Cow Creek Watershed Analysis

Umpqua National Forest
Tiller Ranger District

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Executive Summary

The Cow Creek watershed is located in the southwest corner of the Tiller Ranger District on the Umpqua National Forest. The watershed analysis area encompasses approximately 37,937 acres, with 28,672 acres within the Forest Service boundary. There are 1,386 acres of Administratively Withdraw Area (the Cow Creek Trail), 2,451 acres of Late-Successional Reserves, and 20,260 acres of Matrix lands. There are approximately 4,500 acres of non-federal lands within the Forest Service boundary of the Cow Creek watershed.

The Cow Creek watershed is primarily within the Klamath Mountain geologic province, with a small area on the southeastern edge that lies within the Western Cascade geologic province. Eighty-nine percent of the watershed is either granite or schist. These soil types are susceptible to higher erosion and sliding potential. Due to concerns over the highly erodible nature of the basin, this watershed analysis was conducted, even though it is not required by the ROD.

There are approximately 150 miles of road within the analysis area that are under Forest Service jurisdiction. The miles of non-federal roads is not known. Road densities and channel extension are high in nearly all subwatersheds (WAA's). The average road density is 3.02 mi./mi.^{2} and average channel extension is 27 percent (or another 60 miles to the stream network). All of the roads are in the moderate, high, and very high risk categories for erosion and failures.

There are estimated to be 222 miles of streams within the Forest Service boundary. The upper Cow Creek watershed no longer supports an anadromous fisheries due to the construction of the Galesville Dam in 1985. Approximately 38 miles are Class II streams (resident fish). We expect to find cutthroat and rainbow trout in these streams. There are approximately 13,955 acres of riparian reserves (49 percent of the landbase). Canopy coverage in the smaller streams and tributaries to Cow Creek is good (75 to 100 percent). In the mainstem of Cow Creek starting in WAA N, the canopy opens up and Cow Creek widens downstream in WAA M as the channel becomes less constricted. Stream temperatures are cool throughout most of the watershed; they begin to rise in the wide, shallow part of the mainstem of Cow Creek. The maximum temperature was 75 degrees Fahrenheit in the summer of 1995.

Sediment is likely the most limiting factor to aquatic health throughout the basin. The East Fork, South Fork, and upper parts of Cow Creek are close to equilibrium. The lower parts of Cow Creek, the Applegate drainage, and Dismal Creek are primarily storage systems; fine sediments are stored in pools and behind large woody material, reducing spawning substrate and pool habitat.

The vegetation in Cow Creek includes the Mixed Evergreen and Mixed Conifer Zones described by Franklin and Dyrness (1973). It is near the northern limit of the former zone. Bailey et al. (1994) describe a Mediterranean Regime: Sierran Steppe-Mixed Forest within the Klamath Mountain Ecoregion that would include Cow Creek. Although Douglas-fir is by far the dominant conifer, several other species occur in the watershed. Most notably, Jeffrey and knobcone pines. Prior to modern management, fire was the dominant process affecting upslope and riparian vegetation, above the floodplain. It visited many sites as often as every 15 years and rarely missed a site for more than 100 years. Cow Creek's complex fire regime created equally complex and diverse landscape- and stand- level vegetation.

With the onset of modern management, that disturbance process has been interrupted. Thus, many fundamental ecosystem cycles have been interrupted: plant succession, nutrient cycling, and the life cycles of some individual plants. Timber harvest practices have dispersed high-intensity disturbance across 26 percent of the landscape. Fire suppression has virtually excluded it throughout the rest of the landscape. The result of this changed disturbance regime is a fragmented landscape, low in both early and late-seral vegetation, with high tree density that is reducing total species diversity. A knobcone pine/madrone vegetation type that doesn't appear to occur north of Cow Creek is particularly at risk. These practices have raised sustainablity concerns as well: excessive tree density is already causing high mortality among pines, directly as well as indirectly by insect attack; in addition, the accumulation of live and dead fuels has increased wildfire hazard.

Activities should be concentrated in WAA's that have already been heavily impacted by roads and harvesting (Applegate Creek, East Fork Cow Creek, and the north side of Cow Creek) in order to restore the landscape level vegetation and aquatic conditions. Proposed management activities should focus on reducing sediment production and inputs to streams, minimizing erosional processes, and reducing road densities.

Harvesting projects can provide an opportunity to reduce channel extension and sediment input to streams through KV opportunities and road reconstruction. Adding culverts, draindips, and other drainage structures to existing roads will help to interrupt the direct stream extension and sediment input to streams by dispersing the water on the hillside at desired locations rather than concentrating it into existing streams.. Opportunities to decommission roads after timber harvest should be examined as a way to reduce road density.

Harvest should be deferred in existing interior late-successional patches and their buffers until replacement habitat has developed. The interior late-successional habitat along the South Fork Cow Creek provides connectivity between the low and high elevations of Cow Creek and should be maintained until replacement habitat is available.

Fragmentation should be reduced across the landscape. This can be achieved by aggregating existing and new harvest units. Previously harvested stands should be examined for harvest opportunities prior to looking at uncut stands.

Canopy cover should be maintained or improved in perennial streams (Class II and III) throughout the basin to keep water temperatures low and perpetuate salmonid habitat. Vegetation manipulation within the riparian reserves of Class IV streams is acceptable if it meets site specific riparian objectives.

Silvicultural and reforestation prescriptions should meet management objectives within the context of site conditions and historic fire processes. Second growth stands should be treated to meet stand structure and composition objectives. Non-commercial thinning should be accomplished with KV collections wherever possible. Snag and down wood levels should be managed to perpetuate levels currently found in unmanaged stands.

The 1995 Tiller Ranger District Granite and Schist Policy should be followed when designing projects in this basin. Slopes over 60 percent in granitic and schistose soils should not be harvested. The matrix harvest prescription of retaining 15 percent of the trees on the site will not prevent soil erosion and landslides on slopes between 40 and 60 percent; the project team should examine other harvest prescriptions on these slopes.

Dismal Creek is in a highly degraded condition. Opportunities for restoration and partnerships with private owners and the BLM should be explored. The only tree cutting prescribed for Dismal Creek is precommercial thinning. Lower Cow Creek is wide, shallow, and bedrock/sand dominated. Future riparian objectives (canopy cover, channel stability, etc.) in lower Cow Creek will not be met unless all landowners actively pursue restoring the floodplain and migration path of Cow Creek.

1. Introduction

The Cow Creek watershed analysis area comprises approximately 37,937 acres, with 28,672 acres within the Forest Service boundary. Three of the seven possible land allocations described in the Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl (ROD) are represented within the Forest Service portion of the Cow Creek watershed (USDA Forest Service and USDI Bureau of Land Management 1994). Table 1 shows the acreage in each of the three land allocations and in non-federal lands for Cow Creek within the Forest Service boundary.

Table 1. Land allocations.

Land Allocation	Acres	Percent
Administratively Withdrawn Areas	1,386	4.8%
Late-Successional Reserves	2,451	8.6%
Matrix	20,260	70.8%
Non-Federal	4,500	15.7%

The Administratively Withdrawn Area surrounds the Cow Creek Trail and is not scheduled for timber harvest. The Late-Successional Reserve (LSR) is designed to serve as habitat for late-successional and old-growth related species including the northern spotted owl. Its management will be guided by an LSR management plan. The majority (71 percent) of the Cow Creek watershed is designated as Matrix. Matrix lands are federal land outside the six other land allocations. They are also the areas in which most of the timber harvest and other silvicultural activities will be conducted (USDA Forest Service and USDI Bureau of Land Management 1994).

Watershed analysis is a systematic procedure to characterize the aquatic, riparian, terrestrial, and human features within a watershed. It is one of the four components of the Aquatic Conservation Strategy. Watershed analysis is required for Key Watersheds and Riparian Reserves prior to approval of projects; however, it is not required for matrix lands. Watershed analysis enhances our ability to estimate direct, indirect, and cumulative effects of our management activities (USDA Forest Service et al. 1995). Project teams will use the information gathered during watershed analyses to refine riparian reserve boundaries and prescribe land management activities including vegetation manipulation, watershed restoration, and monitoring programs. Watershed analysis is essentially ecosystem analysis at the watershed scale.

The Cow Creek watershed analysis area is primarily comprised of granitic and shistose soils. These soils are highly erosive and susceptible to sliding and scouring. The Tiller Ranger District has recognized for several decades that in order to maintain site productivity and water quality within the Cow Creek basin, land management activities must be conducted with care. With these concerns in mind, the District Ranger decided that a watershed analysis would be conducted in Cow Creek prior to any further management activities, even though it is not required by the ROD.

This watershed analysis is designed to provide the project implementation team with information about the conditions, processes, and interactions within the Cow Creek watershed. It will establish a watershed context for project-level analyses. However, it should be recognized that watershed analysis is an ongoing, iterative process and will expand as appropriate to consider additional information, changing conditions, and potential effects associated with long-term management issues.

This document is organized into five major sections. The Characterization section will briefly describe the dominant physical, biological, and human dimension features, characteristics, and uses of the watershed. The Issues and Key Questions section will describe the issues of concern within the watershed. The Current Conditions, Reference Conditions, and Interpretations section will be organized by issue. Each subsection will describe the current conditions and trends and the historical reference conditions. Comparisons and interpretations between the two conditions will be made. The Recommendations section will bring the results of the previous sections to a close by providing specific recommendations to be applied within the watershed. The Need for Further Analysis section will discuss the limitations of this watershed analysis and identify further analysis needed.

2. Characterization

The Cow Creek watershed is located in the southwest corner of the Tiller Ranger District on the Umpqua National Forest (Figure 1). It is within 50 miles of two larger population centers, Grants Pass and Roseburg. It is approximately 11 miles in length and nine miles in width. The watershed analysis area encompasses approximately 37,937 acres, with 28,672 acres within the Forest Service boundary. The mainstem of upper Cow Creek flows in a generally westerly direction until it flows into the Galesville Dam above Azalea.

The Cow Creek watershed is primarily within the Klamath Mountain geologic province, with a small area on the southeastern edge that lies within the Western Cascade geologic province.

The Klamath Mountain geologic province extends from northwestern California into southwestern Oregon. It is composed of four belts of island arc-related volcanic and sedimentary rock, intrusive rock and ultramafic assemblages. Generally, the province is composed of arcuate belts of rock, generally east-dipping, with older plates in the east thrust over younger plates to the west (Murray 1994).

The Klamath Mountain geologic province in the Cow Creek area is characterized by serpentine, metamorphosed, and intrusive igneous rocks of Jurassic to early Cretaceous age (200 to 100 million years ago) (Walker and Macleod 1991). The metamorphic rocks are schists, derived from sedimentary rocks such as sandstone, siltstone, and mudstone. The igneous rocks are granitic type rocks, formed from magma injected into existing rock units. In this case, the rock units were the sedimentary rocks. The heat and pressure of the magma caused the alteration of those sedimentary rock to the schists seen today.

Except for scattered areas of serpentine, primarily in the Red Mountain area and upper Applegate Creek, volcanics in upper East Fork Cow Creek, and alluvium along lower Cow Creek, about 90 percent of the analysis area is either decomposed granite or schist (Figure 2). In general, the Cow Creek basin is a highly erodible landscape.

Within the Forest Service boundary, the Cow Creek watershed contains 1,386 acres of Administratively Withdraw Area (the Cow Creek Trail), 2,451 acres of Late-Successional Reserves, and 20,260 acres of Matrix lands. There are approximately 4,500 acres of non-federal lands within the Forest Service boundary of the Cow Creek watershed (Figure 3). There are an estimated 222 miles of stream within the basin and 13,955 acres of riparian reserves. Within the Forest Service boundary, Cow Creek is divided into 18 subwatersheds (Figure 4), ranging in size from 88 to 6,163 acres.

The climate is Mediterranean. Annual precipitation ranges from 40 to 50 inches. The transient snow zone lies above 2,500 feet, with 77 percent of the watershed above this elevation. There are over 160 miles of road in the basin.

Figure 1.
COW CREEK WATERSHED
VICINITY MAP

TILLER RANGER DISTRICT
UMPQUA NATIONAL FOREST

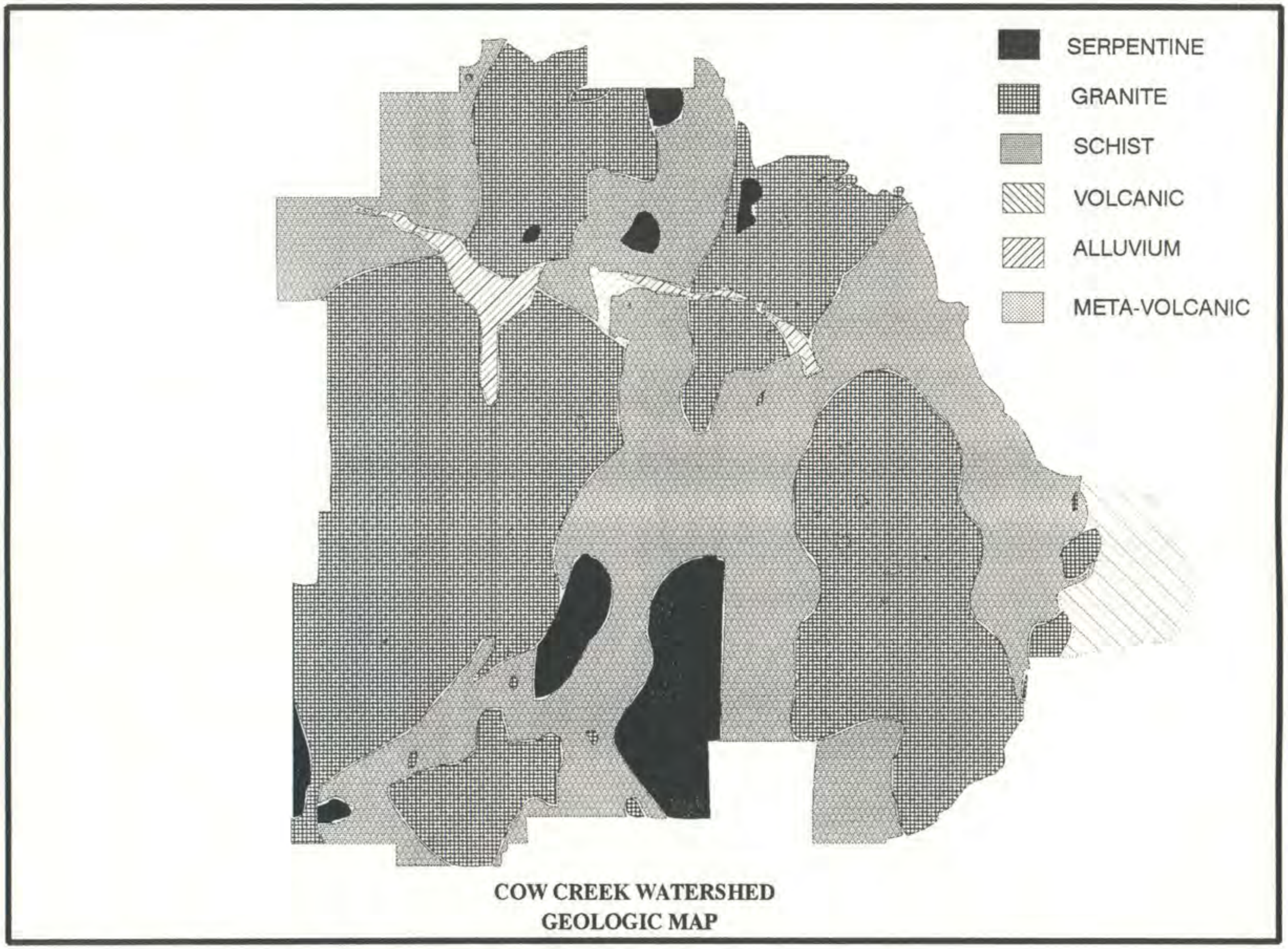


Figure 2. Cow Creek watershed geology map.

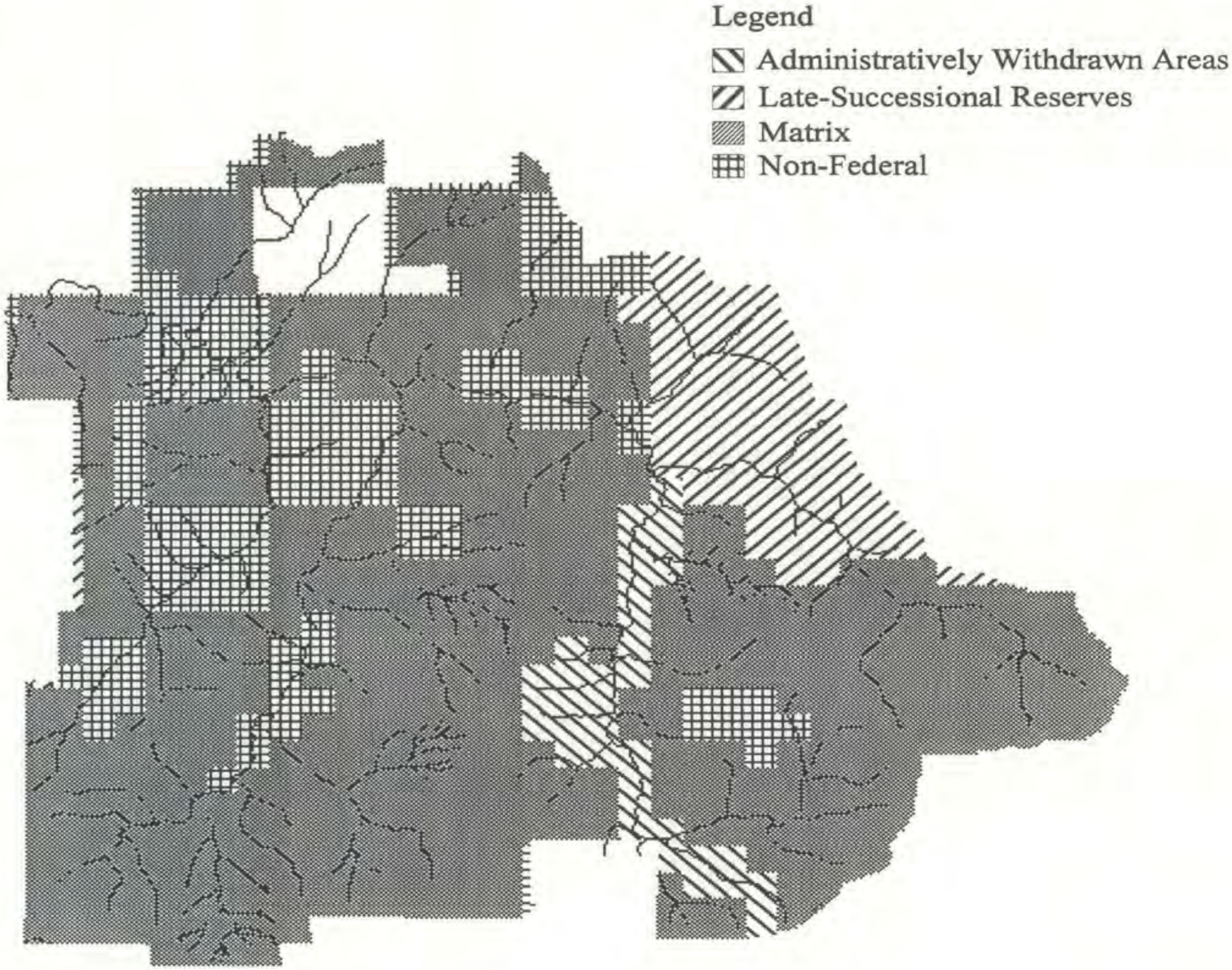


Figure 3. Land allocations within Tiller Ranger District boundary.

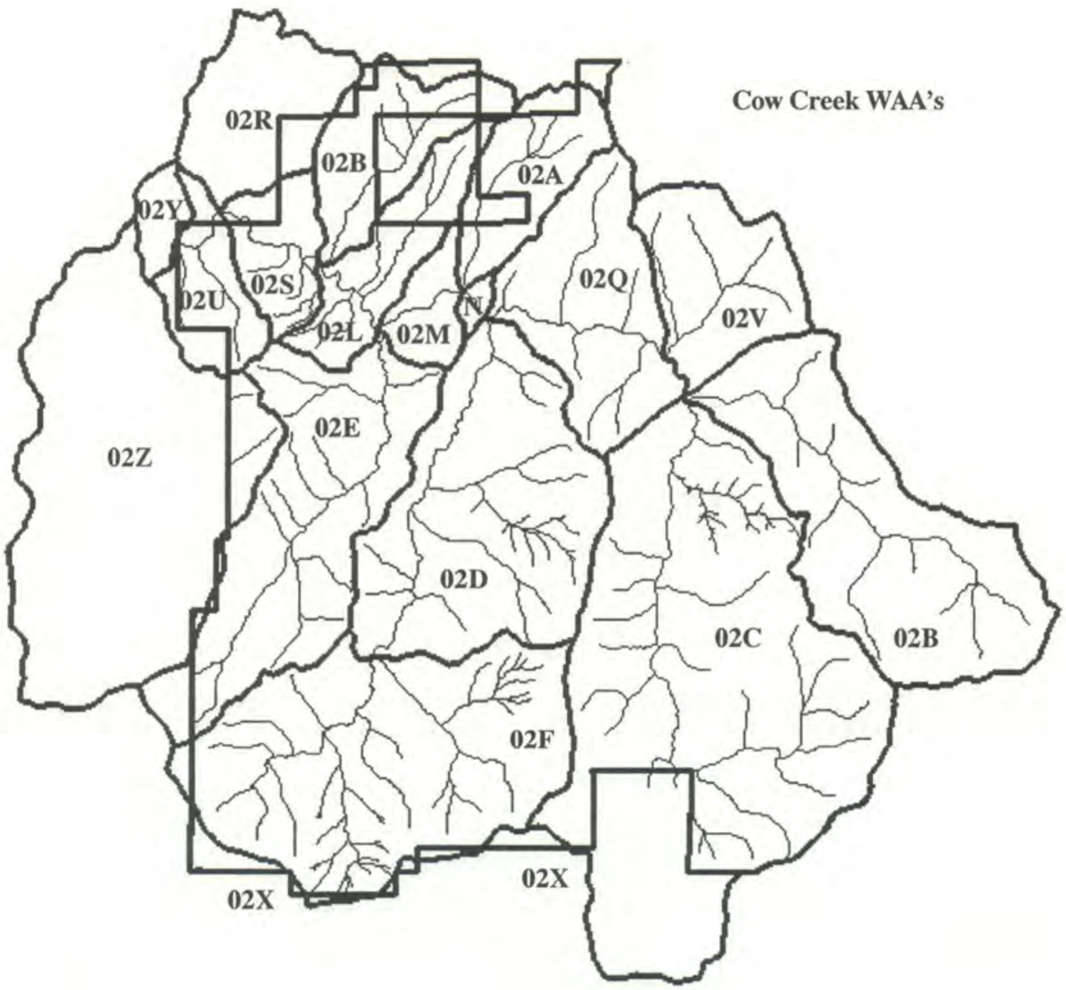


Figure 4. Subwatersheds in the Cow Creek Watershed Analysis Area.

The upper Cow Creek watershed no longer supports an anadromous fisheries due to the construction of the Galesville Dam in 1985. However, it provides habitat for numerous species of resident fish. *Oncorhynchus clarki* (cutthroat trout) are currently proposed for listing as a threatened species under the Endangered Species Act. Sea-run cutthroat, adfluvial cutthroat, and resident cutthroat are all currently being considered under this proposal. Cow Creek has the potential of being listed as critical habitat for resident cutthroat.

The highly erodible nature of the soils within the Cow Creek basin has caused high sediment delivery to streams from landslides and debris torrents. Historically, sediment delivery to these streams has probably always been relatively high; however, human activities such as road construction, timber harvest, mining, and grazing have increased landslide and general sedimentation rates over natural levels.

In addition to the high sediment load being delivered to the stream channels, the streams within the basin are primarily storage systems; fine sediments are stored in pools and behind large woody material, reducing spawning substrate and pool habitat. Fine sediment also simplifies the stream substrate composition, which reduces macro-invertebrate habitat values (an indicator of aquatic system health and diversity).

Bailey et al. (1994) describe a Mediterranean Regime: Sierran Steppe-Mixed Forest within the Klamath Mountain Ecoregion that includes Cow Creek. The Mixed Evergreen and Mixed Conifer Zones described by Franklin and Dyrness (1973) occur within Cow Creek. It is near the northern limit of the former zone. Although Douglas-fir is by far the dominant conifer, several other species occur in the watershed. Most notably, Jeffrey and knobcone pines. Prior to modern management, fire was the dominant process affecting upslope and riparian vegetation, above the floodplain. Cow Creek's complex fire regime created equally complex and diverse landscape- and stand- level vegetation.

With the onset of modern management, that disturbance process has been interrupted. Timber harvest practices have dispersed high-intensity disturbance across 26 percent of the landscape. Fire suppression has virtually excluded it throughout the rest of the landscape. The result of this changed disturbance regime is a fragmented landscape, low in both early and late-seral vegetation. The density and dominance of tolerant conifers is high, commonly at the expense of intolerant conifers and most hardwoods. Fire hazard and the magnitude of insect and disease activity may be higher than before modern management.

Archaeological investigation has revealed that the earliest known human uses of the Cow Creek watershed are aboriginal. Early humans used the watershed for village sites, fishing, hunting, and food gathering. Explorers and trappers recorded the presence of native people in the Umpqua valley at the end of the 18th century. The Cow Creek band of Umpqua Indians was named after the creek running through a major portion of their territory. Euro-American settlers began to appear between 1850 and 1860. The discovery of gold in the Rogue River valley brought many more settlers to the Cow Creek area creating conflicts with the native people.

Logging began in the Cow Creek area following World War II, resulting in timber sales and road construction throughout the basin. Logging still continues in the basin today, but the people and their uses of the watershed has changed dramatically. Most of the residence in upper Cow Creek live there because of their desire for a rural lifestyle. residents

Recreational use of the watershed has been limited. There is one developed recreation site (Devils Flat Campground) and several dispersed sites. There are several trails within this watershed and six more planned in the Forest Plan (USDA Forest Service 1990). One of the significant interests in the area is Galesville reservoir which was built in 1985. The primary use is water-based sports such as water-skiing, swimming, or fishing.

3. Issues and Key Questions

Issue 1: Fish Habitat and Water Quality

The upper Cow Creek watershed no longer supports an anadromous fisheries due to the construction of the Galesville Dam in 1985. However, it provides habitat for numerous species of resident fish. *Oncorhynchus clarki* (cutthroat trout) are currently proposed for listing as a threatened species under the Endangered Species Act. Sea-run cutthroat, adfluvial cutthroat, and resident cutthroat are all currently being considered under this proposal. Cow Creek has the potential of being listed as critical habitat for resident cutthroat.

The habitat conditions for fish within the Cow Creek watershed have been shaped over time as a result of both natural disturbances and human influences. The majority of the soils within the Cow Creek watershed are derived from granitic and schistose parent materials. Both these soil types have common engineering properties which make them susceptible to higher erosion and landslide potential. Historically, sediment delivered to streams due to landslides and debris torrents has probably always been high. However, human activities such as road construction, timber harvest, mining, and grazing have increased landslide and general sedimentation rates over natural levels, adversely impacting water quality and aquatic habitat.

In addition to the high sediment load being delivered to the stream channels, the streams within the basin are primarily storage systems; fine sediments are stored in pools and behind large woody material, reducing spawning substrate and pool habitat. Fine sediment also simplifies the stream substrate composition, which reduces macro-invertebrate habitat values (an indicator of aquatic system health and diversity).

Past timber harvesting and road construction may be altering the magnitude and timing of peak flow events, thereby impacting stream channel conditions.

Riparian area modifications such as road construction; removal of riparian vegetation, large woody material, and complex channel structure; and physical alteration of the channels have adversely impacted fisheries and water quality. In some locations, floodplains have been restricted and riparian microclimates have been altered. Many riparian areas are deficient in large conifers, which are future sources of large woody material.

Key Questions

1. What is the difference between historic and current water quality and quantity provided by the watershed?

- Temperature
- pH
- Turbidity
- Sediment
- Streamflow regime
- Channel complexity
- Channel and bank stability

2. What are the causes of these differences?

3. Will the current conditions meet management objectives or, if not, what actions may be necessary?

4. What is the difference between historic and current fish habitat conditions?

    - Habitat complexity
    - Sediment
    - Pools
    - Shade

5. What are the causes of these differences?

6. Are the results of these differences acceptable?

Issue 2: Vegetation Conditions

Current direction for National Forests is to promote the sustainability of ecosystems by ensuring their health, diversity, and productivity (USDA Forest Service 1994). There is a concern that stand- and landscape-level vegetation conditions and cycles are not consistent with that direction (FEMAT 1993, ISC 1990, Harris 1994, Franklin and Foreman 1987). Prior to human influences, vegetation was primarily influenced by climate, geology, soils, and disturbance. Land management practices that may have affected these conditions and cycles are as follows: fire suppression, timber cutting and subsequent silvicultural activities, grazing, and road construction. These practices have affected the vegetation of riparian zones and uplands. Answers to the following questions will help indicate whether Cow Creek is currently meeting management direction or, if not, what actions may be necessary.

Key Questions

1. What was the frequency, intensity, and extent of historic disturbance?

    - Fire
    - Insects

- Disease
- Wind
- Flood
- Earthflow and debris torrents

2. How did historical disturbance affect the composition and structure of stand- and landscape-level vegetation?

    - What was the range of these conditions?

3. At what scales were these conditions sustainable, healthy, diverse, and productive?

4. What has been the frequency, intensity, and extent of management disturbance?

    - Fire suppression
    - Tree cutting
    - Silvicultural activities

        a) Reforestation
        b) Thinning
        c) Fertilization
        d) Vegetation management

    - Special forest products
    - Grazing
    - Road construction
    - Recreation

5. How have land management activities affected the composition and structure of stand- and landscape-level vegetation and wildlife occupancy?

6. Are these conditions (healthy, diverse, and productive) sustainable within the Cow Creek watershed? What is the relevance of sustainability within the context of other spatial and temporal scales?

Issue 3: Human Dimensions

Human interactions within an ecosystem include all the ways that people are a part of an ecosystem. They include past, present, and future disturbances, uses, and values. The Cow Creek watershed has historically had a considerable amount of human use. The watershed has been important to humans in terms of commercial, recreation, and culturally-motivated uses.

Key Questions

1. What are the historic and current human uses of the watershed and trend of those uses?

    - What is the ability of the watershed to provide for those uses?

2. What man-made infrastructure and facilities (campgrounds, roads, trails, and powerlines) are located within the watershed and what is the trend of their use?

3. Are there anticipated demographic and social trends that will change the human pressures on the watershed?

4. Current Conditions, Reference Conditions, and Interpretations

Geology

The geologic history of the Cow Creek area is complex. The basic bedrock types are serpentines, schists and granites, with a small overlying area of recent volcanics.

Technical terms listed in the discussion below are defined in the Glossary of Geologic Terms (Appendix A).

The serpentine found in the area appears to be a metamorphic remnant of pre-existing green schist or basaltic units. They have been heavily metamorphosed, both with the forces intruding the plutons, and later with tectonic activity. The original ultramaphic rock has been extensively "serpentinized" with pressure changes and addition of water into the serpentine rock found in the area today.

The Western Cascade geologic province is composed of many overlapping flows of volcanic rocks that were laid down between 38 and 17 million years ago. The rocks are mixtures of volcanic tuffs and breccias, minor amounts of basalt (Walker and Macleod 1991 and USDA Geology of the Rogue River National Forest 1994). Subsequent hydrothermal alteration has been responsible for much of the precious metal deposits found in the area.

Following the formation of both the Klamath Mountain and Western Cascade rock sequences, the area has been subjected to numerous tectonic forces which have uplifted and faulted the basic bedrock. Most prominent of which is the Cedar Springs Mountain Thrust Fault, located to the west of the study area (Murray 1994). Old fault zones are now often the contact zones between rock types and have been some of the reasons for the location of many of the streams in the drainage. The rough parallelism of Dismal Creek, Applegate Creek, South Fork Cow Creek and East Fork Cow Creek are reflections of these tectonic activities.

Erosion has been active in all of the bedrock types in the drainage. After placement, the rocks of the Klamath Mountain province were subsequently eroded, then covered with additional sedimentary, and probably some volcanic rock. This material has all been removed, along with the upper portions of the sedimentary and granitic rocks themselves. Active erosion has continually occurred in the Western Cascade province, beginning with the initial rock units laid down (Broeker 1995, personal communication; Geologic Report, Little River AMA 1995).

The result of this active erosion process, is a series of rock units at the surface of the earth that were originally deeply buried. Rocks and minerals that were chemically and physically stable under high heat and pressure are now exposed to low temperatures and pressure. This has resulted in some accelerated weathering of most of the rock types in the drainage.

The granitics in the Cow Creek area are part of the White Mountain Pluton. Geologically, the rock of the pluton is classified as primarily trodhjemite or tonalite, but will be referred to hereafter as granite or granitic rock. The granite is typically massive, crumbly, and crosscut by numerous randomly oriented fractures. Numerous dikes and sills (seams of granite extending into the country rock) also extend from the granitic mass into the surrounding schists. This extension of the granite make mapping exact contacts impossible. In some areas, notably Devils Creek and French Creek, the contact between granite and schist is more properly a zone, rather than a line (Murray 1994). The properties of these mixed granites and schists are very close to those of pure granite, but may exhibit somewhat lower strength and higher erosion potential.

Two units of schist are found in the study area. The May Creek schist and an unnamed mica schist, often casually referred to as the Shively Schist. The two schists vary mineralogically, however, the engineering and structural properties are very similar. Because of these similarities, the two units are treated in this paper as one unit.

The rocks of the schist and granite both contain mica and other minerals that are easily altered to clay minerals. The heavy rainfall and warm climate of the area also contribute to rapid chemical weathering. The combination of rapid chemical weathering and intense fracturing by tectonic activities have lead to a large section of the watershed being underlain by bedrock that is very easily eroded and susceptible to sliding and scouring.

The geometry of the soil particles may be the primary reason that the soils of the schist are slightly more stable and less erosive than the granites. The soil particles in granites are generally spheroidal in shape and the particles in the schists generally have a longer, more platy shape. A soil mass composed of sub-rounded, uniaxial particles has a lower angle of internal friction than one composed of particles of a mixed shape.

Landslides

Landslides are an inherent slope forming process in the Cow Creek landscape, particularly in the granitic and schistose soils. Following fire, when vegetation is killed, landslides may increase due to loss of root strength. These slides are initiated when soils become saturated.

Today, landslides and debris torrents in gullies and stream channels are very evident in the Cow Creek basin. For the basis of analysis, slides and debris torrents were combined, because in this area they are very closely related. The terms "landslides" or "slides" in this report, refers to soil and rock material that has been moved. The slides may move more or less as a unit, as in a rotational slide. They may also completely break apart, as in a debris slide. Both types of mass-wasting failures occur in the rock/soil units of the Cow Creek area. The term "debris torrent" refers to the scouring of a gully or stream channel by a slurry of water, soil, rock, and vegetation that rapidly flows down a draw.

The granitic and schistose soils have some common physical properties that make them susceptible to higher erosion and sliding potential. Both soil types are granular, have low amounts of plastic fine material, and have loam and sandy loam textures. The clay minerals developing in these soils appear to be lean-type clays. The soils are dependent on the angle of internal friction for soil strength, with almost no cohesion.

Granular soils tend to collapse when sheared, which in undrained conditions results in increased pore-water pressures. Consequently, surficial failures in these contractive soils often evolve into debris flows that may travel great distances. Even minor strain may cause liquification (Montgomery, Wright, and Booth 1991). Slides in the Cow Creek area often progress from a simple slide into a debris torrent.

An analysis of the slides and debris torrents noted on aerial photographs found that 71 percent occurred in granite, and 24 percent were in schist. Rudy Edwards and others working on slides in the granitics found that slopes steeper than 60 percent had the highest probability for failure (USDA Forest Service 1979). Field visits to slides that were activated during the January 12, 1995 storm event found that most of the slides initiated were on small sections of hillslope that were steeper than 60 percent, even though the average slope was less than 60 percent.

Many of the slides that occur in the granites and schists, begin in headwall areas at the upper reaches of Class IV streams. These areas are concave slopes where water is more easily concentrated. Planar or convex slope shapes have a much lower incident of slides. Slope shape is one of the key indices used in many of the hazard rating systems used to predict zones of high probability of failure.

Removal of vegetation from the soil is another key indicator to an increase in sliding potential. Even in areas where soil disturbance has not occurred, removal of the vegetation and subsequent loss of root strength, appears to have been significant.

Conversation with Bill Conway, Tiller Ranger District, also produced the information that in the granitic soils, where east-west ridges occur, the north-facing slopes tend to be steeper with more headwall areas and are more sensitive to slides and debris flows.

Geomorphology

The Cow Creek watershed has numerous areas in the granitics soils where concave shaped basins have debris flows as the primary component of erosion and mass movement. These areas are listed as "debris basins", and were entered into the geomorphology layer of the GIS database at the Tiller Ranger District.

Debris basins in themselves are not something that need to be avoided, but should be a warning that the area has a high potential for landslides and debris torrents and management activities in these areas should be done only with the assistance of a qualified person familiar with earth sciences and geomorphology.

Areas in the tertiary volcanics to the east of Wildcat Ridge have some large earthflow zones that were mapped, but none were noted in the Cow Creek watershed, except a small area along South Fork Cow Creek. This earthflow zone is in the Administratively Withdrawn Area along the Cow Creek Trail.

Large scale deformation of the area by tectonic activity dates back to the time of the metamorphism of the schists (greater than 165 Million years, BP). Additional deformation occurred during the Nevadian orogeny, which began around 156 Million years, BP, and is related to the Cedar Springs Thrust Fault. Normal and thrust faulting metamorphic rock also occurred with the placement of the volcanic rocks, about 35 million years, BP. Currently active faults are not known in the Cow Creek area (Murray 1994).

Geologic Hazards

The primary geologic hazard in the Cow Creek area is from landslides. A great number of these slides initiate on slopes steeper than 60 percent. A study by Rudy Edwards and others determined that 60 percent was a critical angle in the stability of slopes in the granitic soils on the Tiller Ranger District (USDA Forest Service 1978). An attempt was made to produce slope maps of the Cow Creek area, but with limited success. A MOSS produced map appeared to greatly over-estimate the amount of area with steep slopes, and an Arc-Info map appeared to greatly under-estimate the area of steep slopes. Until more accurate Digital Terrain Models are available, steep slope areas will need to be identified on a project level. A hazard map prepared by Branchfield in February 1994 for the Cow Creek IRA is based on the MOSS generated slope data and preliminary geologic data. That map should not be used.

Mineral Deposits and Mining

Gold deposits are scattered in some of the areas surrounding the White Mountain Pluton, and in the hydrothermal zones of the volcanic rocks. In some areas, gold has been located in placer deposits in streams. No gold deposits have been noted in the schists in the Cow Creek area.

Minor base metal deposits came from massive-sulfide deposits. Generally, these deposits are concentrated along the boundary with the pre-Tertiary (volcanic) rock units. Within the Richter Mountain quadrangle, thirteen prospects of chrome or mercury have been located. Some copper and silver have also been produced from the area.

Four prospects have had significant development: the Banfield, Rowley, Red Cloud, and Mammoth lode mines, primarily for gold. Other prospects are noted in the MILOC database, maintained by the Oregon Department of Geology and Mineral Industries (DOGAMI).

Small veinlets of chrysotile asbestos are common in serpentines within the area, but rarely make up more than 1 to 2 percent of the rock. A larger (50 centimeter) vein is located north of the area in Hatchet Creek, where some claims have been located (Murray 1994).

Placer mining and slope failure of mine tailing piles can increase sediment in streams. Much of the mining activity is on private land over which the Forest Service has no jurisdiction. The Forest Service still can have input on operating permits issued by DOGAMI. Even small "recreational" type suction dredging has high mortality on aquatic insects and fish eggs (Meehan 1991).

Mine workings, tailings, and processing sites may also be point sources for toxic metals, acids, and other toxic leachates. The products and concentrates depend on the type of mine and extraction process used. Increased acidity of mine runoff should be expected in mines operating in the massive sulfide deposits surrounding hydrothermal areas. DOGAMI, BLM, and Forest Service mining specialists can assist in determining the potential hazards involved and types of mitigation required.

Locations of mining claims and mines in Oregon is listed on the MILOC database maintained by DOGAMI.

Road Construction

Construction or reconstruction of roads in the granitic or schistose bedrock areas should be carefully evaluated and controlled. Road related failures and sediment from roads are some of the leading causes of stream sediment.

Common causes of road related failures are:

- Improper placement and construction of fills
- Inadequate maintenance
- Insufficient culvert sizing
- Steep hillslope gradient
- Sidecast of excess material
- Interception and concentration of surface/subsurface water

Common causes of excessive surface erosion area:

- Inherent erodibility of the soil
- Slope steepness
- Surface runoff
- Slope length
- Lack of ground cover

Roads should be located at, or near ridgetops to minimize effects on hillside processes. Locate roads with geotechnical assistance when steep sideslopes or potential unstable areas are traversed. Long-term planning should be done in areas where roads will be required so that the minimum amount of roads can be constructed and the best locations selected. Consider the use of retaining structures or other design techniques to minimize the width of disturbed areas. Road designs should be low impact to minimize effects on the hillslope.

Stream crossings are potential sources of large sediment yields in the event of catastrophic failure. Stream crossings should be designed so that the chance of failure is minimized by selection of proper size. Crossing sites should also be designed so that in the event of the failure of the crossing structure, water crosses the road quickly and returns to the channel, instead of flowing along the roadway and eroding both the road surface and additional hillside areas.

In addition to designing roads to minimize the potential for excessive erosion, stream crossings need to be designed to minimize changes in channel geometry. In areas where streams have resident fish populations, the barrier effect of the crossing structures needs to be resolved. Stream crossings with fish passage should involve hydrologists and fisheries biologists in the design phase.

Utilize geotechnical and earth science professionals when planning, designing, and constructing roads so that the minimum impact on the soils and streams is achieved. The use of these specialists is most critical when attempting new techniques or materials. The use of new techniques and materials should be encouraged, as many of these offer benefits at reduced costs, while still providing good environmental solutions.

Stream Classification

A reasonable map of all anadromous fish, resident fish, other perennial, and intermittent streams is necessary to plan riparian reserves and potential projects in Watershed Analysis Areas (WAA's), according to the Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl (ROD) (1994). Current mapping systems and databases do not accurately delineate or describe the extent or characteristics of the intermittent stream network.

Intermittent streams and indistinct wetlands are important because of their connections to adjacent uplands and to downstream aquatic systems. Several important ecological processes occur within intermittent streams, including storage and processing of organic materials, the products of which are later transported to downstream areas. Intermittent streams store sediment and wood and are sources of these materials for permanently flowing streams (Forest Ecosystem Management Assessment Team (FEMAT) 1993).

One of the implications of defining an intermittent stream network is in establishment of riparian reserves. Intermittent streams are defined as any non-permanently flowing drainage features having a definable channel and evidence of scour or deposition. This includes what are sometimes referred to as ephemeral streams if they meet these two criteria (FEMAT 1993). These intermittent streams are the "winter baseflow" network and are likely to flow whenever streams rise in response to storms. A procedure for sampling and estimating stream densities and total stream lengths was conducted as part of the FEMAT efforts (see Appendix V-G of the FEMAT report).

The current Umpqua National Forest GIS stream inventory shows Class I, II, III, and IV streams for the Cow Creek watershed. This stream inventory covers only the lands within the Forest Service boundary, not the entire Cow Creek watershed. Since the construction of the Galesville Dam in 1985, the upper Cow Creek watershed no longer supports an anadromous fisheries; therefore, all the streams shown in the current GIS inventory as Class I are now Class II streams. The inventory of the Class II and III streams is believed to be accurate. However, the current inventory of the Class IV (intermittent) streams is believed to be highly inaccurate with many more Class IV streams existing than is currently inventoried.

A procedure for estimating the additional miles of Class IV streams was used within the Cow Creek watershed. The Cow Creek watershed is composed predominantly of two different soil types, granite and schist. Four small watersheds (0.76 to 1.08 square miles) within these two soil types were walked, verifying the presence or absence of streams with signs of deposition or scour. The two granitic watersheds had drainage densities of 5.14 and 5.49 mi./mi.^{2}. The two schistose watersheds had drainage densities of 4.09 and 5.37 mi./mi.^{2}.

Arc Info computer mapping was used to generate streams in each of these four watersheds, using headwater source areas of 1, 2.9, 5, and 10 hectares (2.471, 7.166, 12.355, and 24.710 acres, respectively) for channel initiation. In order to determine channel lengths produced by the Arc Info generated maps for the four watersheds, the streams were manuscripted by hand on the Arc Info maps. The Arc Info layer and the primary base topography were overlaid on the existing GIS streams. Headwater initiation points were selected off the Arc Info maps and streams were drawn along contour crenulations (logical draws) to connect with the existing digitized stream layer. These manuscripted channel lengths were plotted against the drainage densities field measured in each of the four small watersheds. A source area was picked by interpolation which would produce the approximate length of stream measured in the field. The source areas within both soil types were not significantly different and an average source area of 1.0 hectare (2.471 acres) selected to apply to the entire Cow Creek watershed. The Arc Info 1.0 hectare map will be hand-manuscripted for the entire Cow Creek watershed to produce a map of unverified streams prior to project planning in order to aid with analysis of riparian reserves. During project planning, as streams are located in the field, they should be corrected on the GIS layer. Additional riparian reserves will be located around unstable areas and wetlands.

Since the unverified stream layer cannot be produced by the completion of this watershed analysis, we can only make an estimate of the additional miles of Class IV streams we can expect to find in Cow Creek based on the stream densities measured in the field. The drainage densities within the two different soil types are not significantly different; therefore, an average of the four drainage densities was applied to the entire Cow Creek watershed to estimate the additional miles of Class IV streams that can be expected once all streams are field verified.

The stream miles within each WAA were determined by applying an average drainage density of 5.02 mi./mi.^{2}. These estimated stream miles were then compared to the current GIS stream inventory to determine the increase in stream miles that can be expected when the streams are inventoried at the project level. The Estimated Stream Miles column in Table 2 shows that there are approximately 222 miles of stream within the Cow Creek watershed. It also shows that we can expect a 106 percent increase in the number of stream miles once the stream mapping is completed. This would be approximately 114 additional miles of Class IV streams that are not in the current GIS inventory.

Table 2. Estimate of increase in stream miles.

WAA	Area (Acres)	Area (mi.^{2})	Drainage Density (mi./mi.^{2})	Estimated Stream Miles	Current GIS Stream Miles	Increase in Stream Miles	Percent Increase
02A	814.61	1.27	5.02	6.39	3.13	3.26	104.14
02B	3498.52	5.47	5.02	27.44	9.97	17.47	175.24
02C	6163.20	9.63	5.02	48.34	22.11	26.23	118.65
02D	3569.96	5.58	5.02	28.00	13.88	14.12	101.74
02E	2972.41	4.64	5.02	23.31	13.23	10.08	76.23
02F	4383.80	6.85	5.02	34.39	16.28	18.11	111.21
02L	698.76	1.09	5.02	5.48	5.75	0.00	0.00
02M	446.35	0.70	5.02	3.50	1.00	2.50	250.11
02N	87.83	0.14	5.02	0.69	0.38	0.31	81.29
02Q	1990.19	3.11	5.02	15.61	7.10	8.51	119.87
02R	138.23	0.22	5.02	1.08	0.00	1.08	N/A
02S	606.93	0.95	5.02	4.76	3.67	1.09	29.72
02T	761.14	1.19	5.02	5.97	3.72	2.25	60.49
02U	502.48	0.79	5.02	3.94	2.71	1.23	45.44
02V	1418.93	2.22	5.02	11.13	4.70	6.43	136.80
02X	254.87	0.40	5.02	2.00	0.20	1.80	899.57
Total	28308.21	44.23		222.04	107.83	114.48	106.17

The estimated acreage in riparian reserves in shown in Table 3 by stream class by WAA. The current GIS stream layer shows a total of 9,237 acres in riparian reserves for all stream classes. There is estimated to be an additional 4,718 acres of riparian reserves in unmapped Class IV streams within the Cow Creek watershed. This riparian reserve acreage totals to about 49 percent of the landbase within the watershed.

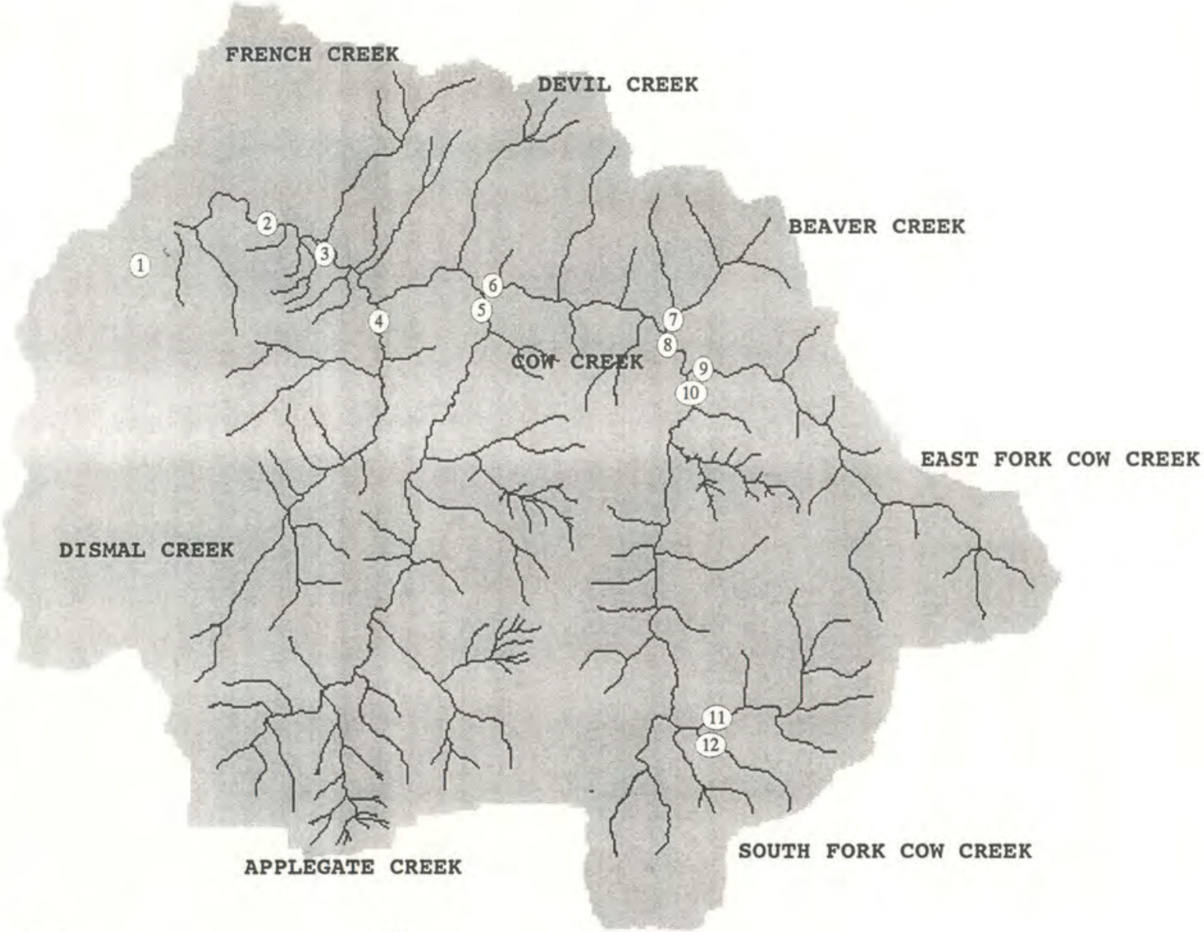
Table 3. Riparian reserves.

WAA	GIS Class II (acres)	GIS Class III (acres)	GIS Class IV (acres)	Additional Estimated Class IV (acres)	Total Riparian Reserve (acres)
02A	2.00	197.15	50.54	134.33	384.03
02B	430.83	540.42	0.50	720.04	1691.79
02C	760.59	907.20	343.27	1081.10	3092.15
02D	536.91	480.37	225.67	581.99	1824.95
02E	423.83	108.58	366.78	415.62	1314.81
02F	364.78	902.70	359.28	746.16	2372.92
02L	99.08	177.64	139.11	0.00	415.82
02M	90.57	4.50	0.00	103.07	198.15
02N	32.02	3.50	0.00	12.73	48.26
02Q	208.16	50.54	225.17	350.74	834.61
02R	3.50	0.00	0.00	44.68	48.19
02S	125.60	0.00	113.59	44.95	284.13
02T	100.08	27.02	111.59	92.74	331.42
02U	63.05	81.56	63.55	50.75	258.91
02V	159.62	286.22	0.00	264.98	710.83
02X	0.00	0.00	10.01	74.15	84.15
02Y	3.00	1.50	0.00	0.00	4.50
02Z	0.00	0.00	55.54	0.00	55.54
Total	**3403.63**	**3768.91**	**2064.59**	**4718.03**	**13955.16**

Percent of Landbase in Riparian Reserves = 49.30%

Stream Temperature

Twelve water temperature monitoring stations were established in the streams in Cow Creek during summer 1995 to help characterize this watershed. This is only one summer's data and is not meant to represent a baseline. The drainage areas above these stations represent a mixture of federal and private lands. Four of the monitoring sites are located on the mainstem of Cow Creek from the Forest boundary in lower Cow Creek to just above Beaver Creek. Three of the sites were on the South Fork of Cow Creek. Smaller tributaries monitored were Snow Creek, Dismal Creek, Applegate Creek, Beaver Creek, and East Fork Cow Creek. Figure 5 shows the location of all 12 monitoring sites.

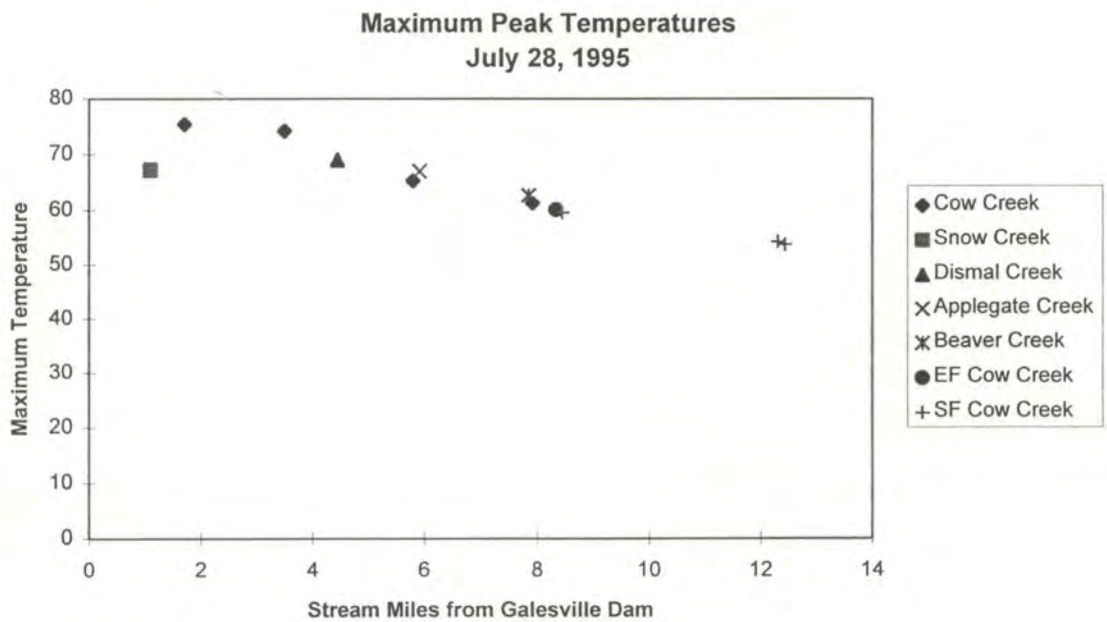


#	Name	#	Name
1	Snow Cr.	7	Beaver Cr.
2	Lower Cow Cr.	8	Cow Cr. above Beaver Cr.
3	Cow Cr. above French Cr.	9	East Fork Cow Cr.
4	Dismal Cr.	10	South Fork Cow Cr
5	Applegate Creek	11	Trib to South Fork
6	Cow Cr. above Beaver Cr.	12	Trib to Trib to South Fork

Figure 5. Location of temperature monitoring sites.

The maximum temperatures in the mainstem of Cow Creek and the South Fork of Cow Creek showed continued warming in the downstream direction (see Figure 6). Cow Creek has no large tributaries that affect its temperature. The mainstem of Cow Creek becomes noticeably wider and the canopy cover shading the stream is greatly reduced below Devil Creek. This is also where we see the largest temperature increase in the mainstem of Cow Creek. Daily high and low temperature for each of the 12 monitoring sites are shown in Appendix B.

Figure 6. Maximum temperatures.



There is one long-term temperature monitoring station in the Cow Creek watershed. It is located on Cow Creek above Dismal Creek and has 15 years of record. Table 4 shows the maximum temperatures at this site for each of the years of record. This long-term data indicates that 1995 was probably a moderate year in terms of stream temperatures.

Table 4. Maximum stream temperatures for Cow Creek above Dismal Creek.

Year	Maximum Temperature (*F)
1978	77
1979	73
1982	71
1983	66
1984	64
1985	67
1986	68
1987	70
1988	68.7
1989	66.0
1990	69.9
1991	65.7
1992	73.8
1993	66.9
1995	69.3

Streamflow

The closest USGS stream gage, Cow Creek above Galesville, has 9 years of record. During that time period, the instantaneous streamflow ranges from a low of 3.5 cfs (probably a result of a freezeup) to 3,560 cfs on January 29, 1993. Summer low flows average about 5 cfs, with the lowest daily mean of 4.2 cfs on September 24, 1994. This year appears to be an above average water year at this gage. Average July streamflow for the period of record is 14 cfs; this year's average July streamflow was 23.3 cfs.

Streamflow was measured at the twelve water temperature monitoring stations (Figure 7) twice during summer 1995. The first set of discharge measurements was taken July 25-27, 1995 and the second set was taken August 14-17, 1995 (Appendix C). Most of the water within the watershed analysis area is present in the mainstem of Cow Creek, South Fork Cow Creek, and Applegate Creek. Snow Creek (below the Forest Service boundary) is also a significant contributor to the flow in Cow Creek. Approximately 48 percent of Cow Creek's July flow at the lower Cow Creek site comes from South Fork Cow Creek and approximately 27 percent comes from Applegate Creek.

Summer maximum stream temperatures from most of the measured tributaries are relatively low and don't appear to cause the warm temperatures seen in the lower section of Cow Creek in the watershed analysis area. Applegate Creek's maximum temperature of 67 degrees Fahrenheit is not extremely high; however, since it is a fairly significant contributor to the flow (27 percent), project level activities should be monitored closely to ensure that water temperatures in this tributary are not increased.

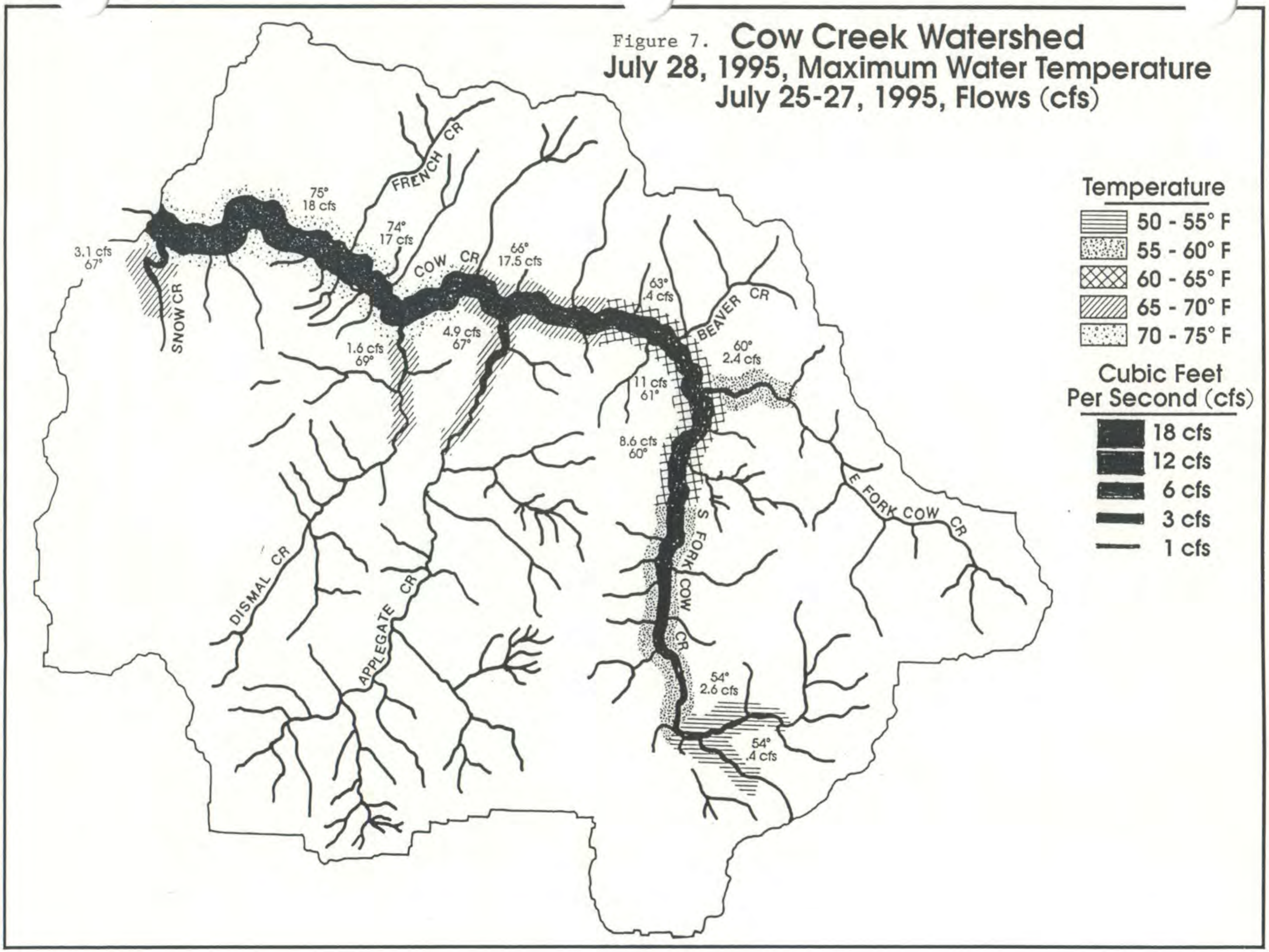


Figure 7. **Cow Creek Watershed**
July 28, 1995, Maximum Water Temperature
July 25-27, 1995, Flows (cfs)

Floods

Very little stream gage data is available for the streams in the upper Cow Creek watershed. A crest gage was operated on Beaver Creek from 1965 through 1977 and on Applegate Creek from 1975 through 1980. USGS currently maintains three nearby stream gages below the Cow Creek watershed boundary. The gages on Cow Creek above Galesville and on Galesville Reservior near Azalea have a relatively short periods of record, 1985 to the present. The gage at Cow Creek near Azalea has a fairly long-term record, 1926-28, 1929-31, and 1932 to the present.

Cow Creek near Azalea had 10-year floods or greater in 1964, 1974, 1981, 1982, and 1983. The 100-year record flood of 10,600 cfs occurred on January 15, 1974. The flood of 8,430 cfs on December 22, 1964 was somewhere between a 25- and 50-year event. It is interesting to note that in many other surrounding basins the flood in 1964 was the record 100-year flood.

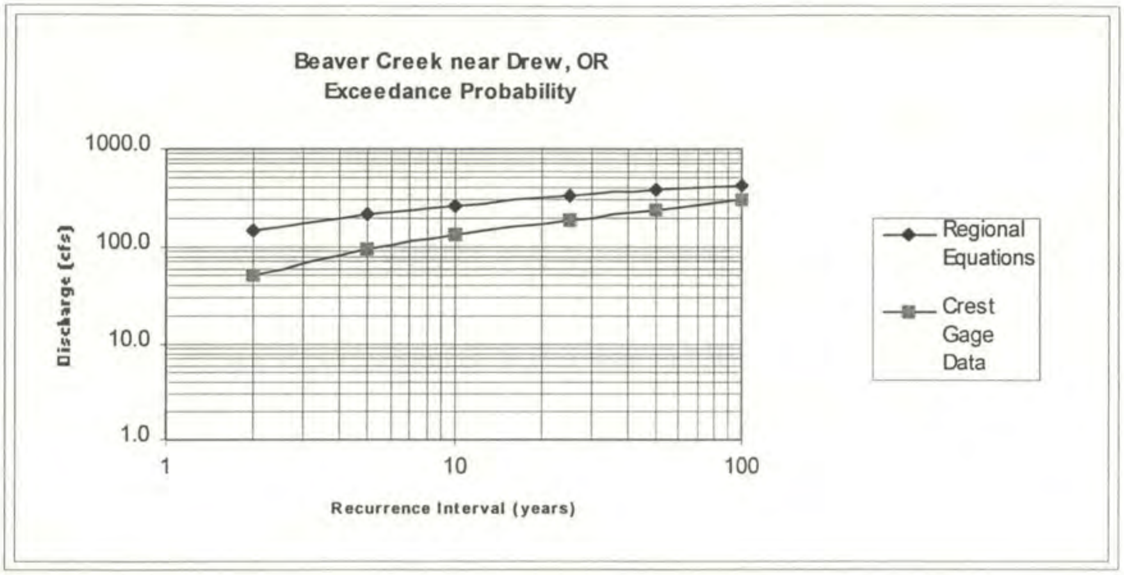
Recently, winter storms during the week of January 9-13, 1995 caused above bankfull streamflow conditions with low land flooding and road damage in the Cow Creek watershed. The 24-hour precipitation for the January 9 storm was 2.27 inches at Devil's Flat in upper Cow Creek. In addition, there was approximately 1.0 inch of water from snow melt available as the freezing level rose and rain occurred above 4,000 feet. The peak streamflow for the Cow Creek above Galesville stream gage (near the Forest boundary) was greater than a 5-year event. The actual peak exceeded the current rating table (which extends to approximately a 5-year flood) by more than 3 feet. Peak streamflow downstream at the gage on Cow Creek near Riddle was estimated as a 9-year event (Hofford 1995).

In order to determine whether the U.S. Geological Survey equations for floods in western Oregon (USGS 1979) give good estimates for flood peaks at ungaged streams in Cow Creek, a comparison between frequency data from a log-Pearson Type-III frequency curve for Beaver Creek and the regional equations was made. The regional equations are often used in road design to determine drainage structure requirements; therefore, it is useful to know whether the estimates from the regional equations are reasonable.

Between 1965 and 1977, a crest gage was operated on Beaver Creek near the mouth. Beaver Creek is a small tributary to Cow Creek with a drainage area of 1.61 $mi.^2$. Frequency data from this gage was compared to the results of applying the USGS regional equations. Figure 8 shows that the regional equations tend to overestimate the flood peaks. The overestimates tend to decrease as the recurrence interval increases. The regional equations overestimate the flow by 175 percent for a 2-year flood and 45 percent for a 100-year event on Beaver Creek. Figure 8 shows measured 100-year floods of 297 cfs and the regional equation's estimate of 431 cfs.

Since this comparison was done only at one site in Cow Creek with a fairly short period of record, we cannot assume that the regional equations will always overestimate peak floods in Cow Creek. However, the regional equations should be used with caution, especially when using them on streams with small drainage areas.

Figure 8. Regional equations compared to crest gage data for Beaver Creek.



Snow Accumulation and Melt

Some research shows that snow accumulation and melt is greater in forest openings, including clearcuts and plantations less than 40 years old (Harr 1981). It is difficult to predict how the higher melt rates measured in open stands might result in higher streamflow, but basins with less forest canopy are more likely to experience higher flows during warm storms. Increased size of peak flows appears to be related to cumulative effects of timber harvesting, primarily clearcut logging in the transient snow zone. The more rapid delivery of water to soil and to streams increases the probability of landslides and stream channel erosion (Christner and Harr 1982).

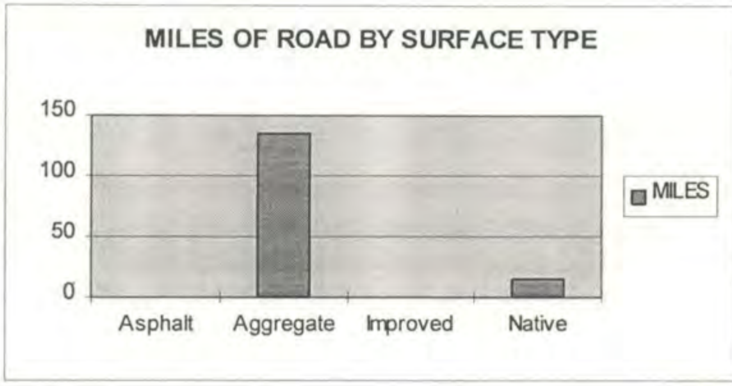
The transient snow zone on the Tiller Ranger District occurs approximately above 2,500 feet elevation. In the Cow Creek watershed, 29, 115 acres or 76.8 percent of the watershed is above this elevation. Since the majority of the Cow Creek watershed is in the transient snow zone, projects which remove canopy cover should consider the effect on peak flows. The cumulative effects of canopy removal and added road ditches on peak flows and aquatic habitat should be examined at the project level.

Roads

Historical Conditions

The transportation system in the Cow Creek watershed is typical of forest roads on the National Forests in western Oregon. The roads are typically single lane with either crushed rock or pit run surfacing. Some shorter roads are native surfaced (Figure 9).

Figure 9. Roads by surface type.



The roads constructed prior to the mid-1970's were built by side-cast excavation and installing culverts at live stream crossings and cross drains at predetermined intervals depending on road grade. The basis for live stream culvert sizing was the expected flow for the drainage area during a 50-year event. Cut slope and fill slope selection was based on soil stability with little or no regard for soil erosion potential.

For many years roads have been contributing sediment to virtually all the streams in the watershed from several different processes. Cut bank stability and/or erosion have been significant factors. The Cow Creek drainage landtype is comprised of soils derived from decomposed granitic and schistose materials. The granitic and schistose soils have common properties that make them susceptible to higher erosion and sliding potential. These soils are typically non-plastic, gravely loam, characterized as loose, noncompetent, and highly erosive. In over steepened slopes (over 60 percent), the decomposed granitic and schistose materials are subject to mass wasting, particularly subsequent to management activity disturbance. Difficulty in revegetating the cut slopes has resulted in many miles of raw cut slopes exposed to soil erosion from rain and snow melt. Sediment from miles of cut banks has been transported by ditches or road inslope to culverts. The sediment-laden water then spills onto ground that may or may not filter out the sediment before entering live streams. In some cases, the road ditches serve as channel extension by emptying directly into running streams or gullies.

Culverts and catch-basins require periodic maintenance in order to function properly in times of heavy flow. Culverts are often undersized for peak flows and either over-top the road, or plug with woody debris and wash out the road fill. The soils of the area are susceptible to channel scours from fill wash outs and from landing embankment failures. In either case, tons of sediment are added to the aquatic system. Culverts sometimes separate at interior connections when an outside shoulder of a road settles, causing water to run into the fill and either erode and gully, or causing the fill to become saturated and fail. "Shotgun" culverts also present a erosion hazard when the increased water velocity creates a gullying effect at the outlet.

Many side-cast fill slopes have become over steepened due to sloughing of unconsolidated embankment and are now showing signs of settling and slumping. As shoulders slump, cracks appear, allowing water to saturate the embankment with potential mass wasting. Some original embankment construction has settled due to woody debris being incorporated in the fill. The fill becomes unstable because of the woody debris decomposing and/or retaining water. The potential for culvert failure and mass wasting is significant.

Current Conditions

In the mid-1970's, there was a moratorium placed on road building and logging in the granitic soils of the Cow Creek drainage. It was determined that previous road building and logging practices had been contributing to the sediment load in area streams. A special team was assembled and given the charge of developing a policy for timber sale activities in granitic soils. The plan was operational by 1980 with specific road design and construction techniques such as insloping, rocking the ditch, outside shoulder berm, and slash pullback on fill slopes. These recommendations were documented in the 1979 Tiller Ranger District Granitics Policy and are being reviewed and updated as a result of this watershed analysis.

The current trend in road maintenance funding is a significant reduction from past levels (50 percent below the 1980's level). There is also less maintenance performed by timber purchasers as part of their contract responsibility. This trend will increase sediment delivery potential due to malfunctioning drainage structures. In time, roads may no longer be maintained to standard and become unsafe for vehicular traffic. The potential for adverse impacts on aquatic systems will increase.

The key to reducing erosion from roads in Cow Creek is to have a maintenance plan that requires at least annual ditch and culvert maintenance on every road in the drainage. During storm events crews should be put on patrol to deal quickly with any drainage problems. Even minor storm events can cause major problems in these highly erosive soils if water is misguided by plugged culverts, ditches, or rutted road surfaces. This makes it even more important to have the maintenance done to standard and in a timely manner.

Construction History and Road Density

Prior to 1950, approximately 37 miles of road had been constructed in the Cow Creek watershed. These roads included the main roads into Cow Creek, French Creek, Dismal Creek, Applegate Creek, Beaver Creek, Wildcat Ridge, and South Fork Cow Creek.

Between 1950-59, an additional 20 miles of road was constructed including a road accessing Red Mountain and the Snow Creek road. Road construction continued at approximately the same rate with 22 miles of road being constructed between 1960-69.

From 1970 to 1979, the road program expanded rapidly, more than doubling the amount of road construction in that decade over the previous two decades. Fifty-six miles of additional road were constructed primarily to provide access for timber harvest.

Between 1980-89, an additional 23 miles of road were constructed and between 1990-95, five miles of road were constructed primarily to provide access for timber harvest.

Table 5 is a summary of the road construction by time period by WAA and is based on information available for system roads in the Forest Travel Management System Database. It does not include all roads that have been constructed on BLM and private land.

Table 5 also displays road density by WAA in miles per square mile. Road densities range from 0.69 mi./mi.^{2} in WAA 02Z to 5.49 mi./mi.^{2} in WAA 02X. On the average, Cow Creek's road density is 3.02 mi./mi.^{2}, although 11 of the 18 WAA's exceed this average.

Table 5. Road construction and densities by watershed analysis area by decade.

WAA	Area (acres)	0-1949 (miles)	1950-59 (miles)	1960-69 (miles)	1970-79 (miles)	1980-89 (miles)	1990-95 (miles)	Total (miles)	Road Density (mi./mi.2)
02A	814.61	0.31		2.39	0.99	0.54		4.23	3.32
02B	3498.52	8.08	3.13	3.35	8.89	2.16		25.61	4.68
02C	6163.20	7.54	0.72	0.80	13.47	2.66		25.19	2.62
02D	3569.96	3.83	5.21	1.71	4.65	1.82	0.10	17.32	3.11
02E	3158.37	0.98	0.84	0.50	6.49	0.68		9.49	1.92
02F	4383.80	2.60	2.81	7.47	9.29	8.25	2.46	32.88	4.80
02L	698.76	1.06		0.01	2.41			3.48	3.19
02M	447.32	0.97			1.17	0.02		2.16	3.09
02N	87.83	0.32	0.25					0.57	4.15
02Q	1990.19	2.11		0.92	2.20	1.18		6.41	2.06
02R	138.23	0.09		0.02		0.54		0.65	3.01
02S	704.43	1.17		0.02	1.14	0.45		2.78	2.53
02T	1184.78	3.69		2.51		0.56	1.18	7.94	4.29
02U	770.22	0.25	1.31	0.58	2.55	0.44		5.13	4.26
02V	1418.93	4.15	1.11	1.35	2.21	1.25	1.14	11.21	5.06
02X	255.22		0.09	0.07		1.87	0.16	2.19	5.49
02Y	273.71	0.28	0.38					0.66	1.54
02Z	5067.75		4.35	0.49	0.50	0.14		5.48	0.69
Total	34625.83	37.43	20.20	22.19	55.96	22.56	5.04	163.38	3.02

Currently, there are approximately 163 miles of road in the Cow Creek drainage in the Forest Travel Management System Database. Aggregate surfaced roads comprise approximately 90 percent of the total and native surfaced roads equate to 10 percent.

Channel Extension

The transportation system in Cow Creek developed over time with a variety of construction methods and practices until the Tiller Ranger District Granitics Policy was adopted in 1979. Several problems were identified with road construction in granitic soils which led to the development of the Tiller Ranger District Granitics Policy. Numerous cases of mass failure and deep gully erosion were the largest of the problems. Smaller problems included the continual raveling of granitic cutslopes resulting in increased ditchline maintenance and increased road surface maintenance due to the poor quality of available surface rock. After 1979, roads constructed within the Cow Creek watershed were built according to the standards described in the Granitics Policy.

The age of a road as well as the standard of construction can be associated with a number of processes that are currently affecting watershed conditions. Specifically, disruption of hydrologic conditions associated with road drainage and erosion relative to the road prism are the two processes that have had significant effects in the watershed.

Hydrologic disruption has occurred in a variety of ways; however, the construction of road drainage improvements such as ditches and culverts appear to have had significant affects on capturing and diverting water. Interception of subsurface flow associated with road cuts is a prime factor in disrupting flowpaths, and consequently capturing the flow and diverting it has artificially increased the surface flow patterns, often into unassociated drainages. Road runoff into ditches has also contributed additional flow into surface flowpaths either as gullies and channel initiation or directly into existing stream channels. In addition to surface flow, runoff from roads also has the potential to affect the subsurface flowpaths downslope. In some areas this could result in drastic consequences such as the dewatering of meadows or the creation of undesired wetlands.

Recent work by Jones and Grant (1994) and Wemple (1994) suggests that roads could be contributing to the extension of the channel network and, therefore, elevating peak flows. Wemple showed that road ditches leading to streams and gullies added to the stream length in watersheds where peaks increased, providing one way that roads could account for higher flow. She found approximately a 60 percent increase over the winter baseflow stream length (channel extension) from road ditches leading to surface flowpaths of Blue River and Lookout Creek in the western Cascades. This is like having 60 percent more streams than before roads were constructed, creating more efficient pathways to get flood peaks downstream faster. In fact, Jones and Grant (1994) found flood peaks arrived sooner in small watersheds with roads.

Based on this premise, the road network in Cow Creek was sampled to determine the extent of road interception, transport, and delivery of water. Appendix D describes the sampling procedure and channel extension in detail. Table 6 shows the percent increase in the stream network due to roads (channel extension) by WAA. Channel extension ranged from 15.6 percent in WAA 02E (Dismal Creek) to 48.6 percent in WAA 02U (unnamed tributaries to Lower Cow Creek). Average channel extension was 27.2 percent for the Cow Creek watershed. Channel extension was expressed as the increase due to added surface flow paths from roads, over the winter baseflow stream length we estimated for Cow Creek (Table 2, Stream Classification section).

Table 6. Estimate of channel extension.

WAA	Surfaced Roads (mi.)	Surfaced Contribution to Streams (mi.)	Native Roads (mi.)	Native Contribution to Streams (mi.)	Total Extension (mi.)	Estimated Stream Miles	Percent Increase in Stream Network
02A	4.21	1.66	0.02	0.00	1.66	6.39	26.03%
02B	19.27	7.60	6.34	0.95	8.54	27.44	31.13%
02C	23.64	9.32	1.56	0.23	9.55	48.34	19.76%
02D	15.51	6.12	1.82	0.27	6.39	28.00	22.81%
02E	9.02	3.56	0.49	0.07	3.63	23.31	15.57%
02F	31.99	12.61	0.88	0.13	12.74	34.39	37.06%
02L	3.25	1.28	0.23	0.03	1.32	5.48	24.01%
02M	1.23	0.48	0.93	0.14	0.62	3.50	17.81%
02N	0.57	0.22	0.00	0.00	0.22	0.69	32.62%
02Q	6.41	2.53	0.00	0.00	2.53	15.61	16.19%
02R	0.65	0.26	0.00	0.00	0.26	1.08	23.64%
02S	2.78	1.10	0.00	0.00	1.10	4.76	23.03%
02T	6.79	2.68	1.15	0.17	2.85	5.97	47.72%
02U	4.69	1.85	0.44	0.07	1.91	3.94	48.58%
02V	8.99	3.54	2.22	0.33	3.88	11.13	34.82%
02X	2.18	0.86	0.00	0.00	0.86	2.00	43.00%
02Y	0.65	0.26	0.00	0.00	0.26	0.00	
02Z	5.48	2.16	0.00	0.00	2.16	0.00	
Total	147.31	58.08	16.08	2.40	60.48	222.04	27.24%

Appendix D shows that there is a large difference between the contribution of surfaced roads and native surfaced roads to channel extension (Table 22 and Table 23, Appendix D). Ditchline length contributing to surface flowpaths was 39.4 percent for surfaced roads and only 14.9 percent for native surfaced roads. This appears to be associated with the relative length distribution of roads, 90 percent surfaced and 10 percent native surfaced, as well as the nature of the two road types. A basic assumption is that surfaced roads have a higher percentage of ditches and culverts, and that native surfaced roads tend to be outsloped with minimal culverts. Native surfaced roads are typically on steeper grades, shorter in length, and are higher on the hillslope. This large difference in channel extension between surfaced and native surfaced roads indicates that perhaps native surfaced roads are not as large a factor in increased stream sedimentation as surfaced roads because the delivery mechanism is not as efficient.

Comparing road density and channel extension by WAA (Table 5 and Table 6) shows that road density may be a good indicator of channel extension. Channel extension in WAA's within Cow Creek that have significant acreage of private and BLM lands, such as 02E (Dismal Creek), 02M, and 02Q may be underestimated because the private roads and BLM roads were not included in the sample survey. Also, anecdotal information indicates that these roads are not built to the same standard as Forest Service roads, and therefore, greater channel extension can be expected.

Riparian Areas

Roads within riparian areas have many direct and indirect effects on aquatic and riparian conditions. Roads contribute to the disruption of floodplain connectivity, large wood and nutrient storage regimes, peak flow routing, aquatic habitat complexity, temperature regimes, and channel morphology. Table 7 shows that approximately 9.5 percent of the riparian acreage in Cow Creek is roaded.

Table 7. Acres of riparian reserves with roads.

Stream Class	Acres of Riparian Reserves	Acres with Roads	Percent of Riparian Reserves with Roads
II	3403.63	385.48	11.33%
III	3768.91	336.06	8.92%
IV	2064.59	158.14	7.66%
Total	**9237.13**	**879.68**	**9.52%**

No surveys were conducted to determine if the roads within the riparian areas in the Cow Creek watershed are constricting stream channels and affecting channel morphology. However, it is likely that the roads within these riparian areas have facilitated the removal of large wood from the stream channels and riparian areas as part of the stream cleanout effort which took place in the 1960's and 1970's due to concerns about fish passage and damage to roads after storms.

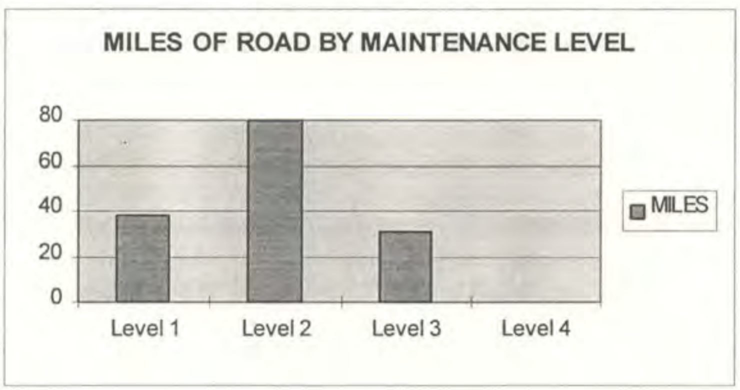
Another impact brought on by the presence of roads within riparian areas is removal of riparian vegetation. Currently, only 31 percent of the riparian reserve vegetation is in a late-seral condition. In comparison, the historic condition was likely 40-60 percent late-seral. Loss of trees from streambanks made the banks more susceptible to erosional processes. In addition, there are now far fewer trees available to fall into the stream and re-establish large instream wood. This is due to the removal of trees as well as the presence of the road in areas formerly occupied by trees. This lack of large wood has simplified channel structure and degraded aquatic habitats.

Access and Travel Management

Although an Access and Travel Management (ATM) plan has been completed for the Umpqua National Forest, it was focused on the existing transportation system and its uses as defined in the 1990 Forest Plan. A new ATM plan for the Forest is to be developed based on maintenance budget and is to be completed by the end of 1996. Following watershed analysis, the District ATM plan can be amended to include the results of the analysis.

Roads in the Cow Creek watershed are categorized by maintenance level (Figure 10) and provide access for a variety of uses including administrative access, commodity production, access for the local residents, and recreation. The roads serve one developed recreation site as well as a number of dispersed sites. In response to a need for more site specific ATM planning, an attempt was made to delineate road related uses and conflicts for the road system in Cow Creek (Appendix E). While this list is not inclusive, it does contain valuable information on each road in Cow Creek and should be incorporated into future ATM planning.

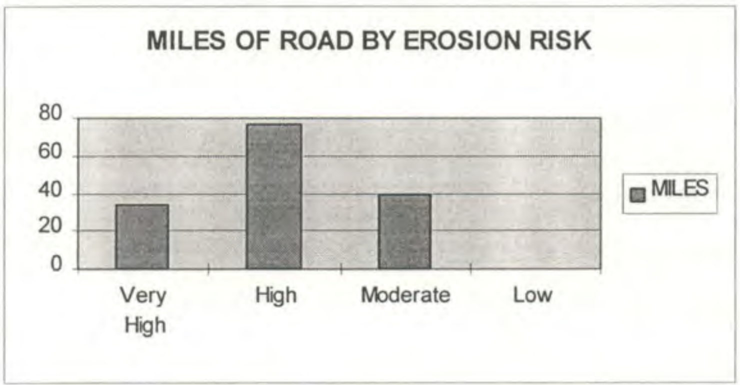
Figure 10. Roads by maintenance level.



An important objective for the ATM plan for the Cow Creek watershed is to reduce sediment impact to the aquatic system while providing safe, maintainable access. Considering the current condition of the transportation system in the Cow Creek watershed and the maintenance funding situation, it may be reasonable to decommission selected roads. The objectives of decommissioning roads are to restore hydrologic function to the roadbed and to reduce stream extension, mass wasting potential, and sediment delivery. Decommissioning will also reduce road density and overall maintenance costs. The decision to decommission a road must be done at the project level and in support of other management objectives. Roads that have been identified as being essential for future uses may be upgraded to reduce potential impacts by replacing undersized culverts, removing unstable embankments, and increasing the number of cross drain culverts. This will reduce the threat of sediment delivery by mass wasting and restore a more natural flow of surface water.

When determining the priority of roads for maintenance, an important factor to consider is the potential risk of erosion from the road. A risk factor has been assigned to each road based on the Umpqua National Forest Soil Resource Inventory (Radtke and Edwards 1976). The risk factor is based on the potential for soil erosion and mass wasting. The analysis of soil components in Cow Creek resulted in combinations that indicated moderate to very high risk in almost every area. Soils of low or low/moderate erosion/mass wasting potential were not analyzed in this study (Figure 11). As project plans are developed, a more in-depth, project-level study of soil erosion and mass wasting potential would be required. Detailed results of this analysis are listed by road in Appendix E.

Figure 11. Roads by erosion risk.



Erosional Processes and Sediment

Some of the WAA's within Cow Creek (WAA's 02A (Devil Creek), 02B (East Fork Cow Creek), 02F (upper Applegate Creek), and 02Q) have more landslides in harvest units and roads than other WAA's within the basin (Table 8).

Table 8. Landslides by watershed analysis area.

WAA	Prior to 1966 (acres)	Prior to 1976 (acres)	Prior to 1988 (acres)	Total (acres)
02A	1.50	0.00	3.00	4.50
02B	3.50	1.00	0.00	4.50
02C	1.00	0.50	0.00	1.50
02D	2.00	1.00	0.00	3.00
02E	1.50	1.00	0.00	2.50
02F	2.50	1.00	3.00	6.51
02L	1.00	0.00	0.00	1.00
02M	1.00	0.00	0.00	1.00
02N	0.50	0.00	0.00	0.50
02Q	1.00	2.50	1.00	4.50
02R	0.00	0.00	0.00	0.00
02S	0.00	0.00	0.00	0.00
02T	0.50	0.50	0.00	1.00
02U	1.00	0.00	0.00	1.00
02V	0.00	1.50	0.00	1.50
02X	0.00	0.00	0.00	0.00
02Y	0.00	0.00	0.00	0.00
02Z	0.00	0.00	0.00	0.00
Total	**17.01**	**9.01**	**7.01**	**33.03**

Landslides and surface erosion put sediment into streams, filling pools and riffles where fish, amphibians, insects, and algae live. The Umpqua National Forest Soil Resource Inventory (Radtke and Edwards 1976) describes four categories of risk ratings based on soil erosion and mass wasting potential. Table 9 shows the acres in each of these risk categories by WAA. It also shows that approximately 69.4 percent of the watershed is in the high or very high risk category.

Table 9. Soil Resource Inventory risk classes by watershed analysis area.

WAA	Low (acres)	Moderate (acres)	High (acres)	Very High (acres)
02A	0.00	224.17	592.46	0.00
02B	0.00	1713.82	1699.81	84.06
02C	0.00	2339.81	1812.90	2021.06
02D	147.11	1028.29	1945.00	447.35
02E	76.56	7.51	554.43	2330.80
02F	41.03	929.72	1991.54	1422.60
02L	112.09	101.58	485.88	0.00
02M	112.59	48.04	284.22	0.00
02N	0.00	5.00	84.06	0.00
02Q	65.05	198.65	1727.83	0.00
02R	0.00	138.61	0.00	0.00
02S	68.55	388.80	131.10	16.51
02T	3.50	440.34	316.74	0.50
02U	83.56	295.73	0.00	128.60
02V	2.00	122.59	1248.46	40.03
02X	0.00	83.56	169.13	2.00
02Y	0.50	5.00	0.00	0.00
02Z	0.00	0.00	0.00	357.78
Total	**712.55**	**8071.23**	**13043.57**	**6851.29**

Percent of Cow Creek watershed in high or very high risk = 69.4%.

More landslides occur on high and very high risk lands where trees are cut and roads have been built, usually when large storms cause rare flood peaks. The floods in 1964, 1974,1980's, and the large storm event January 9, 1995 caused many harvest and road related slides. Figure 12 shows that 76 percent of the landslides and debris torrents are caused by harvest activities, 21 percent are caused by roads, and only 3 percent are natural.

Figure 12. Landslides and debris torrents by management activity.

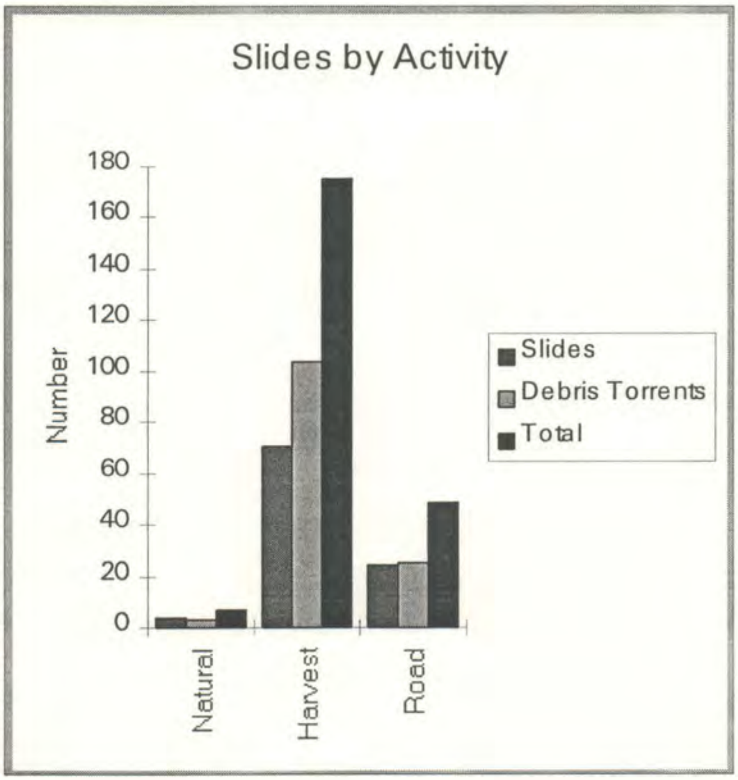
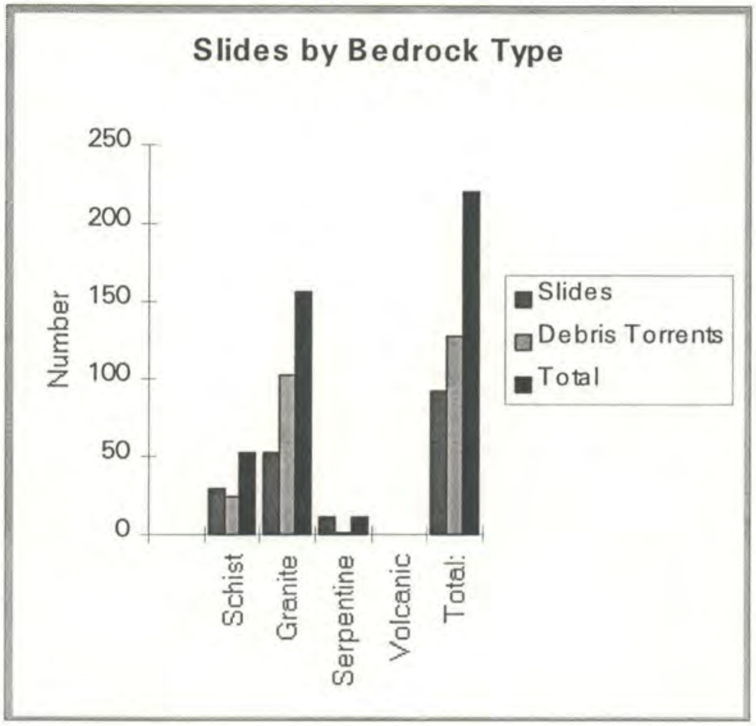


Figure 13 shows the landslides and debris torrents by bedrock type. Seventy-one percent occurred in granite, 24 percent in schist, five percent in serpentine, and none occurred in volcanics.

Figure 13. Landslides and debris torrents by bedrock type.



Stream Chemistry

Beginning in March 1995, nine pH monitoring sites were established by the Friends of Cow Creek (Figure 14). Miscellaneous pH measurements were taken generally in the afternoons on various days throughout the summer. They used a creosote testing kit which measured pH's up to 8.6. Most of the pH measurements were between 7.0 and 8.0. Site 1 (Cow Creek 150 yards upstream of the Snow Creek bridge) recorded the highest pH values; nine days of pH's ranging from 8.2 to 8.6 (the maximum the kit could measure). Other sites that recorded pH's of 8.0 or greater were Site 6 (Cow Creek near the mouth of French Creek), Site 7, and Site 8 (Devil's Creek near the mouth) (Sharkey 1995, personal communication). Field data sheets are in Appendix F. This year was a fairly good water year and stream temperatures were moderate; therefore, we might expect higher pH's in lower water years.

Aquatic algae, which can raise the pH of water during photosynthesis, was often observed in the wide, unconstrained, shallow, bedrock/sand dominated lower reaches of Cow Creek within the watershed in June and July 1995. Bedrock reaches and lots of sunlight in these sections of the stream can increase algae growth. These are only some of the causes of high pH in streams, and it is not clear what the effects are on aquatic life in the basin. We do know that the following certain conditions provide ways for streams to add carbon dioxide back into the water and lower pH.

- Cooler, shaded stream reaches
- Lots of down trees in the creek
- Forest stands using up nutrients

While these principles have been studied elsewhere (Powell 1994), the interactions of forest activities and stream water chemistry in the Pacific Northwest aren't well understood.

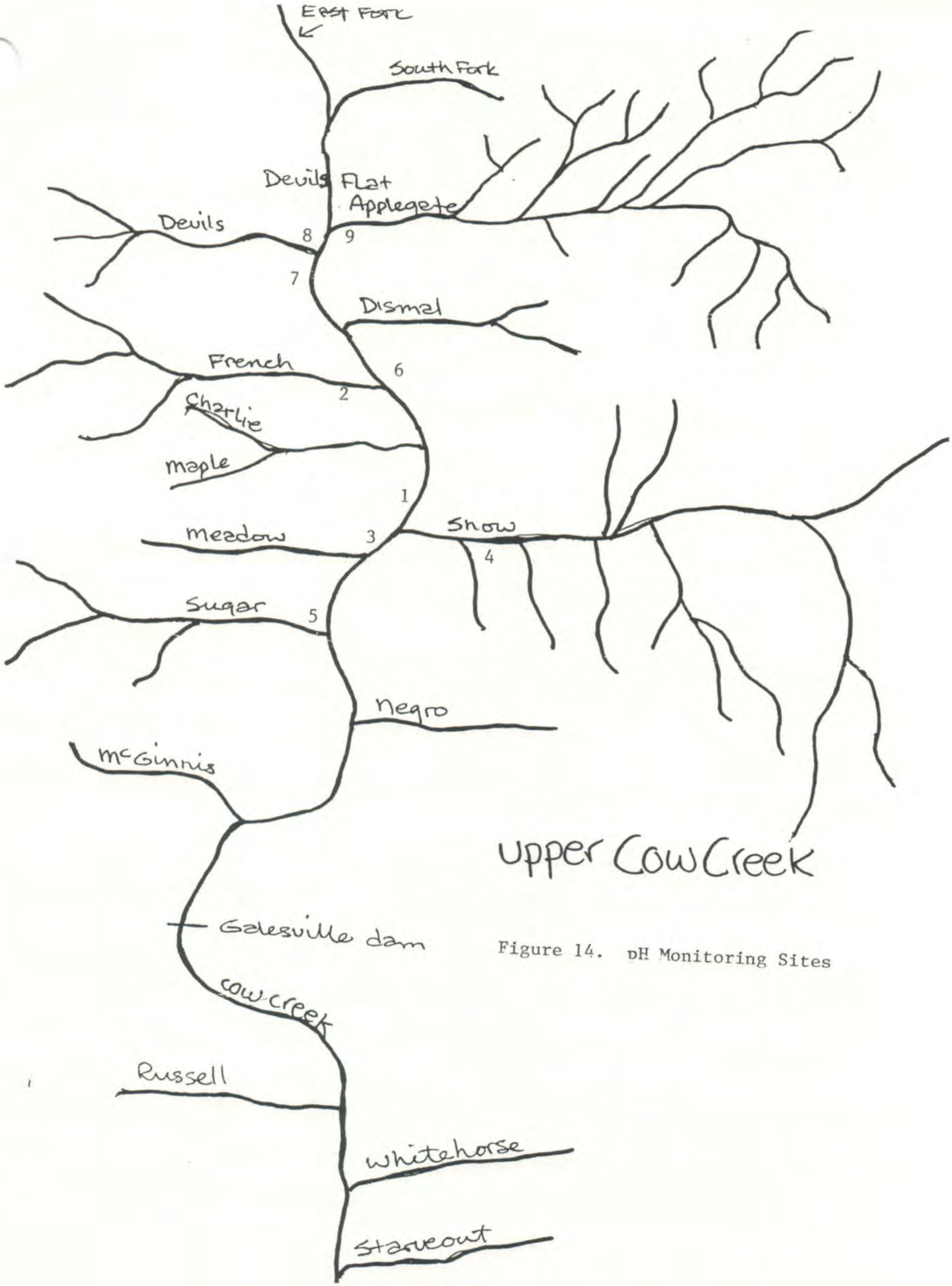


Figure 14. pH Monitoring Sites

Aquatic Habitat Analysis

Historic Fish Population

Until the construction of Galesville Reservoir in 1985, coho salmon, winter steelhead, sea-run cutthroat and possibly Pacific lamprey (*Lampetra tridentata*) were found in these headwaters of Cow Creek (Figure 15). Approximately 18.2 miles of streams within the USFS administered boundary were believed to be used by one or more of these anadromous species. In addition to these Class I streams, approximately 19.5 stream miles of resident trout habitat (Class II) occurred within the boundary.

