produces about 14.9 million kilowatt hours of energy annually.

Agricultural and ***Industrial*** uses of water are not as dependent on water quality as other beneficial uses, but make up a large portion of water consumption by human activities. Small farms and homesteads use water for stock watering, irrigation, or other agricultural uses and *Triple T Studs* sawmill, located near the confluence of Moose Creek and the South Santiam River is the only industrial user in the watershed.

Water quality parameters: The chart below identifies water quality parameters which are critical to the listed beneficial uses.

Table 17: Water Quality Parameters Critical to Beneficial Uses

Beneficial Uses/ Aquatic Resources	**Water Quality Parameters critical to these uses**						
	pH	**Stream Temperature**	**Dissolved O2**	**Turbidity**	**Taste/ Odor**	**Various Chemicals**	**Disease-causing organisms**
Domestic	X	X	X	X	X	X	X
Fisheries	X	X	X	X		X	
Recreation	X	X	X	X	X		X
Hydro-electric				X			
Agricultural	X			X		X	X
Industrial	X			X			

Minimum instream flows: At this time the State of Oregon has not prioritized instream flows for watersheds in the western Cascades. Potential minimum instream flow requirements will vary over the watershed due to topography, vegetation and the beneficial uses being supported. For this reason, minimum instream flows are outside the scope of this document and will not be addressed further.

2.4.2 Water Quality Issues and Key Questions: *The issues and key questions help focus the analysis on the relevant elements of the ecosystem as they relate to management questions, human values or resource conditions within the watershed.*

Issue: In 2004, the mainstem of the South Santiam River was listed under section 303 (d) of the Clean Water Act, for the State of Oregon. This means that existing water quality requirements have been deemed inadequate to provide for attainment and maintenance of water quality standards for this water body. Specifically, the South Santiam was listed as being water quality impaired for stream temperatures, which are outside of standards during low flows in the summer months. Since the mainstem was listed, all streams tributary to the listed stream are also affected, that includes all streams in this analysis area.

This listing is important for a variety of resources including the survival of threatened fish species such as winter steelhead and spring Chinook salmon which could potentially be impacted by reduced water oxygen levels, reduced fish spawning success, and increased incidence of diseases that occur in higher water temperatures. In addition, high stream temperatures can affect bacteria growth and make it harder to treat the water for domestic uses.

Once listed as a 303 (d) water quality impaired stream, it is studied in a river basin Total Maximum Daily Load (TMDL) plan to determine why it failed to meet water quality standards. Then a water quality restoration plan is written that describes how the water quality parameter that is outside of standards is going to be brought back into standards.

Currently a TMDL plan for the Willamette Basin, which includes the South Santiam River, has been developed. This document was conditionally approved by the Dept. of Environmental Quality in September 2005. It provides a basis for analyzing stream shade, effects of shade on stream temperature, and management of riparian areas to meet water quality and broader objectives embodied in the NWFP Aquatic Conservation Strategy (ACS).

- ***Indicators for measuring or interpreting conditions***: Stream temperatures during low flows in the summer months
- ***Key Question*** – Is the system capable of meeting the state water quality standards for temperature? If so, what can be done to bring temperatures into state standards? What processes have affected water quality and stream temperatures? What effect are these processes having on the maintenance and enhancement of aquatic functions? How do these stream attributes change through time?

Issue: Historically sediment and turbidity levels have been high in streams in this watershed. Given earthflow activity and high stream energies here, it is expected that sediment and turbidity levels will remain high.

- ***Indicators for measuring or interpreting conditions***: turbidity
- ***Key Question***: What is the natural range of variability for sediment and turbidity in this watershed? Where on the continuum of natural variability does current sediment and turbidity fall? Where and how should management actions address sediment and turbidity in this watershed?

Issue: Increased awareness of cyanobacteria and its potential health risks has spurred a closer monitoring of water bodies found within the watershed.

- ***Indicators for measuring or interpreting conditions***: Cells/ml
- ***Key Question:*** Where are waterbodies in this watershed that are likely to have cyanobacteria that could possibly pose a health risk to visitors and their pets? What management actions should be taken to best address cyanobacteria populations in these water bodies?

2.4.3 Current Water Quality Conditions: *What are the current conditions and trends of beneficial uses and associated water quality parameters?*

Domestic water quality meets federal Safe Drinking Water Act requirements and is generally of good quality in the watershed for local users including the City of Sweet Home, landowners along Highway 20 and campgrounds.

Trends: No significant change in domestic water quality is expected.

Fisheries: Stream temperatures are outside of state standards during low flow periods in the summer months. High stream temperatures can reduce dissolved oxygen available for aquatic species and increase growth of disease-causing organisms which can affect fish health.

T*rends:* With riparian protection requirements on both public and private lands, it is expected that stream temperatures will improve over time as tree growth continues and woody structure is built up in stream channels. The trees will provide shade and the woody structure will build up sediments to cover bedrock and create pools both of which will help reduce stream temperatures.

Recreation: Sometimes a rapid buildup of algae, called an algal bloom discolors water bodies, making them green, blue-green, white or brown in color. These blooms usually occur in warm, calm water which is high in nutrients during the summer months. A few types of blue-green algae are known to produce toxins, which if ingested can cause a variety of symptoms such as diarrhea, nausea, cramps, fainting, numbness, dizziness, tingling and paralysis. Skin contact can cause rashes or irritation. Depending on the type of algae bloom, the water body may be closed to recreationists during the bloom.

Trends: The awareness of toxic algal blooms is more common now than in the past.

Hydropower –The Falls Creek hydroelectric facility uses very little water. It depends on elevation changes to produce electricity rather than quantity of water like other hydroelectric facilities.

Trends: No changes associated with water quality parameters are expected.

Agricultural and ***Industrial*** uses of water are not as dependent on water quality as other beneficial uses, but make up a large portion of water consumption by human activities. Small farms and homesteads use water for stock watering, irrigation, or other agricultural uses and *Triple T Studs* sawmill, located near the confluence of Moose Creek and the South Santiam River uses water for their industrial operations.

Trends: During periods of low flow in the summer months, there is more demand for water. Since stream temperatures are a concern for threatened winter steelhead and spring Chinook salmon, especially during low flow periods, this competition may increase in the future.

2.4 4 Reference Water Quality Conditions: *What are the historic water-quality characteristics of the watershed?*

There is a relatively poor understanding of historic water quality conditions, over the long-term on in this area.

Temperatures: There is some indication that increased stream temperatures may have occurred historically. After the large, stand-replacing fires in this watershed in 1856 and 1911 it can be assumed there was a significant loss of stream shade. These fires in combination with a large food event, removed much of the large woody structure from stream channels. In addition to these natural events, management actions also had an impact of stream temperatures. When logging began in earnest in the watershed, harvest was allowed down to the edges of the streams thus removing shade and potential for woody recruitment into stream channels. In addition, stream channels were cleaned out of woody debris following timber harvest. So for a period of time after these events and management practices, it is likely that stream temperatures were much higher than they are currently.

Prior to the fires, a large portion of the watershed was likely covered with a relatively contiguous stand of trees providing both shade and woody structure to stream channels.

For the above reasons, and because of fluctuations in climate over time, it is hard to determine what range of stream temperatures are typical for this watershed, but the range was probably fairly wide.

The following chart shows USGS data for mean-seasonal water temperatures for the South Santiam taken during 1977 to 1986.

Table 18: Mean-Seasonal Water Temperatures

Location	Fall	Winter	Spring	Summer
S. Santiam River below Cascadia	50	41	46	61
S. Santiam River near Foster Dam	52	43	48	54

Sediment and Turbidity: This watershed has a significant amount of slope instability, which was likely exacerbated following the large, stand-replacing fire events and floods. Without vegetation on the hillside to help stabilize slopes, quite a bit of sediment would have been introduced into stream channels. Without wood to moderate stream velocities and store the sediments, they would have washed through the system fairly rapidly. For many years following the fires, it is likely that considerable amounts of sediments were introduced into the stream system following major storm events.

The following illustration of stream turbidity came from a description given in a fish survey done in the 1930's on the South Santiam River. Although this part of the survey was taken further downstream than the study area which had more influence from towns dumping raw sewage into the river, it still sets the stage for water quality in the river during the early part of the 1900's.

> *"From the mouth of the South Santiam upstream to a point below the Lebanon Bridge – the stream is very much discolored and very foul smelling. The rubble in the riffles is covered with a thick gelatinous layer of foreign material and in a great many instances the water in the pools is too dirty to permit estimation of the depth…"*

As vegetation became re-established, sediment input began to decrease. Similar to temperature, it is likely that the range of variation of sediment input into this stream system was wide from year to year and from season to season. From USGS data taken between 1977 and 1986, turbidity measurements for the South Santiam at Sanderson Bridge, measured in FTU's, were: fall 6.65, winter 9.74, spring 3.55 and summer 1.88.

pH in this watershed is typical for areas in the Western Cascade range. A snapshot in time of pH measurements for this area are as follows: fall – 7.13, winter – 7.14, spring 7.33 and summer 7.24. These number hover right around 7.0, which is neutral on the pH scale. After large fires, the pH would increase because of the ash. As conifers reoccupied the burned areas, the pH would tend to drop because of the acidic nature of litter fall.

2.4.5 Synthesis and Interpretation of water quality conditions: *What are the natural and human causes of change between historical and current water quality conditions? What are the influences and relationships between water quality and other ecosystem processes?*

Table 19: Changes between Historical and Current Water Quality Conditions.

Changes in water quality conditions?	Natural Causes of Change	Human causes of change
Stream temperatures are outside of state water quality standards during summer months. There is not a good baseline of temperature information to know how this compares to historic conditions.	• Stream temperatures vary in response to fire, flood, sediment and riparian vegetation • Fires remove vegetation that shades streams. This can increase solar radiation to streams and affect temperatures • Drought results in lower water levels which can lead to increased stream temperatures • Fires and floods can affect large wood supplies in stream channels. Lack of large wood in streams, limits pools and does not moderate stream flows which can result in downcutting to bedrock – increasing temperatures	• Management of vegetation in Riparian Reserves to encourage growth to shade streams and provide future sources of large wood for streams. • Past salvage logging in riparian areas and stream cleanout practices led to less large wood being available to streams • Removal of shade through timber harvest and road reconstruction
Sediment and turbidity are high on the lower reaches of the mainstem South Santiam River.	• Lack of large woody structure to store sediments in many areas due to past fires and floods	• Removal of vegetation through agriculture and timber harvest • Little better understanding of the role of fine clays in the longer term suspended sediment. Fine clays cause long-term turbidity. Comes from smectites in earthflows. Pearch (reference paper)
There may be a change in pH between historic and current conditions. It is unknown whether the pH is higher or lower now than in the past.	• Coniferous forests are acidic. After a fire, when forest is removed, the pH may change.	• Timber harvest may possibly affect pH. • Moose Creek study –this study inconclusive for effects of management on pH and turbidity but has established baseline data

Table 20: Influences and Relationships between Water Quality and Other Ecosystem Processes

Water Quality Conditions	Influences and Relationships between water quality conditions and other ecosystem processes
• Temperatures	• Up to a certain point stream temperatures can benefit fish and aquatic organism's productivity. After that point there is an increase in disease, less oxygen available, more stress, etc. • High stream temperatures affect oxygen levels in the water, fish spawning success, diseases are more prevalent in warmer waters and it could affect the food web. Downstream, high temperatures can affect bacteria growth and makes it harder to treat the water??? • Water temperatures frequently exceed biological criteria for rearing and migration and exceed spawning criteria during portions of the spawning period and may be a factor in the decline of some aquatic species
• pH	• Affects benthic organisms and production
• Sediment and turbidity	• Affects fish's ability to find food, and reproduce successfully
• Algae blooms	• Social impacts and health risk

2.4.6 Recommendations: *Which of the changes in ecosystem condition and function require management action (restoration, maintenance, protection, alteration) to achieve management objectives?*

Changes requiring management action	Management objective	Recommended management actions to achieve management objectives	General Locations	Indicator used to measure success	Recommended Monitoring or Research and Data Gaps
• Stream temperatures *High priority*	• Comply with State water quality standards	• Manage riparian areas to maintain and enhance shade on streams as recommended in the Northwest Forest Plan Temperature TMDL Implementation Strategies • Collect and analyze stream temperature background data for watershed • Work with partners like South Santiam Watershed Council to monitor stream temperatures • Establish temperature monitoring stations on entire South Santiam in major influence zones- set up network to monitor those. Use Payco or OWEB grant and partnerships to do this. • Implement riparian improvement/restoration projects as appropriate	• Entire S. Santiam	• Completion of restoration plan	• Monitor stream temperatures and establish baseline information to compare temperature changes over time. • Need to determine which stream reaches are contributing to high stream temperatures

Changes requiring management action	Management objectives	Recommended management actions to achieve management objectives	General Locations	Indicator used to measure success	Recommended Monitoring or Research and Data Gaps
Sediment and turbidity	• Retain sediment in the system as long as possible and meter it out through time	• Ensure long-term availability of large woody material to stream channels to capture and meter out sediments	• Moose Creek • Streams where large woody material is lacking	*Indicator*: feet of large woody material per mile of stream *Expected Outcome:* increase woody material in stream channels where it is lacking *Duration:* long-term *Certainty:* mod-high	• Removal of vegetation from agriculture and timber harvest • Monitor effect of watershed restoration projects on water quality
Other water quality parameters	• Protect water quality with standard parameters	• Continue treatment of sewage • Meet BMP's • Ensure management activities that could affect water quality have input of qualified hydrologist	• Entire watershed	*Indicator:* State water quality parameters *Expected Outcome*: Meet or exceed state water quality standards *Certainty*: High	• Monitor temperatures, dissolved oxygen
Algae blooms	• Meet water quality standards • Ensure public safety	• Monitor water bodies for algae blooms and inform public when algal levels are a concern to health • Take appropriate management action to address algal blooms where needed	Water bodies within the watershed	*Indicator:* Frequency and severity of algae blooms	• Range of natural conditions for algal blooms

3.1 Vegetation

3.1.1 Vegetation Characterization: *(What is the array and landscape pattern of plant communities and seral stages in the watershed (riparian and non-riparian)? What processes caused these patterns (fire, mass wasting)?*

Array of Plant Communities: Plant communities have similar ecological requirements and are useful indicators of various environmental factors. In reality plant communities and the environments in which they grow do not have distinct lines of demarcation, but rather grade more or less continuously across the landscape. For the sake of simplicity, we artificially group these relatively discrete collections of plants growing under similar environmental conditions into plant associations. Normally each plant association group is named by the major climax species. The upper South Santiam, lies mostly within the western hemlock and Pacific silver fir plant associations although it does have inclusions of Douglas-fir and mountain hemlock associations.

Landscape Pattern of Plant Communities: The chart below illustrates that the warmest, low elevation sites tend to support Douglas-fir and grand fir plant associations, while the coldest, high elevation sites tend to support mountain hemlock associations. The area in between, which is where most of the watershed falls, is either in the western hemlock or Pacific silver fir plant association. The chart also shows that tree growth potential is highest in the lower elevation, warmer sites and decreases as elevation increases and site temperature decreases.

Table 21 **Plant Association Characteristics**

Plant Association Group	Percent of forested portion of watershed	Site Temperature	Elevation	Tree Growth Potential
Douglas-fir/grand fir	<1%	warm	low	High
western hemlock	70%	↓	↓	↓
Pacific silver fir	30%			
mountain hemlock	<1%	cold	high	low

The map below depicts the landscape pattern of the major plant associations in the watershed. The drainage bottoms are generally western hemlock associations, the ridge tops are mountain hemlock associations and mid-slopes areas are Pacific silver fir.

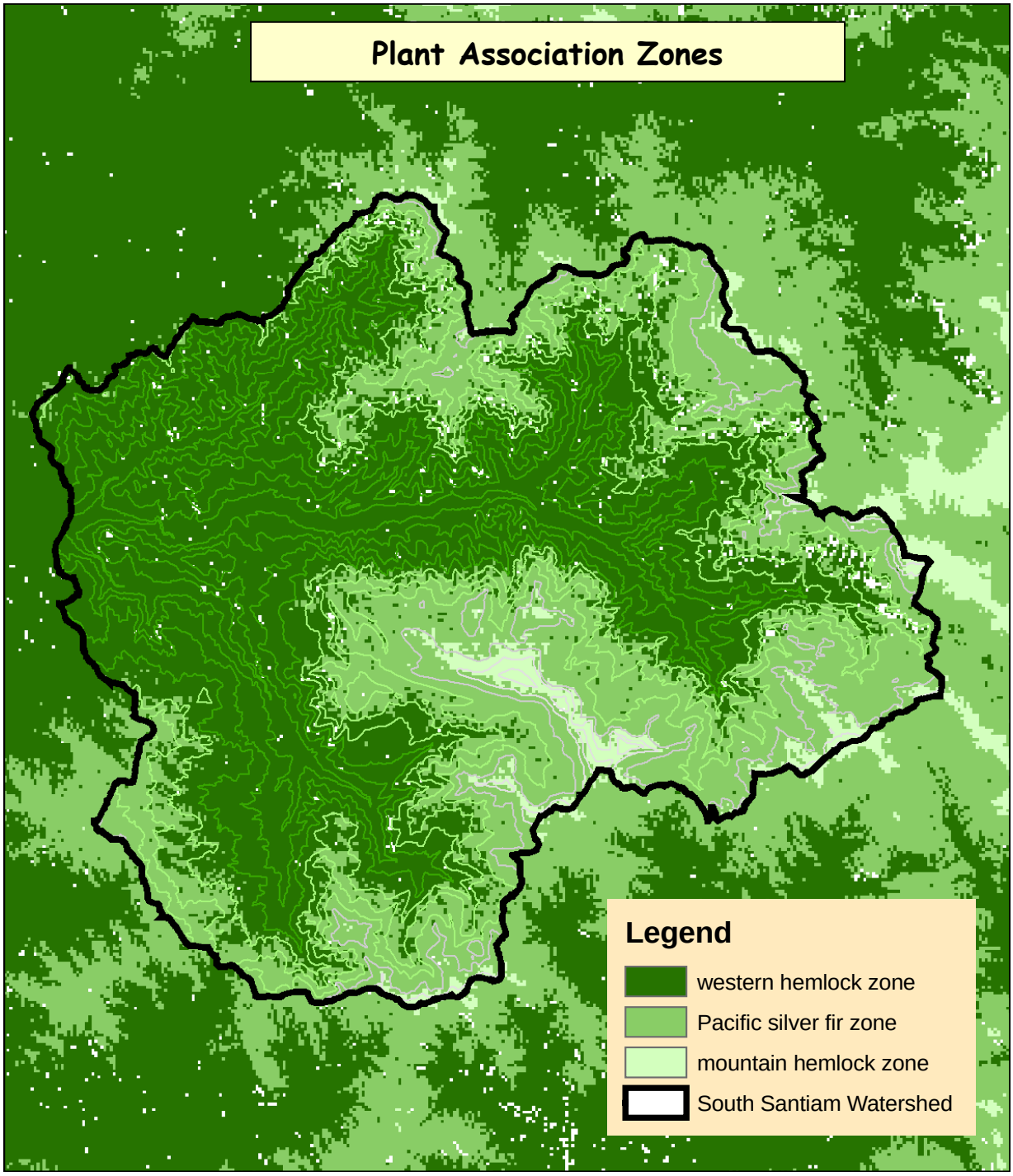


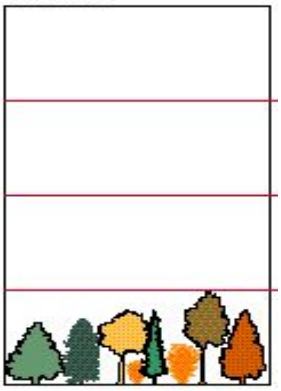
Figure 18

Array of Plant Communities within Riparian Areas: Riparian Reserves are protection buffers placed adjacent to streams. These buffers are located a defined distance from the stream channels and may or may not represent the actual zone of influence that streams have on vegetation. In general, differences in vegetation between riparian and upslope areas disappear in a shorter distance than defined by Riparian Reserve widths.

Differences in plant associations between riparian and non-riparian areas may vary in degree locally, depending on stream class, topographic features, water availability, air drainage, soils, and other factors. The differences in vegetation from riparian areas and upslope sites may be significant enough to classify adjacent sites in entirely different plant associations or there may be no difference at all. In general, riparian plant associations tend to be wetter and cooler than adjacent upslope sites, but these differences decrease or may disappear completely with intermittent streams. Many stream channels and wet areas support pure hardwood stands or include a hardwood component in the timber stands. Red alder, big leaf maple and black cottonwood are common in these areas. The majority of the riparian reserves in this watershed fall within the western hemlock plant association and most of the remainder are in the Pacific silver fir plant association.

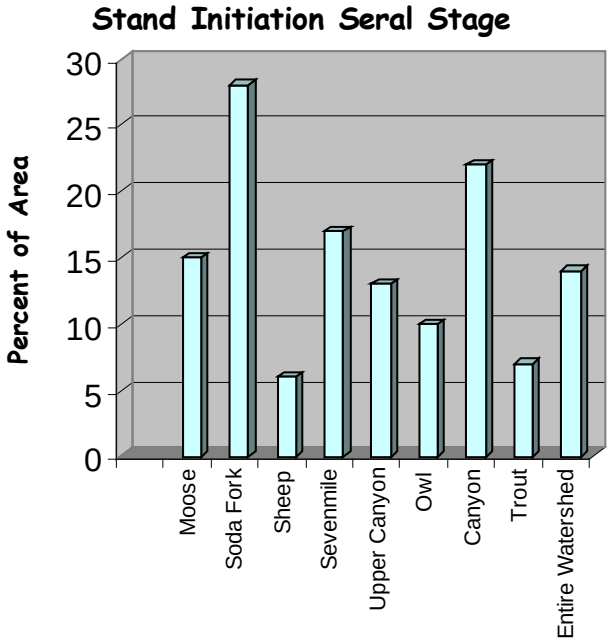
Processes that Caused Plant Community Patterns: This pattern of plant associations was caused by a variety of physical and biological factors including soil types, climate and microclimate, topographic influences, and natural and human-caused disturbance history such as fires, erosional processes, timber harvest, etc.

Array of Seral Stages: There are four major seral stages: stand initiation, stem exclusion, understory reinitiation, and late-successional/old growth. The following discussion describes each stage in more detail for this watershed.



Stand Initiation Stage

The ***stand initiation*** stage occupies only about 14 percent of the watershed as a whole. The chart below shows the percentage of stand initiation in each subwatershed. It ranges from about 6% in Sheep Creek to about 27% in Soda Fork Creek. Stands in this seral stage are typically from 1 to about 20 years of age, depending on site conditions and the degree to which the stand has been managed.



On National Forest lands, most young stands are trending out of the stand initiation seral

stage and growing into the stem exclusion stage because harvest is moving away from clearcutting and toward commercial thinning.

Processes that caused this Seral Stage Pattern: Most stands in this stage were the result of timber harvest and have been regenerated using a variety of techniques over the years.

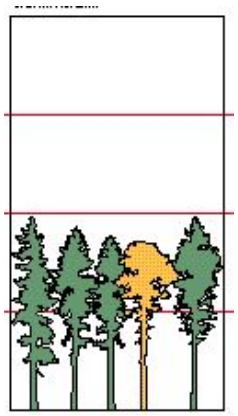
Between 1915 and 1917 parts of the Sevenmile Burn, in the eastern portion of the watershed, were planted. With the exception of this burn, prior to the mid-1950's much of the reforestation in this area was accomplished through natural seed-fall from seed trees left in harvest units for this purpose or from trees in adjacent stands.

In the mid-1950's to late 1960's, a mixture of tree planting and aerial seeding were the dominate reforestation methods. Because tree planting established and grew trees faster and used less seed, it became the primary reforestation method over aerial seeding from the late 1960's to the present.

Early plantings were generally done using only one or two major trees species and it was common for additional tree species to seed into the plantations naturally. At the lower elevations, shade-tolerant species such as western hemlock and western redcedar seeded in, while at the higher elevations Pacific silver fir and mountain hemlock seeded in. Later, more attention was put into planting a diversity of species in plantations to more closely mimic natural conditions.

Seed used for reforestation in the watershed has been evolving toward increased genetic improvement for wood quality and growth while preserving genetic diversity. Since the late 1960's most of the reforestation seed used in the watershed has been from local parent trees selected for their good growth and form characteristics. From the mid-1970's increasing levels of genetically improved seed, from seed orchards and progeny testing have been used for reforestation. Timber Service Company's Mason Seed Orchard is located in the west end of the watershed near Sweet Home and is one of the oldest Douglas-fir seed orchards in the Pacific Northwest. This seed orchard was started in 1960 and since 1974 all their reforestation seed has come from this orchard.

The Forest Service has three evaluation plantations within the watershed which are part of the Willamette National Forest genetic tree improvement program.

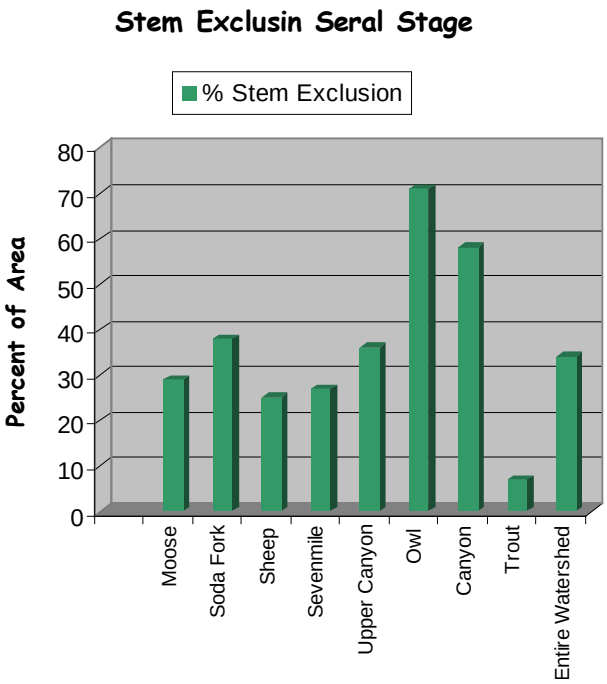


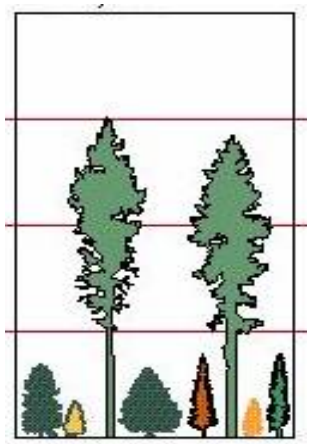
Stem Exclusion Stage

The Stem Exclusion stage comprises about 34 percent of the watershed and includes a variety of stand conditions. Trees in this stage range in age from about 20 to 150 years, with diameters from 5" to 20.9," depending on site conditions and degree of management. These stands have dense crowns which block out light to the forest floor, and limit additional tree regeneration in the understory. Typically, shade tolerant understory trees that are present, persist but grow very slowly. Intermediate or suppressed trees that do not tolerate shade well suffer from competition and have a high mortality rate. Shade-intolerant shrubs and forbs frequently disappear at this stage.

In natural stands, this stage is typically dominated by one or two tree species. In managed stands, pre-commercial thinnings, normally precede this stage and may reduce competition and mortality by favoring the dominant trees. Commercial thinnings further reduce competition and increase average stand diameter. Shade tolerant understory trees and other plants may benefit from increased light and respond to thinnings with vigorous growth.

The chart to the right shows the percent of stem exclusion in each subwatershed. Trout Creek has about 5% in this seral stage in contrast to Owl Creek which has about 70%.



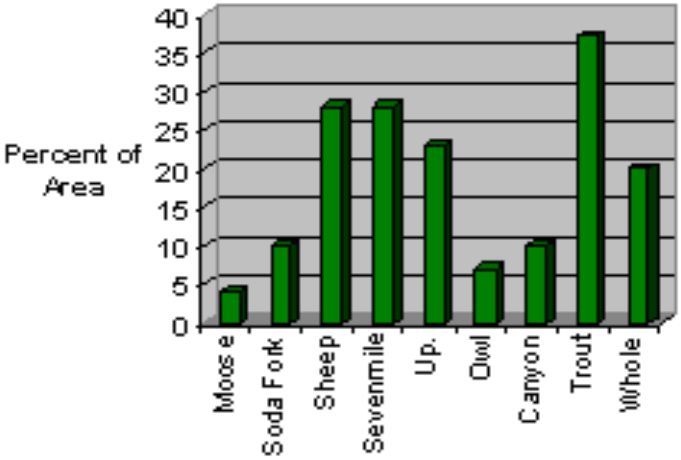


Understory Reinitiation

The ***Understory Reinitiation Stage*** makes up about 20% percent of the watershed. This stage is characterized by stands as young as 80 years to stands as old as 250 years, depending on site conditions. In this stage, the dominant tree layer begins to break up due to mortality and a second, pole-sized, canopy layer generally develops underneath. Although this may simply happen naturally given enough time, small scale disturbance agents such as insects, wind or fire also contributed to development of this seral stage in some areas. These disturbance agents often killed sufficient overstory trees to stimulate regeneration underneath.

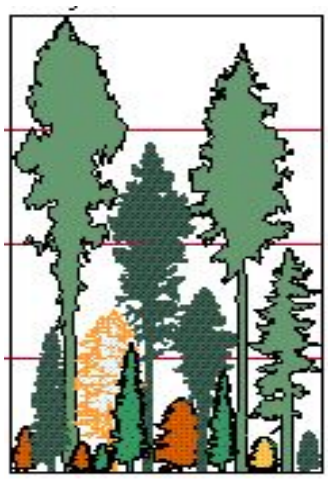
In this watershed, management-induced understory reinitiation has resulted from old salvage logging and more recently from

Understory Reinitiation Seral Stage



commercial thinning. These practices have released shade-tolerant understory that are developing a second canopy later at a much earlier age than would have developed under natural conditions, especially with fire suppression and a lack of natural underburning.

The ***Late Successional/Old Growth*** seral stage comprises about 28% of the watershed. These are the largest and the oldest stands here and range from about 150 to 800 years of age. While a complete record of stand ages is not available, it is believed that a large percentage of these stands date back to the 1500's when large fires burned in this watershed.

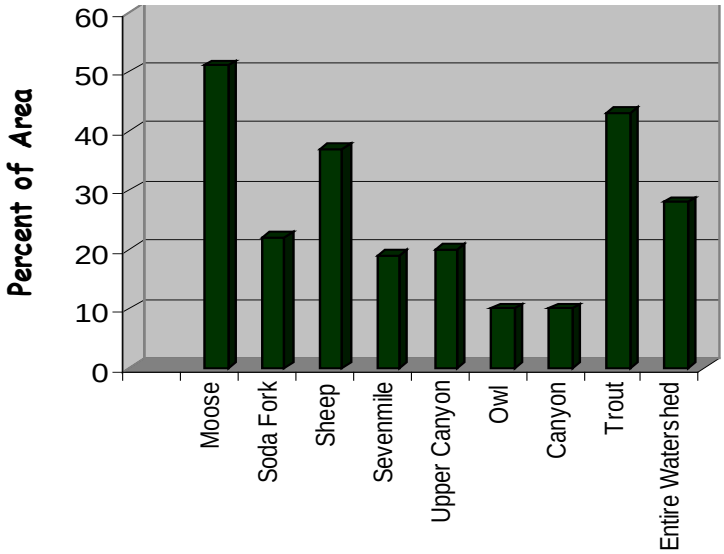


Late Successional/Old Growth

Most of these stands still have a significant component of Douglas-fir or other fire-regenerated species in the upper canopy layers. Second and third canopy layers are usually well developed with shade-tolerant species. A shrub layer is often present as well.