For a three mile reach of Applegate Creek, fish electroshocking surveys conducted in December of 1975 identified adult coho spawners (60), jacks (2), coho smolts (15) and "fry" (98) (North Angel Timber Sell EA, Tiller Ranger District). Also reported in the survey were seven sculpin, three lamprey, five squawfish and five "black-sided" dace. The coho "fry" likely referred to the previous year class and "black-sided" dace either speckled dace or the Umpqua dace. This survey area included Applegate Creek from the Red Mountain bridge up to the forks (East and West Forks). A more recent survey (1987, post Galesville Reservoir) was conducted upstream on the West Fork. Rainbow trout, cutthroat trout and juvenile lamprey were electrofished.

The South Fork and East Fork were known as winter steelhead habitat as well as cutthroat habitat. Mention of sea-run cutthroat was not made in the reviewed documents but these anadromous salmonids likely had the same distribution as steelhead.

Potential fish species present prior to the Galesville Reservoir:

Coho salmon - *Oncorhynchus kisutch*
Cutthroat trout/sea-run cutthroat trout - *Oncorhynchus clarki*
Rainbow trout/winter steelhead - *Oncorhynchus mykiss*
Pacific lamprey - *Lampestra tridentata*
Western brook lamprey - *Lampestra richardsoni*
Speckled dace - *Rhinichthys osculus*
Umpqua dace - *Rhinichthys evermanni*
Umpqua squawfish - *Ptychocheilus umpquae*
Sculpin species - *Cottus species*
Redside shiner - *Richardsonius balteaus*
Largescale sucker - *Catostomus macrocheilus*

Current Fish Population

Recent fish population surveys are limited for the Cow Creek watershed. Oregon Department of Fish and Wildlife (ODF&W) has not conducted recent surveys but expect resident cutthroat and rainbow trout (Loomis, personal communication). Current classification of the watershed's streams includes the culmination of historic records from USFS activity documents and the

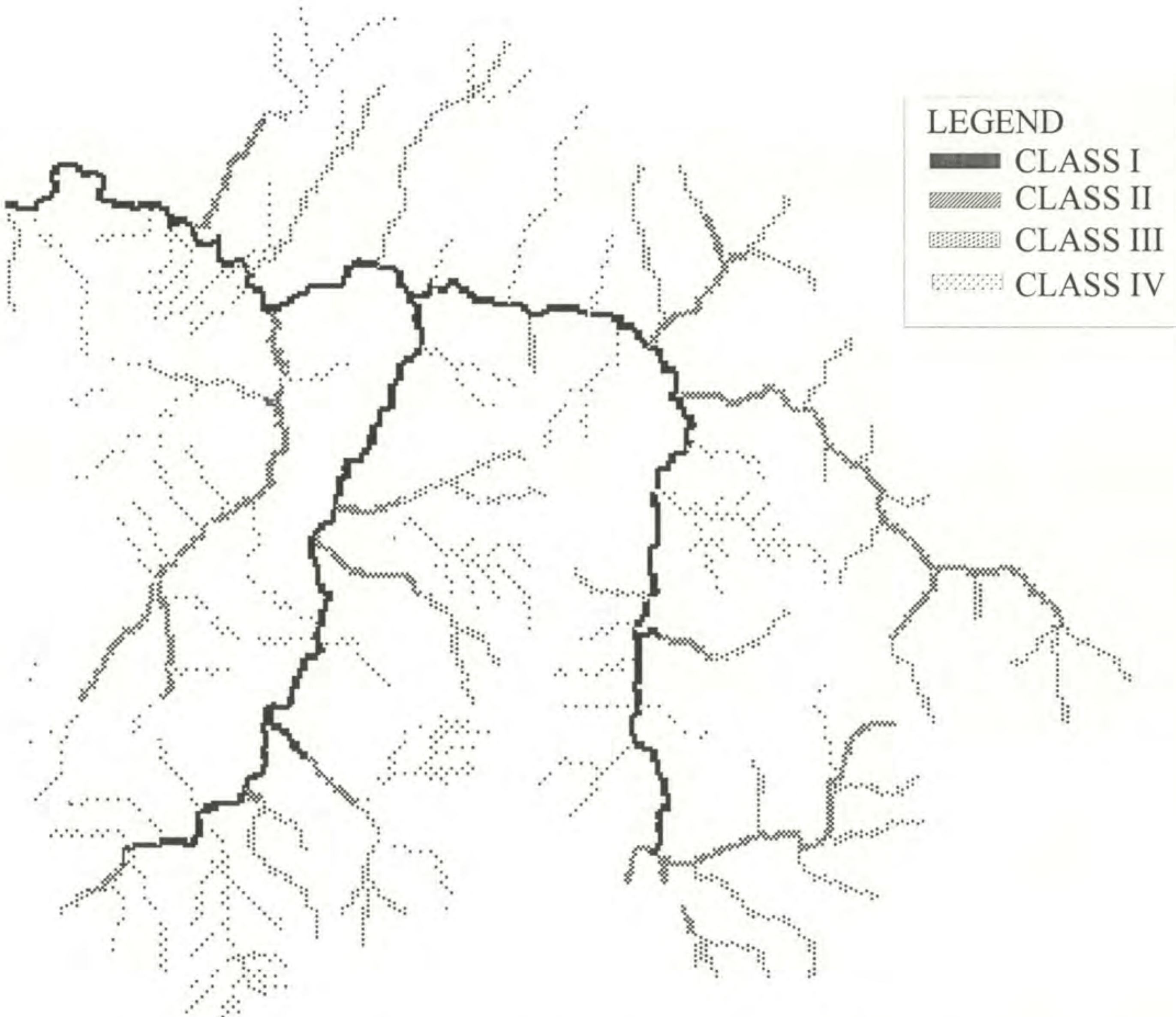


Figure 15. Historic fish distribution for Cow Creek watershed. Class I as anadromous habitat, Class II as resident habitat , Class III as perennial stream and Class IV as winter intermittent.

alteration of all Class I streams (anadromous) to Class II streams (resident salmonids) following the building of Galesville Reservoir (Figure 16). Based on this information, an estimated 37.6 miles of resident trout habitat occurs within the watershed. Any nonanadromous, nonsalmonid species that occurred in the drainage prior to Galesville Reservoir is assumed to still inhabit the watershed.

Fish populations above Galesville Dam are primarily dependent on natural reproduction. In Galesville Reservoir, limited stocking of adult and fry coho as well as the stocking of "legal" and "fingerling" rainbow trout occurs (Loomis, personal communication). Spawning and recruitment of resident salmonids is critical to maintaining salmonid populations in this watershed.

Even though Galesville Reservoir has eliminated anadromous species, aquatic issues identified throughout the Pacific northwest are also applicable to this watershed. Degradation of water quality and simplification of habitat are potential limiting factors for resident salmonids. Identified critical biotic and abiotic processes within the Cow Creek watershed analysis area include the aquatic-hillslope interaction of sediment and waterflow regime, riparian vegetation community, and stream channel complexity and equilibrium. Land use activities may have a variety of negative impacts on these processes and subsequently the biotic environment (Chamberlin et al. 1991, Hicks et al. 1991, Swanston 1991). Response of the biotic community can be measured directly or indirectly through population sampling and habitat characterization.

Landscape Level Analysis

The stream ecosystem is a continuum of biotic and abiotic components integrated spatially and temporally (Beschta and Platts 1986, Cummins 1974, Murphy and Meehan 1991, Poff and Ward 1990, Vannote et al. 1980, Ward 1989). Ward (1989) described the four-dimensional nature of the stream ecosystem. Understanding the very nature of these dimensions (longitudinal, lateral, vertical and temporal) is a prerequisite for evaluating and understanding the watershed processes (Montgomery and Buffington 1993, Heede and Rinne 1990, Rosgen 1994, Ward 1989). The upstream-downstream continuum of biotic organisms, sediment transport, water quality, nutrient spiraling and waterflow is the basis for evaluating watersheds at the landscape level. A common understanding of this longitudinal dimension is necessary before an evaluation and interpretation of present conditions can begin. Depending upon the sensitivity of the measure at hand, the characterization of any point on the stream continuum will provide a characterization of what is occurring upstream of that point. This may be especially true for water quality parameters such as turbidity and temperature as well as sediment transport and water flow.

Sediment Transport Processes

Concerns and indications of problems with sediment and waterflow include high road mileage densities and channel extension. Natural and accelerated earthflow/landslide events indicate higher levels of sediment contribution to the stream. Hicks et al. (1991) and Bjornn and Reiser (1991) discussed the habitat requirements and response of salmonids to various changes in their habitat caused by management activities. Changes in turbidity, channel substrate characteristics,

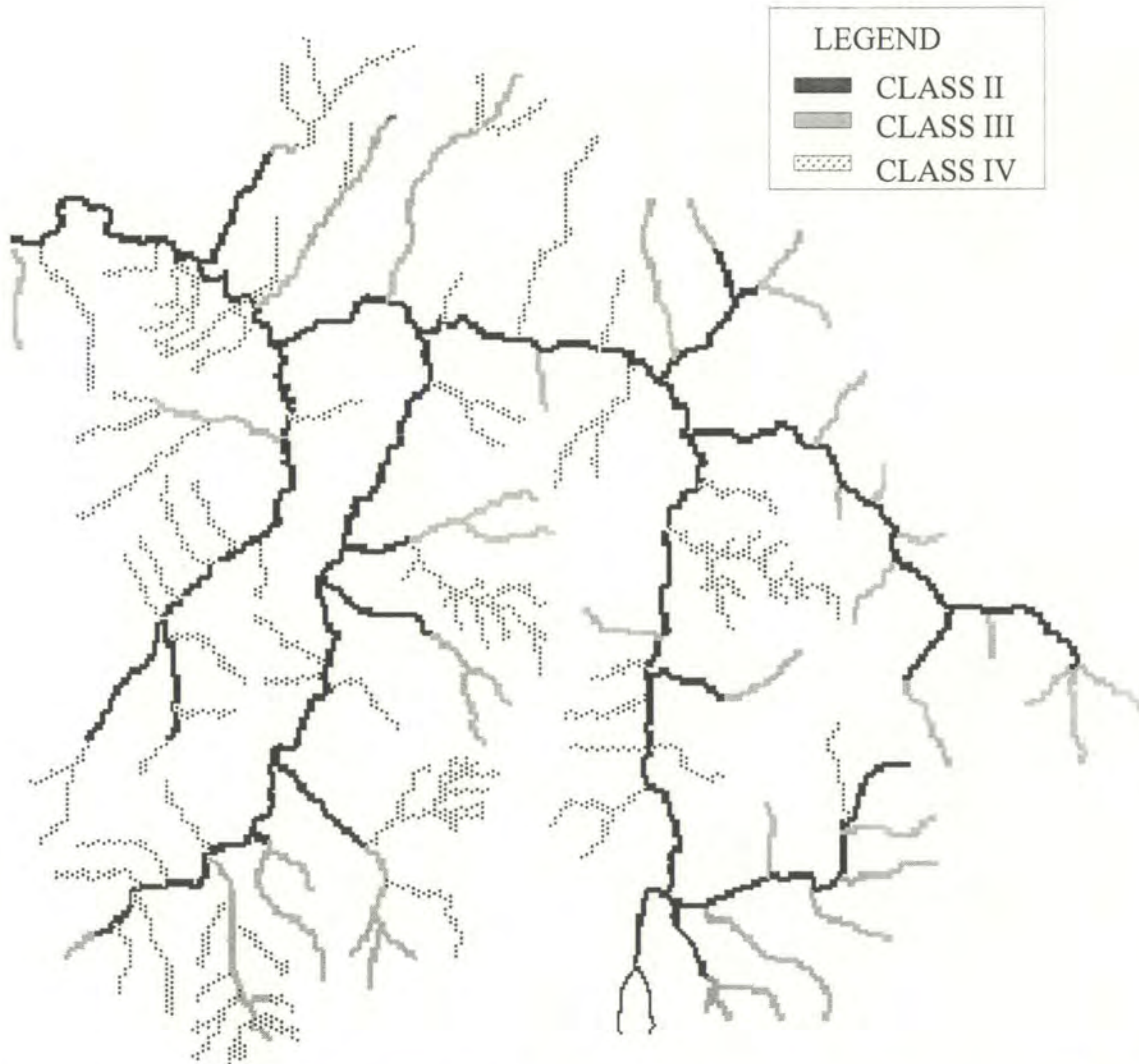


Figure 16. Current stream class and expected fish distribution in the Cow Creek watershed.

and waterflow regime have varying impacts on different species, life stages, and activities of organisms (Bjornn and Reiser 1991, Hicks et al. 1991, Swanston 1991).

Increased sediment fines within a channel cause channel embeddedness. This is the process of fine sediment filling the interstices between the larger substrate particles (Bjornn and Reiser 1991). Filling these openings precludes the use of these spaces, reduces interstitial flow and increases the impacts of high flows due to increased water velocity along the stream bed (Bjornn and Reiser 1991, Hicks et al. 1991). As previously mentioned, land use activities cause a variety of changes in the flow regime (higher peakflows, shortened travel time of flow to the watershed outlet, alterations of the drainage network and others). These too have varying impacts on the biotic community (Bjornn and Reiser 1991, Hicks et al. 1991).

Sediment transport and storage in a watershed is always a concern but within a granite/schist dominated watershed, sediment may be the most limiting factor to the aquatic ecosystem. Fine sediments may fill substrates and pools. The riffle stability index (RSI) was chosen as a technique to evaluate the existing balance of water and sediment (Appendix G, Kappesser 1994). This methodology was used within the Cow Creek watershed to evaluate present channel sediment equilibrium, to evaluate cumulative effects, and to provide a long-term monitoring tool. Sites were selected throughout the drainage to correspond with existing macroinvertebrate monitoring stations, watershed area boundaries and methodology guidelines. Within a selected study area, the first three riffles that met methodology requirements (undivided channel) were selected. These were assumed to be representative of riffles within the vicinity of the sample area. Transect sites for each riffle included the top, middle, and bottom of the riffle. Transects were established from bankfull to bankfull and perpendicular to flow. Using the Wolman pebble count procedure (Wolman 1954) a minimum of 200 points per transect were sampled.

The substrate sample from the Wolman pebble count is used to develop a cumulative percent finer distribution curve. This portion of the methodology represents the size distribution of particles deposited from channel forming events (bankfull stage). Determining the geometric mean size of the largest particles being transported at bankfull is the other portion of this procedure. Comparison of the geometric mean particle size with the percent cumulative finer provides the RSI value. Additional information such as the median surface particle size (d50) may be graphically estimated using the distribution curve. Potyondy and Hardy (1994) suggest the use of Wolman pebble counts is an appropriate methodology for monitoring in granitic watersheds. They used the percent fines less than 6.4 mm as an indicator of impact levels to salmonid ecosystems.

Detailed discussion of the use of these values is presented by Kappesser (1994) and provided in Appendix G. In general, values less than 50 are degrading systems, values of 50 suggest a stable riffle, between 50 and 70 suggest dynamic equilibrium, 70 to 90 as a system approaching a geomorphic threshold and greater than 90 as out of equilibrium and aggrading. When the balance of sediment entering a riffle is less than what is leaving, the riffle is degrading. When the balance of sediment entering a riffle is approximately the same as that leaving, the riffle is in equilibrium. When the balance of sediment entering the riffle is more than what is leaving, the system is aggrading.

The sediment and water balance is a complex process that is difficult to evaluate without long-term studies. The resulting information from the 12 RSI sites (36 riffles) should provide the basis for additional work in the drainage (Figure 17). In general, headwater streams in the South Fork (sites 11 and 12) and Applegate Creek (6) are sediment storage. This is not that unusual in granitic watersheds based on similar conclusions by Potyondy and Hardy (1994). The East Fork (site 9) and South Fork (site 10) as well as Cow Creek sites 7 and 8 are within dynamic equilibrium. There are riffles within sites 8 and 9 that suggest they are approaching a geomorphic threshold. Applegate Creek site 5, Dismal Creek site 3, and Cow Creek site 2 are aggrading and considered out of equilibrium. The lower Cow Creek site 1 has one riffle in dynamic equilibrium and two downstream riffles that are approaching a threshold. It is impossible to say what results would have been obtained prior to this winter's approximate 8-year flood event.

Spawning Substrate

Changes in sediment composition due to road construction, timber harvest, mining, debris torrents, and livestock grazing all have an impact on salmonid reproduction (Hicks et al. 1991). Spawning substrate quality has been measured and evaluated using many different techniques (Bjornn and Reiser 1991, Chapman 1988, Grost et al. 1991, Young et al. 1991). For this evaluation, sediment particle size was the only available information. Determining the percent of fines smaller than 6.3 mm allows some indication of potential embryo survival (Bjornn and Reiser 1991, based on Irving and Bjornn 1984). Irving and Bjornn (1984) developed survival curves for cutthroat trout under laboratory conditions. Although other techniques are available for evaluating spawning substrate (fredle index, modified fredle index, geometric mean, and others), the limitations of using bankfull particle distributions to predict embryo survival needs to be considered. The use of the particle size distribution from bankfull events should only be used as a general indication of what size particle is depositing in potential spawning substrate. Due to the complex conditions surrounding redd construction, water and oxygen flow, timing of sediment deposition, site specific species adaptation and other environmental conditions (water velocity, depth, temperature), these embryo survival predictions should not be used as the only indicator of suitable salmonid spawning habitat. Further site specific investigations are needed to understand the relation of sediment size, egg pocket dynamics, and spawning success in these granitic watersheds for the species present.

Water Temperature

Water temperature is also an identified potential limiting factor for salmonid populations in heavily managed watersheds. Preferred temperatures and lethal temperatures vary by species, life stage, and activity (Bjorrn and Reiser 1991). One result of eliminating the riparian vegetative community or stream canopy is elevated water temperatures (Beschta et al. 1987, Bjornn and Reiser 1991, Chamberlin et al. 1991). Potential for the largest daily temperature fluctuations exist with smaller streams (Murphy and Meehan 1991, Beschta and Taylor 1988). Beschta et al. (1987) suggested significant reduction of summer stream temperatures does not occur readily without mixing cool water. Cumulative loading or thermal loading reflects the

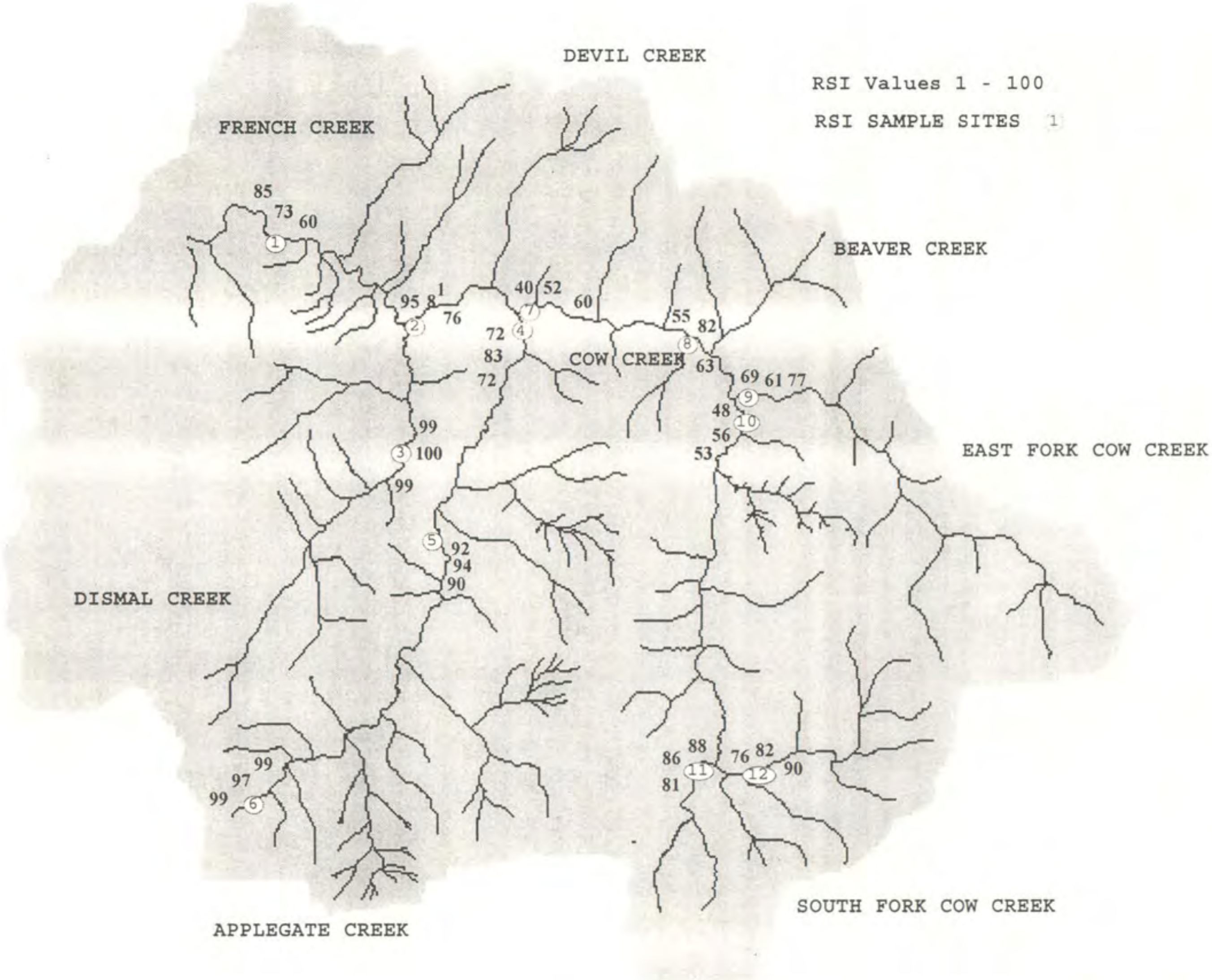


Figure 17. RSI values obtained in the 1995 survey.

longitudinal dimension of streams and the cumulative effects of stream temperature and sediments may have a significant impact at the bottom of a disturbed drainage (Murphy and Meehan 1991). Recovery of the stream shading reduces the temperature and this recovery rate is usually related to stream size (Brown and Krygier 1970, Beschta and Taylor 1988).

Continuous temperature monitors were placed throughout the drainage in an attempt to evaluate thermal loading (Figure 5). In addition to the continuous temperature monitors, water temperature measurements were taken throughout the watershed at the RSI and random survey sample sites (Figure 18). These measurements do not reflect high temperature for each location and vary temporally. These were taken to provide a general sense of condition and are the only temperature measurements available for sites where the continuous temperature monitors were not located.

Stream canopy cover was measured using a densiometer at each riffle within the 12 RSI sites (36 riffles) and at three areas within each random site transect (42 measurements). Mid-channel measurements were taken upstream, downstream, facing the left bank and right bank. Using this sampling procedure, canopy cover was measured within sample transects in the watershed (Figure 18). Cover was above 80 percent for the lower order reaches (first, second and third), averaged 88 percent for fourth order reaches and 52 percent for fifth order reaches of Cow Creek (Figure 19). Water temperatures and canopy suggest good stream shading in the watershed.

Coarse Woody Debris

Stream channel complexity is closely related to the simplification of the riparian vegetation community. Harvest of riparian vegetation and removal of in-channel organic debris decreases channel complexity and results in channel adjustments (Brown and Krygier 1970, Chamberlin et al. 1991, Dose and Roper 1994, Fausch and Northcote 1992, Swanston 1991). Course woody debris serves as a source of channel roughness that determines substrate size and distribution, provides cover for fish, provides water velocity diversity and energy dissipation, storage of Course Particulate Organic Material (CPOM) and develops pools (Bryant 1983, Bisson et al. 1987, Fausch and Northcote 1992, Harmon et al. 1987, Shirvell 1990, Swanston 1991). Survival, recruitment, and population abundance of salmonid species in Pacific northwest streams is related to pools and cover provided by wood debris (Bjornn and Reiser 1991, Fausch and Northcote 1992, Hicks et al. 1991, Martin et al. 1986).

Coarse woody debris occurring below the bankfull level was measured within a 328 foot transect for random sites. The same procedure was used for the RSI sites but included the longitudinal length of the RSI site. Debris diameter (smallest end) and length were measured and recorded. During the analysis, if a piece qualified it was placed in one of three size groups. Wood not qualifying for one of these sizes is not reported within this document. Standard size of large woody debris (LWD; diameter >36 in and longer than 50 ft) and small woody debris (SWD; diameter >24 in and longer than 50 ft) were used. The third category is based on the wood size (diameter, length) and channel width relation developed by Bilby and Ward (1989). This final group is considered the size of material needed to be retained within the surveyed channel size. Material of this size is expected to have long-term retention and provide channel influencing

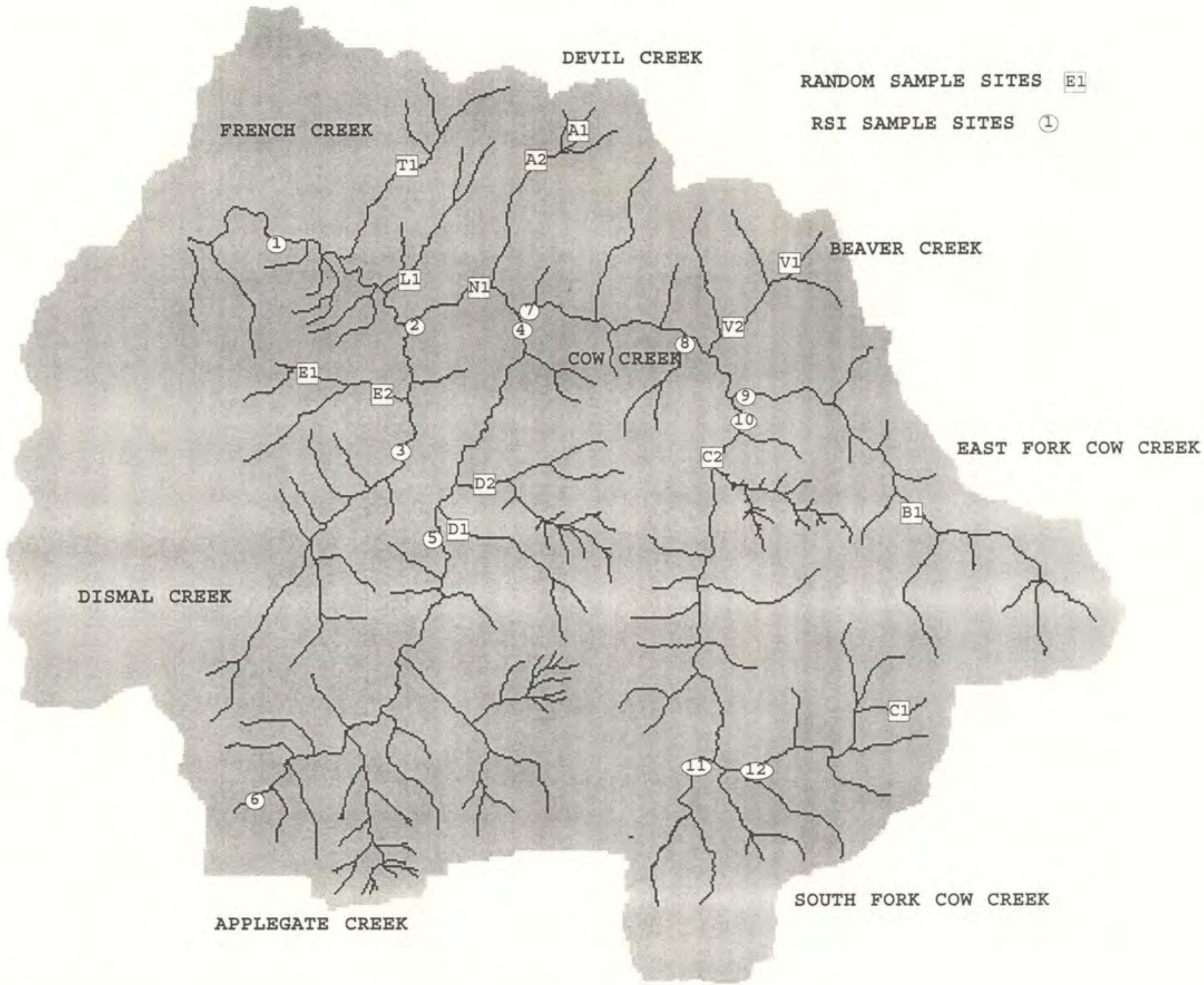


Figure 18. RSI and random survey sites for the 1995 survey.

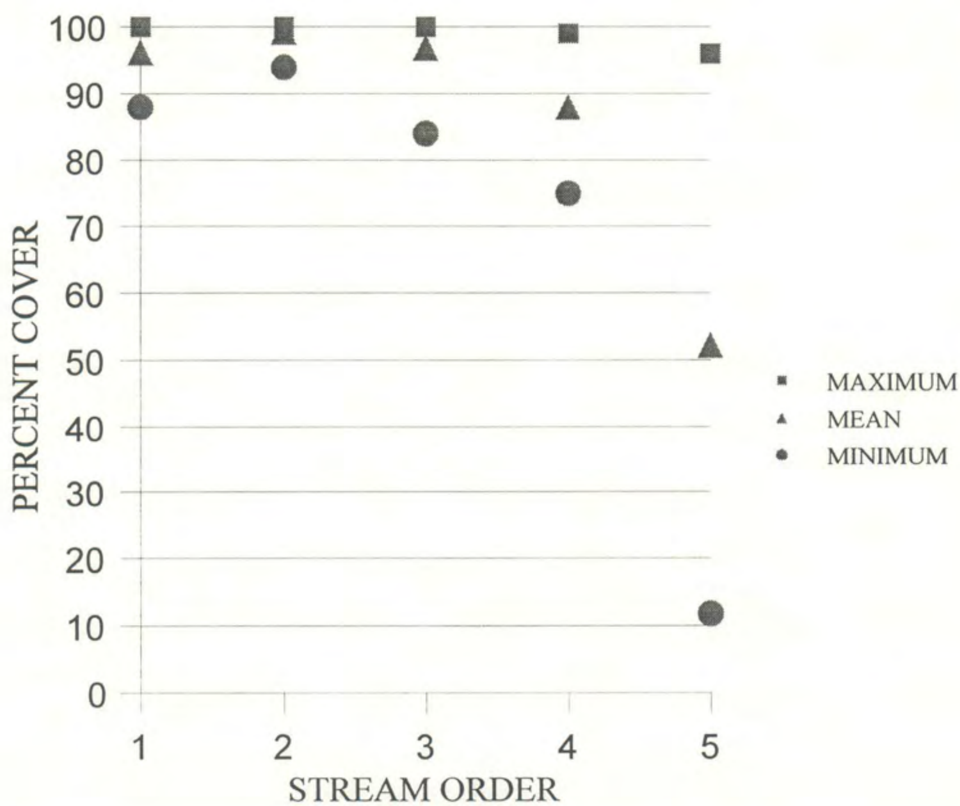


Figure 19. Canopy cover measured at random and RSI sites using a standard densiometer.

properties. The term channel influencing debris (CID) will be used to designate this category of coarse wood.

Surveys conducted at the RSI sites and random sites identified large variability in the coarse woody materials (Figure 20, 21, and 22). Although 35 percent of these transects were located in areas where the stream buffer did not have harvest units, these transects did not have higher amounts of wood. First, third, and fifth order streams did not contain any SWD, even though they did contain CID debris. Except for the fifth order reaches, SWD would usually be larger than the CID size. Fourth order reaches did not contain LWD but in general they contained SWD and CID wood. At this time, the causes of these observed differences are unknown. Some management practices used in the Cow Creek drainage may explain the absence of wood in a few remote locations. One practice was to remove wood by burning the in-channel debris dams during low flow (Hunt, personal communication). This occurred occasionally but cannot explain for all the remote areas. Loss of wood during the 1964 and 1974 floods may also be causes for lower numbers. Smaller drainages may have retained some of this wood during these floods. The 1964 flood was approximately between a 25- and 50-year event and the 1974 flood was approximately a 100-year event. Several 10-year events have also occurred in the last two decades indicating additional periods that marginal sized wood was lost.

Average wetted and bankfull channel widths did not have a large variation within stream orders (Figure 23 and 24). The RSI location (RSI 9) on the East Fork is noticeably wider than all the other second order streams. Several reasons could be attributed to this observation. First, it is likely this stream network is more complex than mapped and the East Fork is a higher order stream. Second, the surveyed area of East Fork is less confined than most of the drainage. Above this site, the East Fork is a confined, step-pool channel.

Pool Habitat

Although pools were not measured directly, coarse woody debris and RSI/sediment storage were measured as indirect indicators. In general, as RSI values approach 100, pool volume decreases and approaches zero (Kappesser 1994). The presence of course woody debris or other large, stable material such as bedrock outcrop will provide the necessary influence on water flow to influence channel morphology. Substrate scour from these materials may be sufficient to make pools within a fine sediment channel. When RSI values approach 100 and corresponding coarse wood values approach 0, pool habitat is likely limited.

Macroinvertebrate Monitoring

Aquatic macroinvertebrates are good indicators of water and habitat quality because they respond quickly to changes, reside in the stream during most of their life cycle, and are relatively immobile, therefore, subjected to short duration or chronic events (Plafkin 1989, Wisseman 1983, Wojcik and Butler 1970). The presence or absence of certain species or species assemblages will indicate specific habitat or water quality limitations (Hynes 1970, Pennak 1978, Plafkin 1989, Poff and Ward 1990). Wisseman (1990) developed an assessment scoring methodology to evaluate the biological integrity of macroinvertebrate populations (Appendix H).

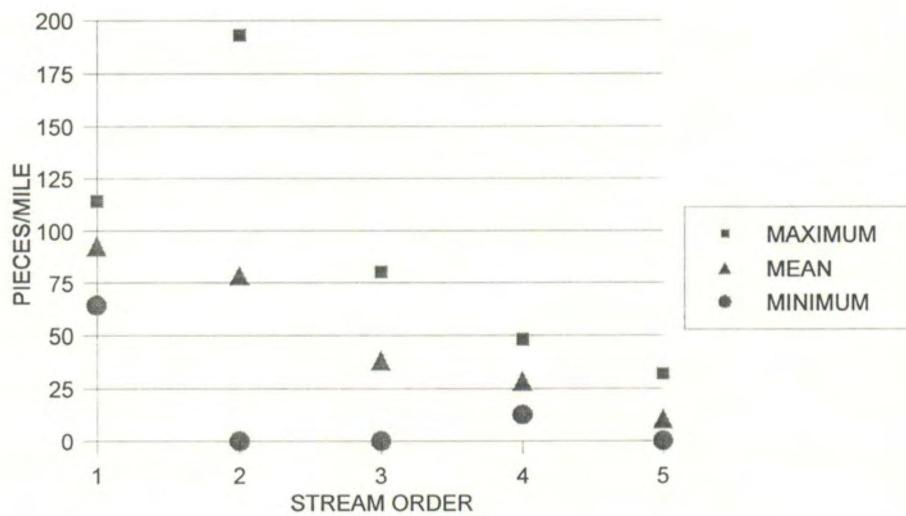


Figure 20. Density of channel influencing debris (CID) observed within the random and RSI survey sites.

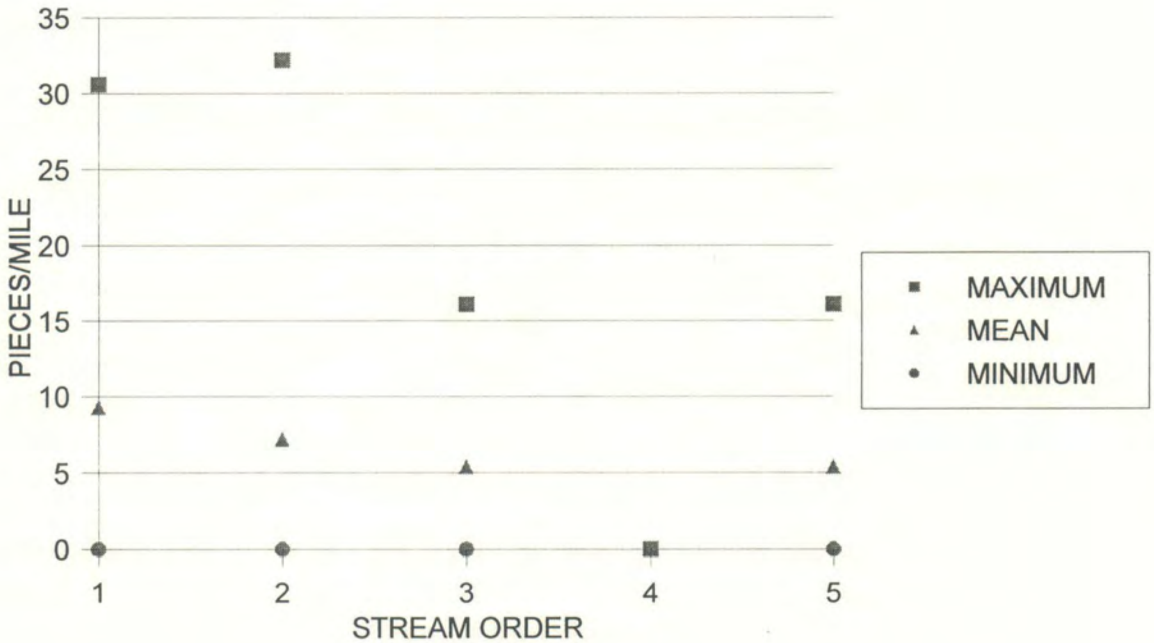


Figure 21. Density of large woody debris (LWD) within the random and RSI survey sites.

Figure 22. Density of small woody debris (SWD) within the random and RSI survey sites.

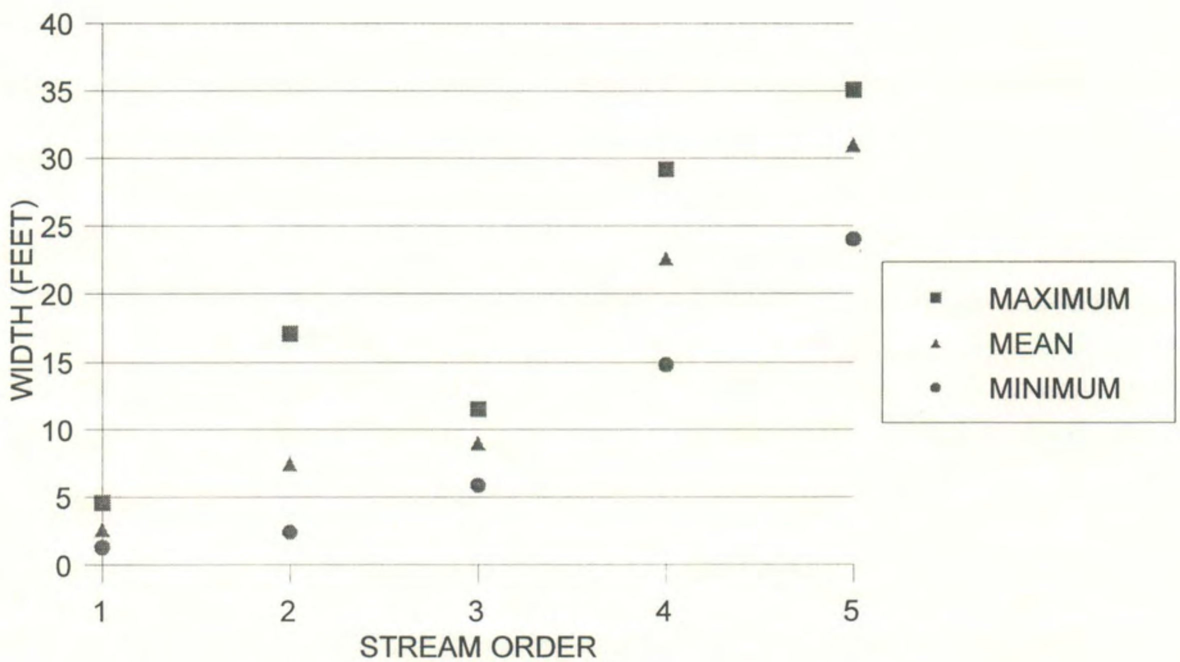


Figure 23. Wetted width for random and RSI survey sites.

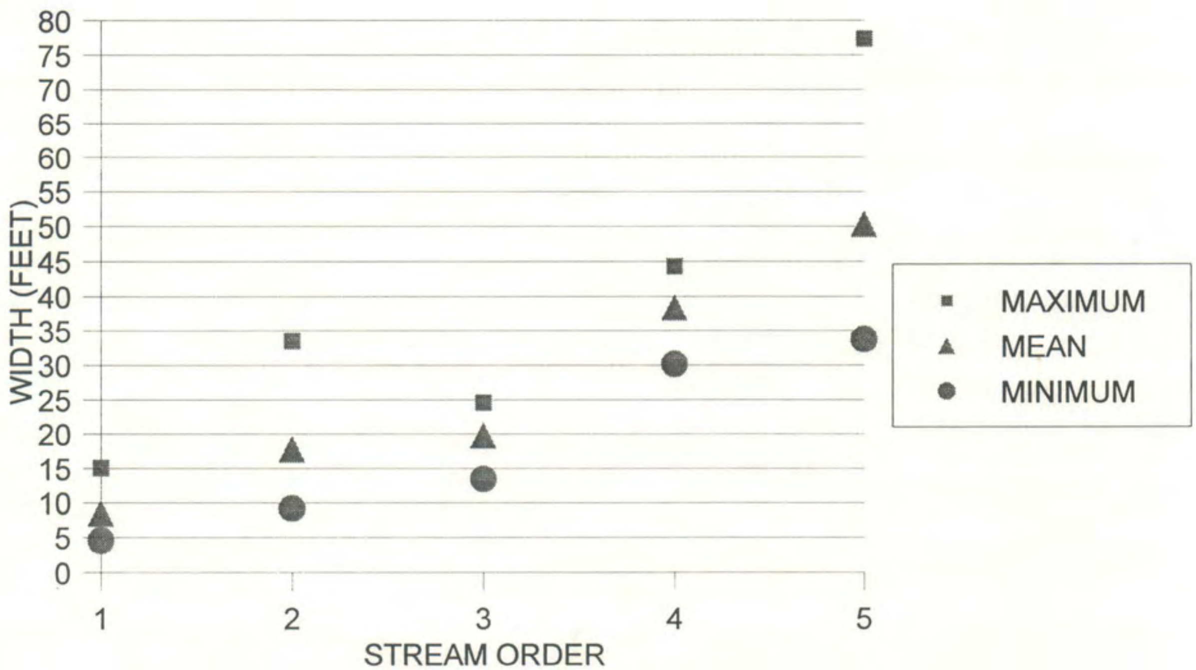


Figure 24. Bankfull width for random and RSI survey sites.

Macroinvertebrate populations will respond to changes in their environment (Hynes et al. 1970, Murphy and Meehan 1991, Poff and Ward 1990). Wisseman (1990) includes numerous taxa groups to define the macroinvertebrate community and these are designated by a unique number. These groups will be referred to throughout the discussion but detailed information is provided in Appendix H. Some of Wisseman's (1993) metrics that specifically indicate heavy winter scour and fine sediment include scraper caddisflies (metric 33, Glossosomatidae and metric 35, Psychomyiidae), net-spinning caddisflies (metric 34, Philopotamidae), predatorial, long-lived net spinning caddisflies (metric 32, Arctopsychidae) and a long-lived stonefly (metric 30, *Pteronarcys*). These species use the substrate interstitial zone. Taxa needing large space in the hyporheic sediments are the previously mentioned net spinning caddisflies (34). Wisseman (1993) included six taxa groups (20,21,27,30,31,32) in his list of long-lived taxa. These include Xylophage (20), intolerant molluscs (21), Gomphidae, a dragonfly (27), Pteronarcys, a stonefly (30), Corydalidae, hellgramites (31) and Arctopsychidae, caddisfly (32). Xylophage (20, wood eaters) are also used as an indicator of CPOM storage and availability. These various taxa may fill specific feeding niches, require specific habitat requirements, or have specific life history requirements, such as the long-lived taxa. Changes in the surrounding environment may eliminate the habitat, provide competitors an advantage or may not provide a stable environment for the necessary duration to complete life history requirements.

Results from macroinvertebrate monitoring in 1990 provides a common temporal comparison of the major tributaries of Cow Creek and a lower reach of Cow Creek (Figure 25). These macroinvertebrate monitoring stations can be related to RSI sample sites (Figure 18). RSI 1 is the lower Cow Creek monitoring site, RSI 4 is the Applegate Creek monitoring site, and RSI 10 is the South Fork's RSI site. The East Fork's monitoring site is located upstream of the 3232 road crossing. This is upstream of RSI site 9. Based on the 1990 samples, indications for the Cow Creek watershed were that the East Fork had high habitat and biotic integrity. The South Fork was within the moderate habitat and biotic integrity range. These are both positive general indicators for these watersheds. Applegate Creek was also in the moderate range but at the lower end. This suggests possible limiting water quality or habitat related factors. The lower Cow Creek site was very low and in the severe habitat and water quality limited range. Further evaluation of the potential indications from these samples are provided in the following drainage specific sections.

Specific Drainages

South Fork Cow Creek (WAA 02C)

The South Fork is an extensive stream network lying mostly in granite (east side), schist (west side and main stem) and some serpentine. At the confluence with the East Fork, the South Fork is a fourth order stream. Road density for the WAA is approximately 2.6 mi/mi^2. One unique feature of this drainage is the South Fork Cow Creek Corridor which provides a Continuous reserve down much of the drainage's length. This watershed drains approximately 6,163 acres.

Sediment Transport Processes

Three RSI sites were established within the South Fork's drainage (sites 10, 11 and 12). Based on the RSI values, site 10 can be characterized as a reach in equilibrium (RSI values 48, 56, 53). The other two sites are located near the headwaters and these sites are sediment storage (site 11 and 12). Macroinvertebrate sampling from the South Fork suggests this watershed contains high biotic and habitat integrity (Figure 26). Taxa requiring stable crevices (30,31 and 32) and taxa sensitive to high water scour (33,35 and 38) are common (Wisseman 1993). Although no fine sediment tolerant species are present, those requiring large pore space (34) are absent or rare. An unexplained reduction in metric scores occurred between the years 1989 and 1990. Potential explanation for this could include variation in sampling or possibly a response to the 1987 fire and subsequent erosion. This fire occurred near the headwaters of the South Fork and sediment transport through the system may have required some time to reach this lower monitoring point. Erosion studies following this fire suggest erosion rates were not high (Schmidt 1995). Assuming these scores were not sampling differences, the community is recovering (Figure 26).

Sediment sizes (d50) at these two higher sites (11 and 12) include fine, medium and coarse gravels. Embryo survival for these sites are predicted to be from 2 to 54 percent based on the percent of fines smaller than 6 mm. Substrate at site 11 on the mainstem of the South Fork were medium and coarse gravels (d50 of 16, 28 and 30 mm). Predicted embryo survival for these riffles were 12, 30 and 54 percent. This site had fewer fines than the tributary site (site 12), which was fine and course gravel (4, 18 and 21 mm, d50s). The predicted embryo survival for site 12 though was considerably lower (2, 6 and 20 percent) due to the much higher percent of fine sands in the substrate. For site 12's three riffles the amount of substrate less than 6 mm was 32, 41 and 53 percent. For site 11, these values were 16, 26 and 35 percent. The east side of the South Fork (site 12's watershed) consists primarily of granite, which degrades to sand size grains. Site 11's watershed is primarily serpentine and schist. The serpentine is more stable than granite or schist and the schist degrades to very fine gravel size.

Site 10 d50's were large cobble (150 mm) and medium cobble (95 and 110 mm). Predicted embryo survival for this site ranged between 60 and 65 percent. Fines smaller than 6 mm were 14, 16 and 18 percent.

Temperature

Temperatures in this drainage were among the lowest in the watershed. The highest temperature recorded at temperature monitoring station 11 (RSI site 11) was 54 degrees Fahrenheit and the tributary next to this site (temperature station 12) was also 54 degrees Fahrenheit (Figure 3). The highest temperature at the bottom of South Fork was 59 degrees Fahrenheit. This monitoring location was at the same site as the South Fork macroinvertebrate monitoring station. Results from the macroinvertebrate sampling support the temperature findings. Numerous taxa that are intolerant of high summer temperatures were collected. For the watershed, canopy cover measurements taken in 14 locations averaged close to 95 percent. Canopy cover throughout the South Fork drainage is likely very high based on the temperature results and survey results for canopy cover.

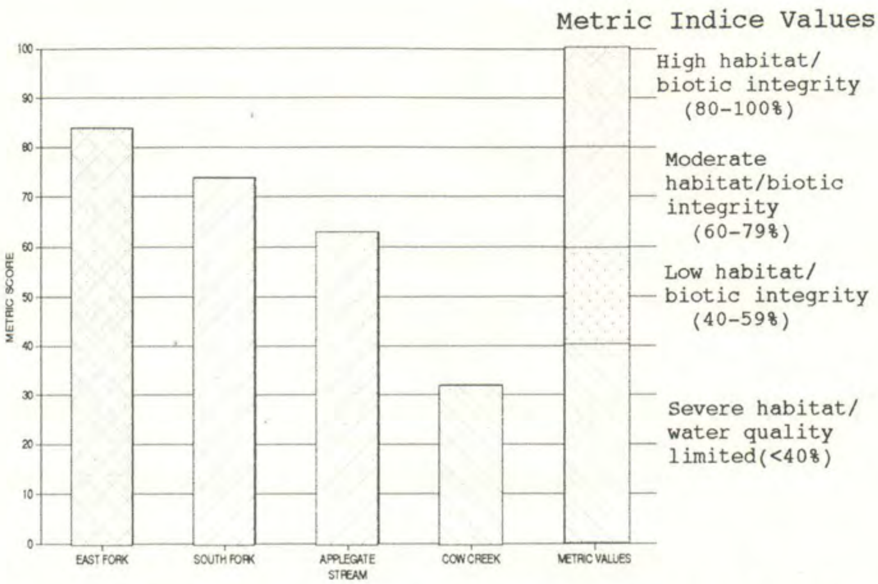


Figure 25. Macroinvertebrate 1990 monitoring for the Cow Creek watershed.

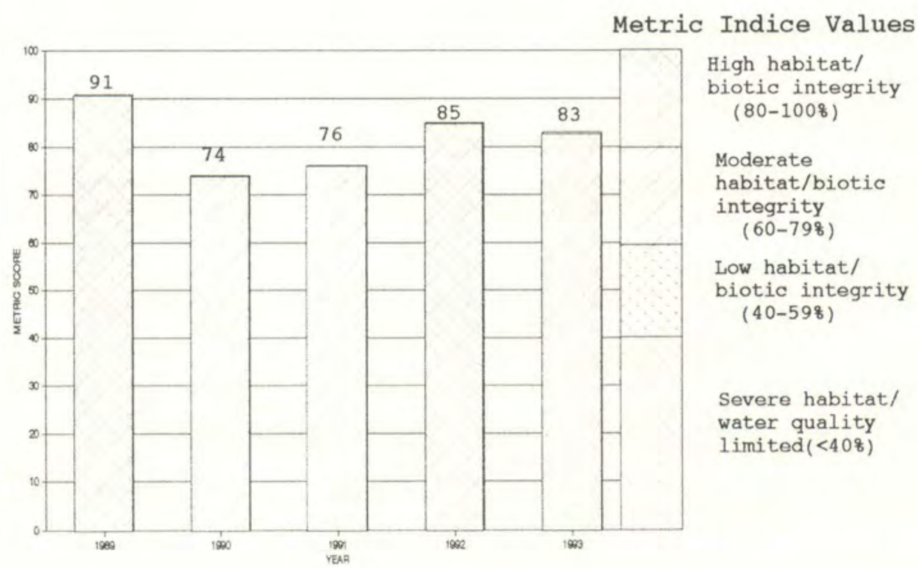


Figure 26. Macroinvertebrate monitoring results for the South Fork of Cow Creek.

Coarse Woody Debris

Course wood in the channel varied considerably. RSI site 12 contained 16 LWD pieces per mile and 32 SWD pieces per mile. This is an upstream site located in a lower gradient valley. All but one South Fork survey site was located in non-harvested riparian buffers. Each of these sites had channel influencing debris ranging from 32 CID pieces per mile to 193 CID pieces per mile (Appendix I). A management practice that involved burning debris dams was mentioned earlier. One place this occurred was on the South Fork, upstream of White Creek (Hunt, personal communication) and upstream of site C2 and RSI 10. A large debris torrent resulting from a road failure developed a large debris dam that was subsequently burned. Remnants of this dam are still evident on the South Fork. The floods during 1964 and 1974 likely also removed many wood pieces from these lower sites. Long-term management of the riparian zone will provide future recruitment to this drainage.

East Fork Cow Creek (WAA 02B)

Much of the East Fork can be characterized as a high gradient, step-pool channel. While the majority of the East Fork lies within schist, a mixture of soils includes the southern side as granite, the upper end as breccia and tuft volcanic soils and some small areas of serpentine. These materials have different erosion patterns. The breccia and tuft volcanic soils likely produce finer sediments than the schist or granites. Turbidity from very fine particles may be more of an issue with these soils than it would be with the sands and very fine gravels of the granite and schist. This WAA is highly roaded and contains approximately 4.7 road mi/mi^2. This watershed drains approximately 3,499 acres.

Sediment Transport Processes

One RSI site (site 9) was established at the lower end where the channel characteristics provided an appropriate survey site. The RSI values suggest some sediment storage above equilibrium (69, 61, 77). These values are not extremely high and perhaps for these granitic/schist systems are within an expected range. The median substrate sizes (d50) for these riffles were 17 mm (coarse gravel), 30 mm (coarse gravel) and 45 mm (very coarse gravel). Fine materials within this area are potentially limiting some reproduction. Predicted embryo survival is 15 percent for all three riffles. Fines smaller than 6 mm were 33, 35 and 37 percent. Macroinvertebrate monitoring has occurred upstream of the RSI site above the crossing of the 3232 road. Although these sites (RSI 9 and macroinvertebrate) are not overlapping spatially or temporally (1990 invertebrate survey), the invertebrate information does support similar conclusions. Taxa requiring stable crevice space in the armor layer (30, 31, 32) and requiring large pore space in hyporheic sediments (34) occur occasionally. Taxa particularly sensitive to scour during high water (33, 35, 38) are rare. The high density of roads (4.7 $miles/miles^2$), harvest history, and gradient of the stream are likely contributing to higher winter scour.

Temperature

Water temperatures within this drainage were low. Continuous temperature monitoring results identified 60 degrees Fahrenheit as the high recorded for the summer. Temperature taken at site B1 was 47 degrees Fahrenheit at 0900 on August 22, 1995. Macroinvertebrate sampling did not collect any high temperature tolerant species and many taxa intolerant of high temperature were present (Wisseman 1993). Canopy cover in these sample sites ranged between 97 and 100 percent. Although this was a limited number of measurements (6 taken), stream temperatures suggest they are fairly representative of watershed values.

Coarse Woody Debris

Coarse woody debris was limited in these sites. There were no LWD pieces in either site. RSI site 9 contained 16 SWD pieces per mile and 64 CID pieces per mile. Site B1 contained only 16.1 CID pieces per mile and no LWD or SWD. This sites' riparian buffer (170 ft on each stream side) is completely located in late-successional stands. The nearest road is located some distance away. Floods of 1964 and 1974 may have depleted the mainstem sites. No CPOM samples were taken in the macroinvertebrate sampling but long-lived taxa (20,21,27,30,31,32) are common and Xylophage (20, wood eaters) are high. Both are indicators of stable conditions and high storage potential. This appears contradictory to the absence of scour sensitive species but this step-pool system does appear to store CPOM.

Applegate Creek (WAA's 02D and F)

Applegate Creek has an extensive stream network and is a fourth order stream at its confluence with Cow Creek. This watershed lies primarily in schist and granite. The mainstem and west side of Applegate Creek is located in granite and the east side in schist. Small areas of the east side are granite and even some serpentine. At the confluence of Applegate Creek and Cow Creek, metamorphosed volcanics occur. This is a more stable soil than either granite or schist. Road density in WAA 02F is one of the highest in the Cow Creek watershed (4.8 mi/mi^2). The combination of road density, timber harvest and recent debris torrents makes this WAA (02F) a great concern. WAA 02D is located on the lower end of the Applegate Creek drainage. Although Applegate Creek is separated into two WAA's, the cumulative effects should consider both WAA's as contributing sources. WAA 02D also contains road densities of concern (approximately 3.1 mi/mi^2). Applegate Creek drainage is 7,954 acres (WAA 02D and 02F).

Sediment Transport Processes

Sediment transport and storage within the system appears to consist of largely fine materials that are stored throughout the drainage. RSI site values range from 72 (RSI 4) to 99 (RSI 6) (Figure 17). These suggest aggredation of the system. Headwater streams with values in the 90's suggest storage of fine particles. This was also observed in the macroinvertebrate sampling at RSI site 4, which supports the indications that the aquatic ecosystem is limited by fine sediments. Taxa requiring stable crevices in the armor layer (30, 31 and 32) are rare. Other indicators include the rarety of taxa requiring large pore space in the hyporheic sediments (34) and taxa sensitive to scour during high water (33, 35, 38). An additional sediment indicator is the presence of fine sediment tolerant taxa (Centroptilum), which is a mayfly genus (Wisseman 1993).

RSI site 5 is downstream of WAA 02F's lower boundary. Channel conditions are influenced primarily by WAA 02F. RSI values for this site were extremely high (92, 94 and 90). This is indicative of a system that is beyond a threshold and is aggrading the channel. Median substrate size (d50) for this site included coarse gravels of 18 and 25 mm. Cutthroat embryo survival may be expected to range from 6 to 22 percent. For the three riffles the percent of fines smaller than 6 mm were 29, 35 and 41 percent. Without further analysis these high RSI values cannot be linked directly to any single cause and in fact are usually not. This year's high water event and debris torrent may be the cause of these observed conditions but without prior substrate information or specific survey objectives to determine these answers, the high road densities and harvest activities must be considered part of the cause. Despite the specific causes, Applegate Creek is out of equilibrium.

The other RSI sites contained substrate d50's ranging from less than 2 to 20 mm. These Applegate Creek riffles included sands, fine gravels and coarse gravels for their d50. Site 4 riffles included d50s of fine gravels and coarse gravels where RSI 6 included only sand. Observations in the Idaho granitic watersheds observed the headwater streams such as RSI 6 also stored many fines less than 6 mm (Potyondy and Hardy, 1994).

Based on the percent of fine substrate in the bankfull discharge composition, predicted embryo survival is very low for RSI sites 4 and 6. Predicted values range between zero and eight percent for the six riffles sampled in these two sites. Although site 4 RSI values are 72 and 83, the percentage of fines are very high. These values are 40, 51 and 51 percent for the three riffles. Site 6 is almost completely sand. The percent smaller than 6 millimeters are 72, 74 and 90. Reproduction is not expected to be successful.

Temperature

Water temperatures taken at the RSI (RSI 4, 5 and 6) and random sites (D1 and D2) ranged from 50 to 61 degrees Fahrenheit. The RSI 4 site, mouth of Applegate Creek, was the highest temperature. The presence of some macroinvertebrate taxa intolerant of high summer temperatures indicate they are not too high, but high enough to have high temperature tolerant taxa present. Continuous temperature monitoring conducted this summer documented 67 degrees as the highest recorded temperature for site 4. For the survey areas, Applegate Creek canopy coverage ranged from 75 to 100 percent. Much of the lower portions of Applegate Creek are at least partially shaded by alder and vine maple, even at the low water stage.

Coarse Woody Debris

Habitat complexity and channel stability may be represented by measuring woody debris present in the channel. Characterized in this way, Applegate Creek has limited complexity when considering LWD and SWD. Only one of five sample transects contained any materials in these size ranges. Random site D1 retained 32 LWD pieces per mile and 16 SWD pieces per mile. By considering channel influencing debris (CID) as defined by Bilby and Ward (1989), four of the sites retain varying pieces of course woody materials. Two of the lower order stream survey sites contain CID. With the eight-year event during this last winter (January 1995), many pieces of marginal size were likely washed out of the larger order reaches (RSI 4 and 5). Materials retained in RSI 4 and 5 sites were primarily contained within debris jams. The survey transect along random site D2 was next to a road and the stream reach is located within a harvest unit (1959 clear cut). Present vegetation includes hardwoods and dense conifers. Although no CPOM samples were collected during the macroinvertebrate monitoring at RSI 4, the absence of Xylophage taxa (wood eaters), rarety of long-lived taxa and low abundance of shredder taxa support the limited habitat complexity description of these lower Applegate Creek reaches.

Dismal Creek (WAA 02E)

Dismal Creek has an extensive stream network and is a third order stream at its confluence with Cow Creek. Approximately 4.8 miles of Dismal Creek are classified as Class II waters. This watershed is primarily in granitic soils with the bottom end classified as alluvium (modern stream deposits). A combination of private land and federally administered land are interspersed throughout the drainage. Road densities are reported as 1.9 mi/mi^2, but this should be recognized as an underestimate for all roads within the basin (private and public). Miles of road at the upper end and outside the USFS boundary were not available.
The drainage is approximately 3158 acres.

Sediment Transport Processes

Sediment transport within the lower portions of Dismal Creek are very limited. RSI site 3 was rated the highest of all sites in the Cow Creek watershed (99, 100 and 99). Dismal Creek is an aggrading system. Sediment size (d50) for the three riffles in this location were very low (sand,<2 mm; very fine gravel, 2 mm; and fine gravel, 4 mm). Predicted embryo survival, based on the percent of fines smaller than 6 mm, is very low (0 to 5 percent). A few salmonids were observed in the RSI survey transect indicating some successful recruitment, but population sizes are expected to be low.

Temperature

Temperature monitoring for this drainage resulted in a summer high of 69 degrees Fahrenheit. Survey areas within the drainage identified high canopy cover for these sites (RSI 3 and random site E1 and E2). Average canopy cover for all Dismal Creek sites combined was 99.5 percent. Temperatures taken in these locations include 52 degree Fahrenheit (E1), 50 degrees Fahrenheit (E2) and 54 degrees Fahrenheit (RSI 3).

Coarse Woody Debris

Coarse woody debris within the Dismal Creek survey areas ranged from 0 LWD pieces per mile to 31 LWD pieces per mile. Based on the available information, harvest units were located within the riparian buffers of at least two of these sites. Random site E1 contained 93 CID pieces per mile, 31 LWD pieces per mile and 0 SWD pieces per mile. Site E2 contained 81 pieces per mile and 0 LWD and SWD pieces. Although no LWD or SWD pieces were present at this site, wood debris large enough to influence channel processes (CID category) in a channel with an average bankfull width of 9.2 ft were present (93 pieces per mile). RSI site 3 contained 16 LWD pieces per mile, 0 SWD pieces per mile and 81 pieces of CID per mile. This RSI 3 site is one survey area that demonstrates the ability of wood debris to influence channel morphology and provide fish habitat.

RSI values of 99 and 100 indicate that sediment load at this site is outside any ability for the water and sediment balance to function. Expected consequences of RSI values at this level would be complete filling of pools and likely a braided channel. In this situation, the amount of wood debris (LWD and CID) present is providing enough scour to develop pools. Salmonids were observed within this transect area. Areas outside this survey transect that do not contain wood may be braided. The Dismal Creek drainage provides an opportunity to document and evaluate in greater detail this relation between RSI values, wood debris and pool development. More of the mainstem of Dismal Creek should be evaluated to determine drainage conditions and potential recovery opportunities.

Beaver Creek (WAA 02V)

Beaver Creek is classified as a Class II stream for 1.9 miles and is a second order stream at its confluence with Cow Creek. Road densities within the drainage are approximately 5.1 mi/mi^2. The lower end of the WAA is privately owned.

Sediment Transport Processes

RSI sites were not located on Beaver Creek due to channel characteristics. Channel type at selected survey sites were step-pool and RSI methodology is not appropriate in this channel type. Observed problems in this drainage did include sediment load. A mining site located near the top of the drainage below Wildcat Ridge is producing a large sediment load. Road density also suggests sediment transport is a concern.

Temperature

A continuous temperature monitor was located at the mouth of Beaver Creek. The recorded summer high temperature was 63 degrees Fahrenheit. Temperatures taken at the two survey sites were 59 degrees Fahrenheit (V1) and 54 degrees Fahrenheit (V2). Canopy cover for these sites averaged 89 percent for site V1 and 99 percent for V2.

Coarse Woody Debris

Site V1 contained 64 CID pieces per mile and 0 LWD and SWD pieces. Site V2 did not contain any debris that qualifies for any of these categories. Both sites are potentially located within recent selective or clearcut harvest units (V1 in a 1974 selective cut and a 1989 clearcut; V2 located in 1974 and 1975 selective cuts).

Devil Creek (WAA 02A)

Devil Creek is a second order stream at its confluence with Cow Creek. Road densities within this WAA are approximately 3.3 mi/mi^2.

Temperature

Temperature measurements taken at the two survey sites were 52 degrees Fahrenheit for site A1 and A2. Canopy cover for these survey sites averaged 100 percent.

Coarse Woody Debris

Site A1 contained 16 LWD pieces per mile and 113 CID pieces per mile. No SWD size debris was present. Site A2 contained 16 pieces of SWD and LWD per mile. This site also contained 81 CID pieces per mile. These sites were located in areas classified as late-successional vegetation.

French Creek (WAA 02T)

French Creek is a second order stream at its confluence with Cow Creek. It is classified as a Class II stream for 1.1 miles. Road densities within this WAA are high (4.3 mi/mi^2).

Temperature

Water temperature taken at the one survey transect (T1) was 52 degrees Fahrenheit. Canopy cover at this location averaged 99 percent.

Coarse Woody Debris

Site T1 contained 40 CID pieces per mile. No LWD or SWD pieces were observed in the transect area.

Cow Creek

The mainstem of Cow Creek can be described as a fourth order stream at the confluence of the East Fork and South Fork. At the confluence of Cow Creek and Applegate Creek it becomes a fifth order stream. The basin in its entirety lies primarily in granitic or schist soils (89 percent).

These soils erode into fine sands (granite) or very fine gravels (schist). Average road density is 3.0 mi/mi^2. Cow Creek can be separated into two different channel morphologies, constrained upper sections (WAA M and upstream) and less constrained lower section (downstream from WAA M). There are exceptions within these areas but in general the channel conditions can be separated by these boundaries.

<u>Sediment Transport Process</u>

Sediment transport and storage within the system changes from what appears to be equilibrium upstream sites (Figure 3, site numbers 8 and 7) to sediment storage sites (Figure 3, site number 1 and 2). The RSI values indicate some finer sediment storage (RSI 82 for site 8), but overall the values are in the 40 to 65 range. An RSI value of 40 indicates a degrading riffle. Macroinvertebrate samples for RSI site 1 also support indications that fine sediments are stored due to the presence of many fine sediment tolerant species (Wisseman 1993). Taxa requiring stable crevice space in the armor layer (taxa groups 30, Pteronarcys, 31, hellgrammites and 32, Arctopsychidae) are rare (Wisseman 1993). Taxa requiring large pore space or taxa particularly sensitive to scour during high water are absent.

The median surface substrate size (d50) is useful in characterizing dominant substrate size. For the upper Cow Creek sites (7 and 8), riffle substrate d50 ranged between 12 and 150 mm. Three of the six riffles had d50 values over 100 mm (105, 110 and 180 mm). The other values represented the sediment storage riffles within the reach (12, 15, and 50 mm). In general, these sizes include medium gravels (11-16 mm), very coarse gravels (45-64 mm), medium cobble (90-128 mm) and large cobble (128-180 mm). Although these sites had RSI values suggesting dynamic equilibrium, fine sediments are stored within some riffles of the reach indicating the large bedload of fine particles.

The lower Cow Creek sites (1 and 2) consisted of smaller materials. Riffle substrate d50 values ranged between less than 2 and 50 mm. Materials less than 2 mm (sand) were the d50 for two of the riffles at site 2. This site also had abundant bedrock material exposed. The third riffle at site 2 had a d50 of 22 mm (coarse gravel). Site 1 contained slightly coarser material with d50s including medium (12 mm), coarse (28 mm) and very coarse gravels (50 mm). These lower reaches can be characterized as wide, shallow reaches that have reached or even exceeded a threshold. RSI 2 is scoured to bedrock indicating a degrading status yet RSI values are 95, 81 and 76.

Sediment substrate size, as a measure of spawning success, indicates RSI sites 1 and 2 may have limited success. Based on the percent finer than 6 mm, embryo survival is expected to range from 0 to 40 percent. Site 2 also contained extensive areas of exposed bedrock which would not provide suitable spawning habitat. For RSI sites 7 and 8, embryo survival is expected to range from 4 to 80 percent.

Temperature

The upper sites (RSI site number 7 and 8 and random site number N1) were narrower with a mean wetted width of 25.8 ft and with good canopy cover (79 to 87 percent). The lower reaches were wider with a mean wetted width of 34.5 ft and an open canopy (12 to 72 percent). Stream temperatures reflect this opening of the canopy (Figure 6). Wider, shallow streams with little canopy coverage should produce warmer temperatures. Macroinvertebrate samples from the lower site also compliment these observations, where there are many high temperature tolerant taxa present and no high temperature intolerant taxa present (Wisseman 1993).

Coarse Woody Debris

Habitat complexity and channel stability may be represented by measuring woody debris present in the channel. Larger channels with higher flows present difficult situations for maintaining woody structure in the channel. The lower sites on Cow Creek did not retain any coarse woody debris in the channel. Standard size LWD and SWD were absent. Due to the large channel size, any materials that might be considered channel influencing (CID) would need to be close to the LWD size. The large storm event (possibly 8-year event) that occurred this year may have removed any material of marginal size. Although CPOM sampling has not occurred in the invertebrate sampling, long-lived taxa and shredders are absent from the riffle sample (Wisseman 1993). This area of Cow Creek probably stores very little organic debris necessary for biotic colonization and nutrient cycling. Future recruitment of LWD may be limited due to the present condition of the riparian vegetative community.

The upper sites retained some coarse woody debris. Random site N1 included 16 LWD pieces/mile and 32 CID pieces/mile. RSI site 8 retained 13 SWD pieces/mile and 13 CID pieces/mile. These upper sites of Cow Creek occur within reaches constrained by topographic features of the landscape. Shortly downstream of random site N1 the valley widens and no longer provides a constraining influence on the channel. Channel morphology for lower Cow Creek can be described as a wide, shallower channel which is subject to streambank erosion and degradation. Over time this channel migrated back and forth across the natural floodplain of the valley floor, while one bank eroded the opposite built. In order to provide LWD for this part of Cow Creek, long-term management of the riparian floodplain is necessary to grow large trees. Detailed analysis of the floodplain is necessary to determine the extent of the natural floodplain. The potential migration path of Cow Creek needs to be predicted and evaluation of tree stands within that path evaluated for species composition and growth potential. Long-term management of a river valley must include managing for where the river will migrate.

Terrestrial Vegetation

Disturbance

Various disturbance processes have affected Cow Creek at a stand and landscape level: glaciation, flooding, fires, wind, insects, diseases, road building, timber harvest, and subsequent management activities. Detailed reviews of many of these processes are provided by Agee (1993) and Oliver and Larson (1990). Exclusion of these processes can be considered another kind of disturbance. Processes which occurred before European influence, with the exception of glaciation, have since been altered by management activities. These processes are all interconnected and altering one or more process will have effects on one or more of the others. Because these processes are strongly related to climate, their intensity and frequency have varied over time and space, just as climate has varied (Figure 27). Thus, a previous era's disturbance regime should be considered in terms of its climate and future disturbance regimes should be considered in terms of the inevitability of future climate change.

Insects and Disease

Historic insect and disease processes were not evaluated for this project. However, it is certain the extent and intensity of insect and disease activity varied with the climate, soil, and vegetation.

A 1995 Insect and Disease Assessment of Cow Creek (Marshall 1995) is included in Appendix J. Key points of this assessment are:

1. Throughout the watershed, sugar pine and ponderosa pine are being killed by mountain pine beetles as a result of mountain pine beetle attack. These trees are susceptible to infestation because of excessive stand density and drought. On some sites, white pine blister rust predisposes the trees to attack. The same processes are affecting western white pines at higher elevations, with similar widespread losses. For ponderosa pine, the situation is not as advanced, but it is becoming more serious. Dense stands of planted ponderosa pine will be especially susceptible. Sugar pine is already rare in the watershed and, unless preventive measures are taken, it could be virtually eliminated from these forests.

2. The most common root disease in the watershed is *Phellinus weirri*. It is infecting large areas in the upper reaches of the East and South Forks of Cow Creek.

3. Western dwarf mistletoe occurs at low levels on ponderosa and knobcone pine in the watershed.

In addition, blackstain root disease is conspicuous along road 3242. The spread of this disease is affected by timing of tree cutting: harvesting, thinning, and roadside brushing.

Wind

Wind storms are a recurring disturbance process in the western Cascades. However, there is little evidence that wind represents more than a fine-scale disturbance in Cow Creek. Wind created disturbance causes gap-phase regeneration in older stands and height differentiation and increasing species diversity in younger stands. No records or anecdotes suggest that wind in the Cow Creek watershed approaches the stand-replacing intensities that occur near the Columbia

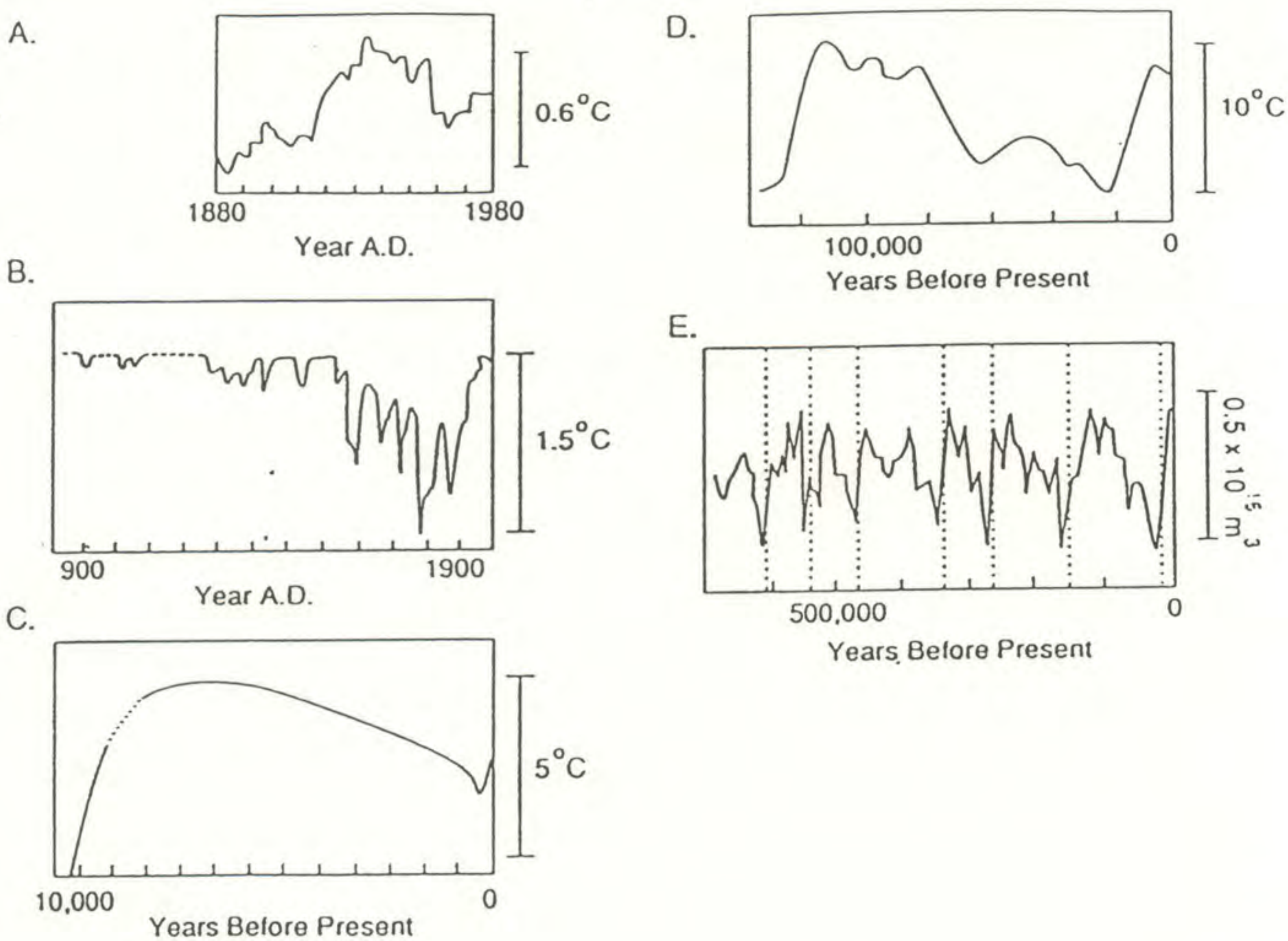


Figure 27. Temperature changes in the Northern Hemisphere for different time scales(adapted from Brubaker 1988): (A) instrument data for annual temperature, latitudes 23.6-90° N, (B) air temperature during the past 1,000 years reconstructed from accounts of sea ice, (C) annual temperature in northeastern United States over the past 10,000 years inferred from fossil pollen data, (D) annual temperature over the past 100,000 years in Europe reconstructed from records of vegetation, seal level changes, and planktonic and geochemical chemical changes in deep sea sediments, and (E), global ice volumes inferred from oxygen isotope variations in deep sea sediments.

Gorge or on the Olympic Peninsula. However, at a small scale, the effects of a single event can be dramatic.

Timber Harvest and Silvicultural Practices

Timber harvest practices in the watershed have occurred on a continuum of increasing intensity: Low intensity, commercial thinning with relatively small effects on stand structure and species composition; medium intensity, selective harvesting removing all or part of the large-tree overstory leaving behind an understory often composed of late-seral tree species; high intensity, and regeneration harvests removing all overstory.

The objective for reforestation has been rapid establishment of uniformly close spaced stands of, primarily, Douglas-fir and/or ponderosa pine. The tight spacing prescribed for commercial thinning has also promoted the dominance of these same two species. Species composition and stand structure have been altered actively, by cutting, and passively, by differences in the relative tolerance to competition of various tree and shrub species and by inducing competition mortality at close spacings.

In general there has been little variation in the treatments prescribed to the vastly different sites across the landscape.

Similarly, site-specific treatments have not been crafted for the riparian zones. Until the late 1970's, the riparian zones of intermittent and many perennial streams were harvested in the same manner and using the same methods as the hillslopes. Beginning about the early 1980's, no-cut buffers were established along perennial streams. The silvicultural practices described above, for the hillslopes, have been applied to harvested riparian zones.

Fire

Fire, from human and natural causes, has burned northwest landscapes for centuries (Agee 1993). It is difficult to identify the relative effects or pattern of human versus natural caused fires during pre-historic times. Burke (1979) found no pattern in lightning fire occurrence between 1910 and 1977 in the central Cascades of Oregon. Ripple (1994) used satellite data to evaluate the distribution of forests in western Oregon. He presents tree-size evidence suggesting that Indian burning may have been concentrated along major rivers. Beginning in about 1870, the pattern of human ignition changed with increasing European settlement and decreasing Indian populations (Barner 1994). The Forest Service began fire detection and suppression activities in the 1910's, but human caused fire was significant until about the 1930's (Barner 1994). The period of effective fire suppression is assumed to have begun about 1930 with the advent of the Civilian Conservation Corps.

The landscape- and stand-level effects of historic fires can be inferred from fire frequency, intensity, and size. Variation in all these fire characteristics is apparent in Cow Creek's vegetation. Because Beaver Creek includes a range of sites representing Cow Creek, its fire history was evaluated in some detail. Fire scar and age-class evidence revealed 12 separate fire episodes between about the late 1800's and 1929-32. These fires are mapped in Figures 28 through 39. Individual fires are represented as a range of dates because of ring-count inaccuracy. Because sampling intensity was low, many fires were probably missed and the area of individual fires cannot be definitively identified.

- Several catfaced trees were located, two of which revealed Mean Fire Return Intervals, at a point, of 14 and 15 years. These are true point estimates and were calculated according to methods described by Agee (1993). They are not area freqeuncy expressed as a point, which often overestimates fire frequency.

- Fire size was probably quite variable. However, the data suggest that at least three fire episodes burned much of the study area: the late 1800's, 1842-1850, and 1873-1878. Evidence of large, stand replacing fires in the early 1900's is apparent on approximately 21 percent of National Forest land within Cow Creek.

- Age class distributions, Figures 40 through 55 indicate there was considerable variation in fire intensity. Within an approximately 1,200 acre area at the head of Beaver Creek, three stand types were found: a mixed species, multiple cohort stand with a mean fire return interval of 14 years; a single species, single cohort stand that established about 180 years ago and has apparently not burned since (thus its domination by a single species); a multiple species, single cohort stand that established about 80 years ago. Tree establishment following stand-replacing events often took several decades, rather than the five years allowed by current reforestation practices. The continuous age class distribution at the landscape- and stand-level is due to the aggregation of several single-age stands and plots as well as multiple-age stands and plots. On individual plots and stands, such as Spyderman 1 and Jeep 7 plot 1, single cohorts indicate high intensity cohort-initiating events. Many of these cohorts survived subsequent, low intensity events. Multiple cohorts occurring on individual plots such as Jeep 7 plot 2A and 3 and Jeep 8 plot 2 are associated with recurring fires, each of which were intense enough to open new growing space. The number of trees surviving low intensity fires was not calculated for Cow Creek. It varied from 27 to 112 in Jackson Creek. Fire regime generalizations can be made for Cow Creek but there was much variation. "Stand replacing" regimes often experienced low-intensity fires and "stand perpetuating" regimes often experience high-intensity fires. This variation is best demonstrated by the knobcone pine/madrone dominated single-cohort stands now found in Cow Creek. These stands developed after high intensity fires. They are perpetuated on a site by high-intensity fires recurring between about 30-40 and 80-100 years (Agee, personal communication). If they miss 2 or 3 fires, the knobcone and madrone die, either of old-age or overtopping by longer-lived, fire resistant conifers, which dominate the site until the next stand replacing fire.

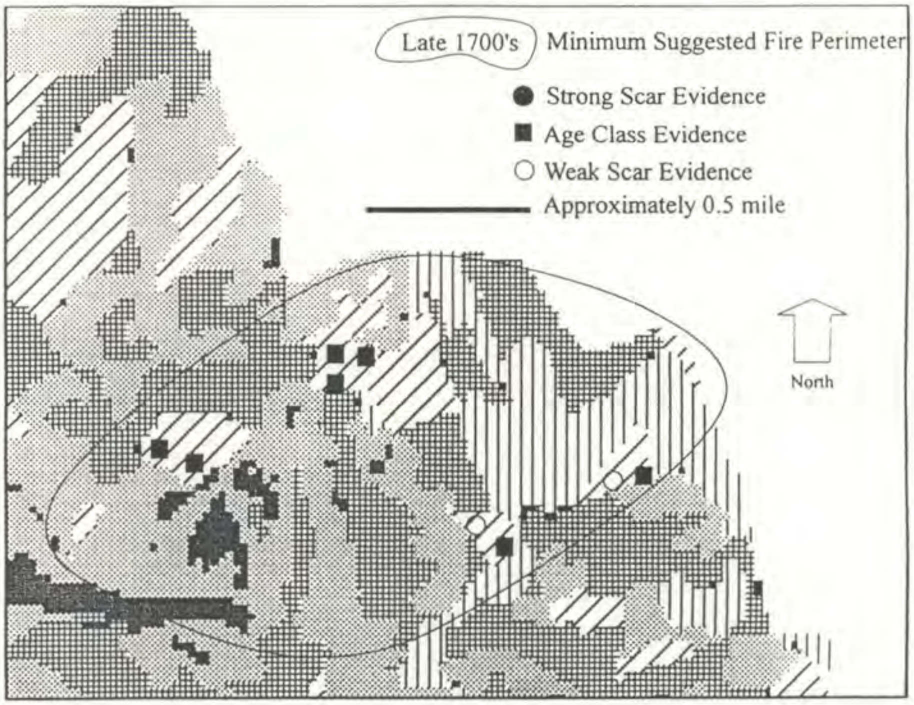


Figure 28. Late 1700's Fire episode.

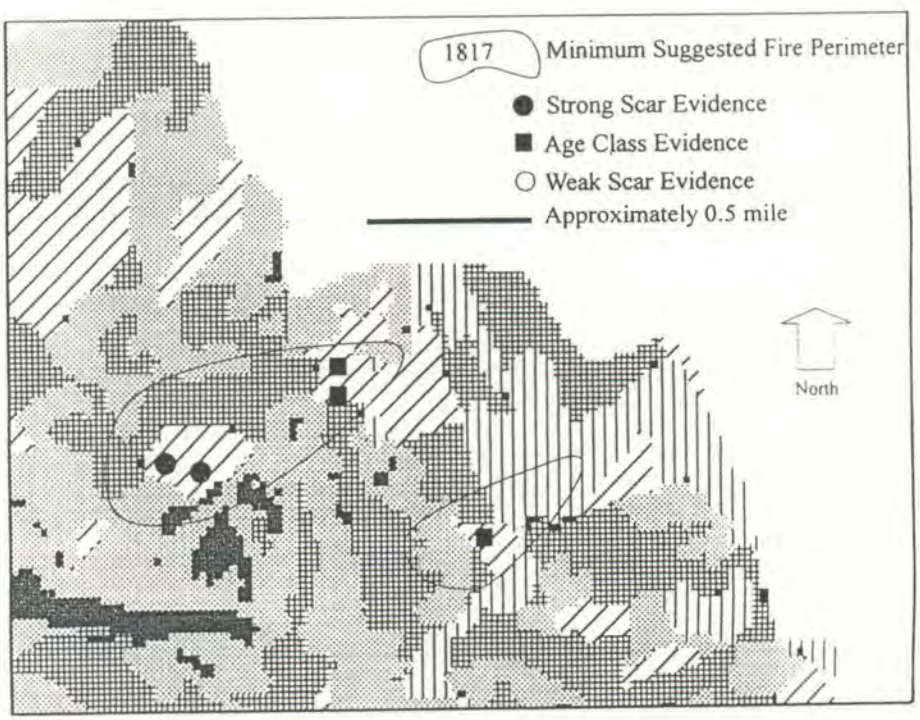


Figure 29. 1817 Fire episode.

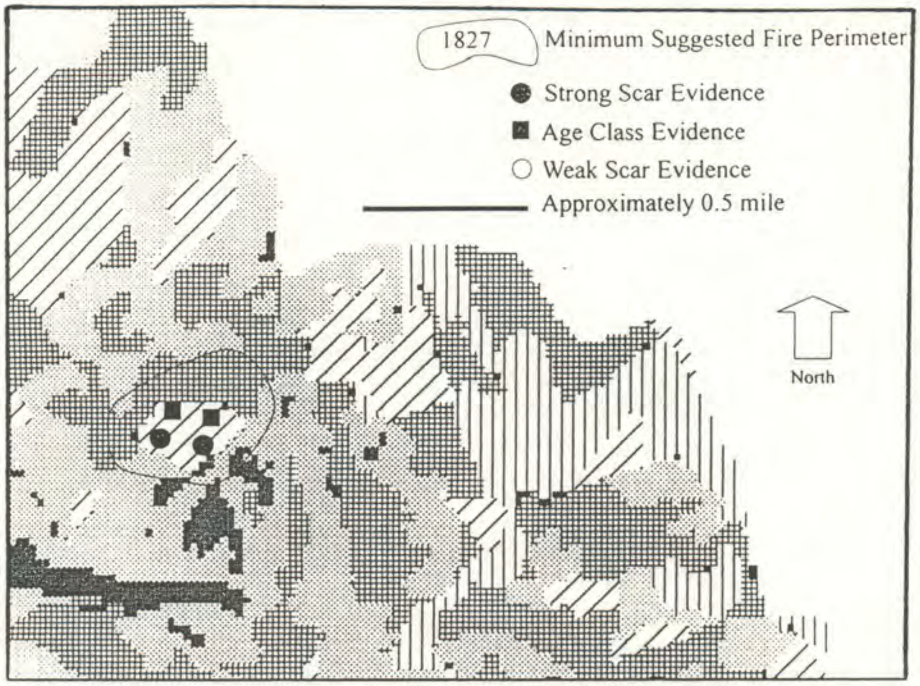


Figure 30. 1827 Fire episode.

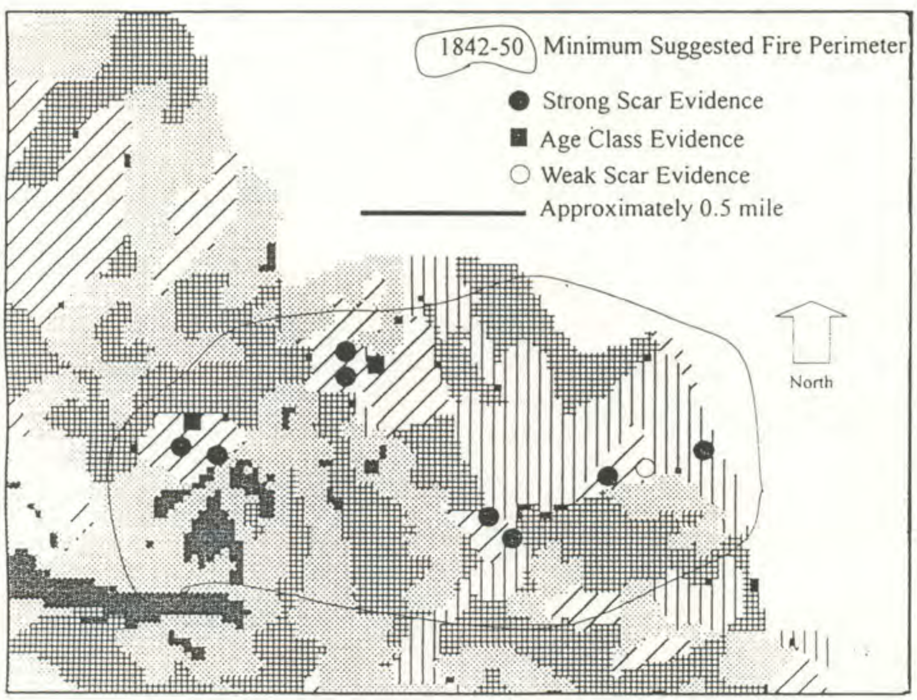


Figure 31. 1842-1850 Fire episode.

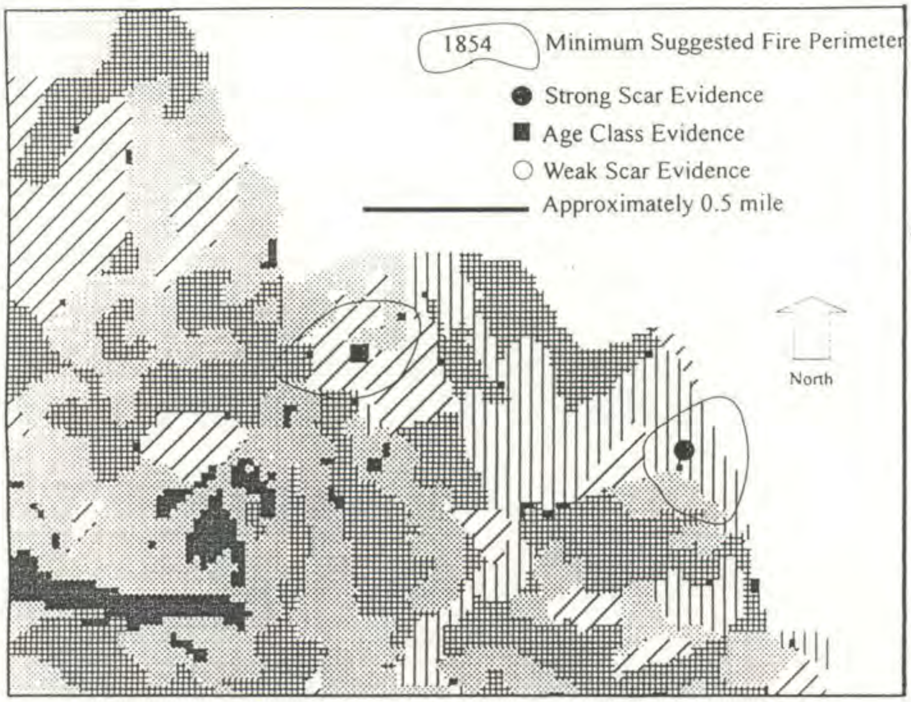


Figure 32. 1854 Fire episode.

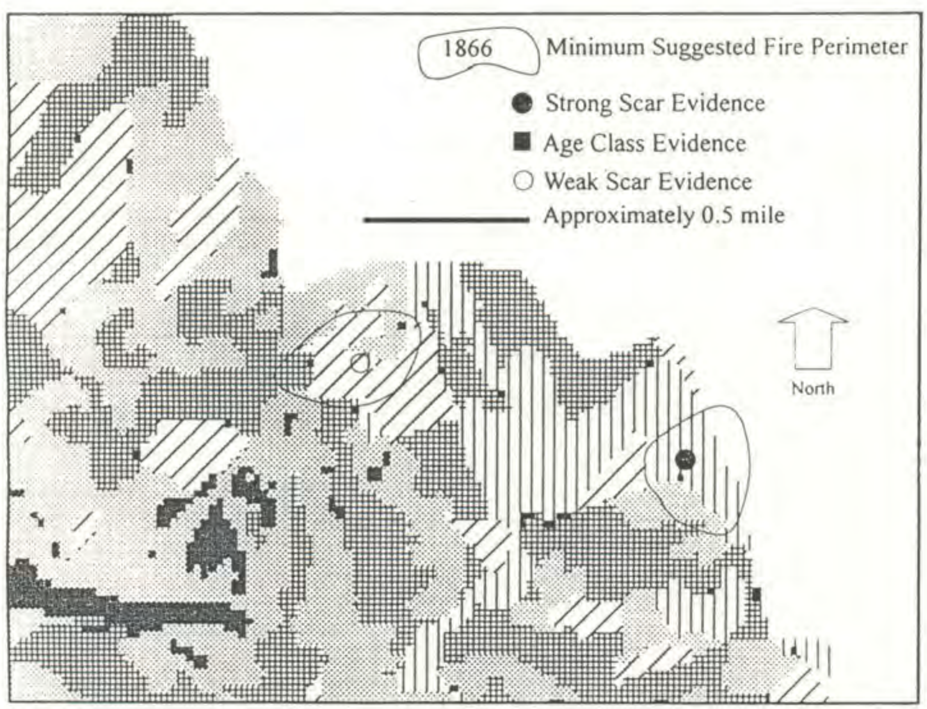


Figure 33. 1866 Fire episode.

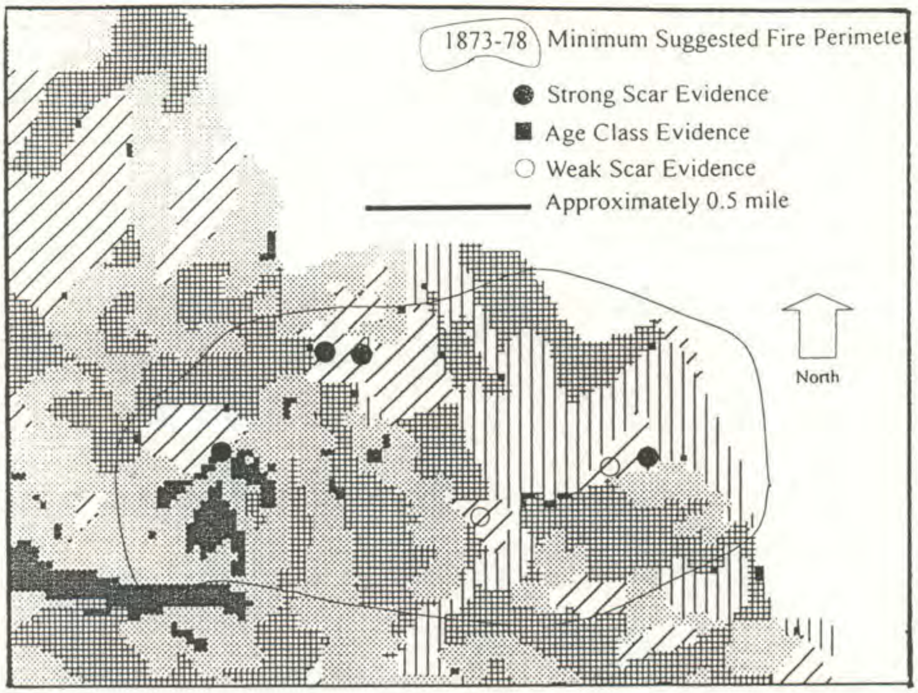


Figure 34. 1873-1878 Fire episode.

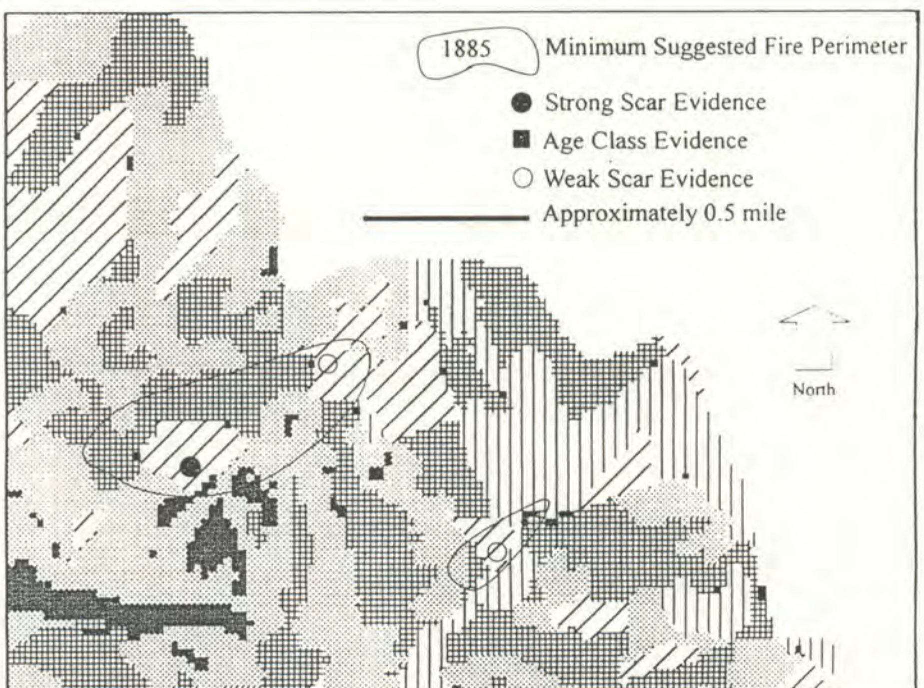


Figure 35. 1885 Fire episode.

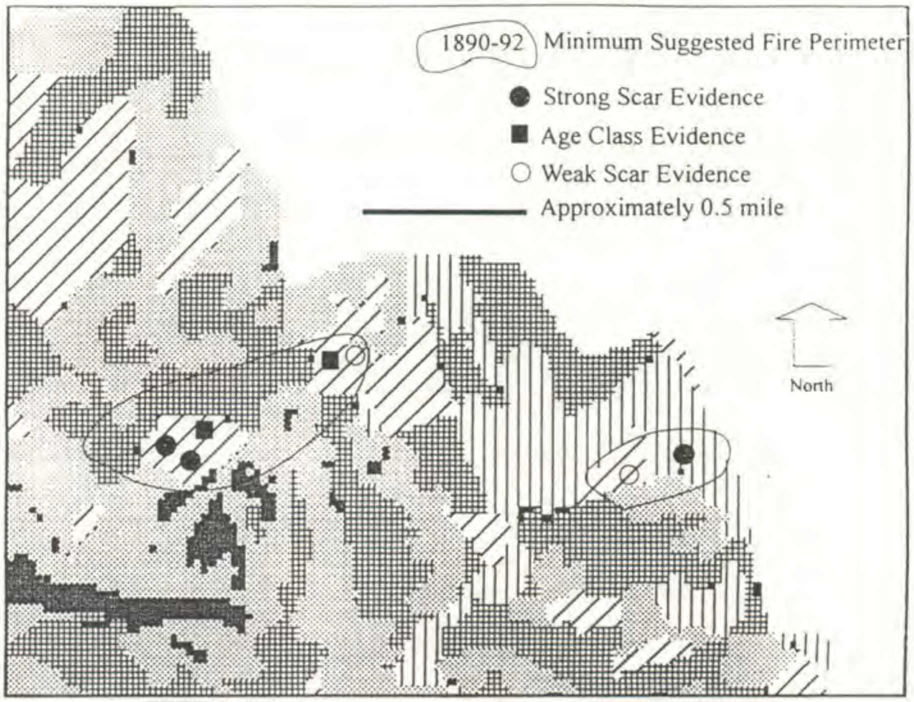


Figure 36. 1890-1892 Fire episode.

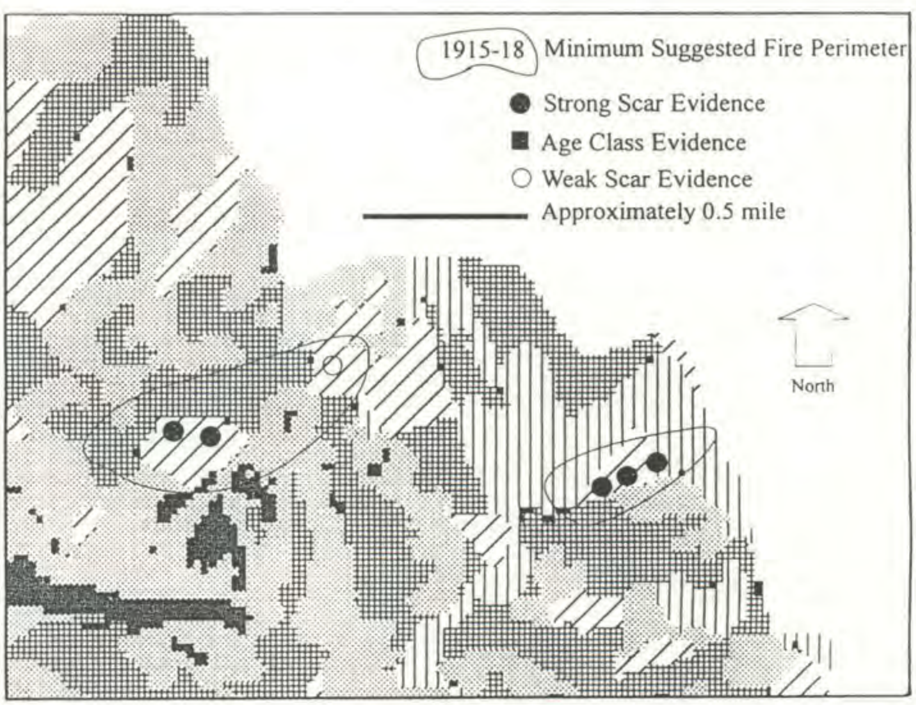


Figure 37. 1915-1918 Fire episode.

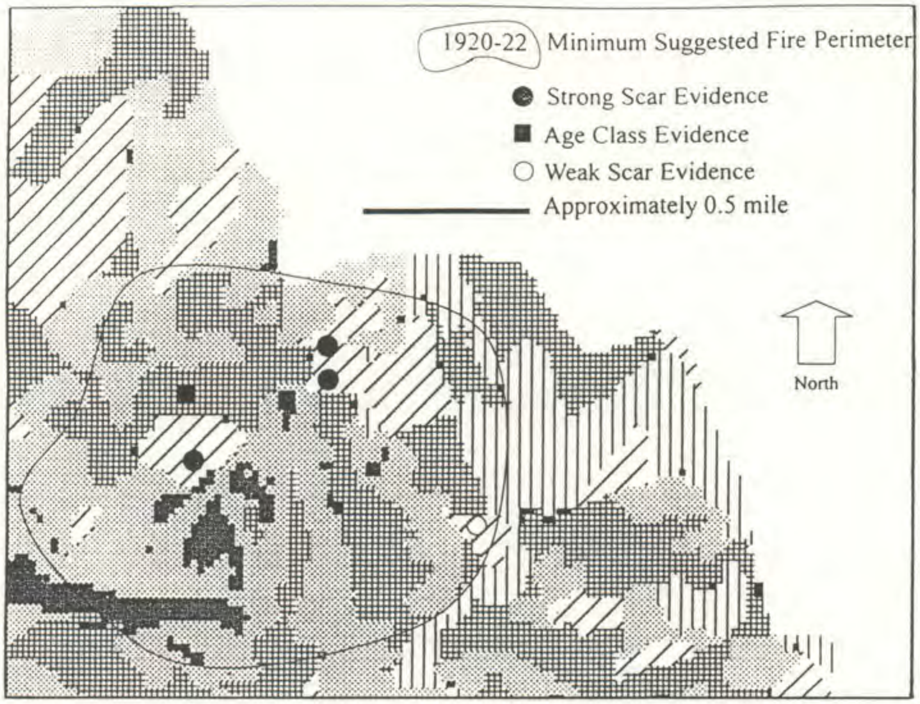


Figure 38. 1920-1922 Fire episode.

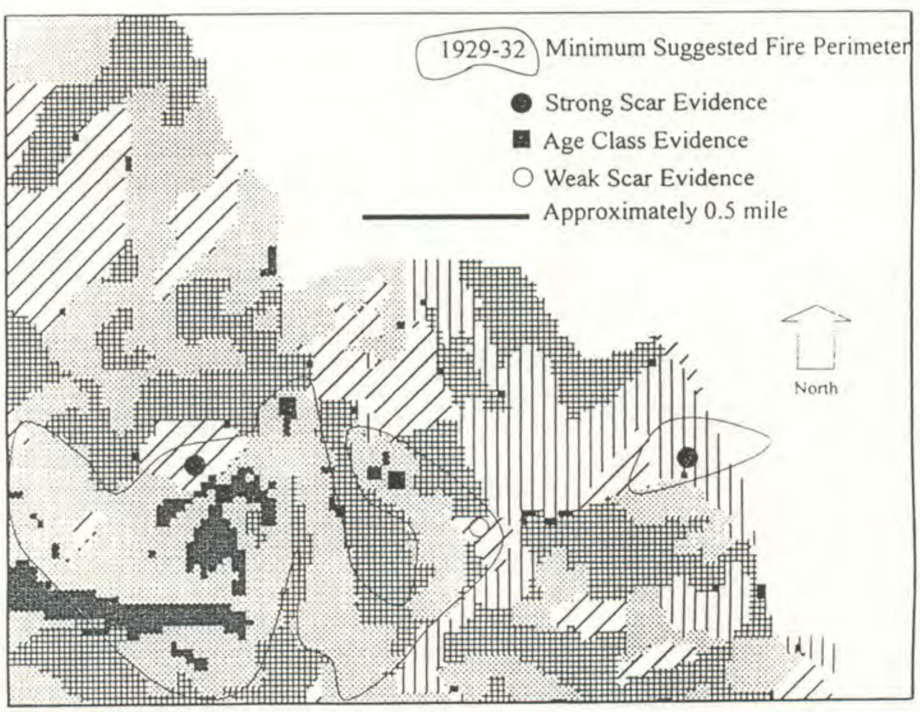


Figure 39. 1929-1932 Fire episode.

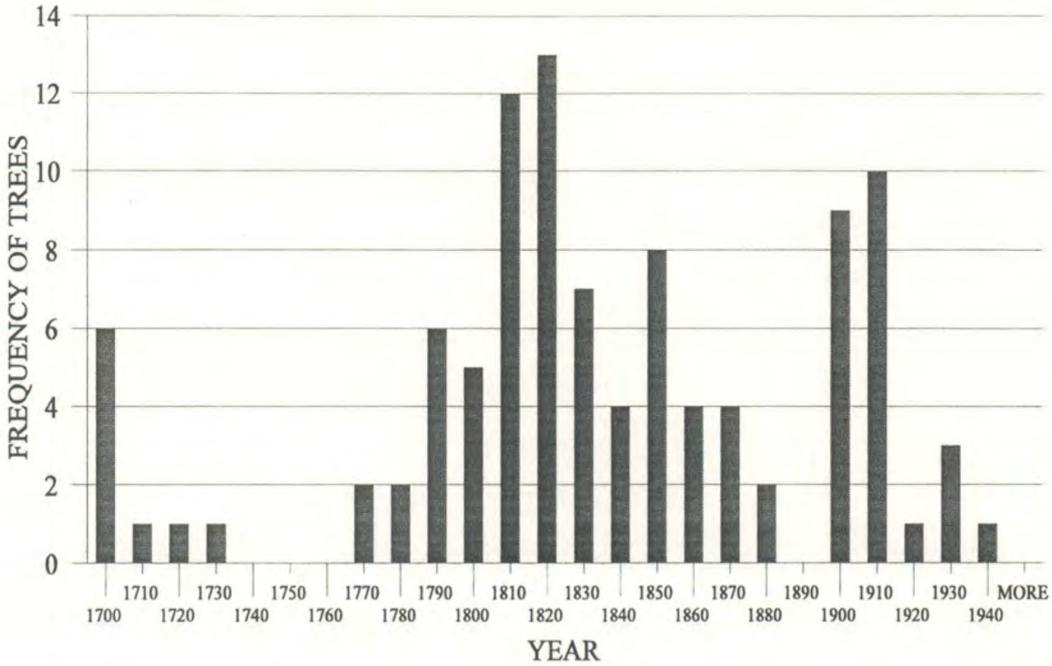


Figure 40. Tree age class distribution for all plots.

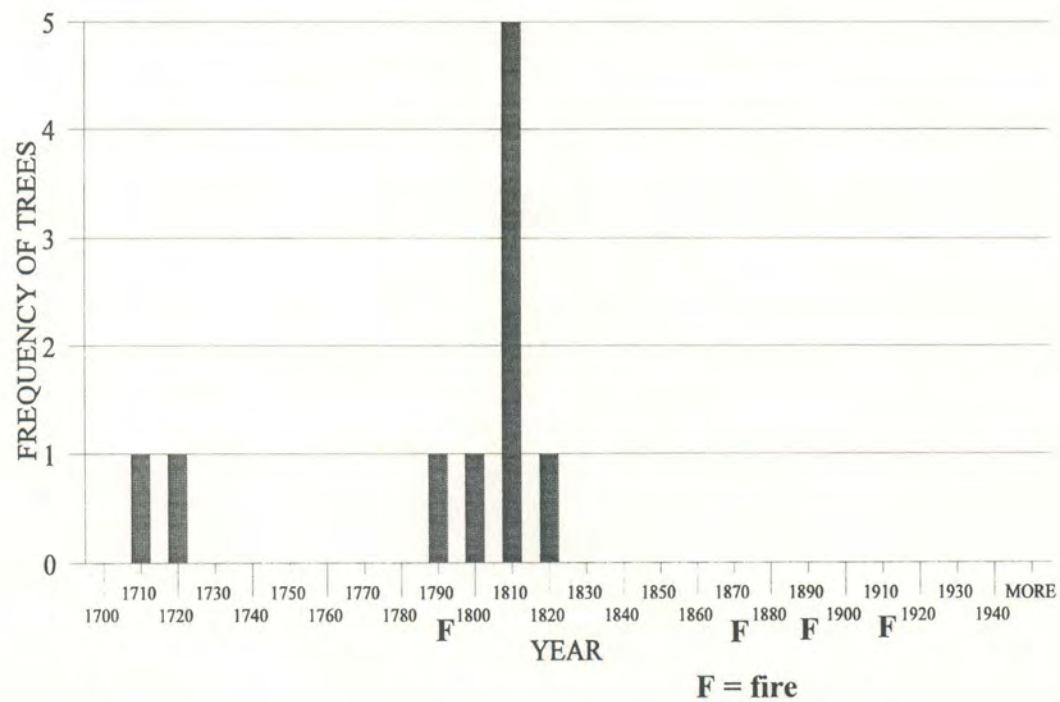


Figure 41. Tree age class distribution for Spyderman 1 (1/10 ac plot).

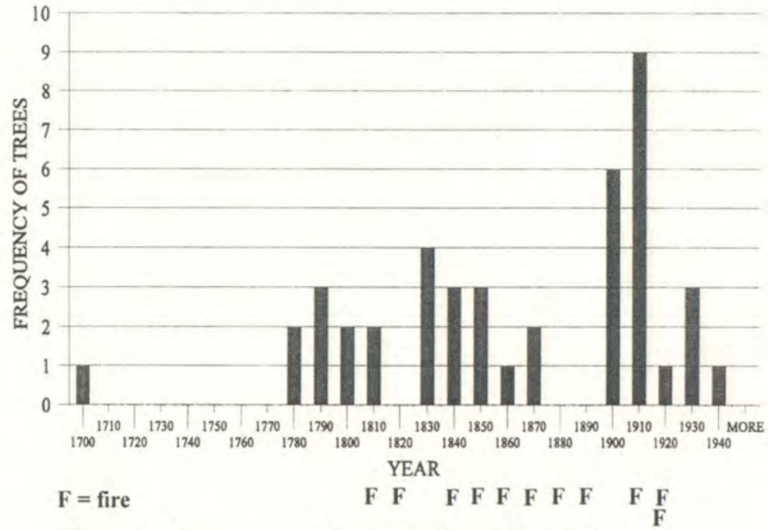


Figure 42. Tree age class distribution for all Jeep 7 plots.

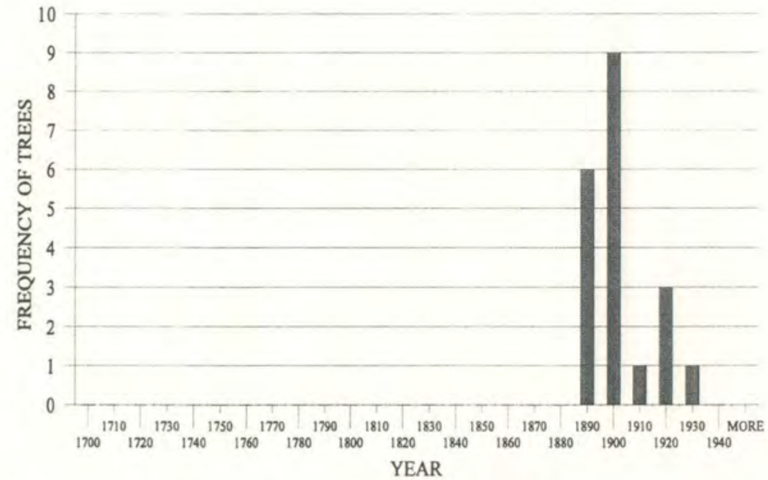


Figure 43. Tree age class distribution for Jeep 7, plot 1 (1/10 ac).

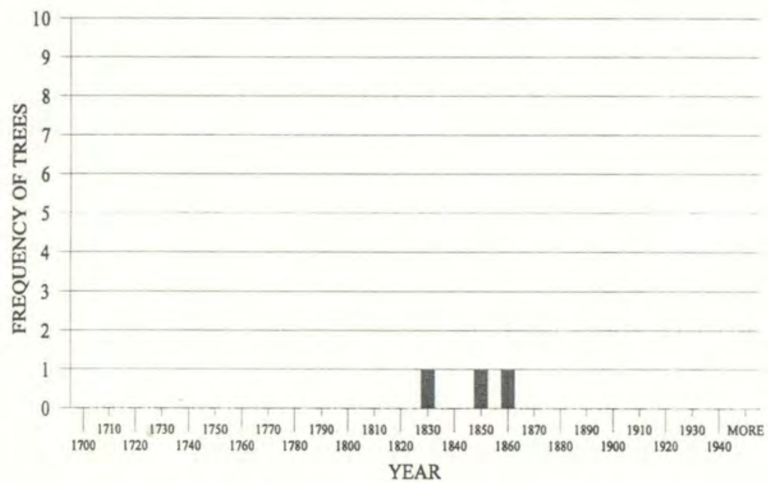


Figure 44. Tree age class distribution for Jeep 7 Plot 2, BAF 40.

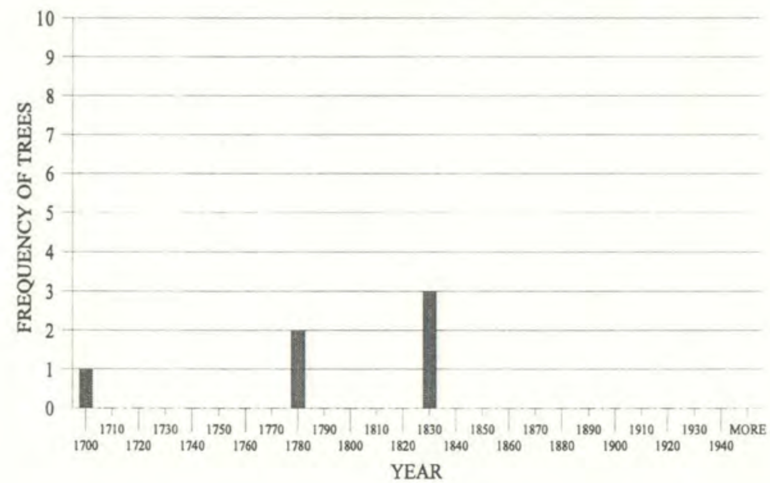


Figure 45. Tree age class distribution for Jeep 7 Plot 2A, BAF40.

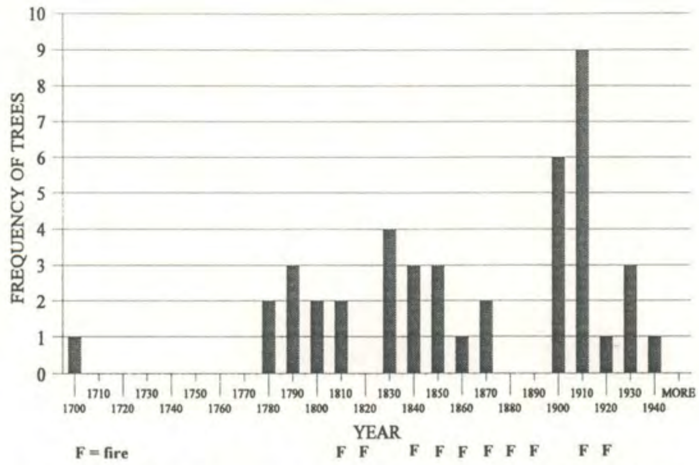


Figure 46. Tree age class distribution for all of Jeep 7 plots.

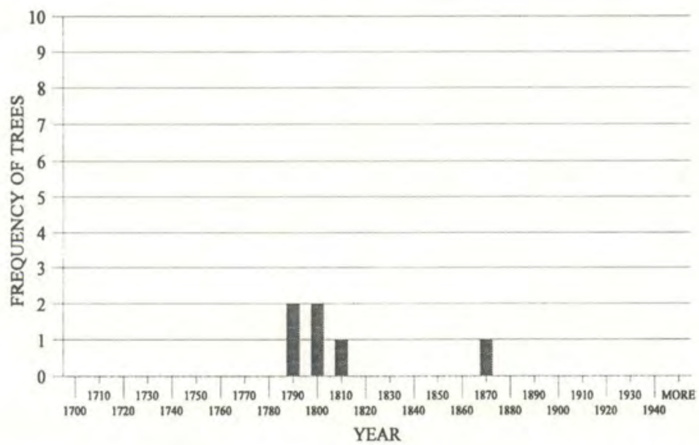


Figure 47. Tree age class distribution for Jeep 7 Plot 4 (1/5 ac).

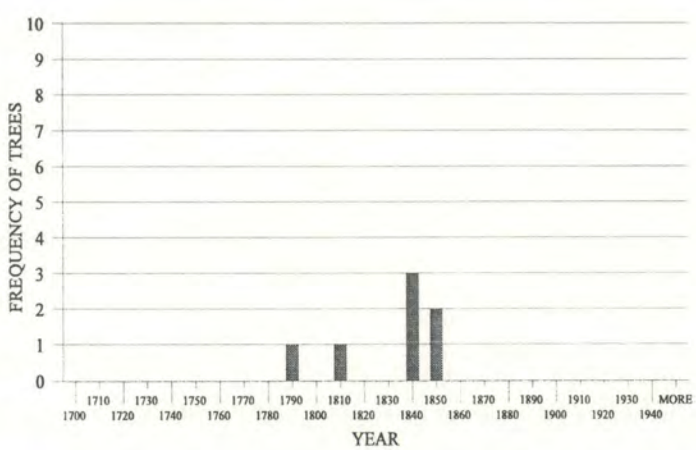


Figure 48. Tree age class distribution for Jeep 7 Plot 3 (1/5 ac).

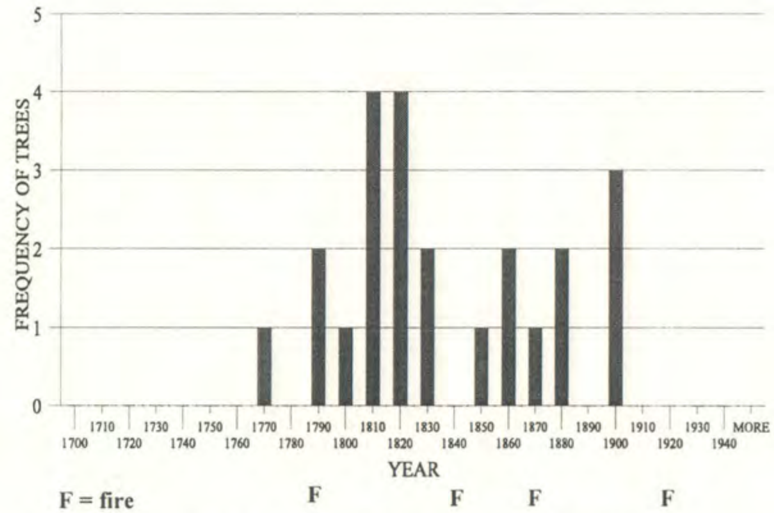


Figure 49. Tree age class distribution for all Jeep 8 plots.

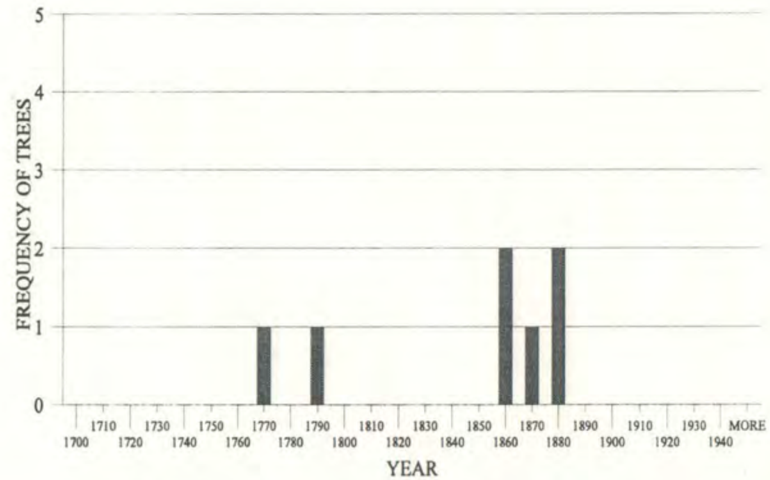


Figure 50. Tree age class distribution for Jeep 8, plot 1 (1/10 ac).

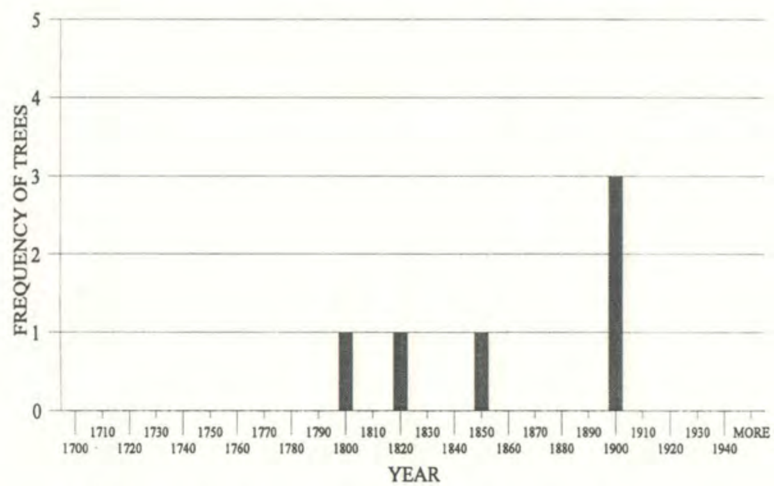


Figure 51. Tree age class distribution for Jeep 8 Plot 2 (1/10 ac).

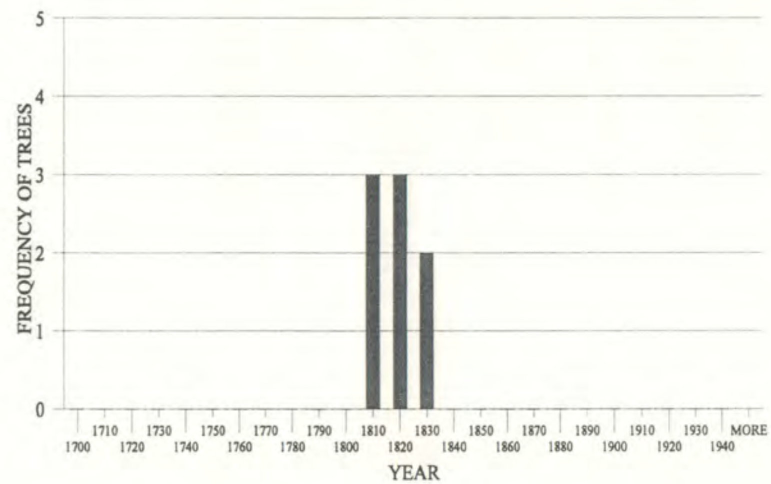


Figure 52. Tree age class distribution for Jeep 8 Plot 3 (1/10 ac).

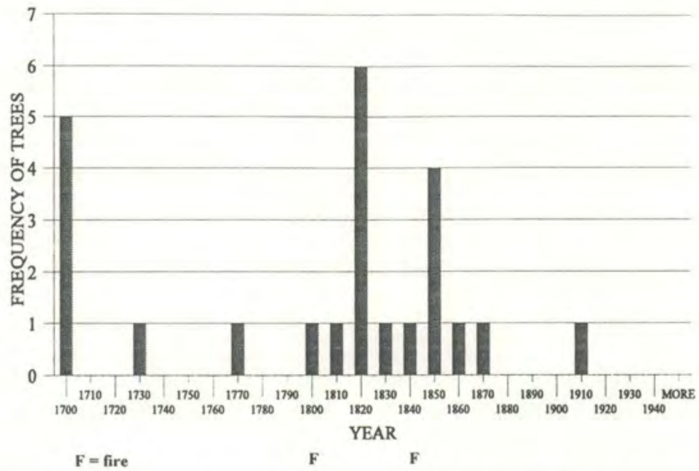


Figure 53. Tree age class distribution for all Jeep 9 plots.

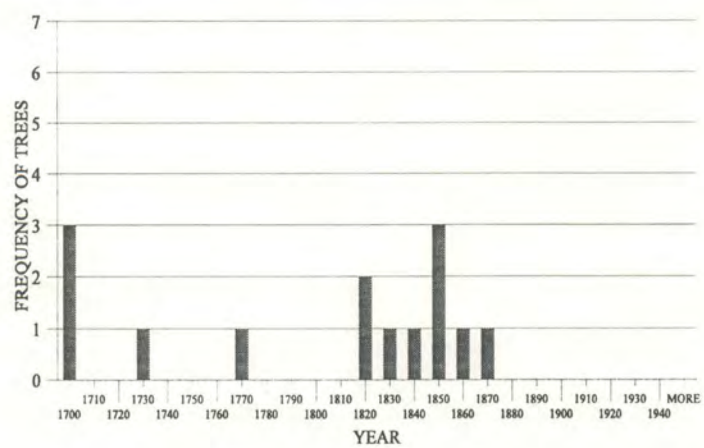


Figure 54. Tree age class distribution for Jeep 9 Plot 1 (1/10 ac).

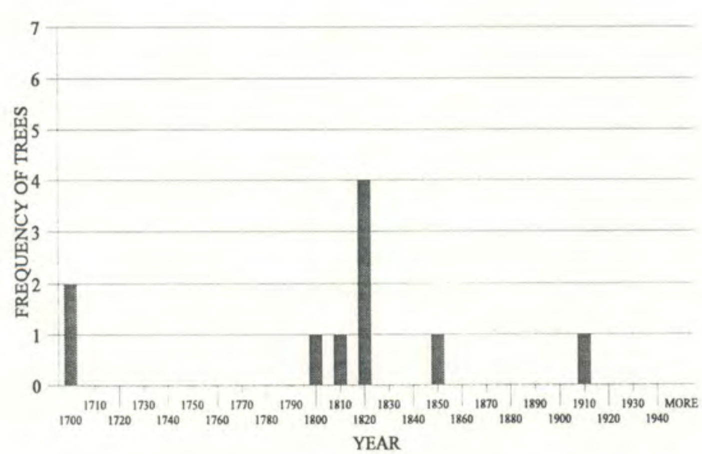


Figure 55. Tree age class distribution for Jeep 9 Plot 2 (1/5 ac).

Riparian Fire Regime

Disturbance is as fundamental an ecosystem process within riparian zones as it is on the hillslopes (Gregory et al. 1991, FEMAT 1993). Even high intensity fire is required in riparian zones if successional processes similar to those occurring on hillslopes are to occur (Meehan et al. 1977). Fire has been a dominant disturbance process in Cow Creek's riparian zones. Fire scar and age class distributions in Jeep 9 and Spyderman 1 reveal the dominance of stand replacing fires in the riparian zones of adjacent perennial streams. Again, variation is common. In the headwaters of Beaver Creek, the south side of the creek is dominated by a stand that shows no evidence of fire for 170 years while the north side has experienced frequent fires during that period. Intermittent streams are less able to influence fire behavior (Agee 1988). Fire history plots in Beaver Creek suggest that the fire regimes of intermittent stream riparian zones and their adjacent hillslopes are similar. However, it is not appropriate to simply take the hillslope frequency and apply it here. Because of higher soil moisture, herbs cure later and live fuel moistures are higher throughout the summer, thus fire conditions are favorable for a shorter period.

Range of Natural Variability

The vegetation of Cow Creek has varied as widely as its climate. During the last ice-age, the landscape was dominated by a dry-subalpine woodland composed of bristlecone and limber pines and Engelmann spruce (Brubaker 1988). This was followed by the Xerothermic period, when the vegetation of southwest Oregon was similar to the present-day chaparral type of California (White 1994). The Douglas-fir dominated forests that dominate the current landscape have only existed for about 5,000 years (Brubaker 1988, White 1994). More recent variation in Cow Creek's vegetation is difficult to identify because of its complex fire regime.

Most investigators agree that continued, rapid accumulation of atmospheric greenhouse gases will affect climate change in the next century (Brubaker 1988). The hotly disputed effects of accumulating greenhouse gases aside, future climate change is both unpredictable and inevitable. However, Brubaker (1988) recommends against making vegetation changes in anticipation of these unknown changes. Considering this, previous disturbance and vegetation patterns can provide a coarse filter approach to maintaining ecosystem processes and diversity. At least in the near-term.

The Regional Ecosystem Assessment Project (REAP) (USDA Forest Service, PNW Region 1993) made an initial effort to characterize the "natural range of variation" for the Pacific Northwest. These are broad-scale ranges and may be misleading when applied to specific locations. Results for the South Umpqua Basin are presented in Table 10.

Table 10. Historic range and current mode of seral stage distribution within the South Umpqua basin as estimated by REAP.

Seral Stage	Range of Variation, Percent of Area	Current Mode, Percent of Area
Riparian Vegetation		
Early Succession	10-40	20
Late Succession	45-75	70
Upslope Vegetation		
Early Succession		
without snags	<5	20
with snags	10-40	0
Late Succession		
single layer	<5	15
multilayered	45-75	50

Historic Vegetation

The successional stages discussed throughout this report include establishment, thinning, and late-succession (FEMAT 1994). Early-succession and establishment are considered synonymous and follow a stand replacing event. Mid-succession and the thinning stage are considered synonomous as well. However, the "thinning" stage will be referred to as the "stem exclusion" stage (Oliver and Larson 1990) because the latter term is more descriptive and to avoid confusion with the silvicultural method thinning. Late-succession includes maturation, transition, and shifting gap (FEMAT 1994).

Historic Landscape Structure

Landscape-level investigations of the proportions and distribution of various forest structural or successional conditions vary, among other ways, by method, assumptions, and the scale and focus of the analysis (Ripple 1994, Zybach 1994, Harris 1984). A landscape analysis of forests in western Oregon, prior to logging, indicated that 80 percent of those dominated by Douglas-fir and 68 percent of those dominated by mountain hemlock/true fir within the Umpqua Basin were in a large (greater than 20 and 16 inches in diameter for each type, respectively), closed condition. Frequent, low intensity fire in the Douglas-fir type eliminated understory competition and perpetuated the dominance of large, fire resistant species. In the mountain hemlock/true fir type, infrequent fire allowed development of an understory between stand replacing events which, in turn, resulted in a smaller proportion of the landscape in this condition. The distribution of these conditions across the landscape is as important as their proportions (Diaz and Apostol). For western Oregon, excluding the north Coast, 89 percent of this large forest was contiguous (Ripple 1994). Mean patch sizes of smaller trees and deforested burns (13,300 acres and 5,287 acres respectively) were smaller in the Umpqua Basin than elsewhere in the region (Ripple 1994).

Maps of historic vegetation are often created using tree age data (Diaz et al. 1993). These data aren't available for Cow Creek and, if they were, interpretation of near-continuous tree establishment dates is beyond the scope of this analysis. Vegetation conditions circa 1910 (Figure 56) were mapped by applying the following assumptions to the Current Vegetation Map:

- Stands currently in the stem exclusion stage and those that have been commercially thinned were in establishment, with snags.

- Current late-successional stands and harvests other than commercial thinnings were stem exclusion and late-successional. This grouping includes the following vegetation types. Their spatial arrangement is unknown.

    1) Late successional vegetation influenced by high-frequency, low-intensity fire. These were typically in the Douglas-fir and White Fir Series. They were relatively low-density stands dominated by large, early seral trees with a broad range of establishment dates and a relatively open understory. Snags, large woody debris and intolerant tree species had short residence times.

    2) Late successional vegetation influenced by low-frequency, high-intensity fire. These were typically in the Western Hemlock and, to a lesser extent, White Fir Series. They were relatively high-density, with a multi-layer canopy, including late seral species, snags, and large woody debris.

    3) Stem exclusion vegetation developing after a stand replacing fire.

Because its harvest history was unknown, land outside the National Forest boundary was excluded from this analysis.

Statistics describing landscape characteristics are often more meaningful in high-contrast than in low-contrast landscapes (Diaz et al. 1993). Historically, much of Cow Creek was low-contrast because of its fire regime and remains so today because of extensive selective timber cutting. Furthermore, the significance of these landscape statistics' magnitude is ambiguous (Diaz et al., 1993). However, they may validate qualitative judgments and, when compared to historical conditions, can quantify the magnitude of changes. This process has risks if the comparison is made with a map representing a single point in time. Particularly if stand replacing fires were predominant. Because high frequency, low intensity fires perpetuated stands a point in time may be less misleading for these types.

Landscape statistics describing the historical condition throughout Cow Creek are presented in Table 11 . The establishment stage includes permanent as well as successional openings. Riparian seral stage percentages are for the area delimited by the Record of Decision for Riparian Reserves. For the Umpqua National Forest, 170 feet is one site potential tree height (Site Index 110, base age 50).

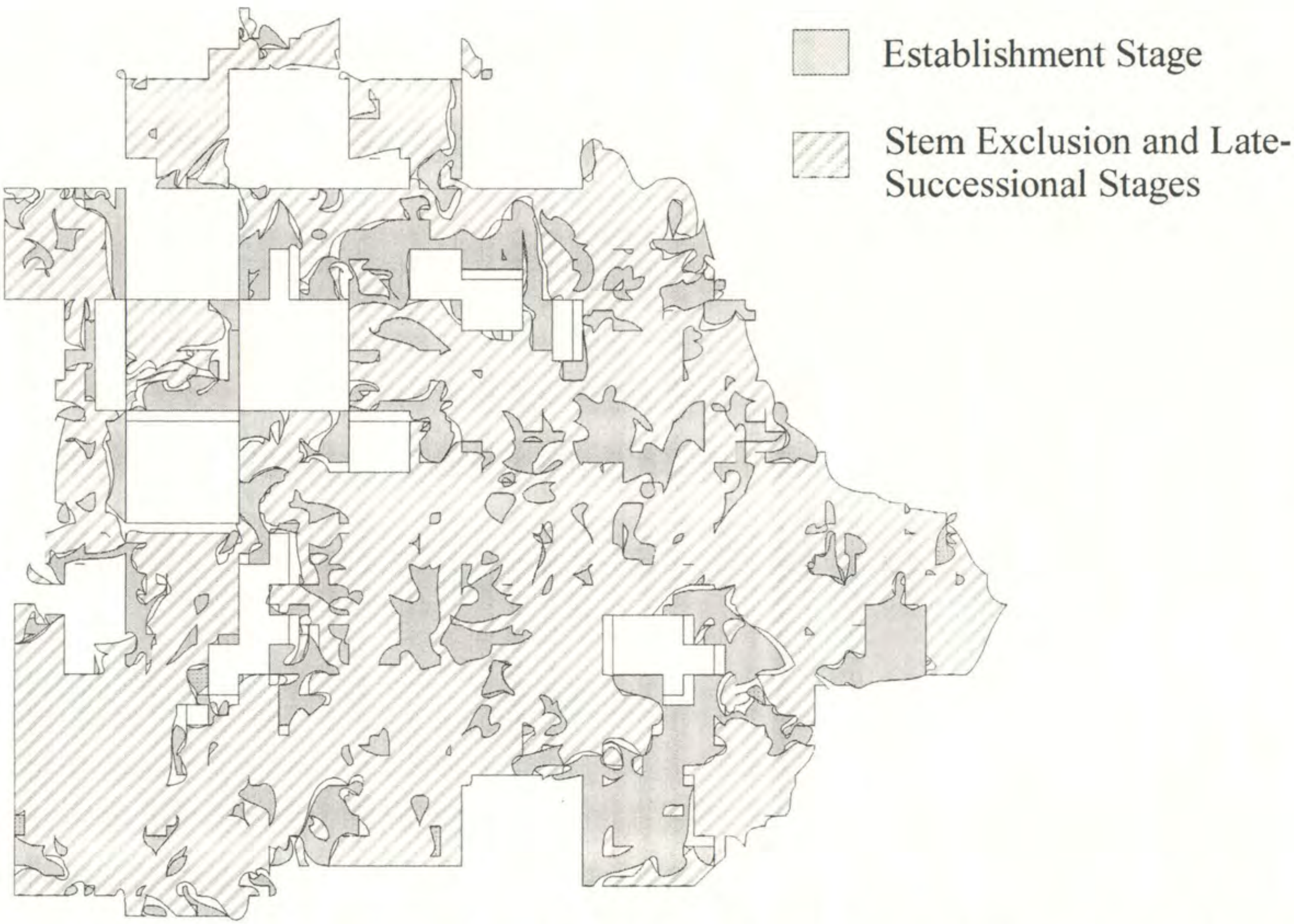


Figure 56. Seral stages, circa 1910, on National Forest land within Cow Creek watershed.

Table 11. Proposed historic landscape structure within the Cow Creek watershed, circa 1910.

Seral Stage	Proportion		Upslope Edge	Number of	Average Upslope
	of Area %		Distance	Upslope Patches	Patch Size ac.
	Riparian	Upslope			
Establishment	29	28		187	72
			201		
Closed Forest				52	657
Stem Exclusion	29	28			
Late Seral	42	44			

The proportional distribution of seral stages was within the range predicted by REAP. The high proportion of establishment may be due to anomalous fires started by early miners and settlers. Alternatively, fire history results indicate that large-scale, high intensity fires have always been a part of the Cow Creek landscape. These large and small stand replacing fires created a mosaic of seral stages that was relatively fragmented compared to some other landscapes, Jackson Creek for example. The proportion of the landscape in the stem exclusion stage was assumed to have approximated the proportion in establishment. However, it is not mapped because its spatial arrangement is unknown. The historic forest matrix was composed of near-contiguous mid- and late-seral forest patches, averaging 657 acres, interspersed with establishment stands, averaging 72 acres. Because of roading and timber cutting adjacent to streams, some valley bottoms such as upper Dismal Creek are currently included in stem exclusion. Consequently, they were wrongly mapped as establishment, rather than late-successional.

Composition and Structure of Historic Vegetation

Riparian Vegetation

Frequent, low-intensity surface fires burned through the riparian zones of most intermittent and some perennial streams in Cow Creek. Their effects were variable. Some reinitiated understory vegetation, others had no effect on available growing space. In addition to fire resistant trees, this fire regime made some growing space available to relatively intolerant deciduous trees, shrubs, and herbs. As fire return intervals decreased, due to climatic variation or site condition, fire intensity increased and stand replacing fires initiated successional processes similar to those on hillslopes (Meehan et al. 1977). These processes were responsible for creating large areas with conditions favorable to intolerant hardwoods early in succession, large Douglas-firs that contributed to channel complexity later in succession, and disturbance conditions to allow the process to continue across the landscape. Thus, riparian zones included spatial and temporal variation in structure, species composition, and successional processes similar to, but in different proportions than, the hillslopes. However, riparian zone species composition was different than that of the hillslopes, particularly near perennial streams. This difference was due to deeper soils and nutrient accumulations, that were themselves a result of disturbance processes, in addition to their more mesic climate.

Early-Successional Vegetation

In areas of frequent, low intensity fire, low fuel loadings were maintained and establishment conditions occurred beneath an overstory of fire resistant trees and where surface fires flared to stand-replacing intensity. Where fires were less frequent but more intense, there were fewer surviving trees and establishment conditions were more open.

Late-Successional Vegetation

Where high-frequency, low-intensity fire regimes dominated, late-successional conditions did not include abundant snags, large woody debris, or a multi-layered canopy of intolerant trees; these things burned up. Rather, stands were dominated by understory reinitiation (Oliver and Larson 1990) conditions where intolerant, fire resistant trees, with a broad range of establishment dates, dominated a relatively open understory. This combination of large tree dominance and frequent fires maintained favorable conditions for a wide range of plant species. Where fires were less frequent but more intense, late-successional stands with an understory dominated by tolerant, fire sensitive trees were more common. Evidence in Beaver Creek suggests that some late-successional stands were relatively unaffected by some low intensity fires that burned them.

Current Vegetation

Current Landscape Structure

Current vegetation is mapped by the combination of three GIS layers (Figure 57):

1. Unique Habitats, consisting of wet and dry meadows, rock outcrops, shrub fields, some hardwood stands, and much of the riparian mosaic in lower Cow Creek

2. Timber Harvest Activity, all known timber harvests since 1948

3. Seral Stage from 1988 satellite imagery, delineating National Forest land where timber harvest has not occurred and all other land into successional stages. The delineated seral stages are: establishment, stem exclusion, and late-succession (FEMAT 1994)

Management activities recorded in the Umpqua Preliminary Activities Database (UPAD) and pixel size/structure and canopy closure data allow classification of this mapped vegetation into a variety of habitat conditions as well as successional stage (Table 12). Activities on approximately 300 acres are unaccounted for in this database. Note that the stem exclusion, a.k.a. mid-successional, stage includes stands regenerated after fire and currently in stem exclusion, all units harvested by selection methods, and plantations where crown closure has occurred. The establishment stage includes unique habitats and successional openings.

Figure 57. Current seral stages within Cow Creek watershed.

Table 12. Mapped habitats, seral stage, and information source.

Mapped Habitats, Successional Processes, and Information Sources						
Brown's Structures	Wildlife Guild Structures	Deer & Elk Habitat	Spotted Owl Habitat Condition	Spotted Owl Habitat Capable	Successional Stage	Vegetation Information Source
(Soil or Climate Controlled) Grass/Forb	Open	Forage	Non–Habitat	Not	NA	Unique Habitat Layer MM, MX, MD
(Follow Regeneration Harvest)				Capable	Establishment	UPAD: S aspect: <3000 ft, yrs 1–10 S aspect: >3000 ft, yrs 1–5 N aspect: all elev, yrs 1–5
(Soil or Climate Controlled) Shrub	Open	Forage	Non–Habitat	Not	NA	
(Follow Regeneration Harvest)				Capable	Establishment	UPAD: S aspect: <3000 ft, yrs 11–15 S aspect: >3000 ft, yrs 6–10 N aspect: all elev, yrs 6–10
Open Saplings and Poles (<70% Crown Closure)	Open	Forage	Non–Habitat	Capable	Establishment	PMR: 10, 11, 20, 23, 27, 30, 33 With Crown Closure < 70% UPAD: S aspect: <3000 ft, yrs 16–20 S aspect: >3000 ft, yrs 11–15 N aspect: all elev, yrs 11–15
Closed Saplings and Poles (>70% Crown Closure)	Small Tree	Hiding	Non–Habitat	Capable	Stem Exclusic	PMR: 10, 11, 36 (none mapped) with Crown Closure > 70% UPAD: S aspect: <3000 ft, yrs >20 S aspect: >3000 ft, yrs >15 N aspect: all elev, yrs >15
Open Small Sawlogs (<70% Crown Closure)	Small Tree	Hiding	Non–Habitat	Capable	Stem Exclusic	PMR: 12, 13, 21, 24 With Crown Closure <70% UPAD: Selective Harvests
Closed Small Sawlogs (>70% Crown Closure)	Small Tree	Thermal	Dispersal	Capable	Stem Exclusic	PMR: 12, 13, 21, 24, (14) With Crown Closure >70% UPAD: Commercial Thinnings
Large Sawlogs (>70% Crown Closure)	Large Tree	Thermal	Nesting, Roostir and Foraging	Capable	Maturation	PMR: 15, 16, (14)
		Thermal	Dispersal	Capable	NA	UPAD: None
Old Growth	Large Tree	Optimal Thermal	Nesting, Roostir and Foraging	Capable	Transition	PMR: 25, 26, 28, 29, 31, 32, (14)

The three layers of the Current Vegetation Map provide the following proportions for seral stages, harvest history, and unique habitats within Cow Creek (Table 13). The Seral Stage Layer for all ownerships and agencies includes private land, most of which has been cut and is in the establishment and stem exclusion stages. There are approximately 28,672 acres within the district boundary. About 4,500 are private land specifically excluded from calculations for the Forest Service administered areas.

Table 13. Current amounts of unique habitats, seral stage, and harvest methods within Cow Creek. All acreages are approximate.

	Forest Service Administered		All Ownerships and Agencies	
Total Acres	24,097		37,937	
Unique Habitat Layer	744	2 %	1320	3.5%
Seral Stage Layer				
Establishment	320	1 %	4,809	12.5 %
Stem Exclusion	5,501	21 %	21,636	57 %
Late-Successional	8,120	34 %	9,867	27 %
Timber Harvest Activity				
Regeneration Harvests	6,375	25 %	included above	
Other Harvests	4,198	17 %	included above	

Landscape statistics calculated from the Current Vegetation Map of National Forest land are presented in Table 14.

Table 14. Current landscape structure of Forest Service land within the Cow Creek watershed.

Seral Stage	Percent		Upslope Edge	Number of	Average Upslope
	of Area		Distance	Upslope Patches	Patch Size ac.
	Riparian	Upslope			
Establishment	11	13		223	27
			75		
Closed Forest					
Stem Exclusion	54	55		110	238
Late Seral	35	32		127	121

For both riparian and upslope areas, the proportion of early successional vegetation is at the lower end of the historical range and well below the current mode reported by REAP. It is also well below the proportion extant in Cow Creek circa 1910. Note that this proportion is for the entire watershed and varies considerably among sub-watersheds. Similarly, late-successional conditions are well below those reported by REAP as historical conditions and the current mode. Although the reconstruction of Cow Creek's historic vegetation doesn't allow direct comparison of historic and current late-successional proportions, a reasonable interpretation is that current levels are well below historic levels. Twenty-eight percent of the current landscape in stem exclusion is native forest establishing after fire. The remaining 27 percent is the result of selective and regeneration harvesting. Unequivocally, the mid-successional proportions are well above historic levels. The dispersion of cutting units has fragmented Cow Creek considerably. Historically, the forest matrix was near-contiguous with an average patch size of 657 acres. Now that matrix is fragmented into unconnected patches that average less than 238 acres in size.

The picture changes somewhat when all ownerships within the entire upper Cow Creek watershed are considered (Table 15).

Table 15. Current landscape structure of the entire Cow Creek watershed.

Seral Stage	Percent of Area		Upslope Edge Distance	Number of Upslope Patches	Average Upslope Patch Size ac.
	Riparian	Upslope			
Establishment	13	16		270	45
			146		
Closed Forest					
Stem Exclusion	55	58	63	79	550
Late Seral	31	26	225	123	160

When the two maps are compared, the proportional distribution of successional stages is remarkably similar but their spatial distribution is considerably different. Because most of the non-Forest Service land is included in the stem exclusion stage, probably due to logging by aggregated methods, patch density increases only slightly while patch size increases considerably. Thus, private harvest practices have created a landscape in some ways more similar to the historic condition than have Forest Service practices.

Riparian Vegetation

Riparian reserves, based on a site potential tree height of 170 feet (Site Index 110, base age 50) within the district boundary using the current GIS stream inventory, are mapped on Figure 58. Because few Class 4 streams are actually mapped they are under-represented. To provide a more accurate estimate of riparian area, channel density within four subwatersheds was field-verified. Based on the results of that survey, approximately 49 percent of the area within the district boundary is within riparian reserves. Thirty-nine percent of the mapped riparian reserves have been harvested, either by regeneration or selection methods. Roads have had a significant impact of the vegetation of Cow Creek's riparian reserves: they've turned it into gravel.

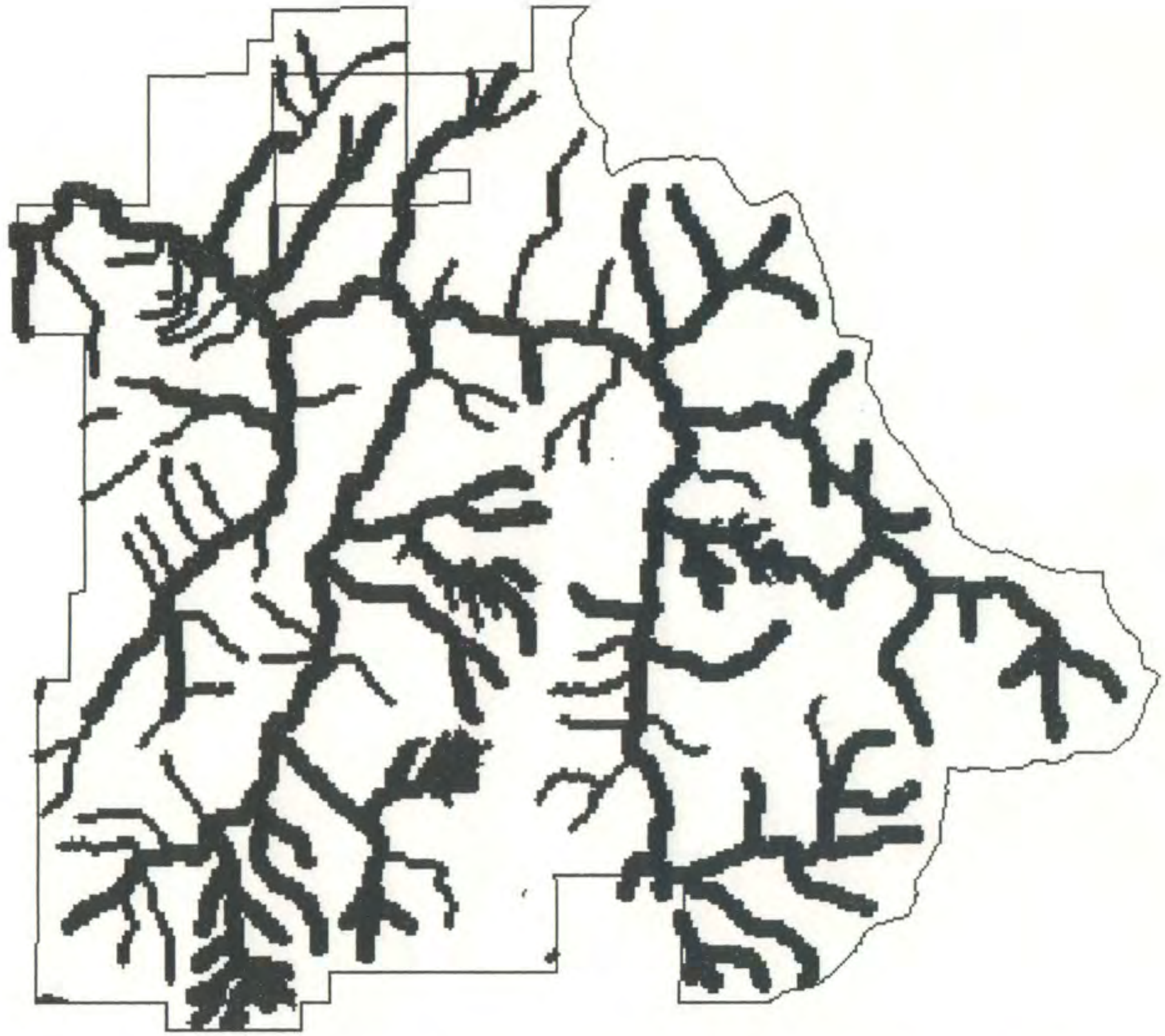


Figure 58. Riparian reserves for mapped stream within Cow Creek watershed.

Interior Forest

Interior forest conditions do not occur immediately at the boundary between a clearcut and closed forest. There is a microclimatic gradient extending into the closed forest that affects burning, vegetation, and wildlife conditions. This "edge effect" depends on the contrast of the edge and the forest condition being considered (Chen et al. 1993). For the western Cascades, Chen et al. (1992) describe a "depth-of-edge-influence" as the distance from a clearcut edge at which several forest conditions have recovered to two-thirds of their interior forest levels. Canopy cover, trees per acre, and western hemlock regeneration (in the 0-25 inch class) recover at 145 feet, 194 feet, and 452 feet, respectively. Edge microclimate conditions may persist for up to 600 from the clearcut boundary (Chen et al 1990). To evaluate interior, late-successional forest conditions, 452 and 226 foot buffers were applied to establishment and stem exclusion stands, respectively. The area inside this buffer is considered edge, rather than interior habitat (Figure 59). A narrower buffer was applied to the stem exclusion stands because their low contrast boundary with late-successional stands reduces the edge influence (Harris 1984). The area outside this buffer is interior, late-successional forest. This method maps 4,020 acres of such habitat in the watershed, including 2,916 acres on National Forest land.

This is important; the mapped interior, late-successional habitat on non-Forest Service land probably isn't. It is mapped that way because the satellite imagery, from which it was mapped, reported it as having size-structure conditions that were considered late-successional on non-harvested Forest Service land. However, in the absence of better stand information (for either private or Forest Service land), we assume that if it has been cut, enough structure has been removed that it no longer functions as late-successional habitat.

Although very little of it is connected, late-successional interior habitat occurs sporadically throughout the watershed as patches, embedded in a matrix of early and mid-seral vegetation. The South and East Forks and Cow Creek itself, in Watershed Analysis Area Q, provide the best connected habitat from low to high elevations within the watershed. There doesn't appear to be any interior, late-successional habitat connecting the LSR in, and to the north of, Beaver Creek with the rest of Cow Creek.

Composition and Structure of Current Vegetation

Cow Creek's potential vegetation is inferred from its dominant climax species: a theoretical, vegetative expression of site conditions in the absence of disturbance. A map of this vegetation (Figure 60) was created by overlaying aspect and elevation maps with a GIS and then applying judgment to delineate approximate series boundaries.

People have modified the vegetation of Cow Creek. Indians modified it primarily by fire, intentional and otherwise. Introduced cultures have modified it primarily by grazing (White 1994), timber cutting, and subsequent management, and fire ignition and suppression.

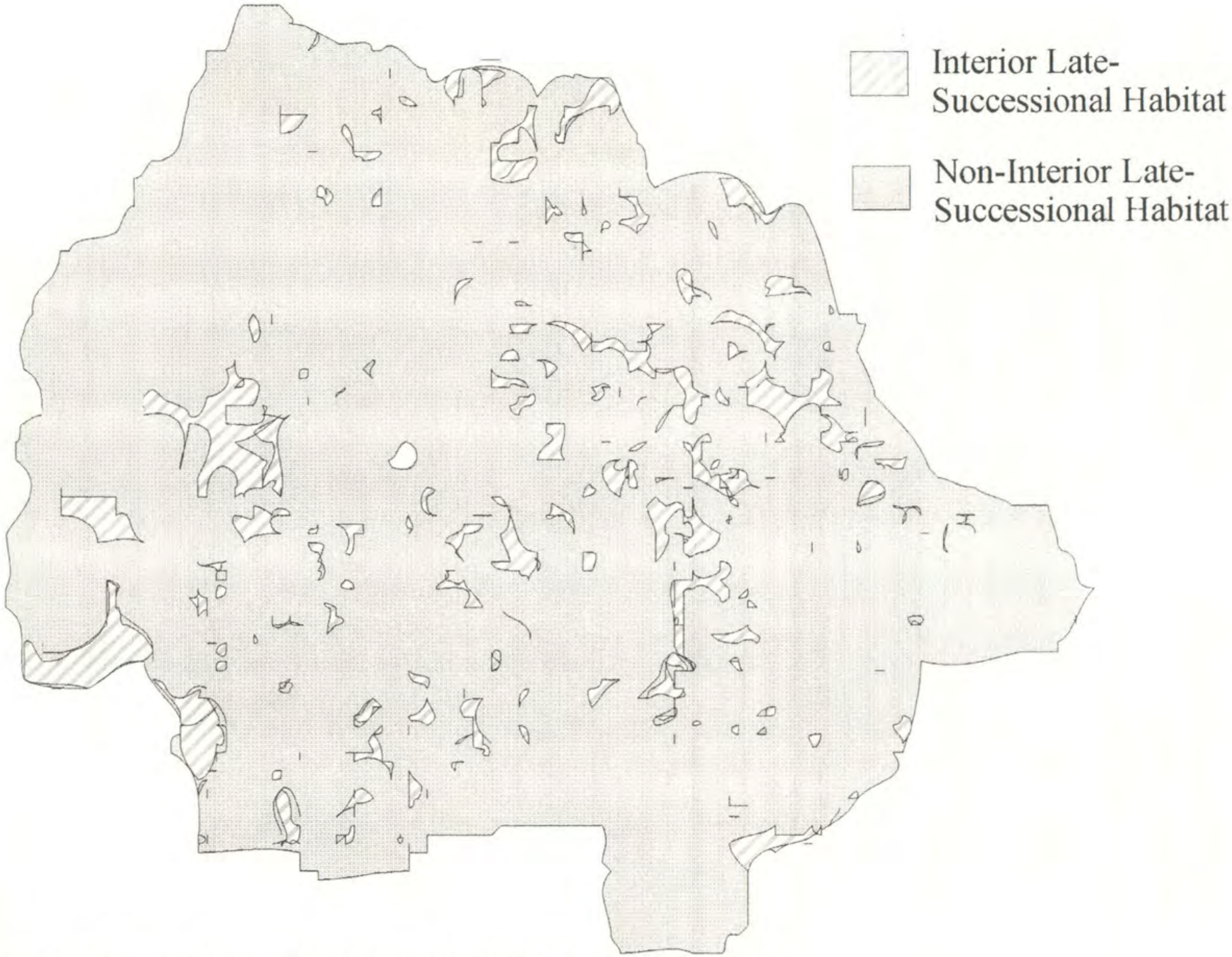


Figure 59. Interior, late-successional habitat within Cow Creek watershed.

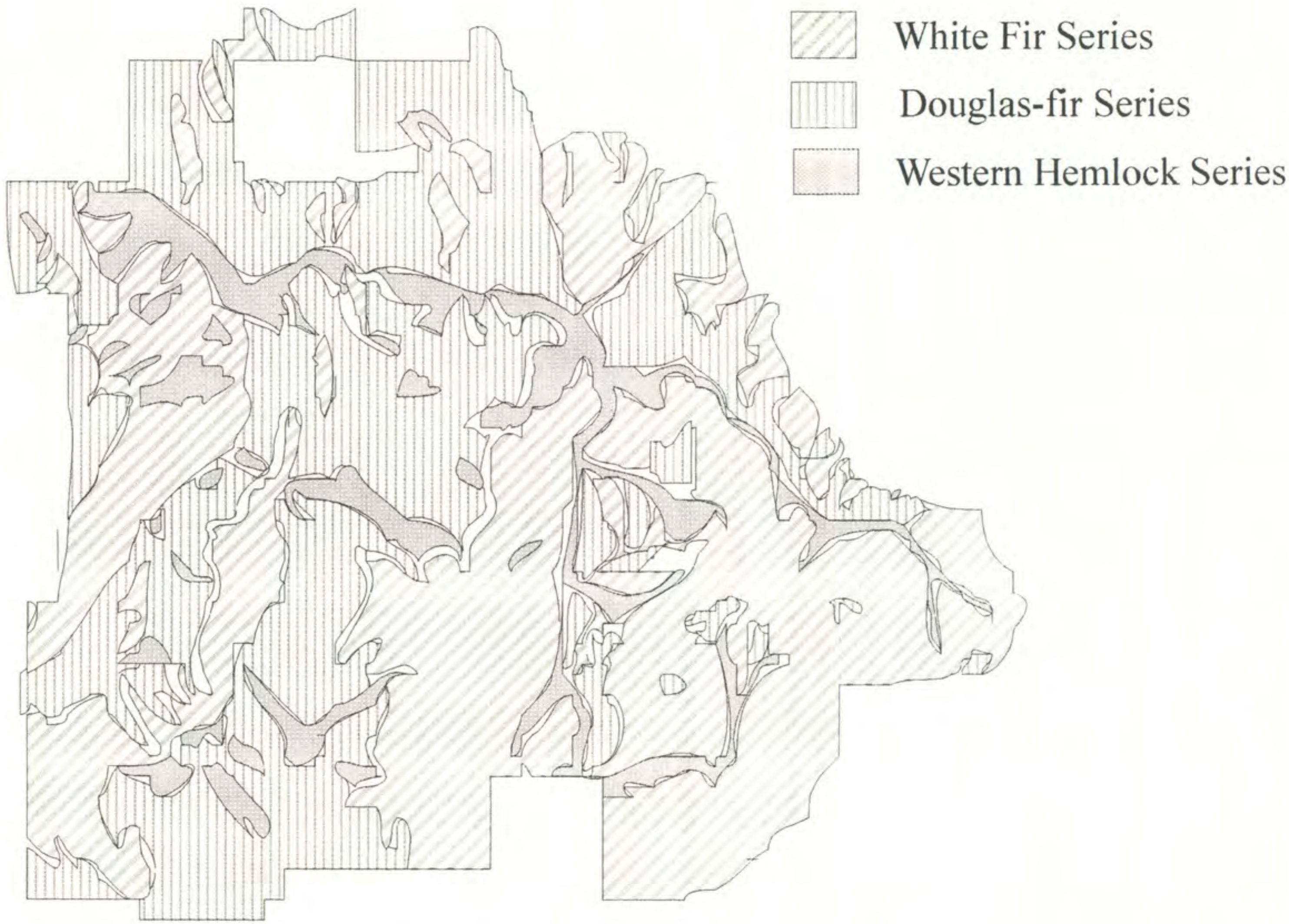


Figure 60. Plant series on National Forest land within Cow Creek watershed.

Initially, two vegetation strata were defined: vegetation affected by fire exclusion; and vegetation affected by timber harvest and subsequent management activities. Although vegetation on harvested lands has been affected by fire exclusion, this impact is generally small relative to other management activities. Uncut vegetation, primarily affected by fire exclusion, was stratified into three vegetation types based on seral stage:

1. stem exclusion with greater than 70 percent crown closure
2. stem exclusion with less than 70 percent crown closure
3. late succession

Vegetation affected primarily by timber management was stratified into two vegetation classes based on silvicultural system:

1. plantations following regeneration harvest
2. selectively harvested stands

After being grouped by Plant Series and mapped vegetation type, the 66 vegetation plots were processed through the Forest Vegetation Simulator as a type. Their Series was determined from plot data, rather than map location. Stand structure, composition, and yields were tabulated to describe the average conditions for these types (Tables 17-19). Snag and down wood density and size results are shown in Table 16.

Table 16. Snag and down wood density and size by vegetation type.

Vegetation Type	Snags per Acre, average (std deviation)				Down Wood per Acre, average (std dev)			
	Class 1, 2 or 3		Class 4 or 5		Class 1 or 2		Class 3	
	<21 in	>=21 in	<21 in	>=21 in	<21 in	>=21 in	<21 in	>=21 in
Late-Seral by Series								
Douglas-fir	0.8 (1.3)	1.4 (2.7)	1.1 (1.7)	0.5 (0.9)	3.1 (4.5)	1.8 (3.8)	3.8 (3.2)	2.7 (3.6)
White Fir	0.4 (0.9)	0.5 (1.2)	1.2 (2.2)	1.7 (2.0)	3.4 (4.3)	2.3 (3.0)	4.2 (5.9)	2.9 (4.5)
W. Hemlock	2.0 (1.7)	2.2 (2.5)	0.9 (1.4)	1.9 (1.6)	1.1 (1.8)	4.2 (5.4)	5.2 (3.5)	3.7 (3.9)
Stem Exclusion	0.9 (1.3)	0.5 (1.2)	0.9 (2.2)	1.5 (1.8)	<0.1	56 (30)	4.0 (3.9)	4.0 (5.4)
Regen. Cut		<0.1	1.1 (1.8)		2.4 (2.8)	2.4 (3.1)	5.5 (3.6)	6.2 (6.4)
Selection Cut	<0.1	1.2 (1.5)	1.2 (2.1)	1.7 (3.6)	3.0 (2.4)	5.7 (7.2)	4.2 (4.8)	3.7 (5.2)
	Snag Height, ft, average (std deviation)				Piece Length, ft, average (std deviation)			
Douglas-fir	44 (34)	73 (28)	17 (9)	18 (11)	32 (17)	38 (18)	26 (12)	43 (18)
White Fir	80 (35)	57 (45)	12 (3)	65 (57)	35 (42)	67 (53)	23 (11)	34 (19)
W. Hemlock	47 (15)	94 (34)	21 (16)	34 (30)	25 (12)	64 (39)	29 (14)	38 (16)
m Exclusion	52 (19)	68 (72)	12 (5)	22 (18)	20	56 (30)	29 (16)	40 (18)
gen. Cut			26 (25)		18 (8)	31 (24)	21 (10)	30 (18)
Selection Cut		95 (39)	25 (5)	17 (7)	34 (17)	36 (20)	23 (13)	26 (15)

Stem Exclusion Vegetation Types

These stands generally initiated after a fire, thus they retain structures usually absent from a harvested stand (Table 17). In fact, both structurally and compositionally, this type is more like the late-successional type than it is like a managed plantation. Stand density is high in this type, more than 800 trees per acre. Stand Density indices indicate competition mortality is occurring in all series and is particularly intense in the White Fir and Western Hemlock Series. The low species diversity, relative to late-successional types, reflects the ability of dominant conifers to suppress and kill other species during the stem exclusion stage. Absent disturbance, species diversity will remain low; the madrone, many of the ponderosa pine and some of the Douglas-fir in the intermediate and suppressed classes will be killed by their more tolerant neighbors; the more tolerant chinquapin and incense cedar in the understory will remain there.

There is much variation in the less-than-70 percent stem exclusion type. It includes, among other conditions: stands where conifer crown closure is less than 70 percent and stem exclusion is due to tree plus shrub dominance; stands that are in transition from establishment to stem exclusion; and stands with low crown closure due to harsh site conditions.

Table 17. Composition and structure of stem exclusion vegetation type.

Series	Basal Area per Ac, ft2	Board Feet per Ac	Tree Height, ft.	Trees Over Five Inches in Diameter QMD, in.	SDI	Trees per Ac, TPA	Trees Per Acre By Diameter Class, in. <5	5–9	9–21	21–34	>34	Species	Species Percent by Diameter Class, in. <5	5–9	>9	Hardwoods and yew per acre
PSME	193	19979	91	13	285	985	788	60	129	6	2	PSME	38	6	9	38 ARME
												PIPO	1		<1	63 CACH
												PILA			1	4 TABR
n=4 Std dev 402 trees/ac 90% Confidence Interval: 511–1458 trees/ac												CADE	31		3	8 CONU
ABCO	299	30432	126	10	547	836	250	401	162	21	2	PSME	18	23	12	17 ACMA
												ABCO	10	9		209 ARME
n=3 std dev=805 trees/ac 90% Confidence Interval: 0–2192 trees/ac												PIAT			<1	
TSHE	258	36304	108	13	403	1418	1167	117	111	20	3	PSME	14	7	<1	17 ARME
												ABCO	1		<1	34 CACH
n=6 std dev=1885 trees/ac 90% Confidence Interval: 0–2970 trees/ac												ABAM	44	2	3	150 TABR
												TSHE				
OPEN PSME	91	16727	70	16	123	1578	1517	30	22	4	5	PSME	55		2	300 ARME
												TSHE	2	2		
												PIPO	1			
n=3 std dev=1198 trees/ac 90% Confidence Interval: 0–3597 trees/ac												PILA	4		<1	
												CADE	15		<1	

Late-Succession Vegetation Types

Stand density is high in this type, largely because of fire suppression (Table 18). Competition mortality is high, particularly in the Douglas-fir and White Fir Series, where Stand Density Indices are near 400. The result will be a loss of tree species diversity as tolerant, late-successional trees kill less tolerant species. Tree volume per acre, another measure of density, is remarkably high in the Douglas-fir type, probably due to chance sampling variation. Structurally then, these types are quite similar: high tree density with an "inverse-J" diameter distribution. Species other than Douglas-fir are poorly represented even in these stands. High hardwood density and the presence of incense cedar in the overstory are probably a result of previous wildfire. They will disappear from the stand if disturbance is excluded in the long term. Notably, sugar pine contributes less than one percent of tree density in the over 5 inch diameter class. This is consistent with ecology program data for Jackson Creek where sugar pine occurred on 42 percent of the ecology plots. However, it contributed only five percent of overstory cover and averaged one percent cover in the understory. Anecdotal reports suggest that sugar pine represented less than 15 percent of stand density historically and that it has been aggressively logged since the 1950's (Lagoudakis 1994). The relatively abundant sugar pine in the understory of this type will certainly die in the absence of disturbance.

Regeneration Harvested Vegetation Types

Twenty-six percent of the public land within the watershed has been regeneration harvested. Depending on their age and site, these stands are in the establishment or stem exclusion stage (Table 19). This discussion applies only to stands in the stem exclusion stage. The snags still present in the fire-established, stem exclusion type are completely absent from the regeneration harvested type. Down woody debris conditions are comparable to the late-successional and stem exclusion types. The diameter distribution of this type could indicate unusually good differentiation in tree height among trees planted at a very high density. Alternatively, it could be due to precommercial thinning with subsequent natural regeneration contributing to the less-than-five inch diameter class. The latter scenario is more likely. Stand differentiation results primarily from variation in tree spacing, age, genetic makeup, and microsite (Oliver 1990). Reforestation in Cow Creek is predominantly Douglas-fir and ponderosa pine planted at densities in excess of 500 trees per acre, conditions associated with slow differentiation and tree growth after crown closure (Oliver 1990). Stand Density Indices, in all but the White Fir Series south of Cow Creek, are curiously low, suggesting that conifers are not fully occupying these sites (Long 1985). This may be an artifact of precommercial thinning. The exclusive dominance of Douglas-fir and ponderosa pine in the larger diameter classes is in sharp contrast to the tree species diversity of the stem exclusion type regenerating naturally after a fire. The conifer diversity in the smallest diameter class and the few hardwoods present are probably natural regeneration following planting or precommercial thinning that made growing space available. Growing at such close spacing and in the absence of disturbance, the suppressed, intolerant conifers and the hardwoods will soon be outcompeted and die. The more tolerant and tenacious incense cedar will be remain in the understory where it will die a lingering death. There is considerably more ponderosa pine in this type than in the late succession or stem exclusion types and probably more than occurred historically. Ponderosa pine has been planted at high densities throughout Cow

Table 18. Composition and structure of late seral vegetation type

Series	Basal Area per Ac, ft2	Board Feet per Ac	Tree Height, ft.	Trees Over Five Inches in Diameter QMD, in.	Trees Over Five Inches in Diameter SDI	Trees per Ac, TPA	Trees Per Acre By Diameter Class, in. <5	5–9	9–21	21–34	>34		Species Percent by Diameter Class, in. <5	5–9	>9	Hardwoods and Yew per acre
PSME	306	60914	133	19	428	477	309	59	45	48	6	PSME	31	6	15	78 ARME
												ABCO	1			8 CACH
												TSHE			<1	4 TABR
n=13 Std dev=378 TPA 90% Confidence Interval: 290–665												PIPO	7		1	8 CONU
												PILA	4		<1	
												PIAT	1	4	2	
												CADE	5		2	
ABCO	254	44920	122	15	390	625	415	90	95	19	6	PSME	20	8	13	6 ARME
												ABCO	30	4	4	29 CACH
												TSHE	<1			25 TABR
n=12 std dev=459 TPA 90% Confidence Interval: 387–863												PILA	4		<1	
												CADE	1		2	
TSHE	125	20922	104	13	187	924	800	75	35	11	3	PSME	26	2	4	31 ARME
												ABCO	3		<1	94 CACH
												TSHE	37	6	<1	6 ALRU
n=8 std dev=1093 TPA 90% Confidence Interval: 191–1657												PILA			<1	69 TABR
												CADE			<1	

Table 19 Compostion and structure of harvested vegetation type.

Series	Basal Area per Ac, ft2	Board Feet per Ac	Tree Height, ft.	Trees Over Five Inches in Diameter QMD, in.	Trees Over Five Inches in Diameter SDI	Trees per Ac, TPA	Trees Per Acre By Diameter Class, in. <5	5-9	9-21	21-34	>34	Species	Species Percent by Diameter Class, in. <5	5-9	>9	Hardwoods and Yew per acre
Regeneration Cut																
PSME	95	3478	61	8	170	740	516	161	63	0		PSME	37	15	6	50 ARME
												ABCO	3			50 ALRU
												TSHE	7			33 TABR
n=6 Std dev=451 TPA 90% Confidence Interval: 369-1111												PIPO		6	3	
												CADE	3			
ABCO	43	245	33	7	83	322	184	129	9	0	0	PSME	41	7		
												ABCO	10			
												PIPO		33	2	
n=32 std dev=101 TPA 90% Confidence Interval: 151-493												CADE	5			
Selection Cut																
ALL	186	21131	95	10	308	1926	1632	206	81	3	4	PSME	4	5	3	69 ARME
												ABCO	14	2	<1	6 CACH
												TSHE	23	4	1	28 ALRU
n=8 std dev=1093 TPA 90% Confidence Interval: 191-1657												PIPO	1			31 TABR
												PILA	<1			38 SALIX
												CADE			<1	

Creek. The seed provenance was non-local between the mid-1950s and the mid-1960s. Without future disturbance, this type will not develop the characteristic structure and composition of naturally regenerated stands.

Selection Harvested Vegetation Type

Generally, these entries were in late-successional stands, but many were in stem exclusion stands to remove scattered, emergent fire survivors. The nominal objective of these entries varied greatly, the outcome less so. Large, high value trees, especially sugar pine were removed. Decayed trees were usually left behind. The newly available growing space was occupied by tolerant species, white fir and western hemlock. This is unlike the situation that occurred in Jackson Creek where the newly available growing space was rapidly filled by a more diverse cohort of trees. In the absence of disturbance conifer diversity will remain low and the intolerant hardwoods will die. This type appears to have structural diversity similar to the late-successional type.

Riparian Vegetation

Because of similar fire regimes, management practices and fire exclusion effects, the vegetation types described above can be extended from the hillslopes to the riparian zones of many intermittent streams. They do not apply to the riparian zones of perennial streams.

Subjective impressions during riparian vegetation sampling suggest that riparian buffers between perennial streams and clear cuts are not retaining such riparian zone functions as: a mesic microclimate, stream shade, nutrient uptake and sediment filtering, and streambank stabilization. This is probably because, for such a high contrast edge, a buffer width of one tree height provides negligible interior conditions (Chen et al. 1992). However, large woody debris input may be elevated, for the short term, because many of these trees tip over. Probably because the buffer is all edge and was placed to meet a prescribed distance rather than an ecosystem function.

Early Succession

A great deal of attention has been paid to late-succession and the effects of its truncation. Specific ecological mechanisms are associated with early succession as well (Oliver 1990, Agee 1993). Silvicultural practices, designed to effect rapid conifer dominance, have foreshortened successional processes. Conifer establishment and ascendance following historic fires occurred over longer time periods (Agee 1993) allowing a greater role for non-conifers. Establishment conditions are within the proposed historical range for the watershed. However, their arrangement and turnover rates may not allow full function of some ecosystem processes. As an extreme example, consider the intolerant C. velutinus. If the conifer canopy closes and kills the ceanothus before it completes its lifecycle its seeds may be lost from the soil seedbank. There may be similar species whose seeds are viable for a much shorter time. A. umbraticus, a species more intermediate in tolerance, may be affected in the same way. In addition to affecting successional processses, excessive, early tree density reduces the rate of tree diameter growth and reduces both species and structural diversity.

Off-site pine

There are 18 plantations that were reforested with off-site-ponderosa pine. The worst are located on Red Mountain. Reforestation records indicate natural regeneration is doing well in these stands. Elsewhere, there is much variation in their condition. On better sites, local species have established and become dominant. On poorer sites, the off-site pine retains dominance or shares dominance with shrubs or hardwoods. Between these two extremes there is a continuum of conditions. In nearly all cases the off-site pine is of poor form, not thrifty and subject to Bynum's blight. The existing off-site pine plantations do not threaten the integrity of the local ponderosa pines (Hamlin per. comm. 1994). However, these stands are not consistent with naturally occurring ecosystem processes. Depending on site specific conditions, they will only slowly attain the structure and composition characteristics typical of stands, in any stage of development, in Cow Creek. Soil chemistry too, may be altered by these pure stands of pine on sites formerly occupied by primarily Douglas-fir/mixed conifer stands.

In the spring of 1988, a small plot of eucalypts and exotic pine was planted in the Angel Fire area. These trees aren't doing well and are insignificant.

Knobcone Pine/Madrone Stands

This vegetation type occurs throughout much of the watershed in both large, over 100 acre, and small, less than1 acre, patches. Because they produce abundant mast, these stands are probably very favorable wildlife habitat. In addition, knobcone pine and madrone both occur as components of more mixed-species stands as well. The death of knobcone pines from old-age is striking in both stem exclusion stands and those just entering late-succession. In the latter, competition mortality is killing these pines as well.. This mortality, the result of excluding disturbance, has two outcomes: fire hazard is increasing rapidly in stands with high knobcone pine density; both knobcone pine individually and the knobcone pine/madrone type will disappear from the landscape.

Human Dimensions

Historic Human Uses

Archaeological investigation has revealed aboriginal use in the Cow Creek watershed for village sites and hunting, fishing, and other food gathering tasks for centuries before the arrival of European peoples. The earliest evidence indicates that the native people lived in small groups, were mobile, and hunted and gathered throughout a somewhat defined territory. The natives moved to the higher elevations during the summer and early fall seeking game and mature berries and nuts. They also congregated at major streams as anadromous fish returned to their spawning grounds. These early natives were totally dependent upon the resources found in their territory for their livelihood. Explorers and trappers recorded the presence of native people in the Umpqua valley of southern Oregon at the end of the 18th century. The Cow Creek band of

Umpqua Indians was named after the creek running through a major portion of the their territory (the Indian name for this creek was "Lakwal") (Harrington 1933). They were Takelman speakers after the manner of the Indians in the Rogue River valley with whom they were traditional enemies (Riddle 1922). The Cow Creek band ranged over an area from modern day Tiller on the South Umpqua River, to Mrytle Creek, southwest to Riddle, south along Cow Creek to Glendale, and then east to the headwaters of Cow Creek.

The band subsisted much as their ancestors had using the natural resources available to them. Cow Creek territory consisted of three identifiable activity areas. Two of these, the lowlands and the uplands, were used as year-round residency areas; the third, the high mountains, was the late summer and early fall site for hunting, food gathering, and spiritual uses (Beckham 1983). Beckham (1983) describes the use of these areas:

> The lowlands setting included meadows and oak groves found in lower Myrtle Creek, Cow Creek, and the South Umpqua River. This setting provided open meadows with camas and tarweed, both important food supplies. Local streams and rivers provided fish and waterfowl and oak groves provided acorns, a winter staple. The mild winters made the area suitable for winter villages. The Cow Creek band manipulated the environment of the lowlands as part of their subsistence activities, burning the fields to secure tarweed seeds, grasshoppers, and yellow jacket larva (Sapir 1907).
>
> The uplands, with elevations ranging from 1000 to 2000 feet, were also suitable for winter villages, especially along Elk Creek near Drew, Upper Cow Creek, and along the South Umpqua River between Days Creek and Tiller. The forest provided elk and deer hunting areas as well as gathering areas. The Indian practice of burning areas periodically controlled the forest understory and contributed to the abundance of game and berries. The streams yielded trout, eels, salmon, crawfish, and freshwater mussels.
>
> The high mountains, 1800 to 5500 feet, near the Rogue-Umpqua Divide offered excellent hunting and extensive patches of huckleberries in the late summer and early fall. The meadows in the forest yielded poo-eat-sic, wild onions, and cat's ears. There were also hazelnut, manzanita berries and chinquapin nuts (Beckham and Minor 1992).

Following the Lewis and Clark expedition in 1804-06, Oregon was beginning to be explored by land for the rich natural resources used by Europeans and Euro-Americans. Initially, the primary interest was in trading with the natives for furs. It was after 1821 that fur traders from the Hudson Bay Company made first contact with the native populations in southern interior Oregon. The traders brought economic change with the introduction of "trade goods' and strange "white man" diseases to the Indians; native lifeways were soon changed forever. The Hudson Bay Company policy to "trap out " streams of an area to eliminate American competition for furs brought a end to fur trading in southern Oregon by 1854 (Schlesser 1973).

Between about 1820 and 1850, southwestern Oregon was visited by increasing numbers of explorers, scientists, pioneers, and adventurers. These travelers passed through the area on their way to California or north to the Willamette Valley. By 1850 there were 11,873 (not counting

Indians) persons living in the area south of the Columbia River, however only 75 lived south of the Calapooya Divide (Bowen 1978). The Oregon Donation Land Act of 1850, the lure of gold, and the natural resources of the area beckoned to early pioneers; by 1860, 4,412 persons resided in the Umpqua watershed (Beckham 1986).

The discovery of gold in California and subsequently in the Rogue River valley brought a rush of travelers through Cow Creek territory on their way to the gold fields. The presence of prospectors in the Rogue River Indian territory led to many unfortunate incidents of conflict between gold crazed miners and native peoples. The influx of settlers who valued the open prairies as home sites and for agricultural purposes displaced the native uses and the natives were forced to retreat to the uplands. The settlers also hunted and fished in traditional native grounds which lead to increased competition for available game.

As the competition for space and resources increased it eventually resulted in the Indian Wars of 1855-56. The Cow Creek band was involved in the conflict despite the efforts of Chief Miwaleta and George Riddle, one of first settlers in lower Cow Creek, to maintain good relationships. By the end of 1856, the Cow Creek band had been decimated by disease, starvation, and killings. The survivors were ordered to a government reservation at Grande Ronde on the Yamhill River (Victor 1894). In spite of the removal program not all the Indians left the Umpqua watershed. Refugees hid in the mountains and eluded repeated efforts by the Army and Indian agents to track them down. These people lived in the foothills of the Cascade Range in the vicinity of Tiller and Elk Creek on the South Umpqua River and in the upper Cow Creek drainage. These people persisted as a distinctive tribe into the modern era and are recognized as the Cow Creek band of the Umpqua Indians (BLM 1994). The Cow Creek band has identified traditional use areas on the Umpqua National Forest, none of which are in the Cow Creek watershed.

The last half of the nineteenth century saw a rapid expansion of the settlers in southern Oregon and the Cow Creek drainage. The lower reach of Cow Creek was developed for farming and grazing on a subsistence level. The building of the railroad through the lower Cow Creek valley to Glendale opened up markets beyond the local area for both agriculture and the timber industry. Consequently, logging became an important industry, and the Cow Creek drainage was an important source of logs for the mills in Glendale.

When gold was discovered in 1852 near Riddle on lower Cow Creek miners searched the South Umpqua River and Cow Creek for the elusive paydirt. Eventually the most productive areas were determined to be the mouth of Cow Creek, the West Fork Cow Creek, and Coffee Creek on the South Umpqua River. The Mother Lode Mine, consisting of three claim groups (Red Cloud, Thompson Prospect, and Mother Lode) was a productive cinnabar mine on upper Cow Creek throughout the first half of the twentieth century (Beckham 1986). The Mammoth Mine was opened in 1948 and produced cinnabar for a number of years until the market failed. Since then, various owners have held the claim with the last one closing the mine in 1994. Although no significant amounts of gold were recovered from upper Cow Creek, efforts to locate gold and silver have continued through the years. There continues to be an interest in locating gold and silver. Five claims have been located and registered with the BLM in the last five years.

During the Depression era the Civilian Conservation Corps established a camp at Devils Flat on the Umpqua National Forest. These young men built roads, bridges, campgrounds, and buildings, fought forest fires, and did other conservation work along the upper reaches of Cow Creek. Due to their efforts, inaccessible areas were opened to vehicle traffic. This made access to the area's timber resources readily available after the Second World War.

Logging was big business in the Cow Creek drainage after the close of World War II. As with the rest of the Umpqua National Forest, the increase demand for lumber resulted in timber sales and road building throughout the drainage. The logging continued until the late 1970's when a moratorium was placed on logging because of problems with soil erosion in the decomposed granites of the area. With the advent of the Tiller Ranger District Granitics Policy in 1979, logging and road building resumed in the Cow Creek watershed within certain parameters designed to reduce soil erosion.

Current Human Uses

Cow Creek has changed dramatically over the last 150 years. The people and their interests and uses of the watershed has changed also. The majority of the residences of upper Cow Creek live in the area because of their desire to have space and land of their own. Most of the homes in the area were owner built on five to twenty acres and are within a quarter mile of Cow Creek. Some residents work out of their homes, most drive to Glendale, Grants Pass, or north along the freeway to other towns to work. The prevailing attitude among the loosely knit community is that of independence and isolationism. An old log building serves as a Community Center where the residents meet periodically to discuss community issues or for social events. Because of their diverse backgrounds and personal values, there are no widespread coalitions among the residences.

In Glendale, the nearest community (population 707), 55 percent of the residents were born out of state (1990 census). It would be reasonable to assume that roughly the same percentage applies to the upper Cow Creek residents. They moved to the upper Cow Creek area to get away from the crowded conditions of cities or neighborhoods in other states. They value the quiet rural setting of the Cow Creek valley and resist changes that might threaten those conditions. Many have "special places" on the National Forest that are important to the them and any changes are perceived as threats. There are many different life philosophies represented in the residents; from the environmentally concerned business person to the "pioneer family" logger whose livelihood depends on continued timber harvest and lumber manufacturing.

The area was dramatically affected by the reduction in National Forest timber sales in the early 1990's. In Glendale, 13 percent of the family incomes were below poverty level in 1989 (1990 census), a time of comparative prosperity. During that time, two large mills were operating in Glendale, employing approximately 475 people. When Gregory Forest Products closed their mill in Glendale in early 1992 it left 400 employees without jobs which severely impacted the town and the surrounding area. Glendale's population and per capita income dropped and unemployment increased dramatically. The one remaining mill, Superior Timber Company, purchased a portion of the Gregory holdings, including 30,000 acres of timber and two veneer and plywood plants. They subsequently employed approximately 150 people (Community Response Team 1993). Douglas County as a whole experienced a 51.7 percent reduction in timber harvest between 1988 and 1992. In an attempt to diversify the economy of the area, a Community Response Team (CRT) was organized in 1992 and has been active in developing a plan to introduce new commercial activities in the area. The Forest Service (Tiller Ranger District) and Bureau of Land Management (Glendale Area) participated with the Glendale CRT and provided grants to fund community analysis and technical assistance for project planning.

Many upper Cow Creek residents show an interest in Forest Service management activities. They seem particularly interested in recreational opportunities and harvest activities adjacent to their property and view area. Another area of concern is the control of wildfire in the drainage. Historically lightning caused wildfire has altered the landscape repeatedly. With the current policy of closely managing fire, the effect of wildfire has been significantly reduced. This situation has resulted in a heavy fuel loads, making the possibility of catastrophic fires a concern to all those who live within or adjacent to National Forest lands. To a lesser degree, the people of Cow Creek are concerned about water quality, erosion, landslides, and road washouts caused by flooding. Many of the residents have springs or creeks on National Forest lands as their source for domestic water, which can be adversely affected by management activities. The community is also interested in the availability of special forest products, especially firewood. There have been a small number of permits issued in the past for posts and poles, but firewood is the most often sought after commodity. Wood heat is the primary domestic heat source in 36 percent of the homes in Glendale and 34.6 percent of the homes in Douglas County (1990 census). The reduction in timber sale activity has reduced the availability of firewood and has increased firewood theft and public concern for this resource.

The "community of interest" is much larger than just the local area. Within a one hour drive, there are several large cities; Medford (pop. 46,951), Roseburg (pop. 17,032), and Grants Pass (pop. 17,488), and smaller communities; Myrtle Creek (pop. 3,063) and Canyonville (pop. 1,219). People from all of these communities have rapid access to the upper Cow Creek area from the I-5 corridor. One of the significant interests in the area is Galesville reservoir which was built in 1985. With the completion of the Chief Miwaleta County Park in the spring of 1987, the use of the area has increased significantly. The primary user in the summer is engaged in water-based sports such as water-skiing, swimming, or fishing. Throughout the remainder of the year, fishing, both from boat and the shore, is the primary use. Chief Miwaleta Park has two boat ramps with parking areas, a 10 unit picnic area, a large-group gazebo with a parking area, and a swimming area adjacent to the picnic area. There are no camping facilities at the park or in the immediate area, the closest campground is Devils Flat, 10 miles above the reservoir. Observations by the Forest Service from mid-April to October 1990, show that 40 percent of the visitors to Galesville were from Glendale and areas south to Grants Pass, 50 percent from Canyonville, Myrtle Creek, and Roseburg, and the remaining 10 percent from outside the area (more than 1 hour drive). Observation by the BLM from June to October 1993 show that these statistics are still basically valid although "out of area users" seem to be more frequent than previously reported and come from as far away as Bandon and Cave Junction on a somewhat regular basis (Haller 1994).

Other recreational opportunities in the upper Cow Creek area are Devils Flat Campground and trails in the area. Devils Flat Campground is in the area of a Civilian Conservation Corp (CCC) camp of the Depression era and later the Cow Creek Ranger District Administrative site. The campground is on the north side of the county highway and consists of three campsites and toilets. No water is available at the site. Elk Skull Bluff Trail, a short loop trail (1/4 mile), leads to a scenic viewpoint above the campground. The site on the south side of the county highway is planned for a horse camp. There is presently a restored 1915 era Ranger cabin and horse barn at this site. Also, Cow Creek Falls Trail is at this site. This trail is a short, 0.3 mile, hiker only, loop trail that accesses the Cow Creek Gorge. The Cow Creek Gorge is a 100 acre Geologic Special Interest Area with an emphasis on interpretation and education of the unique geology of the area. Two major trails in the area are the Cow Creek and Devils Flat Trails. Cow Creek Trail is 6.2 miles long, beginning at a trailhead on Forest Road 3232, and following the main fork of Cow Creek accessing an unroaded recreation area. This 1,268 acre area is managed for a semi-primitive, non-motorized experience, with no timber harvest. The trail ends eventually at the Railroad Gap Shelter. The Devils Flat Trail is 5.1 miles long and goes from Devils Flat to the top of Red Mountain. Both of these trails are open to hikers, mountain bikes, and horses. (Depew 1995).

Sightseeing and pleasure driving seem to be a fairly low use of the upper Cow Creek area on the National Forest. There are no features of regional interest to draw visitors beyond the Devils Flat area. The area receives hunting use in the fall, but is not locally know as one of the better areas for deer or elk.

Future Trends in Human Uses

The development of recreation opportunities in the upper Cow Creek area has been addressed by an inter-agency/area residents work group. The Upper Cow Creek recreation Area Work Group was formed about two years ago and is a combined effort by the Forest Service, Bureau of Land Management, Douglas County, and interested Cow Creek residents. This work group has, through collaborative efforts and consensus building, identified resource issues and local concerns, reviewed potential recreation opportunities, and developed recreation management opportunities. No final recommendations have been made at this time; however, a BLM campground in the area of Galesville Reservoir is one of the major projects being considered.

The Umpqua National Forest Plan lists several projects in the Cow Creek area. Planned Capital Investment Projects for the future include: The white Cow Trail (1.5 miles), the Mine Trail (1.5 miles), Devils Flat Trail-Green Butte Section (3.5 miles), Cow Creek Trailhead, Cow Creek Trail bridges, and Devils Flat Trailhead. These projects are on the regional Capital Investment Plan and will be constructed as funding becomes available (Depew 1995). Studies conducted in 1986 for the President's Commission on American Outdoors (Klar and Kavanagh 1986) reported on the importance of trails to the American public. ,In addition to the studies by Klar and Kavanagh, public interest in trails was exemplified by Oregon Statewide Comprehensive Outdoor

Recreation Plan (SCORP) and the Umpqua National Forest Plan. Analyses show that 35 percent of the public prefer recreational opportunities in or near semi-primitive settings (Allen 1990). From these reports and surveys, it is clear that there will be increased use of trails in southwest Oregon and that the public wants experiences in a semi-primitive forest setting. A trail system in the upper Cow Creek watershed would be able to accommodate some of this public demand for semi-primitive outdoor recreation. Future projections for developed camping and visiting interpretive sites show a positive annual growth rate, while driving for pleasure shows a statewide constant level (SCORP 1988-93).

Changes in the local population will be gradual. The growth rate in Oregon was 12.9 percent during the period 1980 to 1992. The growth rate for Douglas County at that same time was 3 percent (Bureau of Census 1994). Unless there is a change in the employment situation in Douglas County it would be reasonable to assume that the rate of growth would remain somewhat lower than the remainder of the state. The unemployment rate in Douglas County in August 1995, was 6.2 percent which was the lowest it has been since 1980 (News Review 1995). Historically south Douglas County has been heavily dependent on the timber industry with fluctuations in population tied to the health of that industry. It is reasonable to assume that the Cow Creek area will see slow population growth and that the concerns of the current residents will be shared by the newcomers.