Diseases such as dwarf mistletoe, heart rots and root rots are common and contribute to mortality and bole defects. In the oldest stands, especially those in the upper elevations, mortality and rots may occur at high levels. Heavy competition from rhododendron and the other shrubs may inhibit growth of young trees, leaving stands more open.

Late Successional/Old Growth Seral Stage



The chart to the left illustrates the percentage of late successional/ old growth seral stages in each subwatershed. It ranges from about 9% in Owl and Canyon Creeks to about 50% in Moose Creek.

The pie chart below shows the proportion of each seral stage in the entire upper South Santiam watershed.

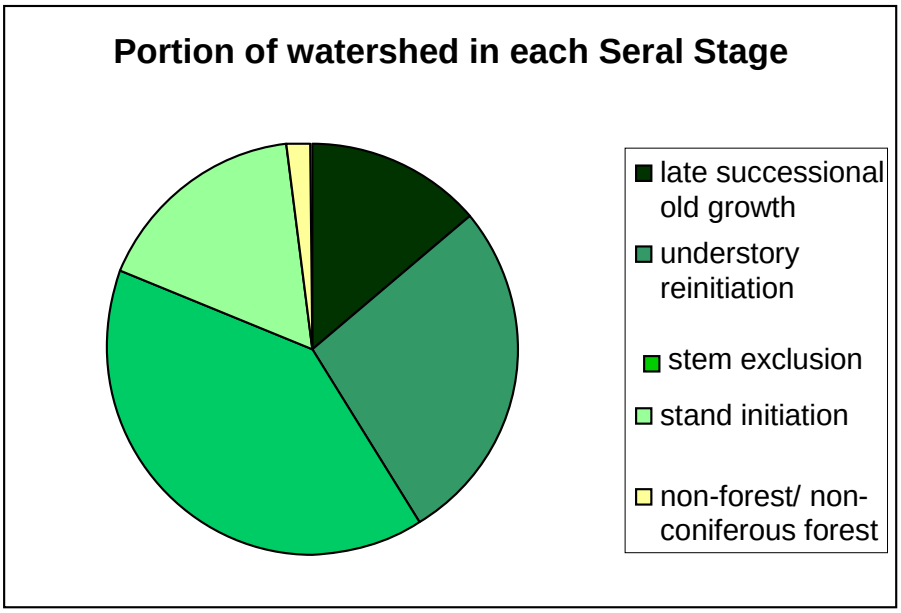


Figure 19

Array of Seral Stage in Riparian areas: Riparian vegetation conditions vary by land ownership and land management allocations. For example, a large percentage of the riparian area in Trout subwatershed is composed of understory reinitiation and late-successional/old growth stands, indicative of the history of the area. On the other hand, Canyon Creek subwatershed is mostly stem exclusion and stand initiation seral stages.

On a percentage basis, the seral stage make up within Riparian Reserves is not appreciably different than the watershed as a whole *(see table 22 below).*

Processes that caused this array of seral stages in Riparian Reserves: Structural stage differences between riparian and non-riparian sites are influenced both by management activities and major natural disturbances such as fire. In addition, floods and debris torrents may have created significantly different vegetation in localized riparian areas.

Table 22: **Distribution of Seral Stages by Subwatershed**

Subwatershed	Non-forest		Stand Initiation		Stem Exclusion		Understory Reinitiation		Late Successional / Old Growth	
	Subbasin %	Riparian %	Subbasin %	Riparian %	Subbasin %	Riparian %	Subbasin %	Riparian %	Subbasin%	Riparian %
Moose	1	2	15	7	29	15	4	5	51	71
Soda Fork	2	2	28	31	38	35	10	10	22	22
Sheep	4	5	6	7	25	30	28	22	37	36
Sevenmile	9	9	17	16	27	28	28	28	19	19
Upper Canyon	8	8	13	13	36	40	23	19	20	20
Owl	2	5	10	5	71	62	7	10	10	18
Canyon	6	2	22	25	58	52	10	9	10	13
Trout	6	8	7	7	7	7	37	33	43	45
Entire Watershed	**4**	**6**	**14**	**12**	**34**	**30**	**20**	**20**	**28**	**32**

3.1.2 Vegetation Issues and Key Questions: *The issues and key questions help focus the analysis on the relevant elements of the ecosystem as they relate to management questions, human values or resource conditions within the watershed.*

Issue: The spatial and temporal distribution and block size of various seral stages is more fragmented than it was historically because of the ownership patterns in the watershed, silvicultural treatments, timber harvest practices on those ownerships, and fire suppression. Generally, on public lands there is a higher percentage of older seral stage stands than on private lands. The percentage of stand initiation seral stages is diminishing on public lands as the type of harvest changes from mostly clearcutting to mostly commercial thinning. As trees move out of the younger seral stage classes and into older ones, there will likely be an interruption in timber supply on public lands at some point in the future if we continue only commercial thinning and not regenerating stands at rotation age.

- ***Indictors for measuring or interpreting conditions***: Seral stage distribution across the landscape and timber supply on public lands.
- ***Key Questions***: What is the natural range of variability of distribution and arrangement of seral stages in the watershed? Where does the current seral stage distribution and arrangement fall along that continuum? What is the appropriate distribution and arrangement of seral stages in the watershed? Where and what management actions are needed to enhance seral stage distribution and arrangement in this watershed?

Issue: Sustainable Communities: The economy of east Linn County is intertwined with the forested, mountainous lands that comprise its geography. Changes in management of Federal lands have changed the relationship between those lands and the communities that are their neighbors. Timber-industry-based employment has declined and many mills have closed. To offset the reduction in jobs based on the harvest of sawtimber, some people have turned to various special forest products to make their living off the forest resource that surrounds them. This has prompted the necessity to make decisions about the management of these resources based on scant information available on levels of sustainable harvest for many of these products.

Reduced timber harvest has also reduced access to wood for home heating and has affected timber market prices. As the value of timber has increased, it has altered how and when industrial as well as non-industrial forest landowners harvest their timber resource, a factor especially in the west end of the watershed.

In addition the role of federal lands in the local economy has changed from primarily supporting timber jobs to playing a more important role in supporting tourism and other areas of economic diversification.

- ***Indictors for measuring or interpreting conditions***: local economic indicators for wood products industries
- ***Key Question:*** What type of commodities can be produced by the watershed on a sustainable basis? Where can they be produced?

Issue: Trying to maintain a static land allocation on a landscape may or may not be compatible with dynamic natural systems operating on it, or with historic ecosystem conditions. For instance, trying to maintain a large block of late-successional seral stages in the LSR, for the long-term, may be difficult without management intervention, given the historic fire regime of periodic stand-replacing fires here. Besides fire, the area is also subject to other natural processes such as wind, insects and diseases, etc. that could affect their intended function on the landscape.

In addition, years of fire suppression have resulted in altered fuel accumulations and vegetative conditions that may change the size and intensity of a fire if it were to start in land allocations such as the LSR, thus potentially affecting the integrity of the allocation.

- ***Indicators for measuring or interpreting conditions***: land allocations that significantly diverge from natural systems operating here or from historic ecosystem conditions
- ***Key Questions***: What and where are land allocations within this watershed in conflict with natural processes? Where or how could these land allocations be altered to be more in concert with natural processes? What protection measures could be taken to ensure the sustainability of these land allocations on the landscape?

Issue: Almost a century of fire suppression may have altered fire condition classes within the watershed. In some areas fuel accumulations may be higher than might be expected under natural conditions. In some areas these fuel accumulations may increase intensities should a fire start here. This would affect the ability to protect adjacent private land, Late-successional Reserves, or Riparian Reserves, etc. within the watershed.

- ***Indicators for measuring or interpreting conditions***: how far Fire Condition Classes are outside of natural Fire Regimes for the area
- ***Key Questions***: What is the range of natural conditions for the Fire Regime within this watershed? Where does the current Fire Condition Class fall along this continuum? Where and how is the Fire Condition Class different from historical conditions? What management strategies can be used to bring the Fire Condition Class here closer to the range of natural conditions?

Issue: Portions of the watershed have a checkerboard ownership pattern where every other section is publicly-owned and alternate sections are privately-owned. Management goals are very different on the various ownerships. Harvest on private lands adjacent to public lands affects management on public lands. Trying to manage on a landscape scale on public lands is difficult with various ownerships interspersed on the landscape.

- ***Indicators for measuring or interpreting conditions:*** Acres and management goals by ownership within subwatersheds and within the watershed.
- ***Key Question:*** What management strategies can be employed on federal lands to better manage vegetation and other resources on a watershed scale with a variety of ownerships?

Issue: When managing stands of trees to achieve late-successional/old growth stand characteristics using various silvicultural techniques some stand characteristics are not re-created well, such as rots, cavities in trees, etc.

- ***Indicators for measuring or interpreting conditions***: amount of rot, cavities, etc. in the stands
- ***Key Question***: What management strategies can be pursued to better facilitate late-successional characteristics like rot, cavities in trees, etc. in younger stands that are being managed for old-growth characteristics.

Issue: Given climatic changes that have occurred over the last century, and those that are expected to occur in the next century, the arrangement of plant associations may change across the landscape. If temperatures rise, as they are predicted to do, snowpacks are likely to diminish and growing seasons will probably lengthen so low-elevation forests may expand upslope. With warmer conditions and longer growing seasons, tree growth and regeneration will likely improve here as well.

- ***Indicators for measuring or interpreting conditions***: rate of change in climate and the arrangement of plant associations across the landscape
- ***Key Question***: What can be done to monitor gradual changes in vegetative patterns tied to predicted climatic changes?

Issue: The Central Cascades Adaptive Management Area *(AMA)* was established by the NW Forest Plan to facilitate the tie between resource management and research on Federal lands and economically sustainable communities. This watershed provides an opportunity to work in creative ways to integrate the needs of the local communities, tribes, plant and animal communities and the larger social framework of the state and nation.

- ***Indicators for measuring or interpreting conditions***: type of research being done in the AMA
- ***Key Questions***: What activities/projects/opportunities can be worked on or developed in the AMA to bring together research, resource managers, and the communities? What management activities in the South Santiam watershed in general, and the AMA in particular, respond to, are supportive of and/or help implement local community Strategic Plan Goals and Objectives?

Douglas- fir Forest

Photo from *www.forestsystems.com/.../ photos/df_stand.jpg*

3.1.3 Vegetation Current Conditions - *What are the current conditions and trends of the prevalent plant communities and seral stages in the watershed?*

Plant Associations: Nearly 70 percent of the watershed lies within the western hemlock plant association which spans a wide range of temperatures and precipitation levels. This common plant association occupies the area above the warmer and drier Douglas-fir and grand fir associations but below the cooler Pacific silver fir and mountain hemlock zones. Precipitation here can fall as either rain or snow, but winter snowpacks are not generally deep or long-lasting.

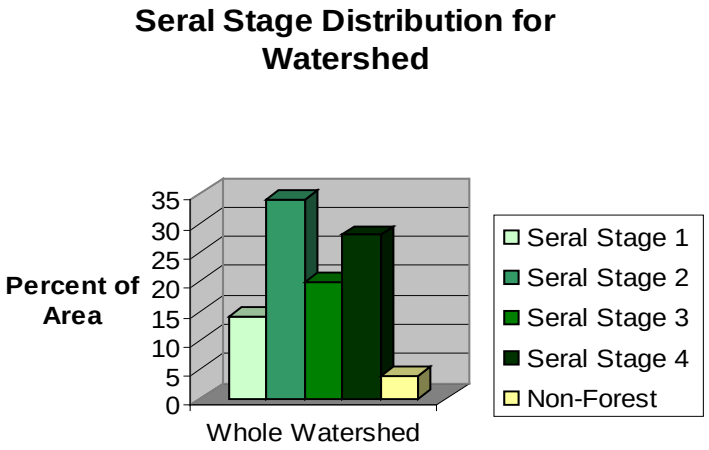
Most of the remainder of the watershed is part of the Pacific silver fir plant association which generally occurs at higher elevations. Growing seasons here are generally short, dry, and cool. Winters are typically wet with persistent snowpacks.

Trends: Current plant associations in the watershed are similar to historic conditions because they are based on geography, soils and weather and these conditions remain fairly constant over time.

However, current climatic trends suggest that average temperatures have been rising over the last century and are predicted to continue into the future. If this projection is true, then it is likely that plant association distributions in the watershed could change. A potential change might be that the highest elevation plant association, mountain hemlock, would be reduced or eventually disappear from the watershed. Then western hemlock and Pacific silver fir associations would migrate to higher elevations, onto what once were mountain hemlock sites. Drier plant associations such as Douglas-fir and Sugar Pine would increase as they fill in portions of sites that were once occupied by western hemlock and Pacific silver fir associations.

The spatial and temporal extent of these plant association migrational trends would be dependant upon the rate of climate changes.

Seral Stages: Currently about 48% of the watershed is in early seral stage development *(Stage 1: stand initiation and Stage 2: stem exclusion)* with the highest percentage in stem exclusion. Soda Fork, Canyon and Owl subwatersheds contain a large percentage of stands in early seral stage development.



Another 48% of the watershed is in later seral stages *(Stage 3: understory Reinitiation and Stage 4: late successional/old growth)* with the highest percentage in late-successional/old-growth. Most of the understory re-initiation and old growth is in Moose, Trout, and Sheep subwatersheds.

The remainder of the watershed is classified as non-forest.

Trends- On public lands the existing seral stage distribution is moving out of the earliest seral stages and into the older ones. On private lands early-seral stages predominate and will likely continue this pattern into the future.

Seral Stage distribution has generally been the result of either timber harvest or past fires. Past forest fires played a key role in shaping the size and distribution of vegetation in the watershed as is characteristic of most Western Cascade forests. Stand replacement fires affecting this watershed occurred around 1200 and 1550, 1856 and 1911. The stands created by these last two fires now occupy about 27% of the watershed, most of it in one contiguous block. See figure 20 which shows the seral stage distribution within the watershed.

Seral Stage Distribution within the Watershed

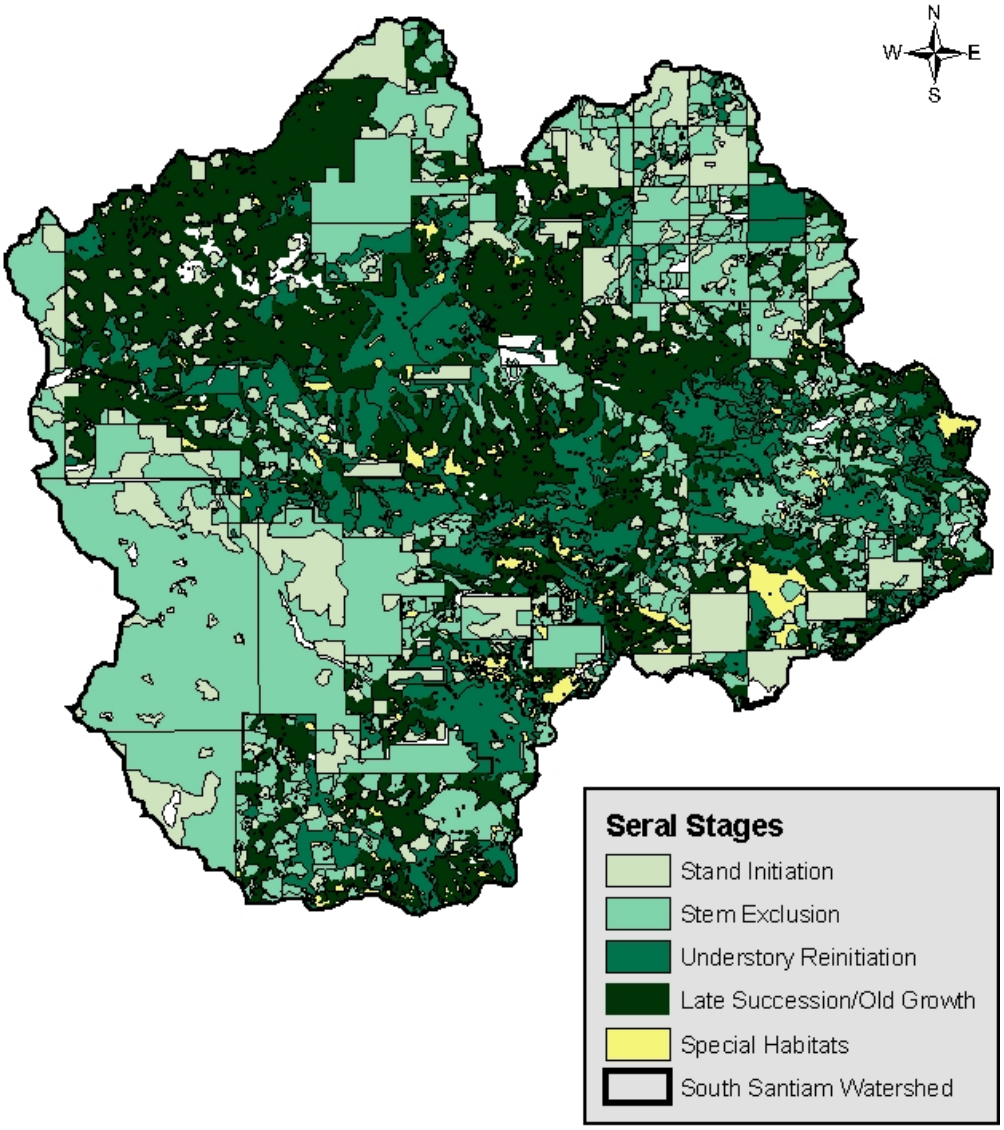


Figure 20

Table 23: The table below shows the age distribution of stands by plant association within the Late Succession Reserves, Matrix Lands, and the Adaptive Managements Areas on National Forest system lands in the watershed. For example: the chart shows that there are 264 acres of 10-19 year old stands of Pacific silver fir plant associations in the Late Successional Reserve.

Acres in Each Age Class by Land Allocation and Plant Association on National Forest System Lands														
		Age in Years												
Land Allocation	**Plant Association**	**<10 years**	**10-19 years**	**20-29 years**	**30-39 years**	**40-49 years**	**50-59 years**	**60-69 years**	**70-79 years**	**80-99 years**	**100-119 years**	**120-149 years**	**150+ years**	**Total Acres**
LSR	Pacific silver fir		264	504	289	335	37	1		148	3833	6	3677	9,094
	Douglas-fir		5			3	1							9
	western hemlock	15	511	546	304	765	456		3	381	7476	43	7128	17628
	Other		40	41	23	99	5			14	348		336	906
LSR Subtotals	**Total LSR Acres**	**15**	**820**	**1091**	**616**	**1202**	**499**	**1**	**3**	**543**	**11657**	**49**	**11141**	**27,637**
Matrix	Pacific silver fir	24	273	416	174	607	46	36		7			687	2270
	Douglas-fir		4			1	1							6
	western hemlock	5	355	248	99	305	205		247	8		1	630	2103
	Other		16	7	5	29	1						27	85
Matrix Subtotals	**Total Matrix Acres**	**29**	**648**	**671**	**278**	**942**	**253**	**36**	**247**	**15**	**0**	**1**	**1344**	**4,464**
AMA	Pacific silver fir	62	89	253	172	130		2	1	4	802	4	2052	3571
	Douglas-fir	3	22	19	7	3								54
	western hemlock	335	1028	1196	651	773	140			6	4674	708	11213	20724
	Other	34	62	126	47	26		5	3	5	342	2	923	1575
AMA Subtotals	**Total AMA Acres**	**434**	**1201**	**1594**	**877**	**932**	**140**	**7**	**4**	**15**	**5818**	**714**	**14188**	**25,924**

3.1.4 Vegetation Reference Condition – *What is the historic array and landscape pattern of plant communities and seral stages in the watershed (riparian and non-riparian)? What processes caused these patterns (wind, fire, etc)?*

Historic Array of Plant Communities: Plant communities here are relatively unchanged over time, as least for the last century. About 70 percent of the watershed lies within the western hemlock plant association and most of the remainder is in the Pacific silver fir association.

The processes that caused this pattern of plant associations are complex interactions among a number of factors including climate, soils, topography, fire, the flora and fauna of the area, and humans, etc. Many of these factors are relatively stable over time so too are the plant associations.

Historic Array of Seral Stages: Forests are, and always have been dynamic. The vegetation in this watershed has adapted to disturbance-driven fluctuations. Seral stage patterns have also experienced a wide range of variability over time as a result of various disturbance agents.

One can describe a snapshot of seral stages at a given point in time such as depicted in the map to the right in 1914, but with a new disturbance all of that can change in a relatively short period of time.

So instead of describing a snapshot of seral stages in time, it is more appropriate to describe the range of seral stage conditions that the watershed has experienced over time. This is called the historic range of variability for seral stage conditions.

Given the large-scale, stand-replacing fire history of this area, the range of seral stage conditions is rather large as well. It is likely that there would have been large, relatively contiguous blocks of stands in the same seral stage intermixed with smaller blocks

Seral Stage Distribution in 1914

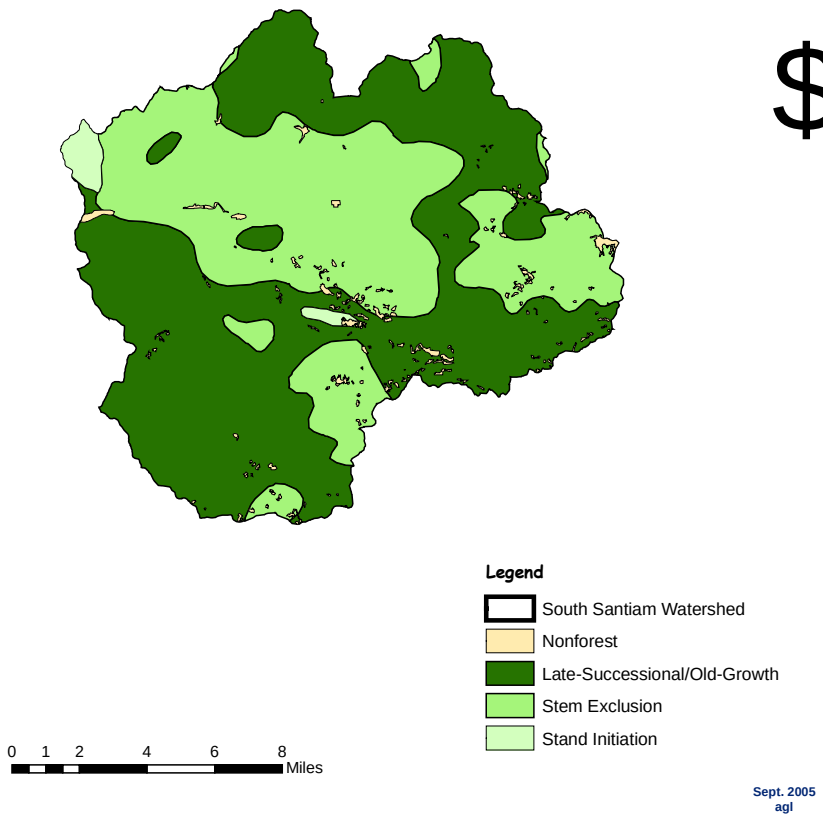


Figure 21

$

of various other seral stages that were either missed by the fires or caused by other disturbance processes. The percentage of the watershed in any given seral stage would have fluctuated a lot over time depending on the fire return interval.

In the 1940's, when timber harvest began in earnest in the watershed, the seral stage patterns began to change. The percentage of land in each seral stage was probably within the range of natural conditions, but the frequency of disturbance, patch size and distribution were not. Landscapes managed for timber production from the 1940s to the early 1990's were managed with dispersed patch clear-cutting for the most part. Unlike fires which tended to produce large blocks of early seral forests, clearcutting produced small patches of early seral forests interspersed with blocks of older seral stages. Figure 22 below shows the decadal harvest on public lands within the watershed. Many of these acres were harvested in patch sizes of 150 acres or less.

Harvest by Decade

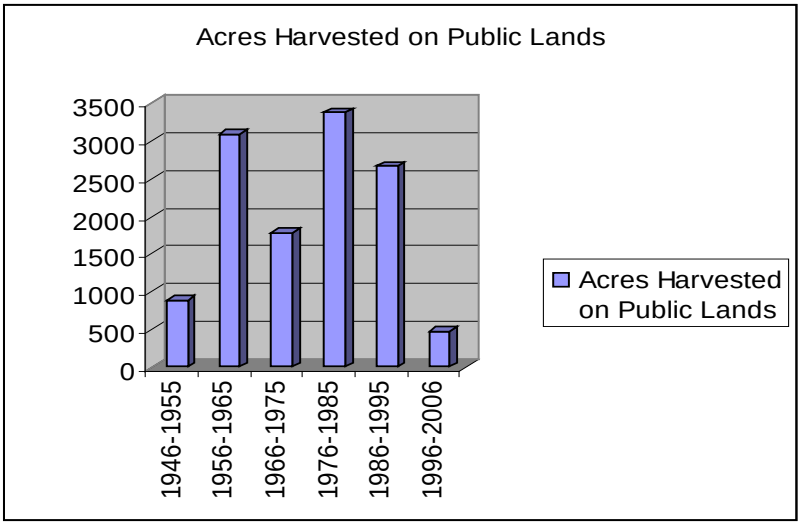


Figure 22

The ***processes that caused these seral stage patterns*** were both natural and human-caused. Prior to the 1900's primarily fire and to a lesser extent wind were the dominant disturbance mechanisms that determined the distribution and pattern of seral stages across the landscape. In its natural state the watershed would have seen a slowly shifting mosaic of large and small patches of various seral stages that came and went with each new disturbance.

For about the last 100 years fires have been suppressed in this watershed. This has reduced the prominence of fire in determining seral stage distribution and arrangement on the landscape. Since the 1940's timber harvest has taken over as the dominant influence on seral stage distribution and arrangement in the watershed.

3.1.5 Synthesis and Interpretation Vegetation: *What are the natural and human causes of change between historical and current vegetative conditions? What are the influences and relationships between vegetation and seral patterns and other ecosystem processes?*

Table: 24 **Natural and Human Causes of Change between Historical and Current Vegetative Conditions.**

Changes between historical and current vegetative conditions	Natural Causes of Change	Human causes of change
The spatial and temporal distribution and block sizes of seral stages	• Fires and other disturbance agents	• Past clearcutting in smaller blocks sizes than historic disturbances created such as fires • Timber harvest occurs much more frequently across the landscape than natural disturbance processes • Ownership patterns and management goals of various landowners • Fire suppression
The younger seral stages on public lands are trending out of the stand initiation stage and into the stem exclusion stage. So overall there are fewer stand initiation acres than at some points in the past.	• Vegetative growth	• Changes in harvest practices from mostly clearcutting to mostly commercial thinning • Decrease in volume of timber harvested • Fire suppression
The amount of timber volume available on public lands for timber -based employment is less than in the past		• Change in management goals on public lands
Reduced natural mortality and stand defects	• Vegetative growth	• Silvicultural treatments such as thinning to capture mortality, etc. • Timber harvest • Fire suppression
Accelerated development of stand initiation and other seral stages over natural conditions. Fewer brush fields.	• Vegetative growth	• Pre-commercial and commercial thinning and other silvicultural treatments • Tree planting or other artificial regeneration • Fire suppression

Changes between historical and current vegetative conditions	Natural Causes of Change	Human causes of change
Commercial thinnings have changed in some areas from thinning to a certain designated spacing to variable density thinning, retaining more minor species, adding gaps, etc. adding diversity		• Change in management goals to more closely mimic natural stand conditions
Private landowners are doing more thinning than they used to. Not thinning very heavy, capturing mortality and will liquidate later.		• Change in management goals
With commercial thinning and only treating a portion of the fuels in high risk areas, untreated activity-generated fuels are increasing over past management practices		• Silvicultural practices • Economics of fuel treatments • Fuel treatment strategies
Biasing future stands toward shade tolerant species – in the long-term may be changing the species composition	• Habitat requirements for various tree species	• Management strategies of thinning also age and size of stands that are treated • Fire suppression
Focus harvesting on stands less than about 120 to 150 years old.		• Public concerns about harvesting timber older than this

Table 25: **Influences and Relationships between Vegetation and Seral Patterns and Other Ecosystem Processes**

Vegetation and seral patterns	Influences and Relationships between vegetation and seral patterns and other ecosystem processes
Seral stage patterns and distribution across the landscape	• Affects type of plant and animal species adapted to those seral stages and patch sizes. • May affect species diversity.
Program of mostly commercial thinning	• Less available forage for big game. • More long-term activity fuels might be setting up conditions for more intense fires, unnaturally increasing fire condition class (effect is temporary until fuels break down) • More soil stability, increasing duff layers • Increased visual aesthetics • Less smoke because not burning as much with thinning than with clearcutting • More connectivity for wildlife • Big game movement from public to private lands • Impacting more acres of land to get the volume of timber desired with thinning than with clearcutting • Less defects than in natural stands.
Accelerate stand initiation, less brush fields	• Faster re-occupancy of site by trees • Time period that browse and forage is available has decreased. • Hiding cover develops faster. • Scenic quality recovers faster • Reduces time frame that stand initiation seral stages or brush fields are on the landscape for dependent species such as some neo-tropical migrant birds, big game, etc.
Capture mortality through thinning	• Less defect, cavities, rots, etc. than in natural stands
Cutting less	• Economics in local community, reducing competition for our product, getting lower price when we sell some products, reducing future special forest products such as boughs because not many new plantations are being created and are moving out of early seral stages. • Increased growth on acres not harvested, affects seral stage distribution

3.1.6 Recommendations: *What changes in ecosystem condition and function require management action to achieve management objectives? How will success of management actions be measured? What monitoring or research is recommended?*

Changes requiring management action	Management objective	Recommended management actions	General Locations	Indicator used to measure success	Recommended monitoring or research
Spatial and temporal distribution and block sizes of various seral stages is more fragmented than it was historically	• Emulate natural processes within their historic range of variability • Maintain habitat diversity for plants and animals and stabilize time frame of seral stage fluctuations • Allow for use of whole array of silvicultural options to meet management objectives for seral stages. • Maintain at least 15% of federal in stands where the average diameter of the overstory trees is greater than 21" • Provide/maintain connectivity between LSR's , especially in the Santiam Area of Concern	• Meet land allocation objectives for seral stage distribution (i.e. late-successional/old growth stages in LSR) • Ensure land allocation distribution and arrangement falls within the range of natural conditions for the watershed. • Provide some stand initiation seral stages especially in Moose, Owl and Upper Canyon subdrainages or other areas where it is lacking • Continue establishment and growth enhancement silvicultural activities in young stands in ways that meet land allocations • Take advantage of opportunities to block up ownership to allow for management on the watershed scale (ex: seral stage distribution and arrangement, etc.)	• LSR • Watershed where needed • Moose, Sheep, Soda Fork and Sevenmile	• *Indicator*: seral stage distribution and arrangement in watershed • *Expected response*: seral stages would be within range of natural conditions for distribution and arrangement • *Duration*: long-term • *Certainty:* moderate	• What is the range of natural conditions for seral stage distribution and arrangement?

Changes requiring management action	Management objective	Recommended management actions	General Locations	Indicator used to measure success	Recommended monitoring, research or data gaps
Reduced timber harvest and effect on local economy	• Provide a consistent and sustainable supply of timber	• Harvest commercial timber in a way that meets resource needs and provides a fairly steady supply to the local wood products industries	• Mostly matrix and Adaptive Management Area lands • Best opportunities in near future in matrix are in Sheep and Sevenmile watersheds.	• *Indicator*: average annual volume of timber offered • *Expected response*: consistent volume offered • *Duration*: long-term *Certainty:* mod.	
Increased demand for special forest products to provide source of local employment	• Manage in accordance with standards and guidelines in Forest Plan • In Riparian Reserves harvest special forest products if it helps maintain or enhance ACSO's and is a low risk project	• Encourage sustainable harvest of a variety of special forest products in an ecologically sensitive manner • Encourage development of new commodities of special forest products that address management issues such as slash generated by yarding tops in thinning units being made into a salable product	• Matrix and Adaptive Management Area	• *Indicator*: dollars generated by sale of special forest products • *Expected response*: increase in money generated through special forest products • *Duration*: long-term • *Certainty:* mod.	• Levels of sustainable harvest for various special forest products • Investigate new or different special forest product markets

Changes requiring management action	Management objective	Recommended management actions	General Locations	Indicator used to measure success	Recommended monitoring, research or data gaps
Firewood availability and down woody material retention needs	• Allow opportunities for firewood gathering to meet community needs • Minimize impacts to ecological processes	• Gather firewood as appropriate. Limit gathering in areas that lack sufficient down woody component.	• Forest Matrix and Adaptive Management Area	• *Indicator:* cords of firewood offered	
Riparian Reserves	• Meet Aquatic Conservation Strategy Objectives (ACSO) • Maintain Riparian Reserves as outlined in management direction • Enhance species diversity, diameter growth for future large wood recruitment and development of late successional/old growth structure	• Use various silvicultural treatments to accelerate development or to achieve Aquatic Conservation Strategy Objectives for vegetation in Riparian Reserves • Take advantage of opportunities to increase tree sizes for future instream and riparian woody structure and to increase stream shade	• Areas in Riparian Reserves that lack complex structure or species diversity especially in Owl, upper and lower Canyon, Soda Fk, Sheep, and Sevenmile	• *Indicator:* percent of Riparian Reserves meeting ACSO's • *Expected response*: increasing percentage of functioning • *Duration*: long-term • *Certainty*: mod.	

Changes requiring management action	Management objective	Recommended management actions	General Locations	Indicator used to measure success	Recommended monitoring, research or data gaps
Fuel accumulation (one of top 10 changes requiring management action)	• Manage fuels across the landscape to reduce the potential for intense, large stand-replacing fires • Maintain/re-create a frequency of fire on the landscape that more closely mimics natural conditions.	• Analyze landscape and place treatments in such as way to limit spread (thinning, pruning, etc. to reduce ladder fuels etc.) • Manage transportation system in a way to provide key access points • Manage fuels in areas high risk for human-caused fires (to prevent starts) • Reintroduce role of fire in the ecosystem in a controlled fashion • Pre-treat fuels in selected areas that we want to burn later. This might include prescribing a series of light burns in the same area to reestablish the historical fire regime there, or other methods • Use fire or other management strategies such as silvicultural practices that mimic natural disturbances	• Adjacent to private land • Highway 20 corridor, and high public use areas • Within and adjacent to LSR's • Adjacent to wilderness • Look at whole landscape, fire history and weather patterns to determine where else to treat • Camas prairie • Cougar rock • Gordon Meadows • Browder Ridge • Sevenmile and Jumpoff Joe • Areas with fire history of underburning	• *Indicator*: acres of fire condition class moved closer to natural fire regime • *Expected response*: return to range of natural conditions for natural fire regime • *Duration*: long-term • *Certainty:* moderate	• Monitor condition class changes over time • Monitor plant community response

Changes requiring management action	Management objective	Recommended management actions	General Locations	Indicator used to measure success	Recommended monitoring or research
Ownership patterns affect landscape scale management of vegetation in the watershed	• Manage vegetative resources on a watershed scale, where possible	• Work in new and creative ways with adjacent landowners to develop strategies to manage vegetation on a watershed scale • Consolidate ownership as needed to achieve desired resource objectives (i.e. connectivity in Santiam Area of Concern)	• Especially in checkerboard ownership areas	• *Indicator*: consistency of management goals on various ownerships • *Expected response*: more consistent management of resources on watershed scale • *Duration*: long-term • *Certainty:* low – mod.	
Silvicultural treatments such as commercial thinning encourage growth of more shade-tolerant species than clearcutting did	• Ensure the variety of plant species (both shade tolerant and intolerant) are within the range of natural conditions	• Utilize a variety of silvicultural and other management techniques to promote vegetative diversity within the range of natural conditions • Encourage a variety of habitat conditions to accommodate species diversity	• Watershed as a whole	• *Indicator*: Species diversity • *Expected response*: species diversity within range of natural conditions • *Duration*: long-term • *Certainty:* mod.	Range of natural conditions of species composition

Changes requiring management action	**Management objective**	**Recommended management actions**	**General Locations**	**Indicator used to measure success**	**Recommended monitoring, research or data gaps**
Management strategies to accelerate development of late-successional/ old growth stand characteristics do not mimic rots, etc. that create cavities in trees, etc.	Meet objectives of accelerating development of late-successional stand characteristics in allocations such as LSR's or Riparian Reserves	• Utilize a variety of management strategies to best mimic late-successional/ old growth stand characteristics as we know and understand them when treating young stands to more quickly develop these characteristics	• LSR's • Riparian Reserves	• *Expected response*: closely mimic late-successional/old growth stand characteristics • *Duration*: long-term	• Develop effective ways mimic late-successional / old growth stand characteristics such as rots, etc. to meet habitat needs of both plants and animals
Species Biodiversity	• Preserve/promote biodiversity at the genetic level, within plant communities and between plant communities	• Implement reforestation/revegetation programs that emphasize genetic diversity in plant materials used	• Areas where management actions affect species make up	• *Indicator*: Preserve species diversity • *Expected response*: Maintain or improve existing species diversity • *Duration*: long-term • *Certainty:* low –mod.	

3.2 Rare, Sensitive and Non-Native Vegetation

3.2.1 Rare, Sensitive and Non-native Vegetation Characterization:

(What is the relative abundance and distribution of species of concern that are important in the watershed? (TE and S, special status species, species emphasized in other plans)? What is the distribution and character of their habitats?

The South Santiam watershed hosts a diverse array of botanical species. It contains more rare species than any other watershed on the District. The watershed includes several old Cascade peaks that contribute greatly to plant diversity. (*For more specific information, lists of species and species descriptions see Botanical Report in Appendix C).*

Relative Abundance and Distribution of Species of Concern

Sensitive species: Eleven plant species on the *Region 6 Sensitive Plant List* have been found in the South Santiam Watershed. In addition to these plants there are nine species of fungi, seven species of sensitive lichens and one sensitive bryophyte.

Relative abundance: These sensitive species range from uncommon to very rare on the Willamette National Forest.

Distribution and Character of their Habitats: Sensitive species often have very specific habitat requirements or may be at the edge of their range. Many of the sensitive vascular plant species occur in non-forested habitats, such as wetlands and rock gardens. However, most of the lichens, fungi, and bryophytes are forest dwellers. Habitat for an additional 40 sensitive plants, lichens and fungi occurs in the watershed. Approximately 25% of the National Forest land in the watershed has been surveyed for sensitive species. No surveys for rare or sensitive plants have been done on private lands here.

Watch/Review or Concern Lists: In addition to sensitive species there are 17 botanical species on Watch or Review Lists and 10 on the Willamette National Forest Concern List documented in the watershed.

Relative abundance: These species range from uncommon to very rare on the Forest.

Distribution and Character of their habitats: Most of these plants are associated with riparian areas or special habitats, including but not limited to, wet meadows, rock outcrops, cliffs and talus. However, the fungi are more often found in conifer forests and are not associated with special habitats.

Special Habitats, Special Areas and Rare Forested Plant Associations: The occurrence of special habitats *(non-forested communities)* and their distribution across the landscape is important for biodiversity of plant and animal species. Eighty-five percent of the flowering plants in the central western Cascades are found in non-forested areas such as rock outcrops and meadows which comprise only about five percent of the landbase

(Hickman 1976). Many sensitive plant species and other plant species of concern are associated with these habitats.

The distribution of special habitats other than rock outcrops is skewed toward higher elevations. Most of the larger special habitats are associated with old Cascade peaks. Some of these peaks host a wide array of community types and thus provide habitat for a great diversity of plants and animals. Special habitats are rarer at low elevations on the west end of the watershed. By far the most common special habitats in the watershed are rock outcrops and cliffs. These are well distributed throughout most of the watershed. Dry rock gardens are associated with some of these rock formations, for instance, on Cougar Rock, Browder Ridge, and Two Girls. Moist rock gardens are less common but are found on Iron Mountain, Two Girls, and scattered other locations. Sitka alder communities are common on the north slopes of old Cascade peaks in the watershed. Vine maple/rock soil associations sometimes occur with Sitka alder but are also found alone; two locations of this community are on the south-facing slopes of Two Girls and Soapgrass Mountain. The only site of the dry beargrass/red fescue community known to occur in the watershed is on Soapgrass Mountain.

Many of the wetter communities are rare or uncommon in the South Santiam watershed. Bogs, with their characteristic Sphagnum and sundew (*Drosera spp.*) communities, are found only in and around Gordon Meadows. A sphagnum bog is found in upper Gordon Lake but it has not developed the diverse plant community found in the Gordon Meadows bogs. Lakes, ponds, sedge meadows and wet meadows are also relatively uncommon. Most occur in flatter portions of the watershed, such as the headwaters of Sevenmile Creek and the Gordon Meadows area.

Scattered mesic meadows are found in the upper South Santiam but are not common; these are good sites for collection of native grass seed, which is grown out and used as stock for re-vegetation projects.

Special habitats have been impacted in areas of past timber harvest. They have been disproportionately impacted in the Soda Fork, Owl, Upper and Lower Canyon subwatersheds, where timber harvest and road building have been the most extensive. Rock outcrops and rock gardens have been used as quarries if the rock was suitable and road building was occurring in the area. Cliffs and rock outcrops have been convenient boundaries for harvest units and have served as efficient fuel breaks during slash burning. The effects of timber harvest and broadcast burning on rock communities is substantial, though not well documented. Many species that inhabit these communities are slow growing, particularly lichens, and little is known about their rates of establishment. Non-native plants that invade harvest units and roads become established on these rock habitats as well. Small wetlands within harvest units were also impacted by removal of the adjacent tree canopy and subsequent changes in the hydrology and species composition. Only recently have buffers been retained around special habitats in an effort to reduce microclimate changes and direct physical disturbance.

Rare Forested Plant Associations contribute to the watershed's diversity of community types. These communities may reflect unusual environmental conditions or be at the northern or southern extent of their range (*Dimling and McCain 1992*). Plant associations that are know from five or fewer sites on a district are considered rare. Plant associations known from 6-11 sites on a district are uncommon. In some instances, the designation rare-uncommon was used if the status was unclear. On-going field observations are needed to verify plant association rarity. These plant associations are treated as special habitats. Five rare or rare-uncommon forested plant associations have been identified in the watershed.

Iron Mountain/Echo Mountain Botanical Special Interest Area (SIA) harbors an incredible array of plants. Over 300 flowering plants are found on Iron Mountain alone *(Ross and Chambers 1988).* Only the west and southwest aspects of Iron Mountain are in this watershed but this portion supports many plant communities, from cliff dwellers and rock gardens to mesic meadows and old-growth forests. The noxious weed, St. John's wort (*Hypericum perforatum*) is increasing in abundance in this SIA.

Camas

Camas Prairie Special Interest Area; This Special Interest Area supports Native American traditional and customary use of camas (*Camassia quamarsh).* This wetland area on the western edge of the watershed has been planted with camas and is periodically burned and receives ongoing weed control in order to perpetuate camas production.

Traditionally, Native Americans harvested camas bulbs, cooked them in pits and either ate them or stored them for future food supply. They would regularly burn areas where camas grew to preserve conditions that encouraged the growth of the plants.

Three Creek Research Natural Area and Three Creek Old Growth Grove: Very old stands of Douglas-fir and Alaska yellow-cedar characterize the forests of the Three Creek area. The old-growth is 400-500 years old with inclusions of small stands 700-850 years old. This area serves as refugia for old-growth related species, including lichens and bryophytes. The entire Three Creek area is now in a Late Successional Reserve (LSR).

Proposed Canyon Creek Botanical Special Interest Area: This is an area of unique topography and vegetation. Meadows with patches of Oregon white oak (*Quercus garryanna)* alternate with cliffs in a series of bands on a southwest-facing slope. Oregon white oak is found at only two locations on the district. The rare forested plant association, western hemlock/vanilla leaf, occurs above the open slopes. These cliffs are the only know location of California swordfern (*Polystichum californicum*) on the Willamette National Forest. It is also inhabited by another sensitive species, *Usnea longissima*.

Proposed Two Girls Botanical Special Interest Area: A variety of special habitats can be found on Two Girls, including rock outcrops, dry meadows, rock gardens, Sitka alder patches and talus. These habitats support a great diversity of plant species. Open seeps provide habitat for Thompson's mistmaiden *(Romanzoffia thompsonii)*, a Region 6 sensitive

species. This area was proposed as a Special Wildlife Habitat in the draft Willamette National Forest Land and Resource Management Plan but was later dropped. \

Proposed Tombstone, Sheep and Longbow Mycological Special Interest Areas: This area was proposed as a SIA to protect two very rare species of false truffles, *Rhizopogon inquinatus* and *Leucogaster microsporus*, and to raise awareness of the importance of fungus in the ecosystem.

Noxious Weeds and Invasive Non-native Plants are a threat to native plant diversity. These species are able to displace and outcompete native species because they arrive without the host of predators, disease and other ecosystem components that limit their abundance in their native habitat. Noxious weeds also reduce the quality and quantity of forage available for animals because many of these weeds are toxic or otherwise unpalatable.

The South Santiam has a greater abundance and diversity of non-native plants than do other watersheds on the district. This is possibly due to the long history of logging and roading and the presence of Highway 20 which serves as a corridor for east-west weed migration. Forty species of non-native plants have been documented in this watershed. Eight of these have been legally designated as noxious, which is defined as "species of plants that cause disease or are injurious to crops, livestock or land, and are thus detrimental to agriculture, commerce or public health" (USDA 1988).

Many non-native species are colonizers of exposed mineral soil. Soil disturbance whether natural or anthropogenic, is generally required for these species to get established. Timber harvest and associated road building provide good conditions for weed establishment (*USDA 1988*). Seeds may be carried in by vehicles, logging equipment, or as contaminates in erosion control and forage seed mixtures. The increased light found along roadsides, combined with continued disturbance from traffic, allow roads to serve as corridors for weed invasion (*Parendes 1997*). Once established, many weed species are dispersed by wind-blown seed and invade open, disturbed sites such as timber harvest units. Birds and other animals may also spread non-native plants by eating the seed and dispersing it elsewhere. Road maintenance activities, such as brushing and ditching, sustain the light and disturbance required by these species, and serve to spread the weeds if the soil and plant material is deposited in another area.

Most of the weed populations found in this watershed are located on roadsides, landings, clearcuts, along trails, and in areas once grazed by livestock. However, several weed species have been observed invading rock garden and dry meadow communities. Small-scale disturbance mechanisms, for example, gopher burrowing, appear to enhance the spread of weeds in these natural openings. These communities are often botanically rich which makes the invasion of highly competitive weeds a notable concern.

Additional weed species are apparently well-suited for invading forested stands. False brome (*Brachypodium sylvaticum*) is a very aggressive grass that does equally well in the understory as it does in openings. It is rampant on private timberlands and a number of sites have been located on federal lands in Moose, Canyon and Trout subwatersheds. It is

invading an oak-madrone opening that is the Forest's only known site of the California swordfern.

False Brome photo by www.appliedeco.org/

Wall lettuce (*Lactuca muralis*) and Himalayan blackberry (*Rubus discolor*) have been documented in unmanaged stands in the South Santiam watershed. Wall lettuce is now widespread and has even been found in the Three Creek Research Natural Area. Presumably, natural disturbance factors, such as windthrow and mountain beaver activity, provide suitable sites for establishment.

The presence of non-native blackberries (*Rubus discolor* and *R. lasiniatus*) is of particular concern in this watershed. They have been documented at over 100 sites, mostly at lower elevations in Moose, Canyon and Trout Creeks. Established populations occur along Highway 20 and the South Santiam River from the western edge of the watershed to Mountain House. River and stream banks are dominated by Himalayan blackberry in several locations. Isolated populations have been found as far east as Sheep Creek and at nearly 4,000 feet elevation on Moose Mountain. It has been observed that blackberries are most likely to get established in moist microsites, for instance, under or between logs, and in areas that are seasonally wet, such as ditches and riparian areas. Blackberries spread vegetatively, growing roots at the end of their canes during the winter when vegetative growth is minimal and soils more easily penetrated. There are no biological controls available for blackberries and manual removal is difficult, particularly once the plants are well-established. These species have the potential to directly compete with tall bugbane (*Cimicifuga elata*); a Region 6 sensitive species that inhabits moist north slopes in the same area of the watershed where blackberries are the most prevalent. The ability of blackberry to spread beneath a forest canopy, rather than remaining in open, disturbed sites, makes it a greater threat to native plant diversity than many of the other weeds found in the watershed. The accidental introduction of a rust that infects blackberry may eventually provide some level of control. The rust has not been found in this watershed to date, however.

Two other non-native species of concern in the watershed are spotted knapweed (*Centaurea maculosa*) and yellow toadflax (*Linaria vulgaris*). Spotted knapweed is found at several locations adjacent to Highway 20 and at two sites near Moose Mountain Road. Yellow toadflax is known from one site near Burnside Road and one site on private land. Both of these species dominate large areas of land in eastern Oregon. A concerted effort is being made to prevent the spread of spotted knapweed from eastern Oregon into the Willamette Valley, where it could potentially become a serious pest on agricultural lands.

spotted knapweed

photo from www.r6.fws.gov/redrocks/ images/spotknap.jpg

3.2.2 Rare, Sensitive and Non-native Vegetation Issues and Key Questions: *The issues and key questions help focus the analysis on the relevant elements of the ecosystem as they relate to management questions, human values or resource conditions within the watershed.*

Sensitive Species

Issues: Natural disturbances, management or recreational activities can reduce habitat of rare or sensitive plant species. This can result in fewer plants than currently exist, putting them in further peril of extinction.

- ***Indicators for measuring or interpreting conditions***: Rare or sensitive plant habitat disturbed.
- ***Key Questions***: What is the historic and current occurrence of rare or sensitive plants in this watershed? What natural or human-caused disturbances affect rare or sensitive plant habitat and what is their effect on the habitat? What can be done to protect rare or sensitive plants from detrimental disturbance? What can be done to restore rare or sensitive plant habitat?

Special Habitats, Special Areas, and Rare Forested Plant Associations

Issues: The occurrence of special habitats and their distribution across the landscape is important for biodiversity of both plant and animal species. Preserving biodiversity has ecological value, but it also has secondary societal value as well. Only a small percentage of plant species have been screened for compounds that may have medicinal, nutritional, or other commercial applications. Plants can be indicators of environmental quality, as in the case of certain lichens that are sensitive to air pollutants. In order to preserve the potential uses of plants, we must protect biodiversity at all three levels: genetic, within plant community, and between plant communities.

Some special habitats have been impacted in areas of past timber harvest, especially in Soda Fork, Owl , Upper and Lower Canyon subwatersheds where timber harvest and road building have been the most extensive. Rock outcrops and rock gardens have been used as quarries for rock to surface roads. Non-native plants that invade harvest units and roads become established on these rocky habitats as well. Small wetlands are impacted by removal of the adjacent tree canopy and subsequent changes in the hydrology and species composition.

- ***Indicators for measuring or interpreting conditions:*** Special habitats disturbed by management activities
- ***Key Questions:*** Where are special habitats and rare-forested plant associations in the watershed? What conditions are likely to have contributed their presence in the watershed? Where have special habitats been affected by management activities? What can be done to restore these habitats that have been affected by

past management practices? How best do we protect and preserve biodiversity within the watershed?

Noxious Weeds and Invasive Non-native Plants

Issue: Noxious weeds and invasive non-native plants are a threat to native plant diversity in the watershed. Once established, they often out-compete native vegetation for available water, nutrients and sunlight. Most of these species take advantage of disturbance gaps such as logged units, roads, rock quarries, burned areas, the areas surrounding human structures, and trails. Once established, these populations can serve as a seed source for further dispersal, generally along road and trail corridors. Weed seeds are generally easily transportable and highly adaptable. Seeds can be transported by vehicles, animals and wind to new locations where they become established. Established populations of non-native plants or noxious weeds can displace native plants with few redeeming qualities of their own. They can lead to significantly reduced forage production, less species diversity and more soil erosion.

- ***Indicators for measuring or interpreting conditions***: Identification, distribution and rate of spread of noxious weed and invasive non-native plant populations
- ***Key Questions***: What are appropriate management options for dealing with noxious weeds and non-native plant species? Where and how can non-native plants and noxious weeds be eliminated or minimized in the watershed? How is road use and construction contributing to non-native plant abundance and spread? What effect does closing or decommissioning roads have on non-native plant abundance?

3.2.3 Rare, Sensitive and Non-native Vegetation Current Conditions:

(What are the current habitat conditions and trends for the species of concern?

Forest and Native Plant Diversity: Changes in the disturbance processes in this century have affected the diversity and distribution of plant species as well as the age class distribution of forested plant communities. Timber harvest and associated road building have decreased and fragmented habitat for old-growth related plants and fungi, while simultaneously increasing habitat for invasive non-native plants. Species composition in riparian areas has been altered by the early seral conditions that follow timber harvest. Special habitats (non-forested communities) have been impacted in areas of intensive timber harvest, but not where they occur within large blocks of younger fire-regenerated stands.

Sensitive Species – There are more sensitive plant species , both in populations and number of species, than there were in 1994 because all of the survey and manage species have been labeled at sensitive. The fire history and resultant pattern of timber harvest in the watershed has led to a limited amount of habitat suitable for species associated with old-growth forest conditions, including some lichens, fungi, mosses, liverworts and vascular plants. The remaining old-growth forest in the watershed is unevenly distributed on Forest Service lands and almost non-existent on private lands. Dispersal capabilities are limited for a number of these species, thus, in a fragmented landscape, gene flow may be restricted between populations. Riparian areas, which are quicker to attain characteristics of old-growth forests, may serve an important role as corridors for dispersal and gene flow.

Populations of fungi, lichens and bryophytes are stable and likely to increase in the future. One population of California sword fern, is the only population on the forest, and is threatened by false brome. Tall bugbane is pretty stable.

Special Habitats: The occurrence of special habitats (non-forested communities) and their distribution across the landscape is central to plant diversity. Special habitats support many plant and animal species which are dependant on a particular habitat during part or all of their life history. For instance, peregrine falcons are only found associated with rocky peaks in the watershed and Townsend's big-eared bats only inhabit dry caves. Most flowering plants in the central western Cascades are found in non-forested areas such as rock outcrops and meadows which comprise only about five percent of the landscape *(Hickman 1976).* Timber harvest impacts to special habitats have been concentrated in the Cascadia, Soda Fork, Owl, Upper and Lower Canyon subwatersheds, where timber harvest has been the most extensive. Most of the rare plants in the watershed, including those that are on the Region 6 Sensitive Plant List, are associated with these special habitats.

Tall bugbane: One sensitive species that is not associated with special habitats is tall bugbane (*Cimicifuga elata*). This species is a perennial herb that inhabits moist, forested north slopes at lower elevations on the west side of the Cascades. Much of its habitat is under private ownership and has been altered by development or timber harvest. This species appears to respond positively to forest canopy gaps that result from features, such as rock outcrops, or small-scale disturbance processes, for instance, laminated root rot pockets. There are 8 populations of tall bugbane known to occur in the watershed. Six of these populations are within the Central Cascades AMA. There is an opportunity to learn how habitat suitability for tall bugbane can be enhanced by harvest methods that mimic natural openings and small-scale disturbances.

tall bugbane - www.appliedeco.org

Non-native plants/Noxious Weeds: The extensive road system in the watershed allows for continued dispersal and colonization of noxious weeds and other invasive non-native plant species. Most of these plants are colonizers of disturbed sites and are thus found on roadsides, landings, clearcuts, trails and other disturbed places. Noxious weeds and other non-native plants are a threat to native plant diversity. These species also reduce the quality and quantity of forage available to animals because many of these weeds are toxic or otherwise unpalatable. Forty species of non-native plants have been documented in the watershed. Two species of particular concern in the watershed are Himalaya blackberry (Rubus discolor) and evergreen blackberry (R. laciniatus). These two species have been documented at over 100 sites on Forest Service land within the watershed and are well established on private land. They are well suited for riparian habitats and quickly out compete and overtop the native vegetation. The ability of non-native blackberries to spread beneath a forest canopy, rather than remaining in open, disturbed sites, makes them a greater threat to native plant diversity than many of the other weeds found in the watershed.

The trend for noxious weeds has been an increase in the number of species and an overall increase in plant populations. On an individual species basis some like blackberry and false brome have increased, while others like spotted knapweed have declined. The biggest problem areas in the watershed for noxious weeds are Moose and Canyon Creek and along many of the road systems.

There has been an increase in awareness of noxious weeds and more coordination between landowners for noxious weed control. Control efforts have also increased.

Noxious Weeds and Invasive Non-native Plants

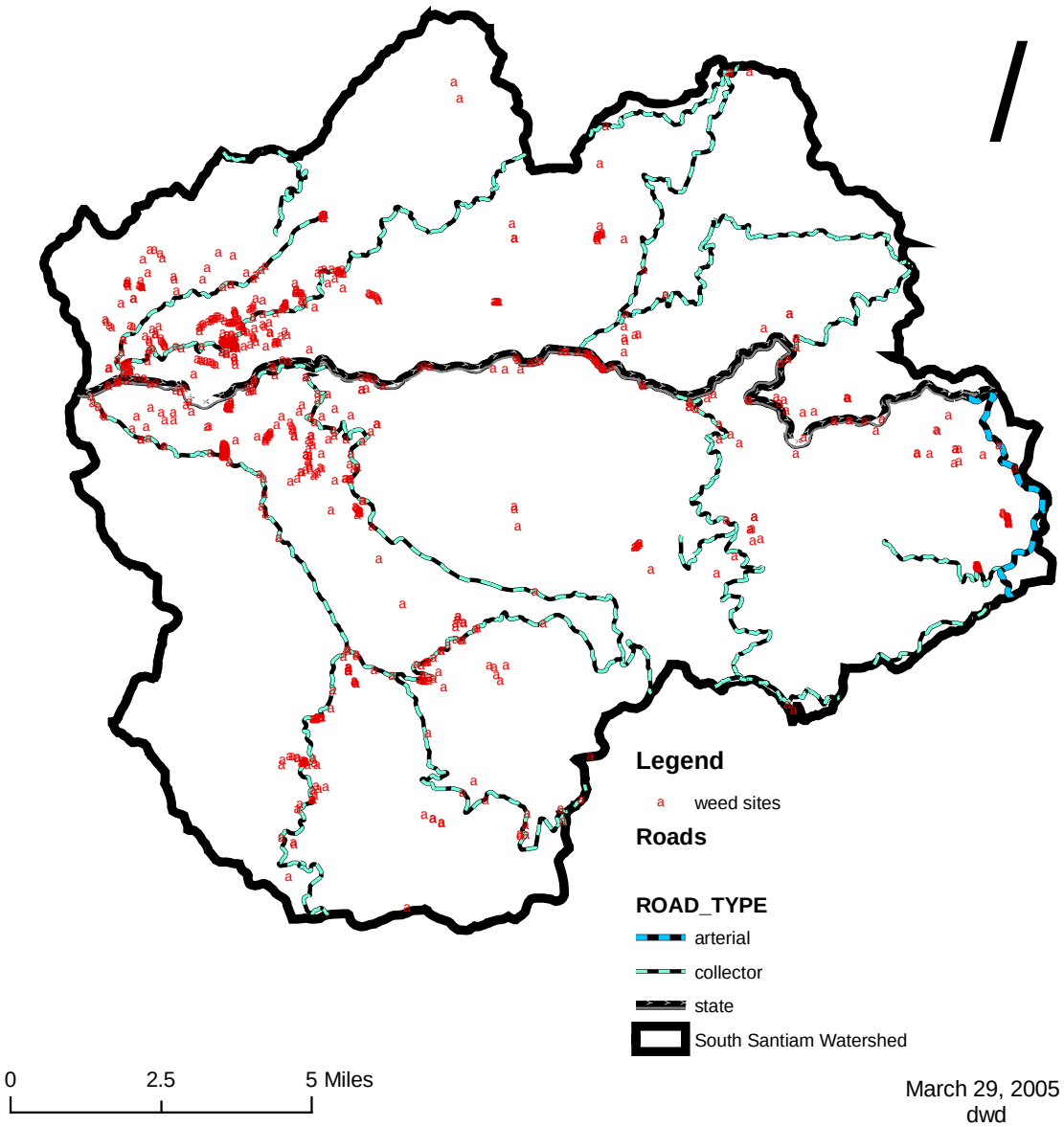


Figure 23

3.2.4 Rare, Sensitive and Non-native Vegetation Reference Conditions -

What is the historic relative abundance and distribution of species of concern and the condition and distribution of their habitats in the watershed?

Historic relative abundance and distribution of rare and sensitive plants: It is difficult to assess the relative abundance and distribution of rare and sensitive plants in this watershed. Many of these plants are rare because they have very specific habitat requirements or they may be on the edge of their range of distribution. Given climatic changes and disturbances such as large, stand-replacing fires that have occurred over time, it is probable that some rare or sensitive plants may have been more abundant and some may have been less abundant in the past. It all depends on their habitat requirements and the availability of that type of habitat.

Condition and distribution of their habitats: Over time the condition and distribution of habitat for rare and sensitive plants has changed depending on natural disturbance processes and burning by indigenous people. In the nearer term, past management practices probably resulted in the inadvertent disturbance to habitat for rare and sensitive plants.

Historic relative abundance and distribution of noxious weeds or invasive plants: Humans have had a great influence on the abundance and distribution of noxious weeds or invasive, non-native plants. Early settlers brought plants with them for medicines and crops. In addition, livestock grazing and the movement of livestock probably also contributed to the increasing abundance of these plants. Travel by foot, horseback, vehicle or other means also has continued to contribute to the spread of noxious weeds and invasive, non-native plants.