The National Forest land in the Cow Creek watershed has been classified for different uses in the Northwest Forest Plan. The Northwest Forest Plan has identified 20,260 acres of matrix classification where timber harvest and special forest products activities will continue to be a management alternative. A smaller portion of the watershed, 2,451 acres, is classified as Late-Successional Reserve dedicated to providing late-successional and old growth related species habitat. The people of Cow Creek and neighboring communities are interested in the management of this land. As project planning begins, it is essential that the public have the opportunity to be informed and involved to the extent of their interest. Involving interested publics in the project decision process through public meetings and other media will help to integrate cultural values, public concerns, and management requirements.

5. Recommendations

Landscape

1. Concentrate activities in WAA's that have already been heavily impacted by roads and harvesting in order to restore the landscape level vegetation and aquatic conditions. Minimize sediment production and inputs to streams, minimize erosional processes, and reduce road densities throughout the watershed. Use KV funding and road reconstruction packages from proposed activities to pay for restoration projects.

2. Defer harvest in existing interior late-successional patches and their buffers until existing stem exclusion stands have developed into replacement habitat. Currently, the South Fork Cow Creek corridor (WAA 02C) and the south side of Cow Creek in WAA Q provide low to high elevation connectivity within Cow Creek. Replacement habitat should be developed to perpetuate it.

3. Reduce fragmentation across the landscape. This can be achieved by aggregating existing and new harvest units. This will allow somewhat synchronous successional processes at the landscape level, similar to historical conditions. Small group selection and 15 percent retention will perpetuate the fine-scale variation typical of this landscape. Over time, areas in various seral stages will shift on the landscape. The landscape proportions described by the Regional Ecosystem Assessment Process (USDA Forest Service, PNW Region 1993) and patch statistics described in this report are reasonable guidelines.

4. Maintain or improve canopy cover in perennial streams (Class II and III) throughout the basin to keep water temperatures low and perpetuate salmonid habitat. Harvesting in Class II and III riparian reserves should only occur to meet site specific riparian objectives.

5. Vegetation manipulation within the riparian reserves of intermittent streams (Class IV) is acceptable. The four general conditions anticipated are the following.

    1) Where the objective is to meet a specific riparian zone objective, that objective will drive the silvicultural prescription.

    2) Where the adjacent stand is composed of a single-cohort and the silvicultural prescription is designed to promote stand differentiation and species diversity, that treatment can be applied throughout the riparian reserve.

    3) Where the adjacent stand is being regenerated, a silvicultural prescription may be developed for the riparian reserve that allows low-intensity disturbance processes to function while retaining stand conditions that meet riparian zone objectives. In no case should trees within the riparian reserve be counted toward the 15 percent

retention mandated by the Record of Decision (USDA Forest Service and USDI Bureau of Land Management 1994).

4) Where the riparian zone is affected by a high-frequency, low-intensity fire regime, the silvicultural prescription for the adjacent stand should be modified to account for the riparian zone's damping effect on fire.

Project Level

1. When planning timber harvesting projects, diagnose and prioritize previously harvested stands ahead of non-harvested stands.

2. Silvicultural prescriptions should meet management objectives within the context of site conditions and historic fire processes. However, deviation from this generality is acceptable in order to retain the stand- and landscape-level complexity that now exists in Cow Creek. Generally, stands should be restored to species composition and structure that is more sustainable and typical of native forests prior to fire suppression.

3. Second growth stands, plantations, and selectively harvested stands are over represented on the landscape. They have a narrow silvicultural treatment window and should be treated in order to meet stand structure and composition objectives and avoid undesirable mortality. However, some dense stands and patches within stands should be retained across the landscape in order to retain diverse habitats.

4. Non-commercial thinning should be accomplished with KV collections whenever possible.

5. Stand density management has a much greater benefit to tree growth and stand differentiation, species composition, and forest health than does fertilization. Over dense stands are abundant and appropriated Timber Stand Improvement money is limited. This money should be spent on thinning rather than fertilization.

6. Reforestation prescriptions and stocking objectives should be tailored to meet site specific objectives. If soil and watershed conditions require rapid recovery of conifer canopy and root-site occupancy, then high initial stocking is appropriate. If large trees, structural diversity, and species diversity throughout the life of the stand are required, then high initial stocking is not appropriate. Precommercial thinning can affect changes in stand structure and development but adequate funding is unlikely. The average 20 year stocking density of regeneration harvested stands in Cow Creek is 531 trees per acre, well above the minimum stocking for the Umpqua National Forest of 125 trees per acre (Fierst 1995, personal communication). In many cases, third year stocking of 200 and 250 desirable trees per acre is acceptable for the Douglas-fir and White Fir/Western Hemlock Plant Series, respectively.

7. Manage stands to perpetuate the snag and down wood levels in the stem exclusion and late-successional seral stages currently found in unmanaged stands within the Cow Creek watershed.

8. Reduce stand density in order to retain old ponderosa and sugar pines and recruit young ones, ideally at the stand-, rather than individual tree-level.

9. Sites defined as TRG (unsuitable for reforestation) by the 1990 Umpqua National Forest Land and Resource Management Plan should not be excluded from treatment when low intensity, selective harvest is applied to large portions of high-frequency fire regime landscape.

10. Until more is known about the desired proportions and spatial arrangement of the knobcone pine/madrone type, cultural practices should create conditions favorable to its retention in existing plantations until the next anticipated entry. The area ecologist and forest silviculturist should be included in an evaluation of silvicultural prescriptions that regenerate the knobcone pine/madrone type.

11. When aggregating harvest units, consider the effect on peak flows. Canopy removal in snow zones may increase streamflow. The cumulative effects of canopy removal and added road ditches on peak flows and aquatic habitat should be examined at the project level.

12. Follow the recommendations listed in the 1995 Tiller Ranger District Granite and Schist Policy when harvesting in granitic and schistose terrains.

13. In granitic or schistose terrains, buffer headwall areas to minimize the vegetation disturbance. Yard timber away from these buffer zones or minimize the number or yarding corridors through them.

14. Anecdotal information indicates that north-facing slopes in granitic soils have an increased probability of failure. Use caution when operating on these slopes and incorporate geotechnical or other earth-science input when planning and implementing management activities in these areas.

15. According the Umpqua Forest Plan (USDA Forest Service 1990), land greater than five acres in size and over 60 percent slope in granitics should be designated unsuitable for timber harvest due to the increased risk of landslides (TML). In the Cow Creek watershed, the granitic and schistose soils behave similarly and therefore, land over 60 percent slope should not be harvested and the vegetation should not be disturbed. Small pockets of greater than 60 percent slope within larger units should be considered as potential unstable areas. The project team should consider leaving reserve trees and minimizing disturbance in these small areas.

16. On slopes between 40 and 60 percent on granitic and schistose soils, the matrix harvest prescription of retaining 15 percent of the trees on the site will not prevent soil erosion and

potential landslides. When planning timber harvest activities on these sites, earth-science professionals should be consulted to determine the harvest prescription on a site-specific basis.

17. Leave large woody material in draws in granitic and schistose soils to help contain slides that may occur. Streams and gullies should be considered at a project level to determine whether the placement of large woody debris would be beneficial. A hydrologist or fisheries biologist should consider the Rosgen stream type and the objectives/consequences of the placement of such material prior to recommending it.

WAA's 02D and 02F (Applegate Creek)

These two watersheds encompass the entire Applegate stream system. The Applegate stream system is a high sediment producing stream system with low transport (high storage). Any activities within this basin should incorporate techniques to reduce sediment input into the stream system. Water temperatures at the mouth of Applegate Creek are higher than most of the other tributaries to the mainstem of Cow Creek. Since Applegate Creek contributes a significant volume of water to the flow regime of Cow Creek, canopy cover on all streams should be maintained or improved throughout this watershed. Harvesting within riparian reserves in this watershed should be kept to a minimum and riparian planting should be considered when implementing projects.

WAA 02F (Upper Applegate Creek)

The upper end of Applegate Creek is fragmented by existing harvest units. Where possible, future harvest units within this WAA should be aggregated with existing harvest units in order to reduce fragmentation. The road density in this watershed is very high, so new road construction should be limited and there should be no net increase in road density. Channel extension is also very high in this WAA. Harvesting projects provide an opportunity to reduce this channel extension and sediment input to streams through KV opportunities and road reconstruction in the sale area. Adding culverts, drain dips, and other drainage structures to existing roads will help to interrupt the direct stream extension by dispersing the water on the hillside at desired locations rather than concentrating it into existing streams. Opportunities to decommission roads after timber harvest should be examined. Other KV and reconstruction opportunities should include rehabilitation of existing slides, precommercial thinning of managed stands, and riparian planting of unshaded streams. All harvesting projects should focus on reducing sediment production, road densities, and fragmentation.

WAA 02B (East Fork Cow Creek)

This watershed encompasses the East Fork of Cow Creek. The lower end of this watershed is designated LSR. The upper end of this watershed is comprised of granitic, schistose, and a small portion of volcanic soils. The volcanic soils are not as sediment producing as the granitic and schistose soils; however, water turbidities may be increased in these kinds of soils. The harvest units within this WAA are fairly well aggregated. The priority for this watershed is to thin previously harvested stands and keep cutting of late-successional stands to a minimum until surrounding stands have developed into a late-successional stage. To make thinning sales economically viable, it may be necessary to harvest additional timber in untreated stands. This additional harvesting should be concentrated along side existing harvested units in order to reduce fragmentation. Channel extension, sediment production, and road density should be reduced in this WAA using the same techniques described for WAA 02F (upper Applegate Creek).

WAA's 02A, 02L, 02M, 02N, 02Q, 02R, 02S, 02T, and 02V (North Side of Cow Creek)

These WAA's generally lie on the north side of Cow Creek. Southwest through southeast aspects are common. The objective for stands within these WAA's is to restore structure and species composition more characteristic of their fire regime: open canopies dominated by early seral, fire resistant species. These treatments should be applied over large areas, where possible. Channel extension, sediment production, and road densities should be reduced in these WAA's using the same techniques described for WAA 02F (upper Applegate Creek).

Restoration

1. Channel extension across the landscape is very high in Cow Creek. Harvesting projects provide an opportunity to reduce this channel extension and sediment input to streams through KV opportunities and road reconstruction in the sale area. Adding culverts, drain dips, and other drainage structures to existing roads will help to interrupt the direct stream extension by dispersing the water on the hillside at desired locations rather than concentrating it into existing streams. Decommissioning roads will reduce road densities and decrease channel extension.

2. Native surfaced roads in this watershed do not contribute significantly to channel extension. Restoration money should not be spent on rehabilitation of native surfaced roads at the expense of rehabilitating surfaced roads in the basin.

3. Roads within the watershed should be "storm proofed" in order to reduce road failures and the sedimentation produced by them. Drainage structures should be upgraded to pass the 100-year flood events.

4. Restoration activities within WAA's containing a high percentage of private and BLM lands should be pursued jointly with the private landowners and/or the BLM. Applying restoration activities to these watersheds without involving other landowners may not be cost effective or achieve the desired results.

WAA 02E (Dismal Creek)

This WAA encompasses the Dismal Creek stream system. This system is in a highly degraded condition. This watershed is heavily roaded on both public and private lands and the streams have high sediment input and low sediment transport (high storage). The objective for this WAA should be restoration projects including such things as road rehabilitation/decommissioning, riparian improvement/planting, and instream habitat restoration. Partnerships with private landowners and the BLM should be pursued for these restoration projects. The only tree cutting treatment that is recommended for consideration at this time is precommercial thinnings at narrow spacings.

WAA's 02L, 02M, 02S, and 02U (Lower Cow Creek)

The upper portions of Cow Creek occur within reaches constrained by topographic features of the landscape. In WAA 02M, the valley widens and no longer provides a constraining influence on the channel. In these lower reaches, Cow Creek is unconstrained and channel morphology is determined by bank erosion and entrenchment (wide, shallow, bedrock/sand dominated). A concerted effort should be made to evaluate current riparian vegetation stands (species composition and growth potential) to determine if long-term riparian vegetation objectives can be obtained. These objectives should include developing large trees within the floodplain and migration path of Cow Creek in order to provide the potential for future channel stability. Mixed ownership of these lower portions of Cow Creek requires a concerted effort by all landowners to obtain the desired results.

WAA 02V (Beaver Creek)

The currently active mining operation on the Cow Creek side of Wildcat Ridge should be examined for stream restoration activities that will reduce the sediment input into Cow Creek.

Fire

1. Consider prescribed fire in serpentine areas to maintain their special habitat characteristics.

2. Consider stand treatments such as thinning and prescribed fire to make the residences in Cow Creek easier to protect from wildfires.

Geology

1. Use geologists, geotechnical engineers, or soil scientists when planning road construction or timber harvesting to assist in delineating headwall areas, unstable zones, or other areas requiring avoidance or specialized techniques.

2. Use mining specialists in assessing active and abandoned mines and claims. Use them to assess water quality problems associated with mining activities.

Transportation Planning

1. Road maintenance in the Cow Creek watershed must be given a high priority for funding. The soils in Cow Creek are among the most erosive and unstable on the district. Adequate maintenance of road surface and drainage structures is key to reducing sediment delivery to area streams. The 1995 Tiller Ranger District Granite and Schist Policy should guide road location, construction, and maintenance activities.

2. Additional cross drains should be placed in Maintenance Level 2 and 3 roads as part of the reconstruction package on timber sales or as KV rehabilitation of sale area roads. Cross drains on Maintenance Level 3 roads should be culverts placed at a spacing interval that will disperse water in a more natural pattern. Draindips or driveable waterbars can be used on Maintenance Level 2 roads.

6. Need for Further Analysis

During the evolution of the Cow Creek Watershed Analysis, the team identified several items that will need to be studied further at both the landscape and project level. The team also identified several items which should be included in a monitoring plan for the Cow Creek basin.

Landscape

1. The unverified stream layer (from Arc Info) should be manuscripted and produced for the watershed prior to project planning in order to aid with the analysis of riparian reserves.

2. The riparian vegetation (species composition and growth potential) should be evaluated for Lower Cow Creek to determine if long-term riparian vegetation objectives can be obtained. The objectives should include developing large trees within the floodplain and migration path of Cow Creek to provide future channel stability.

3. Fish spawning success should be evaluated across the entire watershed.

4. Fish distribution surveys should be conducted for the basin.

5. Habitat guilds were prepared for the Cow Creek watershed to be used in the Habscapes portion of UTOOLS to analyze habitat conditions. Wildlife habitat analysis should be conducted on a landscape level prior to project planning.

6. The ecological and wildlife significance of the knobcone pine/madrone stands should be determined and recommendations for management should be made.

7. The location and extent of exotic plants should be determined.

8. The disturbance regime in perennial riparian zones should be studied further to determine management objectives for these areas.

Project Level

1. As Class IV streams are located and verified in the field during project planning, they should be corrected on the GIS layer.

2. Fish distribution surveys should be conducted at the project level. These surveys can be used to verify stream classification and determine habitat needs.

3. Analysis of wildlife habitat at the site specific level should be conducted during project planning.

Monitoring

1. Sediment transport and storage within the watershed should be monitored using the Riffle Stability Index method to evaluate changes in the balance of water and sediment over the long-term. RSI can also be used following projects to help analyze the effects.

2. Four channel reference sites were established during summer 1995. Channel geometry (cross-section geometry and longitudnal profiles of bankfull and water's edge) were taken. Repeating channel geometry surveys at these sites following project activities can aid in monitoring channel changes.

3. Channel extension should be evaluated following road decommissioning and reconstruction projects to determine the effectiveness of these projects.

4. Macroinvertebrate monitoring should continue as it provides a good indicator of aquatic system health and diversity. It is recommended that the number of monitoring sites be increased to include one at each of the major tributaries to Cow Creek.

5. Fish populations should be monitored throughout the basin.

6. Monitor to ensure that the proportions of seral stages and patch statistics are headed towards management objectives.

7. Fine-scale variation in establishment and late-successional stages should be monitored to ensure retention.

8. Monitor to ensure representation of all pine species, in all age-classes, on appropriate sites across the landscape.

9. Monitor insect and disease conditions and trends.

10. Monitor stucture and composition of managed stands and tree stocking in planted stands.

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Cow Creek

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Appendix A

Glossary of Geologic Terms

Glossary of Geologic Terms

Basalt — A dark colored, fine-grained volcanic rock, commonly extrusive, but locally intrusive (plugs, sills and dikes). Composed chiefly of calcic plagioclase feldspar and ferromagnessium minerals.

Breccia — A volcanic rock formed from mixed types of volcanic products. Often composed of various portions of tuff, fragments of rock and mud. Composition is very variable.

Geologic contact — The plane along which two geologic units meet. The plane may be a smooth surface, or there may be interfingering of the two rock units.

Debris basin — A concave section of hillside, usually in granitic bedrock, where the primary method of mass wasting is by Debris Torrents

Debris flow, Debris torrent — A very rapid downslope movement of rock fragments, soil mass, and organic debris that commonly results from unusually heavy precipitation or from rapid thaw or snow melt.

Erosion — The movement of soil or rock particles by gravity, water or wind, from the place of origin to a place of deposition.

Fault — A place where movement of two sections of the earths crust has occured. The movement may be compressional (thrust fault), tensional or shearing (strike-slip fault).

Geologic provence — A region of which all parts are similar in geologic structure and climate, and which consequently has had a unified geomorphic history.

GIS — Geographic Information System. MOSS and ArcInfo are computer programs used as part GIS.

Granite — An intrusive volcanic rock, high in silica and other lighter colored minerals. Generally has fairly large, descrete crystals. Often, all light colered, crystalline rock is refered to as granite, even though the mineralogical classification may be different.

Headwall — The concave, over-steepened area of a slope at the top of drainages. Often the area of origin for landslides or debris torrents. Concave portions of the side of draws are refered to as "sidewalls".

Hydrothermal Alteration — The chemical alteration of rocks or mineral by the reaction of superheated water.

Mass wasting — The movement of large amounts of soil or rock by the action of gravity or water. Generally Mass Wasting refers to one of the various forms of landslides.

Metamorphism — The mineralogical, chemical, and structural transformation of solid rocks to a different rock type by the physical and chemical conditions which have generally been imposed at depth below the surface zone of weathering. the affects of regional metamorphism are widespread.

MILOC — A database of mines and prospects maintained by the Oregon Department of Geology and Mineral Industries.

Pluton — A intrusive volcanic rock, usually of wide extent. The magma is usually emplaced deeply in the earths crust and cools slowly, allowing the formation of large, descrete crystals.

Pyroclastic — Pertaining to clastic or fragmentary rock material formed by explosive volcanic explosion or aerial expulsion from a volcanic vent.

Saprolite — A soft, earthy, typically clay-rich, thoroughly decomposed rock, formed in-situ by chemical weathering processes. the uppermost horizon of saprolite is transitional into residual soil.

Schist — A rock formed by the metamorphism of prexisting mudstone, siltstone or sandstone. Schist is composed of bands of minerals, that reflect the original mineralogy of the parent rock.

SerpentineAn ultrabasic rock consisting of serpentine-group minerals, such as antigorite and crysotile (asbestos), and assessory chlorite, talc, and magnetite, derived from the alteration of ferromagnesium minerals like olivine and pyroxene.

Silicic — Derived from silica (silicon dioxide)

Tectonism — The large-scale deformation and movement of portions of the earths crust by deep-seated forces within the earth.

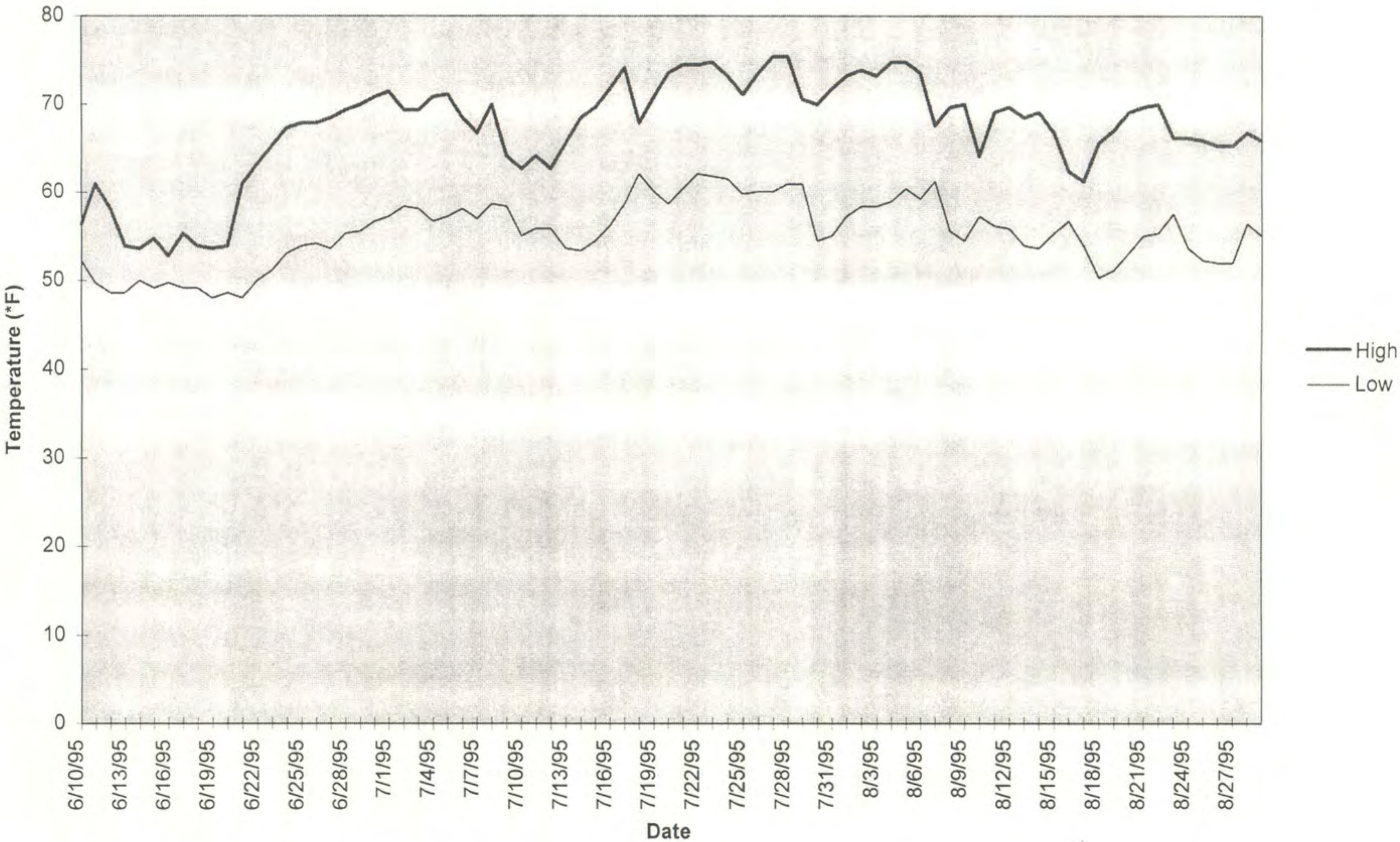
Tuff — A general term for all unconsolidated fine-grained pyroclastic rocks, but typically refers to volcanic ash.

Ultrabasic — An igneous rock having a silica content lower than that of a basic rock. Percentage limits are arbitrary, although an upper limit of 44 percent is recognized. "Ultrabasic" is an end member of a widely used system for classifying igneous rock on the basis of silica content; the other subdivision being acidic, intermediate and basic. The term is frequently interchanged with ultramafic (high iron-magnesium).

Appendix B

Temperature Monitoring Data

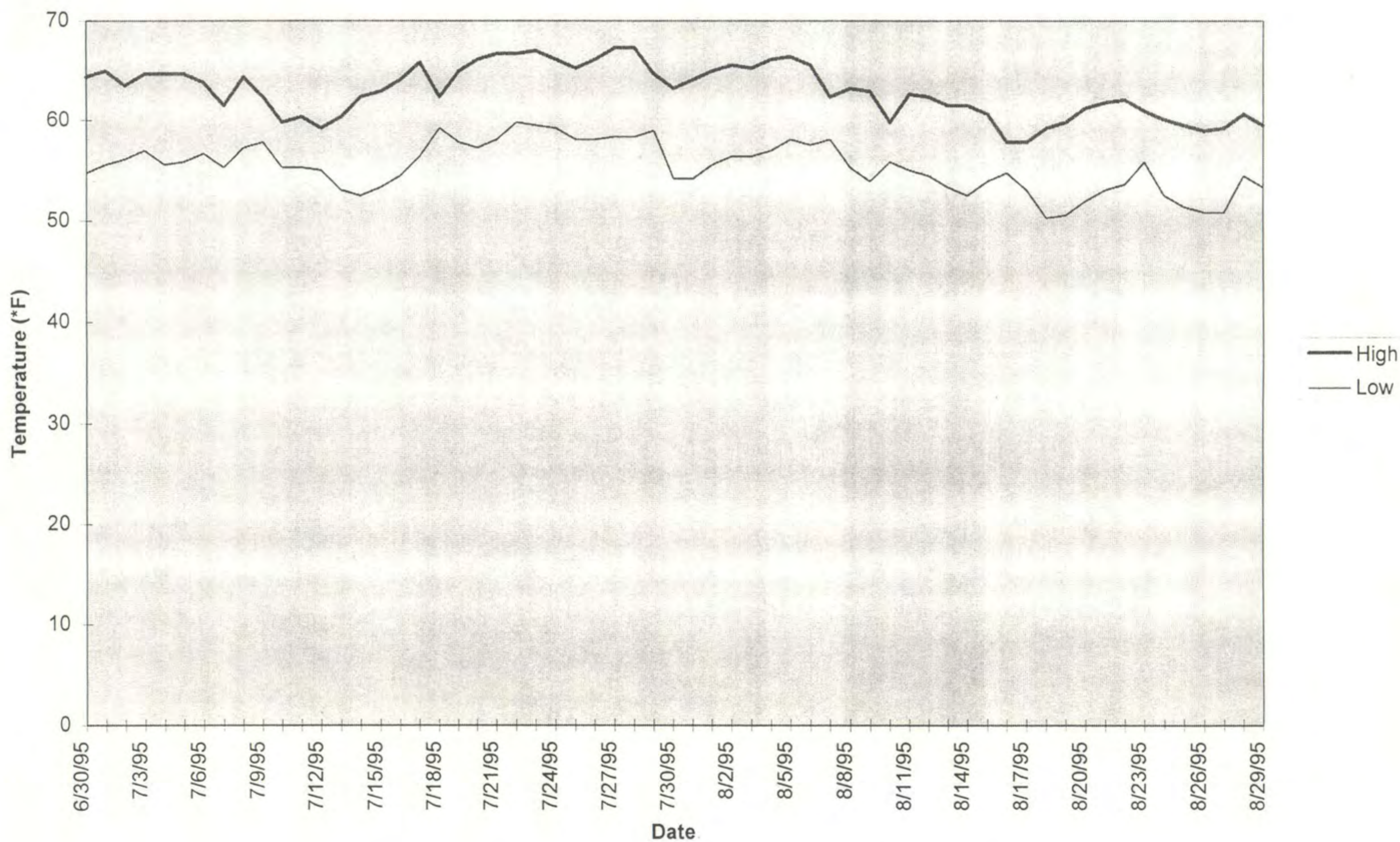
Lower Cow Creek



Lower Cow Creek		
Date	High (*F)	Low (*F)
6/9/95	60.93	
6/10/95	56.41	52.22
6/11/95	60.93	49.72
6/12/95	58.09	48.6
6/13/95	53.9	48.6
6/14/95	53.62	50
6/15/95	54.74	49.16
6/16/95	52.78	49.72
6/17/95	55.3	49.16
6/18/95	53.9	49.16
6/19/95	53.62	48.04
6/20/95	53.9	48.6
6/21/95	60.93	48.04
6/22/95	63.22	50
6/23/95	65.25	51.11
6/24/95	67.28	53.06
6/25/95	67.86	53.9
6/26/95	67.86	54.18
6/27/95	68.44	53.62
6/28/95	69.33	55.3
6/29/95	69.92	55.58
6/30/95	70.82	56.69
7/1/95	71.42	57.25
7/2/95	69.33	58.37
7/3/95	69.33	58.09
7/4/95	70.82	56.69
7/5/95	71.12	57.25
7/6/95	68.44	58.09
7/7/95	66.7	56.97
7/8/95	69.92	58.65
7/9/95	64.09	58.37
7/10/95	62.65	55.02
7/11/95	64.09	55.86
7/12/95	62.65	55.86
7/13/95	65.54	53.62
7/14/95	68.44	53.34
7/15/95	69.62	54.46
7/16/95	71.72	56.13
7/17/95	74.13	58.65
7/18/95	67.86	62.07
7/19/95	70.82	60.07
7/20/95	73.52	58.65
7/21/95	74.44	60.36
7/22/95	74.44	62.07
7/23/95	74.75	61.79
7/24/95	73.22	61.5
7/25/95	71.12	59.79

Lower Cow Creek		
Date	High (*F)	Low (*F)
7/26/95	73.52	60.07
7/27/95	75.37	60.07
7/28/95	75.37	60.93
7/29/95	70.52	60.93
7/30/95	69.92	54.46
7/31/95	71.72	55.02
8/1/95	73.22	57.25
8/2/95	73.83	58.37
8/3/95	73.22	58.37
8/4/95	74.75	58.94
8/5/95	74.75	60.36
8/6/95	73.52	59.22
8/7/95	67.57	61.21
8/8/95	69.62	55.58
8/9/95	69.92	54.46
8/10/95	64.09	57.25
8/11/95	69.03	56.13
8/12/95	69.62	55.86
8/13/95	68.44	53.9
8/14/95	69.03	53.62
8/15/95	66.7	55.3
8/16/95	62.36	56.69
8/17/95	61.21	53.9
8/18/95	65.54	50.28
8/19/95	66.99	51.11
8/20/95	69.03	53.06
8/21/95	69.62	55.02
8/22/95	69.92	55.3
8/23/95	66.12	57.53
8/24/95	66.12	53.62
8/25/95	65.83	52.22
8/26/95	65.25	51.94
8/27/95	65.25	51.94
8/28/95	66.7	56.41
8/29/95	65.83	55.02

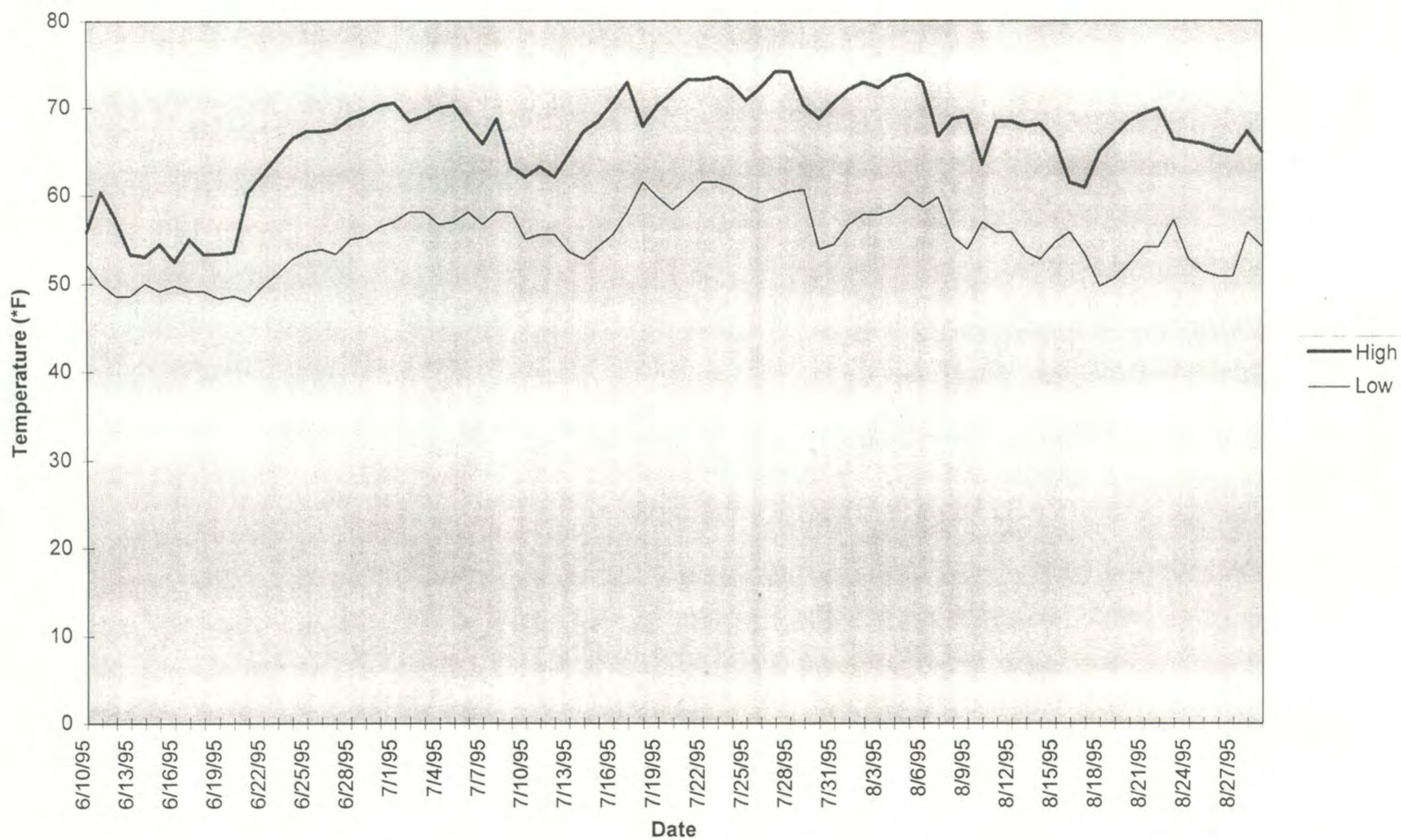
Snow Creek at Mouth



Snow Creek at Mouth		
Date	High (*F)	Low (*F)
6/29/95	63.8	
6/30/95	64.38	54.74
7/1/95	64.96	55.58
7/2/95	63.51	56.13
7/3/95	64.67	56.97
7/4/95	64.67	55.58
7/5/95	64.67	55.86
7/6/95	63.8	56.69
7/7/95	61.5	55.3
7/8/95	64.38	57.25
7/9/95	62.36	57.81
7/10/95	59.79	55.3
7/11/95	60.36	55.3
7/12/95	59.22	55.02
7/13/95	60.36	53.06
7/14/95	62.36	52.5
7/15/95	62.93	53.34
7/16/95	64.09	54.46
7/17/95	65.83	56.41
7/18/95	62.36	59.22
7/19/95	64.96	57.81
7/20/95	66.12	57.25
7/21/95	66.7	58.09
7/22/95	66.7	59.79
7/23/95	66.99	59.5
7/24/95	66.12	59.22
7/25/95	65.25	58.09
7/26/95	66.12	58.09
7/27/95	67.28	58.37
7/28/95	67.28	58.37
7/29/95	64.67	58.94
7/30/95	63.22	54.18
7/31/95	64.09	54.18
8/1/95	64.96	55.58
8/2/95	65.54	56.41
8/3/95	65.25	56.41
8/4/95	66.12	56.97
8/5/95	66.41	58.09
8/6/95	65.54	57.53
8/7/95	62.36	58.09
8/8/95	63.22	55.3
8/9/95	62.93	53.9
8/10/95	59.79	55.86
8/11/95	62.65	55.02
8/12/95	62.36	54.46
8/13/95	61.5	53.34
8/14/95	61.5	52.5

Snow Creek at Mouth		
Date	High (*F)	Low (*F)
8/15/95	60.64	53.9
8/16/95	57.81	54.74
8/17/95	57.81	53.06
8/18/95	59.22	50.28
8/19/95	59.79	50.56
8/20/95	61.21	51.94
8/21/95	61.79	53.06
8/22/95	62.07	53.62
8/23/95	60.93	55.86
8/24/95	60.07	52.5
8/25/95	59.5	51.39
8/26/95	58.94	50.84
8/27/95	59.22	50.84
8/28/95	60.64	54.46
8/29/95	59.5	53.34

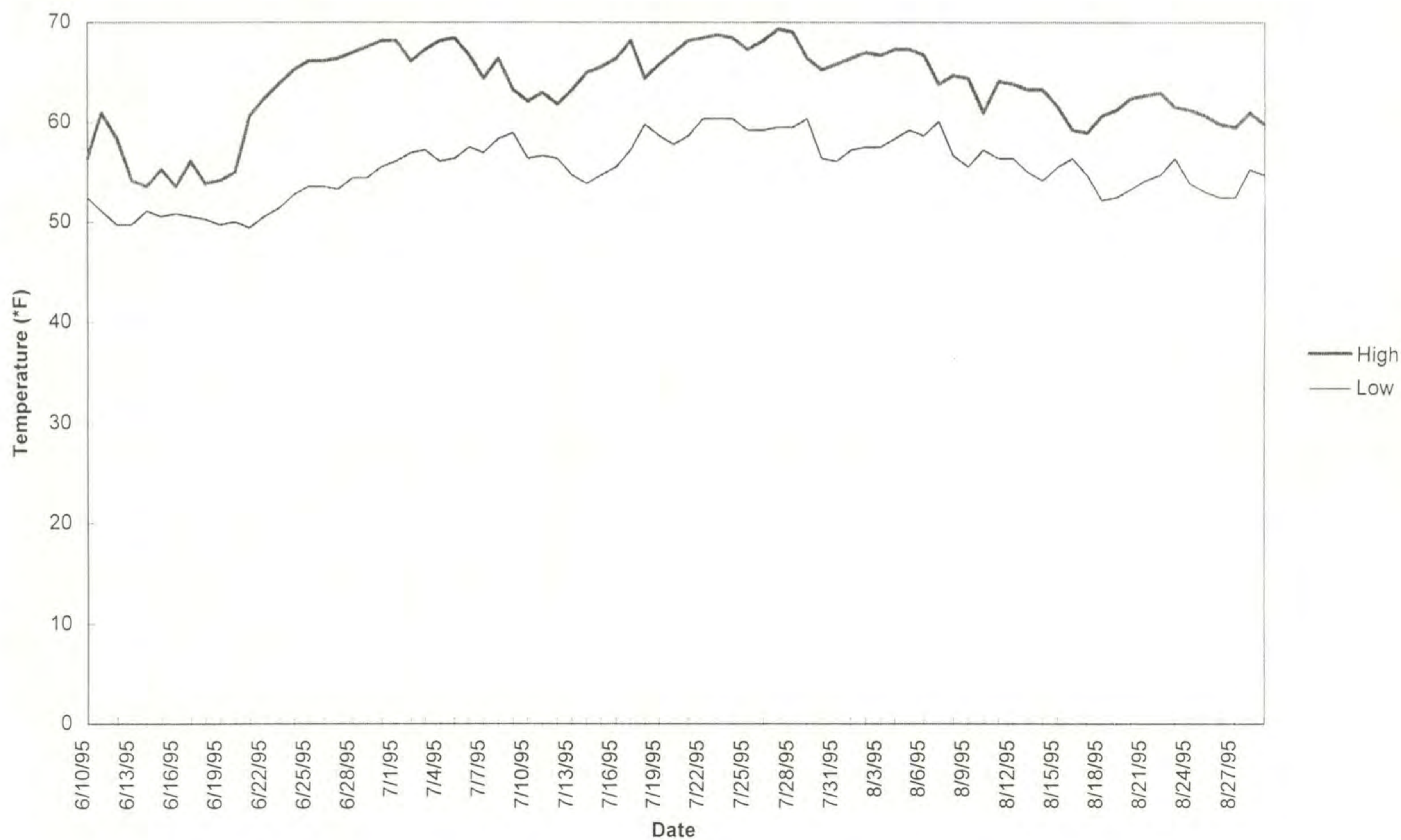
Cow Creek above French Creek



Cow Creek above French Creek Daily High and Low Temperature		
Date	High (*F)	Low (*F)
6/9/95	60.07	
6/10/95	55.86	52.22
6/11/95	60.36	50
6/12/95	57.25	48.6
6/13/95	53.34	48.6
6/14/95	53.06	50
6/15/95	54.46	49.16
6/16/95	52.5	49.72
6/17/95	55.02	49.16
6/18/95	53.34	49.16
6/19/95	53.34	48.32
6/20/95	53.62	48.6
6/21/95	60.36	48.04
6/22/95	62.36	49.72
6/23/95	64.38	51.11
6/24/95	66.41	52.78
6/25/95	67.28	53.62
6/26/95	67.28	53.9
6/27/95	67.57	53.34
6/28/95	68.73	55.02
6/29/95	69.33	55.3
6/30/95	70.22	56.41
7/1/95	70.52	56.97
7/2/95	68.44	58.09
7/3/95	69.03	58.09
7/4/95	69.92	56.69
7/5/95	70.22	56.97
7/6/95	67.86	58.09
7/7/95	65.83	56.69
7/8/95	68.73	58.09
7/9/95	63.22	58.09
7/10/95	62.07	55.02
7/11/95	63.22	55.58
7/12/95	62.07	55.58
7/13/95	64.67	53.62
7/14/95	67.28	52.78
7/15/95	68.44	54.18
7/16/95	70.52	55.58
7/17/95	72.92	58.09
7/18/95	67.86	61.5
7/19/95	70.22	59.79
7/20/95	71.72	58.37
7/21/95	73.22	59.79
7/22/95	73.22	61.5
7/23/95	73.52	61.5
7/24/95	72.62	60.93

Cow Creek above French Creek Daily High and Low Temperature		
Date	High (*F)	Low (*F)
7/25/95	70.82	59.79
7/26/95	72.32	59.22
7/27/95	74.13	59.79
7/28/95	74.13	60.36
7/29/95	70.22	60.64
7/30/95	68.73	53.9
7/31/95	70.52	54.46
8/1/95	72.02	56.69
8/2/95	72.92	57.81
8/3/95	72.32	57.81
8/4/95	73.52	58.37
8/5/95	73.83	59.79
8/6/95	72.92	58.65
8/7/95	66.7	59.79
8/8/95	68.73	55.3
8/9/95	69.03	53.9
8/10/95	63.51	56.97
8/11/95	68.44	55.86
8/12/95	68.44	55.86
8/13/95	67.86	53.62
8/14/95	68.15	52.78
8/15/95	66.12	54.74
8/16/95	61.5	55.86
8/17/95	60.93	53.34
8/18/95	64.96	49.72
8/19/95	66.7	50.56
8/20/95	68.44	52.22
8/21/95	69.33	54.18
8/22/95	69.92	54.18
8/23/95	66.41	57.25
8/24/95	66.12	52.78
8/25/95	65.83	51.39
8/26/95	65.25	50.84
8/27/95	64.96	50.84
8/28/95	67.28	55.86
8/29/95	64.96	54.18

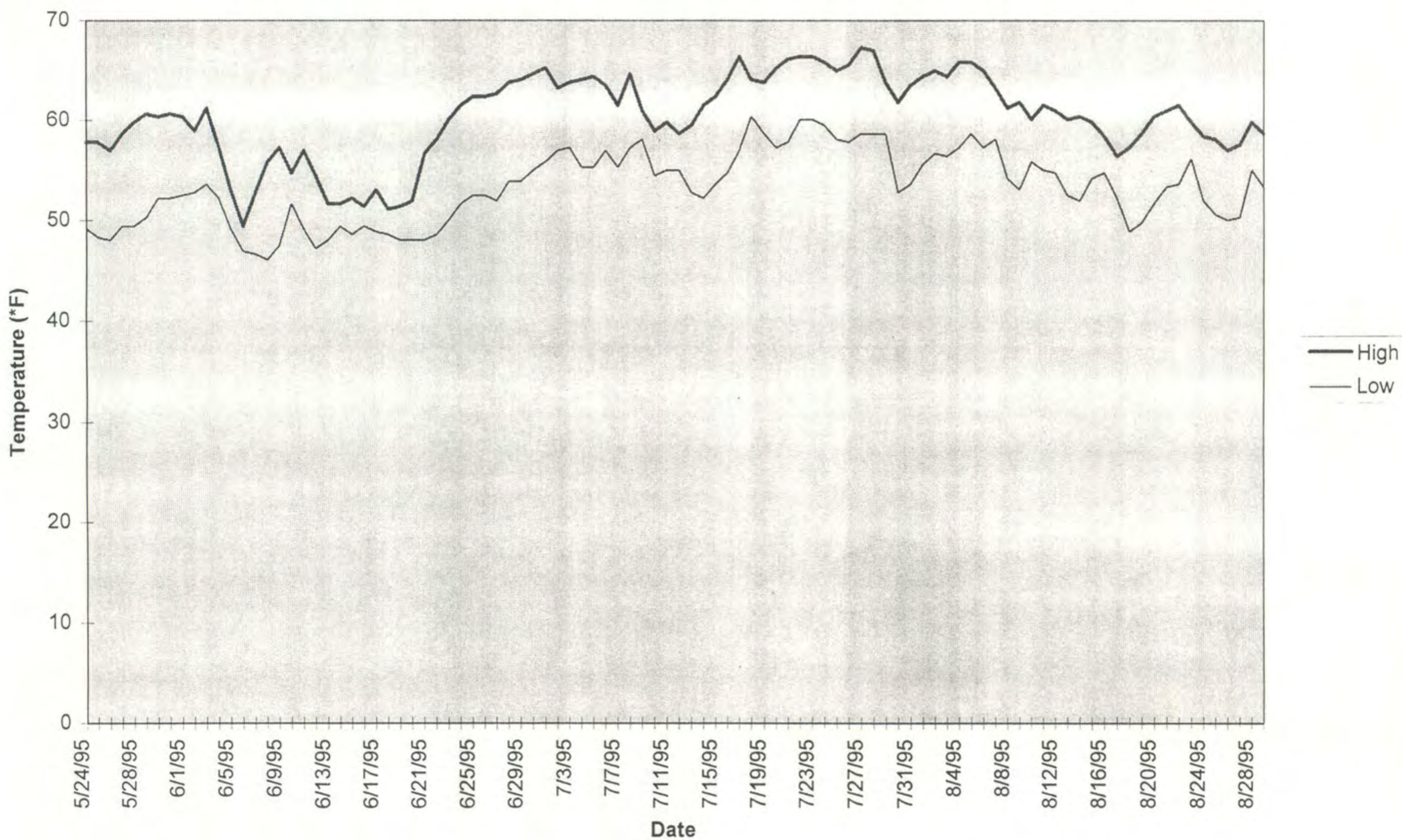
Dismal Creek at Mouth



Dismal Creek at Mouth		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
6/9/95	60.93	
6/10/95	56.41	52.5
6/11/95	60.93	51.11
6/12/95	58.37	49.72
6/13/95	54.18	49.72
6/14/95	53.62	51.11
6/15/95	55.3	50.56
6/16/95	53.62	50.84
6/17/95	56.13	50.56
6/18/95	53.9	50.28
6/19/95	54.18	49.72
6/20/95	55.02	50
6/21/95	60.64	49.44
6/22/95	62.36	50.56
6/23/95	63.8	51.39
6/24/95	65.25	52.78
6/25/95	66.12	53.62
6/26/95	66.12	53.62
6/27/95	66.41	53.34
6/28/95	66.99	54.46
6/29/95	67.57	54.46
6/30/95	68.15	55.58
7/1/95	68.15	56.13
7/2/95	66.12	56.97
7/3/95	67.28	57.25
7/4/95	68.15	56.13
7/5/95	68.44	56.41
7/6/95	66.7	57.53
7/7/95	64.38	56.97
7/8/95	66.41	58.37
7/9/95	63.22	58.94
7/10/95	62.07	56.41
7/11/95	62.93	56.69
7/12/95	61.79	56.41
7/13/95	63.22	54.74
7/14/95	64.96	53.9
7/15/95	65.54	54.74
7/16/95	66.41	55.58
7/17/95	68.15	57.25
7/18/95	64.38	59.79
7/19/95	65.83	58.65
7/20/95	66.99	57.81
7/21/95	68.15	58.65
7/22/95	68.44	60.36
7/23/95	68.73	60.36
7/24/95	68.44	60.36

Dismal Creek at Mouth Daily High and Low Temperature		
Date	High (*F)	Low (*F)
7/25/95	67.28	59.22
7/26/95	68.15	59.22
7/27/95	69.33	59.5
7/28/95	69.03	59.5
7/29/95	66.41	60.36
7/30/95	65.25	56.41
7/31/95	65.83	56.13
8/1/95	66.41	57.25
8/2/95	66.99	57.53
8/3/95	66.7	57.53
8/4/95	67.28	58.37
8/5/95	67.28	59.22
8/6/95	66.7	58.65
8/7/95	63.8	60.07
8/8/95	64.67	56.69
8/9/95	64.38	55.58
8/10/95	60.93	57.25
8/11/95	64.09	56.41
8/12/95	63.8	56.41
8/13/95	63.22	55.02
8/14/95	63.22	54.18
8/15/95	61.5	55.58
8/16/95	59.22	56.41
8/17/95	58.94	54.74
8/18/95	60.64	52.22
8/19/95	61.21	52.5
8/20/95	62.36	53.34
8/21/95	62.65	54.18
8/22/95	62.93	54.74
8/23/95	61.5	56.41
8/24/95	61.21	53.9
8/25/95	60.64	53.06
8/26/95	59.79	52.5
8/27/95	59.5	52.5
8/28/95	60.93	55.3
8/29/95	59.79	54.74

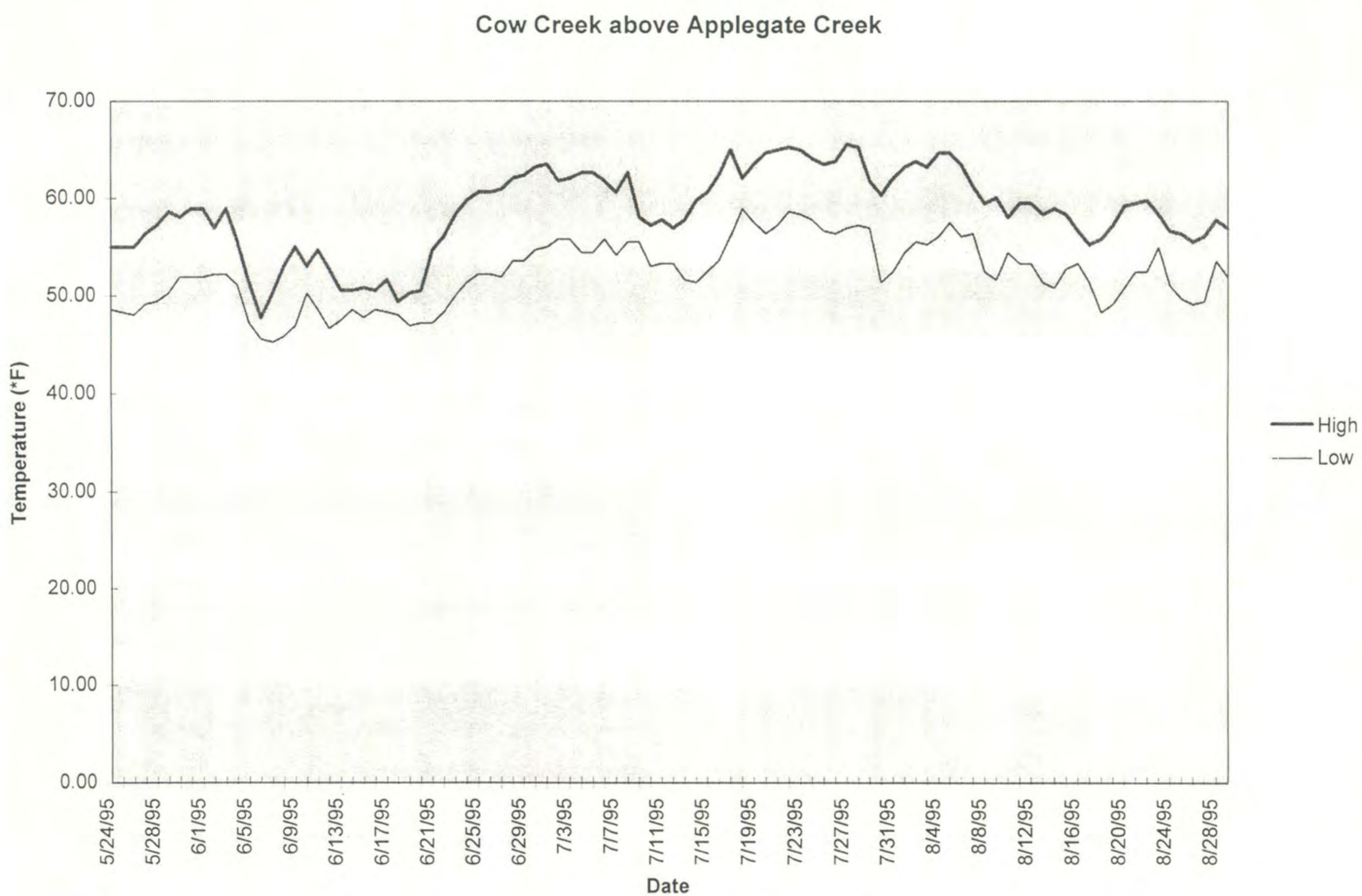
Applegate Creek at Mouth



Applegate Creek at Mouth Daily High and Low Temperature		
Date	High (*F)	Low (*F)
5/23/95	56.97	
5/24/95	57.81	49.16
5/25/95	57.81	48.32
5/26/95	56.97	48.04
5/27/95	58.65	49.44
5/28/95	59.79	49.44
5/29/95	60.64	50.28
5/30/95	60.36	52.22
5/31/95	60.64	52.22
6/1/95	60.36	52.5
6/2/95	58.94	52.78
6/3/95	61.21	53.62
6/4/95	57.25	52.22
6/5/95	53.06	49.16
6/6/95	49.44	46.93
6/7/95	52.78	46.65
6/8/95	55.86	46.1
6/9/95	57.25	47.48
6/10/95	54.74	51.67
6/11/95	56.97	49.16
6/12/95	54.46	47.21
6/13/95	51.67	48.04
6/14/95	51.67	49.44
6/15/95	52.22	48.6
6/16/95	51.39	49.44
6/17/95	53.06	48.88
6/18/95	51.11	48.6
6/19/95	51.39	48.04
6/20/95	51.94	48.04
6/21/95	56.69	48.04
6/22/95	58.09	48.6
6/23/95	60.07	50
6/24/95	61.5	51.67
6/25/95	62.36	52.5
6/26/95	62.36	52.5
6/27/95	62.65	51.94
6/28/95	63.8	53.9
6/29/95	64.09	53.9
6/30/95	64.67	55.02
7/1/95	65.25	55.86
7/2/95	63.22	56.97
7/3/95	63.8	57.25
7/4/95	64.09	55.3
7/5/95	64.38	55.3
7/6/95	63.51	56.97
7/7/95	61.5	55.3

Applegate Creek at Mouth		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
7/8/95	64.67	57.25
7/9/95	60.93	58.09
7/10/95	58.94	54.46
7/11/95	59.79	55.02
7/12/95	58.65	55.02
7/13/95	59.5	52.78
7/14/95	61.5	52.22
7/15/95	62.36	53.62
7/16/95	64.09	54.74
7/17/95	66.41	56.97
7/18/95	64.09	60.36
7/19/95	63.8	58.65
7/20/95	65.25	57.25
7/21/95	66.12	57.81
7/22/95	66.41	60.07
7/23/95	66.41	60.07
7/24/95	65.83	59.5
7/25/95	64.96	58.09
7/26/95	65.54	57.81
7/27/95	67.28	58.65
7/28/95	66.99	58.65
7/29/95	63.8	58.65
7/30/95	61.79	52.78
7/31/95	63.51	53.62
8/1/95	64.38	55.58
8/2/95	64.96	56.69
8/3/95	64.38	56.41
8/4/95	65.83	57.25
8/5/95	65.83	58.65
8/6/95	64.96	57.25
8/7/95	63.22	58.09
8/8/95	61.21	54.18
8/9/95	61.79	53.06
8/10/95	60.07	55.86
8/11/95	61.5	55.02
8/12/95	60.93	54.74
8/13/95	60.07	52.5
8/14/95	60.36	51.94
8/15/95	59.79	54.18
8/16/95	58.37	54.74
8/17/95	56.41	52.22
8/18/95	57.25	48.88
8/19/95	58.65	49.72
8/20/95	60.36	51.67
8/21/95	60.93	53.34
8/22/95	61.5	53.62

Applegate Creek at Mouth		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
8/23/95	59.79	56.13
8/24/95	58.37	51.94
8/25/95	58.09	50.56
8/26/95	56.97	50
8/27/95	57.53	50.28
8/28/95	59.79	55.02
8/29/95	58.65	53.34

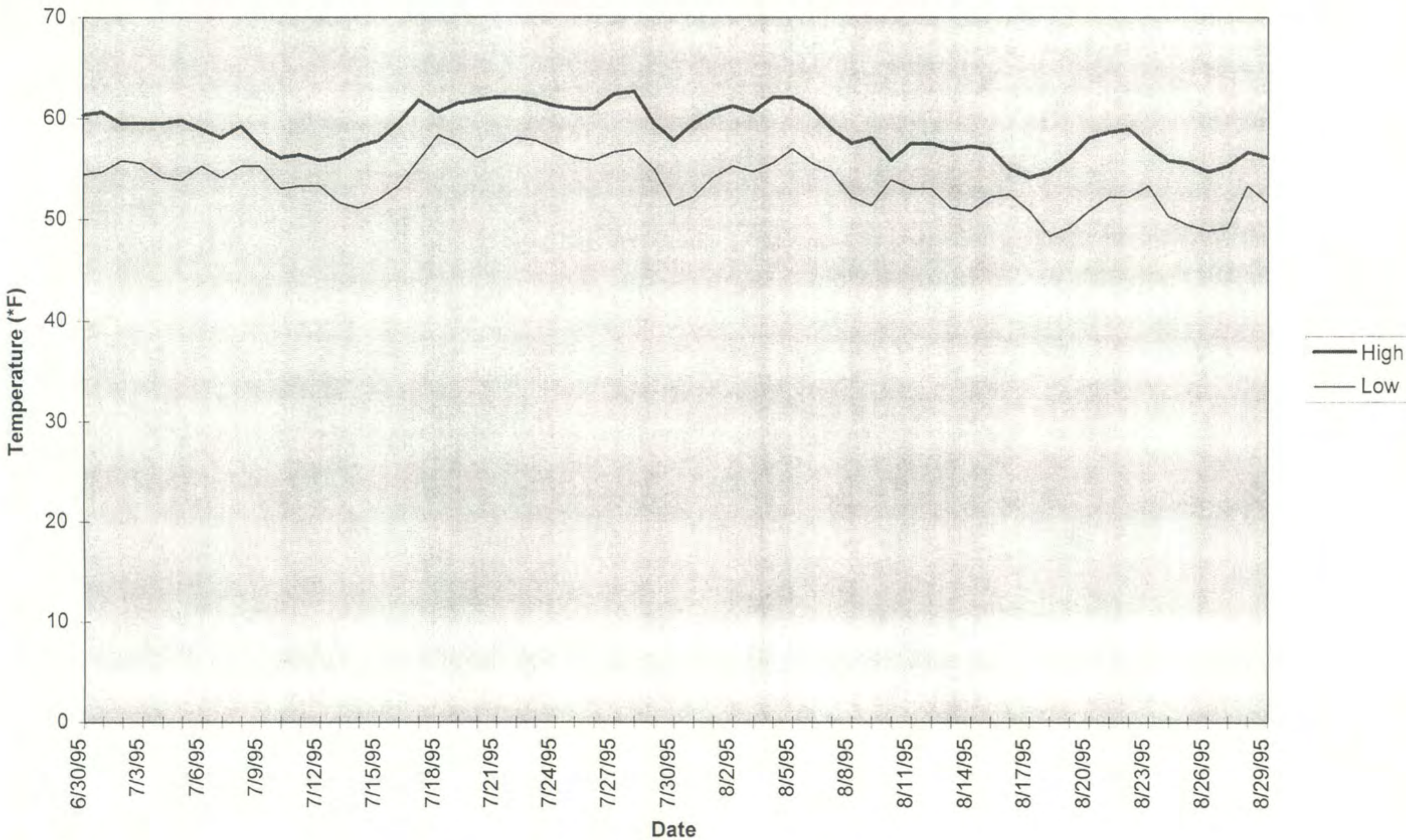

Cow Creek above Applegate Creek
Temperature (*F)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
5/24/95
5/28/95
6/1/95
6/5/95
6/9/95
6/13/95
6/17/95
6/21/95
6/25/95
6/29/95
7/3/95
7/7/95
7/11/95
7/15/95
7/19/95
7/23/95
7/27/95
7/31/95
8/4/95
8/8/95
8/12/95
8/16/95
8/20/95
8/24/95
8/28/95
Date
High
Low

Cow Creek above Applegate Creek Daily High and Low Temperature		
Date	High (*F)	Low (*F)
5/23/95	54.46	
5/24/95	55.02	48.6
5/25/95	55.02	48.32
5/26/95	55.02	48.04
5/27/95	56.41	49.16
5/28/95	57.25	49.44
5/29/95	58.65	50.28
5/30/95	58.09	51.94
5/31/95	58.94	51.94
6/1/95	58.94	51.94
6/2/95	56.97	52.22
6/3/95	58.94	52.22
6/4/95	55.58	51.11
6/5/95	51.39	47.21
6/6/95	47.76	45.54
6/7/95	50.28	45.26
6/8/95	53.06	45.82
6/9/95	55.02	46.93
6/10/95	53.06	50.28
6/11/95	54.74	48.6
6/12/95	52.78	46.65
6/13/95	50.56	47.48
6/14/95	50.56	48.6
6/15/95	50.84	47.76
6/16/95	50.56	48.6
6/17/95	51.67	48.32
6/18/95	49.44	48.04
6/19/95	50.28	46.93
6/20/95	50.56	47.21
6/21/95	54.74	47.21
6/22/95	56.13	48.32
6/23/95	58.37	50
6/24/95	59.79	51.39
6/25/95	60.64	52.22
6/26/95	60.64	52.22
6/27/95	60.93	51.94
6/28/95	62.07	53.62
6/29/95	62.36	53.62
6/30/95	63.22	54.74
7/1/95	63.51	55.02
7/2/95	61.79	55.86
7/3/95	62.07	55.86
7/4/95	62.65	54.46
7/5/95	62.65	54.46
7/6/95	61.79	55.86
7/7/95	60.64	54.18

Cow Creek above Applegate Creek		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
7/8/95	62.65	55.58
7/9/95	58.09	55.58
7/10/95	57.25	53.06
7/11/95	57.81	53.34
7/12/95	56.97	53.34
7/13/95	57.81	51.67
7/14/95	59.79	51.39
7/15/95	60.64	52.5
7/16/95	62.36	53.62
7/17/95	64.96	56.13
7/18/95	62.07	58.94
7/19/95	63.51	57.53
7/20/95	64.67	56.41
7/21/95	64.96	57.25
7/22/95	65.25	58.65
7/23/95	64.96	58.37
7/24/95	64.09	57.81
7/25/95	63.51	56.69
7/26/95	63.80	56.41
7/27/95	65.54	56.97
7/28/95	65.25	57.25
7/29/95	61.79	56.97
7/30/95	60.36	51.39
7/31/95	62.07	52.5
8/1/95	63.22	54.46
8/2/95	63.80	55.58
8/3/95	63.22	55.3
8/4/95	64.67	56.13
8/5/95	64.67	57.53
8/6/95	63.51	56.13
8/7/95	61.21	56.41
8/8/95	59.50	52.5
8/9/95	60.07	51.67
8/10/95	58.09	54.46
8/11/95	59.50	53.34
8/12/95	59.50	53.34
8/13/95	58.37	51.39
8/14/95	58.94	50.84
8/15/95	58.37	52.78
8/16/95	56.69	53.34
8/17/95	55.30	51.39
8/18/95	55.86	48.32
8/19/95	57.25	49.16
8/20/95	59.22	50.84
8/21/95	59.50	52.5
8/22/95	59.79	52.5

Cow Creek above Applegate Creek		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
8/23/95	58.37	55.02
8/24/95	56.69	51.11
8/25/95	56.41	49.72
8/26/95	55.58	49.16
8/27/95	56.13	49.44
8/28/95	57.81	53.62
8/29/95	56.97	51.94
8/30/95		53.34

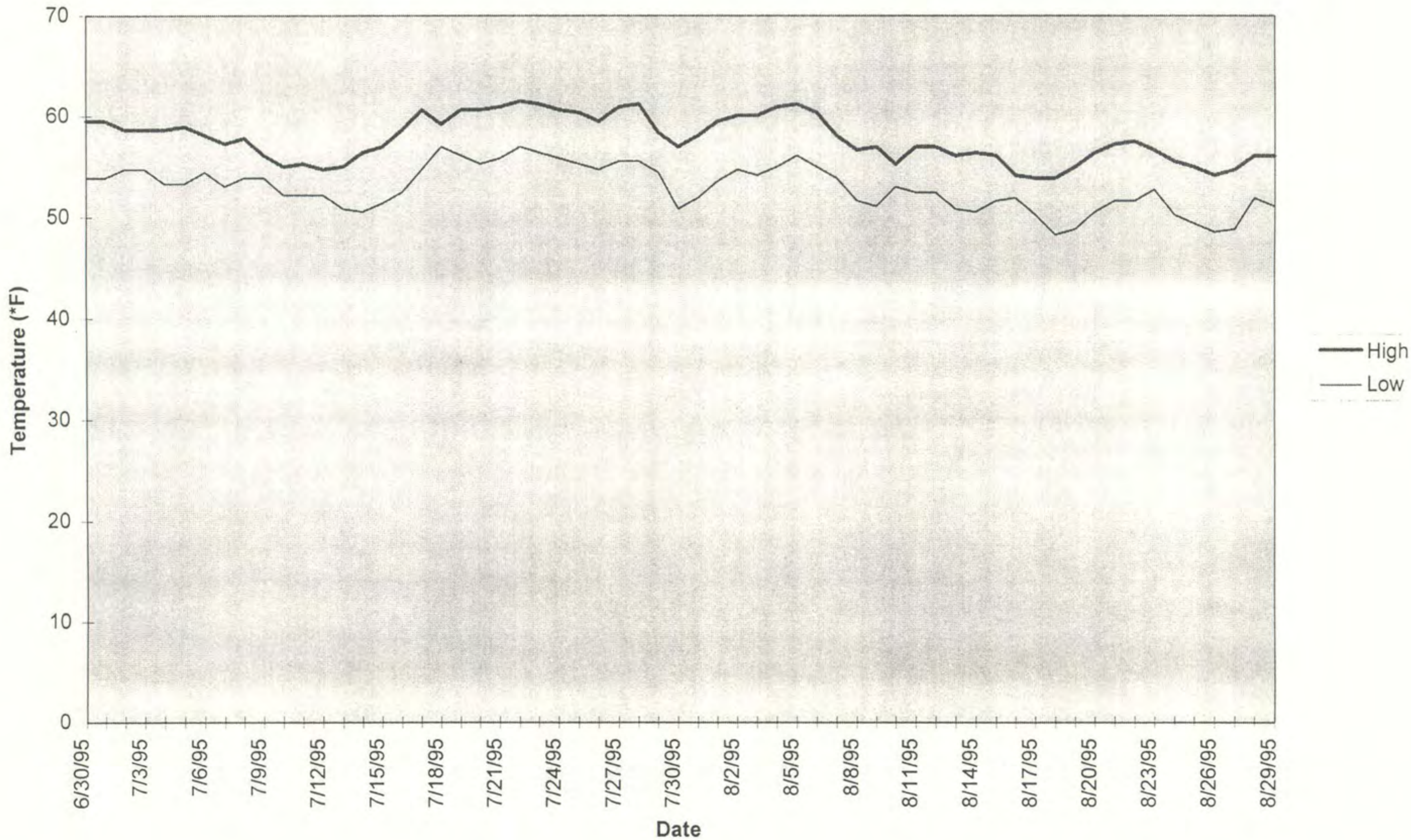
Beaver Creek at Mouth



Beaver Creek at Mouth Daily High and Low Temperature		
Date	High (*F)	Low (*F)
6/29/95	59.5	
6/30/95	60.36	54.46
7/1/95	60.64	54.74
7/2/95	59.5	55.86
7/3/95	59.5	55.58
7/4/95	59.5	54.18
7/5/95	59.79	53.9
7/6/95	58.94	55.3
7/7/95	58.09	54.18
7/8/95	59.22	55.3
7/9/95	57.25	55.3
7/10/95	56.13	53.06
7/11/95	56.41	53.34
7/12/95	55.86	53.34
7/13/95	56.13	51.67
7/14/95	57.25	51.11
7/15/95	57.81	51.94
7/16/95	59.5	53.34
7/17/95	61.79	55.86
7/18/95	60.64	58.37
7/19/95	61.5	57.53
7/20/95	61.79	56.13
7/21/95	62.07	56.97
7/22/95	62.07	58.09
7/23/95	61.79	57.81
7/24/95	61.21	56.97
7/25/95	60.93	56.13
7/26/95	60.93	55.86
7/27/95	62.36	56.69
7/28/95	62.65	56.97
7/29/95	59.5	55.02
7/30/95	57.81	51.39
7/31/95	59.5	52.22
8/1/95	60.64	54.18
8/2/95	61.21	55.3
8/3/95	60.64	54.74
8/4/95	62.07	55.58
8/5/95	62.07	56.97
8/6/95	60.93	55.58
8/7/95	58.94	54.74
8/8/95	57.53	52.22
8/9/95	58.09	51.39
8/10/95	55.86	53.9
8/11/95	57.53	53.06
8/12/95	57.53	53.06
8/13/95	56.97	51.11

Beaver Creek at Mouth		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
8/14/95	57.25	50.84
8/15/95	56.97	52.22
8/16/95	55.02	52.5
8/17/95	54.18	50.84
8/18/95	54.74	48.32
8/19/95	56.13	49.16
8/20/95	58.09	50.84
8/21/95	58.65	52.22
8/22/95	58.94	52.22
8/23/95	57.25	53.34
8/24/95	55.86	50.28
8/25/95	55.58	49.44
8/26/95	54.74	48.88
8/27/95	55.3	49.16
8/28/95	56.69	53.34
8/29/95	56.13	51.67
8/30/95		52.5

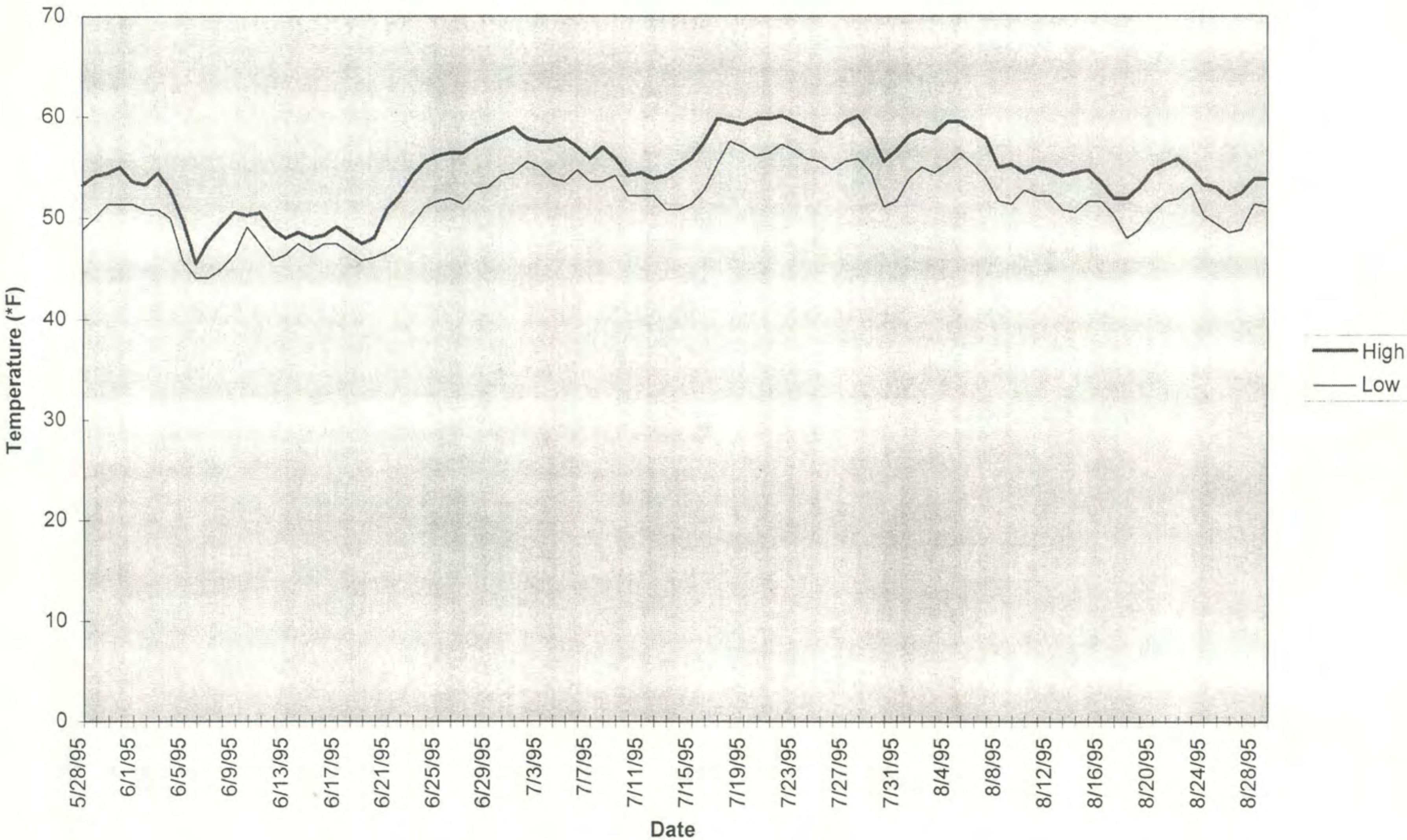
Cow Creek above Beaver Creek



Cow Creek above Beaver Creek		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
6/29/95	58.65	
6/30/95	59.5	53.9
7/1/95	59.5	53.9
7/2/95	58.65	54.74
7/3/95	58.65	54.74
7/4/95	58.65	53.34
7/5/95	58.94	53.34
7/6/95	58.09	54.46
7/7/95	57.25	53.06
7/8/95	57.81	53.9
7/9/95	56.13	53.9
7/10/95	55.02	52.22
7/11/95	55.3	52.22
7/12/95	54.74	52.22
7/13/95	55.02	50.84
7/14/95	56.41	50.56
7/15/95	56.97	51.39
7/16/95	58.65	52.5
7/17/95	60.64	54.74
7/18/95	59.22	56.97
7/19/95	60.64	56.13
7/20/95	60.64	55.3
7/21/95	60.93	55.86
7/22/95	61.5	56.97
7/23/95	61.21	56.41
7/24/95	60.64	55.86
7/25/95	60.36	55.3
7/26/95	59.5	54.74
7/27/95	60.93	55.58
7/28/95	61.21	55.58
7/29/95	58.37	54.46
7/30/95	56.97	50.84
7/31/95	58.09	51.94
8/1/95	59.5	53.62
8/2/95	60.07	54.74
8/3/95	60.07	54.18
8/4/95	60.93	55.02
8/5/95	61.21	56.13
8/6/95	60.36	55.02
8/7/95	58.09	53.9
8/8/95	56.69	51.67
8/9/95	56.97	51.11
8/10/95	55.3	53.06
8/11/95	56.97	52.5
8/12/95	56.97	52.5
8/13/95	56.13	50.84

Cow Creek above Beaver Creek		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
8/14/95	56.41	50.56
8/15/95	56.13	51.67
8/16/95	54.18	51.94
8/17/95	53.9	50.28
8/18/95	53.9	48.32
8/19/95	55.02	48.88
8/20/95	56.41	50.56
8/21/95	57.25	51.67
8/22/95	57.53	51.67
8/23/95	56.69	52.78
8/24/95	55.58	50.28
8/25/95	55.02	49.44
8/26/95	54.18	48.6
8/27/95	54.74	48.88
8/28/95	56.13	51.94
8/29/95	56.13	51.11
8/30/95		51.94

East Fork Cow Creek



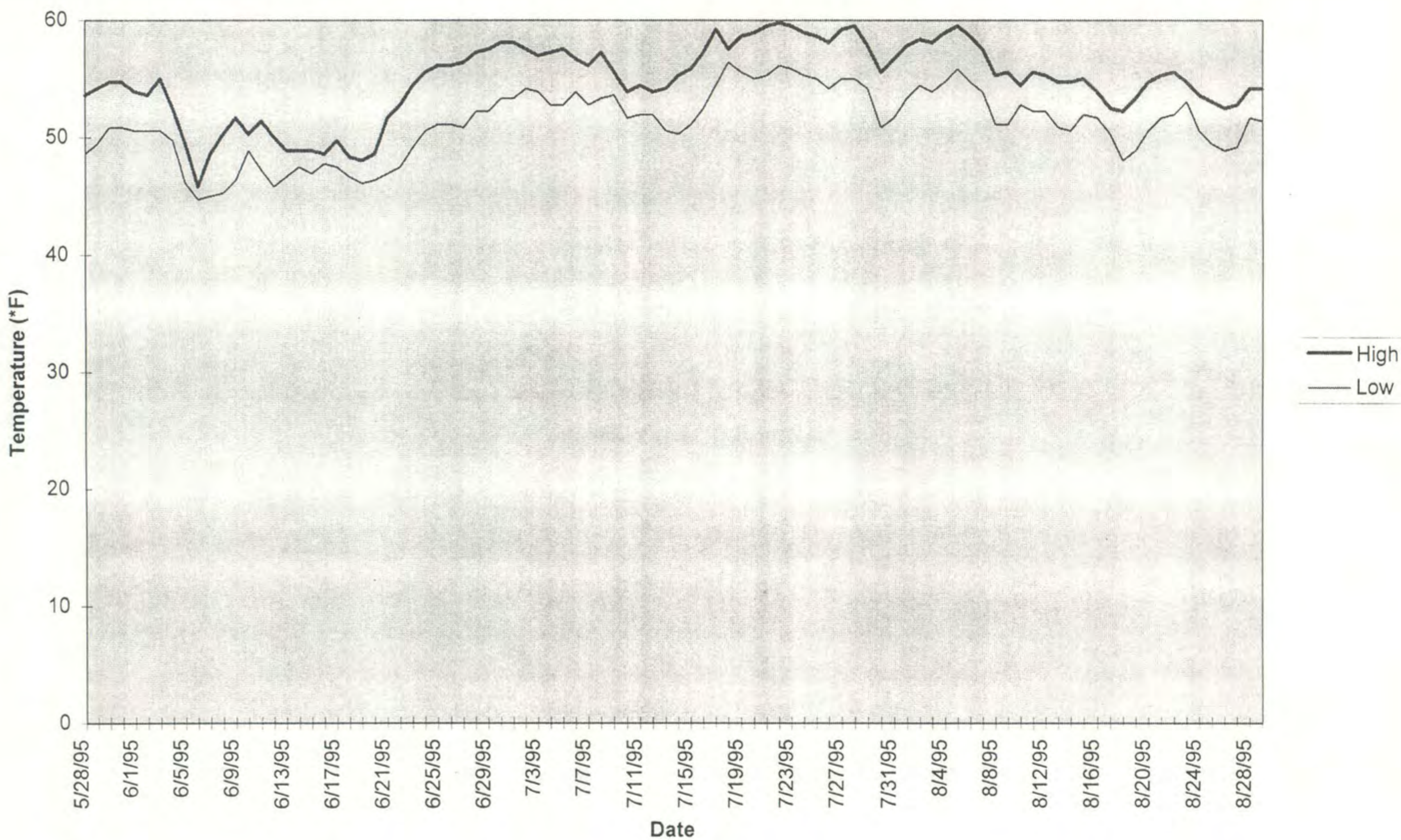
East Fork Cow Creek
Daily High and Low Temperature

Date	High (*F)	Low (*F)
5/27/95	52.5	
5/28/95	53.34	48.88
5/29/95	54.18	50
5/30/95	54.46	51.39
5/31/95	55.02	51.39
6/1/95	53.62	51.39
6/2/95	53.34	50.84
6/3/95	54.46	50.84
6/4/95	52.78	50
6/5/95	49.72	45.82
6/6/95	45.54	44.15
6/7/95	47.76	44.15
6/8/95	49.16	44.99
6/9/95	50.56	46.37
6/10/95	50.28	49.16
6/11/95	50.56	47.48
6/12/95	48.88	45.82
6/13/95	48.04	46.37
6/14/95	48.6	47.48
6/15/95	48.04	46.65
6/16/95	48.32	47.48
6/17/95	49.16	47.48
6/18/95	48.32	46.65
6/19/95	47.48	45.82
6/20/95	48.04	46.1
6/21/95	50.84	46.65
6/22/95	52.22	47.48
6/23/95	54.18	49.44
6/24/95	55.58	51.11
6/25/95	56.13	51.67
6/26/95	56.41	51.94
6/27/95	56.41	51.39
6/28/95	57.25	52.78
6/29/95	57.81	53.06
6/30/95	58.37	54.18
7/1/95	58.94	54.46
7/2/95	57.81	55.58
7/3/95	57.53	55.02
7/4/95	57.53	53.9
7/5/95	57.81	53.62
7/6/95	56.97	54.74
7/7/95	55.86	53.62
7/8/95	56.97	53.62
7/9/95	55.86	54.18
7/10/95	54.18	52.22
7/11/95	54.46	52.22

East Fork Cow Creek		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
7/12/95	53.9	52.22
7/13/95	54.18	50.84
7/14/95	55.02	50.84
7/15/95	55.86	51.39
7/16/95	57.53	52.78
7/17/95	59.79	55.3
7/18/95	59.5	57.53
7/19/95	59.22	56.97
7/20/95	59.79	56.13
7/21/95	59.79	56.41
7/22/95	60.07	57.25
7/23/95	59.5	56.69
7/24/95	58.94	55.86
7/25/95	58.37	55.58
7/26/95	58.37	54.74
7/27/95	59.5	55.58
7/28/95	60.07	55.86
7/29/95	58.37	54.46
7/30/95	55.58	51.11
7/31/95	56.69	51.67
8/1/95	58.09	53.9
8/2/95	58.65	55.02
8/3/95	58.37	54.46
8/4/95	59.5	55.3
8/5/95	59.5	56.41
8/6/95	58.65	55.3
8/7/95	57.81	53.9
8/8/95	55.02	51.67
8/9/95	55.3	51.39
8/10/95	54.46	52.78
8/11/95	55.02	52.22
8/12/95	54.74	52.22
8/13/95	54.18	50.84
8/14/95	54.46	50.56
8/15/95	54.74	51.67
8/16/95	53.62	51.67
8/17/95	51.94	50.28
8/18/95	51.94	48.04
8/19/95	53.06	48.88
8/20/95	54.74	50.56
8/21/95	55.3	51.67
8/22/95	55.86	51.94
8/23/95	54.74	53.06
8/24/95	53.34	50.28
8/25/95	53.06	49.44
8/26/95	51.94	48.6

East Fork Cow Creek		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
8/27/95	52.5	48.88
8/28/95	53.9	51.39
8/29/95	53.9	51.11
8/30/95		51.67

South Fork Cow Creek

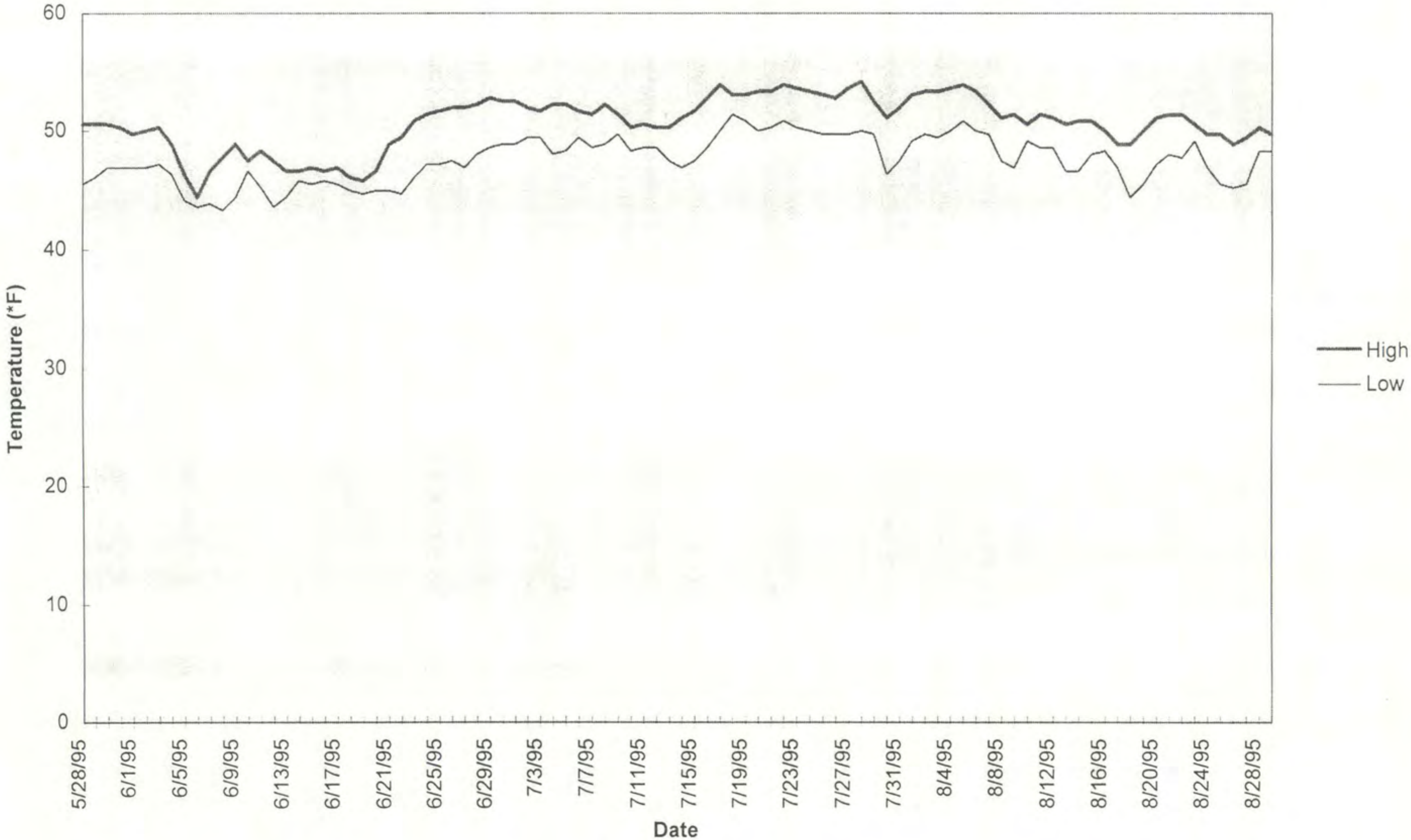


South Fork Cow Creek		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
5/28/95	53.62	48.6
5/29/95	54.18	49.44
5/30/95	54.74	50.84
5/31/95	54.74	50.84
6/1/95	53.9	50.56
6/2/95	53.62	50.56
6/3/95	55.02	50.56
6/4/95	52.5	49.72
6/5/95	49.44	46.1
6/6/95	45.82	44.71
6/7/95	48.6	44.99
6/8/95	50.28	45.26
6/9/95	51.67	46.37
6/10/95	50.28	48.88
6/11/95	51.39	47.21
6/12/95	50	45.82
6/13/95	48.88	46.65
6/14/95	48.88	47.48
6/15/95	48.88	46.93
6/16/95	48.6	47.76
6/17/95	49.72	47.48
6/18/95	48.32	46.65
6/19/95	48.04	46.1
6/20/95	48.6	46.37
6/21/95	51.67	46.93
6/22/95	52.78	47.48
6/23/95	54.46	49.16
6/24/95	55.58	50.56
6/25/95	56.13	51.11
6/26/95	56.13	51.11
6/27/95	56.41	50.84
6/28/95	57.25	52.22
6/29/95	57.53	52.22
6/30/95	58.09	53.34
7/1/95	58.09	53.34
7/2/95	57.53	54.18
7/3/95	56.97	53.9
7/4/95	57.25	52.78
7/5/95	57.53	52.78
7/6/95	56.69	53.9
7/7/95	56.13	52.78
7/8/95	57.25	53.34
7/9/95	55.58	53.62
7/10/95	53.9	51.67
7/11/95	54.46	51.94
7/12/95	53.9	51.94

South Fork Cow Creek Daily High and Low Temperature		
Date	High (*F)	Low (*F)
7/13/95	54.18	50.56
7/14/95	55.3	50.28
7/15/95	55.86	51.11
7/16/95	57.25	52.5
7/17/95	59.22	54.46
7/18/95	57.53	56.41
7/19/95	58.65	55.58
7/20/95	58.94	55.02
7/21/95	59.5	55.3
7/22/95	59.79	56.13
7/23/95	59.5	55.86
7/24/95	58.94	55.3
7/25/95	58.65	55.02
7/26/95	58.09	54.18
7/27/95	59.22	55.02
7/28/95	59.5	55.02
7/29/95	57.81	54.18
7/30/95	55.58	50.84
7/31/95	56.69	51.67
8/1/95	57.81	53.34
8/2/95	58.37	54.46
8/3/95	58.09	53.9
8/4/95	58.94	54.74
8/5/95	59.5	55.86
8/6/95	58.65	54.74
8/7/95	57.53	53.9
8/8/95	55.3	51.11
8/9/95	55.58	51.11
8/10/95	54.46	52.78
8/11/95	55.58	52.22
8/12/95	55.3	52.22
8/13/95	54.74	50.84
8/14/95	54.74	50.56
8/15/95	55.02	51.94
8/16/95	53.9	51.67
8/17/95	52.5	50.28
8/18/95	52.22	48.04
8/19/95	53.34	48.88
8/20/95	54.74	50.56
8/21/95	55.3	51.67
8/22/95	55.58	51.94
8/23/95	54.74	53.06
8/24/95	53.62	50.56
8/25/95	53.06	49.44
8/26/95	52.5	48.88
8/27/95	52.78	49.16

South Fork Cow Creek		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
8/28/95	54.18	51.67
8/29/95	54.18	51.39
8/30/95		51.67

Tributary to Upper SF Cow Creek

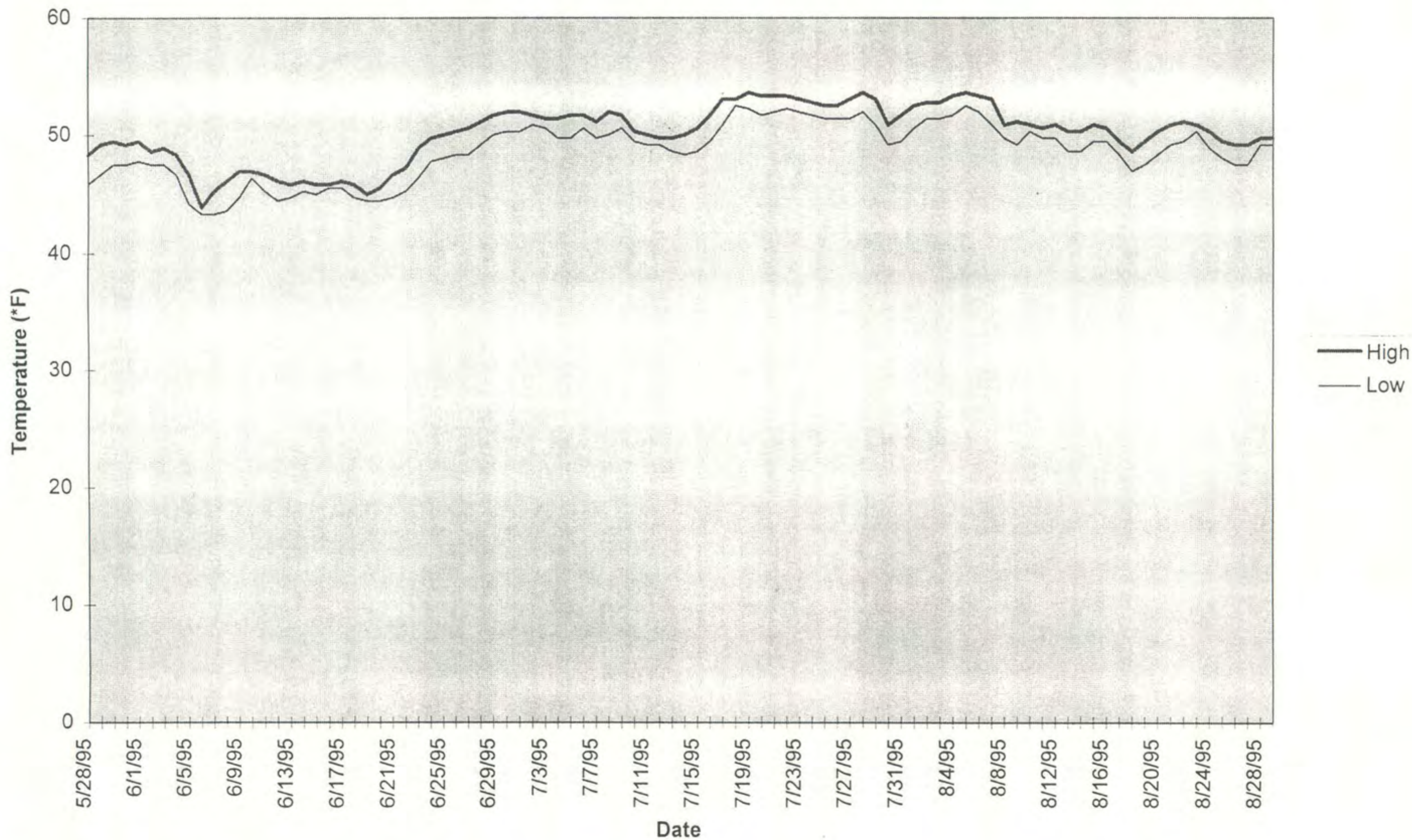


Tributary to Upper SF Cow Creek		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
5/27/95	50.28	
5/28/95	50.56	45.54
5/29/95	50.56	46.1
5/30/95	50.56	46.93
5/31/95	50.28	46.93
6/1/95	49.72	46.93
6/2/95	50	46.93
6/3/95	50.28	47.21
6/4/95	48.88	46.37
6/5/95	46.37	44.15
6/6/95	44.43	43.59
6/7/95	46.65	43.87
6/8/95	47.76	43.31
6/9/95	48.88	44.43
6/10/95	47.48	46.65
6/11/95	48.32	45.26
6/12/95	47.48	43.59
6/13/95	46.65	44.43
6/14/95	46.65	45.82
6/15/95	46.93	45.54
6/16/95	46.65	45.82
6/17/95	46.93	45.54
6/18/95	46.1	44.99
6/19/95	45.82	44.71
6/20/95	46.65	44.99
6/21/95	48.88	44.99
6/22/95	49.44	44.71
6/23/95	50.84	46.1
6/24/95	51.39	47.21
6/25/95	51.67	47.21
6/26/95	51.94	47.48
6/27/95	51.94	46.93
6/28/95	52.22	48.04
6/29/95	52.78	48.6
6/30/95	52.5	48.88
7/1/95	52.5	48.88
7/2/95	51.94	49.44
7/3/95	51.67	49.44
7/4/95	52.22	48.04
7/5/95	52.22	48.32
7/6/95	51.67	49.44
7/7/95	51.39	48.6
7/8/95	52.22	48.88
7/9/95	51.39	49.72
7/10/95	50.28	48.32
7/11/95	50.56	48.6

Tributary to Upper SF Cow Creek Daily High and Low Temperature		
Date	High (*F)	Low (*F)
7/12/95	50.28	48.6
7/13/95	50.28	47.48
7/14/95	51.11	46.93
7/15/95	51.67	47.48
7/16/95	52.78	48.6
7/17/95	53.9	50
7/18/95	53.06	51.39
7/19/95	53.06	50.84
7/20/95	53.34	50
7/21/95	53.34	50.28
7/22/95	53.9	50.84
7/23/95	53.62	50.28
7/24/95	53.34	50
7/25/95	53.06	49.72
7/26/95	52.78	49.72
7/27/95	53.62	49.72
7/28/95	54.18	50
7/29/95	52.5	49.72
7/30/95	51.11	46.37
7/31/95	51.94	47.48
8/1/95	53.06	49.16
8/2/95	53.34	49.72
8/3/95	53.34	49.44
8/4/95	53.62	50
8/5/95	53.9	50.84
8/6/95	53.34	50
8/7/95	52.22	49.72
8/8/95	51.11	47.48
8/9/95	51.39	46.93
8/10/95	50.56	49.16
8/11/95	51.39	48.6
8/12/95	51.11	48.6
8/13/95	50.56	46.65
8/14/95	50.84	46.65
8/15/95	50.84	48.04
8/16/95	50	48.32
8/17/95	48.88	46.93
8/18/95	48.88	44.43
8/19/95	50	45.54
8/20/95	51.11	47.21
8/21/95	51.39	48.04
8/22/95	51.39	47.76
8/23/95	50.56	49.16
8/24/95	49.72	46.93
8/25/95	49.72	45.54
8/26/95	48.88	45.26

Tributary to Upper SF Cow Creek		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
8/27/95	49.44	45.54
8/28/95	50.28	48.32
8/29/95	49.72	48.32
8/30/95		47.76

Tributary to Tributary of Upper SF Cow Creek



Trib. to Trib. of Upper SF Cow Creek		
Daily High and Low Temperature		
Date	High (*F)	Low (*F)
5/27/95	47.76	
5/28/95	48.32	45.82
5/29/95	49.16	46.65
5/30/95	49.44	47.48
5/31/95	49.16	47.48
6/1/95	49.44	47.76
6/2/95	48.6	47.48
6/3/95	48.88	47.48
6/4/95	48.32	46.65
6/5/95	46.65	44.15
6/6/95	43.87	43.31
6/7/95	45.26	43.31
6/8/95	46.1	43.59
6/9/95	46.93	44.71
6/10/95	46.93	46.37
6/11/95	46.65	45.26
6/12/95	46.1	44.43
6/13/95	45.82	44.71
6/14/95	46.1	45.26
6/15/95	45.82	44.99
6/16/95	45.82	45.54
6/17/95	46.1	45.54
6/18/95	45.82	44.71
6/19/95	44.99	44.43
6/20/95	45.54	44.43
6/21/95	46.65	44.71
6/22/95	47.21	45.26
6/23/95	48.88	46.37
6/24/95	49.72	47.76
6/25/95	50	48.04
6/26/95	50.28	48.32
6/27/95	50.56	48.32
6/28/95	51.11	49.16
6/29/95	51.67	50
6/30/95	51.94	50.28
7/1/95	51.94	50.28
7/2/95	51.67	50.84
7/3/95	51.39	50.56
7/4/95	51.39	49.72
7/5/95	51.67	49.72
7/6/95	51.67	50.56
7/7/95	51.11	49.72
7/8/95	51.94	50
7/9/95	51.67	50.56
7/10/95	50.28	49.44
7/11/95	50	49.16

Trib. to Trib. of Upper SF Cow Creek Daily High and Low Temperature		
Date	High (*F)	Low (*F)
7/12/95	49.72	49.16
7/13/95	49.72	48.6
7/14/95	50	48.32
7/15/95	50.56	48.6
7/16/95	51.67	49.44
7/17/95	53.06	50.84
7/18/95	53.06	52.5
7/19/95	53.62	52.22
7/20/95	53.34	51.67
7/21/95	53.34	51.94
7/22/95	53.34	52.22
7/23/95	53.06	51.94
7/24/95	52.78	51.67
7/25/95	52.5	51.39
7/26/95	52.5	51.39
7/27/95	53.06	51.39
7/28/95	53.62	51.94
7/29/95	53.06	50.84
7/30/95	50.84	49.16
7/31/95	51.67	49.44
8/1/95	52.5	50.56
8/2/95	52.78	51.39
8/3/95	52.78	51.39
8/4/95	53.34	51.67
8/5/95	53.62	52.5
8/6/95	53.34	51.94
8/7/95	53.06	50.84
8/8/95	50.84	49.72
8/9/95	51.11	49.16
8/10/95	50.84	50.28
8/11/95	50.56	49.72
8/12/95	50.84	49.72
8/13/95	50.28	48.6
8/14/95	50.28	48.6
8/15/95	50.84	49.44
8/16/95	50.56	49.44
8/17/95	49.44	48.32
8/18/95	48.6	46.93
8/19/95	49.44	47.48
8/20/95	50.28	48.32
8/21/95	50.84	49.16
8/22/95	51.11	49.44
8/23/95	50.84	50.28
8/24/95	50.28	48.88
8/25/95	49.44	48.04
8/26/95	49.16	47.48

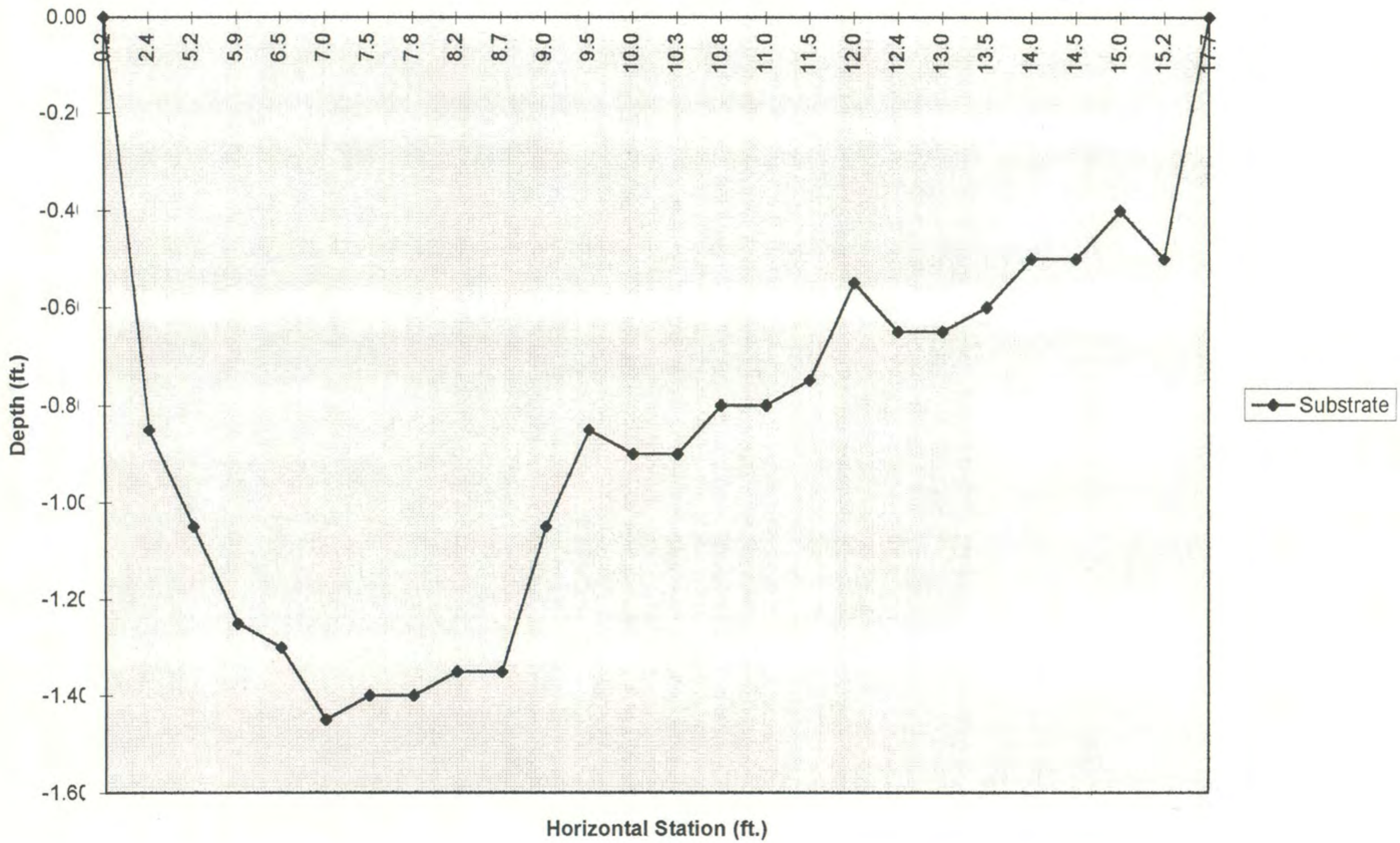
Trib. to Trib. of Upper SF Cow Creek Daily High and Low Temperature		
Date	High (*F)	Low (*F)
8/27/95	49.16	47.48
8/28/95	49.72	49.16
8/29/95	49.72	49.16
8/30/95		48.88

Appendix C

Stream Discharge Data

scharge Measurement for Stow Away #2-Lower Cow Creek							
te: 7/26/95							
Time: 11:15							
Crew: K. Minor, J. Stafford							
Spin Test: 1:00 min.							
Field Notes: Page 106							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.00						IP	0.00
0.2						LEW	0.00
2.4	2.50	0.85	0.223	2.125	0.47		-0.85
5.2	1.75	1.05	0.340	1.838	0.62		-1.05
5.9	0.65	1.25	0.453	0.813	0.37		-1.25
6.5	0.55	1.30	1.760	0.715	1.26		-1.30
7.0	0.50	1.45	1.690	0.725	1.23		-1.45
7.5	0.40	1.40	1.800	0.560	1.01		-1.40
7.8	0.35	1.40	1.890	0.490	0.93		-1.40
8.2	0.45	1.35	2.550	0.608	1.55		-1.35
8.7	0.40	1.35	3.210	0.540	1.73		-1.35
9.0	0.40	1.05	3.520	0.420	1.48		-1.05
9.5	0.50	0.85	3.440	0.425	1.46		-0.85
10.0	0.40	0.90	2.470	0.360	0.89		-0.90
10.3	0.40	0.90	2.150	0.360	0.77		-0.90
10.8	0.35	0.80	1.760	0.280	0.49		-0.80
11.0	0.35	0.80	1.660	0.280	0.46		-0.80
11.5	0.50	0.75	1.690	0.375	0.63		-0.75
12.0	0.45	0.55	2.410	0.248	0.60		-0.55
12.4	0.50	0.65	1.980	0.325	0.64		-0.65
13.0	0.55	0.65	1.140	0.358	0.41		-0.65
13.5	0.50	0.60	1.390	0.300	0.42		-0.60
14.0	0.50	0.50	0.824	0.250	0.21		-0.50
14.5	0.50	0.50	0.347	0.250	0.09		-0.50
15.0	0.35	0.40	0.493	0.140	0.07		-0.40
15.2	1.35	0.50	0.369	0.675	0.25		-0.50
17.7						REW	0.00
19.3						IP	
				Q=	18.04	cfs	

Lower Cow Creek Cross-Section at Discharge Measurement



Discharge Measurement for Stow Away #2-Lower Cow Creek

Date: 8/17/95

Time: 12:45

Stream Temperature: 57 F

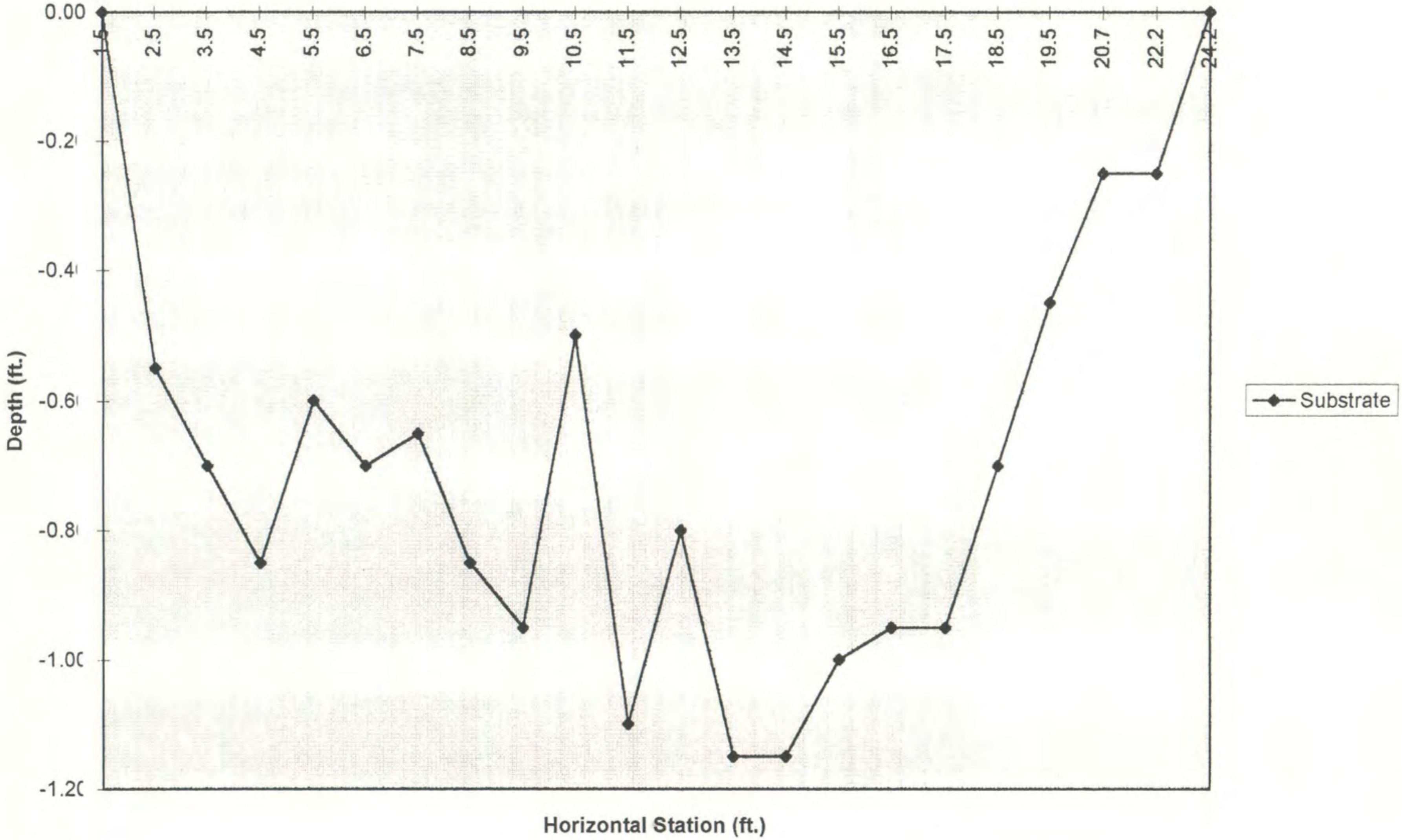
Crew: K. Minor, M. Jones, D. Gray

Spin Test: 1:31 min.