Condition and distribution of their habitats: Noxious weeds or invasive plants spread where people were. They tended to be found along travel routes and near settlement areas. Any area that provided a suitable seedbed provided the opportunity for these plants to become established and spread. Without natural controls, they spread easily from place to place.

3.2.5 Rare, Sensitive and Non-native Vegetation Synthesis and Interpretation: *What are the natural and human causes of change between historical and current vegetative conditions? What are the influences and relationships between vegetation and seral patterns and other ecosystem processes?*

Table 26 **Natural and Human Causes of Change between Historical and Current Rare, Sensitive and Non-native Vegetation Conditions**

Changes between historical and current conditions	Natural Causes of Change	Human causes of change
Some plants have been identified as rare or sensitive in the watershed	• Some species on the edge of their range • Natural disturbances can affect habitat	• Disturbances to habitat from management and/or recreational activities can reduce numbers of rare and or sensitive plants.
Special habitats have been disturbed	• Trees have encroached on some special habitats	• Management activities such as timber harvest, slash burning, etc. have impacted special habitats in the past. Timber harvest has changed microclimates. There have been physical disturbances too. • Rock outcrops and rock gardens have been used as rock quarries
Noxious weeds and invasive or non-native plants are increasing in number of species and populations within a species	• Lack of natural controls • Natural disturbances such as windthrow, expose mineral soil for these plants to get established • Seeds can be transported by wind or animals	• Transportation system development and use • Ground-disturbing management activities • Recreational activities such as ATV use, which can disturb soil • Seeds can be transported by people and vehicles
More herbicides have been used to control noxious weed and invasive, non-native plant populations		• Other methods of control, for some species, have not proven successful
Some wetland areas have been created artificially		• Soil compaction from management activities
Increase in large alders in lowlands in some areas	• Tree growth	• Beaver removal in some areas

Table 27: **Influences and Relationships of Rare, Sensitive, and Non-native Vegetation and Other Ecosystem Processes**

Vegetation and seral patterns	Influences and Relationships between vegetation and seral patterns and other ecosystem processes
Non-native plants and noxious weeds	• Can displace native plants and out-compete them for water, nutrients and sunlight • Can cause reduction in native plant species and general decline in quality of habitat • Can lead to reduced forage production, less species diversity and more soil erosion.
Rare and sensitive plants	• Adds to biodiversity and helps to ensure the health of the ecosystem • Rich legacy of plants affects animals, insects, etc. and various life processes in the web of life
Occurrence and distribution of special habitats across the landscape	• Importance for biodiversity for plants and animals • Potential medicinal, nutritional or other commercial applications • Plants can be indicators of environmental quality

3.2.6 Recommendations: *What changes in ecosystem condition and function require management action to achieve management objectives? How will success of management actions be measured? What monitoring or research is recommended?*

Changes requiring management action	Management objective	Recommended management actions	General Locations for management actions	Indicator used to measure success	Recommended monitoring, research or data gaps
Rare or sensitive plant disturbances	• Protect/enhance populations of rare and/or sensitive plants and special habitats in the watershed	• Identify, inventory and protect/enhance habitat for rare and/or sensitive plants (ex: stands with >50% cover of western redcedar or incense cedar for moonworts, plant pockets of western redcedar on moist flat sites adjacent to wetlands and riparian areas for the Botrychium species) • Allow laminated root rot pockets to convert to hardwoods in the canopy (ex: plant big leaf maple in *Phellinus weirii* pockets to promote habitat for tall bugbane in Moose and Trout Creek subwatersheds). • Control invasive non-native plants or noxious weeds that are encroaching on rare or sensitive plant (ex: false brome in California swordfern population, St. John's-wort in population of Thompson's mistmaiden pop. near Tombstone Pass). • Use signage to discourage Iron Mountain visitors from leaving the trail and threatening the persistence of *Arabis hastatula.*	• Areas of suitable habitat within the watershed for instance: a) moist, flat sites adjacent to wetlands and riparian areas between 3-4,000 feet, b) areas of suitable bugbane habitat, c) Tombstone Pass	• ***Indicator:*** Percent of rare or sensitive plant populations disturbed • ***Expected response:*** Rare or sensitive plant populations would not be disturbed by management actions • ***Duration:*** long-term • ***Certainty:*** moderate	• Monitor rare plant populations

Changes requiring management action	Management objective	Recommended management actions to achieve management objectives	General Locations for management actions	Indicator used to measure success of management action	Recommended monitoring, research or data gaps
Some special habitats and rare forested plant associations/ special areas require restoration or protection measures	• Maintain/ enhance special habitats and rare forested plant associations/ special areas within the watershed • Allow Native American access/use of traditional resources	• Establish Two Girls and Canyon Ck. Botanical SIA's to protect sensitive species and special habitats • Restoration work in Gordon Meadows and other areas including controlling invasive species and reducing tree encroachment. • Continue to promote camas and huckleberry production for Native Am. use while maintaining winter forage for elk. • Continue efforts to eradicate invasive species, particularly St. John's-wort, from the Iron Mountain/Echo Mountain SIA. • Control/eradiate invasive plants/ noxious weeds, tree encroachment, etc in these areas • Restore/protect/enhance habitat conditions as needed in identified areas	• Cougar Rock • Two Girls • Canyon Creek SIA • Camas Prairie • Gordon Meadows • Iron Mountain • Echo Mountain • Other special habitat or rare forested plant association locations	• ***Indicator:,,*** Acres of special habitats restored • ***Expected response:*** Increased habitat and diversity • ***Duration:*** long-term ***Certainty:*** moderate	Monitor response to restoration efforts in these habitats

Changes requiring management action	Management objective	Recommended management actions	General Locations	Indicator used to measure success	Recommended monitoring or research
Invasive and non-native plant/noxious weed populations in watershed have increased *(One of top areas requiring management action)*	• Control spread of existing populations • Prevent introduction and establishment of new species and populations • Reduce spread and abundance of weeds by reducing habitat, controlling the weeds and promoting competitive exclusion of weeds by native species	• Use herbicides on new invaders as outlined in Integrated Weed Mgmt. EA • Use guidelines for Weed Prevention including vehicle cleaning, weed-free rock sources, etc. • Implement integrated pest management strategies including: mechanical, manual, herbicides, etc. • Develop stand treatment prescriptions to reduce potential spread of non-native plants and noxious weeds • Work with partners to get rid of weeds • Increase public awareness and education re: noxious weeds • Collect and propagate native species to reestablish vegetation in disturbed areas	• Location is dependent on the weed species dealing with • Along roads in general and specifically decommissioned roads • Areas of ground disturbing projects • Rare plant sites • Sensitive areas such as Iron Mtn., Gordon Meadows, special habitats, etc. • Big game forage areas	• ***Indicator:*** **Acres treated, number of weed species, population size at a particular site** • ***Expected response:*** Reduced populations • ***Duration:*** long-term • ***Certainty:*** mod	• Monitor populations treated to see if treatment worked • Inventory new areas to see what we have and where • Monitor rare plant populations

Changes requiring management action	Management objective	Recommended management actions	General Locations	Indicator used to measure success	Recommended monitoring, research or data gaps
Species diversity	• Preserve/promote biodiversity at the genetic level, within plant communities and between plant communities • Discourage illegal harvest of moss and lichens	• Protect/preserve rare and sensitive plants • Promote native species diversity in management actions • Year round road closures on selected roads below 3000 feet to discourage illegal harvest of moss and lichens	• Entire watershed	• ***Indicator:*** number of species • ***Expected response:*** maintain or improve native species diversity • ***Duration:*** long-term • ***Certainty:*** mod	• Monitor vegetation for possible species composition changes resulting from livestock removal in Gordon Meadows • Monitor commercial moss and lichen harvest

3.3 Terrestrial Wildlife Species and Habitats

3.3.1 Characterization of Terrestrial Wildlife Species and Habitats:

What is the relative abundance and distribution of species of concern that are important in the watershed? (TE and S, special status species, species emphasized in other plans)? What is the distribution and character of their habitats?

A variety of wildlife species inhabit the upper South Santiam watershed. Some are year-long residents, others use the area seasonally and some just pass through. Habitat condition is the prime determinant of wildlife abundance, both in the number of species and the number of individuals. Some species live equally well in early or late-seral-stage forests, but most have one habitat for which they are better adapted and are found in greater numbers (*Ingles 1965*). Instead of trying to address all the species which inhabit the watershed, the following discussion focuses on species of concern that are important in the watershed.

Relative Abundance and Distribution of Species of Concern

Northern spotted owls are a threatened species which occur, but are rare in the upper South Santiam watershed. There are currently 28 known northern spotted owl activity centers in the watershed, on public lands. Activity centers are areas where single owls or pairs of owls have been detected.

Past surveys indicate that sites are not always occupied from year to year, and this still appears to be true. Approximately half of the 28 activity centers have been surveyed in recent years and spotted owls were noted at 75% of the surveyed sites.

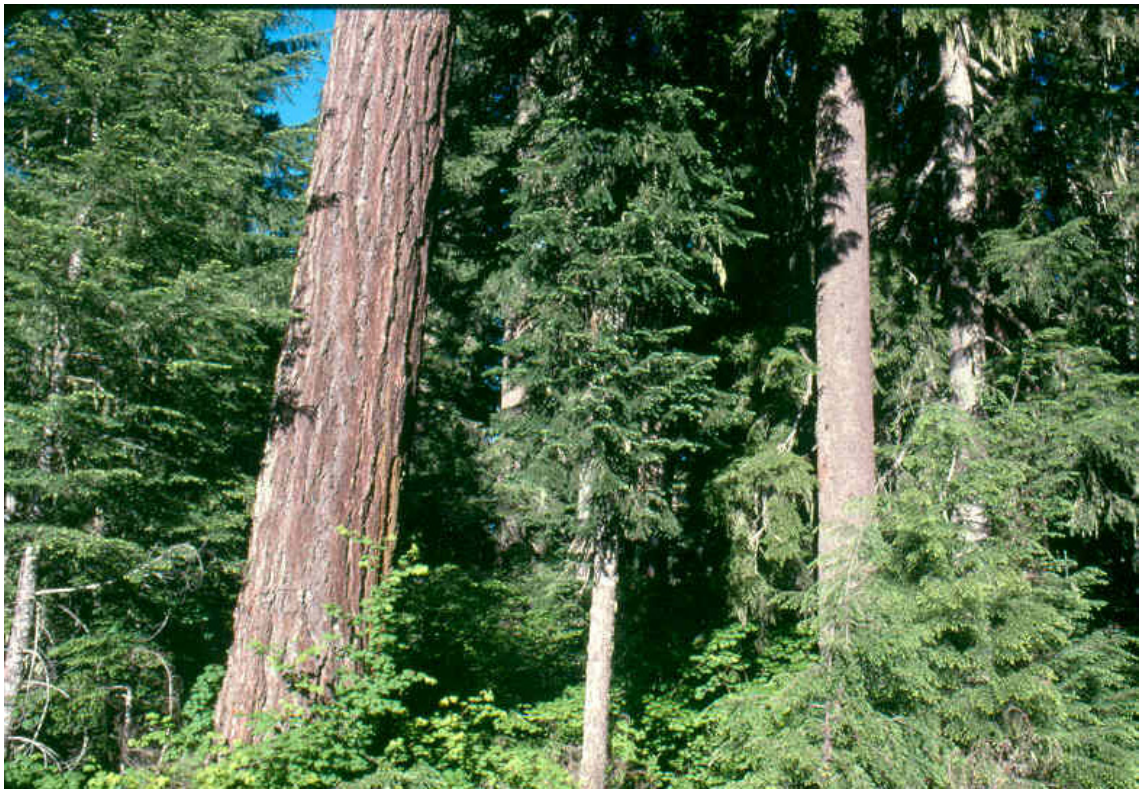
It does, however, appear that spotted owl populations are declining across much of their range according to a survey done by Eric Forsman, a wildlife biologist at the USFS PNW Research Station in Corvallis. It is estimated that the rate of decline on federally-managed lands is about 2.5% per year in California, Oregon and Washington.

Northern spotted owl

Photo by: www.ischool.utexas.edu/ ~i397cpd/images397/Nor...

Several reasons have been cited for the apparent population decline including 1) loss and fragmentation of old growth habitat, 2) habitat damage from fires, insects and pathogens, and 3) invasion by the larger, more aggressive barred owl into spotted owl territory. There is also a potential threat from West Nile virus, since it has been reported in the area since 2004. Besides other threats to their survival, spotted owl reproduction has also varied from year to year.

The loss and fragmentation of habitat has seen some improvements since implementation of the Northwest Forest Plan a decade ago. In addition, this watershed has not recently suffered significant habitat damage from fires, insects or pathogens. On the flip side, recent surveys have noted barred owls at a number of spotted owl activity centers in this watershed. Barred owl presence is a concern because they compete, and often out compete, spotted owls for similar habitat.



Old growth forest - preferred habitat for the northern spotted owl

Distribution and Character of Northern Spotted Owl Habitat: On public lands, 21 of the current 28 owl activity centers are located within old growth stands, primarily in the eastern and southern portions of the watershed. A portion of these old growth stands are small in size and are situated in large blocks of second growth habitat. The remaining seven sites are located primarily in second growth stands in the western portion of the watershed.

Generally habitat which is considered **suitable** for northern spotted owls consists of multi-storied stands exceeding 80 years of age with canopy closures of at least 60%.

These stands also must have sufficient snags and down wood to provide opportunities for nesting, roosting and foraging.

In addition, spotted owls use **dispersal** habitat to navigate between stands of **suitable** habitat and for juveniles to disperse from natal cores. **Dispersal** habitat provides adequate cover for safe travel but provides only limited opportunities for roosting and foraging and lacks suitable structure for nesting. This habitat occurs in timbered stands ranging in age from 40 to 80 years, with greater than 40% canopy closure, and an average stand diameter of at least 11 inches.

To ensure adequate suitable and dispersal habitat for northern spotted owls, the NW Forest Plan established a network of Late Successional Reserves (LSR's) and Riparian Reserves designed to protect and enhance conditions of late-successional and old-growth forest ecosystems, which serve as habitat for late-successional and old-growth related species. The network was designed to maintain a functional, interacting, late-successional/old-growth forest ecosystem across the landscape.

This watershed contains the South Santiam LSR, *(#RO215*), which is 27,637 acres in size and is located near the middle of watershed. About 55% of the LSR lies within the western hemlock zone and 45% lies within the Pacific silver fir zone. Currently about 60% of the LSR (*16,577 acres*) is **suitable** owl habitat and 20% (*5407 acres*) is **dispersal** habitat, and the remaining 20% is currently non-habitat

The amount of **suitable** spotted owl habitat is less now than shown in the *1995 South Santiam Watershed Analysis* due to remapping. A portion of the suitable owl habitat identified in the 1995 report lacks sufficient forest structure to provide for spotted owl nesting and was remapped as dispersal habitat.

According to the *Mid-Willamette Late Successional Reserve Assessment*, key issues for the South Santiam LSR are lack of late-successional and interior forest, connectivity within the LSR and road densities in excess of 2mi/mi^{2}in parts of the watershed.

Land ownership patterns within the watershed have created a mosaic of mixed-aged forest stands which in turn have resulted in impediments to dispersal of the spotted owl. Connectivity between the South Santiam LSR *(#RO215*) and the LSR *(#RO213*) to the north is hampered by the checker-board land ownership pattern in the Harter Mountain area. Because of concerns that spotted owls in this area may become geographically isolated, the U.S. Fish and Wildlife Service designated the Upper South Santiam as an

Area of Concern: In addition, the Endangered Species Act (ESA) directed the U.S. Fish and Wildlife Service to establish Critical Habitat Units (CHU) for the northern spotted owl. The Critical Habitat Units are areas where physical and biological features have been identified as essential to the conservation of the species and that may require special management considerations or protection. They were established to play a role in maintaining a stable and well-distributed population of northern spotted owls over their entire range. Within the upper South Santiam watershed, critical habitat (CHU) OR-16 has been designated in the eastern portion of the watershed.

Relative abundance and distribution of American Peregrine Falcons: Peregrine falcons, a sensitive species, are rare in this watershed mostly because their nesting habitat consists of cliffs which are not common in this area. Peregrines have been found in three locations in the upper South Santiam watershed, but only one of these sites has been verified for reproduction. There are additional sites that contain necessary habitat components for peregrines in the area, but so far no birds have been located at any of them.

Peregrine populations declined over their range as a result of contamination by DDT and other organochlorine pesticides. Elimination of these contaminants has allowed populations to begin to recover to the point that this species has been de-listed under the Endangered Species Act.

Peregrine falcon

Photo by: ww.pgc.state.pa.us /;;/ peregrine_falcon.jpg

Distribution and Character of Peregrine Falcon Habitat: Habitat for these birds generally consists of rock cliffs and ledges overlooking rivers, lakes or other openings. They require a diversity of habitat with an abundance of birds to prey upon.

Peregrines prefer to nest in shallow depressions scraped in gravel and debris on a high cliff ledge, pothole or small cave that provides sanctuary from disturbance. They tend to return to the same nesting cliff year after year, but such habitat is uncommon in this watershed.

Relative Abundance and Distribution of Neotropical Migrant Bird Habitat– Neotropical migrants are protected by the Migratory Bird Treaty Act of 1918, which prohibits their killing or harassment. Depending on the species, some may also be protected under the Endangered Species Act. According to a report published in *Partners in Flight (fall 2002),* between 1992 and 2000 populations of 30 of the 44 target species of Neotropical Migrant birds studied, declined by about 25% on the Willamette National Forest and 6 other national forests in Oregon and Washington. The study was attempting to explain why these bird populations were declining. Initial information shows low or declining productivity and low survival rates driving some of the population declines.

Another study published in *Global Ecology and Biogeography (July 2002*), discovered that "seasonal weather experienced by birds on their Mexican wintering grounds, just prior to spring migration, determines their subsequent breeding success in the forests of the Pacific Northwest."

Further research has shown that conditions in the North Atlantic also affect breeding success of species that breed in the Pacific Northwest. A study demonstrated strong evidence that "food available on feeding grounds prior to nesting is most important to the breeding success of the birds" *(www.intellicast.com/DrDewpoint/library 1137/2/)*

Distribution and Character of Neotropical Bird Habitat: Neotropical migrant bird habitat is variable by species. Those using interior forest ecosystems are at risk from a

variety of threats including ecosystem fragmentation, invasive species, and predation. Species with very specific habitat requirements tend to be affected to a greater extent by habitat changes than species with more general habitat requirements.

Species Emphasized in Other Plans

Relative Abundance and Distribution of Deer and Elk: Deer and elk are moderately abundant is this watershed, although they appear to be less numerous, on public lands, now than they have been at some points in the past. The distribution of animals seems to have changed in recent years, as numbers appear to be declining on federal lands and increasing on privately-owned timber lands. Evidence for increased use on private lands can be seen by increased browse damage of newly planted seedlings there. This is especially true where private harvest units are located in close proximity to cover on public lands. Many private harvest units are quite large, so the majority of elk use is on the edges of the units, close to cover. Overall there tends to be more forage on private lands than public lands, but spraying with herbicides, on private lands, to control unwanted vegetation has affected the availability of forage there.

The apparent reduction of big game animals on public lands can be partially attributed to lack of forage availability and possibly, to some extent, to diseases such as hair-loss syndrome in deer or predation by an increasing cougar population.

This watershed is located within two Roosevelt elk management units identified by Oregon Department of Fish and Wildlife (ODFW) where elk numbers are managed to provide the optimum recreational and aesthetic benefits while maintaining appropriate numbers compatible with primary land uses. The area north of Highway 20 is in the *Santiam Unit* and the area south of Highway 20 is in the *McKenzie Unit*.

The *Santiam Unit* was previously split into two elk management units (North and South Santiam units) but is now managed as one unit. The management objectives in 1994 for these two management areas were 5900 animals, 3900 in the South Santiam Unit and 2000 in the North Santiam Unit. The current management objectives for the entire Santiam Unit are 5200 animals, a reduction of 700 animals. This reduction is based on a decline in the forage base. Current elk numbers within the unit are estimated to be close to the management objective.

In the McKenzie Unit, the management objective has been lowered from 5200 animals to 5000, also based on a reduction in the forage base. The population is currently placed at about 5100 animals.

Distribution and Character of Deer and Elk Habitat: Elk utilize the lower elevations in the western portion of the watershed, in Moose, Canyon and Trout subwatersheds, during the winter months and the northeastern and southern portions during the summer months.

Current Forest Plan direction and Oregon Department of Fish and Wildlife (ODFW) management objectives for big game are somewhat at odds with each other in portions of the watershed. Implementation of the NW Forest Plan has had a dramatic affect not only on the number of acres harvested, but also on the type of timber harvest being done on National Forest lands. Far fewer acres are harvested now than in the past and the majority of harvest is commercial thinning rather than clearcutting. In addition, many older harvest units in the watershed are transitioning out of forage and into hiding cover.

Also land allocations such as Late Successional Reserves are intended to protect and enhance conditions for late-successional and old-growth ecosystems, rather than provide foraging opportunities for big game. Providing late-successional habitat and big game forage are not mutually exclusive, but future elk forage development opportunities are limited in the LSR.

Currently, quality forage on National Forest lands is below goals outlined in the Willamette National Forest Plan and big game have shown increasing activity on private land because there is more forage there.

Open road densities and use have been shown to negatively impact big game through harassment, etc. Although road construction and open-road densities have decreased on public lands in the last decade, harassment may still be a problem as increased ATV activity is occurring on the forest. Many roads, once thought to be closed to vehicular traffic, are used by ATV's.

Elk grazing at Walton Ranch

Livestock grazing is now gone from the watershed.

Snags and Large Woody Material - are important components of wildlife habitats in western forests which furnish cover and serve as sites for feeding, reproduction and resting for many wildlife species. The fire and timber histories of the watershed have resulted in a landscape generally deficient in large snag habitat necessary for such cavity nesting birds such as the Western blue bird and pileated woodpecker. Also missing, in many stands, is the large down wood in various stages of decay necessary as habitat for such species as the Oregon slender salamander. Areas in the watershed particularly low in snags and large woody material are Canyon and Soda Fork Creeks, private timberlands, farms and home sites. In addition, areas along Highway 20 have low snag numbers because snags, that pose a danger to traffic on the highway, are removed.

Table 28: Summary of Terrestrial Wildife Species Status, Abundance and Habitat Distribution

Species	Status	Relative Abundance	Distribution and character of habitats
Spotted Owl	Threatened	Rare in watershed	Closely associated with oldest habitat. Old growth habitat is preferred but is limited in the watershed. Population seems to be declining overall.
Peregrine Falcon	Sensitive	Rare in watershed	Nesting habitat (cliffs) is rare in the watershed. Diversity of habitat for prey species is important for foraging. Population appears to be increasing overall.
Neotropical Migrant Birds		Populations are declining	Habitat is variable depending on species.
Deer / Elk	Game animals	Moderate abundance in watershed	Well distributed forage and cover is important. Early seral stage forage is declining on USFS lands. Quality forage is below goals outlined in the Forest Plan. The distribution of animals has changed in recent years. Numbers appear to be declining.
Cavity nesters		Less abundant than desired in parts of watershed	Because of past fires and harvest activities, snag and down wood is less abundant in this watershed than desired in many areas.

3.3.2 Terrestrial Species and Habitat Issues and Key Questions: *The issues and key questions help focus the analysis on the relevant elements of the ecosystem as they relate to management questions, human values or resource conditions within the watershed.*

Issue: Northern spotted owls have decreased in abundance and distribution due to a variety of natural and human processes including: loss and fragmentation of their habitat by fires, timber harvest, road construction, ownership patterns and differences in land management goals; competition from barred owls for nesting territories; and they may begin to succumb to the West Nile virus as it gains a stronger foothold in the area.

In addition, connectivity between the South Santiam LSR *(#R0215*) and the LSR *(#R0213*) to the north is hampered by the checker-board land ownership pattern in the Harter Mountain area. Because of concerns that spotted owls in this area may become geographically isolated, the U.S. Fish and Wildlife Service designated the Upper South Santiam as an Area of Concern.

- ***Indicators for measuring or interpreting conditions***: Quality, quantity and spatial arrangement of suitable owl habitat in the LSR, habitat connectivity between LSR's, spotted owl population numbers, barred owl presence at spotted owl sites and cases of West Nile virus infecting spotted owls.
- ***Key Questions***: What processes have, and are now affecting habitat and population dynamics of northern spotted owls? What habitat components are necessary to sustain spotted owls in the watershed? Which of these components is limiting? What, where and in what priority should habitat restoration or enhancement of necessary habitat components occur? What management actions can be taken to improve connectivity between LSR's and within the South Santiam LSR? What management actions can be undertaken to minimize or preclude barred owl invasion of spotted owl territory and to minimize exposure to West Nile virus?

Issue: Trying to maintain a large block of late-successional habitat in the watershed, over the long term may be difficult given natural processes at work there including the potential for fire, windstorms, insects, diseases, etc. In addition, nearly 100 years of fire suppression has allowed some areas to build up fuels to unnaturally high levels, increasing the chance for a stand replacing fire event.

- ***Indicators for measuring or interpreting conditions***: Acres of late-successional habitat in the LSR maintained over time.
- ***Key Questions***: Where are the best locations to maintain large blocks of late-successional habitat in the LSR over time, given natural processes at work in the watershed? What can be done to reduce potential loss of late-successional habitat from fire, insects or diseases in the LSR?

Issue: In portions of the LSR and in the remainder of the watershed, road densities are high. High road densities cause wildlife harassment and can limit habitat usability for many species. Efforts have been made to reduce open road densities. This has improved habitat utilization and reduced harassment in some areas, but not everywhere that it is needed. Also, many wildlife road closures are not enforceable because the closures do not include a CFR order.

- ***Indicators for measuring or interpreting conditions***: road densities and enforceable road closures for wildlife
- ***Key Questions***: Where, how and in what priority should road densities be reduced in the LSR in particular and the watershed in general? How should roads be closed?

Issue: Neotropical migrant bird populations dropped 25% between 1992 and 2000.

- ***Indicators for measuring or interpreting conditions***: Neotropical migrant bird populations
- ***Key Questions***: What processes have, and are now affecting habitat and population dynamics of Neotropical migrant birds? What habitat components are necessary to sustain Neotropical migrant birds in the watershed? Which of these components is limiting? What, where and in what priority should habitat restoration or enhancement of necessary habitat components occur?

Issue: Changes in timber management practices on public lands, from mostly clearcutting to mostly thinning, has decreased the amount of early-seral habitat there, which has in turn decreased both quality and quantity of forage for big game animals on public lands. In many cases, big game forage quality and quantity is lower than called for in Forest Plan Standards and Guidelines. Diminished forage has caused big game populations to move off of public lands and onto private lands where forage is more plentiful. The concentration of forage use on private lands is causing damage to young timber stands. Elk moving off of public lands because of decreased forage availability, also results in decreased hunting and wildlife viewing opportunities on public lands and increased cost of reforestation on private lands. On the flip side, eliminating livestock grazing from Walton Ranch has extended the period of use for elk foraging there but it will be necessary to find ways to maintain the high-quality winter forage there for the long-term.

- ***Indicator for measuring or interpreting conditions***: Elk model forage values, spot light counts of animals
- ***Key Questions:*** Where and how is it appropriate to provide big game foraging opportunities in the watershed while meeting other resource objectives? What areas are appropriate for management as high emphasis areas for elk? What is the expected future quantity and quality of big game winter and summer range habitat in the watershed? How can forage best be provided for big game for the long-term?

Issue: Implementation of the NW Forest Plan and changes in salvage harvest on National Forest lands have begun to increase the amount of coarse woody debris and snags on public lands and increase habitat for species dependent on these habitat components. Although desirable on the landscape, snags can also pose a danger to workers in harvest units during logging operations, to firefighters working to put out wildfires, or to travelers on roads adjacent to snags. Sometimes these snags must be felled to ensure human safety. To mitigate some of these snag losses they can be artificially created, but at this time there is still a net deficit in the desired number of snags and down wood in the watershed.

- ***Indicators for measuring or interpreting conditions***: Percent of watershed meeting snag and down wood habitat requirements in the NW Forest Plan.
- ***Key Questions***: Where is snag and down wood deficient in the watershed? Where and in what priority should snag and down wood habitat be restored? How should snag and down wood habitat be restored? How best do we provide snag and down woody habitat while protecting people in the woods?

Issue: Deer Hair-Loss Syndrome, which affects black-tailed deer, was first recognized in Oregon in 1998. The syndrome can decrease body fat and increase parasite load which may lead to pneumonia and ultimately death of the animals. Deer Hair-Loss Syndrome can reduce wildlife viewing and hunting opportunities which could impact local economies. Increased cougar populations may contribute to declines in big game populations throughout watershed.

- ***Indicators for measuring or interpreting conditions***: health and abundance of big game in watershed
- ***Key Questions***: How best do we address big game health and abundance in the watershed?

Issue: There appears to be increasing use of ATV's in the watershed and some of the use is in sensitive areas such as Gordon meadows, etc. Besides habitat disturbances, ATV use can also harass wildlife.

- ***Indicators for measuring or interpreting conditions***: ATV use in sensitive habitats and that causes wildlife harassment
- ***Key Questions***: What management actions would be effective in curbing ATV disturbance of sensitive habitats and harassment of wildlife?

Issue: There are conflicting habitat needs for various wildlife species. Some may require interior habitat and some edge habitat or some may require early seral forests and others late-seral forests. Maintaining a variety of habitat components necessary to sustain the diversity of species indigenous to the area is a concern?

- ***Indicators for measuring or interpreting conditions***: species diversity
- ***Key Questions:*** What processes have led to the current condition of the wildlife species habitats? How have these processes affected the connectivity of late-successional/old growth habitats in the Western Oregon Cascades Province? What is the effect of the current conditions on function of the Riparian Reserves network as habitat for riparian wildlife species and dispersal habitat for terrestrial wildlife species? What, where and in what priority do we need to do restoration or enhancement of habitat for wildlife (particularly T, E and S species)?

3.3.3 Current Conditions of Terrestrial Wildlife Species and Their Habitats: *What are the current habitat conditions and trends for species of concern identified above?*

Threatened Species

Northern Spotted Owl habitat conditions: Suitable spotted owl habitat within the watershed is located primarily on public lands. Much of this habitat has been fragmented by past timber harvest activities but little harvest has occurred in recent years. The large blocks of un-fragmented old growth in the north and central portions of the watershed provide superior owl habitat while the younger, second-growth stands in the western portion of the watershed provide only marginal habitat.

A number of natural stands, primarily in the center of the watershed, are over 90years of age but are dispersal habitat only. These stands lack the tree size, structure, and coarse wood needed for spotted owl nesting. Commercial thinning projects have been implemented in a few of these stands to encourage late-successional characteristics to occur more rapidly.

One land exchange has been completed to consolidate ownerships within the watershed. This exchange provides for more contiguous owl habitat in the center of the watershed and will improve habitat conditions within the late-successional reserve and within designated critical habitat.

Currently there are 16,577 acres of suitable and 5,407 acres of dispersal habitat in the LSR.