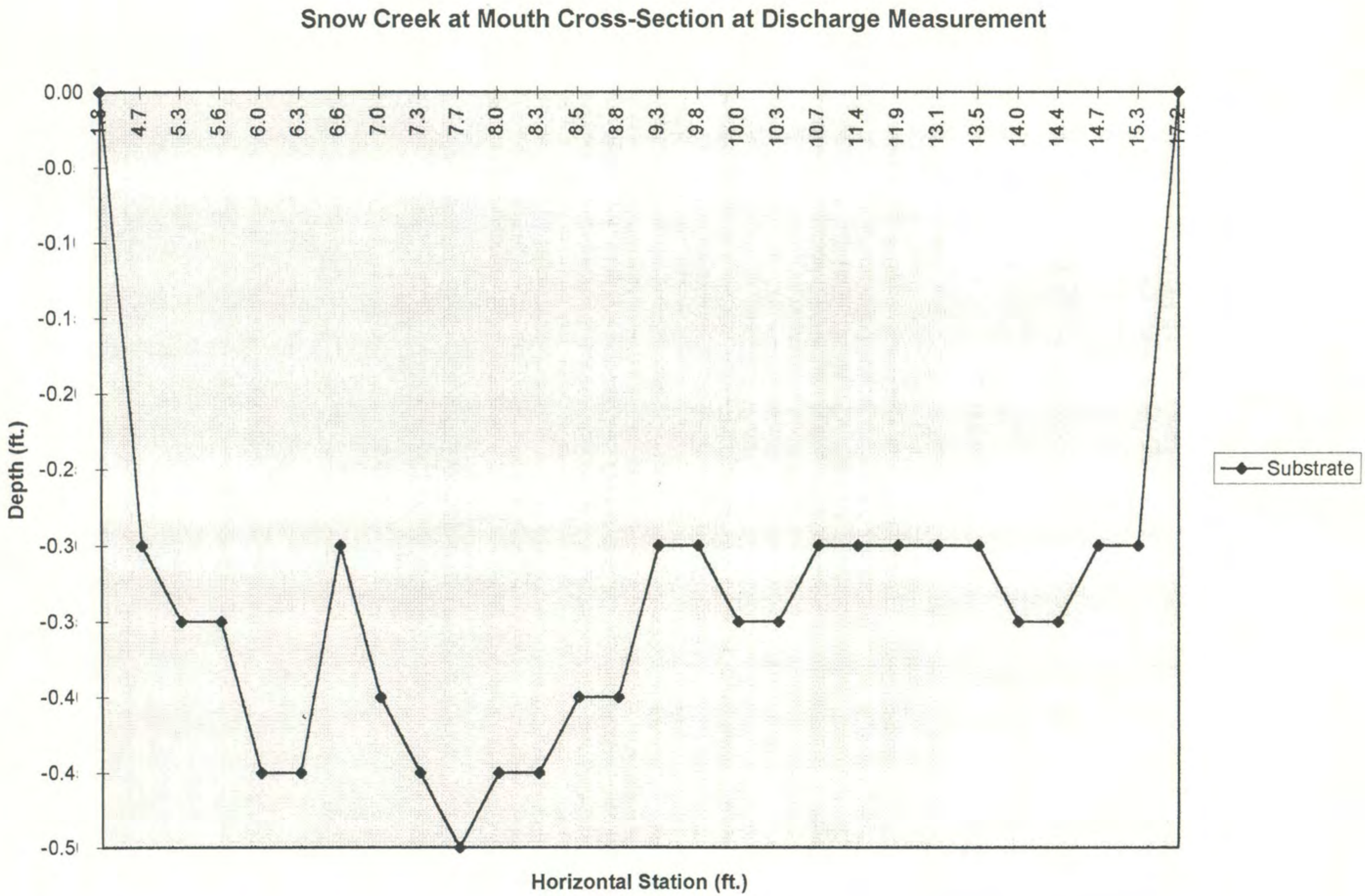
Field Notes: Page 20

Station	Width	Depth	Velocity	Area	Discharge	Comments	Depth
	(ft.)	(ft.)	(ft./sec.)	(sq. ft.)	(cfs)		(ft.)
0.00						IP	0.00
1.5						LEW	0.00
2.5	1.00	0.55	0.472	0.550	0.26		-0.55
3.5	1.00	0.70	0.250	0.700	0.18		-0.70
4.5	1.00	0.85	0.089	0.850	0.08		-0.85
5.5	1.00	0.60	0.052	0.600	0.03		-0.60
6.5	1.00	0.70	0.120	0.700	0.08		-0.70
7.5	1.00	0.65	0.526	0.650	0.34		-0.65
8.5	1.00	0.85	0.937	0.850	0.80		-0.85
9.5	1.00	0.95	0.526	0.950	0.50		-0.95
10.5	1.00	0.50	0.937	0.500	0.47		-0.50
11.5	1.00	1.10	0.526	1.100	0.58		-1.10
12.5	1.00	0.80	1.110	0.800	0.89		-0.80
13.5	1.00	1.15	0.826	1.150	0.95		-1.15
14.5	1.00	1.15	0.710	1.150	0.82		-1.15
15.5	1.00	1.00	0.916	1.000	0.92		-1.00
16.5	1.00	0.95	0.878	0.950	0.83		-0.95
17.5	1.00	0.95	1.360	0.950	1.29		-0.95
18.5	1.00	0.70	0.462	0.700	0.32		-0.70
19.5	1.10	0.45	0.958	0.495	0.47		-0.45
20.7	1.35	0.25	0.937	0.338	0.32		-0.25
22.2	1.75	0.25	0.810	0.438	0.35		-0.25
24.2						REW	0.00
				Q=	10.48	cfs	

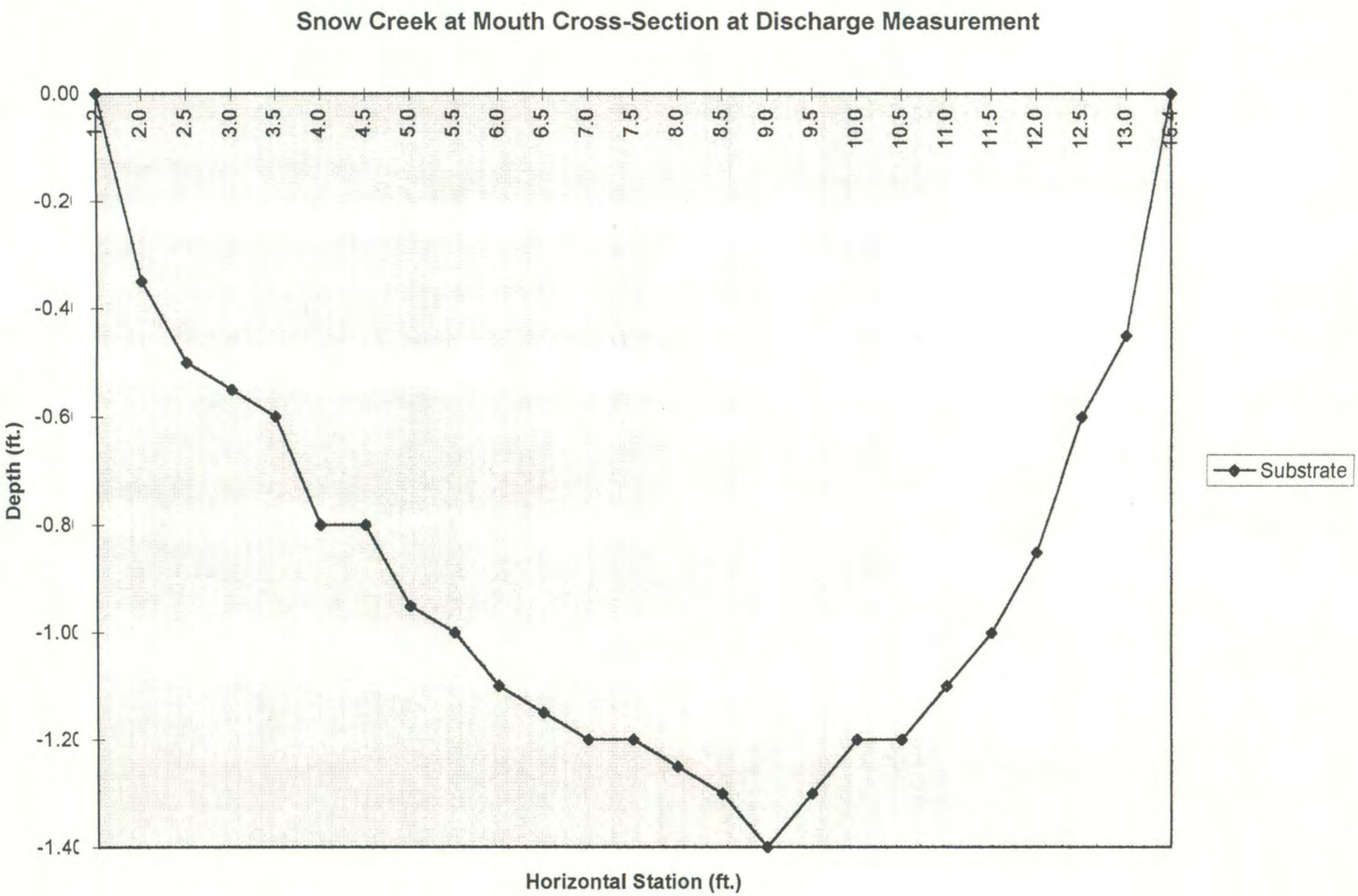
Lower Cow Creek Cross-Section at Discharge Measurement



charge Measurement for Stow Away #1-Snow Creek at Mouth							
ate: 7/26/95							
Time: 9:30							
Crew: K. Minor, J. Stafford							
Spin Test: 1:06 min.							
Field Notes: Page 102							
Station	**Width (ft.)**	**Depth (ft.)**	**Velocity (ft./sec.)**	**Area (sq. ft.)**	**Discharge (cfs)**	**Comments**	**Depth (ft.)**
0.00						IP	0.00
1.8						LEW	0.00
4.7	1.75	0.30	0.361	0.525	0.19		-0.30
5.3	0.45	0.35	0.187	0.158	0.03		-0.35
5.6	0.35	0.35	0.896	0.123	0.11		-0.35
6.0	0.35	0.45	1.250	0.158	0.20		-0.45
6.3	0.30	0.45	1.140	0.135	0.15		-0.45
6.6	0.35	0.30	1.020	0.105	0.11		-0.30
7.0	0.35	0.40	1.140	0.140	0.16		-0.40
7.3	0.35	0.45	1.020	0.158	0.16		-0.45
7.7	0.35	0.50	1.000	0.175	0.18		-0.50
8.0	0.30	0.45	0.679	0.135	0.09		-0.45
8.3	0.25	0.45	0.726	0.113	0.08		-0.45
8.5	0.25	0.40	0.679	0.100	0.07		-0.40
8.8	0.40	0.40	1.140	0.160	0.18		-0.40
9.3	0.50	0.30	0.548	0.150	0.08		-0.30
9.8	0.35	0.30	1.140	0.105	0.12		-0.30
10.0	0.25	0.35	1.110	0.088	0.10		-0.35
10.3	0.35	0.35	1.000	0.123	0.12		-0.35
10.7	0.55	0.30	0.726	0.165	0.12		-0.30
11.4	0.60	0.30	1.050	0.180	0.19		-0.30
11.9	0.85	0.30	0.516	0.255	0.13		-0.30
13.1	0.80	0.30	0.354	0.240	0.08		-0.30
13.5	0.45	0.30	1.140	0.135	0.15		-0.30
14.0	0.45	0.35	1.190	0.158	0.19		-0.35
14.4	0.35	0.35	0.435	0.123	0.05		-0.35
14.7	0.45	0.30	0.160	0.135	0.02		-0.30
15.3	1.25	0.30	0.115	0.375	0.04		-0.30
17.2						REW	0.00
20.0						IP	
				Q=	3.11	cfs	

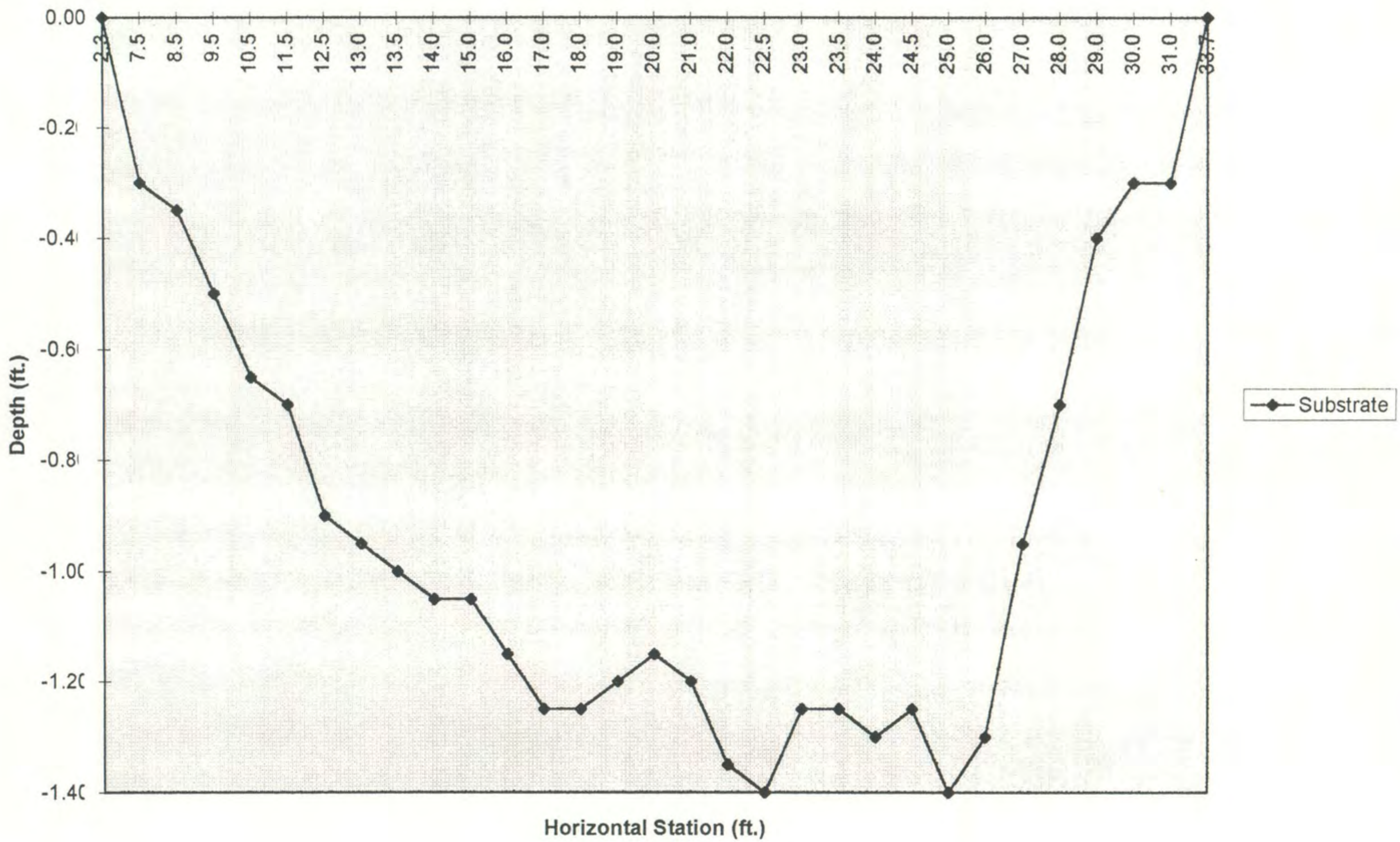

Snow Creek at Mouth Cross-Section at Discharge Measurement
0.00
-0.0
-0.1
-0.1
-0.2
-0.2
-0.3
-0.3
-0.4
-0.4
-0.5
Depth (ft.)
1.8
4.7
5.3
5.6
6.0
6.3
6.6
7.0
7.3
7.7
8.0
8.3
8.5
8.8
9.3
9.8
10.0
10.3
10.7
11.4
11.9
13.1
13.5
14.0
14.4
14.7
15.3
17.2
Substrate
Horizontal Station (ft.)

;charge Measurement for Stow Away #1-Snow Creek at Mouth							
Date: 8/17/95							
Time: 14:00??							
Stream Temperature: 58 F							
Crew: K. Minor, M. Jones, D. Gray							
Spin Test: 1:56 min.							
Field Notes: Page 24							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.00						IP	0.00
1.2						LEW	0.00
2.0	0.65	0.35	0.101	0.228	0.02		-0.35
2.5	0.50	0.50	0.124	0.250	0.03		-0.50
3.0	0.50	0.55	0.160	0.275	0.04		-0.55
3.5	0.50	0.60	0.191	0.300	0.06		-0.60
4.0	0.50	0.80	0.099	0.400	0.04		-0.80
4.5	0.50	0.80	0.052	0.400	0.02		-0.80
5.0	0.50	0.95	0.147	0.475	0.07		-0.95
5.5	0.50	1.00	0.123	0.500	0.06		-1.00
6.0	0.50	1.10	0.183	0.550	0.10		-1.10
6.5	0.50	1.15	0.183	0.575	0.11		-1.15
7.0	0.50	1.20	0.369	0.600	0.22		-1.20
7.5	0.50	1.20	0.444	0.600	0.27		-1.20
8.0	0.50	1.25	0.493	0.625	0.31		-1.25
8.5	0.50	1.30	0.548	0.650	0.36		-1.30
9.0	0.50	1.40	0.610	0.700	0.43		-1.40
9.5	0.50	1.30	0.361	0.650	0.23		-1.30
10.0	0.50	1.20	0.170	0.600	0.10		-1.20
10.5	0.50	1.20	0.052	0.600	0.03		-1.20
11.0	0.50	1.10	0.000	0.550	0.00		-1.10
11.5	0.50	1.00	0.052	0.500	0.03		-1.00
12.0	0.50	0.85	0.052	0.425	0.02		-0.85
12.5	0.50	0.60	0.000	0.300	0.00		-0.60
13.0	1.45	0.45	0.000	0.653	0.00		-0.45
15.4						REW	0.00
				Q=	**2.55**	**cfs**	

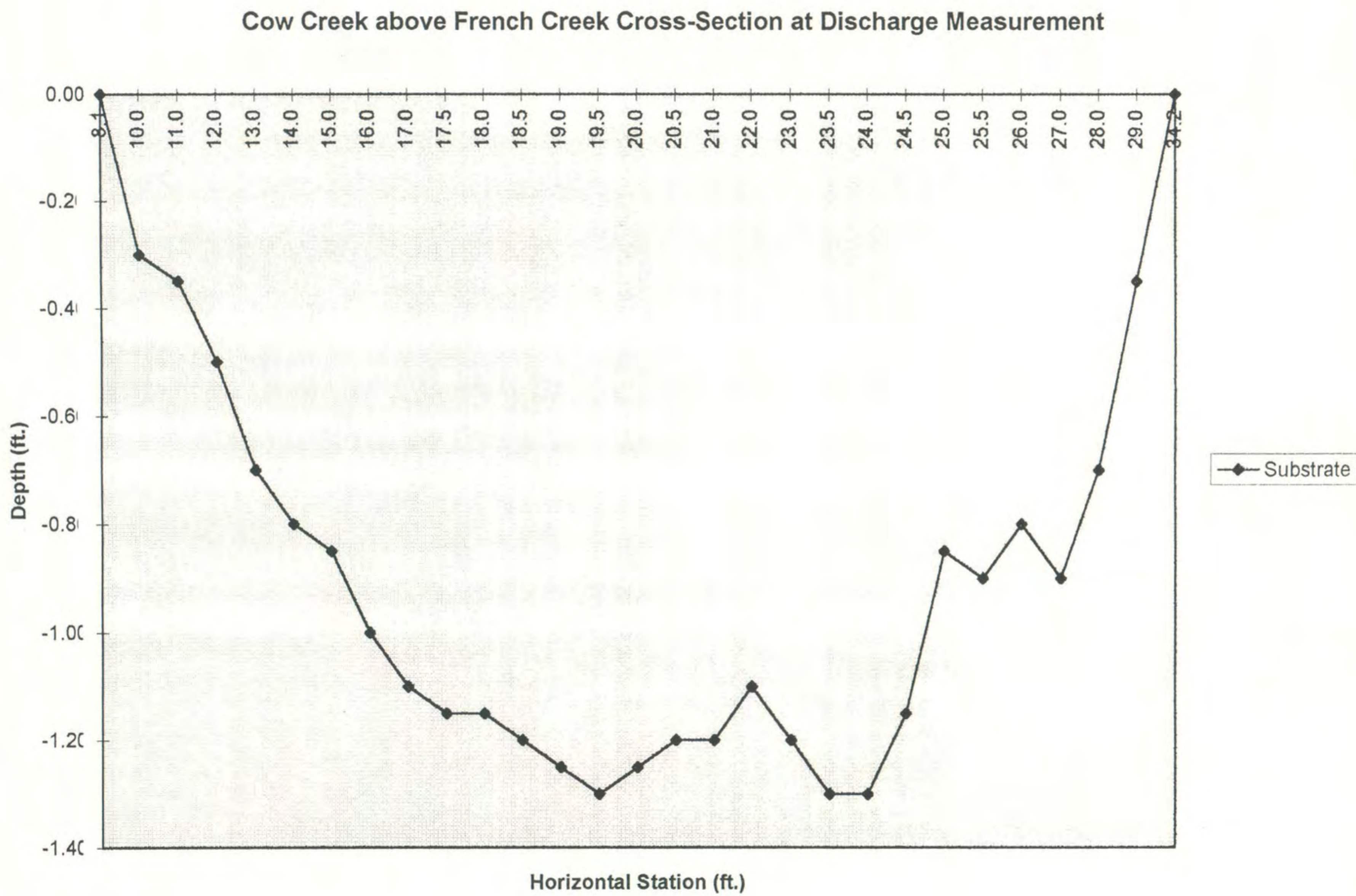

Snow Creek at Mouth Cross-Section at Discharge Measurement
0.00
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
Depth (ft.)
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0
12.5
13.0
Horizontal Station (ft.)
Substrate

...charge Measurement for Stow Away #3-Cow Creek above French Creek							
...ate: 7/26/95							
Time: 13:15							
Crew: K. Minor, J. Stafford							
Spin Test: 1:35 min.							
Field Notes: Page 110							
Station	Width	Depth	Velocity	Area	Discharge	Comments	Depth
	(ft.)	(ft.)	(ft./sec.)	(sq. ft.)	(cfs)		(ft.)
0.00						IP	0.00
2.3						LEW	0.00
7.5	3.10	0.30	0.147	0.930	0.14		-0.30
8.5	1.00	0.35	0.099	0.350	0.03		-0.35
9.5	1.00	0.50	0.129	0.500	0.06		-0.50
10.5	1.00	0.65	0.272	0.650	0.18		-0.65
11.5	1.00	0.70	0.472	0.700	0.33		-0.70
12.5	0.75	0.90	0.743	0.675	0.50		-0.90
13.0	0.50	0.95	0.896	0.475	0.43		-0.95
13.5	0.50	1.00	0.958	0.500	0.48		-1.00
14.0	0.75	1.05	1.090	0.788	0.86		-1.05
15.0	1.00	1.05	1.280	1.050	1.34		-1.05
16.0	1.00	1.15	1.390	1.150	1.60		-1.15
17.0	1.00	1.25	1.390	1.250	1.74		-1.25
18.0	1.00	1.25	1.220	1.250	1.53		-1.25
19.0	1.00	1.20	0.981	1.200	1.18		-1.20
20.0	1.00	1.15	0.765	1.150	0.88		-1.15
21.0	1.00	1.20	0.710	1.200	0.85		-1.20
22.0	0.75	1.35	0.679	1.013	0.69		-1.35
22.5	0.50	1.40	0.794	0.700	0.56		-1.40
23.0	0.50	1.25	0.981	0.625	0.61		-1.25
23.5	0.50	1.25	1.220	0.625	0.76		-1.25
24.0	0.50	1.30	1.220	0.650	0.79		-1.30
24.5	0.50	1.25	0.981	0.625	0.61		-1.25
25.0	0.75	1.40	0.498	1.050	0.52		-1.40
26.0	1.00	1.30	0.144	1.300	0.19		-1.30
27.0	1.00	0.95	0.052	0.950	0.05		-0.95
28.0	1.00	0.70	0.132	0.700	0.09		-0.70
29.0	1.00	0.40	0.052	0.400	0.02		-0.40
30.0	1.00	0.30	0.052	0.300	0.02		-0.30
31.0	1.85	0.30	0.000	0.555	0.00		-0.30
33.7						REW	0.00
35.2						IP	
				Q=	17.03	cfs	

Cow Creek above French Creek Cross-Section at Discharge Measurement

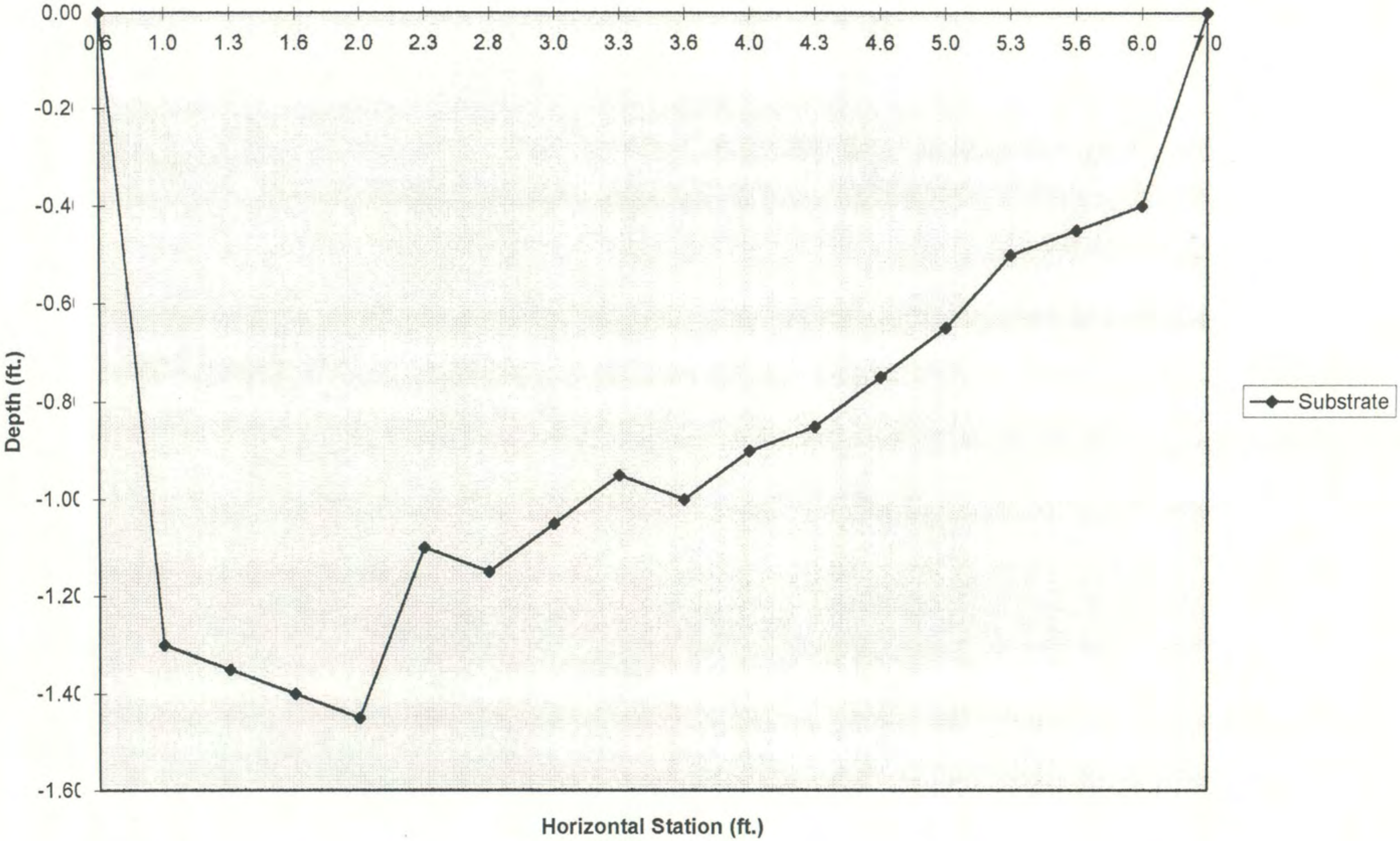


Discharge Measurement for Stow Away #3-Cow Creek above French Creek							
Date: 8/17/95							
Time: 10:00							
Stream Temperature: 55 F							
Crew: K. Minor, M. Jones, D. Gray							
Spin Test: 1:58 min.							
Field Notes: Page 16							
Station	Width	Depth	Velocity	Area	Discharge	Comments	Depth
	(ft.)	(ft.)	(ft./sec.)	(sq. ft.)	(cfs)		(ft.)
0.00						IP	0.00
8.1						LEW	0.00
10.0	1.45	0.30	0.212	0.435	0.09		-0.30
11.0	1.00	0.35	0.146	0.350	0.05		-0.35
12.0	1.00	0.50	0.160	0.500	0.08		-0.50
13.0	1.00	0.70	0.571	0.700	0.40		-0.70
14.0	1.00	0.80	0.859	0.800	0.69		-0.80
15.0	1.00	0.85	1.070	0.850	0.91		-0.85
16.0	1.00	1.00	1.110	1.000	1.11		-1.00
17.0	0.75	1.10	1.300	0.825	1.07		-1.10
17.5	0.50	1.15	1.220	0.575	0.70		-1.15
18.0	0.50	1.15	1.140	0.575	0.66		-1.15
18.5	0.50	1.20	1.090	0.600	0.65		-1.20
19.0	0.50	1.25	1.020	0.625	0.64		-1.25
19.5	0.50	1.30	0.810	0.650	0.53		-1.30
20.0	0.50	1.25	0.596	0.625	0.37		-1.25
20.5	0.50	1.20	0.639	0.600	0.38		-1.20
21.0	0.75	1.20	0.377	0.900	0.34		-1.20
22.0	1.00	1.10	0.397	1.100	0.44		-1.10
23.0	0.75	1.20	0.377	0.900	0.34		-1.20
23.5	0.50	1.30	0.404	0.650	0.26		-1.30
24.0	0.50	1.30	0.354	0.650	0.23		-1.30
24.5	0.50	1.15	0.652	0.575	0.37		-1.15
25.0	0.50	0.85	0.726	0.425	0.31		-0.85
25.5	0.50	0.90	0.419	0.450	0.19		-0.90
26.0	0.75	0.80	0.444	0.600	0.27		-0.80
27.0	1.00	0.90	0.109	0.900	0.10		-0.90
28.0	1.00	0.70	0.124	0.700	0.09		-0.70
29.0	3.10	0.35	0.099	1.085	0.11		-0.35
34.2						REW	0.00
				Q=	11.37	cfs	


Cow Creek above French Creek Cross-Section at Discharge Measurement
0.00
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
Depth (ft.)
8.1
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
17.5
18.0
18.5
19.0
19.5
20.0
20.5
21.0
22.0
23.0
23.5
24.0
24.5
25.0
25.5
26.0
27.0
28.0
29.0
34.2
Horizontal Station (ft.)
Substrate

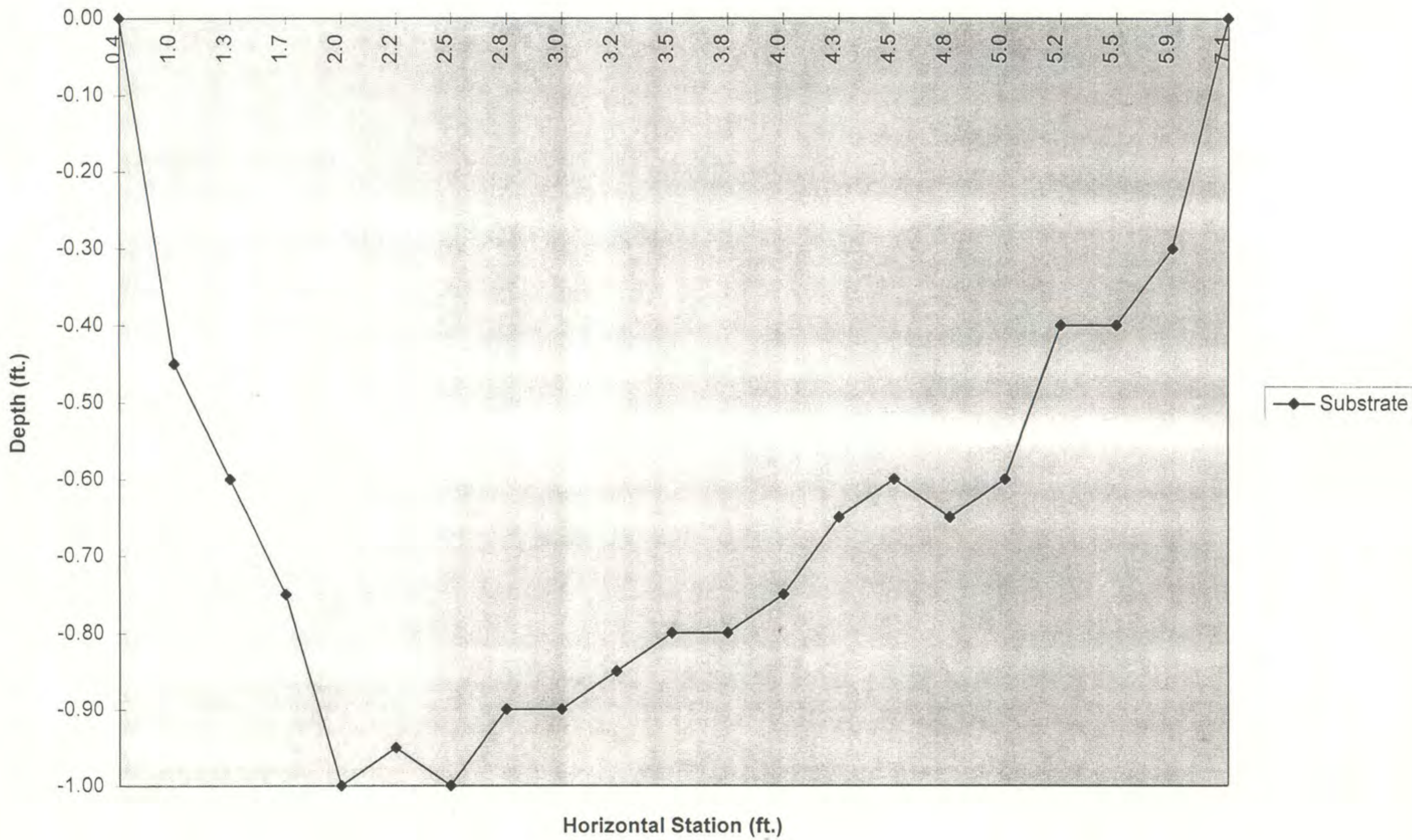
ischarge Measurement for Stow Away #4-Dismal Creek at Mouth							
ate: 7/25/95							
Time: 15:30							
Stream Temperature: 67 F							
Crew: K. Minor, D. Helms							
Spin Test: 1:31 min.							
Field Notes: Page 98							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.0						IP	0.00
0.6						LEW	0.00
1.0	0.35	1.30	0.191	0.455	0.09		-1.30
1.3	0.30	1.35	0.199	0.405	0.08		-1.35
1.6	0.35	1.40	0.404	0.490	0.20		-1.40
2.0	0.35	1.45	0.596	0.508	0.30		-1.45
2.3	0.40	1.10	0.826	0.440	0.36		-1.10
2.8	0.35	1.15	0.354	0.403	0.14		-1.15
3.0	0.25	1.05	0.160	0.263	0.04		-1.05
3.3	0.30	0.95	0.170	0.285	0.05		-0.95
3.6	0.35	1.00	0.209	0.350	0.07		-1.00
4.0	0.35	0.90	0.177	0.315	0.06		-0.90
4.3	0.30	0.85	0.216	0.255	0.06		-0.85
4.6	0.35	0.75	0.132	0.263	0.03		-0.75
5.0	0.35	0.65	0.098	0.228	0.02		-0.65
5.3	0.30	0.50	0.061	0.150	0.01		-0.50
5.6	0.35	0.45	0.150	0.158	0.02		-0.45
6.0	0.70	0.40	0.050	0.280	0.01		-0.40
7.0						REW	0.00
11.4						IP	
				Q=	1.55	cfs	

Dismal Creek at Mouth Cross-Section at Discharge Measurement



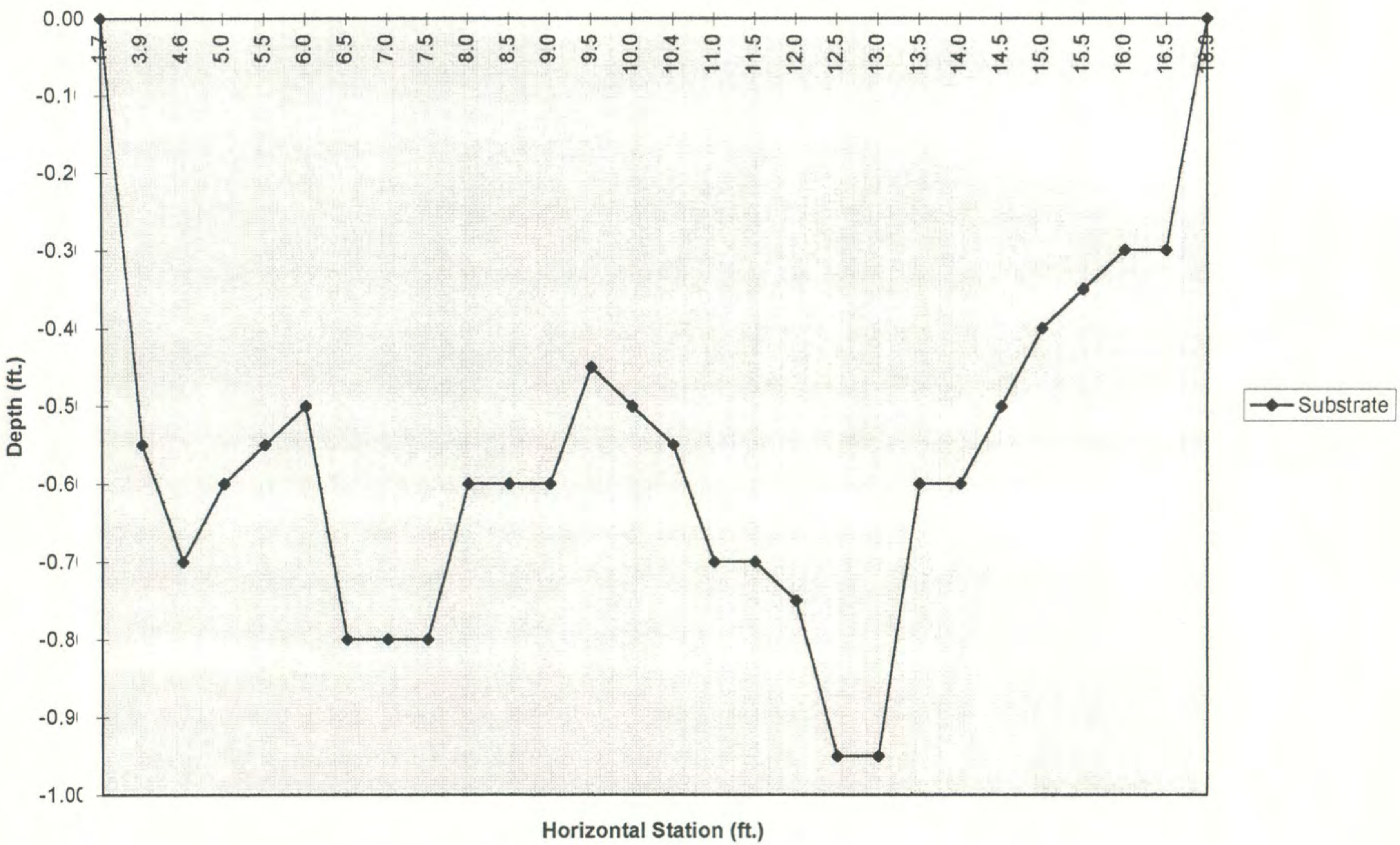
...scharge Measurement for Stow Away #4-Dismal Creek at Mouth							
Date: 8/16/95							
Time: 9:20							
Stream Temperature: 57 F							
Crew: K. Minor, D. Helms							
Spin Test: 1:31 min.							
Field Notes: Page 12							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.0						IP	0.00
0.4						LEW	0.00
1.0	0.45	0.45	0.220	0.203	0.04		-0.45
1.3	0.35	0.60	0.162	0.210	0.03		-0.60
1.7	0.35	0.75	0.294	0.263	0.08		-0.75
2.0	0.25	1.00	0.894	0.250	0.22		-1.00
2.2	0.25	0.95	1.420	0.238	0.34		-0.95
2.5	0.30	1.00	0.482	0.300	0.14		-1.00
2.8	0.25	0.90	0.183	0.225	0.04		-0.90
3.0	0.20	0.90	0.118	0.180	0.02		-0.90
3.2	0.25	0.85	0.134	0.213	0.03		-0.85
3.5	0.30	0.80	0.196	0.240	0.05		-0.80
3.8	0.25	0.80	0.165	0.200	0.03		-0.80
4.0	0.25	0.75	0.150	0.188	0.03		-0.75
4.3	0.25	0.65	0.120	0.163	0.02		-0.65
4.5	0.25	0.60	0.116	0.150	0.02		-0.60
4.8	0.25	0.65	0.170	0.163	0.03		-0.65
5.0	0.20	0.60	0.085	0.120	0.01		-0.60
5.2	0.25	0.40	0.087	0.100	0.01		-0.40
5.5	0.35	0.40	0.000	0.140	0.00		-0.40
5.9	0.80	0.30	0.052	0.240	0.01		-0.30
7.1						REW	0.00
12.2						IP	
				Q=	**1.16**	**cfs**	

Dismal Creek at Mouth Cross-Section at Discharge Measurement



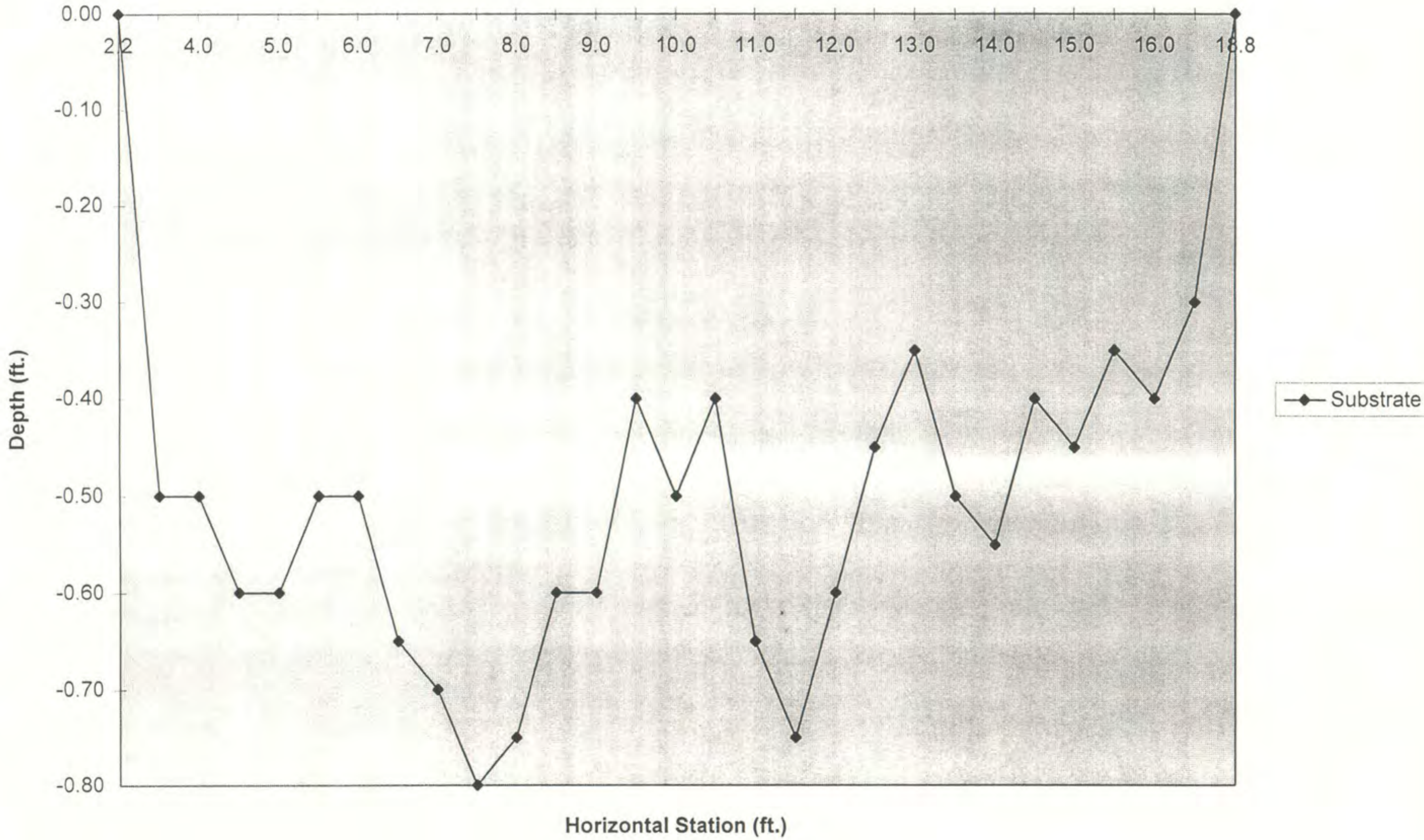
:charge Measurement for Stow Away #5-Applegate Creek at Mouth							
ate: 7/27/95							
Time: 12:50							
Crew: K. Minor, J. Stafford							
Spin Test: 1:52 min.							
Field Notes: Page 128							
Station	**Width (ft.)**	**Depth (ft.)**	**Velocity (ft./sec.)**	**Area (sq. ft.)**	**Discharge (cfs)**	**Comments**	**Depth (ft.)**
0.00						IP	0.00
1.7						LEW	0.00
3.9	1.45	0.55	0.516	0.798	0.41		-0.55
4.6	0.55	0.70	0.227	0.385	0.09		-0.70
5.0	0.45	0.60	0.444	0.270	0.12		-0.60
5.5	0.50	0.55	0.852	0.275	0.23		-0.55
6.0	0.50	0.50	0.826	0.250	0.21		-0.50
6.5	0.50	0.80	0.665	0.400	0.27		-0.80
7.0	0.50	0.80	0.794	0.400	0.32		-0.80
7.5	0.50	0.80	0.272	0.400	0.11		-0.80
8.0	0.50	0.60	0.147	0.300	0.04		-0.60
8.5	0.50	0.60	0.361	0.300	0.11		-0.60
9.0	0.50	0.60	0.493	0.300	0.15		-0.60
9.5	0.50	0.45	0.390	0.225	0.09		-0.45
10.0	0.45	0.50	0.150	0.225	0.03		-0.50
10.4	0.50	0.55	0.191	0.275	0.05		-0.55
11.0	0.55	0.70	0.327	0.385	0.13		-0.70
11.5	0.50	0.70	0.639	0.350	0.22		-0.70
12.0	0.50	0.75	0.937	0.375	0.35		-0.75
12.5	0.50	0.95	0.981	0.475	0.47		-0.95
13.0	0.50	0.95	0.953	0.475	0.45		-0.95
13.5	0.50	0.60	0.794	0.300	0.24		-0.60
14.0	0.50	0.60	0.694	0.300	0.21		-0.60
14.5	0.50	0.50	0.347	0.250	0.09		-0.50
15.0	0.50	0.40	0.537	0.200	0.11		-0.40
15.5	0.50	0.35	0.305	0.175	0.05		-0.35
16.0	0.50	0.30	0.526	0.150	0.08		-0.30
16.5	1.45	0.30	0.694	0.435	0.30		-0.30
18.9						REW	0.00
19.4						IP	
				Q=	4.92	cfs	

Applegate Creek at Mouth Cross-Section at Discharge Measurement



scharge Measurement for Stow Away #5-Applegate Creek at Mouth							
Date: 8/15/95							
Time: 10:15							
Stream Temperature: 54 F							
Crew: K. Minor, P. Branchfield							
Spin Test: 1:17 min.							
Field Notes: Page 156							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.00						IP	0.00
2.2						LEW	0.00
3.7	0.90	0.50	0.333	0.450	0.15		-0.50
4.0	0.40	0.50	0.157	0.200	0.03		-0.50
4.5	0.50	0.60	0.180	0.300	0.05		-0.60
5.0	0.50	0.60	0.394	0.300	0.12		-0.60
5.5	0.50	0.50	0.639	0.250	0.16		-0.50
6.0	0.50	0.50	0.710	0.250	0.18		-0.50
6.5	0.50	0.65	0.462	0.325	0.15		-0.65
7.0	0.50	0.70	0.810	0.350	0.28		-0.70
7.5	0.50	0.80	0.232	0.400	0.09		-0.80
8.0	0.50	0.75	0.160	0.375	0.06		-0.75
8.5	0.50	0.60	0.247	0.300	0.07		-0.60
9.0	0.50	0.60	0.281	0.300	0.08		-0.60
9.5	0.50	0.40	0.170	0.200	0.03		-0.40
10.0	0.50	0.50	0.100	0.250	0.03		-0.50
10.5	0.50	0.40	0.505	0.200	0.10		-0.40
11.0	0.50	0.65	0.236	0.325	0.08		-0.65
11.5	0.50	0.75	0.516	0.375	0.19		-0.75
12.0	0.50	0.60	1.140	0.300	0.34		-0.60
12.5	0.50	0.45	0.950	0.225	0.21		-0.45
13.0	0.50	0.35	0.639	0.175	0.11		-0.35
13.5	0.50	0.50	0.896	0.250	0.22		-0.50
14.0	0.50	0.55	0.794	0.275	0.22		-0.55
14.5	0.50	0.40	0.507	0.200	0.10		-0.40
15.0	0.50	0.45	0.444	0.225	0.10		-0.45
15.5	0.50	0.35	0.453	0.175	0.08		-0.35
16.0	0.50	0.40	0.453	0.200	0.09		-0.40
16.5	1.40	0.30	0.369	0.420	0.15		-0.30
18.8						REW	0.00
20.1						IP	
				Q=	3.50	cfs	

Applegate Creek at Mouth Cross-Section at Discharge Measurement

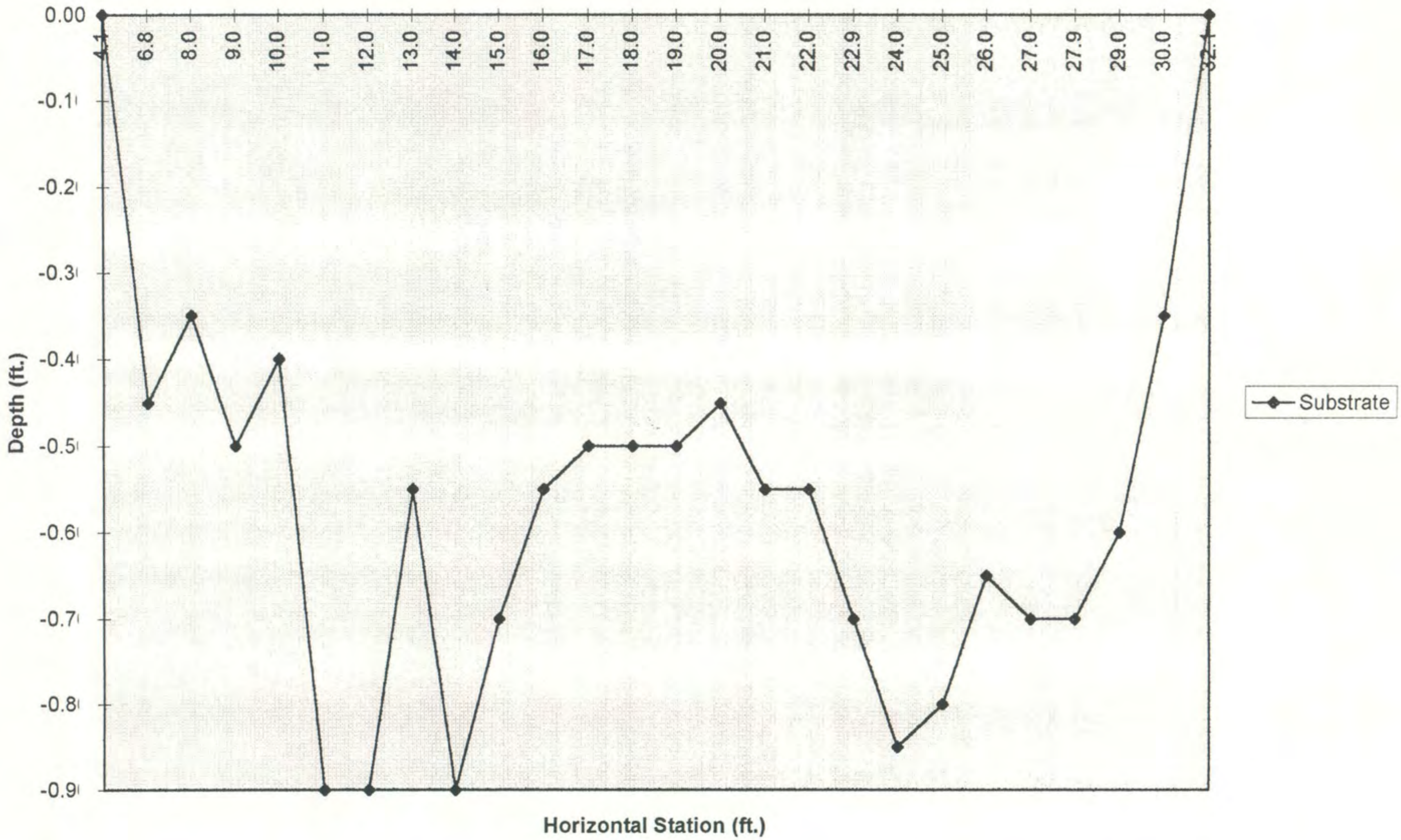


charge Measurement for Stow Away #6-Cow Creek above Applegate Creek

ate: 7/27/95
Time: 14:20
Crew: K. Minor, J. Stafford
Spin Test: 1:30 min.
Field Notes: Page 132

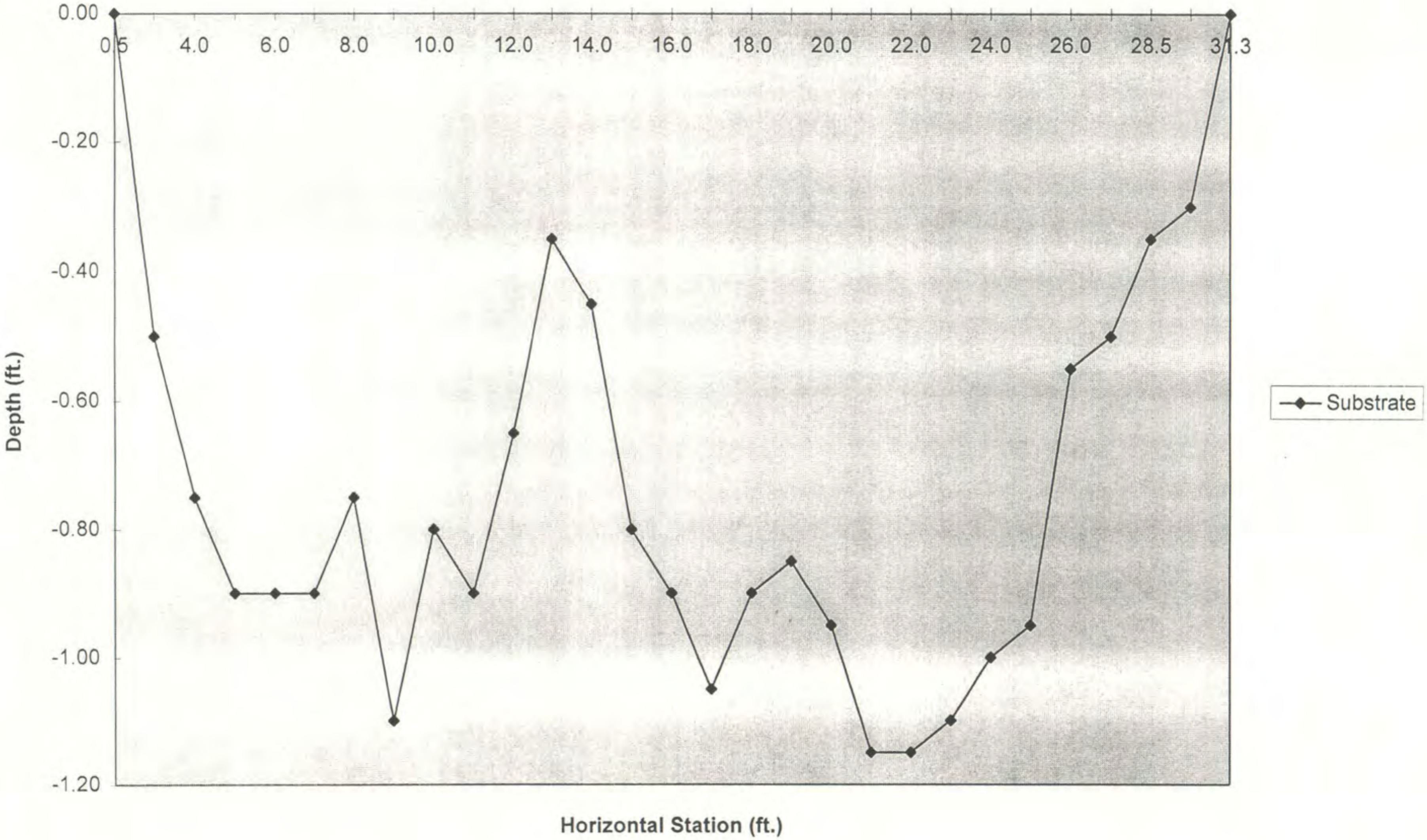
Station	Width (ft.)	Depth (ft.)	Velocity (ft./sec.)	Area (sq. ft.)	Discharge (cfs)	Comments	Depth (ft.)
0.00						IP	0.00
4.1						LEW	0.00
6.8	1.95	0.45	0.101	0.878	0.09		-0.45
8.0	1.10	0.35	0.142	0.385	0.05		-0.35
9.0	1.00	0.50	0.170	0.500	0.09		-0.50
10.0	1.00	0.40	0.194	0.400	0.08		-0.40
11.0	1.00	0.90	0.155	0.900	0.14		-0.90
12.0	1.00	0.90	0.160	0.900	0.14		-0.90
13.0	1.00	0.55	0.404	0.550	0.22		-0.55
14.0	1.00	0.90	0.462	0.900	0.42		-0.90
15.0	1.00	0.70	0.694	0.700	0.49		-0.70
16.0	1.00	0.55	0.937	0.550	0.52		-0.55
17.0	1.00	0.50	1.220	0.500	0.61		-0.50
18.0	1.00	0.50	1.190	0.500	0.60		-0.50
19.0	1.00	0.50	1.160	0.500	0.58		-0.50
20.0	1.00	0.45	1.090	0.450	0.49		-0.45
21.0	1.00	0.55	1.050	0.550	0.58		-0.55
22.0	0.95	0.55	1.490	0.523	0.78		-0.55
22.9	1.00	0.70	1.460	0.700	1.02		-0.70
24.0	1.05	0.85	1.360	0.893	1.21		-0.85
25.0	1.00	0.80	1.330	0.800	1.06		-0.80
26.0	1.00	0.65	1.390	0.650	0.90		-0.65
27.0	0.95	0.70	1.360	0.665	0.90		-0.70
27.9	1.00	0.70	1.020	0.700	0.71		-0.70
29.0	1.05	0.60	0.652	0.630	0.41		-0.60
30.0	1.55	0.35	0.665	0.543	0.36		-0.35
32.1						REW	0.00
35.2						IP	
				Q=	**12.45**	**cfs**	

Cow Creek above Applegate Creek Cross-Section at Discharge Measurement



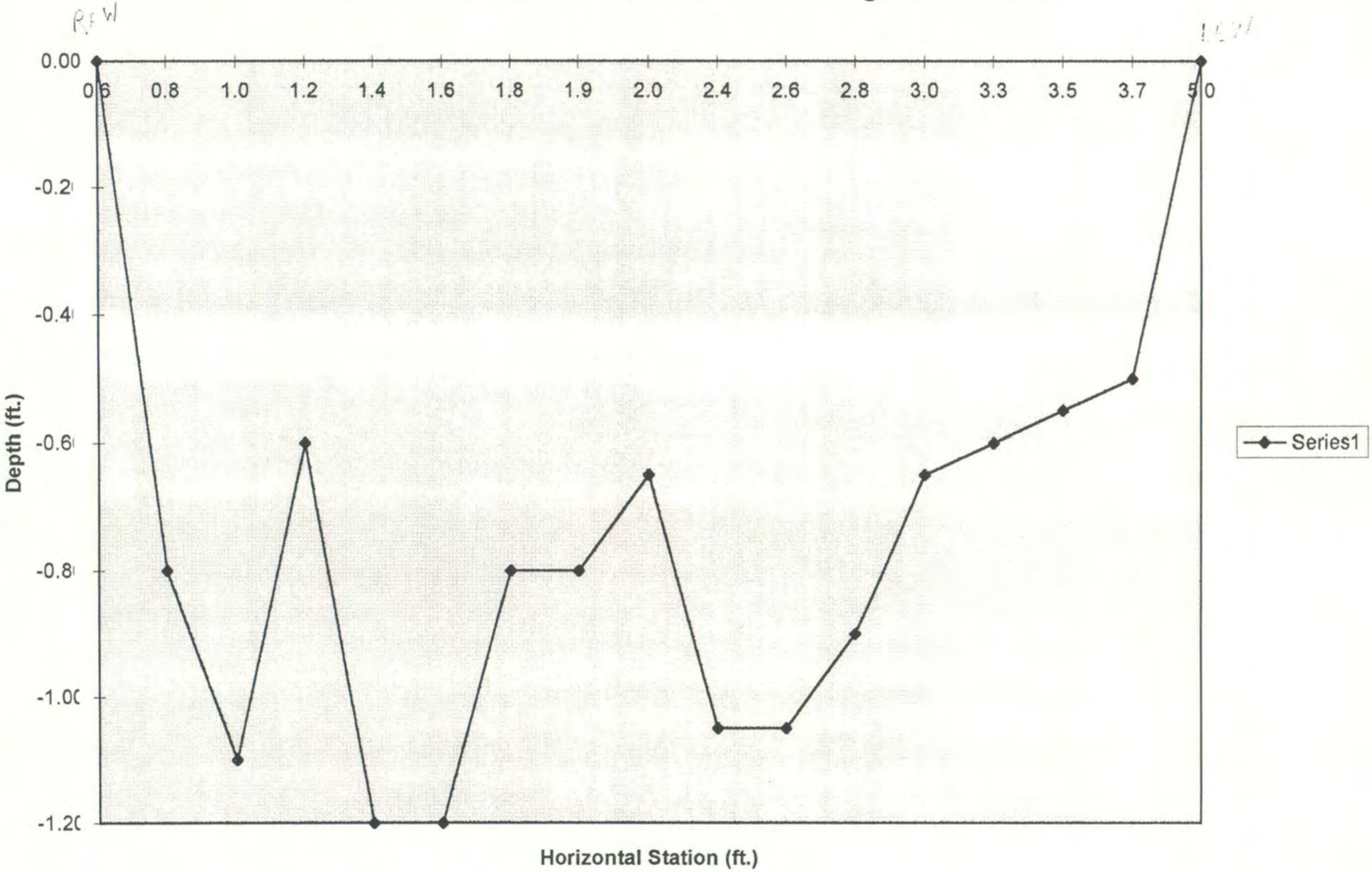
scharge Measurement for Stow Away #6-Cow Creek above Applegate Creek							
Date: 8/15/95							
Time: 11:10							
Stream Temperature: 54 F							
Crew: K. Minor, P. Branchfield							
Spin Test: 1:27 min.							
Field Notes: Page 4							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.00						IP	0.00
0.5						LEW	0.00
3.0	1.75	0.50	0.077	0.875	0.07		-0.50
4.0	1.00	0.75	0.101	0.750	0.08		-0.75
5.0	1.00	0.90	0.052	0.900	0.05		-0.90
6.0	1.00	0.90	0.052	0.900	0.05		-0.90
7.0	1.00	0.90	0.101	0.900	0.09		-0.90
8.0	1.00	0.75	0.333	0.750	0.25		-0.75
9.0	1.00	1.10	0.404	1.100	0.44		-1.10
10.0	1.00	0.80	0.482	0.800	0.39		-0.80
11.0	1.00	0.90	0.453	0.900	0.41		-0.90
12.0	1.00	0.65	0.347	0.650	0.23		-0.65
13.0	1.00	0.35	0.419	0.350	0.15		-0.35
14.0	1.00	0.45	0.080	0.450	0.04		-0.45
15.0	1.00	0.80	0.116	0.800	0.09		-0.80
16.0	1.00	0.90	0.177	0.900	0.16		-0.90
17.0	1.00	1.05	0.139	1.050	0.15		-1.05
18.0	1.00	0.90	0.209	0.900	0.19		-0.90
19.0	1.00	0.85	0.261	0.850	0.22		-0.85
20.0	1.00	0.95	0.294	0.950	0.28		-0.95
21.0	1.00	1.15	0.354	1.150	0.41		-1.15
22.0	1.00	1.15	0.505	1.150	0.58		-1.15
23.0	1.00	1.10	0.498	1.100	0.55		-1.10
24.0	1.00	1.00	0.761	1.000	0.76		-1.00
25.0	1.00	0.95	1.090	0.950	1.04		-0.95
26.0	0.90	0.55	0.394	0.495	0.20		-0.55
26.8	1.25	0.50	0.084	0.625	0.05		-0.50
28.5	1.15	0.35	0.937	0.403	0.38		-0.35
29.1	1.40	0.30	0.878	0.420	0.37		-0.30
31.3						REW	0.00
32.5						IP	
				Q=	7.64	cfs	

Cow Creek above Applegate Creek Cross-Section at Discharge Measurement

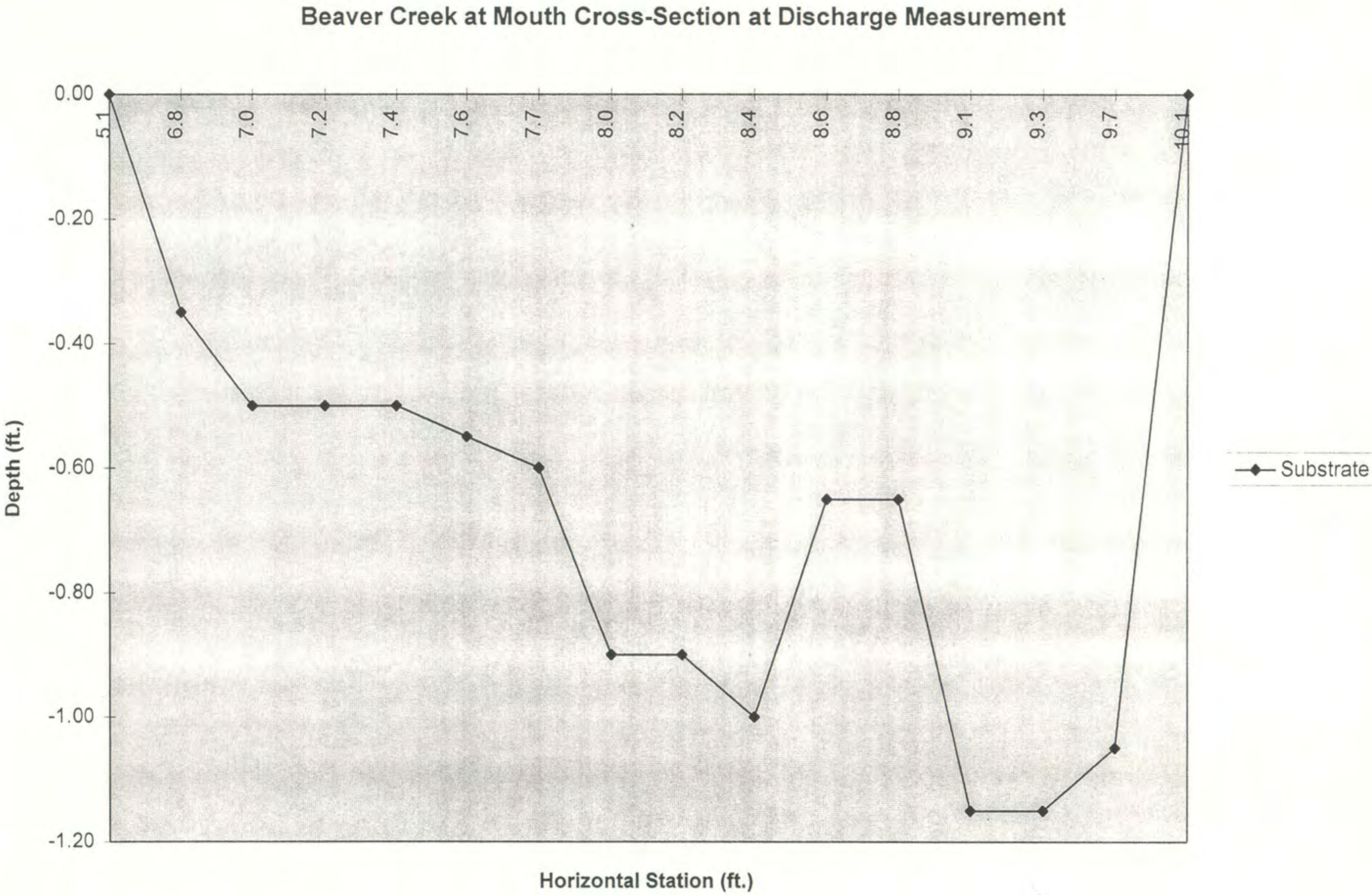


ischarge Measurement for Stow Away #7-Beaver Creek at Mouth							
ate: 7/26/95							
Time: 14:35							
Crew: K. Minor, J. Stafford							
Spin Test: 1:33 min.							
Field Notes: Page 114							
Station	**Width (ft.)**	**Depth (ft.)**	**Velocity (ft./sec.)**	**Area (sq. ft.)**	**Discharge (cfs)**	**Comments**	**Depth (ft.)**
0.00						IP	0.00
0.6						LEW	0.00
0.8	0.20	0.80	0.170	0.160	0.03		-0.80
1.0	0.20	1.10	0.070	0.220	0.02		-1.10
1.2	0.20	0.60	0.652	0.120	0.08		-0.60
1.4	0.20	1.20	0.099	0.240	0.02		-1.20
1.6	0.20	1.20	0.199	0.240	0.05		-1.20
1.8	0.15	0.80	0.101	0.120	0.01		-0.80
1.9	0.10	0.80	0.107	0.080	0.01		-0.80
2.0	0.25	0.65	0.134	0.163	0.02		-0.65
2.4	0.30	1.05	0.124	0.315	0.04		-1.05
2.6	0.20	1.05	0.195	0.210	0.04		-1.05
2.8	0.20	0.90	0.168	0.180	0.03		-0.90
3.0	0.25	0.65	0.118	0.163	0.02		-0.65
3.3	0.25	0.60	0.129	0.150	0.02		-0.60
3.5	0.20	0.55	0.052	0.110	0.01		-0.55
3.7	0.75	0.50	0.052	0.375	0.02		-0.50
5.0						REW	0.00
14.2						IP	
				Q=	0.41	cfs	

Beaver Creek at Mouth Cross-Section at Discharge Measurement



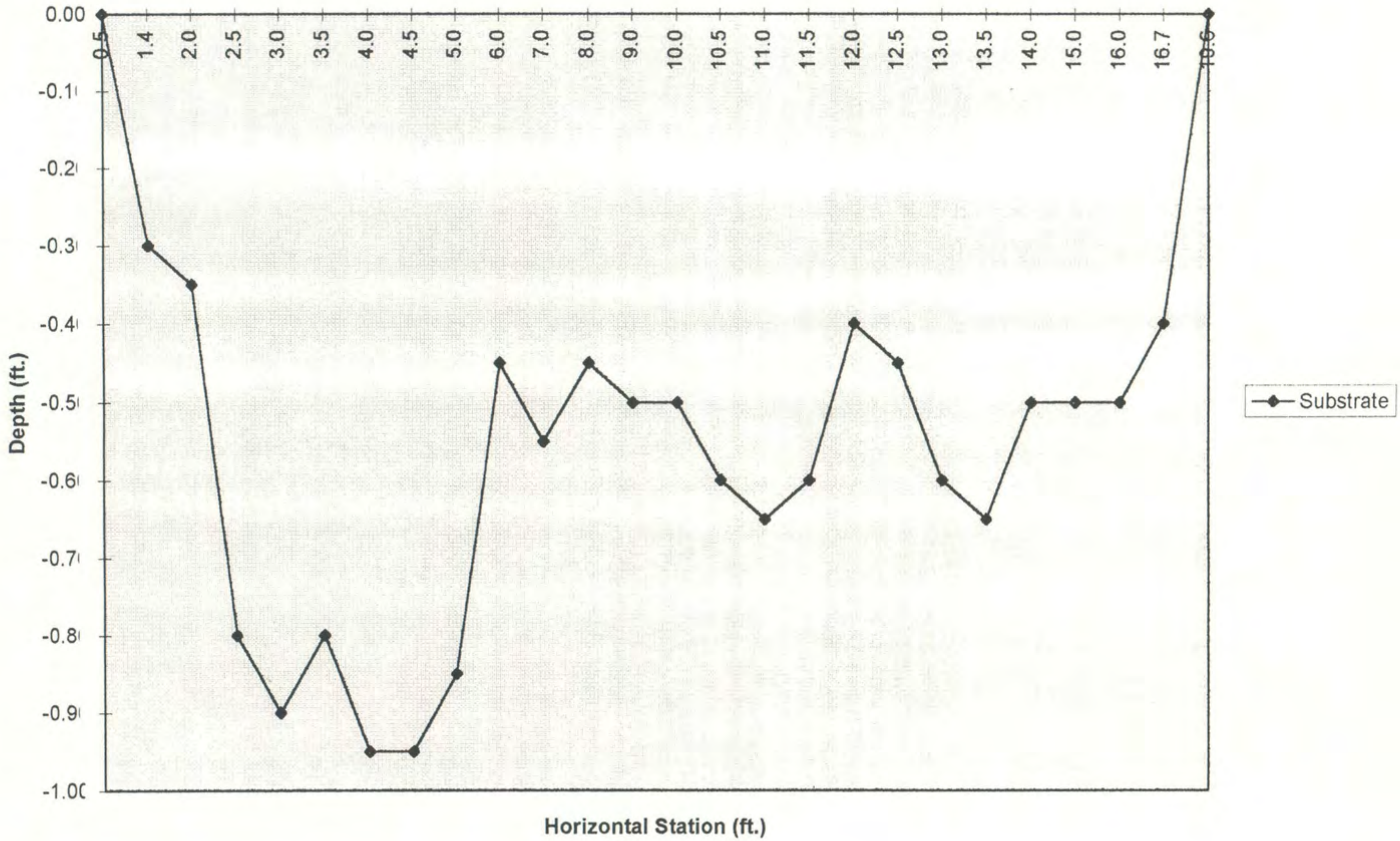
ischarge Measurement for Stow Away #7-Beaver Creek at Mouth							
Date: 8/15/95							
Time: 8:50							
Stream Temperature: 53 F							
Crew: K. Minor, P. Branchfield							
Spin Test: 1:24 min.							
Field Notes: Page 150							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.00						IP	0.00
5.1						LEW	0.00
6.8	0.95	0.35	0.106	0.333	0.04		-0.35
7.0	0.20	0.50	0.095	0.100	0.01		-0.50
7.2	0.20	0.50	0.076	0.100	0.01		-0.50
7.4	0.20	0.50	0.052	0.100	0.01		-0.50
7.6	0.15	0.55	0.126	0.083	0.01		-0.55
7.7	0.20	0.60	0.142	0.120	0.02		-0.60
8.0	0.25	0.90	0.369	0.225	0.08		-0.90
8.2	0.20	0.90	0.427	0.180	0.08		-0.90
8.4	0.20	1.00	0.285	0.200	0.06		-1.00
8.6	0.20	0.65	0.404	0.130	0.05		-0.65
8.8	0.25	0.65	0.250	0.163	0.04		-0.65
9.1	0.25	1.15	0.245	0.288	0.07		-1.15
9.3	0.30	1.15	0.052	0.345	0.02		-1.15
9.7	0.40	1.05	0.000	0.420	0.00		-1.05
10.1						REW	0.00
10.5						IP	
				Q=	**0.48**	**cfs**	


Beaver Creek at Mouth Cross-Section at Discharge Measurement
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
Depth (ft.)
5.1
6.8
7.0
7.2
7.4
7.6
7.7
8.0
8.2
8.4
8.6
8.8
9.1
9.3
9.7
10.1
Horizontal Station (ft.)
Substrate

charge Measurement for Stow Away #8-Cow Creek above Beaver Creek

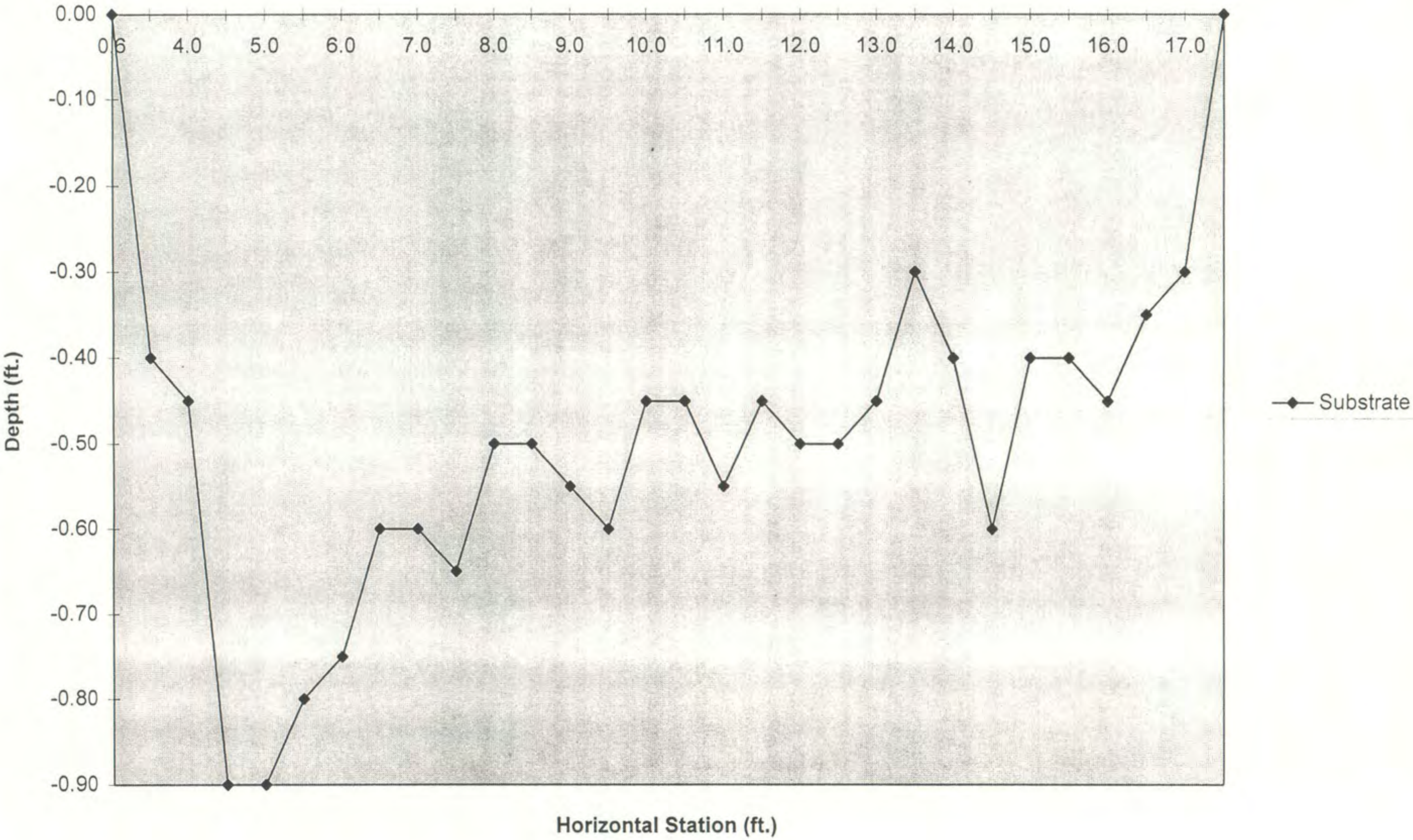
te: 7/26/95							
Time: 15:20							
Crew: K. Minor, J. Stafford							
Spin Test: 1:00 min.+							
Field Notes: Page 118							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.00						IP	0.00
0.5						LEW	0.00
1.4	0.75	0.30	0.516	0.225	0.12		-0.30
2.0	0.55	0.35	0.652	0.193	0.13		-0.35
2.5	0.50	0.80	0.743	0.400	0.30		-0.80
3.0	0.50	0.90	0.916	0.450	0.41		-0.90
3.5	0.50	0.80	1.140	0.400	0.46		-0.80
4.0	0.50	0.95	1.250	0.475	0.59		-0.95
4.5	0.50	0.95	1.590	0.475	0.76		-0.95
5.0	0.75	0.85	0.272	0.638	0.17		-0.85
6.0	1.00	0.45	1.850	0.450	0.83		-0.45
7.0	1.00	0.55	1.000	0.550	0.55		-0.55
8.0	1.00	0.45	1.930	0.450	0.87		-0.45
9.0	1.00	0.50	1.660	0.500	0.83		-0.50
10.0	0.75	0.50	1.190	0.375	0.45		-0.50
10.5	0.50	0.60	1.420	0.300	0.43		-0.60
11.0	0.50	0.65	1.590	0.325	0.52		-0.65
11.5	0.50	0.60	1.020	0.300	0.31		-0.60
12.0	0.50	0.40	1.490	0.200	0.30		-0.40
12.5	0.50	0.45	0.981	0.225	0.22		-0.45
13.0	0.50	0.60	0.958	0.300	0.29		-0.60
13.5	0.50	0.65	1.250	0.325	0.41		-0.65
14.0	0.75	0.50	1.220	0.375	0.46		-0.50
15.0	1.00	0.50	1.250	0.500	0.63		-0.50
16.0	0.85	0.50	1.250	0.425	0.53		-0.50
16.7	1.80	0.40	0.694	0.720	0.50		-0.40
19.6						REW	0.00
21.6						IP	
				Q=	**11.03**	**cfs**	

Cow Creek above Beaver Creek Cross-Section at Discharge Measurement



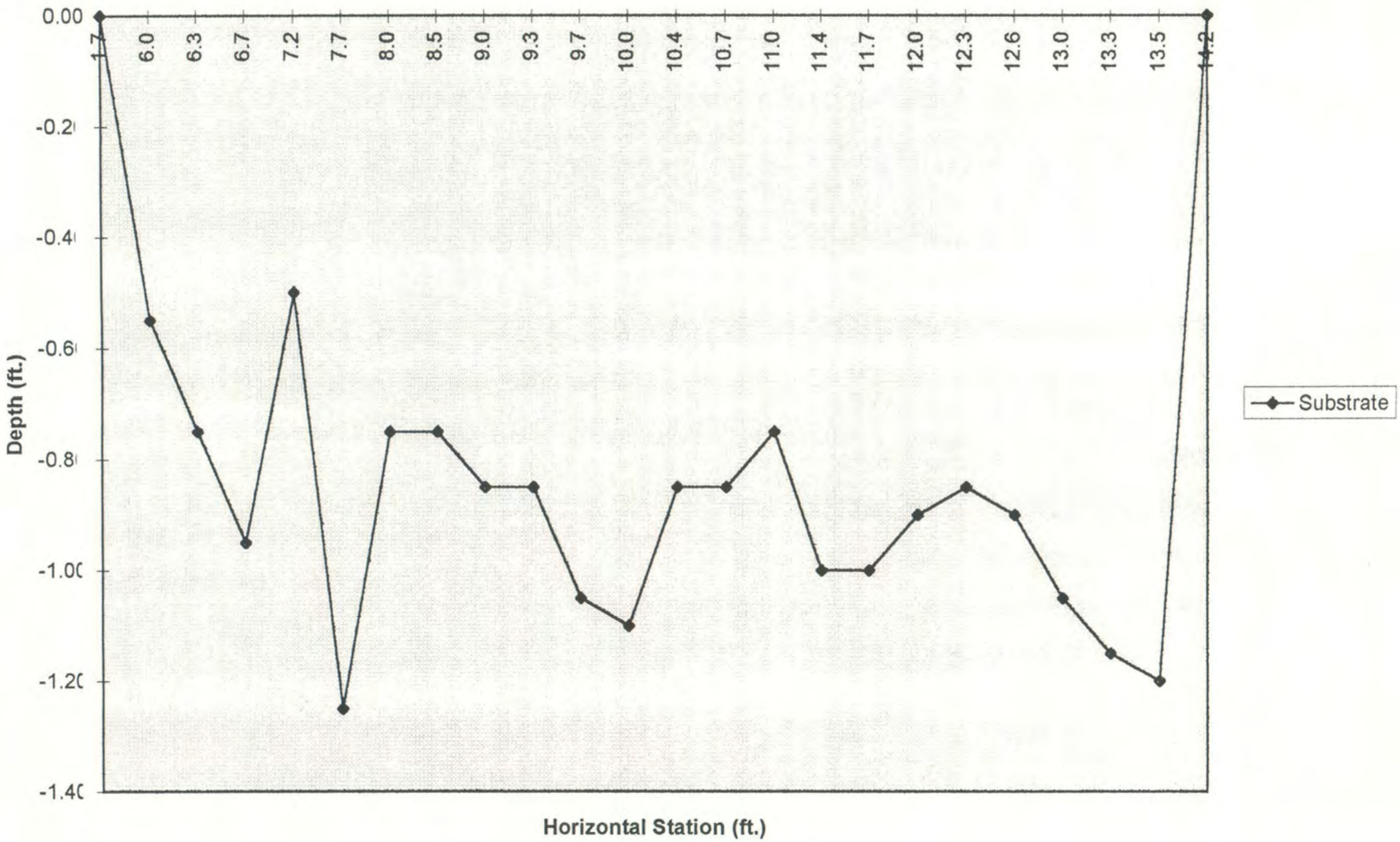
scharge Measurement for Stow Away #8-Cow Creek above Beaver Creek								
Date: 8/15/95								
Time: 9:00								
Stream Temperature: 53 F								
Crew: K. Minor, P. Branchfield								
Spin Test: 1:12 min.								
Field Notes: Page 152								
Station	Width	Depth	Velocity	Area	Discharge	Comments	Depth	
	(ft.)	(ft.)	(ft./sec.)	(sq. ft.)	(cfs)		(ft.)	
0.00						IP	0.00	
0.6						LEW	0.00	
3.3	1.70	0.40	0.583	0.680	0.40		-0.40	
4.0	0.60	0.45	0.694	0.270	0.19		-0.45	
4.5	0.50	0.90	0.596	0.450	0.27		-0.90	
5.0	0.50	0.90	0.916	0.450	0.41		-0.90	
5.5	0.50	0.80	0.842	0.400	0.34		-0.80	
6.0	0.50	0.75	0.652	0.375	0.24		-0.75	
6.5	0.50	0.60	0.453	0.300	0.14		-0.60	
7.0	0.50	0.60	0.253	0.300	0.08		-0.60	
7.5	0.50	0.65	0.526	0.325	0.17		-0.65	
8.0	0.50	0.50	1.020	0.250	0.26		-0.50	
8.5	0.50	0.50	0.299	0.250	0.07		-0.50	
9.0	0.50	0.55	1.460	0.275	0.40		-0.55	
9.5	0.50	0.60	1.450	0.300	0.44		-0.60	
10.0	0.50	0.45	1.140	0.225	0.26		-0.45	
10.5	0.50	0.45	1.390	0.225	0.31		-0.45	
11.0	0.50	0.55	1.250	0.275	0.34		-0.55	
11.5	0.50	0.45	0.726	0.225	0.16		-0.45	
12.0	0.50	0.50	1.000	0.250	0.25		-0.50	
12.5	0.50	0.50	0.639	0.250	0.16		-0.50	
13.0	0.50	0.45	0.810	0.225	0.18		-0.45	
13.5	0.50	0.30	0.665	0.150	0.10		-0.30	
14.0	0.50	0.40	0.743	0.200	0.15		-0.40	
14.5	0.50	0.60	0.493	0.300	0.15		-0.60	
15.0	0.50	0.40	0.794	0.200	0.16		-0.40	
15.5	0.50	0.40	1.000	0.200	0.20		-0.40	
16.0	0.50	0.45	0.361	0.225	0.08		-0.45	
16.5	0.50	0.35	0.409	0.175	0.07		-0.35	
17.0	1.05	0.30	0.052	0.315	0.02		-0.30	
18.6						REW	0.00	
21.4						IP		
				Q=	5.99	cfs		