Trends: The amount of dispersal habitat within the watershed continues to increase as trees grow in managed stands on both private and public lands. Based on the number and age distribution of young stands (*2,542 acres of stands under 40 years of age on forest service lands in the LSR*), this trend of increasing dispersal habitat should continue on public lands. The trend may not be as predictable on private lands as market conditions for wood fiber on private lands will undoubtedly affect this trend.

Overall the spotted owl population seems to be declining ostensible due to habitat fragmentation, competition with barred owls and the newest potential threat that spotted owls appear to be susceptible to West Nile virus which has entered this area.

Peregrine Falcons: Peregrine Falcons are rare in this watershed mostly because their nesting habitat consists of cliffs which are not common in this area

Trends: Over their entire range, peregrine falcon populations appear to be increasing and have been de-listed under the Endangered Species Act. In this watershed, there are few peregrine nest sites and some of those have experienced increasing disturbance by humans, especially by rock climbers.

Neotropical migrants – The current habitat conditions are variable depending on the species. Those using interior forest ecosystems have likely experienced ecosystem fragmentation in the last half century. Since very little clearcutting has occurred in the last decade, however, habitat conditions are improving for interior-dependent species but deteriorating for species who prefer openings, at least on public lands.

Trends– populations on the Willamette National Forest have declined by 25% between 1992 and 2000.

Other Species

Big Game: Implementation of the NWFP has had an impact on big game habitat. Harvest units are planned to minimize fragmentation of late-seral habitat. For the most part, commercial thinning is the norm now and clearcutting is relatively rare. These harvest treatments, though much easier on the land than previous treatments, do not create as much forage for big game.

In addition, many older harvest units in the watershed are becoming hiding cover. These factors along with the reduced rate of timber harvest, has resulted in less forage habitat being available for deer and elk on public land. In addition, fire suppression has reduced the acreage burned and there is less slash burning than in the past. This results in less forbs and grasses becoming established and less mineral soil exposed making it much more difficult for successful forage seeding.

The rate of private timber harvest in the watershed appears to be fairly stable. Elk use on private land appears to be increasing, especially where private harvest units are located in close proximity to cover on public land. Many of the private harvest units are quite large so a majority of the elk use is on the edges of the units. Some private landowners have complained of excessive browse damage to newly planted seedlings.

Besides reductions in forage, road densities are higher than desirable for big game in this watershed. Open roads are a source of disturbance for calving cows and does, and affect how big game utilize an area when feeding. They also increase the pressure on big game from hunters, because many areas more easily accessed. In addition, open roads near foraging areas may have a magnified detrimental effect on big game because they could be disturbed while utilizing the limited foraging opportunities available to them.

In addition, ATV use in the watershed has increased. Use occurs even on sensitive areas like Gordon Meadows, which causes harassment of big game in an area where they forage.

Trends: Forage is declining on National Forest lands because of changes in type of timber management in the last decade. Quality forage is below the goals outlined in the Willamette National Forest Plan and big game have shown increasing activity on private land because there is more forage there. The distribution of animals has changed in recent years from public lands to private lands and the numbers of animals appear to be declining. This reduction can not all be attributed to the reduced amount of forage habitat but other causes as well, such as hair-loss syndrome, predation by cougars, etc.

Snags and Down Woody Habitat: Snag and down wood habitat has been lacking in many parts of the watershed since the large, stand-replacing fires of the mid-1800's and early 1900's, coupled with later timber salvage practices. In more recent years, stands of trees within the watershed are beginning to see some natural mortality, thus creating new snags and down wood.

Trends – the number of snags and down wood is beginning to show some signs of improvement through natural mortality in stands.

Unique/Special Wildlife Habitats

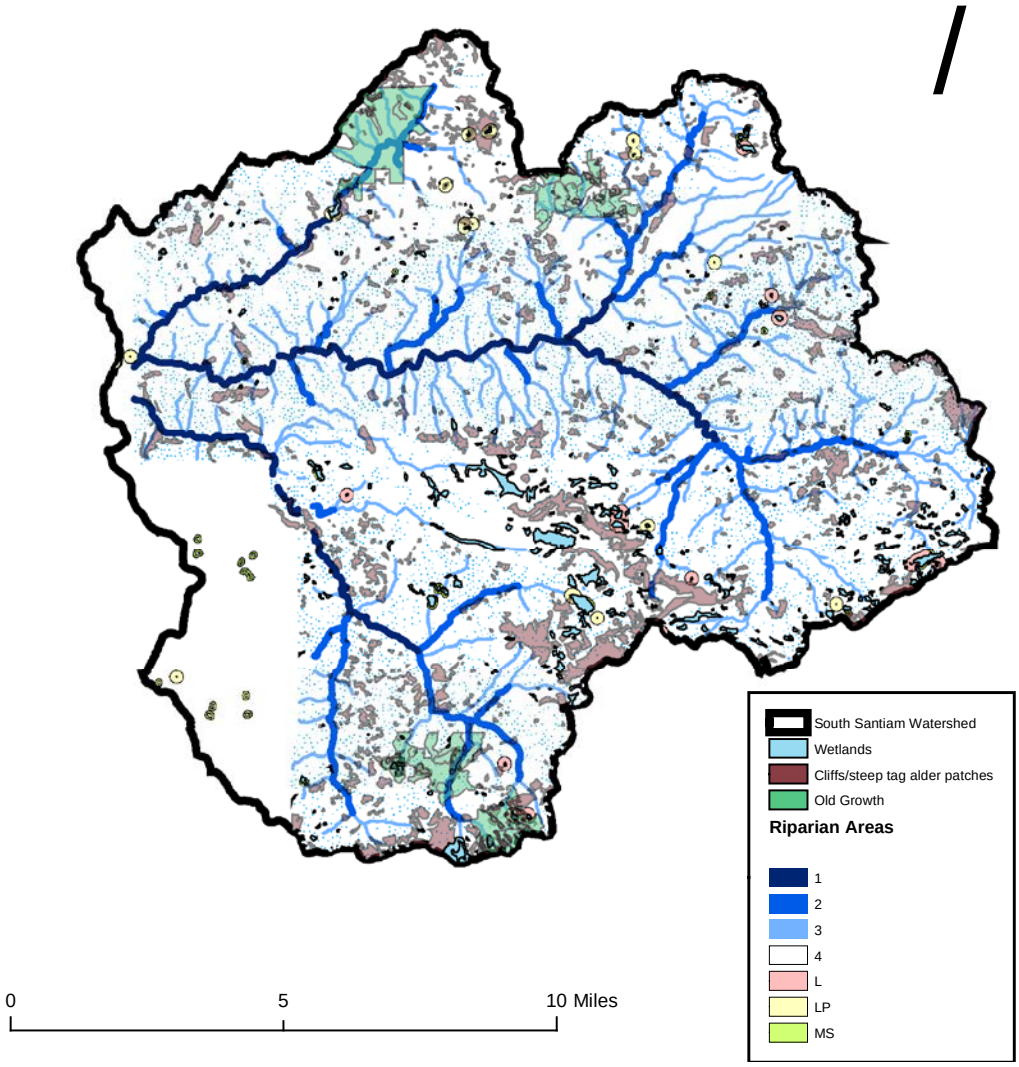


Figure 24

3.3.4 Species and Habitat Reference Condition: *What was the historical relative abundance and distribution of species of concern and the condition and distribution of their habitats in the watershed?*

Little is know of the historic abundance and distribution of wildlife in the watershed. Populations fluctuate over time as species come and go when the habitat they depend on changes through succession, catastrophic events, or land management practices.

Historic Relative Abundance and Distribution of Species:

Northern Spotted Owl: The abundance and distribution of spotted owls was tied directly to the amount of old growth habitat available in the watershed. This varied over time with such events as stand-replacing fires, fire suppression, and timber harvest. There were likely large fluctuations in distribution of owls, in and out of the watershed, following large-scale events such as the fires of the mid-1800 and early 1900 fires. During this time it is likely that there were minor fluctuations in populations, but overall populations were likely greater than currently exists.

When timber harvest began in earnest, fragmentation and loss of habitat began affecting population numbers as well.

Condition and distribution of their habitat: The character of spotted owl habitat was similar to current conditions, in that they utilized late-successional stands with multi-layered canopies, but the distribution of the habitat was most likely in larger patches of suitable nesting, roosting and foraging habitat separated by intermingled patches of unsuitable habitat that had been removed by fire events.

Peregrine Falcon: Most likely there was a larger population of peregrine falcons than currently exists, because the population is just recovering from a decline that previously led to it's listing under the Endangered Species Act. With more birds around, they probably occupied more of the potential habitat than is currently occupied in the watershed.

Condition and distribution of their habitat: Because of the nature of nesting habitat required by peregrines, overhangs and rock ledges, the quantity of habitat has changed very little over time.

Neotropical migrant birds were likely more abundant in the past than they are currently. Recent studies have shown dramatic declines in Neotropical bird populations.

Condition and distribution of their habitat: Habitat for Neotropical migrant birds varies a great deal by species. There were likely, varying amounts of habitat available over time, depending on fire history, regrowth of trees, etc.

Big Game: Historical records indicate that Roosevelt elk were quite common and well distributed throughout most of western Oregon prior to the arrival of white settlers *(ODFW, 1994).* "When the Lewis and Clark Expedition over-wintered at Fort Clatsop in 1805-1806, 146 elk were killed for food in less than 4 months. Early settlements and forts depended upon elk as a source of meat; and market hunting became a respected occupation." *(Land Mammals of Oregon, pg 466).*

Historical records also describe numerous elk in the area as illustrated by the following quote from a 1965 Sweet Home Ranger District employee journal: There was "a kill of five elk and four deer by some boys at Bloody point in 1891, just for the hides."

Market and subsistence hunting reduced the big game population to just a few scattered herds by 1900. Market hunting was prohibited in 1899 and hunting season was closed in 1909. It was generally believed that it would be impossible to re-establish elk as a game animal in Oregon (*ODFW, 1994*).

Besides market hunting, big game had to contend with competition for forage. In 1909 there were 2,803 head of cattle and 44,600 head of sheep grazing on the forest. In 1926 in Moose Creek, 88 head of cattle and 13,104 sheep grazed the area. Sheep use dropped gradually from 1926 to 1942, then dropped rapidly in 1948 when sheep last grazed here.

Transporting elk from other remaining herds, plus protection from market and sport hunting, allowed the herds to quickly re-establish within the South Santiam watershed. In 1938, elk hunting was again permitted in western Oregon.

Later, a 1965 journal entry of a Sweet Home employee stated that "there have been no elk on the district for many years, although a few scattered ones have been seen in late years, probably strays from the Breitenbush herd." Again, the state game department made some elk plants in or adjacent to, the forest in the late 1960's and early 1970's. These elk multiplied until numbers again rebounded.

Condition and distribution of their habitat: Habitat conditions for elk have been variable over time. After fires there would be an abundance of forage. As these areas became reestablished with trees, forage would diminish.

Previous timber harvest activities on public land were often planned and implemented to improve habitat conditions for deer and elk. Harvest units were widely distributed, clearcut harvested, and then broadcast burned to remove logging slash and brush. These treatments allowed grasses and forbs, preferred forage for elk, to become established. Occasionally harvest units were seeded and fertilized to improve forage quality. Big game

populations responded and were well distributed throughout the watershed. Deer and elk could often be observed in the created openings and hunters were a common site in the area during the fall.

Snags and Down Wood: In the past, few snags were left in harvest units because they posed a safety hazard to workers during the logging operations. In addition, there were timber sale contract clauses that required the removal of snags within 200 feet of the harvest unit boundary. If snags were left after the harvest operations, they were often very soft and relatively short. Fire from slash burns would often cause these snags to smolder for a long time, so many of these snags had to be felled after slash burning operations.

Unmerchantable logs where often yarded to the landing, piled up and later used for firewood or burned, so there was very little down woody material left in harvested units.

It wasn't until about the late 1980's or early 1990's that snags and down wood began to be retained to any degree on harvest units.

photo by: Chris Schnepf, University of Idaho, www.forestryimages.org

3.3.5 Synthesis and Interpretation Vegetation: *What are the natural and human causes of change between historical and current species distribution and habitat quality for species of concern? What are the influences and relationships between species and their habitats and other ecosystem processes?*

Table 29: **Natural and Human Causes of Change between Historical and Current Terrestrial Wildlife Conditions.**

Changes between historical and current species distribution and habitat quality for species of concern	Natural Causes of Change	Human Causes of Change
Spotted owl populations have likely decreased in numbers and distribution from historic levels	• Stand-replacing fires • Displaced by barred owls • Potential future threat is the West Nile Virus	• Loss and fragmentation of nesting, roosting and foraging habitat due to timber harvest. • Ownership patterns and differences in land management goals
Spotted owls use similar ***habitat*** now than they did historically but the distribution is different because historically habitat patches were larger in size and were separated by patches of unsuitable habitat that had been removed by fire events. Now habitat is more fragmented. There is less connectivity of habitat within the watershed and between watersheds.	• Fire history	• Ownership patterns and differences in land management goals • Timber harvest removed and fragmented suitable spotted owl habitat • Fire suppression affected size of patches between suitable habitat blocks
Peregrine falcon – Population numbers and distribution have likely changed from historic levels. They are also very susceptible to disturbances near their nest sites.		• Chlorofluorocarbon based pesticides caused population declines • Rock climbers disturbing birds during nesting • Noise from logging operations (helicopters, etc.)
Decline in ***Neotropical migrant bird populations***	• Climate changes affecting oceanic conditions • Stand-replacing fires	• Land management activities affecting habitat

Changes between historical and current species distribution and habitat quality for species of concern	**Natural Causes of Change**	**Human Causes of Change**
Big Game Populations – change uncertain.	• Increase in cougar and bear populations which prey on big game • Stand-replacing fires affected habitat and forage availability	• Increased human presence due to roads • Increased ATV use • Distribution of harvest units or fire events across the landscape. • Deer hair-loss syndrome introduced to deer population
Big game Habitat – Distribution of animals across the landscape has changed. ***Forage***: Early seral stage forage is declining on USFS lands so the amount and quality of forage is less than in the past. There is increasing activity on private lands because there is more forage there. ***Cover:*** Cover quality on public lands is increasing as trees move out of forage and into hiding cover.	• Vegetative growth • Population movements to find forage	• On public lands, changes in amount of harvest and harvest practices from mostly clearcutting to mostly thinning has reduced amount of available forage for big game. • Fire suppression has reduced forage availability • Desired habitat conditions in 1990 Forest Plan for elk habitat is in conflict with direction in NW Forest Plan because LSR 215 is in the same place as high emphasis elk habitat • Eliminating cattle on Walton Ranch has extended the period of use for elk to forage here
General lack of snags and down wood in the uplands and riparian areas	•Natural mortality in timber stands	• Implementation of NW Forest Plan and reduction in salvage harvest in riparian areas have increased snag and down wood habitat on public lands, thereby increasing habitat for species dependent on these habitat components • Fire suppression has impeded snag and down wood development • Snag creation, tree topping and falling trees for down wood in harvest units have partially replaced habitat that was lost in logging operation

Table 30: **Influences and Relationships between Terrestrial Wildlife and their Habitat and Other Ecosystem Processes.**

Species and their habitat	Influences and Relationships between species and their habitat and other ecosystem processes
Spotted owl habitat	• This habitat does not meet the needs of species dependent on edge habitat, such as big game. • Late-successional habitat provides shade and sources of down woody material for adjacent streams and riparian areas. • Provides ascetically-pleasing recreational opportunities
Peregrine Falcon habitat	• Often located in places that rock climbers frequent. There can be conflicts between these two uses during nesting season
Neotropical migrant birds	• There is likely a relationship between global warming, oceanic conditions and Neotropical migrant bird abundance in this area.
Deer habitat	• Edge habitat in late-successional stands, encourages barred-owl competition with spotted owls • Lack of forage on public lands is impacting private landowners, lower in the drainage.
Snag and/or down wood dependent species	• Snag and down woody habitat can affect safety of travelers along adjacent roads, loggers during harvest operations, firefighters, etc. • This habitat provides structure to stream channels and habitat for various species. • Down wood material contributes to the soil development and nutrients. • Down woody material helps to moderate surface erosion processes • Woody material in streams provides fish habitat, moderates stream energies, collects sediments, etc.

Changes requiring mgmt. action	Management objective	Recommended Management Actions	General Locations	How will the indicators respond	Recommended monitoring, research and data gaps
Decline in spotted owl population and habitat conditions	*LSR*- Develop late-successional/ OG characteristics in stands not meeting desired characteristics *Critical Habitat Unit (CHU)* – manage consistent with recommendations made by US Fish and Wildlife Service Recovery Plan (*not complete yet)* *Santiam Pass Area of Concern* – honor previous commitment of maintaining 50% dispersal capabilities in this area	• Accelerate development of late-successional stand characteristics in stands less than 80 years old in the LSR. First target areas that block up interior habitat and provide connectivity within the LSR and between adjacent LSR's. • In LSR 215, assess structural development in stands to determine the need for treatment in natural stands over 80 years of age and treat them (get approval by REO) • Take advantage of all opportunities to block up ownership in areas that facilitate connectivity between adjacent LSR's, especially to the north. First priority is to consolidate ownership in Soda Fork and Sheep subwatersheds to facilitate long-term management in Santiam Area of Concern. Maintain ownership of T13S, R5E, Sec. 18 and 25 and acquire the rest of section 25 and section 19 in land exchange. These areas also contain reaches of Soda Fork Creek which are accessible to andromous salmonids. • Reduce road densities in the LSR • Minimize loss of late successional habitat in LSR to insects, diseases, stand-replacing fires, etc. • Improve spotted owl dispersal habitat. Target areas that provide good connectivity within the LSR and between adjacent LSR's. • Minimize fragmentation of habitat that invite barred owl competition with spotted owls	Late Succession al Reserve (LSR) and Critical Habitat Unit (CHU)	• *Indicators:* acres of interior habitat in LSR, connectivity between LSR's, road densities in LSR • *Expected outcome*: increase in spotted owl habitat conditions leading to increase in populations • *Duration:* long-term • *Certainty:* moderate	• Monitor spotted owl populations and see is populations increase as habitat improves • Determine amount and pattern of seral stages needed to maintain or enhance LSR function • Determine and prioritize areas that need treatment within and between

Changes requiring mgmt. action	Management objective	Recommended Management Actions	General Locations	How will the indicators respond?	Recommended monitoring, research and data gaps
Spotted owls continued	• See above	• Manage Critical Habitat Unit (CHU) consistent with recommendations in Fish and Wildlife Service Recovery Plan • Santiam Pass Area of Concern – maintain greater than 50% dispersal capabilities in this area • Follow recommendations for LSR 215 in Mid-Willamette LSR Assessment. • Treatments within Riparian Reserves which are neutral or beneficial to Aquatic Conservation Strategy Objectives may be undertaken. Thinning, snag creation, and prescribed fires may be suitable treatments. • Evaluate area and recommend options to improve dispersal habitat in the middle of the LSR which is very dense, single-storied, and has very little downed wood or large snags. This area has few late-successional stand characteristics and high potential for fire. Treatments for this 90+ year-old stand would require REO approval.	• See above	• See above	• See above

Changes requiring mgmt. action	Management objective	Recommended Management Actions	General Locations	How will the indicators respond	Recommended monitoring/ research and data gaps
Increasing human disturbance to known peregrine sites Peregrine falcon populations are being de-listed under ESA	Minimize or eliminate human disturbance to know peregrine sites Maintain/enhance peregrine falcon habitat to continue to strengthen populations	• Educate people about consequences of disturbing peregrine sites • Maintain diversity of habitat around known, and potential, peregrine nest sites to ensure adequate prey base for peregrine survival.	• Existing and potential peregrine nesting sites	• *Indicators:* peregrine breeding success and abundance • *Expected outcome*: increased in peregrine populations over time • *Duration:* long-term • *Certainty:* moderate	• Monitor peregrine populations and breeding success

Changes requiring mgmt. action	Management objective	Recommended Management Actions	General Locations	How will the indicators respond to mgmt. activities?	Recommended monitoring and research and data gaps
Neotropical migrants	• Meet requirements of Migratory Bird Treaty Act	• Provide adequate snag and down woody habitat • Provide a diversity of habitat • Limit disturbance of habitat during critical periods • Improve purple marten habitat by installing next boxes next to wetlands	Within watershed	• *Indicators:* Neotropical migrant bird breeding success and abundance • *Expected outcome*: increased in Neotropical populations over time • *Duration:* long-term • *Certainty:* low	• Monitor Neotropical populations • What management actions can best contribute to long-term viability of these birds
Snag and Down Wood	• Meet Standards and Guidelines for snags and down wood requirements	• Improve/create snag and down wood habitat using a variety of techniques such as topping, girdling, prescribed fire, etc., in areas where it is lacking. Target LSR 215 first, then in areas most deficient in habitat such as Upper Canyon, Owl, Lower Canyon and Soda Fork subwatersheds. • Minimize loss of existing snag and down wood habitat during management activities	LSR 215 Upper Canyon Owl Lower Canyon and Soda Fork are highest priorities	• *Indicators:* Snags per acre, pieces of down wood per acre meeting S & G's. • *Expected outcome*: Increase number of snags and down woody habitat • *Duration:* long-term • *Certainty:* mod.	• Monitor snag and down woody habitat

Changes requiring mgmt. action	Management objective	Recommended Management Actions	General Locations for	How will the indicators respond	Recommended monitoring, research and data gaps
Lack of forage for big game on public lands and movement of animals onto private lands lower in the drainage	• Meet Forest Plan Standards and Guidelines for big game forage on public lands • Identify areas appropriate for management as high emphasis areas for elk	• Create forage opportunities for big game on public lands. Consider a variety of techniques to meet forage needs while also meeting habitat needs for other species, such as widely-spaced thinnings, maintaining closed roads in early seral conditions, brush cutback, fertilization, haying and fertilizing Walton Ranch, browse cutting, pruning in plantations, seed along fire breaks, etc. to increase forage quality and quantity. Target important habitat areas in close proximity to cover, especially on Matrix and AMA lands. In lower elevation areas managed to provide forage – located in managed stands rather than on closed road prisms to avoid conflicts with noxious weed control recommendations. • Coordinate with ODFW to redefine big game management emphasis areas to better reflect land management allocations and ownership. Until land ownership patterns are consolidated, Soda Fork, Moose, Upper Canyon and Owl subwatersheds may be areas where big game high emphasis management could be conducted. Moose and Soda Fork are the highest priorities for high-emphasis elk management. • Consolidate ownership in watershed to facilitate mgmt.	Soda Fork Moose Upper Canyon Owl are high priorities	• *Indicators*: forage variable in Elk Model • *Expected outcome*: increase populations on public lands • *Duration:* long-term • *Certainty:* moderate	• Monitor elk response to increased forage on public lands

Changes requiring mgmt. action	Management objective	Recommended Management Actions	General Locations	How will the indicators respond	Recommended monitoring and research or data gaps
Some meadows and wetlands and other special habitats are being encroached by trees or other vegetation	Maintain function of these important habitats	• Restore and/or enhance wetlands, meadows and other special habitats within the watershed. • Maintain beaver-created wetlands in cooperation with ODFW. • Reintroduce beaver in Gordon Meadows to manage encroaching vegetation • Maintain mesic meadows with prescribed burning, hand release, etc. to keep encroaching vegetation out. Coordinate efforts with district botanist, archaeologist, etc.) • Maintain historic meadows from encroachment • Develop wetlands	Meadows, wetlands and other special habitats in watershed	• *Indicators:* habitats enhances or restored • *Expected outcome*: improve function of habitats • *Duration:* long-term • *Certainty:* mod-high	• Inventory special habitats and put on GIS
Wildlife road closures	Establish enforceable road closures for wildlife protection	• Implement CFR road closures on roads closed to protect wildlife. This will help with closure enforcement – especially with ATV's	Identified roads closed to protect wildlife	• *Indicators:* CFR road closures • *Expected outcome*: Wildlife road closures would be enforceable • *Duration:* long-term • *Certainty:* mod. to high	

Changes requiring mgmt. action	Management objective	Recommended Management Actions	General Locations	How will the indicators respond	Recommended monitoring and research or data gaps
General	Eliminate barriers to management on the watershed scale where possible	• Consolidate land ownership to facilitate USFS management on watershed scale. Consider previously mentioned land tracts plus small parcels along the South Santiam River, etc. • Where land exchanges are not forthcoming, actively pursue cooperative agreements with private landowners and State and local resource management agencies to meet common land use objectives	Especially in areas of checkerboard ownership	• *Indicators:* ownership consolidated • *Expected outcome*: more contiguous ownershhihp • *Duration:* long-term *Certainty:* High	Funding opportunities
Bat habitat	Improve bat habitat where possible	• Install bat boxes under bridges on Canyon, Moose, Soda Fork and the South Santiam River, etc.	Canyon Moose Soda Fork and South Santiam River	• *Indicators:* bat habitat improvements • *Expected outcome*: Enhance bat habitat • *Duration:* long-term *Certainty: Mod.*	

Chapter 3.4: Aquatic Species and Habitats

3.4.1 Characterization of Aquatic Species and Habitats: *What is the relative abundance and distribution of species of concern that are important in the watershed? (TE and S, special status species, species emphasized in other plans)? What is the distribution and character of their habitats?*

Threatened Species

spring Chinook salmon

Spring Chinook salmon, one of three anadromous fish native to the South Santiam watershed, were listed under the Endangered Species Act as a threatened species in 1999.

In the entire Willamette River system, of which the upper South Santiam watershed is a part, "wild spring Chinook salmon populations are thought to be small and vastly dominated by hatchery fish" *(Kostow 1995)*.

Relative abundance: The population of spring Chinook salmon is highly variable depending on a host of habitat conditions both in the ocean and the stream system. To illustrate this variability, the chart below shows Chinook counts on the South Santiam River at Foster trap from 1984-2004. Information was obtained from Oregon Department of Fish and Wildlife records.

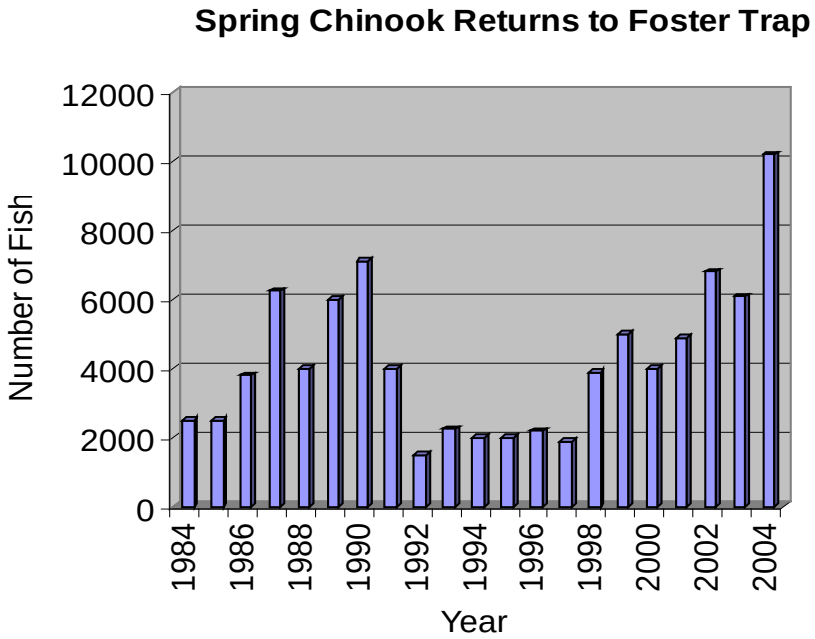


Figure 25

The distribution and abundance of hatchery spring Chinook salmon above Foster Dam has been changing as a result of sporadic hatchery stocking of juveniles here. There has also been an increase in returning unmarked fish, presumed to be wild, but studies have shown that some of these unmarked fish are of hatchery origin. The unmarked appearance results from poor fin clipping or hatchery fish which spawn lower in the river than the collection site. Some of these unmarked fish are actually wild. The exact proportions of wild versus hatchery fish is unknown and likely varies from year to year.

Distribution and Character of Habitats: A historical survey done in 1946 and 1947 indicated that spring Chinook salmon traditionally used the mainstem South Santiam River in a reach that stretches about five miles upstream from Cascadia, as well as, the Middle Santiam River and Quartzville Creek. Both the Middle Santiam and Quartzville Creek are outside of this analysis areas.

Of the historic spring Chinook production in the entire South Santiam system, 85% occurred above the Foster Dam site (*ODFW 1992*). This production was lost with the construction of Foster Dam and only partially mitigated by the Foster Dam fish hatchery. Prior to reintroduction of spring Chinook upstream of the reservoir in 1994, adult Chinook were not passed over Foster Dam because of concerns about disease interactions between downstream hatchery-raised Chinook and the wild run above Foster.

Spawning habitat: Most spawning takes place in the mainstem of the South Santiam River. Generally spring Chinook salmon lay their eggs in deeper water with larger gravel than steelhead do. These fish need abundant, stable substrate that does not shift and damage developing eggs. In addition, substrate needs to have open intergravel spaces that allow for a good flow of oxygenated water to the embryos. Stream flows need to be adequate to flush the redds and allow for adequate oxygen absorbtion. Finally, Department of Environmental Quality (DEQ) temperature critera for salmon spawning is 55.4 °F *(13 °C)* or less.

Rearing habitat: Juvenile fish spend a little over a year in the stream before reaching smolt size. Juvenile rearing occurs in the lower end of Canyon, Trout and possibly Keith Creeks. Juveniles prefer quiet habitat on the margins of the stream, or backwater areas such as side channels, to avoid predatory fish in deeper waters and high flows. During the winter, the fish move to deeper water in the main channel and shelter in the intergravel spaces in the substrate of the stream channel bed. They need an available source of invertebrates on which to feed. DEQ temperature criteria for salmon rearing is 60.8 °F *(18°C)* or less. Young Chinook are susceptible to predation from terrestrial-based preditors such as osprey, river otters, mink and racoons, or predatory fish such as bass and pike minnows so they prefer habitat that offers protection from predators.

Smolt habitat: These fish reach smolt size in the early spring, when they leave their natal streams. As they prepare to go to the sea, the smolts move to portions of the river with faster flows and begin their migration. DEQ temperature criteria for migration is 46-55°F *(8 - 13°C)*. Chinook smolts tend to travel at night to avoid terrestrial and aquatic predators. They generally travel in the main channel, which contains various water depths and stream flows velocities, and feed on a variety of aquatic macro-invertebrates.

Adult habitat: Once the adult Chinook leave the ocean to return to fresh water to spawn, they do not feed. They stay in the main channel of the South Santiam and prefer deep pools in the vicinity of their spawning grounds. Preferred temperatures are 46-55^{0}F *(8 - 13°C),* with the lethal limit of 77°F *(25°C*).

Winter Steelhead, also a threatened species *(listed in 1999*) is another anadromous fish native to the watershed.

The South Santiam watershed contributes to the Willamette native steelhead run. "The North and South Santiam watersheds have the only core and genetic legacy populations of winter steelhead in the Upper Willamette basin." *(McElhany et al 2003)*

Winter Steelhead

Relative Abundance- Prior to construction of Green Peter and Foster dams, the population exceeded 2,600 returning adult fish. The majority of these fish spawned in the Middle Santiam and the remainder in the upper South Santiam. Middle Santiam spawning grounds are no longer accessible because adult fish do not pass over Green Peter dam, but they still do over Foster Dam. In the last five years or so about 600 to 1800 adults were passed over Foster Dam and into the upper South Santiam watershed to spawn. To show how variable the numbers are, a decade ago, only about 200-300 adults passed over Foster Dam.

Native winter steelhead in the upper South Santiam are part of the larger Upper Willamette River Evolutionary Significance Unit (*ESU).* Steelhead in this ESU have exhibited large fluctuations in abundance, and on average, have been declining for about the last 35 years (*Busby et al. 1996*). The South Santiam Watershed Council cited an Oregon Department of Fish and Wildlife report finding that summed up their assessment of this fish by saying "with very little additional stress, South Santiam winter steelhead will not be able to sustain themselves." (*South Santiam Watershed Assessment Jan. 2000).*

The chart below illustrates the variability of the winter steelhead population over time. Data shown in the graph is from numbers of winter spawners reported from 1984 to 2003 in a report by ODFW to NOAA fisheries.

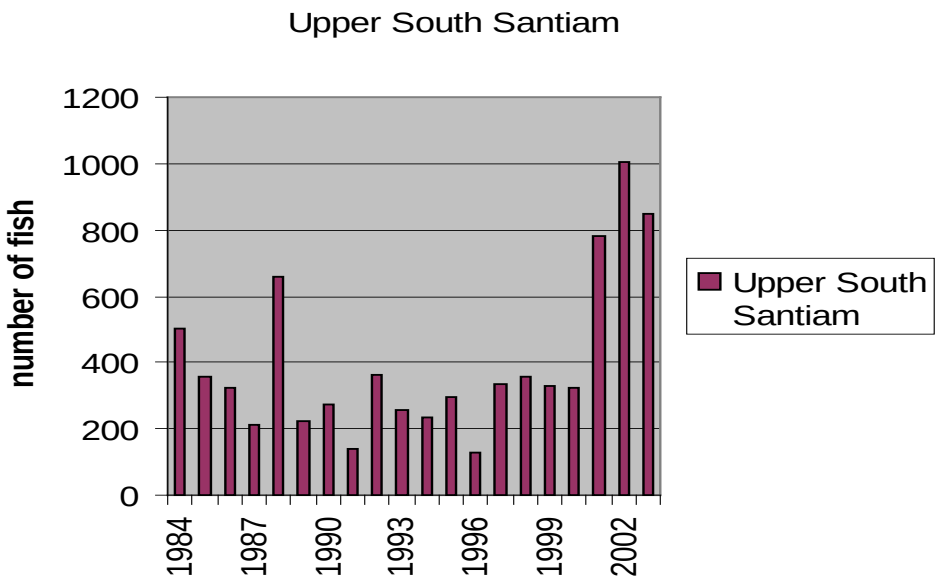


Figure 26: Winter steelhead spawners 1984-2003

Distribution and Character of Habitat: Winter steelhead spawn and rear primarily in Canyon and Moose Creeks and to a lesser extent in the mainstem South Santiam River and Soda Fork Creek.

Spawning habitat: Spawning occurs in Moose and Canyon Creeks. Unlike much of the rest of the watershed, there is instream woody structure providing hiding habitat in Canyon Creek. Rearing habitat here is fairly good. Most of the instream structure in Canyon Creek is natural, but a lot of the structure in Moose Creek has been placed artificially. Natural wood is beginning to come in on its own. Spawning generally takes place during April and May. Eggs are deposited in small to medium-sized gravel with open intergravel spaces that allow for a good flow of oxygenated water to the embryos. Optimum spawning water temperatures for the developing embryos range from about 40-50 °F *(4 – 10 °C).*

Juvenile habitat: Juveniles have been found in many tributaries to Moose and Canyon Creeks, the mainstem of South Santiam River and Soda Fork Creek. Juvenile habitat requirements include escape or hiding cover such as undercut banks, logs or pools and suitable water quality. Optimal water temperatures range from 45-58 °F *(7 - 14°C)*. They also need fast-water feeding areas and/or an abundance of food for growth. Their diet consists of invertebrates and insects such as mayflies or caddis flies. Young steelhead are susceptible to predation from terrestrial-based preditors such as osprey, king fishers, river otters, mink and racoons and predatory fish such as bass, and pike minnows.

Smolt habitat: – Smolts need sufficient flow of water to allow safe passage and protection from predators during migration. Pike minnows are predatory and may have a significant impact on juvenile salmonid survival as they pass through the slow waters of the reservoir. In addition, the reservoir delays steelhead emigration as these fish do not tend to exit the reservoir via the penstocks, so the reservoir is held at a reduced elevation during migration to allow smolts to exit via the spillway.

Adult habitat: For migration, adults need sufficient streamflow to provide passage over shallow riffles, log jams, falls, etc. They also need access to their natal streams and to spawning gravels there. Other habitat requirements include escape cover such as logs and undercut banks and deep pools for spawning.

Pacific lamprey, the third anadromous species that inhabits this watershed has been listed as an Oregon State sensitive species since 1993 and a decade later, in 2003, the US Fish and Wildlife Service was petitioned to list several lamprey species as endangered. In response to the petition, US Fish and Wildlife determined that there was not sufficient information to warrant further review at this time.

Lampreys are ancient fish that appear eel-like, but are not related to eels. They are jawless and have no true fins or bones. Born in fresh water, they spend time in the ocean and return to fresh water to spawn.

Relative Abundance: There is little long-term data documenting the relative abundance of lampreys in many parts of their range. In the Willamette River basin, which includes the South Santiam River, counts at Willamette Falls and Leaburg Dam, provide the only reliable data on lamprey abundance for this basin. According to this information, lamprey populations have decreased dramatically from historic levels.

Distribution and Character of Habitat: Lamprey occur throughout the South Santiam River basin.

Spawning habitat: They spawn on gravelly or sandy stretches of streams and die shortly after spawning. The eggs are slightly adhesive but do not sustain strong stream currents. Often the eggs wash onto nearby rock crevices, downstream from the nest sites. Eggs hatch after about 19 days.

Juvenile habitat: The worm-like larval lamprey soon move out into the stream current and are carried off to suitable areas of soft mud and sand along the margins of creeks and rivers. They are filter-feeders and burrow tail-first into substrates or lie on the stream bottoms, where they spend the next 4 to 6 years filtering water and silt for food. They mostly feed on algae and other organic material. Lampreys are preyed upon by trout, crayfish and birds. These fish metamorphose and leave home during high water when they are about 4.5 inches in length, and migrate to saltwater.

Adult habitat: In the ocean, lamprey are parasitic on larger fish. They spend 2 to 3 years in the ocean, growing to about 30 inches in length and then head back to freshwater to spawn and die. In their migration, lampreys sometimes have difficulty passing through culverts and navigating turbines and fish ladders on dams.

Other Factors Affecting Relative Fish Abundance. The creation of a fish hatchery program to mitigate fish losses caused by creation of Foster and Green Peter dams has affected fish abundance in the watershed. Spring Chinook salmon, winter steelhead and rainbow trout numbers have been supplemented with hatchery fish. In addition, summer steelhead, fall Chinook salmon, kokane, and brook trout have all been introduced to the watershed through hatchery programs. There is also a warm water fisheries that was not present historically such as small mouth bass, large mouth bass, crappie, bluegill, pumpkinseed, and brown and yellow bullhead. Some of these non-native species compete with native fish for habitat or prey directly on them, thus affecting native-fish population numbers.

Other Factors Affecting Character and Distribution of Fish Habitat: Many of the fourth and fifth order fish-bearing streams in the watershed have been scoured to bedrock due to high stream energies and lack of large woody material to dissipate those energies. Most of the woody material was consumed by stand-replacing fires in the mid-1800's and early 1900's.

After 100 years of growth, many of the timbered stands across the watershed are just beginning to contribute large wood to stream and riparian habitat. This large woody material would eventually create quality fish habitat as it accumulates gravels and reconnects streams with their floodplains.

The current habitat can only support a base level population of fish and aquatic dependent species. As habitat improves, and as tributaries and flood plains are reconnected with mainstem streams, population numbers are likely to increase and eventually reach a threshold at which the habitat can support no further increases.

Based upon the characteristically high-energy stream flows in this watershed, combined with occasional stand-replacing fires, it is likely that a boom and bust cycle of fish habitat is probably typical for this area.

3.4.2 Aquatic Species and Habitat Issues and Key Questions: *The issues and key questions help focus the analysis on the relevant elements of the ecosystem as they relate to management questions, human values or resource conditions within the watershed.*

Issue: Anadromous fish have decreased in abundance and distribution in the watershed. Some of the contributing factors to their decline are: migratory impediments such as dams, oceanic conditions, commercial and recreational fishing, predation of young fish by non-native species, loss of genetic integrity due to hatchery practices and introduction of non-local fish stocks, changes in timing and amount of streamflow, water temperatures, and barriers to fish migration such as road culverts, etc.

- ***Indicators for measuring or interpreting conditions***: Numbers of anadromous fish
- ***Key Questions***: What management actions can be undertaken to ensure viability of anadromous fish populations in the watershed? What processes have, and are now affecting population dynamics of anadromous and resident fish and other aquatic species? What habitat components are necessary to sustain the variety of species native to the watershed? Which of these components limiting? What, where and in what priority should habitat restoration or enhancement of necessary habitat components occur? Are there subwatersheds which can function as refugia while these habitat projects occur elsewhere in the watershed?

Issue: A 2001 court ruling has resulted in both hatchery and naturally-spawning Chinook salmon being listed as threatened under the endangered species act.

Issue: In the mid-1800's, a large stand-replacing fire in the watershed loaded the upper South Santiam stream channels with lots of wood. Most of this large wood component was removed by subsequent fires and a significant flood event. Later timber management practices, such as salvage along riparian areas, removed wood that might have fallen into the stream channels to provide structure. In addition, stream cleanout requirements after timber harvest removed even more potential stream structure. This practice ended in the 1980's.

The removal of woody material from stream channels resulted in increased stream energies which downcut many stream channels to bedrock. When stream energies are not moderated by large woody debris, high stream flows can affect the ability of juvenile fish to occupy habitat. During high winter flows young fish can be washed out of streams along with important nutrients. Lack of large wood decreases the amount of hiding cover available for adult fish, especially during low flows. It also reduces pool quality and numbers, affects the amount and distribution of spawning gravels, limits sediment and nutrient storage and contributes to higher stream temperatures.

Stream downcutting also results in stream channels becoming disconnected with their floodplains or some road culverts no longer being on grade with the river, thus hampering fish migration. In recent years many of these culverts have been replaced and fish migration has been restored.

- ***Indicators for measuring or interpreting conditions:*** Number of pieces of woody material per mile in stream channels and pieces of wood per acre in riparian areas
- ***Key Question:*** Which streams are deficient in in-stream and/or riparian large wood? How much large wood recruitment can be expected from riparian areas over time? What processes have affected stream channel structure and stream habitat conditions? What effect are these processes having on the maintenance and enhancement of aquatic functions? How have these stream attributes changed through time? Where in the watershed would it be appropriate to reestablish the link between a stream channel and its floodplain?

Issue: Stream temperatures during summer low flows do not meet established state water quality standards for salmonid-producing streams. High stream temperatures can affect emergence timing of fry, increase susceptibility to diseases, and decrease oxygen content of water. If temperatures are too high, they can be lethal to fish.

- ***Indicators for measuring or interpreting conditions?*** Stream temperatures, especially during summer, low flows
- ***Key Question***: What processes have contributed to high stream temperatures during low flows in the summer? What is the range of natural conditions for stream temperatures in this watershed? Where do current temperatures fall in the range of natural conditions? What can be done to moderate high summer time, low flow temperatures?

Issue: ATV use in the watershed is occurring in areas of winter steelhead redds. There is a concern that use here may be impacting steelhead populations.

- ***Indicators for measuring or interpreting conditions***? ATV use in steelhead spawning habitat. Evidence of redd disturbance in areas of ATV use.
- ***Key Question***: What can be done to minimize redd disturbance by ATV's?

3.4.3 Current Conditions: *What are the current habitat conditions and trends for species of concern identified above?*

Introduction: In 2001 a district court ruled in *Alsea Valley Alliance v. Evans*, that if hatchery fish are determined to be biologically part of a distinct fish population, and if that distinct population merits listing under the Endangered Species Act (ESA), then the entire population (*both naturally-spawning and hatchery fish*) must be included in the listing.

In response to that court ruling, in June 2005, the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service, which is responsible for managing marine species and anadromous fish, established a new policy which:

- outlined the criteria to be used to determine if hatchery fish and naturally-spawning fish should be considered in the same biological unit
- stated that if naturally-spawning fish populations are listed under the ESA, then biologically-related hatchery populations would also be listed
- determined that when considering extinction risk for an ESA listing decision, the entire biological unit, both naturally-spawning and hatchery fish, needed to be taken into account
- allowed harvest of listed, hatchery fish which are surplus to conservation needs

As a result of the 2001 court ruling, NOAA Fisheries proposed to modify its previous listing of steelhead to include rainbow trout in areas where steelhead and rainbow occur together and have an opportunity to interbreed because they considered steelhead and rainbow trout to be a single biological unit. They had previously only listed steelhead because they manage the anadromous steelhead and not the freshwater rainbow trout, which is managed by the U.S. Fish and Wildlife Service. In June of 2005, the U.S. Fish and Wildlife Service questioned the factual and legal basis for NOAA's proposed modification to the previous listing. So far, this question has not been resolved.

Spring Chinook salmon habitat conditions: Four important elements of spring Chinook salmon habitat that are currently of concern in this watershed, are: lack of sufficient structure in stream channels, high summer-time low flow stream temperatures, insufficient amount of adequate spawning gravels, and fish passage over Foster Dam.
Trends: The trend is static for spring Chinook salmon.

- *Woody structure* – Most of the spawning takes place on the mainstem of the South Santiam River. Because of the location of highway 20 in relationship to the river, there is little opportunity to build up woody structure in this part of the river because of potential impacts to the highway. Without large wood, there is less hiding cover, less sediment and nutrient storage capacity, less spawning gravels, etc.
- *Stream temperatures*- Summer stream temperatures exceed State Water quality standards for salmonid-producing streams during low flows. High energy streams

have scoured portions of streams to bedrock, which tend to be solar sinks that can contribute to higher stream temperatures.

- *Spawning gravels*- this portion of the South Santiam river does not have high quality spawning gravels, except in a few locations. Without sufficient woody structure in the channel to store quality spawning gravels, this situation is not likely to change soon.
- *Fish passage*- both upstream and downstream fish passage is limited by Foster Dam. In addition, because of downcutting, some tributary stream channels and some culverts have become barriers to fish passage. This situation is not likely to change soon with respect to Foster Dam, but culverts and stream channels not being on grade can be improved through prudent management and development of woody structure in streams, so this situation is likely to improve over time.

Winter Steelhead habitat conditions – Moose and Canyon Creeks, and to a lesser extent, the mainstem South Santiam River and Soda Fork Creeks, are important spawning and juvenile rearing grounds for native winter steelhead. As with spring Chinook salmon, there is a concern about high summer-time low flow stream temperatures, as well as, lack of woody material in some areas. In addition, there are concerns with loss of fish habitat above Green Peter dam *(as about 1/3 of this historic spawning habitat is now blocked by the dam)*, competition from hatchery summer steelhead, and ATV use near spawning gravels.

Trends: There have been increases in abundance of most steelhead populations in Upper Willamette River Evolutionary Significance Unit (*ESU)* since 2000. However, long-term trends in abundance are down, reflecting a decade of consistently low returns during the 1990's.

- *Competition from summer steelhead* - Studies have shown that hatchery summer steelhead released in the South Santiam negatively affect native winter steelhead because they spawn earlier and gain a competitive advantage once progeny hatch and rear in the stream (*Chilcote 1998*). This can affect abundance, productivity, and diversity the South Santiam winter steelhead population.
- *Woody structure* - In Moose Creek the trend is that habitat conditions are improving as natural and placed large woody structure is beginning to improve habitat conditions there. Currently more steelhead have been seen spawning here than have been seen in the past, or than were expected to be here.

  Fish habitat conditions are variable from year to year, and from reach to reach, in Canyon Creek. There are many gravel bars that move during high flows and change, depending on where large woody structure falls. Undercutting along banks has caused some trees to fall and add structure to the stream channels. Habitat here, for the most part is moderate, but there is enough quality habitat that fish could fill the habitat. At the other extreme, some areas have poor spawning and rearing habitat.
- *Stream temperatures* - Summer stream temperatures exceed State Water quality standards for salmonid-producing streams during summer low flows. High energy streams have scoured portions of streams to bedrock, which tend to be solar sinks.

The trend is likely that stream temperatures will decrease as trees along stream channels develop to provide sufficient shade and woody structure to stream channels.

- *ATV use* - When water levels are low, in mid to late summer and fall, one of the biggest emerging problems in Canyon Creek is ATV use near fish spawning gravels. At times these ATV's drive directly on top of spawning beds and may be crushing developing eggs. When ATV's cross spawning gravels, they stir up the water and increase turbidity. When this occurs upstream of redds, they potentially add sediment into the spawning gravels which can affect survival of the redds. Once the fish emerge, ATV traffic may affect areas where the young fish are feeding. The trend seems to be increasing ATV use in the watershed.

Pacific lamprey habitat conditions – Some potential concerns regarding lamprey habitat in this watershed are: high stream energies, lack of large wood and the dams.
Trends: Although there is no clear data for this watershed, it appears that lamprey populations are declining in the larger Willamette River basin.

- *High stream energies and lack of large wood* - These filter-feeding fish bury themselves in soft mud and sand during the larval stage to feed. Given the lack of large wood in many stream channels to moderate flows and the fact that many streams are scoured to bedrock, would indicate that the trend is likely that there is less available habitat for these fish larva than pre- 1860's when the large stand-replacing fires occurred. Given also that some natural mortality is beginning to occur in many stands, and some of this mortality ends up as structure in stream channels, the trend is slowly moving toward improved habitat conditions.
- *Foster Dam* – Lampreys sometimes have difficulty navigating turbines and fish ladders. It is likely that dam construction along many stream reaches on their journey to and from the ocean, has had a negative impact on their ability to reach spawning habitat and therefore their populations have likely dwindled as a result.

•

3.4.4 Species and Habitat Reference Condition: *What was the historical relative abundance and distribution of species of concern and the condition and distribution of their habitats in the watershed?*

Historical relative abundance of distribution of species of concern:

Spring Chinook Salmon– Historically spring, Chinook salmon spawned in the South Santiam River as evidenced by a 1937 survey: "…salmon were permitted to ascend the South Santiam unhindered, and a fair run of spring Chinook salmon occurred. Whether or not this is the case in other years, is not known but the Chinook fry were fairly numerous in the lower reaches of the river."

Above Willamette Falls, native spring Chinook declined in abundance and distribution after the construction of the Willamette valley dams. In the 1940's, state biologists estimated that nearly half of the spring Chinook spawning habitat would be lost with construction of dams on McKenzie, Santiam and Middle Fork Willamette. Oregon Department of Fish and Wildlife estimated that 85% of the historic spring Chinook production in the entire South Santiam system occurred above the Foster Dam site (*ODFW 1992*). As predicted in the 1940's, this production was lost with the construction of Foster Dam in the 1960's and was only partially mitigated by the Foster Dam fish hatchery. Many miles of historic spring Chinook salmon spawning habitat was lost under the reservoir pools after construction of the dams.

Winter Steelhead: Winter steelhead spawned historically in the upper South Santiam subbasin, above the site of Foster and Green Peter dams. It is estimated that 2,600 winter steelhead spawned in the upper mainstem of the South Santiam and in Thomas, Crabtree McDowell, Wiley, Canyon, Moose and Soda Fork Creeks (*Buchanan et. al. 1993*). Of these, Canyon, Moose, the upper mainstem of the South Santiam and Soda Fork Creeks are in this watershed.

While there is little historical information on the population status of upper Willamette River winter steelhead, of which the South Santiam run is a part, the geographic range and historical abundance are believed to be relatively small in comparison to the range and abundance of other steelhead ESU's . The current production of winter steelhead probably represents a larger proportion of historical production than is the case in other Columbia Basin ESU's but data over the last 30+ years appears to indicate a declining population, however.

Prior to the construction of Foster and Green Peter Dams, the habitats within this watershed supported about 1/3 of the winter steelhead which passed Sweet Home. Now much of that habitat is under the reservoirs.

Pacific lamprey: There is not a lot of historical information on lamprey populations but it is thought that they were relatively abundant and widespread in the watershed.

Other interesting tidbits of information

To understand how fish habitat has changed in the South Santiam over time, the following historical descriptions give a flavor for the area in the past.

Fish habitat: In a fish survey done in the 1930's, the following quotes give a flavor of the fish habitat at that time:

- "From the Lebanon bridge, upstream as far as Sweet Home, bedrock and large rubble are much in evidence. In a great many cases bedrock makes up nearly 100% of the bottom."
- "The South Santiam above the Middle Santiam flows through a bedrock canyon most of the way."
- "Alder is the chief species of marginal vegetation, with considerable quantities of willow and small conifers. The gradient is moderate with numerous, long, deep pools between the vertical canyon walls, as the run-off is not very rapid. Although the bottom is principally open bedrock, there are localized areas of excellent spawning gravels. The stream could support a fair run of salmon, but could never be rated as first-class spawning stream as there is too much bedrock in most places."
- There is "very fast runoff and steep stream gradients above Sweet Home."

The implication of the above descriptions is that the effects of fires that occurred in the mid-1800's and early 1900's, removed much of the woody material from the stream channels. This resulted in high-energy streams which downcut stream channels to bedrock in a great many areas. From this, one can also infer that stream temperatures were probably above current State Water quality standards for salmonid-producing streams during this time.

The following excerpt from a history of the Sweet Home Ranger District written in the 1960's: "The fishery on the Santiam has improved since Green Peter and Foster dams were constructed. Water quality during the summer months is greatly improved below Foster Dam, both cooler temperatures and higher sustained flow. The fish passage facilities over both dams, both upstream and downstream, have been successful. The lakes behind the dams provide rearing ponds, and upstream migration has increased. Lake fishing has been good."

3.4.5 Synthesis and Interpretation Aquatic Species and Habitats: *What are the natural and human causes of change between historical and current species distribution and habitat quality for species of concern? What are the influences and relationships between species and their habitats and other ecosystem processes?*

Table 31: **Natural and Human Causes of Change between Historical and Current Distribution and Habitat Quality for Aquatic Species of Concern.**

Changes between historical and current aquatic species distribution and habitat quality for species of concern	Natural Causes of Change	Human causes of change
Winter steelhead and spring Chinook salmon are listed as threatened species	• Oceanic conditions • Past fires and floods • Predation by other fish • Lack of large woody structure has affected availability of spawning gravels, resting sites, etc.	• Construction of dams on rivers has affected habitat availability, seasonal water temperatures, fish migration and timing of migration, timing of spawning, etc. • Fishing pressure • Land management practices • Sewage and other discharge into streams • Water temperatures
Historically 85% of the spring Chinook production occurred above the Foster Dam site now many miles of that habitat is under the reservoir		• Dam construction and the resulting reservoir covered up much of the historic habitat
Amount of woody structure in stream channels to moderate stream energies was very low resulting in many streams being downcut to bedrock. High energy streams affect the ability of juvenile fish to occupy the habitat. Now some structure is beginning to become reestablished.	• Fires, floods contributed to loss of wood • Tree growth and mortality in riparian areas is contributing to adding some wood back into system • During high winter flows, juvenile fish suffer greater predation and can be washed out of the stream along with essential nutrients.	• Timber harvest, stream cleanout, salvage in riparian areas, etc. contributed to loss of wood. • Establishment of Riparian Reserve network, placing woody structure in streams has contributed to adding some wood back into system

Changes between historical and current aquatic species distribution and habitat quality for species of concern	Natural Causes of Change	Human causes of change
In some reaches, streams cannot utilize floodplains to dissipate energies which results in active downcutting thus disconnecting streams with floodplains or making tributaries or culverts so they are no longer on grade with the main streams, thus hampering fish migration	• Lack of large woody structure in stream channels to moderate stream energies because of past fires and floods	• Highway 20, other roads and structures along streams confine the channel thus increasing energies.
Timing and amount of streamflow has changed		• Construction of Green Peter and Foster Dams have changed the hydrology of the river. Flows have increased in late summer and fall, changing water temperatures. Spring and early summer temperatures are colder, which delays juvenile Chinook growth and fall temps are warmer which accelerates egg development and advances emergence times
Late summer, low flow, stream temperatures exceed State water quality standards in portions of the watershed. *(Note: in a 1937-1940 survey, summer water temperatures were 55—76°F depending on where in the system)*	• Loss of wood in stream channels from fires and floods. • Many streams downcut to bedrock, providing solar sink to raise stream temperatures. • Tree growth is beginning to provide shade to stream channels to reduce stream temperatures • Past fire history	• Timber harvest, road building, removing vegetation along streams, and salvage of trees along streams. • Implementation of Riparian Reserves on public lands and riparian protection on private lands is providing more shade and large wood to streams to reduce temperatures.

Changes between historical and current aquatic species distribution and habitat quality for species of concern	**Natural Causes of Change**	**Human causes of change**
Water quality better now than in 1930's - 1940's	• Vegetation regrowth following fires	• Sewage treatment, discharge permits, timber harvest and road building practices, riparian protection requirements, BMP's
Competition between hatchery and natural fish stocks for habitat	• Natural competition between species for food, shelter, etc.	• Stocking of hatchery fish in areas occupied by salmonids.
Fish distribution		• In early 1900's racks used to collect fish and spawn fish. Then dams were built. This affected natural distribution because it didn't allow the fish to go where they would have gone to spawn naturally. It also covered up some historic habitat.
Predation by pike minnows and bass in reservoir is limiting survival of juvenile, anadromous salmonids during downstream migration	• Natural competition between species for food, shelter, etc.	• Dam construction and resulting reservoir, made water slower and juveniles more subject to predation. • Fish hatchery practices putting non-native fish into the system along with the introduction of non-native species by individuals.

Table 32: **Influences and Relationships between Aquatic Species and Habitat and other Ecosystem Processes.**

Species and their habitat	Influences and Relationships between species and their habitat and other ecosystem processes
No longer releasing hatchery rainbow trout above the reservoir on the S. Santiam side because of possible conflicts with wild winter steelhead	• This has virtually shut down recreational fisheries which has probably reduced recreation use of campgrounds
Large woody structure in stream channels	• Affects hydrology, temperature, sediment retention, retention of nutrients from leaves, aquatic insects and food chain, decreases stream velocity, and floodplain development, etc.
Stream channelization	• Increases stream velocities, reduces sediments, increase in stream energies result in movement of larger particle sizes affecting fish spawning habitat and creation of bedrock chutes. • Disconnect between availability of hyperriac flow which influences water temperature – heat sinks now – historically had subsurface flow – now only channelized flow.
High stream temperatures	• Potential for disease in fish goes up, affects oxygen levels, encourages algal growth, parasites may cross from one species to another but probably diseases don't.
Below dams streamflow has increased in late summer and fall, which also changes water temperatures	• Spring and early summer stream temperatures are colder which delays juvenile Chinook growth and fall temperatures are warmer which accelerated egg development and advances emergence times
Invasive species- bass in foster lake, brook trout, any holdover planted hatchery fish	• Competition for food, predation of juvenile salmonid species, presence of species like bass in lake – led to dramatic changes in zooplankton and phytoplankton which influence nutrient cycling – encourages toxic algae blooms which have effect on fish and humans.
Pike Minnow - predator	• Development of the lake behind the dams makes it easier for pike minnows or bass to be a predators because of slow water– historically it would have been easier for prey fish to move during high flows without being eaten by pike minnows or bass
Return of nutrients to system from salmon carcasses	• Increases fish productivity, more nutrients, more aquatic invertebrates so more food for fish and shore birds, healthy riparian – better species diversity, more insects, etc. ospreys, kingfishers, etc • Nutrients show in vegetation a long ways up the bank so plants near stream channel grow better.

3.4.6 Recommendations:

The purpose of this section is to bring the results of the previous steps to conclusion by focusing on management recommendations that are responsive to watershed processes identified in the analysis.