Cow Creek above Beaver Creek Cross-Section at Discharge Measurement



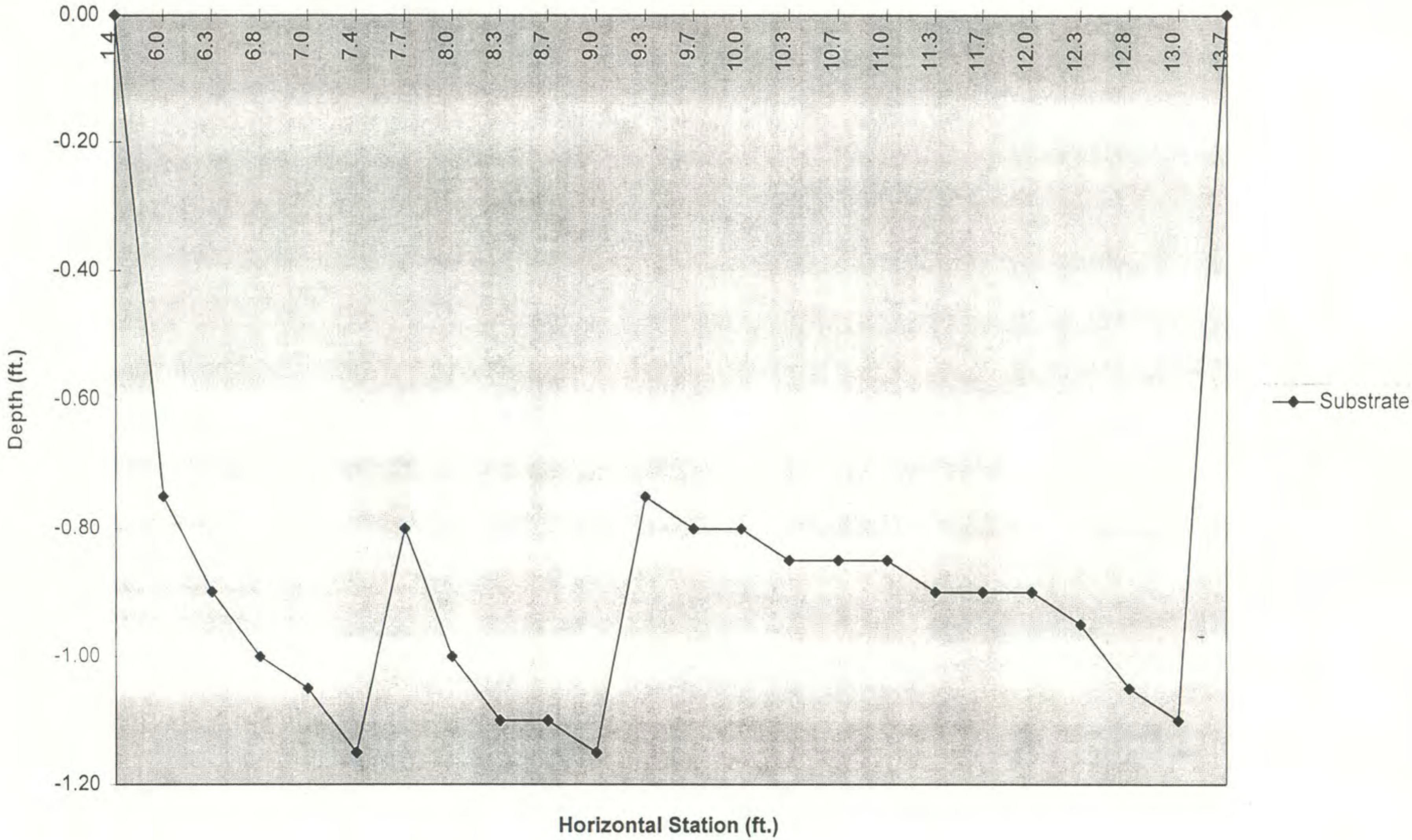
...scharge Measurement for Stow Away #9-East Fork Cow Creek							
...Date: 7/25/95							
Time: 10:50							
Stream Temperature: 56 F							
Crew: K. Minor, D. Helms							
Spin Test: 1:04 min.							
Field Notes: Page 86							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.0						IP	0.00
1.7						LEW	0.00
6.0	2.30	0.55	0.272	1.265	0.34		-0.55
6.3	0.35	0.75	0.272	0.263	0.07		-0.75
6.7	0.45	0.95	0.272	0.428	0.12		-0.95
7.2	0.50	0.50	0.147	0.250	0.04		-0.50
7.7	0.40	1.25	0.112	0.500	0.06		-1.25
8.0	0.40	0.75	0.170	0.300	0.05		-0.75
8.5	0.50	0.75	0.177	0.375	0.07		-0.75
9.0	0.40	0.85	0.199	0.340	0.07		-0.85
9.3	0.35	0.85	0.261	0.298	0.08		-0.85
9.7	0.35	1.05	0.333	0.368	0.12		-1.05
10.0	0.35	1.10	0.369	0.385	0.14		-1.10
10.4	0.35	0.85	0.610	0.298	0.18		-0.85
10.7	0.30	0.85	0.710	0.255	0.18		-0.85
11.0	0.35	0.75	0.710	0.263	0.19		-0.75
11.4	0.35	1.00	0.315	0.350	0.11		-1.00
11.7	0.30	1.00	0.315	0.300	0.09		-1.00
12.0	0.30	0.90	0.427	0.270	0.12		-0.90
12.3	0.30	0.85	0.444	0.255	0.11		-0.85
12.6	0.35	0.90	0.347	0.315	0.11		-0.90
13.0	0.35	1.05	0.101	0.368	0.04		-1.05
13.3	0.25	1.15	0.078	0.288	0.02		-1.15
13.5	0.45	1.20	0.084	0.540	0.05		-1.20
14.2						REW	0.00
16.3						IP	0.00
				Q=	**2.35**		

East Fork Cow Creek Cross-Section at Discharge Measurement

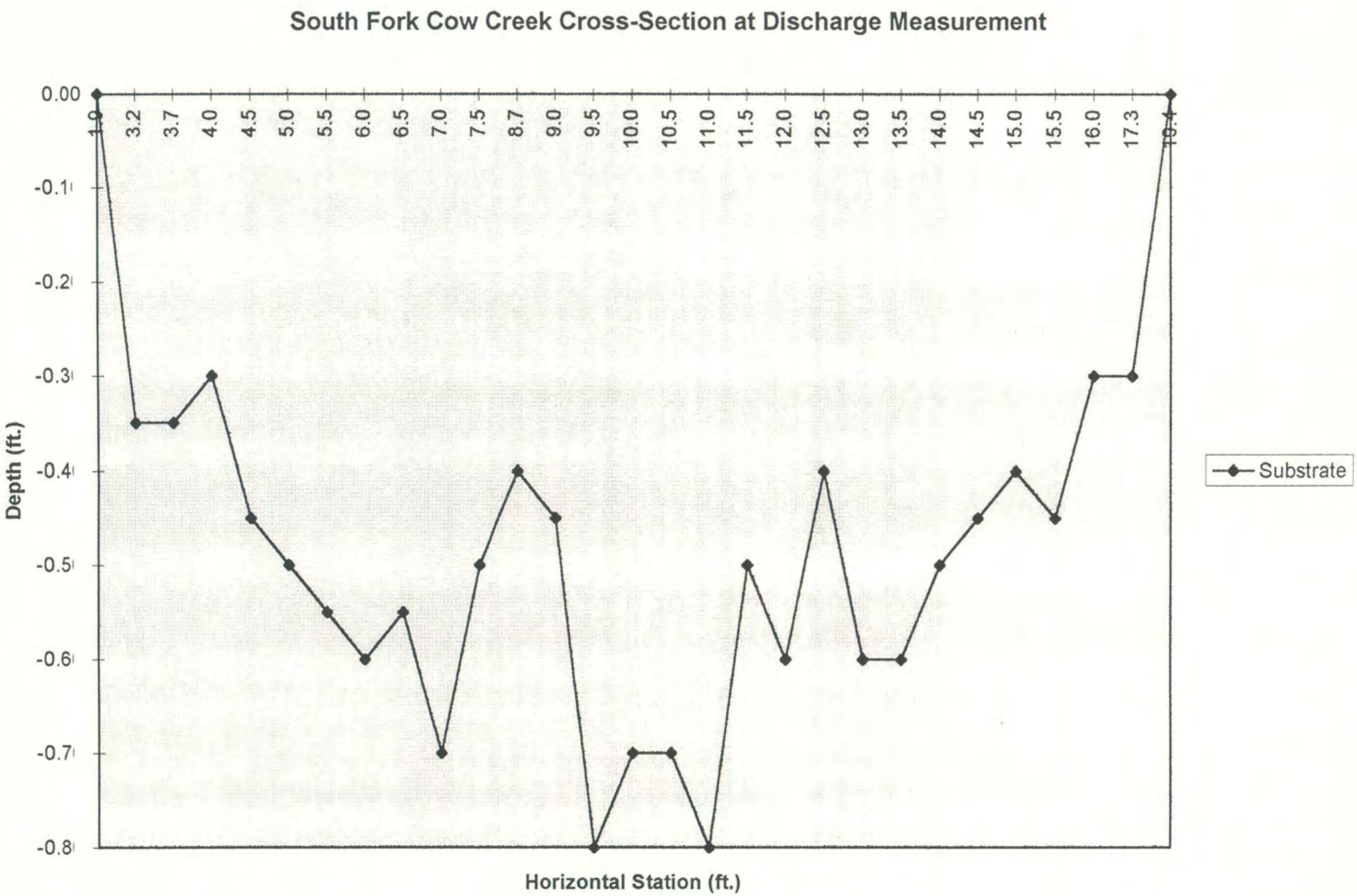


.charge Measurement for Stow Away #9-East Fork Cow Creek							
Date: 8/14/95							
Time: 12:15							
Stream Temperature: 52 F							
Crew: K. Minor, D. Helms							
Spin Test: 1:06 min.							
Field Notes: Page 142							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.0						IP	0.00
1.4						LEW	0.00
6.0	2.45	0.75	0.170	1.838	0.31		-0.75
6.3	0.40	0.90	0.255	0.360	0.09		-0.90
6.8	0.35	1.00	0.150	0.350	0.05		-1.00
7.0	0.30	1.05	0.082	0.315	0.03		-1.05
7.4	0.35	1.15	0.061	0.403	0.02		-1.15
7.7	0.30	0.80	0.104	0.240	0.02		-0.80
8.0	0.30	1.00	0.120	0.300	0.04		-1.00
8.3	0.35	1.10	0.202	0.385	0.08		-1.10
8.7	0.35	1.10	0.266	0.385	0.10		-1.10
9.0	0.30	1.15	0.202	0.345	0.07		-1.15
9.3	0.35	0.75	0.266	0.263	0.07		-0.75
9.7	0.35	0.80	0.347	0.280	0.10		-0.80
10.0	0.30	0.80	0.347	0.240	0.08		-0.80
10.3	0.35	0.85	0.404	0.298	0.12		-0.85
10.7	0.35	0.85	0.516	0.298	0.15		-0.85
11.0	0.30	0.85	0.435	0.255	0.11		-0.85
11.3	0.35	0.90	0.340	0.315	0.11		-0.90
11.7	0.35	0.90	0.212	0.315	0.07		-0.90
12.0	0.30	0.90	0.255	0.270	0.07		-0.90
12.3	0.40	0.95	0.272	0.380	0.10		-0.95
12.8	0.35	1.05	0.147	0.368	0.05		-1.05
13.0	0.45	1.10	0.089	0.495	0.04		-1.10
13.7						REW	0.00
16.2						IP	0.00
				Q=	**1.90**	**cfs**	

EF Cow Creek Cross-Section at Discharge Measurement

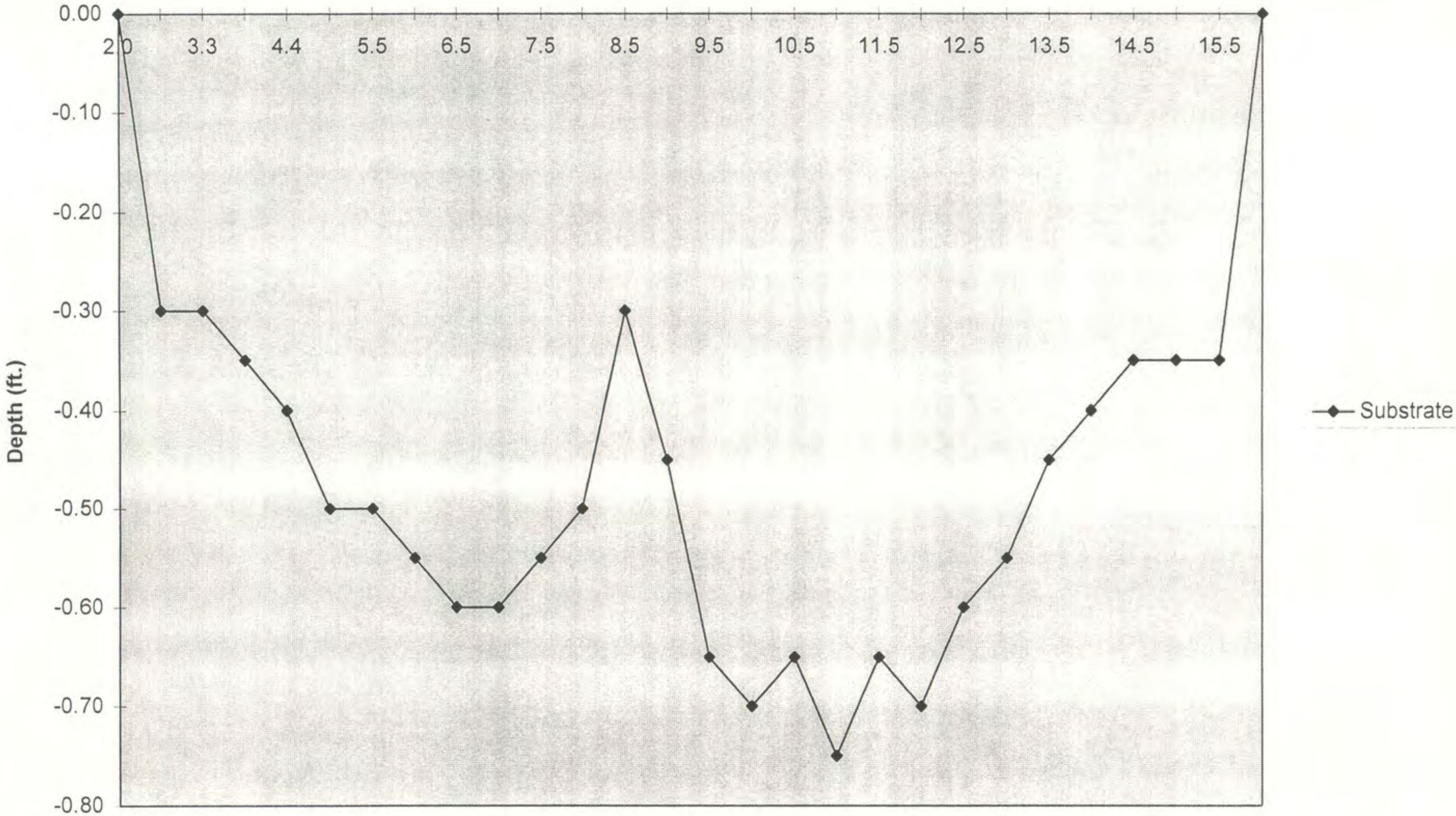


charge Measurement for Stow Away #10-South Fork Cow Creek							
ate: 7/25/95							
Time: 12:30							
Stream Temperature: 57 F							
Crew: K. Minor, D. Helms							
Spin Test: 1:03 min.							
Field Notes: Page 90							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.0						IP	0.00
1.9						LEW	0.00
3.2	0.90	0.35	0.305	0.315	0.10		-0.35
3.7	0.40	0.35	0.069	0.140	0.01		-0.35
4.0	0.40	0.30	0.137	0.120	0.02		-0.30
4.5	0.50	0.45	0.170	0.225	0.04		-0.45
5.0	0.50	0.50	0.310	0.250	0.08		-0.50
5.5	0.50	0.55	0.347	0.275	0.10		-0.55
6.0	0.50	0.60	0.427	0.300	0.13		-0.60
6.5	0.50	0.55	1.420	0.275	0.39		-0.55
7.0	0.50	0.70	1.250	0.350	0.44		-0.70
7.5	0.85	0.50	1.160	0.425	0.49		-0.50
8.7	0.75	0.40	0.710	0.300	0.21		-0.40
9.0	0.40	0.45	1.090	0.180	0.20		-0.45
9.5	0.50	0.80	2.060	0.400	0.82		-0.80
10.0	0.50	0.70	3.080	0.350	1.08		-0.70
10.5	0.50	0.70	3.280	0.350	1.15		-0.70
11.0	0.50	0.80	1.850	0.400	0.74		-0.80
11.5	0.50	0.50	1.690	0.250	0.42		-0.50
12.0	0.50	0.60	0.305	0.300	0.09		-0.60
12.5	0.50	0.40	0.266	0.200	0.05		-0.40
13.0	0.50	0.60	0.354	0.300	0.11		-0.60
13.5	0.50	0.60	0.187	0.300	0.06		-0.60
14.0	0.50	0.50	0.419	0.250	0.10		-0.50
14.5	0.50	0.45	1.480	0.225	0.33		-0.45
15.0	0.50	0.40	0.958	0.200	0.19		-0.40
15.5	0.50	0.45	1.420	0.225	0.32		-0.45
16.0	0.90	0.30	1.050	0.270	0.28		-0.30
17.3	1.70	0.30	1.300	0.510	0.66		-0.30
19.4						REW	0
22.3						IP	
				Q=	**8.61**		

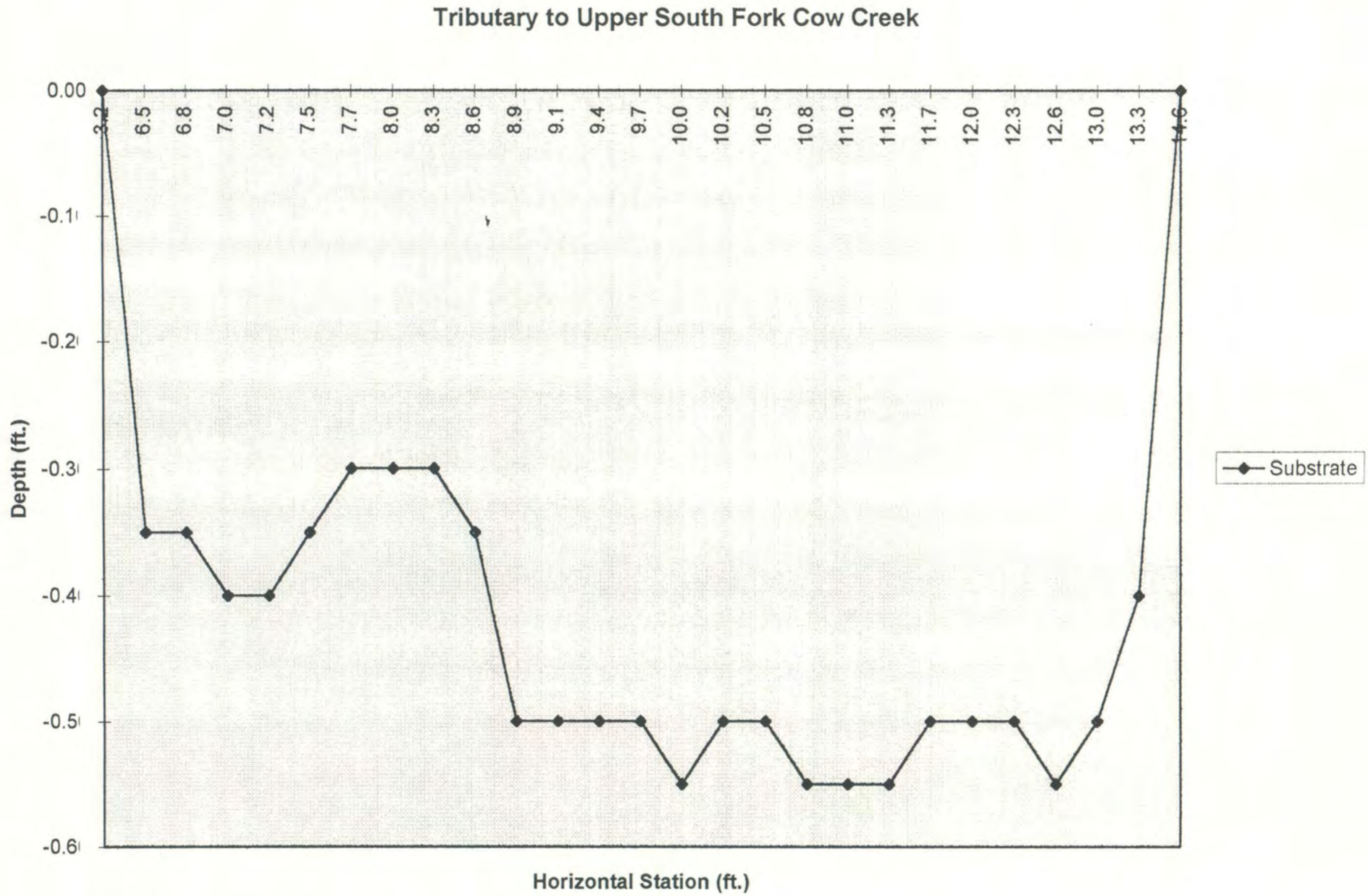

South Fork Cow Creek Cross-Section at Discharge Measurement
0.00
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
Depth (ft.)
3.2
3.7
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.7
9.0
9.5
10.0
10.5
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5
15.0
15.5
16.0
17.3
Horizontal Station (ft.)
Substrate

ischarge Measurement for Stow Away #10-South Fork Cow Creek							
Date: 8/14/95							
Time: 13:35							
Stream Temperature: 54 F							
Crew: K. Minor, D. Helms							
Spin Test: 1:25 min.							
Field Notes: Page 148							
Station	Width	Depth	Velocity	Area	Discharge	Comments	Depth
	(ft.)	(ft.)	(ft./sec.)	(sq. ft.)	(cfs)		(ft.)
0.0						IP	0.00
2.0						LEW	0.00
2.6	0.65	0.30	0.285	0.195	0.06		-0.30
3.3	0.70	0.30	0.076	0.210	0.02		-0.30
4.0	0.55	0.35	0.000	0.193	0.00		-0.35
4.4	0.50	0.40	0.052	0.200	0.01		-0.40
5.0	0.55	0.50	0.000	0.275	0.00		-0.50
5.5	0.50	0.50	0.144	0.250	0.04		-0.50
6.0	0.50	0.55	0.596	0.275	0.16		-0.55
6.5	0.50	0.60	1.020	0.300	0.31		-0.60
7.0	0.50	0.60	2.110	0.300	0.63		-0.60
7.5	0.50	0.55	1.390	0.275	0.38		-0.55
8.0	0.50	0.50	0.240	0.250	0.06		-0.50
8.5	0.50	0.30	0.505	0.150	0.08		-0.30
9.0	0.50	0.45	0.878	0.225	0.20		-0.45
9.5	0.50	0.65	1.330	0.325	0.43		-0.65
10.0	0.50	0.70	2.510	0.350	0.88		-0.70
10.5	0.50	0.65	3.360	0.325	1.09		-0.65
11.0	0.50	0.75	2.250	0.375	0.84		-0.75
11.5	0.50	0.65	1.420	0.325	0.46		-0.65
12.0	0.50	0.70	0.559	0.350	0.20		-0.70
12.5	0.50	0.60	0.340	0.300	0.10		-0.60
13.0	0.50	0.55	0.232	0.275	0.06		-0.55
13.5	0.50	0.45	0.327	0.225	0.07		-0.45
14.0	0.50	0.40	0.444	0.200	0.09		-0.40
14.5	0.50	0.35	0.810	0.175	0.14		-0.35
15.0	0.50	0.35	0.916	0.175	0.16		-0.35
15.5	2.05	0.35	0.482	0.718	0.35		-0.35
19.1						REW	0.00
22.0						IP	
				Q=	6.82	cfs	

SF Cow Creek Cross-Section at Discharge Measurement

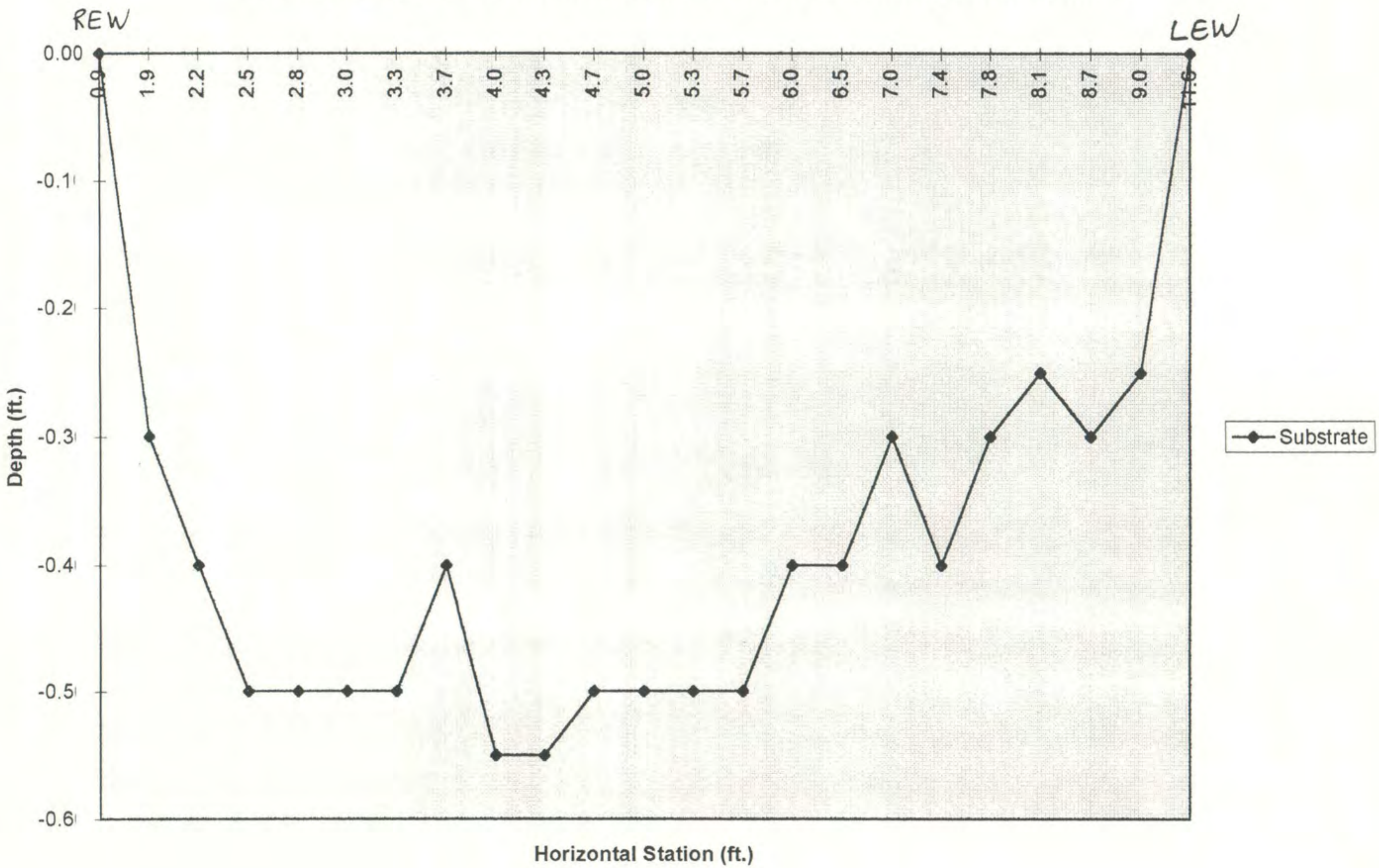


;charge Measurement for Stow Away #11-Tributary to Upper South Fork Cow Creek							
~ate: 7/27/95							
Time: 9:40							
Crew: K. Minor, J. Stafford							
Spin Test: 1:22min.							
Field Notes: Page 122							
Station	Width	Depth	Velocity	Area	Discharge	Comments	Depth
	(ft.)	(ft.)	(ft./sec.)	(sq. ft.)	(cfs)		(ft.)
0.00						IP	0.00
3.2						LEW	0.00
6.5	1.80	0.35	0.626	0.630	0.39		-0.35
6.8	0.25	0.35	1.110	0.088	0.10		-0.35
7.0	0.20	0.40	1.360	0.080	0.11		-0.40
7.2	0.25	0.40	1.460	0.100	0.15		-0.40
7.5	0.25	0.35	1.730	0.088	0.15		-0.35
7.7	0.25	0.30	1.660	0.075	0.12		-0.30
8.0	0.30	0.30	1.390	0.090	0.13		-0.30
8.3	0.30	0.30	1.360	0.090	0.12		-0.30
8.6	0.30	0.35	1.190	0.105	0.12		-0.35
8.9	0.25	0.50	0.916	0.125	0.11		-0.50
9.1	0.25	0.50	1.110	0.125	0.14		-0.50
9.4	0.30	0.50	1.000	0.150	0.15		-0.50
9.7	0.30	0.50	1.090	0.150	0.16		-0.50
10.0	0.25	0.55	0.981	0.138	0.13		-0.55
10.2	0.25	0.50	0.516	0.125	0.06		-0.50
10.5	0.30	0.50	0.199	0.150	0.03		-0.50
10.8	0.25	0.55	0.165	0.138	0.02		-0.55
11.0	0.25	0.55	0.126	0.138	0.02		-0.55
11.3	0.35	0.55	0.199	0.193	0.04		-0.55
11.7	0.35	0.50	0.168	0.175	0.03		-0.50
12.0	0.30	0.50	0.137	0.150	0.02		-0.50
12.3	0.30	0.50	0.272	0.150	0.04		-0.50
12.6	0.35	0.55	0.394	0.193	0.08		-0.55
13.0	0.35	0.50	0.305	0.175	0.05		-0.50
13.3	0.80	0.40	0.394	0.320	0.13		-0.40
14.6						REW	0.00
15.4						IP	
				Q=	2.61	cfs	

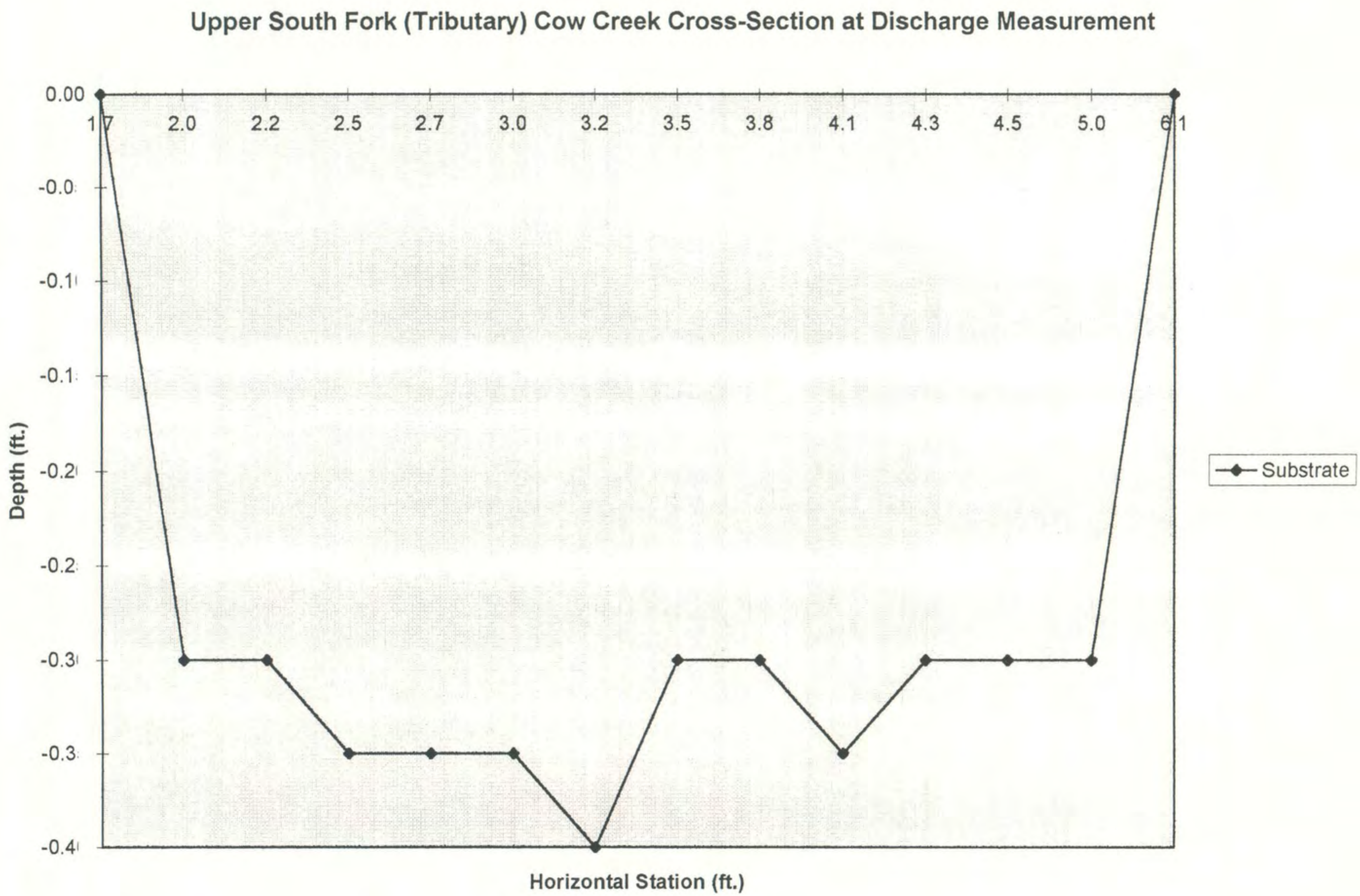

Tributary to Upper South Fork Cow Creek
0.00
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
Depth (ft.)
3.2
6.5
6.8
7.0
7.2
7.5
7.7
8.0
8.3
8.6
8.9
9.1
9.4
9.7
10.0
10.2
10.5
10.8
11.0
11.3
11.7
12.0
12.3
12.6
13.0
13.3
14.6
Horizontal Station (ft.)
Substrate

...scharge Measurement for Stow Away #11-Tributary to Upper South Fork Cow Creek							
Date: 8/14/95							
Time: 9:05							
Stream Temperature: 47 F							
Crew: K. Minor, D. Helms							
Spin Test: 1:27min.							
Field Notes: Page 136							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.00						IP	0.00
0.9						REW	0.00
1.9	0.65	0.30	0.144	0.195	0.03		-0.30
2.2	0.30	0.40	0.236	0.120	0.03		-0.40
2.5	0.30	0.50	0.354	0.150	0.05		-0.50
2.8	0.25	0.50	0.347	0.125	0.04		-0.50
3.0	0.25	0.50	0.199	0.125	0.02		-0.50
3.3	0.35	0.50	0.183	0.175	0.03		-0.50
3.7	0.35	0.40	0.194	0.140	0.03		-0.40
4.0	0.30	0.55	0.130	0.165	0.02		-0.55
4.3	0.35	0.55	0.142	0.193	0.03		-0.55
4.7	0.35	0.50	0.571	0.175	0.10		-0.50
5.0	0.30	0.50	1.070	0.150	0.16		-0.50
5.3	0.35	0.50	0.981	0.175	0.17		-0.50
5.7	0.35	0.50	0.761	0.175	0.13		-0.50
6.0	0.40	0.40	1.090	0.160	0.17		-0.40
6.5	0.50	0.40	1.360	0.200	0.27		-0.40
7.0	0.45	0.30	1.420	0.135	0.19		-0.30
7.4	0.40	0.40	1.690	0.160	0.27		-0.40
7.8	0.35	0.30	1.500	0.105	0.16		-0.30
8.1	0.45	0.25	1.390	0.113	0.16		-0.25
8.7	0.45	0.30	0.937	0.135	0.13		-0.30
9.0	1.45	0.25	0.761	0.363	0.28		-0.25
11.6						LEW	0.00
				Q=	2.48	cfs	

Tributary to Upper SF Cow Creek Cross-Section at Discharge Measurement



.charge Measurement for Stow Away #12-Upper South Fork (Tributary) Cow Creek							
ᴗate: 7/27/95							
Time: 10:30							
Crew: K. Minor, J. Stafford							
Spin Test: 1:08min.							
Field Notes: Page 126							
Station	**Width**	**Depth**	**Velocity**	**Area**	**Discharge**	**Comments**	**Depth**
	(ft.)	**(ft.)**	**(ft./sec.)**	**(sq. ft.)**	**(cfs)**		**(ft.)**
0.00						IP	0.00
1.7						LEW	0.00
2.0	0.25	0.30	0.305	0.075	0.02		-0.30
2.2	0.25	0.30	0.147	0.075	0.01		-0.30
2.5	0.25	0.35	0.427	0.088	0.04		-0.35
2.7	0.25	0.35	0.810	0.088	0.07		-0.35
3.0	0.25	0.35	0.981	0.088	0.09		-0.35
3.2	0.25	0.40	0.427	0.100	0.04		-0.40
3.5	0.30	0.30	0.394	0.090	0.04		-0.30
3.8	0.30	0.30	0.394	0.090	0.04		-0.30
4.1	0.25	0.35	0.079	0.088	0.01		-0.35
4.3	0.20	0.30	0.126	0.060	0.01		-0.30
4.5	0.35	0.30	0.052	0.105	0.01		-0.30
5.0	0.80	0.30	0.052	0.240	0.01		-0.30
6.1						REW	0.00
7.7						IP	
				Q=	**0.37**	**cfs**	

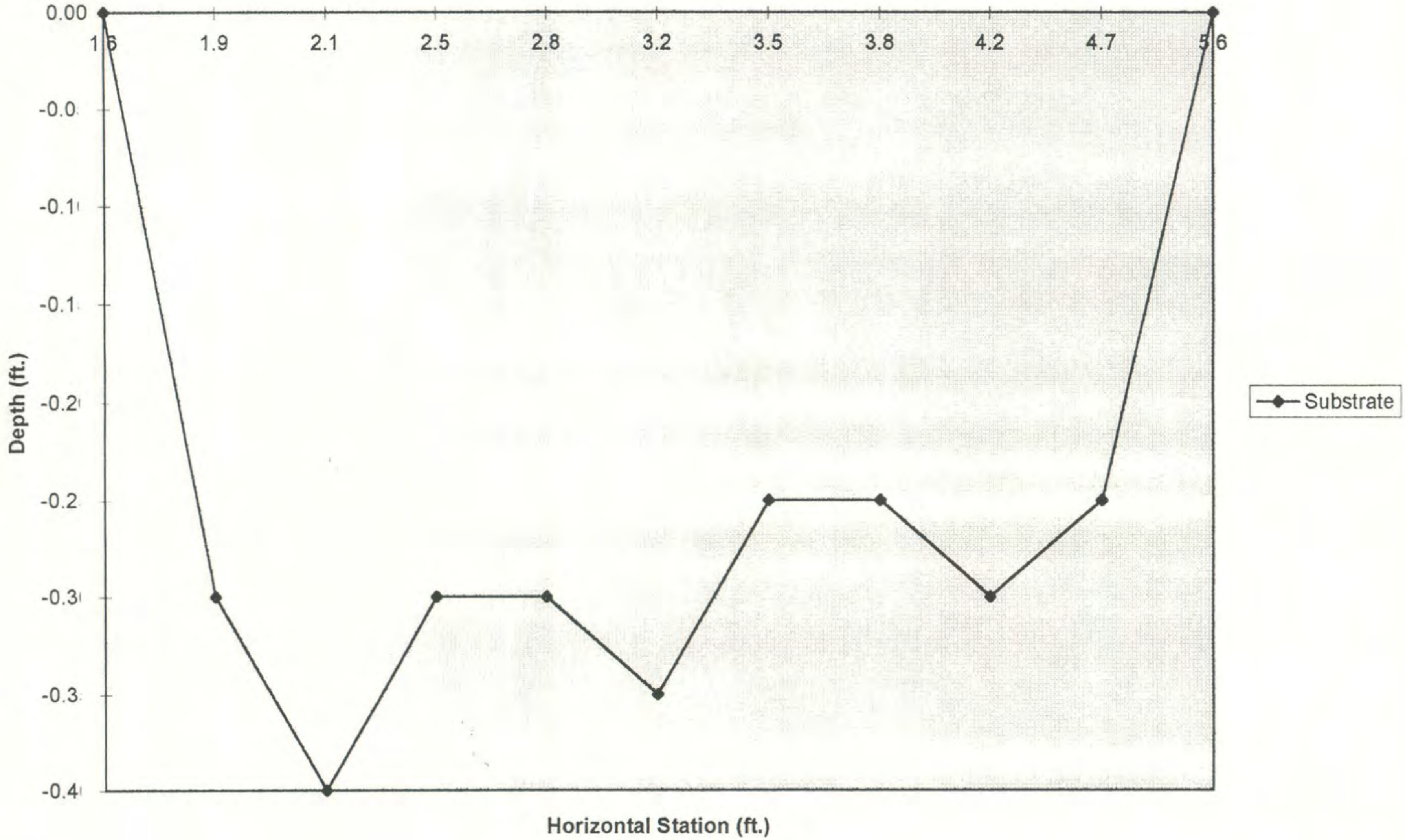


Upper South Fork (Tributary) Cow Creek Cross-Section at Discharge Measurement
0.00
-0.0
-0.1
-0.1
-0.2
-0.2
-0.3
-0.3
-0.4
1.7
2.0
2.2
2.5
2.7
3.0
3.2
3.5
3.8
4.1
4.3
4.5
5.0
6.1
Depth (ft.)
Horizontal Station (ft.)
Substrate

Q8-14-95

;charge Measurement for Stow Away #12-Upper South Fork (Tributary) Cow Creek							
Date: 8/14/95							
Time: 9:55							
Stream Temperature: 49 F							
Crew: K. Minor, D. Helms							
Spin Test: 1:18min.							
Field Notes: Page 140							
Station	Width	Depth	Velocity	Area	Discharge	Comments	Depth
	(ft.)	(ft.)	(ft./sec.)	(sq. ft.)	(cfs)		(ft.)
0.00						IP	0.00
1.6						LEW	0.00
1.9	0.25	0.30	0.240	0.075	0.02		-0.30
2.1	0.30	0.40	0.199	0.120	0.02		-0.40
2.5	0.35	0.30	0.245	0.105	0.03		-0.30
2.8	0.35	0.30	0.842	0.105	0.09		-0.30
3.2	0.35	0.35	0.377	0.123	0.05		-0.35
3.5	0.30	0.25	0.361	0.075	0.03		-0.25
3.8	0.35	0.25	0.548	0.088	0.05		-0.25
4.2	0.45	0.30	0.079	0.135	0.01		-0.30
4.7	0.70	0.25	0.000	0.175	0.00		-0.25
5.6						REW	0.00
				Q=	0.29	cfs	

Upper SF Cow Creek (Trib.) Cross-Section at Discharge Measurement



Appendix D

Channel Extension

Evaluating the Hydrologic Interaction of Roads and Streams in Cow Creek

Beverly Wemple, in her 1994 MS thesis "Hydrologic Integration of Forest Roads with Stream Networks in Two Basins, Western Cascades, Oregon", Oregon State University, assessed how logging-access roads may have contributed to observed historical increases in peak discharges associated with small and large basins in the western Cascades of Oregon. She examined potential road effects on hydrology using a combination of field surveys and spatial modeling with a GIS.

Twenty percent of the road length was sampled in each of the two basins to assess routing of surface flow. Transects were stratified by decade of construction and hillslope position. Along each transect, ditches and culvert outlets were surveyed to predict the probable routing of water to (1) existing stream channels, (2) newly eroded gullies downslope of culvert outlets, or (3) subsurface flow. Wemple found that 60 percent of the surveyed road length appeared to route water directly to stream channels or into gullies. As road construction has progressed from valley bottom roads up the hillslope, the length of road directly connected to stream crossings decreased while the length of road draining to gullies has remained relatively constant, suggesting that roads have the potential to become integrated into stream networks, even when constructed on unchanneled hillslopes. Wemple concluded from her study that (1) roads function as surface flowpaths to channel appreciable volumes of runoff, (2) a substantial portion of the road network in her study area is hydrologically integrated into the stream network, and (3) a number of factors influence the magnitude of road impacts on streamflow.

The Cow Creek Watershed Analysis Team used Wemple's process and refined an inventory procedure to evaluate the connection of roads and hydrologic function. Kathy Minor, Paul Uncapher, Mikeal Jones, and Bill Kimball have all provided input into portions of this process.

Cow Creek has approximately 163 miles of road which are in the Forest Travel Management System Database. These roads are in a variety of age classes, surface types, and maintenance levels. The total miles of road in the Cow Creek watershed on Forest Service, BLM, and private is unknown and it should be noted that field surveys were only conducted only on the 163 miles of road in the database.

The survey area was stratified by WAA (85-6200 acres). Consultation with several road managers and engineers suggested that there is a difference in how road drainage was incorporated into the road design between surfaced roads and roads with native surfaces. The assumption was that surfaced roads generally had a higher percentage of ditches and culverts, and that native surfaced roads tended to be outsloped with minimal culverts. Native surfaced roads also tended to be short spurs out to ridgetops to access landings.

An attempt was made to sample about 20 percent of the roads within each WAA. This sample set was to include a 20 percent sample of each road type (surfaced or native surfaced). A conscious attempt was made to maintain a representative sample of ridgetop, midslope, and valley bottom roads in each WAA. The sample selection was done by Kathy Minor and is recognized as a non-random sample; however, care was made to consistently select sample reaches that would provide representative information.

Due to time constraints for the study, limited access on some of the native surfaced roads, and the extremely small size of some of the WAA's, a 20 percent sample was not achieved in every WAA. Table 20 shows the percent of the roads within each WAA by road type which was sampled. Approximately 19 percent of the surfaced roads and 6 percent of the native surfaced roads in Cow Creek were sampled. A total of 18 percent of all the roads were sampled.

Table 20. Roads sampled for channel extension.

WAA	Surfaced Roads (mi.)	Native Roads (mi.)	Total Road Miles	Surfaced Sampled (mi.)	Native Sampled (mi.)	Total Sampled (mi.)	Percent Surfaced Sampled	Percent Native Sampled	Percent Total Sampled
02A	4.21	0.02	4.23	1.248	0	1.248	29.64%	0.00%	29.50%
02B	19.27	6.34	26.18	5.32	0	5.32	27.61%	0.00%	20.32%
02C	23.64	1.56	25.2	4.513	0	4.513	19.09%	0.00%	17.91%
02D	15.51	1.82	17.33	5.617	0	5.617	36.22%	0.00%	32.41%
02E	9.02	0.49	9.51	0.446	0	0.446	4.94%	0.00%	4.69%
02F	31.99	0.88	32.87	5.093	0	5.093	15.92%	0.00%	15.49%
02L	3.25	0.23	3.48	0.058	0	0.058	1.78%	0.00%	1.67%
02M	1.23	0.93	2.16	0.463	0.286	0.749	37.64%	30.75%	34.68%
02N	0.57	0	0.57	0.232	0	0.232	40.70%	0.00%	40.70%
02Q	6.41	0	6.41	0	0	0	0.00%	0.00%	0.00%
02R	0.65	0	0.65	0	0	0	0.00%	0.00%	0.00%
02S	2.78	0	2.78	0.244	0	0.244	8.78%	0.00%	8.78%
02T	6.79	1.15	7.94	1.832	0.547	2.379	26.98%	47.57%	29.96%
02U	4.69	0.44	5.13	1.242	0.191	1.433	26.48%	43.41%	27.93%
02V	8.99	2.22	11.21	2.246	0	2.246	24.98%	0.00%	20.04%
02X	2.18	0	2.18	0	0	0	0.00%	0.00%	0.00%
02Y	0.65	0	0.65	0	0	0	0.00%	0.00%	0.00%
02Z	5.48	0	5.48	0	0	0	0.00%	0.00%	0.00%
Total	147.31	16.08	163.96	28.554	1.024	29.578	19.38%	6.37%	18.04%
%Total	89.85%	9.81%							

Information collected in the field at each sample transect included:

- Mileage from beginning of transect
- Length of ditchline drained
- Drain type (culvert, grade break, dip, lead-off ditch)

- Culvert diameter
- Flow type (ditch to stream, ditch to subsurface, ditch to gully)
- Gully type
- Ditchline grade to drain type
- Downhill slope (slope below fill slope)
- Culvert plunge height
- Upslope vegetation (clearcut, plantation, uncut, natural meadow)
- Soil/rock contact (exposure of soil/rock contact in cut slope)
- Comments (important anecdotal information)

Table 21 shows the results of the entire survey, Table 22 details the survey results for surfaced roads, Table 23 details the survey results for native surfaced roads, and Table 24 shows the estimate of channel extension by WAA. The analysis of sample results shows that the ditchlines on roads in the Cow Creek watershed contributing runoff to surface flowpaths, streams and culvert outfalls forming gullies, was 11.4 miles. The total road length surveyed was 29.6 miles; therefore 38.6 percent of the roads surveyed contribute to surface flowpaths.

Stratifying the results of the sample road surveys to surfaced versus native surfaced roads, ditchline length contributing to surface flowpaths (streams and gullies) was 39.4 percent of the road length on surfaced roads and 14.9 percent of the road length on native surfaced roads (see Table 22 and Table 23).

To determine the percent increase that these ditchline flowpaths represent over the existing stream channel network in Cow Creek, the length of intermittent streams showing evidence of scour and deposition (FEMAT 1993) were estimated. Streams were sampled (approximately eight percent of the basin) and channel lengths estimated according to drainage density (see Stream Classification section, pages 19-22). Total estimated streams within the Forest Service Cow Creek watershed boundary is 222 miles. Wemple (1994) estimated a winter stream network that was shorter than an estimated high flow stream network. The scour and deposition network of 222 miles estimated for Cow Creek more closely resembles Wemple's shorter winter baseflow network.

In each of the 18 WAA's in Cow Creek, the average percentages of surfaced and native surfaced roads contributing ditch runoff to streams and gullies were multiplied by the miles of road in these categories, respectively. The sums of these were divided by the winter baseflow stream length estimated in each WAA and expressed as a percentage increase in channel length, or percent channel extension (see Table 24). Channel extension ranged from 15.6 percent in WAA 02E (Dismal Creek) to 48.6 percent in WAA 02U (unnamed tributaries to Lower Cow Creek). Average channel extension was 27.2 percent in Cow Creek. It should be noted that channel extension estimates would be lower if applied to a highflow stream network. The results by WAA are shown in the last column of Table 24.

Table 21. Results of channel extension survey.

SHEET NO.	# CMP'S	TOTAL RD LENGTH (MI.)	DRAIN TYPE* #			ASSOC. LENGTH / TYPE (FT.)			AVG LENGTH / TYPE (FT.)			Surfacing	WAA
			1	2	3	1	2	3	1	2	3		
5-15-3	9	0.888	0	4	5	0	1423	3626	0	356	725	AGG	02A
5-16-3	8	0.360	0	2	5	0	429	1413	0	215	283	AGG	02A
5-24-2	7	0.640	1	3	3	699	875	1371	699	292	457	AGG	02B
5-24-3	12	0.518	2	7	3	428	1653	838	214	236	279	AGG	02B
6-6-4	10	0.628	0	10	0	0	2787	0	0	279	0	AGG	02B
6-6-5	9	0.870	0	9	0	0	4918	0	0	546	0	AGG	02B
6-6-6	5	0.292	0	5	0	0	883	0	0	177	0	AGG	02B
6-6-7	8	0.361	0	8	0	0	2222	0	0	278	0	AGG	02B
6-6-8	5	0.274	0	5	0	0	1326	0	0	265	0	AGG	02B
6-6-9	8	0.381	0	5	3	0	1390	954	0	278	318	AGG	02B
6-6-11	1	0.054	0	1	0	0	283	0	0	283	0	AGG	02B
6-12-4	2	0.319	2	0	0	1669	0	0	835	0	0	AGG	02B
6-12-5	1	0.197	0	1	0	0	614	0	0	614	0	AGG	02B
6-12-6	4	0.429	0	4	0	0	2313	0	0	578	0	AGG	02B
6-12-7	2	0.357	0	0	2	0	0	1505	0	377	753	AGG	02B
5-24-1	8	0.388	0	3	5	0	783	1276	0	261	255	AGG	02C
5-24-4	9	0.579	1	7	1	200	2277	584	200	325	584	AGG	02C
5-24-5	8	0.568	3	2	3	1226	880	939	409	440	313	AGG	02C
5-24-6	12	0.378	0	11	1	0	1926	351	0	175	351	AGG	02C
5-24-7	1	0.037	1	0	0	196	0	0	196	0	0	AGG	02C
6-12-1	7	0.478	2	5	0	727	1702	0	364	340	0	AGG	02C
6-12-2	5	0.609	0	5	0	0	2517	0	0	503	0	AGG	02C
6-12-3	0	0.269	0	0	0	0	0	0	0	0	0	AGG	02C
6-12-8	7	0.502	2	5	0	892	1676	0	446	335	0	AGG	02C
6-12-9	3	0.487	1	2	0	1057	1510	0	1057	755	0	AGG	02C
6-12-10	6	0.218	0	6	0	0	1594	0	0	266	0	AGG	02C
5-16-1	6	0.597	0	3	3	0	935	1722	0	312	574	AGG	02D
5-16-5	6	0.659	2	3	1	1505	1427	322	753	476	322	AGG	02D
5-16-6	6	0.255	1	5	0	360	1100	0	360	220	0	AGG	02D
5-16-7	7	0.405	2	5	0	671	1414	0	336	283	0	AGG	02D
5-16-8	5	0.325	0	7	0	0	1712	0	0	245	0	AGG	02D
5-16-9	5	0.407	0	3	2	0	973	547	0	324	274	AGG	02D
5-16-10	3	0.519	0	3	0	0	1057	0	0	352	0	AGG	02D
5-22-1	11	0.760	2	3	6	2661	1088	1792	1331	363	299	AGG	02D
5-22-2	5	0.207	0	5	0	0	1252	0	0	250	0	AGG	02D
5-22-3	8	0.630	0	5	3	0	2094	1403	0	419	468	AGG	02D
5-22-7	7	0.853	2	4	1	1311	2417	777	656	604	777	AGG	02D
6-19-3	5	0.446	1	3	1	606	932	361	606	311	361	AGG	02E
6-19-4	8	0.523	1	7	0	317	1592	0	317	227	0	AGG	02F
5-22-4	9	0.622	4	4	1	1604	1339	800	401	335	800	AGG	02F
5-22-5	0	0.407	0	0	0	0	0	0	0	0	0	AGG	02F

SHEET NO.	# CMP'S	TOTAL RD LENGTH (MI.)	DRAIN TYPE* #			ASSOC. LENGTH / TYPE (FT.)			AVG LENGTH / TYPE (FT.)			Surfacing	WAA
			1	2	3	1	2	3	1	2	3		
5-22-6	9	0.487	2	6	1	457	1663	234	229	277	234	AGG	02F
5-22-8	4	0.113	2	2	0	324	516	0	162	258	0	AGG	02F
6-5-1	7	0.398	2	5	0	801	1106	0	401	221	0	AGG	02F
6-5-2	2	0.076	0	2	0	0	484	0	0	242	0	AGG	02F
6-5-3	11	0.449	6	5	0	1664	1082	0	277	216	0	AGG	02F
6-5-4	2	0.180	1	1	0	509	441	0	509	441	0	AGG	02F
6-5-5	9	0.839	3	4	2	1195	1825	753	398	456	377	AGG	02F
6-5-6	6	0.393	1	4	1	405	1362	106	405	341	106	AGG	02F
6-5-7	0	0.254	0	0	0	0	0	0	0	0	0	AGG	02F
6-5-8	0	0.352	0	0	0	0	0	0	0	0	0	AGG	02F
6-19-2	0	0.058	0	0	0	0	0	0	0	0	0	AC	02L
5-16-4	2	0.463	2	0	0	928	0	0	464	0	0	AC	02M
5-16-2	3	0.286	0	3	0	0	1165	0	0	388	0	NAT	02M
5-16-1	1	0.232	0	0	1	0	0	560	0	0	560	AC	02N
6-19-1	1	0.244	0	1	0	0	731	0	0	731	0	AC	02S
5-15-4	8	0.616	2	0	7	393	0	2807	197	0	401	AGG	02T
5-15-6	10	0.667	2	6	2	863	1796	853	432	299	427	AGG	02T
5-15-7	5	0.549	1	2	2	669	1168	1632	669	584	816	AGG	02T
5-15-10	1	0.000	0	0	0	0	0	0	0	0	0	AGG	02T
5-15-8	0	0.217	0	0	0	0	0	0	0	0	0	NAT	02T
5-15-9	1	0.330	0	1	0	0	1740	0	0	1740	0	NAT	02T
5-15-2	6	0.588	0	0	5	0	0	2287	0	0	457	AC	02U
5-15-1	7	0.654	0	3	4	0	1102	1300	0	367	325	AGG	02U
5-15-5	2	0.191	1	0	0	806	0	0	806	0	0	NAT	02U
6-5-9	5	0.347	0	1	4	0	496	1305	0	496	326	AGG	02V
6-6-1	7	0.649	2	3	2	1071	1149	1205	536	383	603	AGG	02V
6-6-2	7	0.484	0	7	0	0	2521	0	0	360	0	AGG	02V
6-6-3	11	0.493	0	10	1	0	2183	416	0	218	416	AGG	02V
6-6-10	3	0.273	0	3	0	0	706	0	0	235	0	AGG	02V
TOTAL	378	29.578	57	239	81	26214	78549	34039	460	329	420		

Miles of Ditch to Stream (1) =	4.965	or	16.79%
Miles of Ditch to Subsurface (2) =	14.88	or	50.30%
Miles of Ditch to Gully (3) =	6.447	or	21.80%

Roads Contributing to Stream Network = 38.58%

* Drain Type: 1=ditch flow directly to stream channel, 2=ditch relief to subsurface flow, 3=ditchrelief to gully.

Table 22. Channel extension survey results for surfaced roads.

SHEET NO.	# CMP'S	TOTAL RD LENGTH (MI.)	DRAIN TYPE* #			ASSOC. LENGTH / TYPE (FT.)			AVG LENGTH / TYPE (FT.)			Surfacing	WAA
			1	2	3	1	2	3	1	2	3		
5-15-2	6	0.588	0	0	5	0	0	2287	0	0	457	AC	02U
5-16-1	1	0.232	0	0	1	0	0	560	0	0	560	AC	02N
5-16-4	2	0.463	2	0	0	928	0	0	464	0	0	AC	02M
6-19-1	1	0.244	0	1	0	0	731	0	0	731	0	AC	02S
6-19-2	0	0.058	0	0	0	0	0	0	0	0	0	AC	02L
5-15-1	7	0.654	0	3	4	0	1102	1300	0	367	325	AGG	02U
5-15-3	9	0.888	0	4	5	0	1423	3626	0	356	725	AGG	02A
5-15-4	8	0.616	2	0	7	393	0	2807	197	0	401	AGG	02T
5-15-6	10	0.667	2	6	2	863	1796	853	432	299	427	AGG	02T
5-15-7	5	0.549	1	2	2	669	1168	1632	669	584	816	AGG	02T
5-15-10	1	0.000	0	0	0	0	0	0	0	0	0	AGG	02T
5-16-1	6	0.597	0	3	3	0	935	1722	0	312	574	AGG	02D
5-16-3	8	0.360	0	2	5	0	429	1413	0	215	283	AGG	02A
5-16-5	6	0.659	2	3	1	1505	1427	322	753	476	322	AGG	02D
5-16-6	6	0.255	1	5	0	360	1100	0	360	220	0	AGG	02D
5-16-7	7	0.405	2	5	0	671	1414	0	336	283	0	AGG	02D
5-16-8	5	0.325	0	7	0	0	1712	0	0	245	0	AGG	02D
5-16-9	5	0.407	0	3	2	0	973	547	0	324	274	AGG	02D
5-16-10	3	0.519	0	3	0	0	1057	0	0	352	0	AGG	02D
6-19-3	5	0.446	1	3	1	606	932	361	606	311	361	AGG	02E
6-19-4	8	0.523	1	7	0	317	1592	0	317	227	0	AGG	02F
5-22-1	11	0.760	2	3	6	2661	1088	1792	1331	363	299	AGG	02D
5-22-2	5	0.207	0	5	0	0	1252	0	0	250	0	AGG	02D
5-22-3	8	0.630	0	5	3	0	2094	1403	0	419	468	AGG	02D
5-22-4	9	0.622	4	4	1	1604	1339	800	401	335	800	AGG	02F
5-22-5	0	0.407	0	0	0	0	0	0	0	0	0	AGG	02F
5-22-6	9	0.487	2	6	1	457	1663	234	229	277	234	AGG	02F
5-22-7	7	0.853	2	4	1	1311	2417	777	656	604	777	AGG	02D
5-22-8	4	0.113	2	2	0	324	516	0	162	258	0	AGG	02F
5-24-1	8	0.388	0	3	5	0	783	1276	0	261	255	AGG	02C
5-24-2	7	0.640	1	3	3	699	875	1371	699	292	457	AGG	02B
5-24-3	12	0.518	2	7	3	428	1653	838	214	236	279	AGG	02B
5-24-4	9	0.579	1	7	1	200	2277	584	200	325	584	AGG	02C
5-24-5	8	0.568	3	2	3	1226	880	939	409	440	313	AGG	02C
5-24-6	12	0.378	0	11	1	0	1926	351	0	175	351	AGG	02C
5-24-7	1	0.037	1	0	0	196	0	0	196	0	0	AGG	02C
6-5-1	7	0.398	2	5	0	801	1106	0	401	221	0	AGG	02F
6-5-2	2	0.076	0	2	0	0	484	0	0	242	0	AGG	02F
6-5-3	11	0.449	6	5	0	1664	1082	0	277	216	0	AGG	02F
6-5-4	2	0.180	1	1	0	509	441	0	509	441	0	AGG	02F
6-5-5	9	0.839	3	4	2	1195	1825	753	398	456	377	AGG	02F
6-5-6	6	0.393	1	4	1	405	1362	106	405	341	106	AGG	02F
6-5-7	0	0.254	0	0	0	0	0	0	0	0	0	AGG	02F

SHEET NO.	# CMP'S	TOTAL RD LENGTH (MI.)	DRAIN TYPE* #			ASSOC. LENGTH / TYPE (FT.)			AVG LENGTH / TYPE (FT.)			Surfacing	WAA
			1	2	3	1	2	3	1	2	3		
6-5-8	0	0.352	0	0	0	0	0	0	0	0	0	AGG	02F
6-5-9	5	0.347	0	1	4	0	496	1305	0	496	326	AGG	02V
6-6-1	7	0.649	2	3	2	1071	1149	1205	536	383	603	AGG	02V
6-6-2	7	0.484	0	7	0	0	2521	0	0	360	0	AGG	02V
6-6-3	11	0.493	0	10	1	0	2183	416	0	218	416	AGG	02V
6-6-4	10	0.628	0	10	0	0	2787	0	0	279	0	AGG	02B
6-6-5	9	0.870	0	9	0	0	4918	0	0	546	0	AGG	02B
6-6-6	5	0.292	0	5	0	0	883	0	0	177	0	AGG	02B
6-6-7	8	0.361	0	8	0	0	2222	0	0	278	0	AGG	02B
6-6-8	5	0.274	0	5	0	0	1326	0	0	265	0	AGG	02B
6-6-9	8	0.381	0	5	3	0	1390	954	0	278	318	AGG	02B
6-6-10	3	0.273	0	3	0	0	706	0	0	235	0	AGG	02V
6-6-11	1	0.054	0	1	0	0	283	0	0	283	0	AGG	02B
6-12-1	7	0.478	2	5	0	727	1702	0	364	340	0	AGG	02C
6-12-2	5	0.609	0	5	0	0	2517	0	0	503	0	AGG	02C
6-12-3	0	0.269	0	0	0	0	0	0	0	0	0	AGG	02C
6-12-4	2	0.319	2	0	0	1669	0	0	835	0	0	AGG	02B
6-12-5	1	0.197	0	1	0	0	614	0	0	614	0	AGG	02B
6-12-6	4	0.429	0	4	0	0	2313	0	0	578	0	AGG	02B
6-12-7	2	0.357	0	0	2	0	0	1505	0	377	753	AGG	02B
6-12-8	7	0.502	2	5	0	892	1676	0	446	335	0	AGG	02C
6-12-9	3	0.487	1	2	0	1057	1510	0	1057	755	0	AGG	02C
6-12-10	6	0.218	0	6	0	0	1594	0	0	266	0	AGG	02C
TOTAL	372	28.554	56	235	81	25408	75644	34039	454	322	420		

Miles of Ditch to Stream (1) = 4.8121 or 16.85%
Miles of Ditch to Subsurface (2) = 14.327 or 50.17%
Miles of Ditch to Gully (3) = 6.4468 or 22.58%

Roads Contributing to Stream Network = 39.43%

* Drain Type: 1=ditch flow directly to stream channel, 2=ditch relief to subsurface flow, 3=ditchrelief to gully.

Table 23. Channel extension survey results for native surfaced roads.

SHEET NO.	# CMP'S	TOTAL RD LENGTH (MI.)	DRAIN TYPE* #			ASSOC. LENGTH / TYPE (FT.)			AVG LENGTH / TYPE (FT.)			Surfacing	WAA
			1	2	3	1	2	3	1	2	3		
5-15-5	2	0.191	1	0	0	806	0	0	806	0	0	NAT	02U
5-15-8	0	0.217	0	0	0	0	0	0	0	0	0	NAT	02T
5-15-9	1	0.330	0	1	0	0	1740	0	0	1740	0	NAT	02T
5-16-2	3	0.286	0	3	0	0	1165	0	0	388	0	NAT	02M
Total	6	1.024	1	4	0	806	2905	0	806	2128	0		

Miles of Ditch to Stream (1) =	0.1527	or	14.91%
Miles of Ditch to Subsurface (2) =	0.5502	or	53.73%
Miles of Ditch to Gully (3) =	0	or	0.00%

Road Contributing to Stream Network = 14.91%

* Drain Type: 1=ditch flow directly to stream channel, 2=ditch relief to subsurface flow, 3=ditchrelief to gully.

Table 24. Estimate of channel extension.

WAA	Surfaced Roads (mi.)	Surfaced Contribution to Streams (mi.)	Native Roads (mi.)	Native Contribution to Streams (mi.)	Total Extension	Estimated Stream Miles	Percent Increase in Stream Network
02A	4.21	1.66	0.02	0.00	1.66	6.39	26.03%
02B	19.27	7.60	6.34	0.95	8.54	27.44	31.13%
02C	23.64	9.32	1.56	0.23	9.55	48.34	19.76%
02D	15.51	6.12	1.82	0.27	6.39	28.00	22.81%
02E	9.02	3.56	0.49	0.07	3.63	23.31	15.57%
02F	31.99	12.61	0.88	0.13	12.74	34.39	37.06%
02L	3.25	1.28	0.23	0.03	1.32	5.48	24.01%
02M	1.23	0.48	0.93	0.14	0.62	3.50	17.81%
02N	0.57	0.22	0.00	0.00	0.22	0.69	32.62%
02Q	6.41	2.53	0.00	0.00	2.53	15.61	16.19%
02R	0.65	0.26	0.00	0.00	0.26	1.08	23.64%
02S	2.78	1.10	0.00	0.00	1.10	4.76	23.03%
02T	6.79	2.68	1.15	0.17	2.85	5.97	47.72%
02U	4.69	1.85	0.44	0.07	1.91	3.94	48.58%
02V	8.99	3.54	2.22	0.33	3.88	11.13	34.82%
02X	2.18	0.86	0.00	0.00	0.86	2.00	43.00%
02Y	0.65	0.26	0.00	0.00	0.26	0.00	
02Z	5.48	2.16	0.00	0.00	2.16	0.00	
Total	147.31	58.08	16.08	2.40	60.48	222.04	27.24%

Appendix E

Access and Travel Management

KEY TO ROAD ANALYSIS TABLE

ROAD NUMBER AND LENGTH - Taken from district TMS data base.

RISK - Compiled from the Umpqua National Forest Soil Resource Inventory . The RISK factor is a combination of Soil Erosion and Mass Wasting/Land Stability component. The Soil Erosion components used were moderate, high, or very high Surface Erosion Potential and Sediment Yield Potential -Accelerated (indicating road construction and /or harvest activities) . The Mass Wasting/Land Stability component was moderate or high potential, using the Road Construction - Low Density (<6 miles /square mile) factor. A combination of components in the moderate range would result in a Moderate rating. The combination of two moderates and one high would require a judgment call based on the high component and the type of wasting /erosion potential. If the high rating was an erosion component it generally resulted in a Moderate rating. Two or more high potentials resulted in a High overall rating. Any combinations of ratings that included a Very High in Granite or Schist type soils resulted in a Very High rating overall.
Soils of low or low/moderate erosion/mass wasting potential were not analyzed in this study. As project plans are developed a more in-depth project level study of soil erosion and mass wasting potential would be required.

RANGE -Taken from the District Winter Range Map developed for the current Access and Travel Management Plan. All roads with Winter Range indicated with either N for Normal Winter Range, or 4 for 4 Part Winter Range have a standard Road Closure Period of Dec.1 to April 30.

STREAM CLASS - Stream Class was obtained by overlaying the transportation map with the stream layer map and noting the intersections of streams with roads. This will indicate stream crossing , but not necessarily how many crossings or culvert size.

SOCIAL USES - R - Recreation facility or significant established use.
A - Administrative - ties to adjacent watershed or administrative unit.
P - Private land access.
M - Matrix land designation.
LSR - Late Successional Reserve land designation.

RISK CATEGORY - Roads were assigned a Risk Categories based on one or more of the Erosion/ Mass Wasting Potential and Social Uses criteria.

C-1 Catagory 1 Roads - Significant traditional use
- Tie thru to adjacent watershed or administrative unit
- Private land access

C-2 Catagory 2 Roads - Significant traditional use
- High sediment delivery potential

C-3 Category 3 Roads - Accesses potential commodity opportunities
- Low to moderate watershed impacts

C- 4 Category 4 Roads - High sediment delivery potential
- High /Moderate mass wasting potential
- Located within Late Successional Reserves

ROAD #	LENGTH	MTCLVL	SRI RISK	RANGE	STREAMS	SOCIAL	C-1	C-2	C-3	C-4	REMARKS
3200000	8.68	A-3	HIGH	N	2,3,4	A	X				TIE COW CR TO CO.HWY 1
50	1.4	A-1	LO/HI	<N		P	X				
51	0.2	N-1	LO			P	X				
100	1.48	A-2	HI	N	3		X				ACCESS PRIVATE
101	0.33	N-1	HI	N						X	
102	0.34	N-1	HI	N						X	
130	0.1	A-3	HI			A	X				DEVILS FLAT CG
131	0.1	A-3	HI			A	X				DEVILS FLAT
140	1.4	N-2	HI	N	2					X	LSR
250	0.2	N-2	HI							X	
256	0.42	N-2	HI							X	
260	0.27	A-2	MOD						X		
280	0.35	A-2	MOD/HI	<N						X	LSR
281	0.3	N-2	HI							X	
330	0.68	A-2	MOD							X	LSR
370	0.73	A-2	HI							X	
372	0.1	N-2	HI							X	
500	2.83	A-2	MOD	N					X		
501	0.27	N-1	MOD						X		
505	0.48	N-1	MOD						X		
510	0.57	A-1	MOD						X		
520	0.2	N-1	HI							X	
560	0.32	A-1	MOD						X		
3220000	5	A-3	HI							X	
800	2.98	A/I-1	HI							X	
815	0.4	A-1	HI							X	
818	0.42	A-1	HI							X	
877	0.14	A-1	HI							X	
880	0.5	N-2	HI			A				X	
900	2.11	A-2	MOD						X		
910	0.25	N-1	HI							X	
920	0.3	N-1	MOD						X		
930	0.2	N-1	MOD						X		
935	0.21	A-1	MOD						X		
980	1.2	A-1	<HI/MOD						X		
981	0.15	A-1	MOD						X		
3230000	1.1	A-3	HI/ V HI							X	LSR
135	0.8	N-2	HI			P				X	LSR,ROCK PIT
136	1.21	A-1	HI	N	4					X	LSR,SEASONAL CLOSURE
137	0.82	A-1	MOD/HI	N	3,4					X	LSR
139	0.28	A-1	HI	N	4					X	LSR
140	0.54	A-1	HI	N						X	LSR
3231000	2.1	A-3	V HI		2,4	P,A	X				TIE THRU RD
"	4.97	A-3	HI		2,4	P,A	X				TIE THRU RD
300	4.1	A.2	V HI/ HI					X			
310	0.2	N-1	HI							X	
315	0.4	A-1	HI/ V HI							X	
320	0.53	-3200000	V HI							X	
321	0.3	A-1	V HI							X	
330	0.64	A-2	HI	N						X	
340	0.17	A-1	V HI							X	
345	0.4	N-1	V HI							X	
350	0.1	N-1	V HI							X	
355	0.1	N-1	V HI							X	
360	0.9	A-2	V HI		4					X	
361	0.34	A-1	V HI	N						X	
390	1.7	A-2	V HI/HI		2					X	
391	0.05	N-1	V HI							X	

ROAD #	LENGTH	MTCLVL	SRI RISK	RANGE	STREAMS	SOCIAL	C-1	C-2	C-3	C-4	REMARKS
395	0.36	A-1	HI							X	
400	0.76	A-2	HI	N						X	
401	0.56	A-2	HI	N						X	
405	0.18	A-2	HI	N						X	
500	0.67	A-2	V HI							X	
600	5.86	A-2	HI / V HI							X	
620	0.7	A-1	V HI							X	
621	0.26	A-1	V HI							X	
622	0.14	A-1	V HI							X	
623	0.15	N-1	V HI							X	
625	0.17	N-1	V HI							X	
630	0.1	A-1	V HI							X	
636	0.41	S-1	V HI							X	
691	0.08	A-1	V HI							X	
692	0.12	A-1	V HI							X	
700	1.17	A-1	HI							X	
740	0.11	A-1	HI							X	
750	0.06	N-1	HI							X	
3232000	4.4	A-2	MOD		2,3,4	P, A		X			TIE THRU RD
	1.2	A-3	HI		"	"		X			PRIVATE ACCESS
	4.5	A-2	HI/ V HI		"	"		X			PRIVATE ACCESS
600	1.1	A-2	V HI							X	
	2.8	A-2	HI							X	
609	0.15	A-1	HI							X	
610	1.23	A-2	HI/ V HI		4					X	>CS EROSION,LNDG SLUMP.
611	0.59	A-1	HI							X	
612	0.18	A-1	HI							X	<CS EROSION, LNDG SLUMP
616	0.93	A-1	HI							X	< CS EROSION
619	0.95	A-2	V HI							X	SLUMPY SOILS,, EROSION
620	0.42	A-2	V HI							X	< EROSION
790	0.2	N-1	HI							X	
791	0.2	N-1	HI							X	
793	0.4	N-1	HI							X	
799	0.19	A-1	HI							X	
800	1.66	A-2	HI							X	
801	0.31	A-1	HI							X	
840	0.3	N-1	HI							X	
850	2.07	A-2	HI		3					X	
851	0.7	N-1	MOD						X		
855	0.1	N-1	MOD						X		
870	2.54	A-2	MOD		2,3				X		
871	0.25	A-1	MOD						X		
872	0.58	A-2	MOD						X		
875	0.39	A-1	MOD						X		
885	0.2	N-1	MOD						X		
887	0.3	N-1	MOD						X		
889	0.2	N-1	MOD						X		
890	0.4	N-2	MOD						X		
891	0.2	N-2	MOD						X		
900	2.22	A-2	MOD						X		
911	3.29	A-2	MOD						X		TRAILHEAD
912	0.8	A-2	MOD						X		RAILROAD GAP
3242000	7.81	A-3	HI	N	3	P,A	X				P,STATE,BLM, TIE THRU RD.
15	0.79	A-1	LO/HI							X	PRIVATE ACCESS
16	0.4	A-1	HI							X	
20	0.5	A-2	HI		3					X	
50	1.87	A-2	HI							X	
51	2.39	A-2	HI		4					X	

ROAD #	LENGTH	MTCLVL	SRI RISK	RANGE	STREAMS	SOCIAL	C-1	C-2	C-3	C-4	REMARKS
52	0.54	A-2	HI							X	
55	1.05	A-2	HI							X	
90	1.17	A-2	MOD/HI						X		
200	2.42	A-2	MOD		3,4				X		
201	1.62	A-2	MOD		3				X		
202	0.24	A-1	MOD						X		
203	0.21	A-1	MOD						X		
205	0.53	A-1	HI/MOD						X		
206	0.14	A-1	HI							X	
210	0.31	A-1	MOD						X		
211	0.1	A-1	MOD						X		
215	0.83	A-1	MOD/HI						X		
220	0.85	N-1	HI							X	
221	0.27	N-1	HI							X	
224	0.1	N-1	HI							X	
230	1.77	A-2	MOD/HI				X				A (ROCK PIT-LOOKOUT SITE)
231	0.54	N-1	MOD						X		
232	0.37	N-1	MOD						X		
234	0.11	N-1	MOD						X		
300	1.76	A-2	V HI/MOD	N						X	
301	0.73	A-2,N-1	MOD	N					X		
310	0.15	A-2	V HI							X	
311	0.31	A-1	V HI							X	
320	0.35	N-1	MOD	N					X		
400	1.49	A-2	MOD	N					X		
401	0.64	A-1	HI	N						X	
900	0.2	N-2	V HI	N				X			STATE LAND ACCESS
3243050	0.5	A-1	MOD			4			X		OFF SNOW CR. RD.
51	0.5	N-1	MOD						X		
200	3.96	A-2	MOD/HI			4			X		
210	0.53	A-1	MOD			4			X		
212	0.64	A-1	MOD/V HI			4			X		
220	0.05	A-1	MOD						X		
221	0.44	A-1	MOD						X		
222	0.58	A-1	MOD						X		
223	0.5	N-1	MOD						X		
224	0.3	A-1	MOD						X		
225	0.21	A-1	MOD						X		
226	0.14	A-1	MOD						X		
227	0.34	A-1	MOD						X		
228	0.23	A-1	MOD						X		
229	0.27	A-1	MOD						X		< EROSION
230	0.16	A-1	MOD						X		< EROSION
234	0.1	A-1	MOD						X		
235	0.34	A-1	MOD						X		
271	0.17	N-1	MOD						X		
300	0.47	A-1	MOD						X		
700	1.01	A-2	V HI							X	
795	0.39	A-1	V HI							X	
800	0.23	A-1	V HI							X	

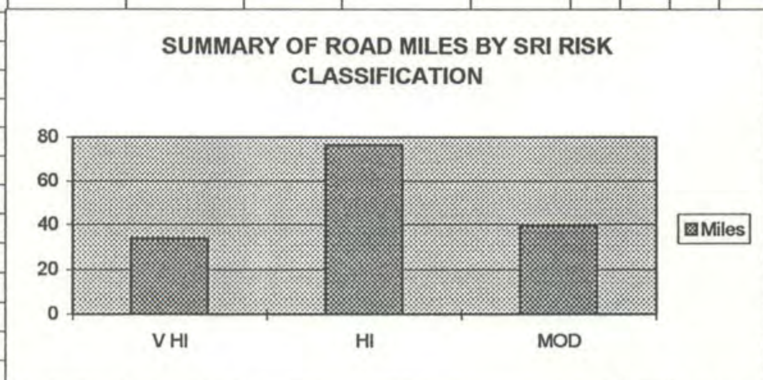
ROAD EROSION RISK SUMMARIES

Miles by RSI Risk Classification

V HI/ HI	5.8
HI/ VHI	13.09
V HI	12.55
HIGH	63.65
MOD	39.28
HI / MOD	1.73
V HI/MOD	1.76
MOD/HI	8.9
MOD/V HI	0.64
LO/HI	2.19

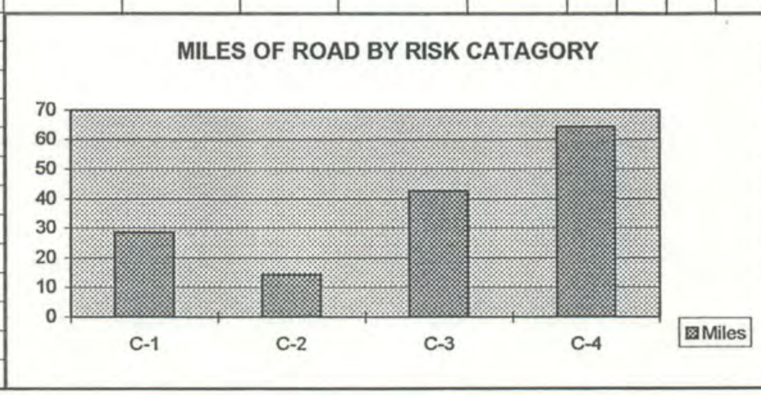
Summary by **Highest** SRI Risk Classification

Risk	V HI	HI	MOD
Miles	33.84	76.47	39.28

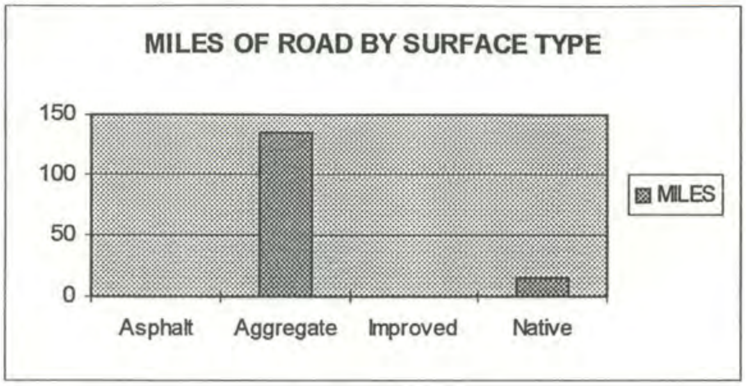


Miles of Road by Risk Catagory

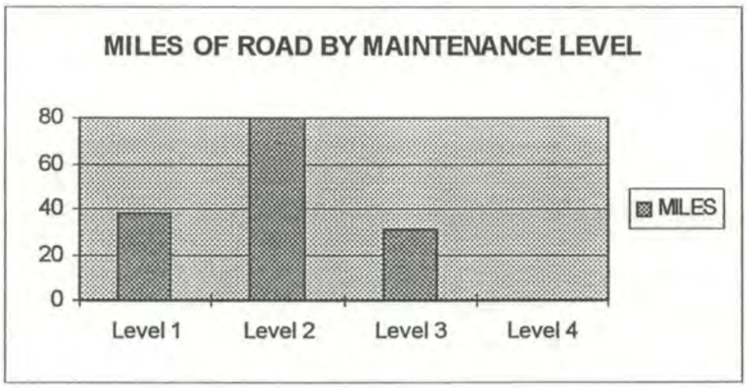
Risk	C-1	C-2	C-3	C-4
Miles	28.6	14.4	42.5	64.3



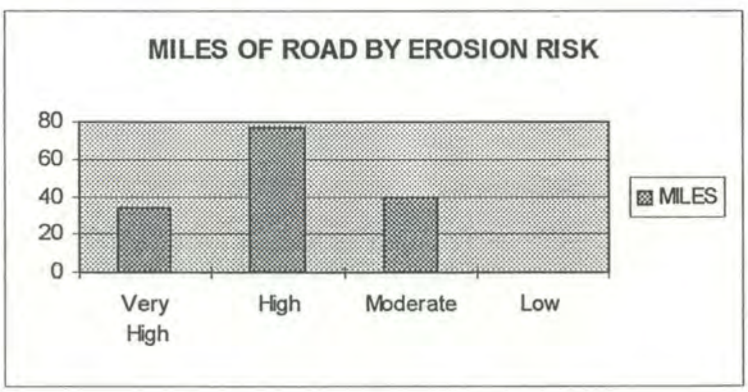
COW CREEK WATERSHED ROAD SUMMARY



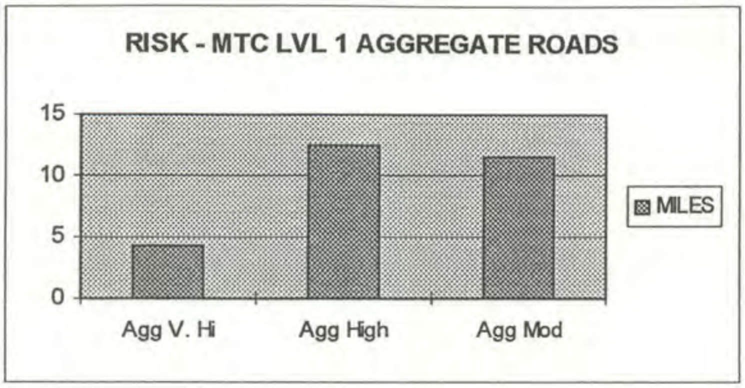
SURFACE	Asphalt	Aggregate	Improved	Native
MILES	0.3	134.7	0.4	14.7



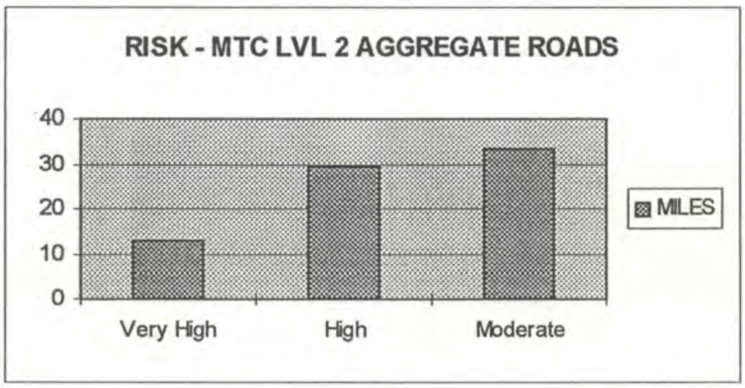
MTC LVL	Level 1	Level 2	Level 3	Level 4
MILES	38.5	79.84	31.5	



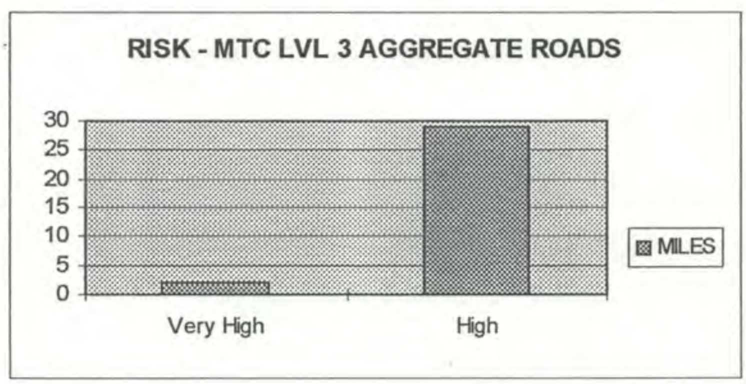
RISK	Very High	High	Moderate	Low
MILES	33.8	76.5	39.3	



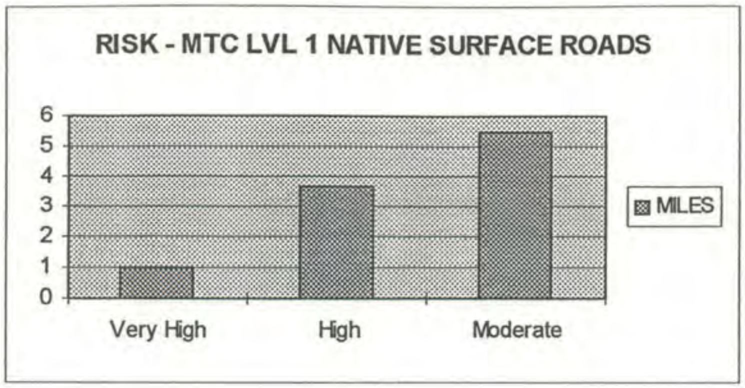
MTC LEVEL 1	Very High	High	Moderate
MILES	4.35	12.5	11.45



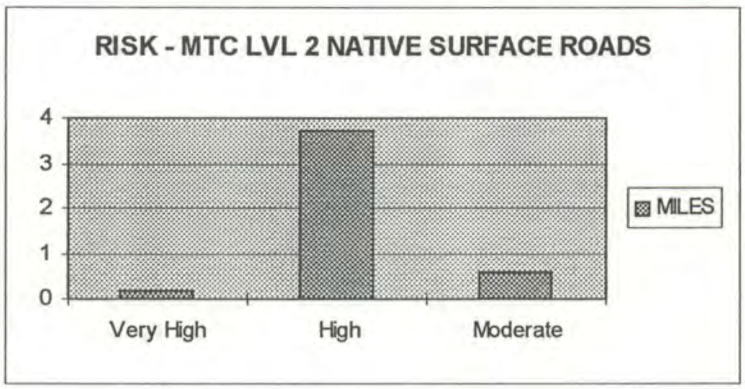
MTC LEVEL 2	Very High	High	Moderate
MILES	12.76	29.35	33.20



MTC LEVEL 3	Very High	High	Moderate
MILES	2.1	29.0	0.3



MTC LEVEL 1	Very High	High	Moderate
MILES	0.97	3.7	5.49



MTC LEVEL 2	Very High	High	Moderate
MILES	0.2	3.72	0.6

Appendix F

Field Data Sheets for pH

DATE	TIME	AIR TEMP	WATER TEMP	PH	WATER LEVEL	WEATHER CONDITIONS	VISIBLE STREAM CONDITIONS	Initials
3-26	3:35	54.0	42.4	7.5	HIGH	PRTLY CLDY	POST RAIN/SNOW TURBIDITY	
5-20	4:20	80.4	57.9	7.7	MED	PTLY CLDY, SMOKEY	CLEAR	
6-10	3:30	77.6	58.2	7.7	MED	OVERCAST	WATER COLOR BRN, MURKY	
7-14	5:20	74.7	68.0	8.3	MED	CLR, SUNNY	yellow/brn nodules of algae on rock surfaces under water lt grn algae on surface	
7-17	5:03	91.5	73.9	8.6+	MED	" "	" " " & lt green algae on bot	[illegible]
7-28	5:15	88.4	74.3	8.6+	"	CLR SUNNY HOT	[illegible]	[illegible]
7-30	3:20	81.7	67.3	8.6+	MED	" " "	[illegible]	
8-4	5:10	88.0	72.9	8.4	"	" " "	Large patch of subsurface algae continues to [illegible] inlet	
8-8	6:00	80.1	67.5	8.4	"	" " warm	rained on 8/6 [illegible]	[illegible]
8-23	4:50	84.2	64.8	8.2	"	" " warm	[illegible] less sun on water [illegible] on bottom	[illegible]
9-11	5:10	87.1	66.7	8.2	med-low	" " hot	[illegible]	
9-17	4:14	79.5	68.4	8.2	"	" " warm	[illegible]	

LOCATION

[illegible] CREEK - SWIMMING HOLE (approx 150 yds. upstream of Snow Crk bridge)

Snow creek recreation site

WATER QUALITY TEST RECORD

DATE	TIME	AIR TEMP	WATER TEMP	PH	WATER LEVEL	WEATHER CONDITIONS	VISIBLE STREAM CONDITIONS	Initials
3-25-95	2:23p	52.2	41.5	7.3	up	partly cloudy	slight Turbidity	MC
9-13-95	3:47pm			7.3	ext. Low	hot, dry	creek has disappeared into pools - no flowing water	MC
upstream: at big pool near culvert								
9-13-95	3:52p			7.3	big pool,	hot, dry	Turbid, no flow but culvert still trickling	MG.

LOCATION French Creek just below crossing at Cow Creek Road (2)

Friends of Cow Creek

WATER QUALITY TEST RECORD

DATE	TIME	AIR TEMP	WATER TEMP	PH	WATER LEVEL	WEATHER CONDITIONS	VISIBLE STREAM CONDITIONS	Initials
3-26	4:00	50.4	45.0	7.3	HIGH	SITE SHADED CLEAR SUNNY	SLIGHT TURBIDITY	
5-28	3:05	77.5	56.7	7.2	med	PTLY CLDY	" "	
6-10	4:40	73.4	55.2	7.2	med	OVERCAST	WATER MURKY	
7-30	2:45	74.3	58.5	7.2	Low	CLR SUNNY	WATER CLEAR	
9-17	3:30	74.7	59.7	7.2	low	" "	" "	

LOCATION
MEADOW CREEK JUST ABOVE CCRD (3)

Friends of Cow Creek

WATER QUALITY TEST RECORD

DATE	TIME	AIR TEMP	WATER TEMP	PH	WATER LEVEL	WEATHER CONDITIONS	VISIBLE STREAM CONDITIONS	Initials
3-26	3:50	48.9	41.2	7.2	HIGH	PTLY CLDY	CLEAR - SMALL RIFFLE UPSTREAM	
5-20	4:45	73.9	52.2	7.6	MED	" "	CLEAR - SITE SHADY MOST OF DAY	
6-10	5:10	72.7	53.3	7.6	MED	OVERCAST	WATER SLIGHTLY MUDDY	
7-30	3:00	82.6	57.9	7.7	MED	CLR SUNNY	CLEAR	
9-17	3:45	77.5	58.3	7.7	med	" " 16th was overcast	" completely shaded - on site	
							[illegible]	

LOCATION
SN[illegible] CREEK ON 32-3-7.4 RD OFF OF 32-[illegible]7.3 RD (4)

Friends of Cox Creek

WATER QUALITY TEST RECORD

DATE	TIME	AIR TEMP	WATER TEMP	PH	WATER LEVEL	WEATHER CONDITIONS	VISIBLE STREAM CONDITIONS	Initials
3-26	3:45	53.4	43.5	7.4	HIGH	CLR - SUNNY SITE IN SHADE	WATER CLEAR	
5-28	3:00	78.7	56.2	7.2	MED	PTLY CLDY	" "	
6-10	4:30	75.4	55.9	7.2	MED	OVERCAST	water slightly murky	
7-30	2:30	79.7	55.9	7.2	LOW	Low 30's last night CLR SUNNY	WATER CLEAR	
9-17	3:12	78.3	56.3	7.2	very low	CLRSUNNY [illegible]	" " ~~[illegible]~~ site in shade	

LOCATION
S[illegible]R CREEK JUST ABOVE CC RD (5)

Friends of Cow Creek

WATER QUALITY TEST RECORD

DATE	TIME	AIR TEMP	WATER TEMP	PH	WATER LEVEL	WEATHER CONDITIONS	VISIBLE STREAM CONDITIONS	Initials
3-25-95	2 pm	60.6	42.1°	7.4	up	partly cloudy	slight Turbidity, day after rain	MG
6-7-95	4 30 pm			7.6		partly cloudy	clear (after 2 days of rain)	MG
7-27-95	5 00 pm			8.0		clear, not too hot	clear, lots of algae	MG
9-13-95	3:33 pm			8.0	low	warm,	clear, hot + dry weather lately	MG

LOCATION Cow Creek near mouth of French Creek (Approx. 1/8th mile upstream)

6

Friends of Cow Creek

WATER QUALITY TEST RECORD

DATE	TIME	AIR TEMP	WATER TEMP	PH	WATER LEVEL	WEATHER CONDITIONS	VISIBLE STREAM CONDITIONS
7-30-95	12:36	78.1	55	8.1	Low	Clear SKY	Clear, some green Tint on rocks
~~7-30~~	~~12:36~~	~~78.1~~	~~[illegible]~~	~~8.1~~			
7-30	12:36	75.1	59.4	8.0	LOW	Clear SKY	Same as at 12:36 hrs.