What changes require mgmt. action	Recommended management actions	General Location	How will the indicators respond to mgmt. activities	Recommended monitoring and research actions and data gaps
• Stream temperature increases • Lack of woody structure in stream channels and riparian areas	• Manage riparian areas to increase tree sizes for shade and for future instream and riparian woody structure. • Plant conifers in riparian areas devoid of conifers to ensure long-term woody recruitment in streams especially along the mainstem South Santiam River and Soda Fork Creek. • Reduce the amount of bedrock-controlled portions of streams through introduction of woody material, to reduce solar sinks contributing to stream temp. increases • Strategically placed, correctly-engineered wood and boulder placement projects to restore instream woody structure. Priority – Moose, Canyon, mainstem South Santiam River and Soda Fork Creeks because they are important refugia and spawning areas for native winter steelhead and spring Chinook salmon. Improving habitat here will provide additional habitat and refugia and an improved corridor to spawning grounds above Foster Dam.	• Prioritize for areas where summer stream temperatures are a concern • Areas where large woody structure is lacking	• *Indicator*: stream temperatures • *Expected response*: downward trend in stream temperatures • *Duration*: Long-term as riparian shade improves over time • *Level of certainty*: High certainty (*see next section for indicators for large woody structure)*	• Monitor summer-time low flow temperatures • Stream temperature monitoring throughout the basin to establish baseline, especially in Canyon and Moose Creeks. • Determine what portions of the watershed are contributing to high summer-time low flow temperatures so treatment areas can be prioritized

What changes require mgmt. action to achieve mgmt. objectives?	What is the relative sequence of recommended management actions, based on resource risk and legal requirements?	General Location	How will the indicators respond to mgmt. activities and over what duration? What is level of certainly?	Recommended monitoring and research actions and relative priorities?
Lack of woody structure in stream channels and riparian areas *(continued)*	• Restoration Needs: Assess impacts to other resources like roads before restoring structure in mainstem and Soda Fork. These two streams offer the best potential habitats for spawning and rearing of anadromous salmonids.	• Areas where large woody structure is lacking	• *Indicator*: amount of wood per mile in streams and per acre in riparian areas • *Expected response*: increase in woody structure available to streams • *Duration*: long-term • *Certainty:* high	• Monitor improvement in habitat complexity, moderation of stream energies, sediment and nutrient storage, etc.
Competition and/or predation on salmonids by non-native or invasive fish species	• Eliminate programs that introduce non-native or invasive fish into the watershed. • Work to eliminate existing non-native or invasive fish species populations in the watershed	• Ares with non-native or invasive fish populations, like the reservoirs.	• Indicator: Populations of non-native or invasive fish species • Expected response: decrease in populations • Duration: long-term • Certainty: unknown	• Fish surveys (species and populations) • Distribution and abundance of non-native or invasive fish species in watershed

What changes require mgmt. action	Recommended management actions	General Location	How will the indicators respond to mgmt. activities	Recommended monitoring and research actions and data gaps
Spawning gravel availability	• Take advantage of opportunities to encourage recruitment or placement of large woody structure in stream channels and/or riparian areas to capture spawning gravels	• Spawning grounds	• *Indicator:* accumulation of spawning gravels behind large wood • *Expected response:* increase accumulation of spawning gravels • *Duration*: long-term • *Certainty:* moderate	• Monitor improvement in spawning gravel availability
ATV use in spawning gravels	• Education campaign • Manage ATV use to minimize conflicts with natural function of the area	• Areas where ATV use is affecting spawning gravels or could affect them	• Indicator: ATV use in spawning beds and redds disturbed • Expected response: decrease in ATV disturbance of redds • Duration: short-term • Certainty: Low to moderate certainty	• Monitor use of site by ATV's • Monitor disturbance of redds
Loss of fish habitat under reservoirs, etc.	• Take advantage of opportunities to improve or develop suitable fish habitat when appropriate • Protect existing suitable fish habitat from degradation by management or recreational activities • Enhance existing suitable fish habitat as needed	• Areas of potentially suitable fish habitat	• *Indicator:* increase in or improvement of suitable fish habitat • *Expected response:* increase in quality and quantity of suitable fish habitat • *Duration:* long-term • *Certainty*: moderate	• Monitor spring Chinook salmon, winter steelhead and lamprey populations and use of habitat • Locations of potential stream reaches that could be improved to meet salmonid habitat requirements

What changes require mgmt. action	What is the relative sequence of recommended management actions	General Location	How will the indicators respond to mgmt. activities	Recommended monitoring and research actions and data gaps
Barriers to fish passage	• Reconnect streams to their floodplains by introducing woody material into stream channels to moderate stream energies • Improve smolt passage at Foster Dam • Ensure culverts don't block fish passage to habitat. Many public roads have had culvert replacements	• Areas identified as barriers to fish migration	• Moderate chance of success	• Set up monitoring sites for these items • Priorities for reconnecting streams with their floodplains • Locations of culverts that block fish passage
Fewer salmonid species return to spawn and die so there are fewer nutrients in streams for whole host of organisms	• Introduction of nutrients to streams by placing fish carcasses, etc.	• Salmonid spawning grounds	• *Indicator*: fish carcasses placed • *Expected response*: increase in stream nutrients	• Research the impact of fewer nutrients being introduced to streams because of fewer salmonid species spawning and dying and what impact that has on future salmonid populations and other organisms
Decline in populations of winter steelhead and spring Chinook salmon	• More education – reason why catch and release in South Santiam • Interpretive signs on fish viewing platforms • Habitat improvement projects listed above • Minimize predation on winter steelhead and spring Chinook salmon	• Fishing areas within watershed	• Moderate to low change of increasing population numbers	• Monitor numbers of adults put above the dam and smolts passing downstream.

What changes require mgmt. action	Recommended management actions	General Location	How will the indicators respond to mgmt. activities	Recommended monitoring and research actions and data gaps
Presence of pike minnows and bass in reservoir is limiting survival of juvenile anadromous salmonids during downstream migration	• Brook trout eradication – no catch limits, etc. Bounty on pike minnows and no limit on bass. • Place traps above reservoir and below the dam to get a handle on juvenile survival.	• Reservoir	• Moderate to low • Moderate change to see what is happening	Creel census and bounty records

4.1 Social Characterization

4.1.1 Human uses - *What are the major human uses, including tribal uses and treaty rights? Where do they generally occur in the watershed?*

Human use of the area dates back to prehistoric times. Through site excavation archaeologists have discovered that humans have inhabited this watershed for at least 8,000 years. Major human uses in the area have centered on either permanent or temporary settlements, travelways and transportation, subsistence and commercial use of resources, and recreation.

Settlements have varied from seasonal camps used by indigenous people to permanent settlements such as Upper Soda, Cascadia and Sweet Home.

Native people had winter camps in the Cascadia subwatershed, just to the west of the analysis area and summer camps in Owl, Sevenmile and Upper Canyon subwatersheds. Early pioneers and most of the people who followed have settled along the South Santiam River corridor. Like the Native American winter camps, both Cascadia and Sweet Home lie just to the west of this watershed.

Travelways and Transportation in the watershed began as foot trails, followed by horse and wagon roads, and later roads that accommodated automobiles. Major transportation routes used by indigenous people, early pioneers and people today, paralleled the South Santiam River from east to west through the watershed. There were also major north/south routes such as the Mollala Trail. Following establishment of these main transportation routes, tributary routes were later developed throughout much of the watershed.

Use of Resources began with indigineous people hunting and gathering. Later early pioneers used watershed resources for food, clothing and shelter. As settlements became more established here, people began to use the resources for commercial ventures such as agriculture and timber harvest. These uses have occurred throughout the watershed.

Recreation in the watershed has increased along with access to the area. As more roads were constructed and transportation became easier, recreational use of the area increased. Many of the developed recreational activities center around the Santiam River corridor while dispersed activities such as hunting, hiking, and berry picking occur throughout the watershed.

4.1.2 Social Domain Issues and Key Question: *The issues and key questions help focus the analysis on the relevant elements of the ecosystem as they relate to management questions, human values or resource conditions within the watershed.*

Travelways and Transportation

Issue: Between Mountain House and Tombstone Summit, Highway 20 crosses six large, naturally active slump/earthflows, at least seven additional smaller, volatile and unstable areas, and includes even more sites that are prone to failure during periods of heavy rainfall. These slope failures contribute varying amounts of sediment into stream channels during storm events. In addition, the failure-prone road poses safety concerns for highway travelers, a constant need for expensive road maintenance and a constant need for waste areas to place debris that has come onto the road prism.

The road is unstable enough in this area, that gates were installed after the 1996 flood to control public access through the failure-prone areas. These gates have been rarely used, but are available should a road failure occur.

Oregon Department of Transportation would like to study a new location for Highway 20 and/or possibly shift highway maintenance dollars elsewhere. The City of Sweet Home wants to maintain Highway 20 as a trans-Cascade travel route. To further complicate the issue, Highway 20 has recently been designated as a State Scenic Byway and is being promoted to attract more people to use the road to enjoy its scenic qualities as well as to contribute tourist dollars to local economies. Traveler safety with the expected increased use is even more of a concern here.

- ***Indicators for measuring or interpreting conditions:*** frequency and severity of road failures along highway 20. Cost/mile for ODOT to maintain this section of Highway 20. Traffic accidents in this failure-prone section of road.
- ***Key Question:*** What management actions can be taken to minimize sediment input into stream channels, minimize safety concerns for travelers, and minimize the need for constant and expensive road maintenance on Highway 20?

Issue: Decreased log harvest activities have reduced funding available for maintenance of roads. At the same time there has been an increased public use of forest roads. Public use may increase even more because of increased promotion of the Santiam Wagon Road and the designation of Highway 20 as a State Scenic Byway which is expected to bring even more recreational driving into the area, not only on Highway 20 but also on forest roads leading to local attractions adjacent to the highway. This increased public use has lead to an increased need to maintain roads for safe travel and to maintain environmental standards, but reduced road maintenance budgets have limited the ability to manage the transportation system in accordance with the Highway Safety Act, Aquatic Conservation Strategy Objectives and/or other resource requirements.

- ***Indicators for measuring or interpreting conditions***: Percentage of road miles with appropriate road management objectives for the level and type of use they receive. Percentage of road miles maintained to planned safety and environmental standards.
- ***Key Questions***: Which roads are expected to experience increased recreation use? How can we best manage the road system to meet planned road safety and environmental standards while also addressing budget shortfalls?

Issue: Resource concerns and fewer road maintenance dollars have necessitated an intensive evaluation of the transportation system to determine long-term transportation needs. For both transportation and resource protection reasons, many roads that have been deemed unnecessary have been decommissioned; many roads that will likely be used in the future, but are not needed currently, have been storm proofed, stabilized and stored for future use; and many roads that are currently used remain open but might not be maintained to the same level as in the past.

At the same time as budgets dictate a reduction in miles of open roads, there is also a need to maintain access to private lands intermingled with National Forest System lands and to retain fire access on both public and private lands. Not all roads identified for closure have been closed, but overall, there are fewer open roads than there have been in the past which can adversely affect administrative and recreational access, but can be beneficial for many resources.

- ***Indicators for measuring or interpreting conditions***: Percentage of transportation system that meets identified long-term needs.
- ***Key Questions***: What is the current condition of the transportation system? What changes are expected to be made in the transportation system? What are the likely effects of these changes? Where and how are identified transportation needs not being met? Where and in what priority should unmet transportation needs be addressed?

Issue: Fewer road maintenance dollars have affected the maintenance of some roads to such an extent that it is requiring much more reconstruction money to restore road templates for use with commercial activities. This makes it more difficult to produce commodities that have value to the community.

- ***Indicators for measuring or interpreting conditions***: miles of backlog road reconstruction
- ***Key Questions***: How can we best address road maintenance needs given the lack of funding currently available to do the job?

Issue: During timber sale activities we are not always able to do the degree of road reconstruction that we would like to do to benefit Threatened, Endangered and Sensitive species, such as replacing culverts because of short-term impacts that may get a determination from US Fish and Wildlife that the activity may likely adversely affect the species, even though it may benefit them in the long-term. This minimizes our ability to influence road impacts to resources in the watershed.

- ***Indicators for measuring or interpreting conditions***: conflicts in management direction with respect to roads and resource impacts
- ***Key Questions***: What and where is conflicting management direction, with respect to roads and resource impacts, occurring in the watershed? What management actions are needed to address this conflicting management direction?

Issue: Roads alter drainage patterns that feed streams, lakes and ponds by creating obstructions to the natural flow of water. Properly built roads allow subsurface water to drain naturally, but the very nature of roads tends to restrict and channelize surface water flow. A primary goal in road design and maintenance is to limit any detrimental effects caused by this flow of water. With limited road maintenance budgets, detrimental effects caused by restricted and/or channelized surface water flow will likely become a greater concern in the future.

- ***Indicators for measuring or interpreting conditions***: Miles of roads where drainage is causing detrimental effects such as sedimentation, etc.
- ***Key Questions***: Where are road drainage issues a concern in this watershed? Given limited road maintenance budgets, what can be done to minimize these drainage issues?

Use of Resources (Subsistence and Commercial)

Issue: A significant portion of the local economy is still dependent on the wood-products industry. Timber supplies from federal lands have fluctuated significantly over the last 15+ years and so too have local jobs. Stability in the supply of timber is a concern for these industries.

- ***Indicators for measuring or interpreting conditions***: average annual volume of timbered offered
- ***Key Questions***: What level of timber harvest can be sustained on the landscape while meeting other resource objectives in this watershed?

Issue: Local economic conditions may be driving more people into the woods to get special forest products to sell. It is difficult to determine a sustainable level of harvest for these products. In addition, illegal special forest product gathering is increasing because of less USFS presence on the land.

- ***Indicators for measuring or interpreting conditions***: law enforcement actions with respect to special forest products
- ***Key Questions***: Where and how can special forest products be offered? What level of harvest of special forest products is sustainable for the long-term? How can illegal gathering of this resource be successfully reduced/eliminated?

Issue: Increases in technology may result in more permits issued for things like cell towers, seismic studies, etc. Some of these technological facilities may be in conflict with other resource values.

- ***Indicators for measuring or interpreting conditions***: permits issued
- ***Key Questions***: Where and how can technological facilities be utilized/located in the watershed to address societal needs while still protecting other resource objectives?

Recreation

Issue: As the population ages, the type of recreation use is changing (i.e. demand for more motor home spaces over tent spaces and short hikes versus longer ones).

- ***Indicators for measuring or interpreting conditions***: demand for different recreation facilities than currently provided
- ***Key Questions***: Where and how can the changing demand for recreation facilities meet user needs, especially given current budgets? What creative ways can be utilized to meet recreational objectives with these increasing demands and shrinking budgets?

Issue: District-sponsored Heritage-Hikes have been very successful. As a result of these hikes and some promotional advertising, there has been increased interest in the Santiam Wagon Road and recreational use in the area. This increased use has necessitated some transportation improvements that require maintenance, adjacent to facilities here. A time of increasing use at a time of decreasing budgets limits the ability to accomplish needed improvements/maintenance.

- ***Indicators for measuring or interpreting conditions***: Unmet need for facilities based on demand
- ***Key Questions***: Where and how can unmet recreational needs be addressed in times of decreasing budgets?

Issue: The "Catchable Trout" program in which hatchery rainbow trout were stocked in the South Santiam River for recreational fisheries was dropped to remove competition between the rainbow trout and threatened winter steelhead and spring Chinook salmon. This has reduced recreational fisheries in the river and has affected early-season campground use by the fishing public.

- ***Indicators for measuring or interpreting conditions***: recreational fishing opportunities in the watershed
- ***Key Questions***: Where and how can recreational opportunities for fishing be addressed in this watershed? Where and how does the change in fishing recreational opportunities affect other recreational use of the area?

Issue: Road management decisions and activities have affected the amount of use at existing dispersed recreation sites. It has redirected some dispersed use, especially driving, on fewer road miles.

- ***Indicators for measuring or interpreting conditions:*** dispersed recreational opportunities affected by road management decisions
- ***Key Questions:*** Where and how can dispersed recreational opportunities best be addressed in our road management decisions?

Issue: Designation of Highway 20 as a Scenic Byway will likely contribute to increased recreational use here. Current funding is inadequate to maintain forest roads to recreational attractions off of Highway 20 to planned safety and environmental standards.

- ***Indicators for measuring or interpreting conditions:*** Access to attractions associated with Scenic Byway
- ***Key Questions:*** Where and how can management best address road safety and environmental issues to attractions associated with the Scenic Byway, given decreasing road maintenance budgets?

Issue: Increased fees for disposing of household waste have resulted in trash dumping along forest roads in the lower watershed.

- ***Indicators for measuring or interpreting conditions:*** illegal dumping sites
- ***Key Questions:*** What are the best ways to minimize or eliminate illegal dumping on forest lands, especially in areas close to population centers?

Issue: Current economic conditions have left some people homeless causing some of them to established camps in the lower part of the drainage.

- ***Indicators for measuring or interpreting conditions:*** homeless camps
- **Key Questions*:*** What are the best ways for management to address homeless camps in this watershed?

Issue: There is more ATV traffic on the road systems now than in the past. This has the potential to degrade the road prism and result in associated resource damage (i.e. sedimentation). This is especially a concern when it causes damage to roads that have been decommissioned or otherwise closed to vehicular traffic.

- ***Indicators for measuring or interpreting conditions***: miles of roads damaged by ATV use
- ***Key Questions***: Where and how should ATV use on forest roads be managed? What is the most effective and enforceable way to close roads to ATV traffic and meet resource objectives?

4.1.3 Current Conditions: *What are the current conditions and trends of the relevant human uses in this watershed?*

Settlements

Within the watershed there are permanent residences in Upper Soda and in a few places along the South Santiam River corridor. In addition, there are 10 recreational residences at Fernview summer home tract near Fernview Campground. These recreational residences are occupied on a part-time basis. There has been increased use of the forest by homeless people noticed mostly along Moose Creek, Squaw Creek and a couple of spur roads in Canyon Creek.

Just to the west of the watershed lie the communities of Cascadia, with a population of 45, and Sweet Home, with a population of 8,200.

Trends: The communities within the watershed are not likely to change much in the near future because they are fairly remote and offer few amenities or jobs. Homelessness and the use of the forest by homeless people will likely continue into the future.

Just outside the watershed, the City of Sweet Home is diversifying its economy and has been growing fairly steadily in recent years. It has become less dependent on the timber industry than it has been in the past and this is likely to continue into the future.

Travelways and Transportation

Highway 20 is a major travel corridor between I-5 and the crest of the Cascades. It attracts people to, and is the primary access for, the upper South Santiam watershed and has been for decades. The highway is the starting point for many backcountry roads providing access to forest lands in the area.

Currently this windy, mountain highway crosses several active slump/earthflows and areas of unstable ground which are prone to slope failures during heavy rainfall. This portion of the highway requires constant maintenance and is a concern for traveler safety.

Recently, the *Over the Rivers and Through the Woods* State Scenic Byway was designated along Highway 228 from its junction with I-5 to the junction with Highway 20 near Sweet Home. The byway then turns east along Highway 20 to the junction with Highway 126, near the crest of the Cascades. The entire stretch of Highway 20 passing through this watershed is part of that scenic byway.

Trends - Highway 20 will continue to serve as a major east/west travel corridor through the Cascades. It is likely to attract more travelers in the future because of its designation and promotion as a State Scenic Byway. This could possibly attract some funding to address some of the safety issues associated with this highway.

Forest Roads: In this watershed, the road system represents a large capital investment that provides administrative, recreational and commercial access to large tracts of forest lands. There are about 362 miles forest roads accessing public and private lands in the watershed. The chart below shows the miles of various types of roads within each subwatershed and for the entire South Santiam watershed. Road densities here average 2.43 miles per square mile.

Table 33: **Miles of Road by Maintenance Class**

Subwatershed	Basic Custodial Care (closed)	High Clearance Vehicles	Suitable for Passenger Cars	Moderate Degree of User Comfort	Total Road Miles
	Mtce. Level 1 road miles	Mtce. Level 2 road miles	Mtce. Level 3 road miles	Mtce. Level 4 road miles	
Moose	1.6	44.21	6.68	0	**52.49**
Canyon	0	25.53	12.97	0	**38.5**
Owl	1.41	19.58	7.37	0	**28.36**
Sevenmile	1.43	39.45	17.83	0	**58.71**
Sheep	3.01	23.29	11.98	0	**38.28**
Soda Fork	1.54	37.34	16.68	0	**55.56**
Trout	0.09	34.49	12.28	0.74	**47.6**
Upper Canyon	0.17	30.09	12.39	0	**42.65**
Watershed Totals	**9.25**	**253.98**	**98.18**	**0.74**	**362.15**

Trends - In recent years, reduced harvest levels on federal lands have resulted in less money available for the maintenance and care of the existing transportation system. For this reason, the road system was analyzed and many miles of roads have been obliterated, or stored and storm-proofed for later use. On many of the roads that are left open, maintenance levels are being downgraded because the roads cannot be maintained at currently prescribed levels. This has reduced the ability to manage maintenance-level III roads in accordance with Highway Safety Act requirements so recently many maintenance level III roads were proposed for downgrading to maintenance level II.

Overall the condition of the entire, federal transportation network is degrading as miles of deferred road maintenance are adding up. Roadside vegetative growth is not being controlled in many areas, causing some roads to narrow and eventually grow closed. Road surfacing is also not being done as often as in the past.

These management actions will change where people can go. Roads on public lands will be less accessible due to lack of surface and roadside maintenance and fewer miles will be available because some roads have been obliterated or decommissioned. Fewer open roads on public lands have increased the recreational pressure on roads on private industrial lands in the watershed. Owners there are putting more

restrictions on public use of their lands because of increasing vandalism, fire risk and other liability concerns.

Use of Resources (Subsistence and Commercial)

The economy of east Linn County is intertwined with the forested, mountainous lands that comprise its geography. Changes in management of National Forest lands have changed the relationship between those lands and the communities that are their neighbors. Timber harvest levels have decreased dramatically in the last 15 years and the type of harvest has moved from mostly clearcutting on public lands to mostly commercial thinning. In addition, the prices now being paid for wood fiber have changed how and when industrial as well as non-industrial forest landowners harvest their timber resource, a factor especially in the west end of the watershed.

Access to wood for home heating has been much more limited, affecting those on the margins of financial well-being the most. The decline of timber-industry-based employment has increased the harvest of special forest products as people are still trying to make a living off the forest resource that surrounds them. There is little information available to make management decisions on levels of sustainable harvest for many of these products. Federal lands also have an important role to play in supporting tourism and other areas of local economic diversification.

Trends: Local communities have started to rebound from the economic downturn that resulted from decreased harvest levels on federal lands in the late 1980's and 1990's. They have started to diversify their economies and are less dependent on the wood-products industry, although it is still a major player in the local economy.

Recreation

Developed Recreation: The following campgrounds are located within the upper South Santiam watershed: Longbow Organizational Camp, Sevenmile Horse Camp, House Rock Campground, Trout Creek Campground, Yukwah Campground and Fernview Campground.

Yukwah Fishing Platform photo by Joanne West

Longbow Organizational Camp is a Civilian Conservation Corps historical group camp that was built in the 1930's. The camp is located on 10 acres and includes six alpine shelters, a covered cooking area, fireplace and amphitheater. Tents and trailers are not allowed at this site.

Sevenmile Horse Camp consists of four campsites, each with fire rings, and picnic tables. This campground also features horse corrals, water for stock, and a vault toilet.

Activities people participate in here include: camping, horseback riding, hiking and mountain biking.

House Rock Campground is located at the confluence of Sheep Creek and the South Santiam River in an old growth grove. People enjoy camping, picnicking, swimming, hiking and fishing here. The campground has 17 sites, five of which are for tents only. The remainder of the sites are tent, auto or small RV sites.

Trout Creek Campground has 24 sites for tent, autos or RV's. There are opportunities here for camping, picnicking, hiking, swimming, fishing and enjoying the viewpoint. This campground is due west of the historic Long Ranch that is now an elk refuge.

Yukwah Campground is located in a second-growth stand of Douglas-fir along the banks of the South Santiam River. It has 20 sites, all of which accommodate RV's and one site accommodates groups. People using this campground fish, camp, swim, and hike the interpretive trail along the river's edge or in the Menagerie Wilderness.

Fernview Campground offers opportunities for camping, hiking, fishing and swimming at the 11-site facility.

Trends: People are generally spending less time on trips and demanding more services such as electricity, running water, and better toilet facilities. Campers come with well-outfitted RV's that they want to use to their fullest capabilities which often require electricity and running water. Their busy lifestyles don't allow for long, leisurely trips as in the past. In addition the cost of fuel is keeping people closer to home.

The season of campground use seems to be shifting. There used to be a lot of early season use when the fishing season began but once the river was no longer stocked with "catchable" fish, early season campground use has declined. The same is true for the fall during hunting season, but overall, there are probably as many people camping, but use is spread out over a different period of time.

There is an increasing trend toward fascination with motorized recreation and there is a more urban/suburban character to the recreational crowd using National Forest facilities. In addition, with the information age, people rely less on their own capabilities and desire to know as much as they can about something before they go do it. Internet searches are common ways to find out about the recreational information they desire.

Finally, there are more volunteer organizations partnering with us for recreation maintenance, etc.

Dispersed Recreation: The Santiam River corridor attracts a variety of recreational use. Dispersed opportunities here include camping, auto tours, fishing, hunting, berry picking, hiking, mountain climbing, horseback riding, backpacking, winter sports, river rafting, photography, and viewing wildlife to name a few. ATV use is increasing on forest roads here and a new National Forest policy is calling for designation of roads where this type of use will be allowed. If not designated for use, roads would be closed to this type of activity.

There are numerous dispersed sites scattered throughout the watershed. They are often located near streams or lakes.

The Santiam Wagon Road is a notable feature in the watershed that attracts hikers, horseback riders, mountain bikers and vintage automobiles.

Trends: Dispersed recreation seems to be changing. Younger people seem to be doing more extreme sports such as waterfall jumping in their kayaks and riding ATV's. There are more outfitter guides doing a variety of activities, possibly because people are more urban and less skilled in the out-of-doors. Many people want to recreate closer to home and they stay for shorter periods of time. They also tend to want short loop trails for day hikes. This may partially be due to aging population and busy lifestyles.

Dumping: A percentage of the population, mostly local, is illegally dumping trash, especially in the lower portions of the watershed. Part of the waste being dumped is kitchen trash but it also includes larger items such as propane tanks, batteries, refrigerators, tires, etc. This trash is often dumped in dispersed sites, just off the road and near water. This waste can have detrimental consequences to natural resources in the vicinity, especially in riparian areas.

Trends: Illegal dumping is probably growing because of the increased cost of properly disposing of waste materials.

Viewshed: From the 1990's until now, there is less harvest on federal lands and the type of harvest has changed from mostly clearcutting to mostly thinning. This has resulted in less visual impact on the landscape. In addition, trees have grown back in many cutover areas. On the other hand, harvest on private land has continued with both clearcutting and thinning occurring during that time.

Trends: The visual impacts of management activities are less apparent than in the past.

Wilderness: The Menagerie Wilderness is in a thick forest of second growth Douglas-fir, western hemlock and western redcedar. The primary use of this wilderness is day-hiking and rock climbing. Rooster Rock is the main destination. There are a series of rock pinnacles each uniquely named from the imagination of past climbers, hence the name, Menagerie. Mountaineers from around the Pacific Northwest use the spires and cliffs to hone their technical climbing skills. This is primarily a low elevation wilderness which can be used year-round.

Trends: The numbers of rock climbing enthusiasts who use this area have remained fairly stable.

Wild and Scenic Rivers: Under the Wild and Scenic Rivers Act, selected rivers which possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, are considered eligible for inclusion in the national wild and scenic rivers system and are classified, designated, and administered as one of the following: wild, scenic or recreational rivers.

The 1990 Forest Plan identified the South Santiam River and Sevenmile Creek as being eligible for designation under the Wild and Scenic Rivers Act. The 1995 Watershed Analysis evaluated these and validated the outstandingly remarkable recreation, fisheries, prehistoric and historic values of the South Santiam River and the scenic values of Sevenmile Creek. The analysis also determined that Sevenmile Creek should be further

studied for its prehistoric and historic values. In addition, the following creeks were recommended for further study for their potential Outstandingly Remarkable Values:

- Latiwi Creek – scenery *(waterfalls, vegetation, geology)*
- Moose Creek – Anadromous fish *(wild winter steelhead),* geology/hydrology *(landflow blockage)* and scenery *(engorged stream, clear water, lake)*

4.1.4 Social Domain Reference Condition: *What are the major historical human uses in the watershed, including tribal and other cultural uses?*

Settlements

Native Americans: The watershed was strategically important to people from the Willamette Valley, Cascades mountains, and plateaus of Central Oregon. The Mollala, Kalapooya and Warm Springs used the area on a recurrent seasonal basis.

Benches and terraces along major trail systems may have served as winter camps for the Cascade mountain-dwelling Mollala and also provided the base for summer use by the Willamette Valley-based Kalapooya. Summer base camps have been found in Owl, Sevenmile, and Upper Canyon subwatersheds.

The Tenino and Northern Paiute bands from Central Oregon used the eastern portion of this watershed for summer subsistence, religious, and trading activities at the time of contact. The upland glaciated flats near the headwaters provided locations for their base camps and resource exploitation.

This model of at least four different indigenous cultures sharing this watershed at the time of contact is very likely one that had occurred for millennia. Limited resources and shared need for survival created the necessity for inter-tribal relations.

The Homestead Era – Early settlers arrived in this area in the 1850's and tended to occupy the broad river terraces that are found along the South Santiam River as well as other low elevation areas on gentle slopes. Eventually people began to move farther up into the watershed and settled at Walton Ranch and in the communities of Cascadia and Upper Soda.

Tribal populations declined significantly as a result of disease introduced by these settlers. Descendants of these people are currently part of the Siletz, Grand Ronde, and Warm Springs reservations.

Early Twentieth Century - Homesteads in the upper parts of the watershed were abandoned when mining died out around the turn of the century because they could no longer support the families trying to live there. At this time the current ownership pattern began to take shape. The Hill family (now known as Timber Services Company) purchased the alternate sections along the South Santiam River that had been granted by the Federal government to the company who built the Santiam Wagon Road.

The Depression Era saw a busy Civilian Conservation Corps camp at Canyon Creek and a work camp at House Rock.

World War II and Post-War Era: After the war, Sweet Home, the major population center in the area, grew quickly. The 1950 census placed the population of Sweet Home at 3,603. By 1980 the population grew to nearly 7,000 and in 2005 it is over 8,200.

Travelways and Transportation

Native Americans: The initial access to the South Santiam area was a trail system created by the indigenous people. Major travelways for trade and subsistence consisted of the South Santiam River corridor, an east/west route between the Willamette Valley and central Oregon and the Mollala trail, a north/south route that followed Canyon Creek and Moose Ridge between Tidbits Mountain and Cougar Rock.

The Homestead Era: Access was later modified by trappers, grazing permittees, and early Forest Service administrative needs. As early pioneers began to settle here, the need for a better transportation system was recognized. The first roading began in 1861 with the construction of the Santiam Wagon Road. The old Santiam Wagon Road was scouted in 1859 in hopes of finding a way from the Willamette Valley to the excellent grazing lands in Eastern Oregon. In 1865 the road was completed. It became one of the main east/west travel corridors for the area This road allowed people to move farther up into the watershed. In 1866 the company managing the road was granted a charter to charge tolls.

Santiam Wagon Road

By 1891 there was heavy traffic on the road. Hundreds of wagons were hauling wool from Eastern Oregon ranches to the woolen mills at Waterloo and Brownsville and thousands of cattle and horses were driven over the road to rich pasture lands in eastern Oregon.

Early Twentieth Century: In 1905, the first automobile to cross the continent came down the Santiam Wagon Road and through this watershed. Local pressure was generated for the establishment of a State Highway along the Santiam Wagon route and the last toll on the wagon road was charged in 1921. The road was sold to Linn County in 1925.

The Depression Era: Construction of Highway 20 as far as Cascadia was completed in 1930 and the railroad made it to the area in 1931. The Civilian Conservation Corps built and improved trails, lookouts and roads accessing the lookouts on Iron and Jumpoff Joe mountains.

Construction of Highway 20 pushed farther east, following part of the old Santiam Wagon Road. In about 1936, road construction activities ignited a fire which burned a large part of Sevenmile watershed. The highway was completed in 1939 and a dedication was held at Lost Prairie on September 3, 1939 with more than 1500 people in attendance. The completion of Highway 20 not only served as a conduit for east/west commerce and trade, but also became an important part of the economic base of local communities.

World War II and Post-War Era: The principal timber management transportation system for the area began in the late 1940's with access to the private land interspersed with the national forest system lands. These facilities began off of Highway 20 at the bottom of the major drainages emptying into the South Santiam River including: Canyon, Moose, Soda Fork, Sheep, Latiwi, Falls, and Deer creeks. The growth of the system continued with cooperation between the USFS and the private parties through cost-share agreements for the major areas beginning in 1965. The majority of the transportation system was in place on private lands by the 1960's and on National Forest system lands by the late 1980's. Around 362 miles of access roads now exist within the watershed with minor expansion occurring each year.

In the period between the late 1940's and 1975, road location and construction techniques differed from techniques used today. In the 1940's and 50's log culverts were used and beginning in the 1960's metal culverts became the norm. For many years organic debris was buried in road fills and excess excavation material was side cast or put over the side of the hill. In addition, road fills were not always compacted and road grades were limited to 8% because loaded log trucks could not negotiate steeper grades. Finally, the density of roading was dictated by what was needed for timber management.

Later, land managers began to discover that:

- log culverts rotted and did not perform their intended function
- many metal culverts were undersized for winter storm events and sometimes got plugged causing water to back up behind them, resulting in road failures
- organic debris in road fills decomposed causing fills to settle and culverts to buckle
- side-cast material and uncompacted road beds sometimes became saturated and triggered landslides that took the roads with them
- road grade limitations limited flexibility in fitting roads to the lay of the land
- high road densities had negative impacts on fish and wildlife.

During this period, road failures contributed both fine and course sediment to streams. Accumulated road failures in large storm events exacerbated the situation. It is estimated that erosion rates during this period were equal to natural processes.

In the late 1970's geologists and transportation planners were hired. At that time there were major advances in transportation planning and road construction techniques. This included end-hauling road excavation material rather than side-casting it, compacting road fills, elimination of burying of organic matter in road beds, changes in road grades and alignments to fit the landscape since newer trucks could better negotiate the grades, and road locations that were determined with geotechnical input, etc. In addition to improving construction of new roads, a lot of energy was spent stabilizing old roads. From the late 1970' to about 1990 there was still a fairly aggressive road construction program in the watershed.

In the early to mid-1990's fewer dollars were available to maintain the large transportation network that developed in the watershed because timber sale revenues,

that had paid for the majority of past road construction and maintenance, had declined significantly. Access and travel management, prior to this time, reflected a philosophy that the District and its travel corridors were open unless designated otherwise. This philosophy began to change with the budget declines. Decisions had to be made about the best way to manage the transportation system with small budgets. The 1990's and early 2000's brought many miles of road closures and decommissioning to meet both resource needs and budget constraints resulting from a decline in timber harvest and an associated decline in revenues to maintain the road system.

Use of Resources (Subsistence and Commercial)

Native Americans made summer trips into the area for berries, deer and salmon. They foraged, hunted, and held religious activities here. To increase their hunting and gathering success, they regularly used fire on the landscape.

The Homestead Era – Early settlers used resources found in the watershed mainly for subsistence.

In the 1880's there was a mining boom in the area. Most of the mining took place in the Quartzville and Calapooia watersheds since mineralization is rare in this watershed. However hunting to support the mining population increased dramatically. Elk were hunted extensively for hides and antlers as well as food.

Grazing of domestic livestock in Gordon Meadows probably began around this time.

The need for wood from the forests in the watershed also increased but was still minimal. Most logging occurred in the areas closest to the Santiam Wagon Road and in the westernmost part of the watershed. The first sawmills were built here in the 1850's to supply lumber for homebuilding in the local area.

Early Twentieth Century - Around the turn of the century mining activity died out agriculture was the economic mainstay of the community.

The Cascade Forest Reserve was established in the area that is now the Willamette National Forest but not much timber harvest occurred in the watershed because wood was more accessible and more economical to log west of the watershed and many of the stands that were accessible from the Santiam Wagon Road and Highway 20 burned in the 1856 and 1911 fires and still contained relatively small trees.

The Depression Era - The watershed was no longer just a conduit for east/west commerce and trade but was becoming an important part of the economic base of the community. By 1939 there were 4 major sawmills operating in Sweet Home.

World War II and Post-War Era: Timber harvest in the watershed increased in order to support the war effort and national post-war housing needs. The timber industry replaced agriculture as the economic base of the local communities. Initially, most of the

harvest occurred on private lands but in the late 1940's, timber harvest began on public lands in the watershed as well.

The 1950's brought the consolidation of many smaller mills and land-holdings into the large industrial ownerships found in the watershed today. These mills depended on this and other nearby watersheds for their timber supply. For the next half century, the wood products industry played an important role in the lives of local residents.

In the 1960's, timber harvest on public lands increased dramatically in response to the economic development needs of the nation and the local communities. The community also began experiencing boom/bust cycles tied to the national housing market.

Forest management practices were quite similar on both public and private lands in the watershed. This is particularly evident in the Soda Fork subwatershed which contains the largest area of checkerboard ownership in the watershed.

Construction of Foster Dam began in 1961 and was completed in 1968. It was built to provide flood control, electrical power and water recreation.

The late 1960's and 1970's brought enactment of many of the environmental and land management laws that influence this landscape today. The first Willamette National Forest Land and Resource Management Plan was completed in 1977. The Oregon Department of Fish and Wildlife started working with the Forest Service on elk management. Heavy timber harvest continued on public and private lands and unit size restrictions were put into place.

Timber harvest began to peak and by the end of the 1980's environmental concerns and public interest in management of public lands increased. Sweet Home mills had been producing about 1% of all the softwood used nationally and this watershed became a microcosm of the conflict developing over management of the National Forests. What had been local issues became national issues. The growing debate over old-growth and the Northern spotted owl was highlighted by events in the Three Creeks area (Menageris and Sheet subwatersheds) during the second round of land management planning. Even individual old trees became an issue. Anadromous fish, and particularly salmon, also became an issue.

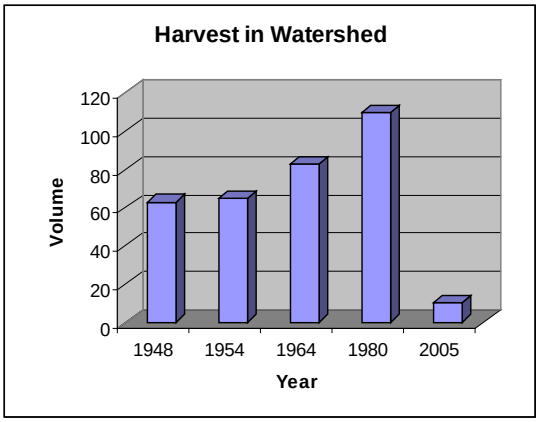


Figure 27 *shows timber harvest by decade*

During the 1980's, forest management practices on public and private lands became substantially different. Silvicultural practices in the stand reinitiation and stem exclusion seral stages became much more intensive on private lands (thinning, fertilization, pruning, brush control, etc.) Use of herbicides was restricted on National Forest lands and logging

prescriptions became more restrictive. On the National Forest lands instead of removing wood from the streams, wood was starting to be put back into the channels. Road closures for protection of wildlife and other resource concerns became more common.

Timber supply from public lands was curtailed. In the late 1980's, eastern Linn County hit economic hard times. Mill closures were a common occurrence and resulted in an unemployment rate that often exceeded 10%. Unlike previous downturns, this one was not tied to a national recession or bad housing market.

Environmental issues forced the closure of mills and logging operations resulting in a major decline in industry and population for Sweet Home. The population in 1980 was 6,960 and over the next decade it dropped to 6,850. Historically, employment in Sweet Home was dominated by the wood products industry which accounted for about 23% of the total employment in 1990 and dropped to about 16% of total employment by 1997. (*Sweet Home Housing and Economic Analysis 1991).*

The 1990's saw dramatic decreases in timber harvest levels and increased environmental protection measures. In 1990 the second Willamette National Forest Land and Resource Management Plan went into effect. During this time Gustina Land and Timber Company joined Timber Service Company and Willamette Industries as major industrial land owners in the watershed. In addition, there was an increasing awareness of the importance of working the Native American tribes on resource management issues on public lands. In 1994, the Northwest Forest Plan went into effect. The local business community began diversifying and retirees began moving into the area. Economic recovery slowly began to take place and unemployment began to drop.

The 1990 Farm Bill helped with the economic recovery of the area. The community of Sweet Home established the Sweet Home Economic Development Group and Linn County communities joined to establish the East Linn County Economic Development Alliance to respond to the need to diversity the local economy. The Sweet Home Ranger District participated in both groups. These groups identified the following strategic goals and objectives for developing a sustainable economic base for the area:

- Maintain and/or enhance the livable environment
- Maintain forest-based employment and diversify the uses of wood fiber
- Expand the economic base by developing commercial and industrial sites
- Develop recreation and tourism capacity with a focus around the lakes, rivers and trail system in the area.

Sweet Home weathered the economic changes during this recession and has begun to prosper in recent years. The downtown corridor was revitalized using federal grant dollars and the city attracted several businesses to the community. Since 1990 the population grew steadily at about 1.6% per year to an estimated population of 8,238 in 2003.

Recreation

The Homestead Era – After construction of the Santiam Wagon Road in the 1860's, access to this area was easier and Cascadia became a popular mountain resort because of its mineral springs, abundant fish and game, camping and swimming opportunities.

The Depression Era - The Civilian Conservation Corps built Longbow Organizational camp and the bulk of the other campground facilities in the watershed between 1934 and 1936. With the completion of Highway 20 in 1939, these facilities received heavy use. The resort business in Cascadia later became unprofitable and in 1940 the land was sold to the State of Oregon to eventually become Cascadia State Park.

World War II and Post-War Era - Other uses of the forest increased during this time. Campgrounds such as Trout Creek and Fernview were constructed and there were increases in all types of dispersed recreation activities. In the 1950's limited funding was available for maintenance of existing campground facilities and by 1958 many facilities were in poor condition. In the 1960's existing campgrounds were rehabilitated and Yukwah Campground was constructed.

1980's to Present: Since about 1980 recreational use of public lands has doubled. Along with increased use has come a simultaneous increase in the number of types of recreational activities taking place. In addition to traditional outdoor activities, such as hunting, fishing, hiking, horseback riding, camping, boating, biking, and rock climbing there is also a myriad of new, extreme and adventure-based recreational activities such as waterfall jumping in kayaks, hang gliding, riding ATV's, geocaching, heritage hikes, etc. campgrounds, maintaining trails, addressing a backlog of facility maintenance needs, providing needed facility upgrades and, reducing vandalism, etc.

4.1.5 Synthesis and Interpretation Social Domain: *What are the causes of change between historical and current human uses? What are the influences and relationships between human uses and other ecosystem processes in the watershed?*

Table 34 **Causes of Change between Historical and Current Human Uses**

Changes between historical and current human uses	Natural Causes of Change	Human causes of change
Settlements		
• Indigenous people's use of watershed has changed significantly • Some settlement areas were disbanded because of poor economics at the turn of the century. • Other settlement areas were covered by Foster Reservoir. • Most settlements now are permanent and are concentrated in cities but numerous individuals have settled mostly along the river corridor. • Some homeless people have set up residence on the National Forest		• Most indigenous people were moved to reservations after early settlers came to area. • Availability of jobs or ways to make a living • Construction of reservoir • Increasing population • Poverty
Travel and Transportation		
• Main transportation routes have changed from foot travel to horses to cars. Narrow foot trails have given way to wider, surfaced roads for use by automobile.		• Invention of automobile
• Miles of roads increased dramatically, especially during the heyday of timber harvest between the 1940's and 1980's.		• Human settlement was the initial driver of transportation development, then the driver became timber harvest.

Changes between historical and current human uses	Natural Causes of Change	Human causes of change
Transportation (continued)		
Management of the transportation system has changed. • Road analysis done to decide a) which roads are needed currently to access federal, and private land for public use, resource management and protection, b) which roads should be stored for later use and c) which roads should be decommissioned or eliminated. • Road maintenance levels reanalyzed for many Level III roads. Most where changed to Level II to save money and because of inadequate funding to maintain roads to standards that meet Highway Safety Act requirements • Maintenance Level 1 roads, which are intended to be closed to vehicular traffic, in the past may have received more than basic custodial maintenance. Now funds are not available to do this. • Less road maintenance being done and many roads are beginning to brush in • Road closures resulting in concentrating use on fewer roads.	• Environmental concerns – wildlife, hydrology, fisheries, etc.	• Decrease in timber harvest has resulted in fewer dollars available to manage/maintain the transportation network difference recreational experience vs. those who want access, protect investment, no longer needed (not harvesting-don't need except for fire access, private, etc).
• Designation of Highway 20 as a State Scenic Byway and promotion of Santiam Wagon Road will likely increase tourist traffic in watershed.	• Scenic beauty and natural resources draw people to area	• Marketing and advertisement to attract tourists to use these roads
• Increased ATV use on forest roads. Of particular concern is use on closed and stored roads		• Popularity of ATV's and more demand for urban-type recreation on forest lands
• ODOT shifted from cinders to chemical deicer		• Environmental concerns

Changes between historical and current human uses	Natural Causes of Change	Human causes of change
Transportation (continued)		
• Renamed 2044 to the Latiwi road		• Societal awareness of derogatory connotations of previous names
• Hwy 20 is in worse condition than in 1995 because of earthflows. ODOT got money to study instability along the highway.	• 1996 flood • Natural instability	• Construction of highway on active landflows
• Some of our earliest storm proofing was done prior to 1996 flood. This made a difference in the number of failures we had.	• Vegetative growth	• Geologic and geotechnical input on road construction/rehabilitation
• Have infrastructure in place and more advanced logging systems so don't have to build as many roads		• Use of helicopters, processor forwarders, etc.
• Road construction techniques changed over time. Now there is less surface erosion and road fill failures than in the past.		• Better trucks • Roads located with geology input, better fit the lay of the land, • Excess material is end-hauled, • More appropriate drainage structures, etc.
• The extensive road system has substantially increased the drainage network. This is especially evident in Upper Canyon and Owl subwatersheds.		• Road construction techniques – drainage structures, etc.
• Exchange of ownership of private lands – must keep up with easements changing hands.		• Checkerboard ownership • Philosophies change with ownership. It depends on who owns the land as to how they provide access.

Changes between historical and current human uses	Natural Causes of Change	Human causes of change
Use of Resources		
• Gathering and hunting gave way to farming and now most people purchase most of their food from stores.		• Population increases and commercial agriculture contributed to these changes
• Timber harvest on public lands has decreased substantially from harvest levels in 1940-1980's.		• Changes in management goals based on public concerns for resource impacts from harvesting and road building practices
• Changes in harvest prescriptions from mostly clearcutting to mostly commercial thinning on public lands		• Changes in management goals • Public concerns about environmental effects of clearcutting
• More special forest products being utilized		• Increased employment opportunities from greater variety of forest products • Developed new uses for various forest products
Recreation		
• Recreation road use has increased 10 times from the 1950 rate		• Increased population • Improvement in automobiles, recreational vehicles and transportation network
• Use is changing from activities such as backpacking to RV camping, for example. Use is more urbanized such as ATV's.		• Population is aging and is more affluent • More urban-based population • Latest fad- ATV industry is providing family riding machines
• Decreased fishing use in watershed because fishing is catch and release only. Hatchery fish are not being placed to minimize competition with threatened fish.	• Reduction in winter steelhead and spring Chinook salmon populations	• Fishing rules changes in effort to protect threatened fish populations

Changes between historical and current human uses	Natural Causes of Change	Human causes of change
Recreation		
• **Use is changing and includes both traditional uses such as hunting, fishing and camping as well as** new, extreme and adventure-based recreational activities such as hang gliding, riding ATV's, geocaching, heritage hikes, etc. • There are also more outfitter guides on the landscape--- doing a variety of activities		• More people with varied interests have access to recreational opportunities here because of better transportation system, etc. • People are more urban and may be less skilled so use guides more • Technological advances in equipment • Thrill-seeking youth
• Hunting patterns have changed. Fewer hunters on National Forest lands because animals have moved onto private lands	• Tree growth in plantations	• Less forage on public lands due to reduce clearcutting • Less road access because of road closures
• Over the last five years, we have reduced the number of recreation sites in the fee demo system and that makes more free recreation sites available to the public		• Public policy changes
• Added and improved sanitation systems along Highway 20 at developed sites and trailheads. (Had aging facilities that needed to be replaced and popular trailheads needed basic health and safety and to maintain recreation setting.)		• Increased public demand • Resource protection requirements

Changes between historical and current human uses	Natural Causes of Change	Human causes of change
Partnerships and Research		
• Restoration of traditional Native American uses such as huckleberry gathering, meditation sites, camas planting, etc. • Reconnecting Native American youth with their culture		• Better communication between USFS and tribes • Development of partnerships with tribes • Better understanding and communication between governments
• More volunteer organizations partnering with USFS to do various habitat enhancement projects, monitoring, recreation maintenance, etc.		• Development of partnerships
• Central Cascades Adaptive Management Area was established by the President's Plan to facilitate the tie between resource management and research on Federal lands and economically sustainable communities. This watershed provides an opportunity to work in creative ways to integrate the needs of the local communities, tribes, plant and animal communities and the larger social framework of the state and nation. • More agencies are doing studies here including the EPA, DEQ, OSU, U of O		• Increased interest in management of public lands • Finding ways to better manage natural resources to meet resource objectives

Table 35 **Influences and Relationships between Human Uses and Other Ecosystem Processes**

Human Uses	Influences and Relationships between human uses and other ecosystem processes
Settlement	• Location of settlements can affect wildlife habitat use • Infrastructure from settlements has affected the ability of the South Santiam River to fully utilize its traditional floodplain thus affecting its ability to dissipate stream energies
Transportation system	• Road system made more of the watershed accessible to the general public for recreation use and firewood gathering. • Designation of the Santiam Wagon Road as a recreation trail complements east Linn County's Strategic Action Plan's recreation and tourism objectives. Use here will likely increase. • Designation of Highway 20 as a State Scenic Byway will likely attract tourists to the watershed. • Walton Ranch provides opportunities for education and interpretation of examples of old homesteads along the Santiam Wagon Road. • Dispersed recreation use occurs throughout the watershed. Some of this dispersed use is occurring on closed and decommissioned roads. • Landings have attracted dumping of trash including garden waste which can contribute to the spread of non-native plants, especially blackberries.
Use of Resources	• Use of the Walton Ranch as a homestead which has been grazed for 130 years, has narrowed the area of riparian vegetation on that side of the S. Santiam River. This river terrace would have a stand of conifers and alders if not for the grazing history. • Timber harvest and road construction has fragmented and affected use of habitat, reduced shade adjacent to stream channels, affected erosion rates, etc. • Road construction and use has created vectors for disease, non-native plants, point source pollution such as erosion and road failures, hunting pressure, fire starts, etc. • Road construction has enabled fire suppression, provided more recreational access, etc.
Recreation	• Hunting and fishing have affected fish and wildlife populations • Dispersed camping, ATV use etc. can cause soil compaction and erosion.

4.1.6 Recommendations: *Which of the changes in the ecosystem condition and function require management action to achieve management objectives?*

Changes requiring management action	Management objective	Recommended management actions	General location	Indicator used to measure success	Recommended monitoring, research or data gaps
• Travelways and Transportation					
Long-term transportation needs	• Maintain a safe, environmentally sound and economically efficient road network that meets land and resource management objectives and is responsive to both administrative and public access needs • Reverse adverse ecological impacts associated with roads • Maintain access to private lands	• Analyze transportation system to determine which roads to perpetuate, store or eliminate • Roads should be stored in a manner that minimizes the risk of slope failures, etc. • Identify the minimum road system that is commensurate with resource objectives, reflects available and projected funding, and minimizes adverse environmental effects • Identify unneeded roads that should be decommissioned and prioritize decommissioning to roads that pose the greatest risk to public safety or environmental quality • Survey and eradicate noxious weeds before closing roads. Allow red alder to invade road beds to shade out weeds. Seed high elevation roads with native herbaceous species.	• Entire watershed	• *Indicator:* Efficiency and effectiveness of transportation network in watershed • *Expected response:* Transportation network would become smaller and more efficient • Duration: long-term • Certainty: high	• Monitor to ensure that transportation network meets management objectives • Monitor the effect of recreational use of decommissioned roads on accomplishing the treatment objectives for those roads. • Data needs – updated transportation system changes in GIS system

Changes requiring management action	Management objective	Recommended management actions	General location	Indicator used to measure success	Recommended monitoring, research or data gaps
Highway 20 crosses several active slump/earthflows and is prone to failure during periods of heavy rainfall. The failure-prone road contributes varying amounts of sediment into stream channels during storm events. poses safety concerns for highway travelers, requires constant and expensive road maintenance and a need for waste areas to place debris that has come onto the road prism	• Maintain Highway 20 as major east-west travel route • Meet public safety regulations • Minimize adverse ecological impacts associated with Highway 20 • Maintain slow, windy, scenic character of the road • Support addition of turn lands for safety	• Encourage development of a viable and effective solution to potential resource impacts and safety issues associated with the failure-prone section of Highway 20, while maintaining this east/west travel route and it's slow, windy, and scenic character. • Support addition of turn lanes for safety on Highway 20 • Maintain waste areas and gates for Highway 20	• Highway 20	• *Indicator:* Improvement of failure-prone section of Highway 20 • *Expected response:* improved safety and resource impacts in failure-prone section of highway • *Duration:* long-term • Certainty: low	

Changes requiring management action	Management objective	Recommended management actions	General location	Indicator used to measure success	Recommended monitoring, research or data gaps
Funding available to maintain road system	• Road crossings should accommodate 100-year floods as the opportunities arise • Reduce cost of maintaining road system • Roads that are stored should be done in a manner that minimizes the risk of slope failures, etc. • Minimize adverse resource effects resulting from the reduced road maintenance	• Accommodate 100-year flood crossing on roads as plan new projects • Prioritize roads requiring maintenance • Continue to work with cost share partners on road maintenance • Review/revise/initiate road management objectives as opportunities arise during project planning and implementation (i.e. timber sales, etc.) • Find alternative funding sources like stewardship projects to accomplish some work we need to have done that we can't afford	• Cost share areas • Level III roads • Project areas • Anadromous and/or sensitive fish population areas	*Indicator:* Economic efficiency and accomplishment of road maintenance *Expected response:* Road maintenance will become more efficient and cost effective *Duration:* long-term *Certainty:* high	• Monitor roads in INFRA

Changes requiring management action	Management objective	Recommended management actions	General location	Indicator used to measure success	Recommended monitoring, research or data gaps
Use of Resouces					
Widely variable timber supply	Provide a sustainable supply of timber while meeting other resource objectives	• Utilize timber harvest as a tool as appropriate to meet various resource *objectives (ex: growing larger trees faster in LSR, develop big game forage, etc.)* • Establish harvest levels that are sustainable in the long-term and consider ecological limits of the watershed and land allocation requirements • Meet Forest Plan objectives for timber management in the various land allocations	Land allocations within watershed allowing timber harvest	• *Indicator*: Average volume of timber offered per year over time • *Expected response*: Similar volume offered annually	
Demand for a variety special forest products is increasing	Provide a sustainable supply of special forest products	Harvest special forest products in accordance with Forest Plan standards and guidelines, on a sustainable basis, while also meeting other resource objectives	Generally in the Matrix, AMA lands, but in other allocations as appropriate	• *Indicator*: based on results of research • *Expected response:* special forest products will be harvested on a sustainable basis	• Research method and criteria for determining sustainable supply of various special forest products • Monitor commercial moss and lichen harvest

Changes requiring management action	Management objective	Recommended management actions	General location	Indicator used to measure success	Recommended monitoring, research or data gaps
Because of checkerboard ownership, what private landowners do on their lands influences management on public lands	Improve our ability to manage the whole landscape regardless of ownerships	• Create partnerships with private industrial landowners to accomplish various resource objectives (fire management, fuels, fish, noxious weeds, road management, etc.) • Acquire private lands that are key to meeting identified resource objectives on public lands	Checkerboard ownership Canyon Cr,, Soda Fork, Moose,	*Indicator:* Number of partnerships established *Expected response*: Mutual projects accomplished	Monitor how successful we are at meeting our objectives
Firewood gathering	Provide firewood for local citizens to heat their homes	• Utilize opportunities to provide firewood to the public where feasible and practical while also meeting other resource objectives	Matrix and AMA	*Indicator*: cords of firewood provided *Expected response*: steady supply of firewood to public	
Local employment in wood products related fields has decreased in the local communities	Encourage local employment opportunities when implementing restoration or other management activities where appropriate	• Use methods of accomplishing watershed restoration and other management activities that provide stable, year-round employment opportunities for the local community	Entire watershed	*Indicator:* Employment opportunities in natural resource related restoration projects/mgmt activities Expected response: increased employment in these areas	

Changes requiring management action	Management objective	Recommended management actions	General location	Indicator used to measure success	Recommended monitoring, research or data gaps
Recreation					
• Increasing demand for recreation opportunities especially along Highway 20 corridor	• Provide recreational opportunities commensurate with demand and available budget	• Develop/update SHRD recreation Management Plan, Highway 20 Corridor Plan, Dispersed Recreation Strategy and Scenic Byway Strategy Plans • Implement recommendations in recreation management plan as funding becomes available • Promote recreational opportunities so visitors know wider range of activities available to them to enhance their enjoyment of the area and encourage longer stays in the area	• Along Highway 20	• *Indicator:* recreational opportunities available • *Expected response:* recreational opportunities will increase • *Duration:* unknown • *Certainty* low due to funding availability	
• User needs preferences and values - People are demanding more services such as electricity, running water, and better toilet facilities in developed campgrounds.	• Address recreational needs in an environmentally-responsible way	• Maintain/upgrade campground facilities to meet user needs as appropriate and as funding becomes available	• Developed recreational facilities	• *Indicator:* Campground use based on levels of available amenities • *Expected Response:* Use rates may change based on level of amenities desired by user	• Monitor campground use to see if it changes based on level of available amenities

Changes requiring management action	Management objective	Recommended management actions	General location	Indicator used to measure success	Recommended monitoring, research or data gaps
• Season of campground use is shifting. For instance, early season use for fishing is diminishing.	• Use recreation facilities and funding in efficient and effective manner	• Adjust season of operation to meet the user needs while also considering economics of operations	• Developed recreational facilities	• *Indicator:* use rates • *Expected Response:* more efficient campground operations based on use • *Duration*: long-term • *Certainty*: Mod.	• Monitor use rates and costs of operation
• Resource impacts such as compaction and loss of vegetation at some dispersed sites	• Decrease resource impacts and improve aesthetics at recreational areas	• Rebuild duff layer by adding wood chips, etc. in heavy use areas • Restore/rehabilitate resource damage in recreation sites • Close problem sites if necessary	• Recreation sites experiencing resource impacts	• *Indicator*: response of sites to treatments • *Expected Response:* reduced resource impacts	• Monitor resource impacts on dispersed sites
• Increasing ATV use and more extreme sports/activities	• Address recreational needs in an environmentally-responsible way	• Develop policies and provide consistent management direction for these activities • Identify areas where these activities will be allowed and where they won't be allowed.	• Entire watershed	• *Indicator*: consistent management direction for these activities	Monitor recreational use of decommissioned roads on accomplishing road treatment objectives

Changes requiring management action	Management objective	Recommended management actions	General location	Indicator used to measure success	Recommended monitoring, research or data gaps
• Reduced funding for maintenance and operation of recreational resources	• Maintain facilities at or above acceptable standards and meet public needs	• Develop partnerships to maintain recreational resources as budgets decline • Upgrade/install sanitary facilities at recreation use areas with sanitation issues, as needed where feasible • Improve parking and access at facilities as needed (including barrier-free access, etc.) • Correct existing traffic and facility safety issues • Narrow the range of recreation facilities to meet standards within budget constraints	• Various recreation sites within the watershed	• Indicator: recreation facilities meeting standards and needs • Expected response: recreation facilities maintained and operated to high standards and meet public needs	
• Illegal dumping, vandalism, user conflicts, etc.	• Minimize and/or eliminate these behaviors	• Educate public • Law enforcement presence in problem areas • Cite offenders	• Entire watershed especially near forest roads	• *Indicator*: amount of this type of activity occurring • *Expected response*: decrease in activity	
• Wild and scenic river study	• Further study	• Study and determine eligibility for Latiwi and Moose Creeks under the Wild and Scenic Rivers Act • Protect values that make these streams potentially eligible for inclusion in the Wild and Scenic Rivers system	• Latiwi, (scenery) and Moose Creeks (anadromous fish)	• *Indicator*: eligibility determined	

Changes requiring management action	Management objective	Recommended management actions	General location	Indicator used to measure success	Recommended monitoring, research or data gaps
• Scenic Byway Corridor Management	Encourage visitors to stay longer and return for additional visits	• Promote wider range of recreational activities adjacent to Byway • Implement Scenic Byway Interpretation Plan Recommendations and other projects that promote objectives for the Scenic Byway	Along Highway 20	• *Indicator*: amount of tourism along byway • *Expected response*: increase in tourism	
Other					
• Misc. small scale projects that may be proposed in the future	Implement small scale projects, as appropriate, that generally not alter the processes operating in this watershed	• Continue Heritage Hikes • Various, yet unknown projects will come up in the future. Implement these projects as appropriate	Entire watershed	• Indicator: variable depending on project • Expected response: with range of conditions expected in the watershed	Monitor misc. small scale projects to ensure they do not alter the processes operating in this watershed

Changes requiring management action	Management objective	Recommended management actions	General location	Indicator used to measure success	Recommended monitoring, research or data gaps
Heritage Resources					
Increased understanding of cultural importance of Native American traditional uses in the watershed	o Encourage Native American ceremonial and traditional uses in the watershed o Enhance communications and collaborative relationships with tribes	• Continue providing access to and restoring, as appropriate, traditional and ceremonial resources such as huckleberry, beargrass, camas, cedar, salmon, and elk • Continue restoration efforts at Camas Prairie and Cougar Rock Special Interest Areas • Protect/respect areas of traditional values, beliefs, practices • Continue building trust and strengthening relationships between Forest Service and tribes through regular communication and collaboration especially regarding management activities	Cougar Rock Special Interest Area Camas Prairie Other locations identified within the watershed	• *Indicator:* relationships with tribes and use of traditional and/or ceremonial places of importance in watershed • *Expected response:* improved relationships with tribes and increased use • *Duration*: long-term	
Increased interest by Native American youth in their heritage	Tribal youth participation in educational, project work and traditional use activities	• Utilize Walton Ranch as traditional encampment for Native American use • Involve Native American youth in native plant transplanting and seed collection • Involve Native American youth in various projects relating to their heritage and use of resources in this watershed	Walton Ranch Entire watershed	• *Indicator*: tribal youth participation • *Expected response*: increased tribal youth participation • *Duration:* long-term • *Certainty:* mod-high	

Changes requiring management action	Management objective	Recommended management actions	General location	Indicator used to measure success	Recommended monitoring, research or data gaps
Portions of Santiam Wagon Road are under private ownership	Consolidate ownership of Santiam Wagon Road from Fernview Campground to Forest Boundary	• Implement recommendations in Santiam Wagon Road Special Interest Area Plan • Acquire portions of Santiam Wagon Road between Mountain House and Fernview Campground	Santiam Wagon Road	• *Indicator*: miles of ownership of Wagon Road • *Expected response*: increased miles of public ownership	

Potential theories to test in Adaptive Management Area

Hypothesis	Recommended Management Actions
Firewood can be supplied in a way that meets community needs, is cost-effective to manage, and does not impair ecological processes	Test hypothesis
Harvesting of special forest products can be done in an ecologically sustainable way	Test hypothesis
Thinning and some special forest product harvest in Riparian Reserves can meet ACSO's	Test hypothesis
Riparian Reserves meet the ACSO's for terrestrial species	Test hypothesis
In-channel restoration structures are accomplishing their objectives.	Test hypothesis Include Moose Creek in OSU/PNW pool complexity study
An adequate quality and quantity of elk forage can be provided under partial canopy conditions.	Validate and/or adjust Wisdom Model for big game habitat
Silvicultural treatment in stand initiation, stem exclusion and understory reinitiation stands do accelerate development of late-successional structure.	Test hypothesis (tie in with young stand study and the very young stand study efforts)
Tall bugbane population viability is related to various small-scale disturbance processes	Test hypothesis