LOCATION (7) Cow Creek, 16.4 mile[illegible], approx.

WATER QUALITY TEST RE[illegible]ORD

DATE	TIME	AIR TEMP	WATER TEMP	PH	WATER LEVEL	WEATHER CONDITIONS	VISIBLE STREAM CONDITIONS	Initials
4-2-95	17:19	50	44.1	7.2	Mod High	Clear Sky	Water Fairly clear	
5-20	1600	68.2	50.9	7.8	Mod	Sunny, High Clouds	Clear	[illegible]
7-30	1206	75.2	54.3	8.0	Low	Clear Sky	Clear, no algae visible	[illegible]

LOCATION (9) Devil's Creek, just east of cuvert, Cow Creek Road

WATER QUALITY TEST RECORD

DATE	TIME	AIR TEMP	WATER TEMP	PH	WATER LEVEL	WEATHER CONDITIONS	VISIBLE STREAM CONDITIONS	Initials
4-2-95	1737	48.6	46.4	7.6	Med Hi	Clear Sky	Clear	[illegible]
5-20	1540	75.7	54.7	7.7+	Moderate	Sunny, High Clouds	Clear	[illegible]
7-30	1218	75.7	54.3	7.8	Low	Clear Sky	Clear, no algae visible	[illegible]

LOCATION Applegate Creek, just west of Cow Ck

Friends of Cow Creek

WATER QUALITY TEST RECORD

HO-1-III-G-WA/

RIFFLE STABILITY INDEX

a procedure to evaluate stream reach and watershed equilibrium

Gary B. Kappesser
Forest Hydrologist

August, 1994

RIFFLE STABILITY INDEX

Jefferson National Forest
Roanoke, Virginia 24019

Gary Kappesser, Forest Hydrologist (8/94)

INTRODUCTION

This method may be used to determine the degree of aggradation, degradation, or dynamic equilibrium of gravel and cobble stream channels. It requires a set of measured field data which includes the particle size distribution of riffle material and a sample from a fresh depositional feature, or alternatively channel geometry and energy gradient. The largest commonly occurring size of particle that will be moved by the force created at frequent flood events is compared with the cumulative particle size distribution of bed material on the riffle to determine the size class percentile of riffle material moved at channel forming flows, This information has three applications.

First, it provides a quantiative determination of the existing balance of water and sediment in a stream channel.

Second, it is a cumulative effects tool. The existing channel stability is the reflection of all past and present activities in the watershed above the point of measurement.

Third, it is a monitoring tool which allows the land manager to detect changes in channel stability over time. Further, these changes can be linked to hillslope processes (cause) and to changes in fish habitat components such as residual pool volume (effect).

BACKGROUND

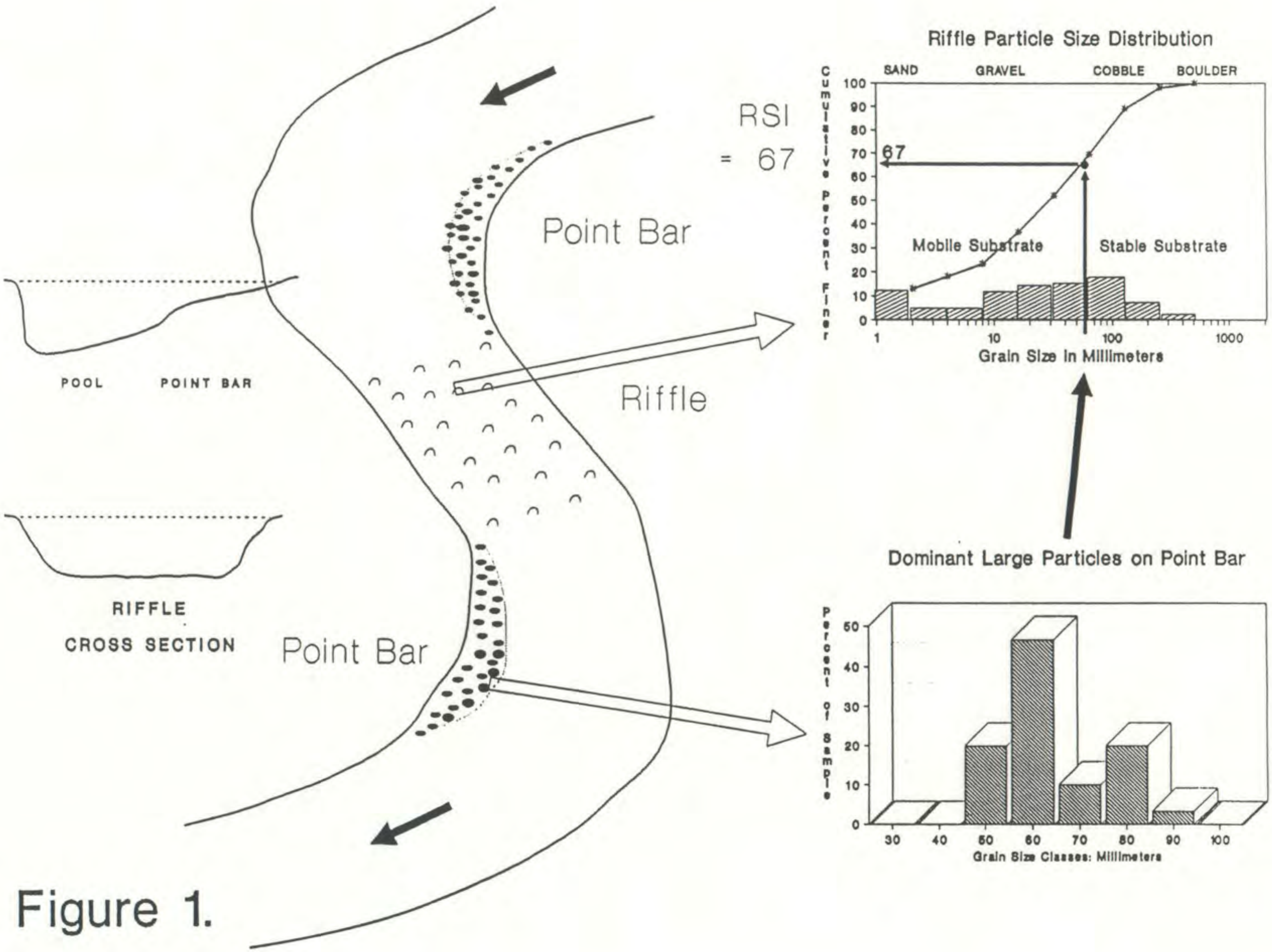
Dynamic equilibrium is the balance of hydrologic variables in a stream channel, as defined by the relationship "Sediment load multiplied by sediment size is proportional to streamflow multiplied by channel gradient" (Lane, 1955, Heede, 1985). Under conditions of dynamic equilibrium, a stream's energy is at a level that allows sediment loads entering a stream reach to equal those leaving it. (Heede, 1986) An imbalance can occur in either direction; resulting in aggradation or degradation. When more sediment enters a reach than leaves it, aggradation will occur as the stream's transport capacity is exceeded. Lisle (1982) reports aggradation to be accompanied by a decrease in bed material size in his study and those of other researchers. In contrast, degradation occurs when a stream has excess energy and more sediment leaves a reach than enters it. Channel downcutting will occur until a bed armor layer develops (Heede, 1986). Thus, degradation is accompanied by a relative increase in bed material size (Lane, 1954). The decrease or increase of bed material size is relative to the condition of dynamic equilibrium. A channel that is highly aggraded has a large proportion of its bed material at a threshold of incipient motion at channel forming flows. A channel that is degraded to an armor layer has a very low proportion of its bed material capable of movement at channel forming flows. It follows that the proportion of material capable of movement at channel forming flows in a channel in dynamic equilibrium must be somewhere between these end points (Mackin, 1948).

Gessler (1971) observes that "In the headwaters of a natural gravel-sand river, there are many grain sizes, including those the river cannot carry downstream." He concludes "...under any discharge condition (except extremely high floods), there is always a number of grains not movable." Leopold, Wolman and Miller (1964) report that for Seneca Creek, Maryland, the movement of gravel of the median size on the riffle requires a one year flood event. Lisle (1979) suggests the largest particles in the riffles may be essentially static except during extreme flows. Riffles are the logical place to evaluate bed material mobility. Beschta and Platts (1986) explain that riffles are "...remnant channel features formed at higher flows and are major storage locations of bed material. They further state "Their form represents a balance between the frequency and magnitude of flows, sediment transport, and other channel characteristics...", which is another expression of dynamic equilibrium. Knighton (1984) believes riffles to be established and maintained by high discharges of bankfull and above. Wolman and Miller (1960) identify bankfull flow as the dominant discharge responsible for the shape and dimensions of river channels.

The relative mobility of bed material on the riffle at bankfull discharge becomes an indicator of the riffle's equilibrium, aggradation, or degradation. The distribution of particle sizes residing on a riffle may be determined by a procedure called a Wolman Pebble Count (Wolman, 1954). If the largest mobile particle sizes can be identified within the distribution of sizes present, and if the percentile of the distribution can be determined, then this can be used as an index of bed material mobility and hence of dynamic equilibrium. Williams, Thomas, and Daddow (1988) state "If the study objective is to determine a size class percentage which is in transport during bankfull flows, it may be appropriate to measure particle sizes at high water deposition sites, for example, the downstream extent of a point bar. Kappesser (1983) observed that "At bankfull, the large gravel trapped by the Helley-Smith sampler approximated the median large particle size on fresh gravel bars".

Where a fresh high water deposition site can be identified adjacent to a riffle, it can be sampled and the dominant large size can be used to estimate the largest mobile particles on the riffle. That size and all particles smaller are mobile, while sizes larger are static or stable. When the largest mobile size is compared to the cumulative particle size distribution on the riffle, the percent of riffle material that is mobile can be identified. This percent becomes an index of riffle dynamic equilibrium, and is referred to in this document as the Riffle Stability Index (RSI). The relationship defined by the index is shown in Figure 1.

Figure 1. diagrams the RSI analysis procedure for the Halsey Creek channel. The upper graph displays the Wolman Pebble Count data from one riffle. Individual size class particle abundance is shown by the bar graphs along the X axis. These are added from finest to coarsest (left to right) to construct the cumulative particle size distribution curve. The lower graph shows the size class distribution of large particles on an adjacent fresh depositional feature; in this case a point bar. The most frequent large size particle is in the size class of 50 to 60 millimeters intermediate diameter. The upper end of this size class is also expressed by the geometric mean of 59 mm. This size is compared with the distribution of particles on the riffle. Particles smaller than 59 millimeters are interpreted as potentially mobile during bankfull flow events. They represent 67 percent of the particles present on the riffle. This percent is the Riffle Stability Index, which in this example would be 67.



RSI = 67
Point Bar
Riffle
Point Bar
POOL
POINT BAR
RIFFLE
CROSS SECTION
Riffle Particle Size Distribution
SAND
GRAVEL
COBBLE
BOULDER
Cumulative Percent Finer
67
Mobile Substrate
Stable Substrate
Grain Size in Millimeters
Dominant Large Particles on Point Bar
Percent of Sample
Grain Size Classes: Millimeters

Figure 1.

PROCEDURE

This procedure is best applied to a watershed as a system. The network of channels within the watershed must be divided into uniform reaches by the system developed by Rosgen (1985) as updated in his 1993 version. Three riffles are measured within each uniform Rosgen Channel reach. Each riffle selected for measurement should be representative or typical within the reach. For each riffle, field data are gathered to determine the distribution of particle sizes present, and an estimate of the largest size of particle capable of movement at channel forming discharge.

I. PARTICLE SIZE DISTRIBUTION

A particle size distribution is obtained on the riffle by a bed material sampling procedure termed a "Wolman Pebble Count" (Wolman, 1954). A sample size greater than 200 provides the reproducible estimate of the distribution necessary for this methodology. The sampling points are determined by paced transects across the channel from bankfull to bankfull. Transects should include the top, middle, and bottom of the riffle. At each transect, start at bankfull width on one side and continue until the bankfull width is reached on the opposite side of the stream. Walking heel to toe, identify the first particle at the end of your boot touched by your finger and measure or estimate the intermediate diameter of the particle. Tally the samples by Udden-Wentworth size class as less than 2 mm, 2 - 4 mm, 4-8 mm, 8-16 mm, 16 - 32 mm, 32 - 64 mm, 64 - 128 mm, 128 - 256 mm, 256 - 512 mm, and 512 - 1024 mm. For very large particles, count the same particle as many times as your toe encounters it. The cumulative percent finer is then calculated for each size class.

II. ESTIMATE OF DOMINANT LARGE PARTICLE SIZE MOVED AT BANKFULL DISCHARGE

(a). BAR SAMPLE.

Measure 10 to 30 of the largest dominant particles residing on fresh bars or depositional areas to estimate the largest particle size moved at bankfull discharge. Freshness is evaluated by lack of growing vegetation and lack of embeddedness of the particles. The bar or depositional area must be in close proximity to the riffle being examined. Depositional features can include point bars, central bars, or depositional areas behind channel constrictions. For point bars, the sampling area should be limited to the facet of the point bar downstream from the smallest radius of curvature. If other depositional features are used to obtain the sample, the professional judgement of an experienced field hydrologist is needed to verify the site. For ***each*** of the particles, the intermediate axis of the particle is measured and recorded to the nearest millimeter. From this recorded information the geometric mean particle size will be calculated. This size is used as an estimate of the largest common size of bedload transported in the channel at channel forming discharge.

(b). TRACTIVE FORCE ALTERNATIVE

In some streams, appropriate fresh depositional areas may not be available. In these instances, a tractive force equation may be substituted if the following criteria can be met. The riffle must be contained in a single channel. Multiple channel reaches are not compatible with this methodology. The channel should have uniform depth and flow, and be in a "straight" reach. The riffle should have identifiable evidence of bankfull discharge. Downstream obstructions that may create a backwater effect are undesirable. Two parameters are measured at the riffle. These are channel cross section, and the gradient of the water surface at bankfull discharge.

Channel cross section is surveyed using standard surveying techniques with a level, rod, and tape (or alternatively, a transit and rod). The instrument used must be able to determine level to an accuracy of plus or minus 0.1 foot in a distance of 100 feet. Sufficient survey points should be established to define the geometry of the section. The survey should extend up the banks well above bankfull stage; evidence of which should be clearly defined in the survey notes.

The energy gradient of the water surface at bankfull discharge should be measured as precisely as possible as shear stress calculations are extremely sensitive to this parameter. For field measurements where clear evidence of bankfull stage is absent, the gradient of the water surface at bankfull may be approximated by measuring channel gradient from riffle crest to riffle crest. The riffle crest (sometimes called the pool tail crest) is found at the transition between the pool tail out and the top of the dowstream riffle. A hand held clinometer should never be used to measure gradient because of the large errors in calculation that can be introduced by slight instrument error.

A permanent monument should be installed to clearly identify the location of the surveyed cross section. This will consist of either an aluminum tag on a witness tree with distance and bearing to the first survey point, or a sackcrete monument in the ground. Rebar stakes should not be used for this purpose. The surveyed cross section is also photographed in both upstream and downstream directions.

DATA REDUCTION AND ANALYSIS.

The field data are entered into a PC computer program named RSI.EXE. A use manual is provided with the program. For the Wolman pebble count, the program accepts as raw data the number of particles tallied in each size class. It calculates the percent in each size class, cumulative percent finer, and interpolates cumulative percent finer for a range of sizes between each class break. For the thirty largest particle sizes on a fresh bar, the program calculates the geometric mean particle size, compares that to the range of sizes produced from the Wolman pebble count, and displays the RSI index. If surveyed cross section and gradient are entered, the program will calculate width/depth ratio, discharge, shear stress, and critical grain size for a specified range of stages in 0.1 foot increments. It permits the user to either input an estimated Manning's "N" or will calculate this value from a relationship developed by Jarrett (1987). Shear stress is calculated by the formula ***To = vRS*** (Simons, 1969) where ***To*** is shear stress (lb/ft^2), ***v*** is the unit weight of water (62.4 lbs/cubic foot), ***R*** is the hydraulic radius (ft), and ***S*** is the energy gradient of the water surface (ft/ft). Critical grain size in millimeters is determined from shear stress by the formula ***[D = 47.84 To]*** where ***D*** is critical grain size and ***To*** is shear stress. The program compares the critical grain size transported at bankfull discharge with the range of particle sizes present on the riffle (the pebble count data) and displays the RSI index.

INTERPRETATION

Either the geometric mean particle size of the dominant large particles on a fresh point bar or the critical grain size moved at bankfull discharge is compared to the cumulative particle size distribution of riffle material as determined by Wolman pebble count. For example, if the dominant large particle on a fresh point bar was estimated to be 43 millimeters and 65 percentile of the riffle particle sizes were 43 millimeters or smaller, then the resulting RSI number would be "65". It is the size class percentile that becomes an index of stability.

The index numbers can range from less than 50 to 100. An index number of 50 is representative of a stable riffle in an alluvial channel. An index number of 100 represents a riffle that is entirely aggraded. The range of indices between 50 and 99 are to be regarded as a continuum of aggradation with no single index number to be interpreted as a threshold. However, logical groupings may be made for general watershed interpretations. Index numbers less than 70 indicate systems that are in dynamic equilibrium. Numbers greater than 90 indicate watershed systems that are out of equilibrium and/or where geomorphic thresholds have been exceeded. Index numbers intermediate between 70 and 90 are approaching a geomorphic threshold and require the judgement of an experienced professional hydrologist to ascertain the degree of aggradation.

Index numbers less than 50 may either indicate stable large bed element channels or channels where downcutting (degradation) has occurred. Degrading reaches will usually have an adjacent aggrading reach immediately downstream. For example, the degraded riffle may have an index number of 35, and the downstream aggraded riffle may have an index number of 80.

This procedure is best applied on a system basis to the network of channels that comprise a watershed. For watersheds that have a uniform longitudinal profile, the spacial distribution of index percentiles may be used to identify sediment source and relative age. For example, if the index percentile increases uniformly down channel, this indicates an older source of sediment that is being moved through the system. An abrupt increase in the index is indicative of a major sediment source just upstream from the increase. This could come from a landslide, debris torrent, or from a tributary stream with its own stability problems. If the index percentile increases upstream, recent sources of bedload are indicated. Watersheds that have high index percentiles from the main stem to the headwaters have long term and continuing sediment sources. Within a reach, the low gradient riffles will show aggradation more readily than the high gradient riffles. This may present some apparent variability within the reach.

The procedure is most applicable to gravel and cobble streams in single channels. It can not be directly applied to sand bed channels where the bedforms are ripples and dunes. Indirect methods must be used to determine whether the sand is nutural or the result of the total aggradation of gravel or cobble substrate by sand sized bedload. The streambed should be probed with a spade or pry bar to determine whether and at what depth coarser bed material is present. The presence of coarse material at shallow depth suggests aggradation. Absence of coarse material indicates a natural sand channel. Where gravel or cobble reaches are present downstream from the sand reach, the RSI procedure may be used to evaluate the rate of sand bedload transport from upstream. Energy limited systems will show a percentage of sand sizes and smaller in the riffle approaching 50 percent.

When the tractive force altenative is used to determine the RSI index, the reliability of the result is somewhat lower than the point bar sample method. Errors in measurement of channel gradient can produce magnified errors of the estimate of particle size moved at bankfull. In addition, the relationship between shear stress and grain size does not apply equally well to all combinations of gradient and hydraulic radius. It does not work well in large rivers. When the tractive force alternative is used, the index number should be used in combination with other factors that may be extracted from the channel geometry data to develop a "riffle diagnostic". The width-depth ratio at bankfull discharge can be compared with known values for stable channels of the same type. The channel cross section can be evaluated for evidence of the convex profile typical of aggrading systems. The distance between riffle crests that was measured to determine gradient also represents the wavelength of the channel system. This can be compared with the width of the channel at bankfull discharge and expressed as a ratio. A stable channel will have a riffle spacing of five to seven times bankfull width. The particle size distribution can be evaluated for distribution of size classes. Bimodal size class distributions are also indicative of watersheds with sediment problems. When the RSI index, width-depth ratio, cross section shape, riffle spacing, and size class distribution are cumulatively considered, they provide a versatile analysis tool for the watershed manager.

APPLICATIONS

The following examples of Riffle Stability Index application are from field data collected on the Idaho Panhandle National Forests during the 1991 and 1992 field seasons as part of either inventory or project work, and in conjunction with a USDA River Basin Study of the Coeur d'Alene River. Most of the data is from watersheds ranging in size from 10 to 20 square miles. The main stem channels of the St. Joe and Coeur d'Alene Rivers were also sampled in several locations. All of the data presented utilize the bar sample methodology.

Figure 2. shows the cumulative particle size distribution curves of B-3 channels in three belt geology watersheds of about 15 square miles. All three have similar soils and landtypes and are pristine unentered drainages. They are assumed to be in dynamic equilibrium. The very close agreement of the distribution curves suggests that for similar climate, geology, soils, watershed size, and channel type, there exists a characteristic and predictable particle size distribution for watersheds in dynamic equilibrium.

The data base includes 315 riffles from belt geology B Type channels in the Coeur d'Alene and St. Joe drainages. These were stratified for analysis as entered or unentered. The results are displayed in ***Figure 3.*** The 29 riffles from unentered watersheds have a mean Riffle Stability Index (RSI) of 50.8 and a range of 33 to 74. The 286 riffles from watersheds with varying levels of roading, timber harvest, or mining activity have an average of 79.5 and a range of 38 to 100. The skewness of the distribution curve suggests a population shift towards increasing riffle substrate mobility with increasing activity.

The relationship between timber harvest and stream channel equilibrium is evaluated further. The data set includes 43 watersheds with varying levels of harvest activity that were scaled from zero to ten. A scale of one would indicate light roading and little harvest. A scale of nine reflects an Equivalent Clearcut Area of 20% to 30%, and a system road density of two to four miles per square mile, with associated jammer logging road densities greater than ten miles per square mile. One representative RSI value from a lower B reach of each watershed is plotted against the relative magnitude of harvest and roading in ***Figure 4.*** The index values increase with increasing impact. The trend line relates an impact rating of 0 to a RSI index of 53, and an impact rating of 10 to a RSI index of 90. Scatter in the data points indicates that channel equilibrium is related to much more than simply the proportion of a drainage basin that is harvested. Other variables include the location and spatial distribution of harvest, size of openings, location and density of roads, and the presence or absence of effective Best Management Practices.

Aggradation on riffles is accompanied by filling of pools. ***Figure 5.*** displays data from B channel types in both entered and unentered belt geology watersheds of the upper St. Joe river. Residual pool volume is divided by watershed area to eliminate watershed size as a variable. The data show a dramatic decrease in pool volume with increasing RSI. As RSI approaches 100, pool volume approaches zero. The relationship is statistically significant at the .999 level. Variability may be explained by other factors that create and maintain pools such as large woody debris and bedrock outcrops.

Figure 6. shows the shift of channel particle size distribution and RSI index in the Coeur d'Alene River near Prichard over the past twenty-five years. Long time residents remember a river whose bottom was made up of "large plates of rock". In 1967, the U.S. Geological Survey used Wolman pebble count techniques to characterize the size distribution of the river channel near their stream gage (12412000). Barnes (1967) reports the d50 as 103 mm, and the d84 as 650 mm. Channel surveys conducted by the U.S. Forest Service in 1991 at the same location show the d50 to be 32 mm and the d84 as 64 mm. RSI index in 1991 was 98, and is projected to have been 60 in 1967. The shift in the RSI index expressed the aggradation that has taken place as the large bed elements were buried by cobble and gravel. The elevation of the channel bottom has raised more than two feet since 1967, and the channel capacity has been reduced by approximately thirty percent.

The RSI procedure measures dynamic equilibrium at one point in the stream channel. Several samples are needed to ascertain the equilibrium of a watershed as a system. Sampling is stratified by dividing the network of stream channels into similar reaches using Rosgen's (1985) method as updated in 1993. For each reach, a minimum of three representative riffles are selected and measured.

Figure 7. displays the cumulative particle size distribution for three riffles representing three different reaches in a small watershed. In each case, the dominant large particle size on nearby fresh depositional features is approximately 30 millimeters for all reaches. This represents 95 percentile of Curve 1, 59 percentile of Curve 2, and 20 percentile of Curve 3. Thus, the RSI indexes would be 95, 59, and 20 respectively.

Curve 3 represents a headwaters "A" channel that has experienced downcutting or degradation; perhaps as a result of increased peak flows from timber harvest and increased effective gradient following removal of Large Organic Debris from the channel. This phenomenon has been observed by Madej (1982) and others. Small transportable particle sizes have been flushed from the channel and are absent. ***Curve 1*** represents lower reach "B" channel that has received the sediment scoured from the headwaters. The same particle size classes absent from ***Curve 3*** are overabundant in ***Curve 1.*** The segment of ***Curve 1*** from 4 mm to 32 mm has a steep slope indicating a large percent of sediment present in the these sizes. ***Curve 2*** represents a transition reach of equilibrium. The watershed as a system is **NOT** in dynamic equilibrium.

Data from degrading reaches is scarce and difficult to measure. As a channel scours to bed armor, mobile particles are evacuated from the reach and fresh depositional features may become difficult to find. They are often step - pool rather than pool - riffle channels. Identification of representative high gradient components becomes problematic in the field.

When used as a diagnostic tool, the RSI index numbers should not be averaged either for the three samples within a reach, or for the several reaches of a watershed. Within a reach, variability is to be expected in response to subtle differences in gradient; especially in a reach that is trending away from equilibrium. Low gradient riffles will aggrade more readily than high gradient riffles, and will degrade more slowly. Averaging reaches can produce misleading results. For example, if Reaches 1 and 3 of the watershed in Figure 7 were averaged, (95 + 20 /2) the average would be 58. This would lead to an erroneous conclusion of watershed stability. Similarly, measurements from one riffle or reach should not be used to characterize a watershed. If Reach 2 in Figure 7 was measured, its index of 59 would lead to the same erroneous conclusion. Professional analysis is needed to synthesize the data from all riffles and reaches to produce a diagnosis.

The Riffle Stability Index procedure is proving to be a useful management tool for watersheds in belt series geology in north Idaho. It can quantify the current watershed condition relative to dynamic equilibrium and relative to the natural variability of watershed ecosystems. In forested watersheds, variability may be the result

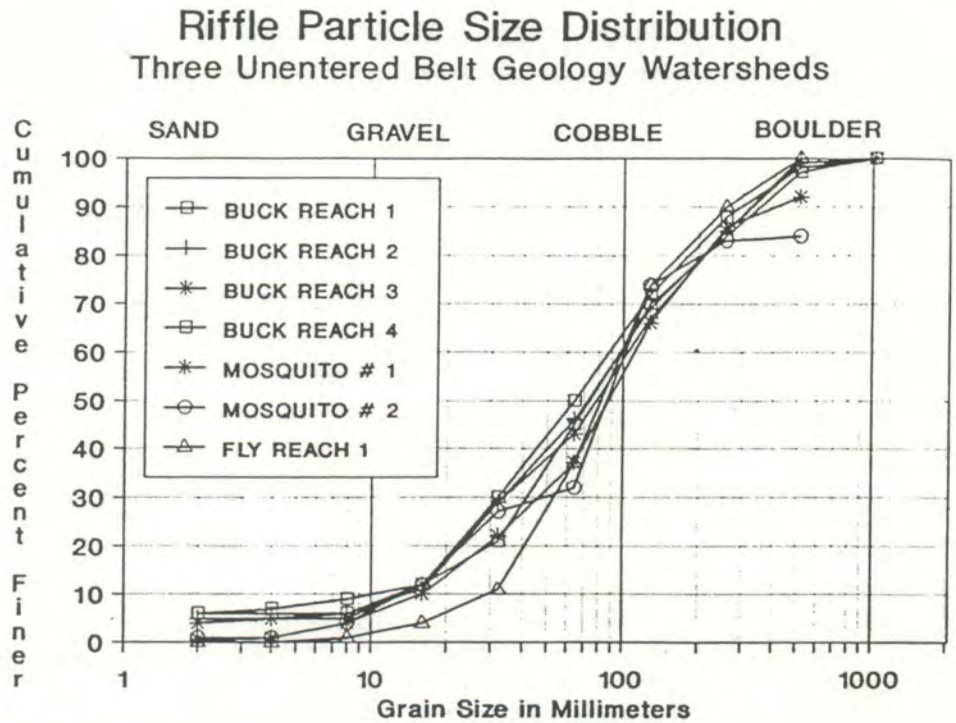


FIGURE 2.

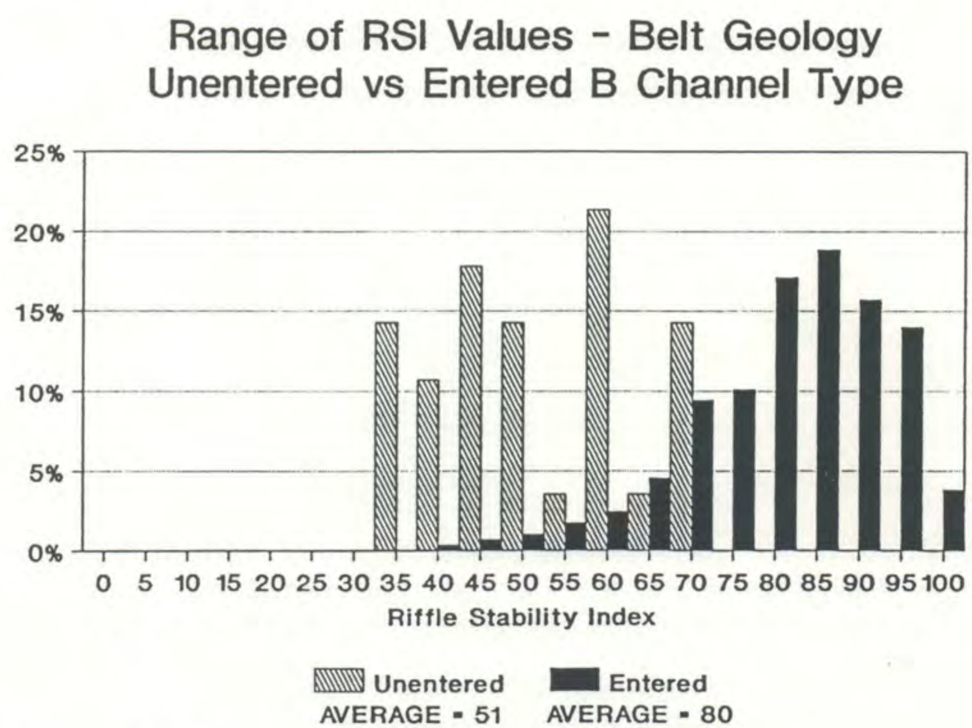


Figure 3.

RSI vs HARVEST AND ROADING LEVEL

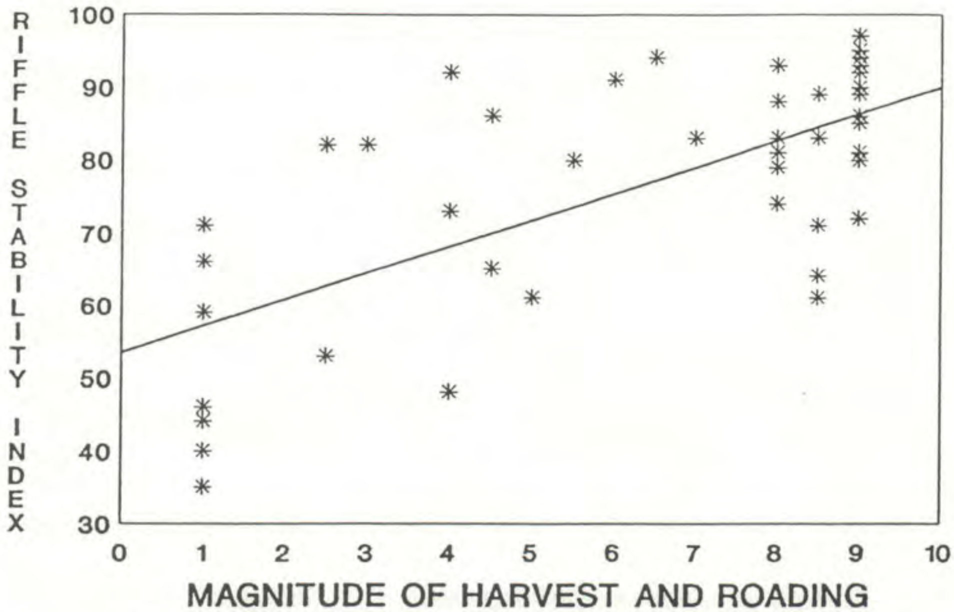


Figure 4.

RSI vs RESIDUAL POOL VOLUME
St. Joe River Tributaries - B Channels

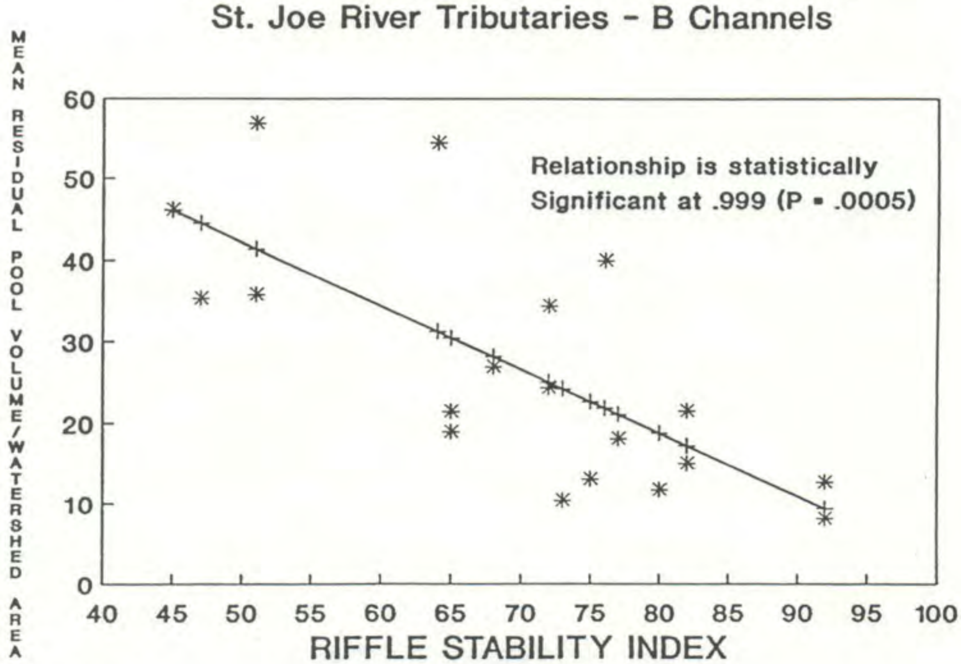


Figure 5.

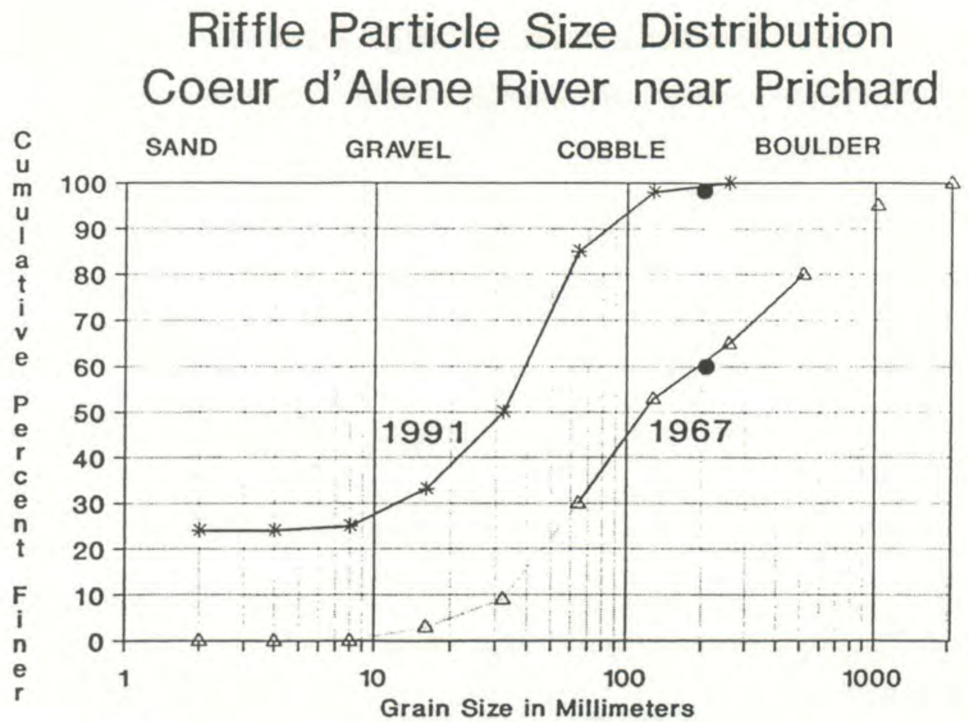


Figure 6. • Dominant Large Particle on Fresh Point Bars

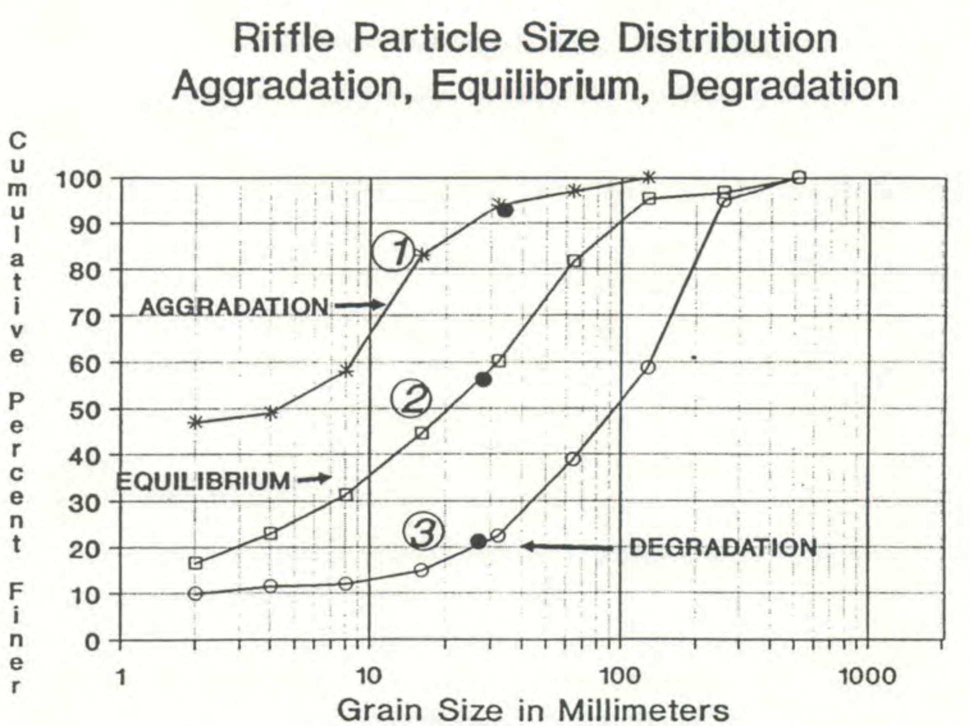


Figure 7. • Dominant Large Particle Size on Fresh Depositional Feature

of changes in ecosystem dynamics following fire, insect and disease, and vegetative successional stage. RSI can be used to monitor trend over time, and the effectiveness of mitigation, BMP's and proposed activities. As equilibrium is a necessary prerequisite for successful fish habitat improvement structures, It can be used to evaluate project risk.

Data for other geologies is somewhat limited at this time. However, the procedure appears to be equally applicable to granitics, basalts, and mica schists as well as to the belts. Data from Chamberlain and Jefferson creeks in central Montana indicate that the geographic applicability extends beyond the Idaho panhandle.

The RSI index numbers and particle size distribution curves can be related to hillslope process, and to the routing of sediment through watershed systems. Anomolously high index numbers and shifts of distribution curves can show relative contributions of landslides, debris torrents, and road fill failures.

Riffle Stability Index can also be used as an indicator of beneficial use; especially as related to cold water biota. Lisle (1982) noted that pool filling accompanies aggradation. Pools are the major habitat of most fish (Beschta and Platts, 1986). Because of the irregular geometry of pools, measurement of pool volume and volume reduction by aggradation is difficult or imprecise. Fish habitat surveys may be improved by including the RSI procedure and developing regional relationships between RSI and loss of residual pool volume.

The substrate mobility expressed by RSI may also be related to the density and species composition of stream insects. Cobb, Galloway, and Flannagan (1992) report a decrease in insect density up to 94% in an unstable riffle, while no reduction occurred in a stable riffle. In a study of benthic invertebrates in Colorado, von Guerard (1991) concluded that as the grain size of streambed material approaches that of bedload, benthic invertebrate populations might be adversely affected.

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Appendix H

Macroinvertebrate Monitoring

BENTHIC INVERTEBRATE BIOASSESSMENT

Aquatic Biology Associates, Bob Wisseman
March 1993 Version

Aquatic Biology Associates has designed a sampling and bioassessment protocol for benthic macroinvertebrate communities found in montane streams in western North America. This protocol is a modified version of the Rapid Bioassessment Protocols (RBP) developed by the US EPA.

The ABA Bioassessment is a much more intensive analysis of the benthic invertebrate communities present at a monitoring site. It is designed to detect impacts and trends in montane watersheds where monitoring objectives seek to document cumulative impacts from land management activities.

As a survey tool, it can be used to initially rate impairment in many watersheds of a given region. Specific watersheds of interest identified after initial screening can then be sampled and evaluated on an annual or semi-annual basis to determine if the invertebrate community is experiencing recovery, deteriorating, or remaining static.

Bioassessments using benthic invertebrate communities in streams has received a great deal of recent attention. Advantages of using invertebrates to monitor water/habitat quality include:

1. Invertebrates respond quickly to changes in water/habitat quality.

2. They reside in streams during most of their life cycle and thus integrate impacts over time.

3. Are relatively immobile and cannot avoid "events" or "pulses" of pollutants or other forms of stress often missed by conventional water or habitat quality sampling.

4. Are abundant and diverse in most streams and rivers, and are relatively easy to sample and analyze.

5. Presence or absence of specific taxa can be indicative of specific environmental factors.

6. While monitoring physical/chemical parameters can be used to predict impacts on biological systems, analysis of invertebrate communities directly assesses the biotic integrity of a major component of freshwater systems.

7. Benthic invertebrates can be used as a barometer of the overall biodiversity of aquatic/riparian ecosystems.

8. Serve as the primary food source for stream fishes and thus, reflect potential impact to the fishery.

Bioassessment protocols will continue to evolve and be refined over the next several years. The sampling and laboratory analysis advocated by Aquatic Biology Associates is more rigorous than those currently being used by state and federal agencies in pilot programs. This enables a more extensive analysis to be conducted that can point to specific habitat limitations in a stream. Our data can be easily "down-sized" to fit EPA or state protocols. However, if more stream-lined protocols are found to be insensitive at a later date it is impossible to retroactively upgrade data which is based on inadequate sampling regimes or taxonomic analysis.

SAMPLING

Starting in 1991, ABA has adopted a protocol that includes samples from three different habitats or substrates. These include:

1. RIFFLE SAMPLE (Includes all erosional habitats present): "Riffles" are traditionally sampled in nearly all benthic invertebrate monitoring programs. Riffles in montane streams usually support a rich and productive invertebrate community. The structure of the riffle community can be diagnostic of general environmental conditions in stream ecosystems.

Riffles are stream habitats where water flow and hydraulics are strongest. Thus, riffle communities may lag in their response to impacts occurring in the entire stream ecosystem, because stronger hydraulics keep substrates well aerated and mostly clear of fine sediment and extensive growth of filamentous algae.

ABA uses a kick-net with 500 micron mesh to sample erosional habitats at a stream monitoring site. Five points are chosen for sampling that include riffles, runs, and cascades (if present). At each of the 5 points an area of approximately 0.1 square meter above the net is brushed and stirred to dislodge invertebrates into the net. The sample consists of a composite of these five points, representing approximately 0.5 square meter.

2. MARGIN SAMPLE: ABA developed this sampling protocol in response to frustrations to riffle only sampling. Margins are defined here as wetted substrates in slower water near shore.

Stream margins are important rearing and refugia areas for many aquatic invertebrates. Also, a number of taxa are found almost exclusively in the margin area. It is also a habitat of considerable importance to juvenile fish.

This is a habitat that is often impacted heavily by management activities. Substrates in the slackwater along the stream margin can be fouled more easily by fine sediment, or elevated stream temperatures and/or decreased summer flow can lead to extensive growth of filamentous algae. Margins are more susceptible to winter scour and desiccation in the summer.

Changes in basic stream morphology can lead to large impacts on the margin habitat....e.g. shift in the channel cross-section from a more deep & narrow profile towards a more wide & shallow one.

Twenty margin cobbles are selected from the stream margin, 10 from margins in erosional reaches and 10 from pool margins (if present). Cobbles are chosen that appear to represent the best available habitat to be found on the margin, and thus are chosen on a non-random basis. The analysis of this sample does not stress absolute estimates of abundance. Metrics evaluate not only "who" is utilizing this habitat and their relative abundance, but as importantly "who" is not there.

3. CPOM Sample (Coarse particulate organic matter, or detritus): **Organic matter derived from terrestrial and aquatic vegetation is an important energy source for montane streams. It is the prime source for heavily shaded small streams.**

Macroinvertebrates called shredders are instrumental in the metabolism of detritus and ultimately in its conversion to higher trophic levels. Shredders are primarily stoneflies and caddisflies in montane streams, which require one or more years to complete their life cycle.

The variety and abundance of shredders utilizing CPOM in a stream relates to the streams efficiency at converting this resource to secondary production. In order for many of the shredder taxa to maintain robust populations, it is necessary for the CPOM (especially deciduous leaves) to persist in the stream for a sufficient time period to allow completion of life cycles. It must also be available for shredder colonization for the time required to complete life cycles (e.g. not stranded above the water or trapped in anaerobic sediment conditions).

The kinds of shredder taxa found in western montane streams can be indicative of a streams ability to retain organic matter. For example, in southwest Oregon streams with excellent retention capability, from 5-10 taxa of shredder caddisflies can be found. The presence/absence and abundance of certain taxa appear to be directly related to retention capabilities.

The CPOM sample consists of well conditioned, higher nutrient detritus (typically deciduous leaves). A gallon bucket of this detritus is taken from pockets on stream margins, pool bottoms, and leaf packs in faster current. As for the margin sample, the CPOM collection is non-random. Best available, and biologically active substrates are selected in order to determine the full range of shredder taxa present and their relative abundance.

SAMPLE AND DATA ANALYSIS

Samples are processed in the lab. Either the entire sample is sorted under 6X magnification with a dissecting microscope, or a fraction is sorted that contains a minimum of 300 organisms. The minimum amount of organisms sorted will probably increase to 400 or 500 in the near future.

Organisms are identified by qualified specialists. The quality of identifications being made by some other labs which process Forest Service and BLM samples is very low.

The level of taxonomic effort applied to each group of invertebrates is standardized. This is usually genus for most insects, though some of the better known and more distinct taxa are taken to species. Chironomid midges are taken to genus since they are usually a taxa rich and abundant component of most freshwater benthic communities.

Standardization of taxonomic effort is extremely important, since the vast majority of the metrics used in the bioassessment are either direct expressions of taxa richness, or richness estimates are a coefficient in the metric equation.

Clients are provided with a tabular listing of taxa identified and their abundances for each of the three sample types, plus an exhaustive listing of community composition metrics calculated from the sample data. These provide complete documentation and can be found in appendices provided the client.

Summaries of selected metrics are prepared for inclusion in the main report, and to aid in the bioassessment and for reference for written interpretation of site conditions and trends.

BIOASSESSMENT

A sample template for the bioassessment conducted by ABA and the scoring criteria used are provided in the following pages. In our bioassessment we use 53 metrics to rate the riffle sample, 30 for the margin sample, and 27 for the CPOM sample. The site score columns of the template list maximum possible scores for the particular metrics. Individual metrics are discussed in more detail below.

Scoring Criteria

Each of the metrics (e.g. Total taxa richness) receives a score based on the value calculated for the site. For many of the metrics, a site value is scored 4,3,2,1,0, depending on what class interval the site value falls into. Higher individual metric scores indicate more positive or healthy conditions. Metrics may also be scored on a 3,2,1,0; 2,1,0; 2,0; or 1,0 basis, depending on metric sensitivity and/or how much that individual metric is weighted in the overall analysis.

For our scoring criteria, we have adopted a fixed value approach instead of attempting comparisons with a reference value as advocated for the EPA Rapid Bioassessment Protocol. That is, actual site values are scored directly and not first expressed as a % comparison with a reference value. Thus if a site has >60 taxa it receives a 4, 50-59 taxa a 3, 40-49 taxa a 2, and so on. A suitable reference site data base is simply not available at this time.

Scoring criteria are currently based on subjective "best professional judgement". However we feel that the class intervals that have been selected are realistic, and related to habitat/water quality. They are based on personal experience with nearly a thousand stream sites in western North America. Our fixed system of scoring criteria will evolve and become more objective as more information is assimilated.

Tiered Assessment

The ABA Bioassessment Protocol provides a tiered approach to assessing the integrity of benthic invertebrate communities at a site.

1. First, there is a single "bottom line" value given for each of the three sample types (line 65 of the bioassessment) that is a cumulative score of all the metrics which, and is expressed as a % of the maximum possible score. These single cumulative values can be viewed as a final grade for the site for three habitat types.

2. Second, metrics have been grouped into three categories, and subtotal scores are calculated for each of these categories.

Primary Metrics: There are 6 primary metrics used (lines 2-7) that evaluate community composition in general terms.

Positive Indicators: These are particular taxa, taxa assemblages, or feeding groups whose presence or increased abundance is a positive sign.

Negative Indicators: Converse of the positive indicators.

Subtotal scores from the metric groups can be tracked can be tracked individually...e.g. is a site losing or gaining positive indicators over time.

3. Third, individual metrics or collections of metrics can be used as indicators of specific habitat parameters such as; CPOM retention capability, winter scour, excessive summer water temperatures, hyporheic and crevice space limitation, etc.

Bioassessment Model

It is important to note that the ABA Bioassessment (as do most other bioassessments), evaluates a benthic invertebrate community based on what is considered to be "ideal". Thus, a high taxa richness, or a predominance of cool-adapted, rheophilic taxa is considered to be a positive sign.

The "ideal" that the ABA Bioassessment is based on is a mid-order montane stream with:

1. A dense riparian overstory providing heavy shading to the channel.
2. A moderate to high gradient.
3. Cobble and boulder substrates dominant (i.e. high roughness).
4. A strong, perennial flow of cool or cold water.
5. A more narrower and deeper channel with high habitat complexity.
6. A moderate to high amount of bole wood present to increase habitat complexity and aid retention of CPOM.
7. High diatom production to support scrapers, and low filamentous algae production.
8. High inputs of deciduous leaves and conifer needles.
9. Low inputs of fine sediment.
10. Limited scouring and resorting of substrates, but with an intermediate level of disturbance to increase habitat complexity.
11. A hyporheic zone open to invertebrate colonization.
12. A high amount of "crevice space" around and under surface rocks.

etc.

Possession of the entire suite of ideal habitat/water quality conditions is probably only met by a limited number of streams in old-growth forests in western North America. Most forested watersheds display more limited or impaired habitat conditions even in the absence of human management regimes. Sites which are more open, lower gradient, more riverine or in larger streams will naturally score lower.

Potential total scores for least impacted streams is expected to vary from region to region, and within a region. For example, western Cascade streams may tend to score higher than streams in interior mountain ranges. Or, a north-facing watershed may have habitat conditions which more nearly approximate the "ideal" than near by south-facing watershed.

The scoring adopted in the ABA Bioassessment Protocol is purposefully "strict". This increases sensitivity and allows a fuller range of final values to be obtained. If class intervals are used that are set too low, then individual metric scores for most streams encountered will be high, and total scores will invariably also be high, regardless of whether a sewage lagoon or pristine montane stream is sampled.

Total scores (% Maximum Possible Score) should be interpreted as being "graded on a curve". Thus, impairment categories don't conform to a 90-100%= A, 80-89%=B, etc., type of scaling. General impairment categories have been tentatively assigned as follows.

80-100% Non-impaired. Excellent habitat/water quality.

60-79% Slightly impaired. The benthic invertebrate community points to habitat limitations.

40-59% Moderately impaired. The community reflects significant habitat and/or water quality limitations.

<40% Severely impaired. The community present has developed under habitat conditions that represent a severe departure from the ideal conditions.

INDIVIDUAL METRIC LISTING

Brief descriptions of metrics selected for the bioassessment are given below. Numbers correspond to line numbers of the template.

1. Primary Metrics: These are 6 general community structure metrics that rate standing crop, total richness, diversity, and tolerance of organisms present. Many of these metrics are used in the EPA's Rapid Bioassessment Protocols.

2. Total abundance: The 5 point kick sample provides a rough estimate of standing crop. Riffles in productive montane streams will usually have at least 1000 invertebrates per square meter.

Densities on the 20 margin cobbles will exceed 500 in streams where the margin habitat is in good condition. Heavily impacted streams where margin cobbles are fouled with fine sediment or filamentous algae; or where temperatures are high during the summer will often have <100 organisms present on the 20 cobbles.

CPOM samples from streams with good retention capabilities will have over 600 organisms in the 1 gallon detritus sample, and the majority of these will be shredders.

3. Total taxa richness: Scores are provided for class intervals of the total number of distinct taxa identified from each of the three sample types. Unimpacted streams that are very rich in will occasionally exceed 70 taxa in riffle samples. Total taxa richness in least impacted streams varies geographically.

Margin cobbles usually have fewer taxa present, though robust margin communities may have over 50 taxa present. In streams with high fine sediment inputs, or extensive fouling of margin cobbles, taxa richness can be below 20 or even 10; and those present will be highly tolerant.

CPOM samples naturally have fewer taxa present. Rheophilic taxa are not commonly found in detritus accumulations.

4. EPT taxa richness: This is the richness of the insect orders Ephemeroptera + Plecoptera + Trichoptera. Many of these taxa are some of the more intolerant aquatic invertebrates, though tolerant forms can also be found in these orders. EPT richness appears to be a good indicator of over all habitat/water quality.

5. % Dominant taxa: This is the % contribution of the most numerous taxa present in a sample. It is a simple measure of diversity. Stressed communities often are composed of not only fewer taxa, but also overwhelmed by a few tolerant and/or "weed" type taxa. Margin and CPOM samples in least impacted streams may have a higher % of the most numerous taxa, but these will usually be more intolerant taxa. Margin samples often have a high proportion of early instar mayflies.

6. Brillouin diversity (H): The Brillouin is a diversity index based on information theory. It is similar to the Shannon Index. The higher the index number, the higher the diversity of the community. Communities dominated by a few numerous taxa will have low diversity index scores, while those where the abundance of taxa are more evenly distributed will have higher diversity scores.

7. The Hilsenhoff Biotic Index is a saprobic index that evaluates the tolerance of the benthic taxa present at a site to organic enrichment. Taxa tolerant of organic enrichment are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth. The scale is 0-10, with 0 meaning that all taxa present are highly intolerant, and taxa inhabiting sewage lagoons would probably approach 10.

8. Positive Indicators: These are particular taxa, taxa assemblages, or feeding groups whose presence or increased abundance is a positive sign.

9. % Predator: Invertebrate predators typically make up a relatively proportion of montane stream benthic communities. Many predator taxa are long-lived and tend to be fairly susceptible to stress.

10. Predator richness is the total number of distinct predator taxa identified from a sample. Unimpacted montane streams are almost always rich in predator taxa, while stress typically reduces the number of taxa present.

11. % Scraper: Scrapers are invertebrates that scrape the diatom algae and organic film off hard surfaces (rock or wood). At least 10% of the fauna in least impacted montane stream riffles usually belongs to the scraper feeding group. Margin cobbles should have a higher % contribution, as the margin is an important rearing area for early instar scrapers. Many of the scrapers present in montane streams are mayflies or caddisflies.

12. Scraper richness: High numbers of scraper taxa, as with predators, is a positive sign.

13. Caddis scraper richness: Caddisfly scrapers appear to be more sensitive to impacts than the mayfly scrapers. High numbers of caddis scraper taxa at a site is usually a very positive sign about habitat quality.

14. % Shredder: Shredders appear to be a very sensitive indicator of certain habitat parameters. Unimpacted streams with relatively stable substrates and good retention capabilities will have a much higher % of the taxa present as shredders, even in riffle samples.

15. % Caddis shredder: CPOM samples in montane streams with high biotic and habitat integrity will have a high % of caddis shredders.

16. % Stonefly Shredder: Same as for % caddis shredder.

17. Shredder richness: This is the total number of shredder taxa present. Montane streams with high biotic/habitat integrity will support many shredder taxa.

18. Caddis shredder richness: The number of caddis shredders present appears to be a function of retention capabilities of the stream, plus overall habitat complexity. Caddis shredder taxa appear to disappear from streams in a consistent order as impacts increase.

For example, in western Oregon streams with low retention capabilities & little roughness or pockets where CPOM can accumulate, *Heteroplectron californicum* will invariably be absent. This is a slow-growing caddis shredder that is easily "blown out" of this type of stream. A small caddisfly taxa, panel-case *Lepidostoma*, will often be found in streams where all other caddis shredders have disappeared. This is a faster growing taxa that can complete its life cycle by mid-fall, before winter storms push most of the CPOM out of the stream.

19. Stonefly shredder richness: same as for caddisflies.

20. Xylophages are invertebrates that eat wood. Though many taxa will scrape wood surfaces for the more nutritious algal/periphyton film present, xylophages derived a large part of their nutrition from consuming the wood itself. Since wood is a nutrient poor substrate, these taxa either take a long time to complete their life cycle (7 or more years in some cases), or supplement their diet when other more nutrient rich substrates become available.

The presence of xylophages is a positive sign. These taxa disappear quickly when the habitat quality of a stream is depressed. Xylophage taxa include the beetle *Lara avara*, the mayfly *Cinygma*, and the caddisflies *Heteroplectron californicum* and *Cryptochia*.

21. Intolerant molluscs: These include some rare and endemic molluscs found in only a few drainages. Hydrobiid snails and unionid mussels are also considered to be intolerant and respond negatively to declines in habitat/water quality.

22. % Intolerant mayflies: This assemblage of mayflies from several families is composed of taxa that are cool-adapted, intolerant of fine sediment, require high oxygen tensions, and are sensitive to high winter scour/resorting of substrates. These taxa are found throughout western North America, and are typically found where habitat integrity is high. Taxa include *Baetis bicaudatus, Caudatella spp., Drunella doddsi, and Epeorus grandis*. Some rarer, less widely distributed taxa are also included in this group.

Montane streams, even at lower elevations will have intolerant mayflies present if habitat integrity is high (i.e. ideal).

23. % Intolerant stoneflies: This is an assemblage of stoneflies that are cool-adapted, and fine sediment and winter scour/resorting intolerant. Many of the taxa are shredders, though predaceous taxa are also included. Taxa include; capniids, leuctrids, *Visoka cataractae, Zapada columbiana, Zapada frigida, Doroneuria, Megarcys, Setvena*, and peltoperlids.

24. Intolerant stonefly richness: The intolerant stoneflies seem to be particular sensitive to almost all forms of habitat degradation and decline in water quality. They can be found at lower

elevations, but usually only where summer water temperatures are relatively low, and where shading to the stream channel is high.

25. Intolerant caddisflies: Similar parameters as the intolerant mayflies and stoneflies. They are scored as either present or absent, e.g. at least one taxa is present. Widespread and common taxa include *Parapsyche elsis, Anagapetus, Ecclisomyia, some Psychoglypha, Dolophilodes, Rhyacophila Alberta Group, Rhyacophila Iranda Group, Rhyacophila verrula, Farula, Neothremma and Oligophlebodes*. Taxa of more limited distribution are also included in this assemblage.

26. Intolerant dipterans: These are non-chironomid taxa that tend to be found in streams with high habitat/water quality. Most unimpacted montane streams will have at least one taxa. Taxa include the blepharacerids , deuterophlebiids, pelecorhynchids, tanyderids, and some tipulid genera.

27. Gomphidae: Members of this dragonfly family are generally tolerant fine sediment, warmer water, and lower oxygen tensions. However, they are also long-lived taxa that live in detritus accumulations which are easily flushed from streams with low retention capabilities.

28. Ephemerellidae richness: This family of mayflies has many taxa that are widespread and common in western montane streams. The family also includes a number of intolerant taxa. If taxa richness in this family is high at a site, then habitat complexity and integrity is usually high and summer water temperatures are not high.

29. Heptageniidae richness: The heptageniids are a family of scraper mayflies that are also widespread and common in western montane streams. The same comments as for the ephemerellids apply.

30. *Pteronarcys*: This is the "salmonfly" of fly-fishing fame. Though moderately tolerant, *Pteronarcys* is a long-lived taxa that can be easily lost from a stream system where scouring and resorting of substrates is high and retention of CPOM is low. *Pteronarcys* is an omnivore.

31. Corydalidae (hellgrammites): Corydalids are not found in all ecoregions, though they are common along the Pacific coastal mountain ranges. These large, long-lived predators can tolerate warmer water, but are intolerant of high winter scour and resorting of substrates. They are also tend to disappear from streams where embeddedness is high, as fine sediment closes then out of their preferred retreats beneath the armor layer cobble.

32. Arctopsychidae: Arctopsychid caddisflies are predators that spin coarse nets of silk and trap and eat small invertebrates that drift into them. Two taxa, *Parapsyche elsis* and *Arctopsyche*

grandis, are widespread and common taxa in montane streams in western North America. Like the Corydalids, they are long-lived, larger taxa that are found in net retreats beneath the cobble armor layer. They are susceptible to high winter scour/resorting and high embeddedness. *Parapsyche elsis* is found in small to mid-size, colder streams, while *Arctopsyche grandis* can be found from mid-size streams to rivers.

33. Glossosomatidae: Glossosomatids are relatively intolerant scraper caddisflies that can typical components of montane streams and rivers. They do poorly where winter scour is high, where filamentous algae fouls rock surfaces, where fine sediment smothers rock surfaces, or where low summer flows leave much of the margin stranded in streams that are wide and shallow.

34. Philopotamidae: Philopotamids are net-spinning caddisflies found beneath the armor layer and in the hyporheos. Where hyporheic habitats and crevice space in the armor layer is closed due to excessive fine sediment or sluicing to bedrock, philopotamids will tend to disappear.

35. Psychomyiidae: Psychomyiids are scraper caddisflies that build tube retreats on rocks, usually on stream margins, or in slower water. They are intolerant of fine sediment and heavy winter scour.

36. *Rhyacophila* richness: This is a diverse genera of predaceous caddisflies that are ubiquitous in western montane streams. Though generally a cool-adapted genus, there are taxa that tolerate warmer water. High taxa richness typically corresponds to high habitat complexity and integrity.

37. Nemouridae richness: Nemourids are a family of shredder stoneflies that are also ubiquitous in western montane streams. Taxa range from moderately tolerant to highly intolerant, and can be found in a variety of habitats and mature in various seasons. High taxa richness in this family also corresponds to high habitat/water quality.

38. *Cricotopus Nostococladius* is a chironomid midge that lives in symbiosis with the blue-green algae *Nostoc*. When the midge infects the algae, *Nostoc* changes from a globular ball to an ear shaped growth that is attached tightly to hard substrates. *Nostoc* is common in western montane streams. It prefers cooler water. Absence of the midge and the algae from a stream that otherwise has cool water temperatures and an abundance of rocky substrate, typically indicates that winter scour may be severe, or fine sediment may be high.

39. Other intolerant midges include such taxa as *Heterotrissocladius, Krenopsectra, Pagastia, Potthastia, Pseudorthocladius,* and *Synorthocladius*.

40 Negative Indicators are taxa are feeding groups whose presence or unusually high abundance is indicative of a stressed stream system and a departure from ideal habitat/water quality conditions.

41. %Collector-gatherer: Members of this feeding group "collect" fine organic particles as food. They can be found on rocky substrates, but are usually most numerous on soft bottoms or in pools. Collector-gatherers are a normal constituent of all aquatic ecosystems, however high numbers in riffle, margin or CPOM habitats is generally indicative of stressed habitat conditions. Many of the collector-gatherers are "weed" type, tolerant taxa that can proliferate in streams that have lost many or most of the intolerant forms.

42. % Collector-filterers are a diverse feeding group that capture small organic particles from the water column through a variety of adaptations (e.g. silk nets, or rows of fine hairs on appendages). They are ubiquitous in running waters. Taxa range from intolerant to very high in their tolerance.

In forested, heavily shaded, cool montane streams, collector-filterers usually appear in insignificant numbers. Their numbers increase when shading decreases and both water temperatures and production of filamentous algae increases. They are common or abundant in open, more nutrient enriched systems and in larger streams and rivers.

43. % Parasite: Stresses aquatic ecosystems may have elevated numbers of parasites present. Common parasites in montane streams are mites (Acari) and nematode worms.

44. % Oligochaeta: Oligochaet worms thrive in habitats where organic rich fine sediment has built up. Some taxa are extremely tolerant. High numbers in montane riffles, margins, and CPOM is usually a negative sign, though numbers can build up in spring-fed systems where a more constant annual hydrograph and infrequent floods allows pockets of fine sediment to accumulate.

45. %Leech (Hirudinea): High leech densities in montane streams is almost always a negative sign, often pointing to some kind of nutrient enrichment.

46. %Tolerant snails: *Juga, Ferrissia*, physids, most planorbids, and many lymnaid snails are tolerant of fine sediment, warmer water and depressed oxygen tensions. High numbers of these snails typically indicate depressed habitat/water quality.

47. Tolerant amphipods: *Hyalella azteca* is a tolerant amphipod encountered infrequently in western montane streams. It is not found in higher gradient streams.

48. Tolerant odonates are dragonfly or damselfly taxa that can be

found where nutrient enrichment or filamentous algae production is high. They are occur at sites where summer water temperature is high, and usually in low to moderate gradient streams.

49. Tolerant mayflies are an assemblage of taxa that exhibit high tolerance to warmer water, fine sediment, and/or nutrient enriched situations. *Caenis* and *Tricorythodes* are the two tolerant taxa that are common and widespread in western North America. Their presence in mid-size, moderate to high gradient montane streams is highly indicative of nutrient enrichment and high summer water temperature. Enrichment may be derived in part from high filamentous algal production and lack of flushing due to low flows.

50. % Acentrella: This baetid mayfly is a taxa commonly found in warmer, low to moderate gradient, large streams and rivers. When it appears in high numbers in mid-size, moderate to high gradient montane streams it means that summer water temperatures are high, and often nutrient enrichment from high filamentous algal and lack of flushing is occurring.

51. *Baetis tricaudatus* is one of the most common mayflies to be found in western montane streams in rivers. It is relatively tolerant, and can be found in a wide range of stream/ riverine sizes. Though invariably present, high numbers of this more "weed" taxa point to a general decline in habitat/water quality.

52. *Hydropsyche* is a net spinning, collector-filter caddisfly. The same comments as for *Baetis tricaudatus* apply.

53. *Cheumatopsyche and Helicopsyche* are two highly tolerant caddisflies. They are normally present in larger, lower gradient, warmer streams and rivers in western North America. When they appear in relatively high numbers in small to mid-size montane streams, then stress from high summer temperatures, nutrient enrichment and/or low flows is indicated.

54. % Tolerant hydroptilids (microcaddisflies): Same comments as for *Cheumatopsyche* and *Helicopsyche*.

55. % Tolerant elmids (riffle beetles) include *Cleptelmis, Optioservus and Zaitzevia*. These genera will be found in abundance at sites with impaired habitat/water quality. Very high densities of these beetles can be found where nutrient enrichment is occurring. They are often the only elmid genera present in more impacted systems.

56. % Tolerant beetles: Haliplids, gyrinids (whirligigs) and psephenids (water pennies) are beetles that are also tolerant. They can be found in warmer streams.

57. % Simuliidae (black flies) are a normal component of almost all montane streams. High densities of these larvae are usually

associated with disturbed or enriched streams.

58. % Antocha is a tipulid (cranefly) larvae that is widespread and common in western North America. High numbers are usually indicative of excessive filamentous algae production and/or a lack of flushing, allowing fine organic and mineral sediment to accumulate in a stream channel.

59. % Other Tolerant dipterans (flies) include taxa in the families Athericidae, Ceratopogonidae, Culicidae, Dolichopodidae, Ephydridae, Muscidae, Stratiomyiidae and Tabanidae. Though these taxa are commonly encountered in montane streams, they are usually rare or absent in streams of high habitat/water quality.

60. % Chironomidae: Chironomid midges are nearly ubiquitous in freshwater ecosystems. This is a diverse family that represent all feeding groups and can be found in nearly all habitat types. Their abundance can increase dramatically in montane streams that are stressed. "Blooms" of one or a few tolerant midges can occur. Many of the more tolerant members of this family are short generation time "weed" taxa. Total midge abundances in excess of 30% may indicate depressed habitat/water quality.

61. Highly tolerant midges include *Ablabesmyia, Cryptochironomus, Dicrotendipes, Endochironomus, Psectrocladius, Rheotanytarsus, Tanytarsus, Stictochironomus and Zavrelimyia.* Their appearance in riffle samples is regarded as a negative sign.

Appendix I

Woody Debris

Appendix I

Survey information from the 1995 survey locations.

CODE USED IN TEXT(FIG4)	1995 SAMPLE SITE FILE CODE	WAA	STREAM ORDER	STREAM DRAINAGE	WOODY DEBRIS (#/mile) CID	LWD(>36 IN)	SWD(>24 IN)	BANKFULL WIDTH(ft)	WETTED WIDTH(ft)
RSI6	**95ACRS2**	02F	1	APPLEGATE CREEK	80.5	0.0	0.0	7.5	1.6
V1	95BC1V	02V	1	BEAVER CREEK	64.4	0.0	0.0	9.8	3.3
A1	95DE1A	02A	1	DEVIL CREEK	112.6	16.1	0.0	15.1	4.6
E1	95DI1E	02E	1	DISMAL CREEK	93.3	30.6	0.0	5.6	2.2
C1	95SF1C	02C	1	SOUTH FORK CC	114.3	0.0	0.0	4.6	1.3
D1	95AC2D	02D	2	APPLEGATE CREEK	96.6	32.2	16.1	22.0	6.2
V2	95BC2V	02V	2	BEAVER CREEK	0.0	0.0	0.0	17.1	7.2
L1	95CC2L	02L	2	COW CREEK	112.6	0.0	16.1	13.1	7.2
A2	95DE2A	02A	2	DEVIL CREEK	80.5	16.1	16.1	11.2	2.7
E2	95DI2E	02E	2	DISMAL CREEK	80.5	0.0	0.0	9.2	3.3
B1	95EF2B	02B	2	EAST FORK CC	16.1	0.0	0.0	27.9	10.8
T1	95FC2T	02T	2	FRENCH CREEK	64.4	0.0	0.0	11.5	2.4
RSI12	**95SFRS2**	02C	2	SOUTH FORK CC	193.1	16.1	32.2	15.1	10.5
RSI9	95EFRS1	02B	2	EAST FORK CC	64.4	0.0	16.1	33.5	17.1
D2	95AC3D	02D	3	APPLEGATE CREEK	0.0	0.0	0.0	13.5	5.9
RSI3	95DI3E	02E	3	DISMAL CREEK	80.5	16.1	0.0	24.6	9.5
RSI11	95SF3C	02C	3	SOUTH FORK CC	35.4	0.0	0.0	21.3	11.5
RSI5	95AC4D	02D	4	APPLEGATE CREEK	16.1	0.0	0.0	30.2	14.8
RSI4	**95ACRS1**	02D	4	APPLEGATE CREEK	48.3	0.0	0.0	43.0	21.3
RSI7	**95CCRS3**	02Q	4	COW CREEK	16.1	0.0	0.0	37.1	29.2
RSI8	95CC4Q	02Q	4	COW CREEK	12.7	0.0	12.7	41.3	24.3
RSI10	**95SFRS1**	02C	4	SOUTH FORK CC	48.3	0.0	0.0	34.5	20.7
C2	95SF4C	02C	4	SOUTH FORK CC	32.2	0.0	32.2	44.3	25.3
RSI1	**95CCRS1**	02S	5	COW CREEK	0.0	0.0	0.0	33.8	33.8
N1	95CC5N	02N	5	COW CREEK	32.2	16.1	0.0	40.0	24.0
RSI2	**95CCRS2**	02M	5	COW CREEK	0.0	0.0	0.0	77.4	35.1

Appendix J

Insects and Disease

INSECT AND DISEASE CONDITIONS IN THE COW CREEK WATERSHED ANALYSIS AREA

A variety of insects and diseases are active in the Cow Creek watershed analysis area. They include two major root diseases, several needle diseases, blister rust, three species of dwarf mistletoes, stem and butt decays, and a number of bark beetles and wood borers.

Insects and diseases have significant roles in the ecosystem of this watershed. Along with other agents such as fire, wind, landslides and timber harvesting (and often acting together in "complexes") they create disturbances that trigger changes in the species composition, structure and stocking levels of the vegetation.

The activities of insects and diseases have probably increased since the early 1900s due to fire exclusion, the introduction of exotic organisms and timber harvesting. Single species, even aged plantations of Douglas-fir and ponderosa pine that have been established where mixed conifer stands previously grew are providing more uniform hosts for insects and diseases to attack. The recent drought has contributed to decreased tree vigor. The most noticeable effects from insects and diseases in this watershed at the present time are due to laminated root rot (Phellinus weirii), Bynum's blight (Lophodermella morbida), white pine blister rust (Cronartium ribicola), mountain pine beetle (Dendroctonus ponderosae), western pine beetle (Dendroctonus brevicomis) and western hemlock dwarf mistletoe (Arceuthobium tsugense subsp. tsugense).

CURRENT CONDITIONS AND TRENDS

Root Diseases and associated bark beetles: The most common root disease in this watershed is laminated root rot, caused by the fungus Phellinus weirii. The most extensive infected area appears to be in the southeast part of the watershed, in section 20, near Richter Cabin. Here several hundred acres in both plantations and natural stands may be affected to some degree. Smaller infected areas are present elsewhere in the watershed as well. Douglas-fir and grand fir are the most readily infected and killed by laminated root rot. Other conifer species may be infected, but are not often killed. However, these other species may perpetuate the disease on the site. The fungus can also survive for up to 50 years in large stumps. Susceptible hosts become infected regardless of their vigor, when their roots contact these stumps or other infected roots. Thus, over many years the disease spreads along the edges of an infected area as new root contacts are made. Within the infected area the disease will persist as long as susceptible species are present. Infection centers in the Cow Creek watershed are naturally regenerating with highly susceptible Douglas-fir and grand fir, less susceptible western hemlock and incense cedar, as well as with immune chinquapin, madrone, vine maple, oceanspray, Oregon grape and other shrubs, grasses and herbaceous species.

Armillaria root disease, caused by the fungus Armillaria ostoyae, occurs in small pockets widely scattered around the watershed. Grand fir and Douglas-fir are the most common hosts here, but all conifers and some hardwoods are also susceptible. This disease is often associated with trees that are under stress. Seedlings are often infected when their roots contact infected stumps.

Both Armillaria root disease and laminated root rot are considered "diseases of the site" because they move primarily from tree to tree, rather than over great distances via air or waterborne spores. Root diseases influence species composition, stand structure and density. They may eliminate the most susceptible hosts from stands, or prevent the survival of susceptible trees beyond seedling or sapling size. This can advance or retard succession depending on which species fill in the openings that are created. Due to the fact that they can persist for a long time on a site even after the living hosts have been removed the long term effect of root diseases may be greater than most other disturbance agents. Harvesting large, infected Douglas-fir followed by planting of Douglas-fir has favored these diseases by providing a long-lasting source of fungus inoculum (the infected stumps) and a large population of susceptible hosts (the Douglas-fir seedlings).

The Douglas-fir beetle (Dendroctonus pseudotsugae), fir engraver beetle (Scolytus ventralis) and flat-headed borers (family Buprestidae) are attracted to root disease weakened Douglas-fir and grand fir. The root disease centers provide habitat for endemic populations of these beetles. Douglas-fir beetles in particular are often found in large Douglas-fir that have blown over after their roots were decayed by laminated root rot. Outbreak populations may result when the surrounding trees are stressed by environmental conditions or when large-scale windthrow events occur. Douglas-fir pole beetle (Pseudohylesinus nebulosus) and Douglas-fir engraver beetle (Scolytus unispinosus) attack sapling or pole size Douglas-fir that have been weakened by root diseases or are under stress due to overstocking or soil compaction.

Off-site pine plantations, Bynum's blight and associated bark beetles: Many pure ponderosa pine plantations have been established in areas of the watershed where ponderosa pine occurs only occasionally in natural stands. Some of these plantations originated from off-site seed sources. In the Red Mountain area the effects are especially dramatic. Many of the planted pines are severely stunted and heavily infected with Bynum's blight, caused by the fungus Lophodermella morbida. Ridetops and natural basins near 2500 to 3000' in elevation where clouds linger after storms are particularly favorable locations for this disease. The fungus can cause severe growth loss in infected pines that are repeatedly defoliated. The stress caused by this repeated defoliation may make the trees susceptible to bark beetles and other agents.

Sugar pines, white pine blister rust and mountain pine beetles: Sugar pines throughout this watershed are being killed by white pine blister rust (an introduced diease caused by the fungus Cronartium ribicola) and the mountain pine beetle (Dendroctonus ponderosae), although the effects appear less dramatic here than in some other watersheds on the District where sugar pines are more common. White pine blister rust kills seedlings, saplings and pole size sugar pines outright. It causes topkill and branch flagging of larger sugar pines and predisposes them to attack by the mountain pine beetle. The disease is more severe on moist sites such as riparian areas and on ridgetops where clouds hang during summer and fall.

Mountain pine beetles are also killing many otherwise healthy sugar pines that are growing in stands that have become overstocked due to fire exclusion. In addition, the prolonged drought of past years has intensified the competition for water. On moderate sites, sugar pines larger than 14" in diameter, more than 140 years old and in stands with basal areas greater than 140 sq. ft. per acre have a high risk of being attacked by mountain pine beetles. Today, almost all the natural stands in this watershed are quite a bit denser than that. Once the sugar pines have been killed the chances that they will be replaced by natural regeneration are poor because of the high levels of seedling mortality due to blister rust. Thus, the risk is high that sugar pines will eventually be eliminated from the watershed due to the combined actions of blister rust and bark beetles.

Ponderosa pine and bark beetles: Mountain pine beetles and western pine beetles (Dendroctonus brevicomis) are also killing scattered ponderosa pines in natural stands, and small groups of ponderosa pines in plantations where the average diameter is above 8". Competition caused by overstocking is the most important pre-disposing factor. The off-site origin of some of the planted ponderosa pine increases their susceptibility to attack. At this time, the losses are still small. However, the risk to both the large and small ponderosa pines in natural, mixed conifer stands as well as the ponderosa pines in plantations will continue to increase as long as stand densities are higher than 120 sq. ft. per acre.

Dwarf mistletoes: The most severe and widespread dwarf mistletoe in this watershed is Arceuthobium tsugense subsp. tsugense, found on western hemlock. It causes severe growth loss, distortion, topkill and tree mortality. The effects are most severe when the infections are in the upper portion of the crowns. The potential for the greatest impact occurs where infected western hemlock are found in the overstory of stands that also have western hemlock in the understory.

Grand fir and ponderosa pine in this watershed are also infected by dwarf mistletoes. Dwarf mistletoe by itself on grand fir often does not have severe effects on the vigor of infected trees. However, it is often associated with the canker fungus Cytospora abietis, which invades and kills infected branches. This may have severe effects on the trees and predispose them to attack by the fir engraver beetle. In this watershed the level of Cytospora infection appears to be low.

Western dwarf mistletoe (Arceuthobium campylopodum) occurs on ponderosa pine in this watershed, although the current incidence of infection appears to be low. This species of dwarf mistletoe also infects knobcone pine. Western dwarf mistletoe can have severe effects on the growth and survival of infected pines when the level of infection on trees is high. Like other species of dwarf mistletoes, the greatest impact occurs when small pines are growing underneath an overstory of infected trees. The incidence and severity of this disease was probably lower before fire was excluded from the ecosystem.

Stem and butt decays: Tree with decay caused by the fungi Phaeolus schweinitzii, Phellinus pini and Echinodontium tinctorum are scattered throughout mature stands in this watershed. The heartwood of infected trees is attacked, causing decay and eventual breakage. Phellinus pini invades the heartwood of Douglas-fir, ponderosa and sugar pines through living and dead branches or branch stubs. Echinodontium tinctorum also invades through small branch stubs on suppressed hemlock and grand fir trees, but seems to require subsequent wounding to develop. Regeneration that has been suppressed in the understory of infected trees is likely to have a high incidence of infection. Phaeolus schweinitzii generally infects Douglas-fir (and occasionally pines) through basal wounds or fire scars. Infections can spread via airborne spores or root contacts. Conversion of many mature stands in the watershed to plantations has reduced the incidence of these diseases from past levels. As the trees in these plantations age and develop heartwood, the incidence of decay will increase.

IMPLICATIONS OF INSECT AND DISEASE ACTIVITY FOR FUTURE MANAGEMENT

The activities of insects and diseases at endemic levels are responsible for many of the small openings in the forest. These are where small-scale changes in species composition, structure and density take place that bring about the mature, transition and shifting-gap stages of old-growth forest development.

Trees killed by insects and diseases are one source of large, woody debris in riparian zones. Insects and diseases are responsible for many of the platforms, cavities, snags and down logs utilized by many species of wildlife. Some of these species such as ants, spiders, woodpeckers and other insectivorous birds and small mammals are natural enemies of the insects that feed on trees. These natural enemies do not control outbreak populations of insects, but play an important role in limiting their numbers at other times.

At higher levels, the activities of insects and diseases can have profound effects on species composition, structure and stocking levels that may interfere with management objectives. Where root disease centers are large and active, the development of well-stocked stands of large conifers will be unlikely as long as the stocking is primarily Douglas-fir or grand fir. Regeneration by these species will perpetuate the diseases on infected sites. This will affect timber production on matrix land and the development of large conifers in late successional reserves. Regeneration of root disease centers by natural or planted pines or cedars will replace the susceptible trees with conifers that can survive to large sizes. In plantations where root diseases are present, the level of disease should be assessed prior to thinning. In areas where the level of disease is relatively low it may be possible to manipulate species composition to reduce its impact. In severely affected plantations it may be better not to thin if only highly susceptible species are present.

Ponderosa and sugar pines will be at risk of attack by bark beetles as long as stocking levels remain high in natural stands and older plantations. Bark beetles have decimated overstocked ponderosa pine plantations in other areas once they reached 50 to 80 years of age. Plantations from off-site seed sources (especially those infected with Bynum's blight) will be especially at risk. Controlling the density in these plantations will be important to maintain pines at adequate stocking levels for timber production and to produce large trees with acceptable canopy closures for wildlife habitat. Controlling the density in natural stands will be essential if pines are to remain as a component in the future. Since the level of mortality in ponderosa pines is still low, the opportunity exists to protect them now, before widespread mortality occurs.

Successful regeneration of substantial numbers of sugar pine in the future may depend on planting blister rust-resistant seedlings. Root disease centers may be ideal places for introducing rust-resistant sugar pines.

The brooms caused by dwarf mistletoes, especially western hemlock dwarf mistletoe, provide nesting and hiding cover for small mammals and birds. The seeds of dwarf mistletoes are also a source of food. However, severe infections may result in growth losses that are unacceptable in stands managed for timber production. In addition, trees that are severely infected early in life are unlikely to survive to large sizes that may be desirable in stands managed for late successional habitat or other objectives where large trees are needed.

The rotten wood and breakage caused by stem decays are extremely valuable sources of food and habitat for many species of wildlife. Second growth stands that are managed in short rotations may not have time to develop the minimum diameter of decayed heartwood needed by cavity nesting species. On the other hand, stands that are managed in long rotations using multiple entries of cutting or underburning may have higher levels of stem decay than are seen at present.

SUMMARY

A variety of insects and diseases are active in the Cow Creek watershed. At endemic levels the small-scale changes they cause in species composition, structure and density are important factors in the process of old growth stand development. Relatively recent changes in stand conditions caused by fire exclusion, timber harvesting and drought have contributed to an increase in the level of activity of some of these insects and diseases. In some cases they may significantly alter stand structure, density and species composition. Sugar pines have already been affected by bark beetles and blister rust throughout the watershed. Ponderosa pines are at risk of high levels of mortality from bark beetles in the future. Douglas-fir, grand fir and western hemlock are affected primarily at the stand level by root diseases, associated bark beetles and dwarf mistletoes. In such situations, insects and diseases have significant effects on the development of stands that should be accounted for during the analysis and planning process so that forest management objectives can be met.

The staff of the Southwest Oregon Forest Insect and Disease Technical Center is available to provide additional information and assistance with watershed analysis and project level surveys and planning. Please call us at 858-6125, or contact us on the DG: R06F10D19A.

/s/ Katy Marshall
Forester/Plant Pathologist
SWOFIDTC

INSECTS AND DISEASES OBSERVED IN THE COW CREEK WATERSHED 7/95

Insects	Scientific name	Seen on
flat-headed borers	family Buprestidae	DF,GF
western pine beetle	*Dendroctonus brevicomis*	PP
mountain pine beetle	*Dendroctonus ponderosae*	SP,PP
Douglas-fir beetle	*Dendroctonus pseudotsugae*	DF
turpentine beetle	*Dendroctonus valens*	SP
pine sawfly	*Neodiprion* spp.	PP
Douglas-fir pole beetle	*Pseudohylesinus nebulosus*	DF
Douglas-fir engraver beetle	*Scolytus unispinosus*	DF
fir engraver	*Scolytus ventralis*	GF

Diseases		
true fir dwarf mistletoe	*Arceuthobium abietinum* f.sp. *concoloris*	GF
western dwarf mistletoe	*Arceuthobium campylopodum*	PP
western hemlock dwarf mistletoe	*Arceuthobium tsugense* subsp. *tsugense*	WH
Armillaria root disease	*Armillaria ostoyae*	DF,GF
white pine blister rust	*Cronartium ribicola*	SP
brown stringy rot	*Echinodontium tinctorum*	GF
Elytroderma disease	*Elytroderma deformans*	PP
incense cedar broom rust	*Gymnosporangium libocedri*	IC
Bynum's blight	*Lophodermella morbida*	PP
red-brown cubicle butt rot	*Phaeolus schweinitzii*	DF
red ring rot	*Phellinus pini*	DF,PP
laminated root rot	*Phellinus weirii*	DF,GF,WH

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Medford District Office
3040 Biddle Road
Medford, Oregon 97504

IN REPLY REFER TO:

1619(11800)
LSR Assess
Casey
G4034(RS:sb)

Ms. Joyce Casey
Strategic Planning - U.S. Forest Service
PO Box 3623
Portland, Oregon 97208-3623

MAY 31 1996

Dear Ms. Casey:

Enclosed are several copies of the Late-Successional Reserve Assessment for the South Umpqua/Galesville LSR in southwest Oregon as called for in the Record of Decision for the Northwest Forest Plan. This assessment is the result of an interagency effort by the Medford District, BLM; the Roseburg District, BLM; and the Tiller Ranger District on the Umpqua National Forest. The three line managers, Alan Wood in Roseburg, Roy Brogden at Tiller, and I, feel this assessment meets the requirements set forth in the ROD and is ready to be adopted.

Larry Larsen in the Oregon/Washington BLM State Office recommended we send this assessment to you for review by the Issue Resolution Team and then to the Regional Ecosystem Office for their review.

We would like to have this assessment reviewed in time for implementation of possible management actions in Fiscal Year 1997. With that in mind, we ask that the IRT complete their review by July 15, 1996. We hope to complete the REO review by September 1, 1996.

If you have questions concerning the contents of this LSR assessment, please feel free to contact Roger Schnoes in Medford (phone: 541-770-2296; E-mail: rschnoes@or.blm.gov) or Paul Meinke in Roseburg (phone: 541-440-4930; E-mail: pmeinke@or.blm.gov).

Thank you for your assistance with this effort. I look forward to hearing from you.

Sincerely,

Diane

Diane M. Chung
Glendale Area Manager

Enclosure (as stated)

cc: Roy Brogden, Tiller Ranger District
27812 Tiller Trail Highway
Tiller, Oregon 97484

Larry Larsen (OR931)
Alan Wood - Roseburg District, BLM

6/3 TILLER RD
DR AO ENG
FMO FSR RA
JUN 3 1996
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WA FSH GIS

Late-Successional Reserve Assessment

for the

South Umpqua River/Galesville LSR

(LSR #R0223)

Glendale Resource Area, Medford District, BLM
South Douglas Resource Area, Roseburg District, BLM
Tiller Ranger District, Umpqua National Forest, USFS

May 1996

Late-Successional Reserve Assessment
South Umpqua River/Galesville LSR
(LSR # R0223)

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Summary

This Late-Successional Reserve (LSR) assessment was prepared as directed by the Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl and Attachment A to the Record of Decision (ROD) for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl. The physical and biological features which contribute to late-successional forest habitat characteristics were assessed with the intent of providing federal land managers with information for making site specific decisions.

Management objectives of Late-Successional Reserves are to maintain and promote a functional and interacting late-successional and old-growth forest ecosystem. Late-Successional Reserves are designed to provide three purposes: 1) provide a distribution, quantity, and quality of old-growth forest habitat sufficient to avoid eliminating future management options, 2) provide habitat for populations of species that are associated with late-successional forest, and 3) help ensure that late-successional species diversity will be conserved.

The assessment incorporates Late-Successional Reserve (LSR) and Roseburg BLM's District Defined Reserve (DDR), which is to be managed as LSR, for a total of 66,903 acres. There are approximately 37,234 acres of non-federal lands intermingled with the federal LSR lands.

The geology of the LSR is quite complex, dominated by geologic patterns of alternating bands of metasedimentary and metavolcanic formations of Jurassic age. Vegetative communities have developed on the weathered soils at differing rates and species composition based upon the mineral content of the rock, depth of soil, and available moisture. The area has a temperate marine climate (warm summers and mild, wet winters) with rainfall averaging between 45 and 60 inches, falling mainly during the winter months.

Vegetative conditions have been influenced by environmental and human factors. Both factors have changed the vegetative communities over time.

By the turn of the century, agriculture, the introduction of exotic species, ranching, and timber harvesting had affected much of the native vegetation in the lower elevations. The advent of fire suppression, advances in road building which allowed timber harvesting at the higher elevations, and intensive forestry practices also began to change the character of the forest.

Present vegetative communities have been placed into 6 groupings based on the dominant late seral conifer species. The plant communities are influenced by elevation and soil types. Seral stage groupings and structure classes were compiled from BLM's operations inventory (OI), the Timber Production Capability Classification (TPCC) and from satellite imagery of USFS lands.

A variety of older stands (greater than 80 years old) which have had some level of partial cutting were identified as modified older stands. Obtaining a better inventory to determine if modified older stands are functioning as late-successional/old-growth habitat is a need for future management within the LSR.

Connectivity is defined as a measure of the extent to which conditions between late-successional/old-growth forest areas provide habitat for dispersal, movement, feeding, and breeding of late-successional/old-growth associated terrestrial and aquatic species. Connectivity within the LSR is currently very poor due to isolation of late-successional forests from other similar forest pieces. Reasons for this isolation include checkerboard ownership of BLM lands, private holdings within federally administered lands, past timber harvesting practices, natural disturbances (including fire), and geologic and geographic influences.

The checkerboard ownership prevents attaining contiguous blocks of late-successional forest in most of the LSR. The scarcity of large areas of late seral and old growth habitat are a major area of concern. Small block sizes are generally inadequate to provide for those species which need interior habitat to survive.

North and south of the South Umpqua River/Galesville LSR there are essentially no neighboring LSRs. To the south is an area of intermingled BLM and private timber lands and then the large Rogue River valley in which Grants Pass and Medford are located. Similarly, intermingled BLM and private timber lands extend to the north until reaching the large Umpqua valley where Roseburg is located. As a result of the location between these two large valley systems the South Umpqua River/Galesville LSR lies in a critical East-West connectivity area. The link is made even more significant by the presence of I-5 as a barrier to movement. This barrier is significant to species associated with late-successional/old-growth (LSOG) habitat, especially those which are less mobile than spotted owls, such as plants and salamanders.

Because of the location on the landscape, as well as the checkerboard land ownership pattern over most of the LSR, it is likely this particular LSR will play a much larger role in providing large scale connectivity east and west between the Cascade, Siskiyou, and Coast Range Mountains than by providing a reservoir or refuge for LSOG associated species in itself. It is important to maintain genetic flow between reserves and the landscape pattern across the I-5 corridor in most of western Oregon points to this area as a vital link between major physiographic provinces. This role may also indicate the western portion of the LSR may be especially important since connections with other reserves to the west are more uncertain than to the east.

The Forest Ecosystem Management Assessment Team (FEMAT) report identified approximately 1,100 species (not counting arthropods) as closely associated with late-successional forests. Because of the abundant information about the northern spotted owl and its association with late-successional/old-growth forests, this assessment tends to focus on the spotted owl and how activities in the LSR may affect the spotted owl.

Coho salmon, Umpqua cutthroat trout, steelhead, Pacific Lamprey, and Umpqua chub are special status species documented or suspected to live in streams within the LSR. Limiting factors affecting aquatic health and fisheries in this LSR include low summer flows, elevated water temperatures, restricted access for anadromous salmonids to areas of their historic distribution, the lack of instream habitat structure, the relatively high amount of sediment found in the spawning gravel, and the lack of future LWD recruitment into the stream channels from the adjacent riparian area. Minimizing or reducing the effects of the limiting factors should be a goal within the LSR.

The northern portion of the LSR includes two elk management areas identified in the Roseburg District RMP/ROD (1995) and the Proposed Roseburg District Resource Management Plans/EIS (1994). Managing for the variety of habitats that elk need may conflict with LSR objectives.

Appropriate treatments within the LSR can be divided into four categories: salvage, risk reduction, enhancement of late-successional habitat conditions, and other non-silvicultural activities. All management activities should be designed to accelerate or not to impede the development of late-successional forest conditions.

Three general landscape criteria were identified for setting priorities for the location of future treatment areas:

1) establishing large blocks of LSOG habitat,
2) enhancing connectivity across the landscape, and
3) enhancing suitable spotted owl habitat conditions around centers of activity.

The objective of fire and fuels management in the LSR is to maintain late-successional habitat by reducing the risks of high intensity, stand replacing wildfires. Prescribed fire is recognized as a valuable tool to meet LSR objectives, especially in southwest Oregon where fire is such an integral part of ecosystem functions. Wildfires in the LSR should be aggressively attacked to keep fires to the smallest possible size.

Priority areas for projects are described, along with other potential projects which have been tentatively identified. In addition, a monitoring strategy is presented to address monitoring needs within the LSR.

Late-Successional Reserve Assessment
South Umpqua River/Galesville LSR
(LSR # R0223)

I. Introduction

This Late-Successional Reserve (LSR) assessment was prepared as directed by the Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl, Attachment A to the Record of Decision (ROD) for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl or SEIS ROD (USDA Forest Service and USDI Bureau of Land Management 1994) and the Record of Decision/Resource Management Plans (ROD/RMP) for the Medford and Roseburg Bureau of Land Management (BLM) Districts. It is also subject to the Umpqua National Forest Land and Resource Management Plan. These documents state that a management assessment should be prepared for each Late-Successional Reserve (or group of smaller Late-Successional Reserves) before habitat manipulation activities are designed and implemented.

The Medford and Roseburg RMPs are intended to be consistent with the SEIS ROD; any apparent inconsistencies are oversights or misinterpretations of SEIS ROD language. This LSR assessment is intended to be consistent with the SEIS ROD, also.

This LSR Assessment provides Federal land managers information to help when making site specific project decisions. This assessment is not a decision making document. It is a basis for developing site specific proposals and determining monitoring and restoration needs for this Late-Successional Reserve.

Late-Successional Reserves are to be managed to maintain and promote a functional and interacting late-successional and old-growth forest ecosystem. Late-Successional Reserves represent a network of existing old-growth forests that are retained in their natural condition where natural processes are allowed to function to the extent possible. Late-Successional Reserves are designed to provide three purposes: 1) provide a distribution, quantity, and quality of old-growth forest habitat sufficient to avoid eliminating future management options, 2) provide habitat for populations of species that are associated with late-successional forests, and 3) help ensure that late-successional species diversity will be conserved. The objectives of this document are to assess the physical and biological features which contribute to late-successional forest habitat characteristics and to provide a context for managing the LSR to maintain and promote late-successional habitat.

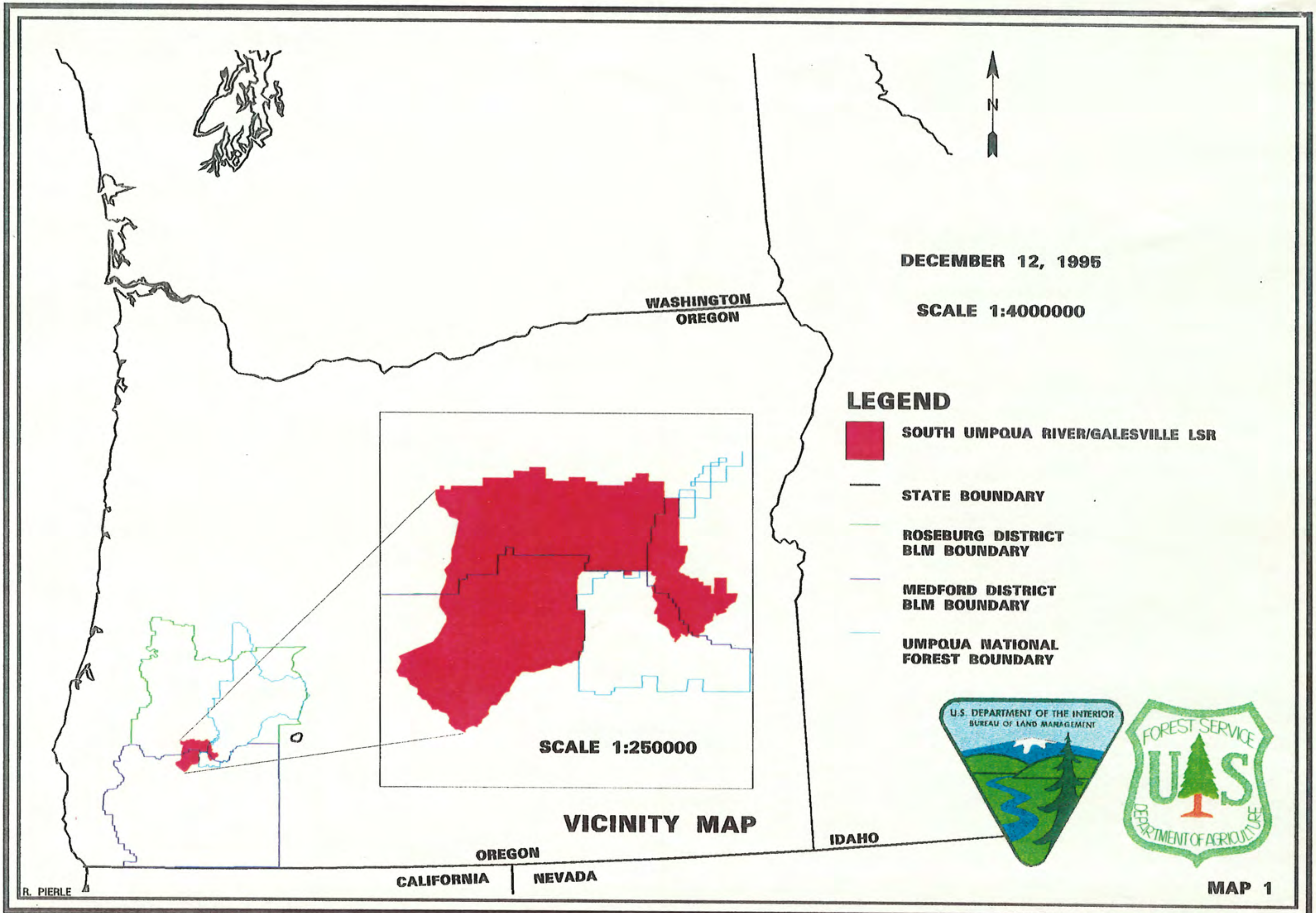
Portions of this LSR have been discussed in Watershed Analysis (WA) documents prepared by the BLM and USFS. These include the Middle Cow and Upper Cow interim WA completed by the Glendale Resource Area, Medford District, BLM; the Stouts/Poole/Shively-O'Shea WA prepared by the South Douglas Resource Area, Roseburg District, BLM; the Cow Creek WA prepared by the Tiller Ranger District, Umpqua National Forest and the Elk Creek WA to be prepared in 1996 by the Tiller Ranger District.

A. Characterization of the LSR

The South Umpqua River/Galesville Late-Successional Reserve (LSR #R0223) is located in the Oregon Klamath Physiographic Province in southwest Oregon. It is roughly located between Glendale, Canyonville, and Tiller, Oregon, east of Interstate 5 and south of the South Umpqua River (see Map 1). The LSR encompasses 66,173 acres of Federally managed lands. An additional 730 acres in the South Douglas Resource Area of the Roseburg BLM is designated as District Defined Reserve (DDR) which are to be managed as LSR. This assessment incorporates LSR and DDR land use allocations totaling 66,903 acres. The acres for Riparian Reserves are included within this LSR assessment. Where Riparian Reserves occur within the LSR, the standards and guidelines of both designations apply. Standards and guidelines apply for allocations where they are more restrictive or provide greater benefits to late-successional forest related species.

Federal and non-Federal ownership is intermingled in a "checkerboard" pattern characteristic of Revested Oregon and California Railroad Lands (O&C) in western Oregon. Forest Service administered lands are in a block of ownership with small areas of privately owned lands intermingled. There are approximately 37,234 acres of non-Federal lands intermingled with the Federal LSR lands. Ownership is summarized in Table 1 and shown on Map 2.

The upper South Umpqua River Basin has been designated in the SEIS ROD as a Tier 1 Key Watershed. The Key Watershed designation overlays land use allocations and places additional management requirements or emphasis on activities in this area. The portion of the LSR in Stouts Creek, Poole Creek, Shively-O'Shea, and Elk Creek Watersheds are included in this Tier 1 Key Watershed. Approximately 33,639 acres of the LSR is located within this key watershed. The Roseburg BLM administers 21,369 acres and 12,270 acres are administered by the Tiller Ranger District.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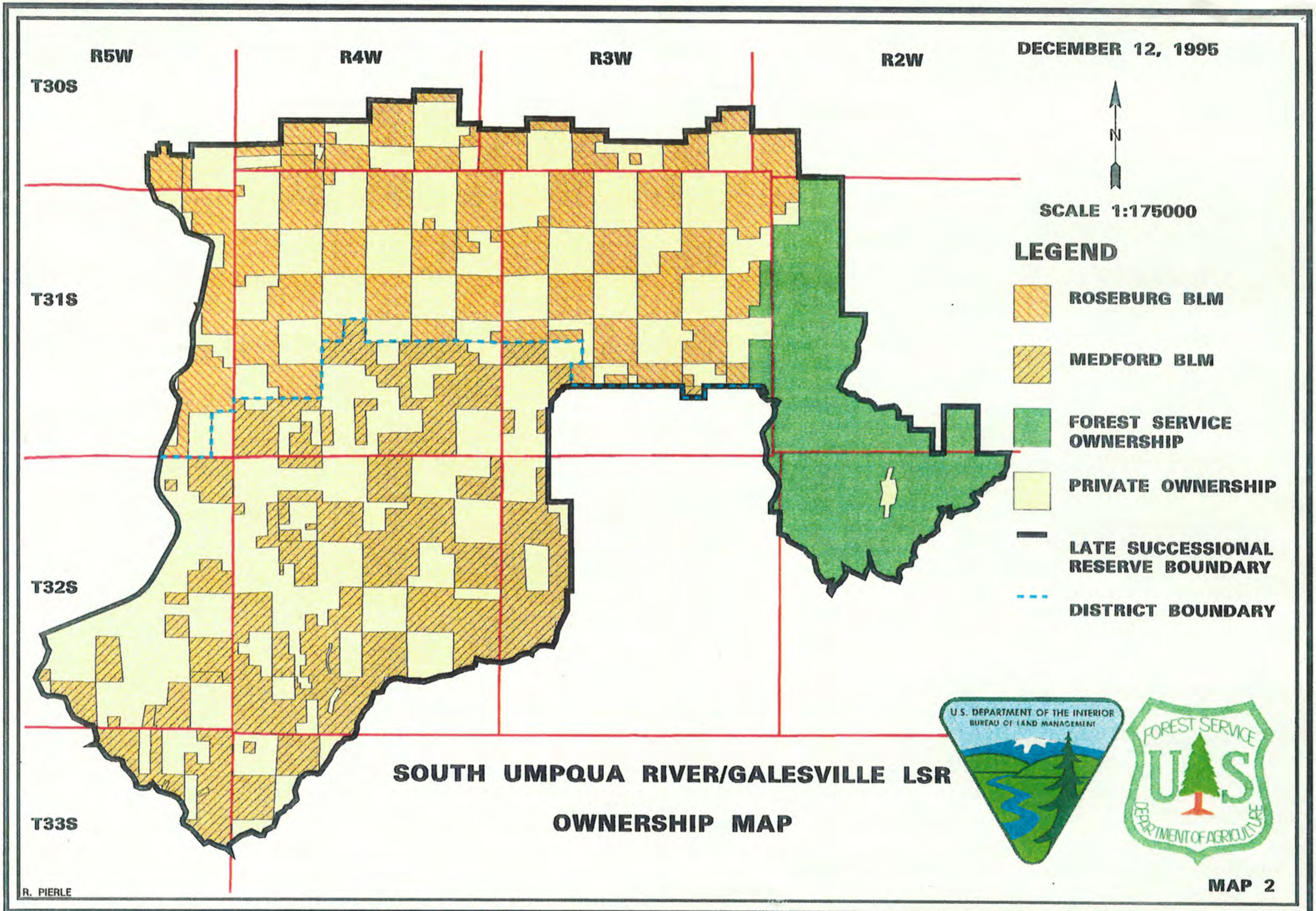
WASHINGTON
OREGON
DECEMBER 12, 1995
SCALE 1:4000000
LEGEND
SOUTH UMPQUA RIVER/GALESVILLE LSR
STATE BOUNDARY
ROSEBURG DISTRICT BLM BOUNDARY
MEDFORD DISTRICT BLM BOUNDARY
UMPQUA NATIONAL FOREST BOUNDARY
SCALE 1:250000
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
FOREST SERVICE
DEPARTMENT OF AGRICULTURE
VICINITY MAP
IDAHO
OREGON
CALIFORNIA
NEVADA
R. PIERLE
MAP 1



R5W
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T30S
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LEGEND
ROSEBURG BLM
MEDFORD BLM
FOREST SERVICE OWNERSHIP
PRIVATE OWNERSHIP
LATE SUCCESSIONAL RESERVE BOUNDARY
DISTRICT BOUNDARY
SOUTH UMPQUA RIVER/GALESVILLE LSR
OWNERSHIP MAP
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE
R. PIERLE
MAP 2

B. The LSR and the Landscape

North, west, and south of the LSR, the landscape is dominated by intermingled BLM and private lands. The pattern is similar to that found in the BLM portion of the LSR. The Federal lands in these areas adjacent to the LSR are designated as Matrix. The watersheds directly north and northeast of the LSR are included within the upper South Umpqua River Tier One Key Watershed. Similar to the situation within the LSR, virtually all of the private timber lands in these areas have been harvested and are dominated by recent clearcuts, hardwood stands, or second growth conifer forests 25-40 years old.

Adjacent to the west side of the LSR is the Interstate-5 (I-5) corridor. Along the northwest and southwest edges of the LSR this corridor is contained within fairly wide valleys where private lands dominate and the major land uses are agriculture and residential areas. Between these valleys I-5 runs through a narrow, forested canyon.

South of the eastern portion of the LSR the Forest Service manages a contiguous block, rather than the checkerboard pattern found with BLM administered lands. These lands are also designated as Matrix and are currently a mix of late-successional/old growth (LSOG) forests and recent clearcuts. East of the LSR there is a band of intermingled Forest Service and private timber lands, then a large block of Forest Service ownership at the higher elevations in the Cascades.

The closest neighboring LSR is approximately four miles east of the South Umpqua River/Galesville LSR, administered by the Umpqua National Forest and Medford District BLM. That LSR is part of a network of LSRs running North/South along the Cascades which is virtually uninterrupted. To the west, across the I-5 corridor the closest LSR is approximately 12 miles west in the Roseburg District, BLM. The connectivity between this LSR and the LSR to the west is much more tenuous than to the east. North and south of the South Umpqua River/Galesville LSR there are essentially no neighboring LSRs. To the south is an area of intermingled BLM and private timber lands and then the large Rogue River valley in which Grants Pass and Medford are located. Similarly, to the north lies more BLM and private timber lands and then the large Umpqua valley where Roseburg is located.

As a result of the location between these two large valley systems the South Umpqua River/Galesville LSR lies in a critical East-West connectivity area. The United States Fish and Wildlife Service (USFWS) identified this area as a primary "Area of Concern" for the northern spotted owl in providing for east-west flows between the Cascade, Siskiyou, and Coast Range Mountains (Federal Register 1991). The link is made even more significant by the presence of I-5 as a barrier to movement. This barrier is significant to species associated with LSOG habitat, especially those which are less mobile than spotted owls, such as plants and salamanders.

Because of the location on the landscape, as well as the checkerboard land ownership pattern over most of the LSR, it is likely this particular LSR will play a much larger role in providing large scale connectivity east and west between the Cascade, Siskiyou, and Coast Range Mountains than by providing a reservoir or refuge for LSOG associated species in itself. It is important to maintain genetic flow between reserves and the landscape pattern across the I-5 corridor in most of western Oregon points to this area as a vital link between major physiographic provinces. This role may also indicate the western portion of the LSR may be especially important since the connections with other reserves to the west are more uncertain than to the east.

II. Past and Present Vegetative Conditions of the LSR

Vegetative conditions, both past and present, have been affected by natural and human influences within the LSR. Natural influences include climate, geology, and fire. An in-depth historical perspective of human influenced changes has been completed for the Cow Creek Basin (unpublished manuscript on file at the Medford BLM District office). Historical conditions are essentially the same throughout the South Umpqua River Basin.

The area has a temperate marine climate with warm summers and mild, wet winters. The rainfall in the area varies from about 45 to 60 inches, falling mainly during the winter. Elevation, aspect, geology, and distance from the Pacific Ocean greatly influence the plant communities.

The geology of the LSR is quite complex. The dominant geologic pattern is alternating bands of metasedimentary and metavolcanic formations of Jurassic age. The eastern portion of the LSR is composed of a large area of granitic textured igneous rocks. Several seams of serpentine and peridotite derived rock formations appear in the metavolcanic formations. Geologic units including Triassic Applegate Group metasediments and metabasalts and Late Jurassic sediments of the Dothan and Otter Point Formations occur to a lesser degree. Vegetative communities have developed on the soils weathered from these geologic formations at differing rates and species composition based upon the mineral content of the native rock, available moisture, and soil depth.

A. Past Vegetative Conditions

Native patterns of vegetation, extant at the time of European exploration and settlement, were the result of both natural and human influences. Native human influences included pruning and cultivation of key materials, such as basketry materials; weeding and tilling of certain plant communities; and the use of fire for many different purposes. Extensive use of fire is documented in the accounts of early explorers, trappers, and pioneers.

The effects of Native American burning were to keep valley and foothill areas open and covered in native grasses. Fire also promoted the existence of oak-pine savannahs, throughout the valleys and foothills, and chaparral plant communities. At higher elevations, fire--both natural and human-caused--kept upland meadows open and productive of plant foods and browse for deer and elk, and kept ridge systems open for travel. Early Euro-American travelers remarked consistently on the lush prairies of the lowlands, tall timber of the foothills and mountains, and abundant wildlife.

When early explorers, trappers, and pioneers entered the area they immediately began altering the native landscape. Before 1850, trappers cleared beaver out of local streams, affecting the riparian areas through the loss of these animals. Miners altered stream terraces through hydraulic mining, and settlers soon changed the character of the valleys and foothills by introducing agriculture, foreign plants and animals, and by cutting timber.

Agricultural activities and stock raising immediately affected the native vegetation. Valley bottom prairies and meadows were transformed to agricultural fields and orchards, native species in the grasslands were diminished and new species introduced. The settlers built houses and wooden fences around their farms, and discouraged the native practices of burning the landscapes. Farmers' hogs and livestock grazed and rooted through the native grasslands and camas fields, destroying the camas and changing the character of the grasslands.

The coming of the railroad in the 1880s stimulated the logging industry in the valleys. Numerous small sawmills operated at lower elevations up creeks and streams. Splash dams and water diversion ditches affected streams and riparian vegetation.

By the turn of the century, much of the native vegetation of the valleys and foothills had been transformed through the introduction of agriculture and exotic species, ranching, and timber harvest. Riparian areas had been affected by the removal of beaver, and by mining, and logging practices.

In the early twentieth century the advent of fire suppression policies began transforming the open aspect of much of the forest, and reducing the extent of upland meadows. After World War II, advances in road building and transportation opened up the higher elevations to extensive timber harvest. New intensive forestry practices also began to change the character of the forests.

B. Present Vegetative Conditions

1. Plant Groupings and Late-Successional Conditions

Plant community groupings are used to characterize the vegetation in the LSR for this assessment. A plant community grouping is defined as an aggregation of plant associations with similar management potential, the same dominant late seral conifer species, and the same principle early seral species.

Based on the plant community groupings identified in the Medford and Roseburg BLM RMPs, six major plant groupings were identified within the LSR:

White oak/ponderosa pine grouping. This grouping is found primarily at low elevations near Cow Creek.

Incense cedar/Jeffrey pine grouping. This grouping occupies a small percentage of lands dominated by serpentine soils.

Mixed conifer/madrone grouping. This grouping constitutes a large portion of the area at mid elevations.

Douglas-fir/mixed brush/salal. Along with the mixed conifer/madrone grouping this group dominates much of the mid-elevations within the LSR.

Douglas-fir/white fir grouping. This grouping occupies some of the higher elevation lands and generally north slopes in lower elevations.

Douglas-fir/western hemlock/rhododendron grouping. This grouping occurs in the higher elevations and generally on northern aspects.

Fire frequency and fire return intervals vary depending on stand characteristics, plant community grouping, weather, and topography. Within the LSR, it appears that fires were probably more frequent and more intense in the hot, low elevation areas and on south slopes than at higher elevations where conditions are more moist. While fire frequencies varied a great deal, it appears likely that the fire return interval for this LSR was probably on the order of 30-80 years (Agee 1993).

The white oak/ponderosa pine plant grouping probably had more frequent fires than the Douglas-fir and other conifer dominated types at higher elevations. Not only were the fuel characteristics more conducive to frequent fires, but the lower elevations probably received more frequent human-caused fires as Native Americans burned the valleys and foothills for their own uses.

Vegetation communities associated with meadows, rock outcrops, rock cliffs, or talus slopes occur within the defined major plant groupings. These communities cover only a small percentage of Federal lands within the LSR. Meadow habitat is very limited in distribution within the LSR. Sites dominated by rock are common within upper reaches of the Cow Creek drainage. Special status plant species are most likely to occur in these unique habitats.

Riparian areas are extensive throughout the LSR. Forested riparian zones are generally more complex than adjoining plant communities. The diversity of vegetation ranges from plants submerged in water to species common in upland plant communities. Annual and perennial plants, as well as tree species mix, are likely to be more diverse than adjacent upland forests.

A higher occurrence of bigleaf maple, red alder, willow, and vine maple is likely in riparian areas. Pacific yew is minimally represented within the riparian zones. Western hemlock is more prevalent in the upper reaches of the streams.

2. Seral Stages

In compiling vegetation data for the LSR, assumptions and aggregations were made to accommodate different types of data from BLM and USFS. The BLM data was derived from the operations inventory (OI) and the Timber Production Capability Classification (TPCC). Stand age, size class, stocking and canopy closure were the primary factors utilized. Vegetation on Forest Service lands was assessed using satellite imagery using the process described in the Jackson Creek Watershed Analysis, Tiller Ranger District.

Seral stage groupings and structure classes for this LSR assessment roughly follow those described in Brown (1985) using the following approximate stand ages and groupings:

Nonforest	=	rock, meadows, residential, agricultural, etc.
Early (grass/forb)	=	stand age approximately 0-10 years
Mid (shrub, open sapling/poles, closed sapling/poles, open small sawlogs)	=	11-40 years
Closed small sawlogs	=	41-80 years
Large sawlogs (>70% canopy closure)	=	81-200 years
Old-growth (>70% canopy closure)	=	200 years and older
Modified older stands	=	stands older than 80 years old which have been partial-cut or modified in other ways so they may not be functioning as Late-Successional Old-growth (LSOG) habitat.

The acreage and distribution of the seral stages/structure classes are displayed in Table 1 and in Maps 3, 4, 5, and 6. The difference between the way the Forest Service and BLM data is displayed on the maps is due to the different methods of obtaining the vegetation data.

Map 4 shows where late successional/old-growth stands are located within the LSR. Late-successional forests are defined as forest seral stages which include mature and old-growth age classes. The mature seral stage is the period in the life of a forest stand from culmination of mean annual increment (generally between 80 and 100 years old) to an old-growth stage or to 200 years old. Brown used the term large sawlog to describe this seral stage. In this assessment the Large Sawlog seral class includes stands that are from 81 to 200 years old. Old-growth exists from approximately 200 years old until stand replacement occurs and secondary succession begins (SEIS).

Approximately 43 percent of the federal lands in the LSR are in late-successional/old-growth stands. However, on a landscape basis, considering all ownerships, approximately 30 percent of the area contains late-successional/old-growth stands. Late-successional stands are estimated to have covered from 40 to 75 percent of Southwestern Oregon, historically (USDA 1993). The amount of late-successional/old-growth stands in this LSR currently falls within the lower end of this range or below.

The white oak/ponderosa pine grouping and the incense cedar/Jeffrey pine grouping do not have the potential to reach late-successional or old growth habitat conditions with a multi-layered, closed canopy with trees of several age classes as defined by FEMAT and as used in the Northwest Forest Plan. These groupings have a very open canopy, often approaching a savannah type. These plant groupings occupy only a very small proportion of the LSR, generally at lower elevations, on south aspects or on serpentine rock outcrops. The other major plant groupings do have the potential for providing LSOG habitat.

The modified older stands category includes a variety of stands with older trees which have had some level of partial cutting in the past. The level of cutting varies considerably, but generally has resulted in stands with open canopies, with either shrubs or small conifers in the understory, and which may be lacking in snags or large down wood.

The "modified older stands" category is problematic because the stands represent a wide range of habitats and structure classes. The available inventories do not do a good job of identifying whether these stands, most of which have been partially cut, are still functioning as late-successional old-growth (LSOG) habitat. Approximately 3,733 acres in this category has been identified within the LSR (Table 1 and Map 6). Obtaining a better inventory and classification of these older stands is a need for future management within this LSR.

Table 1
Seral Stages/Structural Classes by Ownership in LSR #R0223

Seral Stage/ Structural Class	Medford BLM Acres	Roseburg BLM Acres	Umpqua NF Acres	Total Federal Acres	Total Private Acres
Nonforest[1]	592	554	442	1,588	3,986
Early (Grass/forb) (0-10 years)	4,764	4,842	1,270	10,876	2,734
Mid (11-40 years)[2]	4,239	3,893	5,745	13,877	9,776
Closed small sawlog (41-80 years)	3,361	2,237	2,547	8,145	18,594
Large sawlog (81-200 years)[3]	6,063	4,444	4,314	14,821	1,448
Old-growth (200+ years)[3]	3,795	9,668	400	13,863	696
Modified older stands[4]	3,538	183	12	3,733	0
Total acres	26,352	25,821	14,730	66,903	37,234
Total late-successional habitat[5]	9,858	14,112	4,714	28,684	2,144

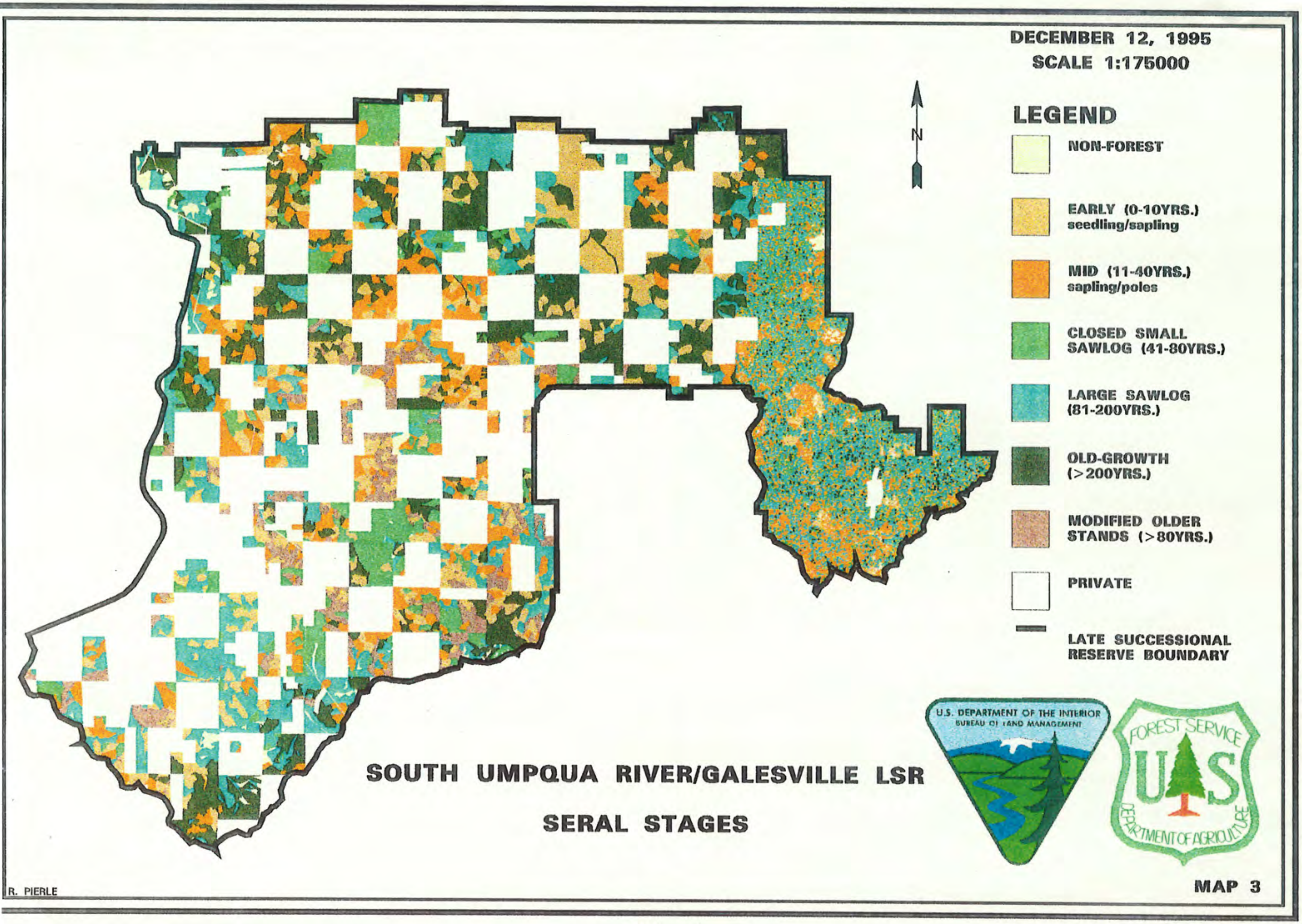
1 Includes rock outcrops, residential, agricultural, meadows, etc.

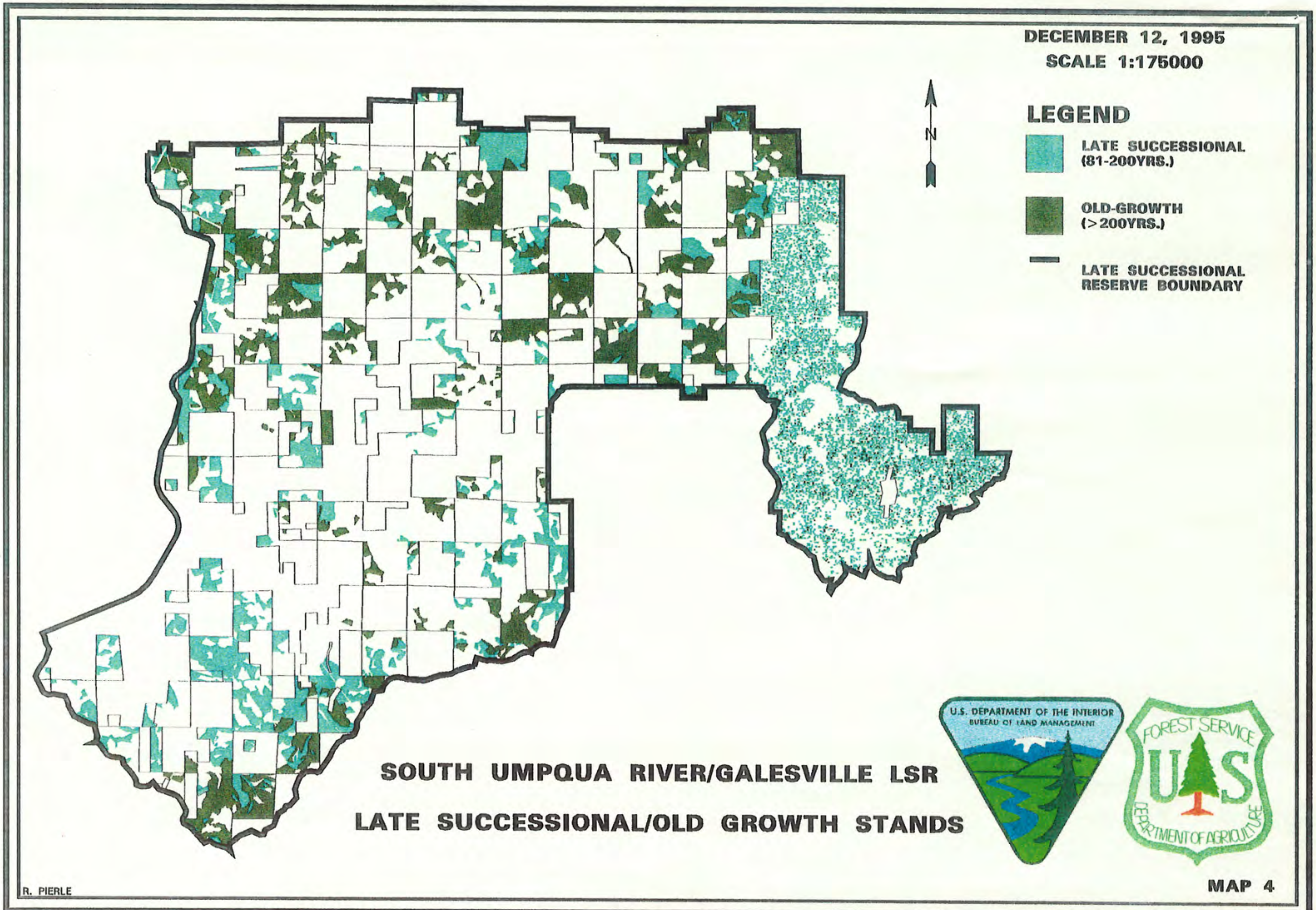
2 Includes shrub, open sapling/pole, closed sapling/pole, and open small sawlog stages from Brown (1985).

3 Included as late-successional forest habitat

4 Stands older than 80 years old which have been partial-cut or modified in other ways so they may no longer function as LSOG habitat.

5 Includes acreage for large sawlogs and old-growth classes.


DECEMBER 12, 1995
SCALE 1:175000
N
LEGEND
NON-FOREST
EARLY (0-10YRS.) seedling/sapling
MID (11-40YRS.) sapling/poles
CLOSED SMALL SAWLOG (41-80YRS.)
LARGE SAWLOG (81-200YRS.)
OLD-GROWTH (>200YRS.)
MODIFIED OLDER STANDS (>80YRS.)
PRIVATE
LATE SUCCESSIONAL RESERVE BOUNDARY
SOUTH UMPQUA RIVER/GALESVILLE LSR
SERAL STAGES
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
FOREST SERVICE
DEPARTMENT OF AGRICULTURE
R. PIERLE
MAP 3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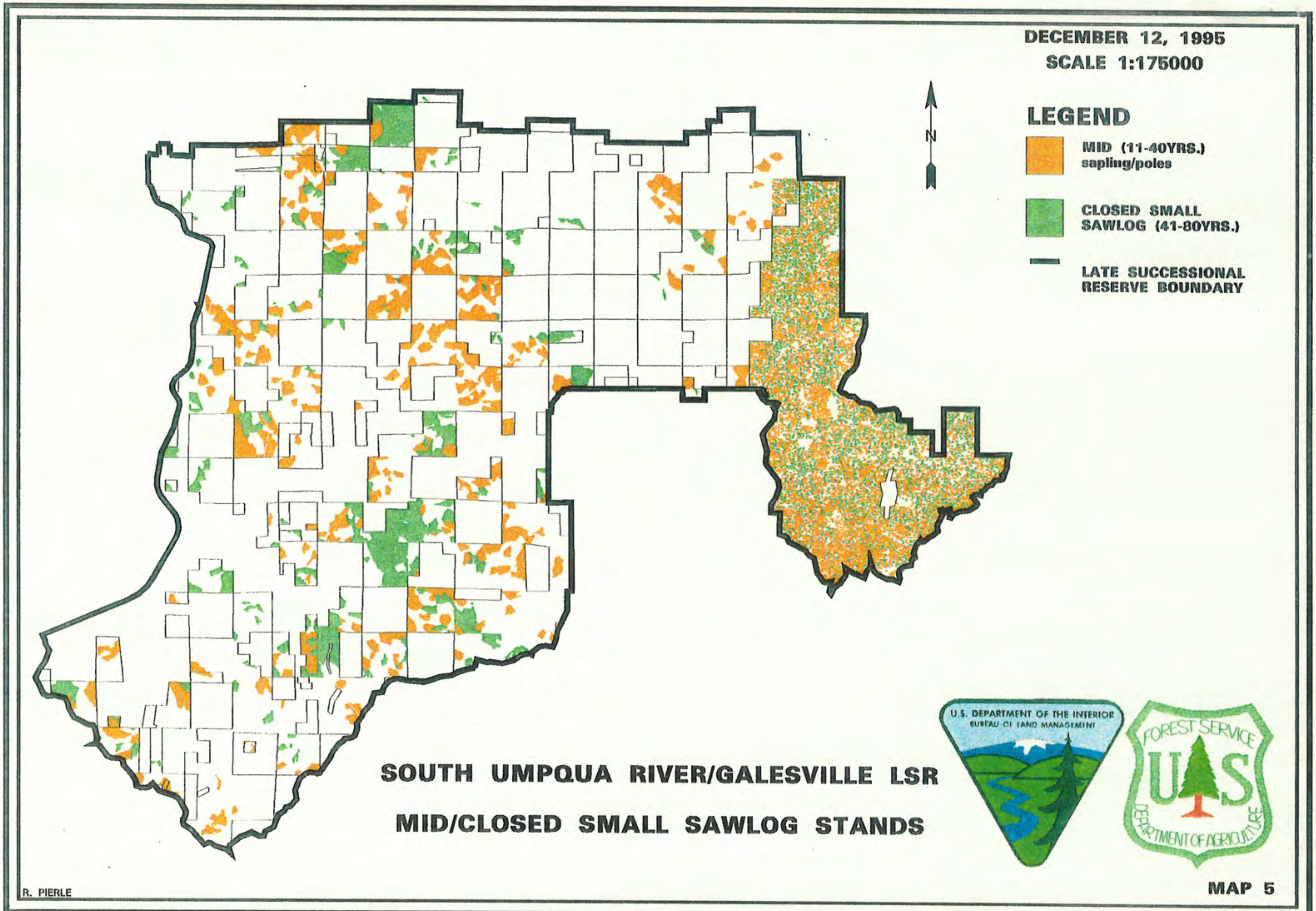
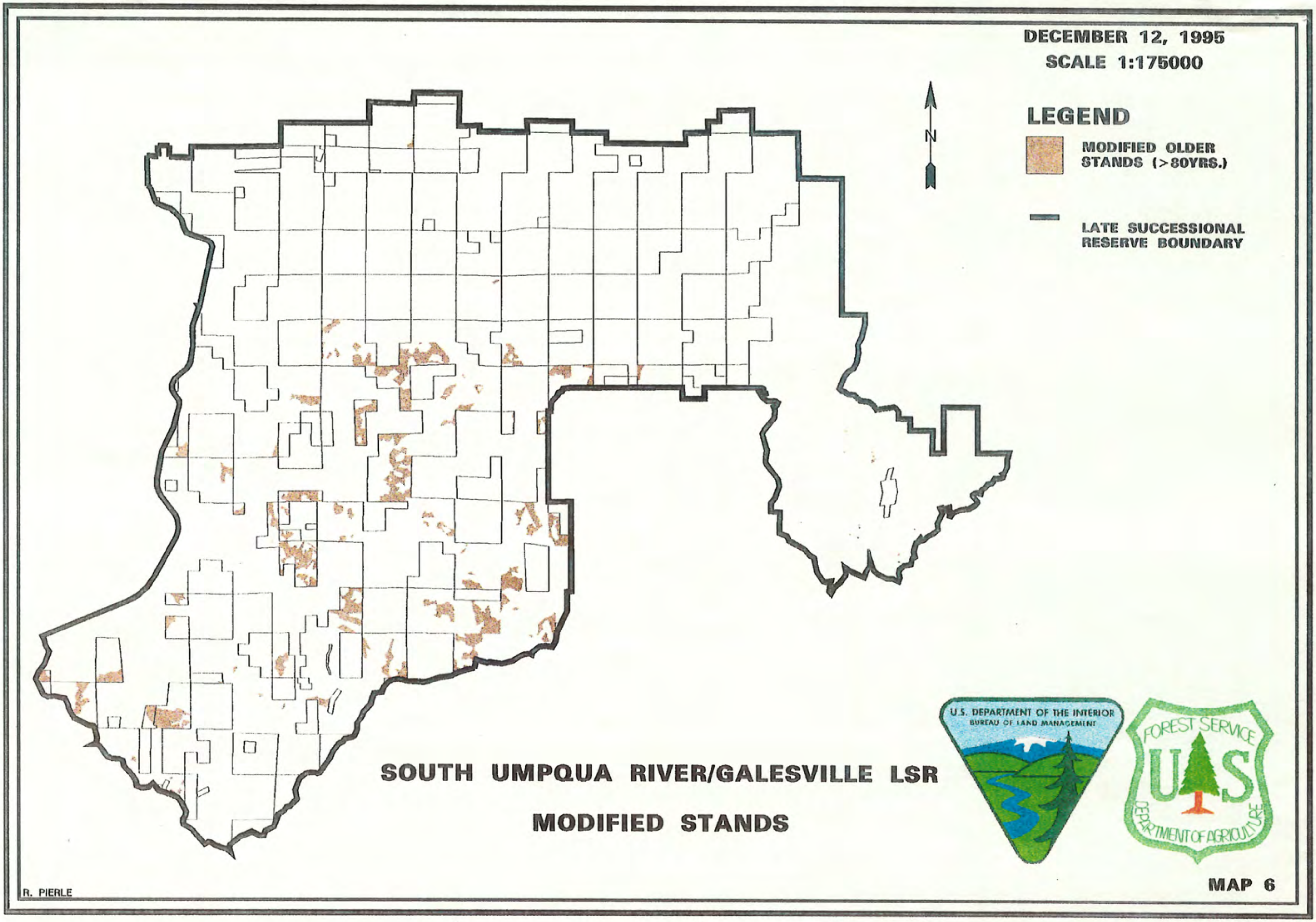
LEGEND
LATE SUCCESSIONAL (81-200YRS.)
OLD-GROWTH (>200YRS.)
LATE SUCCESSIONAL RESERVE BOUNDARY
SOUTH UMPQUA RIVER/GALESVILLE LSR
LATE SUCCESSIONAL/OLD GROWTH STANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE
R. PIERLE
MAP 4


DECEMBER 12, 1995
SCALE 1:175000
N
LEGEND
MID (11-40YRS.) sapling/poles
CLOSED SMALL SAWLOG (41-80YRS.)
LATE SUCCESSIONAL RESERVE BOUNDARY
SOUTH UMPQUA RIVER/GALESVILLE LSR
MID/CLOSED SMALL SAWLOG STANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE
R. PIERLE
MAP 5


DECEMBER 12, 1995
SCALE 1:175000
N
LEGEND
MODIFIED OLDER STANDS (>80YRS.)
LATE SUCCESSIONAL RESERVE BOUNDARY
SOUTH UMPQUA RIVER/GALESVILLE LSR
MODIFIED STANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE
MAP 6
R. PIERLE

3. Connectivity and Fragmentation

Connectivity is defined as a measure of the extent to which conditions between late-successional/old-growth forest areas provide habitat for dispersal, movement, feeding and breeding of late successional/old-growth associated terrestrial and aquatic species. Connectivity does not necessarily mean that LSOG areas are physically joined since many late-successional species can move or can be carried across areas that are not in late-successional conditions. Landscape features affecting connectivity of late-successional ecosystems are: distance between LSOG areas, and forest conditions between LSOG areas.

Within this LSR connectivity varies. In some areas large stands or entire sections of late-successional stands are adjacent or in relatively close proximity to other late-successional stands. Connectivity of late-successional stands is better where federally managed lands share boundaries or section corners. In other areas connectivity is not as good because late-successional forest stands are separated by large areas of early seral stands. On the landscape, these isolated pieces act like small islands of late-successional stands surrounded by early seral age class stands.

An overview of the LSR (Map 4) indicates that more functional connectivity, due to larger blocks of LSOG habitat in relatively close proximity to each other, occurs along the northwestern border of the LSR, along the east side of Interstate 5 (T.31 S., R. 5 W., Sections 1, 13, 24; T. 31 S., R. 4 W., Section 7); and west and southwest of the Bland Mountain Fire area (T. 30 S., R. 3 W., Section 31; T. 31 S., R. 4 W., Section 1; T. 31 S., R. 3 W., Sections 7, 17, 21, 27). On the east side of the LSR the block ownership pattern of the Forest Service shows a more contiguous late-successional forest area that connects on the western side to three BLM sections with late-successional stands. Other sections with late-successional forest blocks occur in the southwestern portion of the LSR, but they tend to be fragmented and not well connected. Concentrations of early seral age stands adjacent to, in the vicinity of, or with the possibility of connecting these blocks could be considered for silvicultural manipulation to accelerate the development of late-successional stands.

The rest of the LSR provides less connectivity and more fragmented habitat conditions. Connectivity within portions of the LSR is currently very poor due to isolation of late-successional forests from other similar stands. Reasons for this isolation include the checkerboard ownership pattern of BLM lands, private land holdings within Federally administered lands, effects of past timber harvesting practices, natural disturbances (including fire), and geologic and geographic influences.

The checkerboard ownership within the LSR prevents attaining large contiguous blocks of late-successional forest except on Forest Service lands. Because of the checkerboard ownership, with the private lands intensively managed for timber production, there is an inherent fragmentation in existing LSOG habitat which will continue in the future. The vast majority of private lands are less than 80 years old now and would be expected to remain in these seral age classes. The Forest Service has the greatest potential for producing larger blocks of LSOG habitat and interior habitat with the continuous ownership in that portion of the LSR.

As a result of fragmenting forces on Federally managed lands, primarily logging and road building and to a lesser extent natural features such as meadows and serpentine openings, LSOG habitat exists as relatively small blocks (<200 acres) fairly evenly distributed across the LSR. A preliminary look at the block size in the LSR indicates the vast majority of LSOG patches are less than 50 acres and only three blocks are over 500 acres. For this LSR, the scarcity of large areas of late seral and old growth habitats are a major area of concern. Small block sizes are generally inadequate to provide for those species which need interior habitat to survive. Interior habitat is defined as late-successional and old-growth habitat at least 400 feet from the edge with an adjacent stand younger than 80 years old. Interior habitats are greatly limited in this LSR, even though over 40 percent of the LSR is in late-successional/old-growth condition.

Sections currently with small fragmented pieces have future potential of becoming a solid block of late-successional forest. Such areas noticeably lacking LSOG habitat include Whitehorse and Fizzleout Creeks on Medford BLM and the Bland Mountain Fire on Roseburg BLM. Much of the former area has been classified as suitable spotted owl habitat, but is too young to qualify as good LSOG habitat.

III. Species Associated with Late-Successional Habitat

Thousands of species exist within late-successional and old-growth forests in the Pacific Northwest. The Forest Ecosystem Management Assessment Team (FEMAT) report identified approximately 1,100 species (not counting arthropods) as closely associated with late-successional forests, on Federal lands. Appendix A lists animal and plant species that have special status designation or survey and manage status (SEIS 1994 Table C-3), information on their presence in the LSR, and the level of monitoring completed. Similarly, Appendix B lists animal and plant species associated with late-successional/old-growth forests that are suspected or known to occur within the South Umpqua River/Galesville LSR. These species are included in this assessment because they are known to occur in the LSR or are suspected to occur and might be affected by activities discussed in this assessment.

A. Animals

Special Status Wildlife Species associated with late-successional habitat in the LSR are listed in Appendix A. The only wildlife species listed as Threatened or Endangered under the federal Endangered Species Act of 1973 as amended, and known to occur within the LSR is the northern spotted owl. The area has potential habitat for bald eagles and peregrine falcons. This LSR is more than 50 miles from the coast so it is not considered potential habitat for marbled murrelets. Other species associated with LSOG habitat are listed in Appendix B.

1. Spotted Owls

There are 46 active owl sites in the LSR (a total of 37 on BLM lands and 9 on Forest Service lands). An active site is one which has been occupied by a pair of owls or a territorial single owl for at least one year since 1985.

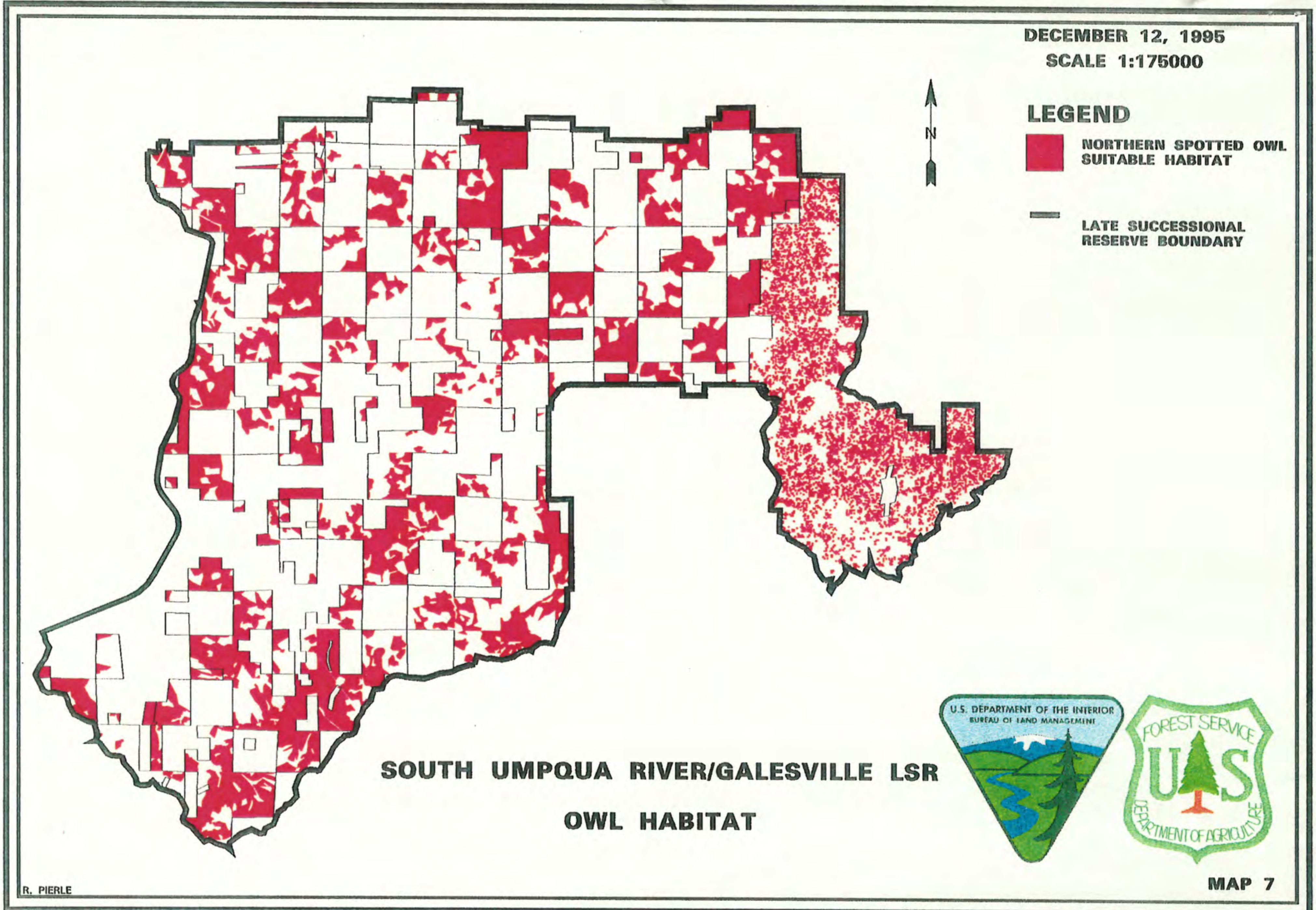
Suitable spotted owl habitat classified as nesting, roosting, and foraging habitat; or roosting and foraging habitat has been identified on BLM lands within the LSR. On Forest Service lands large sawlog and old-growth stands are considered suitable habitat. There are 30,655 acres of suitable spotted owl habitat within the LSR (Map 7).

The USFWS uses thresholds for the amount of suitable habitat around spotted owl sites as an indication of the site's viability and productivity. The thresholds have been defined as 50 percent of the area within 0.7 mile of the nest or center of activity, or approximately 500 acres; and 40 percent of the area within 1.3 miles or approximately 1338 acres. These radii pertain to the Klamath Mountain Physiographic Province.

Of the 46 active owl sites in this LSR, 11 sites (24 percent) contain suitable owl habitat above the thresholds for 0.7 and 1.3 mile radii (see Appendix D, Table D-2). Thirty-five (76 percent) contain suitable owl habitat below the thresholds for both radii. Closer examination shows that 25 of the 35 sites have less than 30 percent suitable owl habitat within the provincial 1.3 mile radius. This assessment is considering these values and the USFWS thresholds as a guide to identify and prioritize areas for possible habitat manipulation.

There are ten sites for which successful reproduction has been documented more than twice since 1985, eleven sites have had no documented reproductive success during that period, and the remaining 25 sites have had successful reproduction one or two years since 1985. Overall, the existing sites have been relatively successful, but because of habitat fragmentation, this success is not likely to improve until additional habitat begins to develop on previously harvested lands. Most second growth in this area is 25-40 years old so significant increases in suitable habitat availability may be 30-50 years in the future.

The level of monitoring in this LSR is relatively high so it is unlikely there are very many undiscovered sites, although four new BLM sites were located in 1994. Even with this level of effort, however, reproductive success (confirming presence of young) for 36 percent of the active sites could not be determined in 1994.


DECEMBER 12, 1995
SCALE 1:175000
N
LEGEND
NORTHERN SPOTTED OWL SUITABLE HABITAT
LATE SUCCESSIONAL RESERVE BOUNDARY
SOUTH UMPQUA RIVER/GALESVILLE LSR
OWL HABITAT
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE
R. PIERLE
MAP 7

Critical habitat for the recovery of the northern spotted owl was designated in 1992 (Federal Register 57(10):1796-1838) and applies to Federal lands only. The intent of critical habitat is mainly to maintain and provide protection for 1) habitat that contains "habitat elements in sufficient quantities and quality to maintain a stable population of owls" (spotted owls) throughout its range, and 2) critical habitat identified lands that "may be needed" for the eventual recovery and delisting of a species.

Critical habitat unit (CHU) OR-32 is larger in gross federal acres (69,731 acres) than the LSR (66,903 acres) but the boundaries are similar to the BLM portion of the LSR. The boundary of CHU-OR-32 includes 26,691 acres (38%) from the Roseburg District and 43,040 acres (62%) from the Medford District. This critical habitat unit does not extend onto Forest Service land. This CHU provides connectivity between the Western Cascades, Coast Range and Klamath Mountain Physiographic Provinces.

Within CHU-OR-32, 65,208 acres are known to be forested. Of this total, 34,414 acres (53%) are currently considered suitable spotted owl habitat, and 30,794 acres (47%) do not meet suitable spotted owl habitat criteria. Since the landscape consists of checkerboard ownership, only about half of the land mass within the CHU boundary (i.e., 25 percent of the landscape) contains suitable owl habitat. This low number shows a need to increase suitable owl habitat in the CHU.

The target for the CHU is to bring all of the BLM lands (that are capable) to the point where they contain suitable habitat for spotted owls. Emphasis should be placed in those areas of the landscape where large gaps in suitable owl habitat currently occur, and which contribute to the fragmentation of forest stands. This critical habitat unit was identified as OD-16 in the Draft Recovery Plan for the Northern Spotted Owl (USDI 1992a). The recovery plan identified current projected and future projected owl pair numbers for this area. Based on five years of data collected from 1986 to 1990, or 1987 to 1991, the Draft Recovery Plan in April 1992 expected the number of owl pairs to drop from 23 known pairs to 17, if the population stabilized with the habitat conditions at that time. Projections into the future were also made. Twenty two pairs were projected to live within the CHU if all of the forest stands in Federal ownership capable of attaining suitable habitat characteristics were to develop suitable spotted owl habitat. Since the CHU-OR-32 (OD-16) boundary is nearly identical to the BLM portion of the LSR boundary, the Draft Recovery Plan estimate of owl pairs can be applied to the BLM lands within the LSR.

A revised Final Draft of the Recovery Plan (USDI 1992b) identified CHU-OR-32 as OD-32. It revised the projected owl pair numbers expected within the boundary of CHU-OR-32. Pair numbers were projected to drop from 21 known pairs to 11, if the population stabilized with the habitat conditions at that time. Fifteen owl pairs were projected in the area if all the forest stands in Federal ownership capable of attaining suitable habitat characteristics were to develop suitable spotted owl habitat.

Based on pair determination as outlined in the spotted owl survey protocol, 33 owl pairs were present within the boundary of the LSR as of 1994. Not counting pair data from the Forest Service portion gives a total of 30 spotted owl pairs on BLM lands. This is eight owl pairs above projections in the Draft Recovery Plan of April 1992 and 15 pairs above future projections in the Final Draft Recovery Plan (December 1992). Differences in pair numbers between the Recovery Plan and known owls is due to the assumptions used in the Recovery Plan. Because the Final Recovery Plan Draft (USDI 1992b) has not been approved the pair numbers for CHU-OR-32 are not official numbers.

Even if all of the BLM lands within CHU-OR-32 contained suitable spotted owl habitat, only about 50 percent of the landscape would have suitable spotted owl habitat. Opportunities such as creating partnerships with private landowners, or blocking up BLM lands by purchase or land exchange could be pursued to increase the amount of suitable habitat within the LSR boundaries.

2. The American Bald Eagle and the Peregrine Falcon

These two bird of prey species occur in the area, but do not appear to nest within the South Umpqua River/Galesville LSR boundary. Yearly inventories (1971-1994) of known bald eagle sites by Isaacs and Anthony (1994) of Oregon State University do not list any sites, nests, or territories within or in the vicinity of this LSR.

The peregrine falcon is not considered a species associated with late-successional habitat but is briefly discussed here due to its endangered status. Peregrines have been documented in the vicinity but surveys have not been conducted to locate this species in the LSR (as of 1994). The parent material that makes up the topography within the LSR, has in some places eroded to create cliffs and ledges. These areas considered to be potential peregrine falcon habitat are present within the LSR. Surveys to inventory potential peregrine habitat in the LSR have not been done.

3. The Marbled Murrelet

The South Umpqua River/Galesville LSR is located outside of the 50 mile zone inland from the Oregon coast. The western edge of the LSR is 60 air miles from the coast. Known information about the biology and inland nest sites of the murrelet indicates that it is unlikely to be found beyond the 50 mile zone set by the new forest plan (USDA and USDI FEIS 1994, USDI 1992).

4. Avian Species Associated with Late-Successional Forests

Over 26 bird species have been documented to be dependent or associated with mature to old growth forests in the Pacific Northwest (Ruggiero et al. 1991, Brown 1985). The majority of this group is composed of migratory bird species known as neotropical birds. Neotropical refers to the seasonal behavior of breeding in North America in the summer and flying south to Mexico, Central America, and South America to spend the winter.

Appendix A and B list the bird species that occur or are suspected to occur in the LSR. All of these species depend on mature and older forest for their food, resting and nesting needs. Some species, like the brown creeper, hermit thrush, pileated woodpecker, winter wren, hairy woodpecker, and Vaux's swift are closely associated with late-successional forests.

A large number of bird species not associated with older age stands are present throughout the LSR. As stand ages increase through time, the available habitat for these species will diminish.

5. Amphibian and Reptile Species

The amphibian species in Appendix A and B use unique habitats that are found across vegetation classes. These habitats include large down woody material, snags, talus slopes, creeks, seeps, ponds and wetlands. These features are present throughout the LSR.

An inventory of amphibians in the South Douglas Resource Area (Roseburg District) was completed by Bury in 1994. The northern red-legged frog, foothill yellow-legged frog, and clouded salamander have been documented in the LSR. The spotted frog is not expected in the LSR and was not found during the 1994 inventory. The tailed frog is present in the geographic area but was not documented within the northern portion of the LSR. This species can serve as an indicator of watershed water quality, because of its sensitivity to changes in sediment loads, and water temperature. The cascades frog was located north of the LSR boundary at higher elevations. This species is probably present, especially on Forest Service lands within the LSR. The southern torrent salamander was documented in the northern area of the LSR and is also known to occur elsewhere in the LSR.

6. Mammals

Mature and older age classes are an important habitat component for many mammals, such as bats, red tree voles, fisher, pine marten, ringtail, elk, and deer. All the bat species listed in Appendix A utilize large older trees for roosting and resting between feeding periods (Cross 1988; Christy and West 1993). No information is available on the hibernating or nursery areas used by these bat species in the LSR. Limited inventories to locate caves, mine shafts, and other structures used by bats have been conducted in the LSR.

Mammals like the red tree vole use old-growth, mature (large sawlog), and closed small sawlog seral age classes for primary habitat (Carey 1991). These seral age classes are used for nesting, resting, and foraging (Carey 1991). Other mammals like the fisher, pine marten, and ringtail require large blocks (greater than 200 acres) of mature to old-growth forest stands. This is important because the environment (temperature, moisture, and plant community) found in interior portions of large blocks of mature and old-growth forests is different than smaller pieces (less than 200 acres) of mature and old-growth stands.

Elk and deer forage in open areas where the vegetation includes grass-forb, shrub, and open sapling communities. Both species use a range of vegetation age classes for hiding. This hiding component is provided by large shrub, open sapling, closed sapling, and mature or old-growth forest components (Brown 1985).

The northern portion of the LSR includes two elk management areas (Green Butte and Hyde Ridge) identified in the Roseburg District RMP/ROD (1995b) and the Proposed Roseburg District Resource Management Plan/EIS (1994). Communication with the Oregon Department of Fish and Wildlife identified this area as lacking current estimates of the elk population (personal communication).

Elk management goals for the identified management areas have not been developed. Some potential management activities designed to improve elk habitat conditions may support LSR objectives and others may conflict. Managing for optimal cover (basically LSOG stands) and thermal cover are essentially identical to LSR goals and objectives. Closing roads to reduce harassment to elk may also benefit LSR goals by reducing disturbance to LSOG associated species, minimizing loss of habitat due to illegal firewood cutting and reducing the chance of accidental wildfire ignition. Some activities, such as creating or maintaining early seral stands for forage may conflict with LSR objectives, although it may depend on how extensive such proposals might be. Such proposals would only be implemented if it is determined that they would not interfere or conflict with LSR goals of maintaining and improving LSOG habitat. This would not be necessary throughout most of the LSR since private lands would probably continue to provide early seral stages for elk foraging areas. Transplanting elk from other areas may be neutral in regard to LSR objectives. Any approach to elk management would benefit from information about distribution and habitat use of elk within the LSR. This information is not currently available.

7. Invertebrate Species

The ecosystem in the Pacific Northwest is dependent in part on the invertebrate species found in the area. These species serve as a primary energy source for the rest of the food chain. The LSR is likely to contain representative members of the 3400 species of arthropods (insects, spiders, millipedes, centipedes) that have been catalogued in coniferous habitats in the Coast Range and Western Cascade Provinces (Parsons et al. 1991). Many of these species are associated with late-successional and old-growth habitat. Inventories for invertebrate species listed in Appendix A have not been done.

Other invertebrates like snails and slugs are abundant in the Pacific Northwest in both aquatic and terrestrial systems. Over 350 species of snails and slugs have been described from western North America. Within the LSR, two species of land snails (*Helminthoglypta hertleini, Vespericola shasta*) and three species of slugs (*Deroceras hesperium, Prophysaon* *coeruleum*, *P. dubium*) are suspected to be present and are on the Survey and Manage list in the SEIS ROD. Other mollusc species associated with late-successional forests are listed in Appendix B. Inventories for these mollusc species have not been done in the LSR.

8. Fish

The South Umpqua River historically supported healthy populations of resident and anadromous salmonid fish. A 1937 survey conducted by the Umpqua National Forest reported that salmon, steelhead, and cutthroat trout were abundant throughout many reaches of the river and its tributaries (Roth 1937). Excellent fishing opportunities for resident trout and anadromous salmon and trout historically existed within the South Umpqua River (Roth 1937). The historical condition of the riparian zone along the South Umpqua River favored conditions typical of old-growth forests found in the Pacific Northwest. The river and its tributaries were well shaded by the canopy closure associated with mature trees. Streambanks were provided protection by the massive root systems of these trees.

Winter steelhead and resident rainbow trout (*Oncorhynchus mykiss*), fall and spring chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*) and sea-run cutthroat and resident cutthroat trout (*Oncorhynchus clarki*) have been documented utilizing the LSR. Over the last 150 years, salmonids have had to survive dramatic changes in the environment where they evolved. The character of streams and rivers in the Pacific Northwest have been altered by settlement, urban and industrial development, and land management practices. Modifications in the landscape and waters of the South Umpqua Basin, beginning with the first settlers, have made this river less habitable for salmonid species (Nehlsen 1994).

The South Umpqua River once supported abundant populations of chinook and coho salmon, steelhead, and cutthroat trout. These species survived in spite of the naturally low streamflows and warm water temperatures that occurred historically within this subbasin (Nehlsen 1994). Currently, salmonid populations throughout the Pacific Northwest are declining. A 1991 status report identified a total of 214 native, naturally spawning stocks as vulnerable and at-risk of extinction (Nehlsen 1991). According to this 1991 report, within the South Umpqua River, one salmonid stock is considered extinct, two stocks of salmonids are at-risk of extinction, and two stocks were not considered at-risk.

Coho salmon, Umpqua cutthroat trout, steelhead trout, Pacific lamprey, and Umpqua chub are special status species documented or suspected to live in streams within this LSR. The National Marine Fisheries Service proposes to list Umpqua River basin coho salmon and cutthroat trout as Threatened and Endangered, respectively. The Pacific lamprey and the Umpqua chub are on the Federal candidate list.

Limiting factors affecting aquatic health and the fisheries resource differ among the streams. The limiting factors affecting fisheries in this LSR include low summer flows, elevated water temperatures, restricted access for anadromous salmonids to areas of their historic distribution, the lack of instream habitat structure (large woody debris, boulders, side channels, and pools), the relatively high amount of sediment found in the gravel substrates required by spawning salmonids, and the lack of large woody debris (LWD) for future recruitment into the stream channels from the adjacent riparian area.

Low summer flows and elevated water temperatures are inherent to interior southwest Oregon. Natural contributors to these conditions include geology, climate, low elevation and stream orientation. The problems of naturally low flows and high water temperatures are compounded by human-related activities. Logging, placer mining and livestock grazing in riparian areas and some logging-related activities in upland areas have reduced the productivity of many streams in the LSR. Roads constructed in riparian zones and erosion from tractor skid roads, as well as from poorly constructed and maintained road systems, have degraded streams throughout the LSR. Roads constructed within riparian zones and timber harvested to the edge of streams have removed shade and potential sources of large woody debris. In addition, salvage operations commonly removed woody material from streams. The vegetative cover significantly influences the numbers and distribution of the fish species listed in this assessment. The canopy cover over streams range from essentially nothing to almost 100 percent in certain areas of the Late-Successional Reserve.

Minimizing or reducing the effects of the limiting factors within the LSR on the fisheries resource should be a goal within this LSR. The designation of the upper South Umpqua River as a Tier 1 Key Watershed further emphasizes the intent of these watersheds as future refuges for the at-risk and depressed stocks of anadromous salmonids. Part of the watershed restoration strategy within Key Watersheds is to reduce the amount of existing roads. If funding is insufficient to implement reduction, there will be no net increase in the amount of roads in Key Watersheds.

Environmental conditions and activities outside the LSR, such as ocean productivity, sport and commercial fishing, and private and public land management activities greatly influence the number of anadromous fish returning to spawn. The checkerboard ownership pattern of private and BLM administered lands also influences the management abilities of the fisheries resource within the LSR. However, opportunities exist for the BLM and Forest Service to positively affect the streams in this LSR and to improve their overall aquatic health.

The objectives for maintaining and enhancing LSOG habitat conditions in the LSR would also serve to enhance fish habitat. Silviculture treatments such as planting unstable areas along streams, thinning densely-stocked young stands, releasing young conifers overtopped by hardwoods, and reforesting shrub and hardwood dominated stands with conifers would improve streambank stabilization, increase shade, and accelerate development of large wood desired for future in-stream structure. The watershed analysis documents provide more specific information on fish habitat and evaluate and identify priority projects for fish habitat improvements.

B. Plants

1. Fungi, Lichens, and Bryophytes

The Forest Ecosystem Management Assessment Team (FEMAT) report considered 109 fungi, 26 lichen, and 32 bryophyte species endemic to the Pacific Northwest to be closely associated with late-successional forests. Unrecorded observations and the variety of habitats within the LSR indicate the possibility some of these species may be present.

No surveys for fungi, lichens, or bryophytes have been conducted for any of the Survey and Manage species listed in the SEIS ROD. Surveys would be completed before ground disturbing activities are implemented in fiscal year 1999 or later (SEIS ROD 1994).

Habitat components important to fungi, lichens, and bryophytes include dead down wood, standing dead trees, and live old-growth trees, as well as a diversity of host species and microhabitats. Generally these habitat characteristics are achieved by more extensive and interconnected late-successional and old-growth forest conditions.

Small patches of LSOG forest fragments distributed across the landscape can function as refugia and centers of dispersal where these species may persist until suitable habitat conditions become available in adjacent stands. Patches of old-growth forests 25 acres or less may provide habitat for a wide variety of organisms even though edge effects may eliminate fully buffered interior habitat.

Older stands that are well distributed geographically are important to the survival and persistence of many plant species in the ecosystem. Some lichens, as an example, do not become established until stands are several hundred years old. The location of old-growth stands, such as ridgelines that are optimum for dispersal, is also important for some species.

Older stands that provide complex canopy structure are beneficial for many plant species. Trees that are asymmetrical or have leaning boles promote a diversity of habitat substrates and often have more lichen and moss epiphytes on large lateral limbs than symmetrical trees.

2. Vascular Plants

The FEMAT report considered approximately 124 vascular plant species to be closely associated with late-successional forests. Vascular plants known or suspected to exist within the LSR are listed in Appendix B.

A review of the range and habitat requirements for the vascular plants listed as Survey and Manage species in the SEIS ROD indicates the following species are potentially present within the LSR:

Allotropa virgata	Candystick
Aster vialis	Wayside aster
Cypripedium fasciculatum	Clustered lady-slipper orchid
Cypripedium montanum	Mountain lady-slipper orchid

Plant surveys have been conducted to a limited extent for timber sales and other management activities, but no special status species or species designated as Survey and Manage in the Northwest Forest Plan were found.

The Oregon Klamath Physiographic Province has some of the largest numbers of endemic vascular plant species in the Pacific Northwest. Rare and local plants are often restricted to distinctive soils, such as serpentine, and to special habitats, such as rock outcrops, bogs, and wetlands.

Most species closely associated with late-successional and old-growth forests are long-lived perennials. Many woody and herbaceous vascular plants are extremely long-lived, requiring decades to reach reproductive size.

Habitat components, such as coarse woody debris, associated with late-successional, riparian, and old-growth forests are essential for some species of vascular plants. Some vascular plants establish themselves only on large decaying logs or coarse woody debris. Microclimate, log decaying processes, and fungal associations may be altered by the removal of canopy cover.

IV. Past and Present Uses of the LSR

A. Past Uses

Archaeological evidence of human habitation in southwest Oregon stretches back at least 10,000 years. The first inhabitants seemed to live in small, mobile groups, hunting and gathering throughout a defined territory.

Approximately 3,000 years ago cultural patterns began to change. Population growth, permanent villages, long-distance trade in luxury items, the appearance of wealth items and the development of social classes characterize this later period. This was a time of increasingly intensive use of natural resources as well as an increasing focus on the aquatic resources of the rivers. Permanent settlements appeared along the major rivers, such as the South Umpqua River, and their tributaries.

The first Euro-American arrived in the area in the early 1800's. The Hudson Bay Company fur traders aggressively trapped beaver and other fur-bearing animals in an effort to eliminate them, and in effect to eliminate competition from American trappers. Between 1820 and 1850 explorers, scientists, pioneers, and adventurers passed through the region collecting information and/or travelling to either the Willamette Valley or California.

The discovery of gold in the Rogue Valley brought a large influx of people to the area. Placer and lode mining for gold, silver, copper, mercury, and nickel were the primary minerals mined.

Federal policies beginning with the Donation Land Claim Act of 1850 and subsequent homestead acts encouraged settlement. Ranching and farming complemented the more transient mining industry. Small communities developed and grew, aided by the building of the railroad along Cow Creek in the 1880s. Rail transportation stimulated logging in the valleys.

The early decades of the twentieth century witnessed the continuation of economic trends of earlier years. Mining, ranching, farming, and logging continued to be major industries and uses in the area now defined as the LSR. Growing concerns over conservation issues led to the creation of the Forest Service. Federal land policies, such as fire suppression, began to affect the LSR.

A subsistence way of life, which was similar to earlier native ways of life, developed and persisted through the Depression era of the 1930's. It was characterized by low cash flow and a dependence on hard work to produce the necessities of life. Residents built their own homes; gathered, hunted, fished, and preserved much of their own food; traded and bartered for other necessities; and earned limited amounts of cash from a variety of tasks. These activities relied to a great extent on the natural resources in the area.

The Depression era also brought the Civilian Conservation Corps to the area. These young men built roads and bridges, and engaged in fire suppression and other land conservation work. As a result of their efforts, formerly inaccessible areas in the forested mountains were opened. The new roads and bridges expedited the harvesting of timber.

After World War II population growth, better roads and cars, and increased tourism has allowed more people access to the LSR for a variety of reasons. Also, improvements in transportation, especially the availability of heavy duty trucks and equipment for road construction, and the increased demand for lumber has increased timber harvesting within the LSR.

B. Present Uses

Present uses and activities within and adjacent to the LSR include timber harvesting, road construction and rights-of-way, agriculture, residential, utility rights-of-way, mining, recreation, habitat improvement projects, and harvesting of special (minor) forest products. Timber harvesting has been the dominant use within the LSR during the past 50 years until very recently. Nearly all of the private lands have been harvested, with 50 percent of the private lands in the closed small sawlog (41-80 year) class (see Table 1). Timber harvesting is expected to continue to be the dominant use on private timber lands in this area.

On Federally managed lands timber harvesting has occurred to a lesser extent, although 52 percent of the LSR is in the younger age classes less than 80 years old. The emphasis on timber harvesting has been reduced due to the development of the Northwest Forest Plan. The goal of the LSR is to maintain and promote a functional and interacting late-successional and old-growth forest ecosystem. This may include some timber harvesting, such as with density management.

Road construction in the recent past has been associated with timber harvesting. Generally, main haul forest roads have been located where the gradient is gentle, frequently along streams. These roads, for the most part are needed and used for accessing areas for land management activities.

Nonforest uses of lands in the vicinity include agriculture, residential, and utility rights-of-way. Agriculture and residences occur primarily in the valleys of the South Umpqua River and Cow Creek and their major tributaries. There are some scattered isolated parcels in the upland areas. Utility rights-of-way consist of powerline and fiber optic telephone cable corridors that run through the LSR.

There are numerous mining sites located throughout the LSR. Mining and mineral exploration over the past decade has been minimal. Some portions of the LSR have a moderately favorable potential for mining gold, silver, copper, lead/zinc, and chromium/nickel deposits. Exploration would be expected to concentrate on potential lode deposits.

Recreation within the LSR occurs in dispersed and concentrated forms. The most common forms of dispersed recreation found in this area include driving for pleasure, camping, picnicking, hunting, gathering (berries, flowers, mushrooms, greens, and rocks), photography, and target shooting. Lands in the LSR are generally managed for dispersed recreation. The proposed Bear Gulch Research Natural Area (RNA) is within the LSR. This RNA is closed to Off Highway Vehicles and recreation use is discouraged at this time.

Developed recreation sites in the LSR are concentrated in the Galesville Reservoir area in the Cow Creek drainage on the Medford District, BLM. Galesville Reservoir, completed in 1986, has had a significant impact on recreation and has led to designating the surrounding area as a Special Recreation Management Area. A portion of the LSR is within the Upper Cow Creek Recreation Area (UCCRA) established jointly with the Medford District BLM, Umpqua National Forest, Roseburg District BLM, Oregon Department of Fish and Wildlife (ODF&W), and Douglas County Park Department. Existing facilities include several trails, Chief Miwaleta Picnic Area and boat ramp, and a designated wildlife area on the eastern end of Galesville Reservoir. There is an increasing demand for recreational opportunities in this area. The current demand is not being met. Locations and a more complete list of existing and proposed recreation facilities are included in the Medford District's Upper Cow Creek Watershed Analysis document.

Habitat improvement projects, consisting of placement of logs and boulders in streams to improve habitat complexity, have been constructed in Quines, Bull Run and Whitehorse Creeks to improve spawning and rearing habitats for adult and juvenile anadromous fish. Additional opportunities may become apparent as data from stream surveys becomes available.

Special forest products is the term used for those forest products commercially and recreationally harvested/collected in relatively small amounts. Special forest products collected in the LSR include vegetative materials such as grasses, beargrass, tree boughs, christmas trees, burls, seeds, roots, bark, berries, mosses, ferns, edible mushrooms, tree seedlings, transplants, poles, and firewood (fuelwood). Until recently, the major special forest product gathered has been firewood. Logging slash is the primary source of firewood cut. Recently, beargrass and tree boughs have become more important as marketable species. The demand for other products may increase in the future.

V. Stand-Level Criteria for Developing Appropriate Treatments

Late-successional reserves are to be managed to protect and enhance late-successional and old-growth forest ecosystem conditions. Appropriate treatments can be divided into four categories: salvage, risk reduction, enhancement of late-successional habitat conditions, and other non-silvicultural activities. Risk reduction efforts are encouraged where they are consistent with the overall recommendations in the Standards and Guidelines of the ROD. The ROD also encourages the use of silvicultural practices to accelerate the development of overstocked young plantations into stands with late-successional and old-growth forest characteristics.

For this LSR assessment, late-successional character is defined as stands with:

- multiple canopy layers,
- canopy dominated by later seral tree species,
- a moderate to high number of large trees greater than 20" dbh and with an average age of more than 80 years,
- relatively high canopy closure of at least 55-65 percent,

- relatively high decadence as measured by the abundance of snags, down logs, and deformed trees,
- presence of canopy gaps, and
- diverse species composition, depending on site conditions.

It needs to be understood, however, that there is a great deal of variation within the broad category of late-successional/old-growth forest. In this area, even-age stands approximately 80 years old which originated from a stand-replacement fire, frequently have a closed canopy, an open understory, and are beginning to show some mortality and snag creation. These stands do provide some degree of suitable habitat for several species which are associated with LSOG habitat and therefore do make a substantial contribution to the objectives of the LSR. However, they do not provide nearly the quality or diversity of LSOG habitat typically found in unentered stands which have not had a stand replacement fire for 200 years or more. These stands often have the full range of habitat characteristics listed above and offer more suitable habitat for most or all of the species associated with LSOG habitat.

A. Salvage Guidelines

Tree mortality is a natural process in a forest ecosystem. Dead and damaged trees are key structural components of late-successional forests. However, excessive amounts of coarse woody debris may interfere with stand regeneration and create a high risk for future stand-replacing disturbances. Management activities, such as salvage, following events creating excessive amounts of coarse woody debris should be designed to accelerate or not to impede the development of late-successional forest conditions.

Salvage involves the removal of forest components (i.e., green standing trees not likely to survive, dead standing trees, live or dead blown over trees) after an event like fire, wind, insect or disease outbreaks, or other natural events. These stands may have various levels of trees blown down, scorched, standing live and dead, etc. based on the intensity of the event. The goal here is not to list every possible salvage scenario but to outline the likely options that may help "protect and enhance conditions of late-successional and old-growth ecosystems" (SEIS ROD 1995) after a forest disturbance. All salvage projects should be evaluated on site by area specialists applying the possible scenarios and actions listed below:

1. **Disturbed areas equal to or less than 10 acres, or disturbed stands where canopy closure remains greater than 40 percent** should not be considered for salvage. Disturbed areas less than 10 acres may be salvaged only if a risk reduction evaluation indicates a need to salvage to meet LSR objectives. Refer to "Management actions for risk reduction" section later in this document.

2. **Individual or groups of trees along roads, trails, or recreation sites** may be salvaged if it is determined that they pose a hazard to people using the area. Salvage of down trees along roads, trails, or in recreation sites may also occur if the trees are blocking

or are an obstruction to using these areas. All these opportunities should be evaluated by specialists, to ensure meeting LSR objectives listed in the USDA SEIS ROD (USDA Forest Service and USDI BLM 1994) and the Medford and Roseburg RMPs (1995a and 1995b) as well as the Umpqua National Forest Plan (1990).

3. Areas greater than 10 acres which have been disturbed by wind, fire, insect or disease, and that have canopy closures below 40 percent as a direct result of the disturbance, may be considered for salvage. Any proposed salvage after such a disturbance would be evaluated on a site-specific basis by an interdisciplinary team. The overall goal would be to conduct salvage operations, consistent with standards and guidelines in the SEIS ROD and the appropriate RMP or Forest Plan, as well as being consistent with LSR objectives. All green trees, likely to survive, would be retained. How many snags and down logs should be retained will vary based on plant community, site conditions, potential for re-burns, and other factors.

Some options for salvage in those situations include:

a. No salvage - consider the value to the site of not conducting salvage if such action aids in meeting LSR objectives. This evaluation could be based on the size of the disturbance, type of disturbance, location, etc.

b. Partial salvage - consider leaving forest components (standing or down trees) in the disturbed area to meet LSR objectives. This may include leaving on site variable numbers of snags and down woody components that would emulate the conditions in late successional forests. It should include options like leaving all standing live trees, including injured trees that are likely to survive the event. Other general salvage guidelines may be found in the SEIS ROD (1994) on pages C-13 to C-15.

c. Other scenarios presented in the SEIS ROD (1994) should be used to guide actions not presented here.

B. Risk Reduction

1. Current Situation and Risk Factors

The SEIS ROD recognizes the Oregon Klamath Physiographic Province has an increased fire risk due to lower moisture conditions and the rapid accumulation of fuels after insect outbreaks and drought. Risk reduction activities in the LSR should be designed to prevent large scale losses of late-successional habitat conditions due to major disturbances, such as wildfire, insects, disease, and wind storms. The primary purpose in risk reduction activities in this LSR is to prevent the large scale loss of older forest stands to wild fire. Prevention of widespread loss of habitat to insects, disease or wind may also be necessary.

There is presently a moderate to high fire hazard in the LSR. Much of the private land, particularly small ownerships near the valley floor, have been harvested recently. Very little slash disposal was done, so for the next 5 years, until decomposition occurs, this hazard will remain high. Because of the proximity to the valley floor, the number of residences in the vicinity, and the number of people using the area for recreation, especially in the vicinity of Galesville Reservoir, the risk is also relatively high.

Additionally, the suppression of wildfires and the creation of dense young plantations has resulted in the accumulation of dense fuels over large continuous areas. This creates the potential for rapidly spreading, large scale fires. At the same time these plantations are susceptible to insects and disease, which would increase the risk for large scale fires.

2. Management Actions for Risk Reduction

In younger stands (i.e. grass/forb through open small sawlogs) fire risk can be reduced by promoting a closed canopy condition to reduce the fuel loading on the ground, or by chipping or lopping and scattering precommercial thinning (PCT) slash to facilitate rapid decomposition. Risk to younger stands from insect and diseases can be reduced by shifting monoculture, even-age stands toward more mixed-species, multi-age stands.

While risk reduction efforts should generally be focused on young stands, activities in older stands may be appropriate if: 1) the proposed management activities will clearly result in greater assurance of long-term maintenance of habitat, 2) the activities are clearly needed to reduce risks, and 3) the activities will not prevent the Late-Successional Reserve from playing an effective role in the objectives for which they were established. In larger size classes or dense younger stands, fire risk can be reduced through thinning to reduce stem density and improve vigor, pruning to remove fuel ladders and maintain or improve forest health, tree culturing to protect valuable trees, particularly large pines, creating fuel breaks, or using prescribed burning to reduce fuels.

Risk reduction for wildfires may also include the construction of water sources, such as heliponds, to be used for fire suppression. These ponds would be planned to have the least possible adverse impact on late-successional habitat.

In the Oregon Klamath Province some salvage that does not meet the preceding guidelines discussed in part A of this section would be allowed if it is essential to reduce future risk of fire, insect damage, or disease. Some limited salvage activities may be appropriate in insect and disease pockets in order to reduce the threat of future fires or spreading infestations which would be counter to LSR objectives. The focus should be on areas where there is a high risk of large scale disturbance. In these cases the value of reducing the risk of future loss of LSOG habitat will be weighed against the value of the snags or logs as existing habitat structures.

Loss of late-successional components due to insects or diseases may be reduced by conducting some of the activities mentioned above, planting resistant species or by eliminating a host species. An example would be planting blister rust resistant sugar pine seedlings.

C. Enhancement of Late-Successional Habitat Conditions

The overall criteria for management actions designed to enhance late-successional habitat is that they will improve LSOG habitat characteristics or result in late-successional habitat conditions earlier than would occur if the action had not been taken. There are two general types of management activities which enhance late-successional conditions; accelerating the development of LSOG habitat and providing LSOG habitat characteristics which are missing:

1. Activities in younger stands designed to accelerate the successional development of stands to a late-successional character. Younger stands, approximately 0-80 years old, could be managed to accelerate the development of late-successional character by:

a. Increasing stocking levels of conifers and species diversity through methods such as interplanting with seedlings of various species, or creating openings in existing brush patches within conifer plantations and allowing natural seeding from nearby overstory conifers. Areas needing conifer plantings might be young stands, with trees smaller than six inches in diameter, that are below some minimum target level, such as fewer than 100 trees per acre.

b. Reducing competing vegetation by cutting, burning, pulling out or digging up the unwanted vegetation, or avoidance strategies such as allowing higher densities of young conifers at early age establishment to shade out competing vegetation then thinning conifers once this has been accomplished. These release treatments in young stands help to assure tree survival and avoid stand growth stagnation.

c. Managing the spacing of conifers and desired hardwood species. This can be accomplished through density management, by increasing conifer density to reduce competing vegetation, or by decreasing stand densities by precommercial or commercial thinning, to promote faster diameter growth and larger more frequent limbs/branching on desirable conifer or hardwood species. Decreasing conifer/hardwood densities to promote individual growth may be used where the desired trees are already above competing ground and shrub vegetation or where the competing vegetation is not a major problem. Stands targeted for precommercial thinning might be those stands with an average diameter between one and six inches and having stand densities greater than 350-400 trees per acre. The timing of a commercial thinning would depend on stand density, minimum average diameter for an economic entry, site quality, and previous silvicultural treatments.

d. Increasing the stocking of desired hardwood species in stands where they are lacking. This can be done by planting hardwoods or by reducing competition from conifers where hardwood stumps or sprouts are present. This can increase the species diversity of a stand, one of the elements for late seral character.

e. Employing growth enhancing measures such as fertilization, and density management as described previously. These treatments would be used to accelerate diameter growth.

Proposed projects would be reviewed by an interdisciplinary team to determine if they would actually result in achieving late-successional habitat conditions earlier than if the project were not implemented. Tree growth simulation models, such as Organon, could be used to assess the desirability of applying a silvicultural practice to a stand. In these cases, plots would be taken and the effects of the proposed action would be compared with projected stand development if the management action were not implemented. In addition, proven treatments would be acceptable if consensus can be reached that they would accelerate development of late-successional conditions. If it cannot be demonstrated that the action would significantly speed up the development of late-successional character, the action would not take place.

2. Activities within older stands designed to provide one or more characteristics which may be missing or inadequate, either naturally or through past management actions.

Older stands which currently exhibit late-successional or old-growth characteristics should be retained without active management, unless they are identified as needing treatment as part of a risk reduction effort.

Other older stands, such as those in the Modified Older Stand category, which do not currently exhibit late-successional characteristics could be managed using many of the same management practices as described for younger stands. The intent here would generally be to treat the understory to promote the rapid establishment of a diverse and multi-layered canopy. Potential treatments include increasing stocking levels of conifers or hardwoods, altering stand species composition, and accelerating the growth of the existing stand through fertilization or density management of the understory. In these cases, no overstory trees would be harvested.

In addition, there are other possibilities for enhancing late-successional conditions, including:

a. creating small canopy gaps (approximately 1/4 to 1 acre) where they are not present, to increase stand diversity,

b. underburning to reduce heavy brush and increase diversity,

c. treating the understory using young stand treatments to facilitate development of multi-layered canopies, and

d. tree-culturing to protect desirable trees such as pines and large hardwoods, and to develop large limbs.

Proposed projects would be evaluated by an interdisciplinary team to determine if the short and long term benefits to LSOG habitat outweigh any adverse effects. A conservative approach will be employed in these evaluations. It is better to err on the side of maintaining current LSOG habitat than to risk degrading habitat conditions. Experimental or unproven treatments should be attempted outside the LSR first.

D. Other Nonsilvicultural Activities

Nonsilvicultural activities located inside Late-Successional Reserves that are neutral or beneficial to the creation and maintenance of late-successional habitat are allowed. Most of the following activities are expected to have neutral or beneficial effects on late-successional habitat. Multiple-use activities other than silvicultural activities that may have potentially adverse impacts to the creation and maintenance of late-successional habitat must be reviewed by the Regional Ecosystem Office if adjustments in standards and guidelines are going to be made (SEIS ROD 1994 p. C-16). Some of the following activities may need adjustments in the standards and guidelines in order to occur within the LSR. Other nonsilvicultural activities that may arise in the future should be analyzed following the standards and guidelines in the SEIS ROD.

1. Habitat Improvement Projects

The ROD states that habitat improvement projects designed to improve fish, wildlife or watershed conditions should be considered if they provide late-successional habitat benefits or if their effect on late-successional associated species is negligible. Projects required for recovery of threatened or endangered species should be considered even if they result in some reduction of habitat quality for other late-successional species. In most cases habitat improvement projects for fisheries would have a neutral or negligible effect on late-successional species.

Part of the LSR is in a Tier 1 Key Watershed. Key Watersheds should be given the highest priority for watershed restoration. Stouts Creek Watershed, within the upper South Umpqua River Tier 1 Key Watershed, has potential opportunities for habitat improvement projects due to the Bland Mountain Fire. These projects would be designed and implemented in a manner consistent with Late-Successional Reserve objectives. More detail would be available at the project level.

Past land management activities (clearcutting and road construction) and the Bland Mountain Fire have reduced riparian vegetation adjacent to streams in the Stouts Creek Watershed. An Aquatic Habitat Inventory of the Stouts Creek Watershed conducted by ODFW identified limiting factors as low numbers and volume of LWD, sediment in streams, and the lack of pools greater than three feet in depth. Also, roads constructed within riparian areas limits future recruitment of LWD into the streams.

A stream restoration project has been planned on the mainstem of Stouts Creek located in T. 31 S., R. 3 W., Section 3. The proposed project site, approximately 0.4 mile of Stouts Creek, was determined to be deficient of several desirable instream habitat features (i.e., LWD and pools). The materials (i.e., logs and boulders) have been delivered to the project site, so disturbance of existing vegetation would be minimal. The 31-3-34.0 road located adjacent to the mainstem of Stouts Creek provides access for heavy mechanized equipment to the project site. The Stouts Creek Fisheries Habitat Enhancement Project was developed prior to but has been on hold since the signing of the SEIS Record of Decision.

The Stouts Creek restoration project includes plans for providing LWD structures to the stream channel, placement of boulder-rootwad clusters, construction of blast pools and alcoves, and placement of shade logs across the stream channel. These structures are intended to provide a variety of habitats for the fish species and other aquatic organisms within Stouts Creek.

2. Recreation/Developments

The Upper Cow Creek Recreation Area lies within the LSR. The Upper Cow Creek WA includes a complete list of existing and proposed recreation facilities within the Upper Cow Creek Recreation Area.

The Medford BLM proposes to build a campground adjacent to Galesville Reservoir within the LSR. The proposed campground would affect approximately three acres between the reservoir and a county road. The trees in this area are approximately 40-50 years old. Many of the trees and much of the canopy would be retained to keep a forested aspect within the campground. Since the construction of the Galesville Reservoir in 1986, and the boat ramp and day use facilities associated with it, overnight camping use has occurred indiscriminately on the logging roads surrounding the lake. The proposed campground would provide benefits by keeping camping centralized and undesired impacts to a minimum. This project is expected to be initiated in fiscal year (FY) 1996.

Lands within the Roseburg District BLM portion of the LSR are managed generally for dispersed recreation. Recreation potential identified in the South Douglas Resource Area is included in the Stouts/Poole/Shively-O'Shea Creeks WA. The proposed Bear Gulch Research Natural Area (RNA) is within the LSR. However, recreation use within this RNA is discouraged at this time.

Several existing trails occur within the LSR. Maintenance of the existing trails, such as the felling of hazard trees, is allowed within the LSR (SEIS ROD 1994). Other trails are proposed to be constructed in the future. Two examples within the South Douglas Resource Area on the Roseburg BLM are trails along Stouts Creek and from the end of the 31-3-10.3 road along the ridge top to Green Butte. These trails may require the cutting of vegetation within late-successional forests but would not adversely affect late-successional habitat because of the relatively small amount of vegetation cut. Generally, the proposed trails would be consistent with the overall semi-primitive nature of the area and LSR objectives.

3. Research

The main extent of research within the LSR is tied to the Tree Improvement Program. This program, established in the 1960's, is an ongoing cooperative project with Federal agencies and private timberland owners. Trees which exhibited good form and volume growth characteristics were selected as "plus trees". The "plus trees" remain an important component of the research program. To maintain the vigor of the "plus trees", removing the competing vegetation around the trees may need to be accomplished. Removing the competing vegetation would be similar to tree culturing mentioned previously in the risk reduction section.

The seedlings of the "plus trees" are grown in progeny test sites to test the qualities of the "plus trees". The Roseburg BLM district maintains one progeny test site in the LSR. The Cow Creek Progeny Test Site is located in T. 31 S., R. 4 W., Sec. 29. The Medford BLM maintains two progeny test sites in the LSR. The Galesville Progeny Test Site is located in T. 31 S., R. 4 W., Sec. 21 and the Whitehorse Progeny Test Site is located in T. 32 S., R. 4 W., Sec. 3. Routine maintenance of the progeny test sites consists mainly of measuring the trees at five year intervals and eliminating the competing vegetation. Thinning of the sites may occur at some time.

Any new research activities should be consistent with Late-Successional Reserve objectives. New research activities which are potentially inconsistent with LSR objectives should only be considered if there are no equivalent opportunities outside of the LSR and would be subject to review by the Regional Ecosystem Office (REO).

4. Special Forest Products (SFP)

Special forest products collected in the LSR include vegetative materials such as beargrass, salal, other forest greens, evergreen tree boughs, christmas trees, burls, berries, mosses, ferns, edible mushrooms, and firewood (fuelwood). The management and/or sale of special forest products may occur when such an activity is neutral or beneficial to meeting LSR objectives and neutral or beneficial to the species itself.

Throughout the LSR, harvest will be planned to insure viability of species. As an example, the South Douglas Resource Area has been divided into three areas for beargrass collecting to ensure sustainability of the resource. Only one area will be open for beargrass permits at any one time to allow the other areas time to recover for two years before allowing people to collect beargrass again.

Firewood cutting is conducted to a lesser extent than beargrass picking. Firewood should be cut only in existing cull decks, where green trees are marked by silviculturists for thinning, where blowdown is blocking roads, or in recently harvested timber sale units when down material will impede scheduled post sale activities or pose an unacceptable risk of future large scale disturbance.

Bough collecting occurs on a limited scale, mainly near existing roads. As allowed, bough cutting does not alter the upper two-thirds of a tree and is not permitted on trees shorter than fifteen (15) feet. Any whole trees available for bough collection will be those felled as part of a silvicultural or risk reduction activity.

5. Roads

Routine road maintenance, roadside brushing, repair of storm damage to roads, culverts and facilities would be accomplished following best management practices (BMPs) to provide safe access routes and reduce hazards to humans along roads. Access to non-Federal lands, existing right-of-way agreements, contracted rights, easements and temporary use permits in the Late-Successional Reserve are recognized as valid uses. New road construction should be designed and located to have the least impact on late-successional habitat or avoid late-successional habitat if possible.

Closing roads to public motor vehicle use serves many functions, including reducing disturbance and harassment to elk and other wildlife, reducing erosion into streams, reducing loss of snags and down logs to illegal firewood cutting, reducing potential for accidental fire ignition and others. Generally these closures would contribute to meeting LSR objectives.

Other aspects associated with roads are road decommissioning and the operations of rock quarries. As mentioned earlier in this document, the upper South Umpqua River has been designated as a Tier 1 Key Watershed. Part of the strategy within Key Watersheds is to reduce the amount of existing roads through decommissioning. If funding is insufficient to implement reduction, there will be no net increase in the amount of roads in Key Watersheds. Within the Roseburg BLM portion of the LSR, Transportation Management Objectives identified 36 road segments under BLM control for possible decommissioning.

Operations within existing rock quarries would be continued, as long as they do not have an adverse effect on LSR objectives. Currently there are 13 active quarries within the LSR. Another two quarries have been reclaimed. The full development of the Stouts Creek community pit would require extensive vegetative disturbance. Some of the vegetation disturbed may include late-successional habitat. The rock from this quarry would supply the adjacent rock poor watersheds north of the South Umpqua River and the east side of the

Stouts Creek Watershed. These watersheds are within the upper South Umpqua River Tier 1 Key Watershed. This rock may be used to help upgrade existing roads causing problems and help attain Aquatic Conservation Strategy objectives. The potential benefits of attaining Aquatic Conservation Strategy objectives in this key watershed may exceed the costs of habitat loss.

There are also three identified locations which have the potential for quarry development. Development of these new quarries may involve some loss of LSOG habitat, generally in patches of 2-3 acres and along existing roads. Future development of new quarries would be evaluated to weigh the benefits of extracting the rock against the loss of LSOG habitat and other adverse effects.

6. Nonnative Species

Standards and Guidelines in the SEIS ROD state that nonnative species should not be introduced into LSRs. If introduction of a nonnative species is proposed, an assessment of impacts should be completed and any introduction should not retard or prevent achieving LSR objectives. The introduction of nonnative plant species has often been through management activities such as road construction, seeding of grasses and legumes, and activities that create disturbances. Stabilizing road banks by mulching or seeding with grasses may inadvertently introduce nonnative species into the LSR. However, this should not retard or prevent achieving LSR objectives.

The BLM and the Oregon Department of Agriculture (ODA) have an agreement where the BLM identifies and monitors noxious weed locations and the ODA implements the control measures. Controlling or reducing the extent of noxious weeds such as star thistle would generally benefit LSR habitat as long as undesirable side effects do not degrade habitat conditions.

VI. Landscape-Level Criteria for Developing Appropriate Treatments

Based on the analysis of the existing habitat conditions within the LSR, as well as the individual recommendations for treatments found in the wildlife and vegetation sections, four general landscape criteria were identified for setting priorities for the location of future treatment areas:

1. establishing large blocks of LSOG habitat,
2. enhancing connectivity across the landscape,
3. enhancing suitable spotted owl habitat conditions around centers of activity, and
4. integration of two or more of the previous three criteria.

Often these criteria overlap, which could result in high priority treatment areas which could meet more than one need. There may also be isolated smaller treatment needs which would be handled on a site-specific basis. The following discussion provides an overview of the major facets of the three criteria with recommendations for how they should be implemented:

1. Promote the establishment of large blocks of late-successional and old-growth forest habitat. Promote large blocks of interior habitat. Interior habitat is defined as LSOG habitat at least 400 feet from the edge of a block.

  a. Identify existing large blocks of LSOG habitat and interior habitat which have the greatest potential for enhancement. Priority blocks would be larger than 200 acres with inclusions of mid-seral stands which could be treated to create LSOG characteristics within the next 10-40 years. Use the treatments identified under the stand level criteria.

  b. Identify existing large areas of mid-seral stands, which have inclusions of LSOG patches. Treatment of the mid-seral stands could result in large LSOG blocks within 10-40 years.

  c. Identify areas within the LSR where large blocks of LSOG habitat do not currently exist. Select stands for treatment which would develop into LSOG habitat more quickly than others. The objective here is to develop large LSOG blocks throughout the LSR to provide connectivity and reduce the risks of large fires and other agents.

Specific areas which were identified under this criteria include the southwest portion on Medford BLM, the northwest portion and the area surrounding the Bland Mountain Fire on Roseburg BLM, and the eastern portion of the LSR on Forest Service lands.

2. Maintain and enhance connectivity across the landscape for plant and animal species associated with late-successional and old-growth forest habitat.

  a. Analyze existing data and maps to identify areas with low connectivity, or which create barriers to species moving across the landscape. Connectivity of late-successional habitat could be identified with the aid of a photo of the LSR and seral age class maps. This may be the best way to appreciate the connection of late-successional blocks and the relationship to topography. Topography is important because knowing where connectivity is lacking or present in relation to riparian systems or uplands can make a difference on the success of connecting late-successional blocks. Because of the checkerboard ownership in the BLM portion of the LSR, connectivity of the remaining older forest stands is very important. Even birds, which are capable of straight line flying, require connectivity of habitat for movement. The ability to move within the forest from one place to another becomes more important to species that require or have dependency on the older age classes, have small territories, or move along the ground.

Specific evaluation should:

- identify existing habitat in these areas where opportunities exist for providing connectivity (e.g. stream buffers, small patches of LSOG habitat, mid-seral stands).

- identify stands in these areas which could allow for providing LSOG habitat within 10-40 years.

- identify large areas where treatment is needed to ensure establishment and survival of conifers following timber harvest or other disturbance.

- employ treatments based on those discussed in the section on stand level criteria.

b. Identify important existing connectivity areas. Treat stands in these areas to reduce risk of habitat loss and to maintain existing connections over the next few decades.

Specific areas which were identified under this criteria include:

Stands within the 50 to 70 year age class that provide connectivity between large late-successional blocks. These stands would be more likely to have reached an average stem size and density that would benefit from density management.

The central area of the Medford District portion of the LSR, which has very little LSOG habitat.

The area burned by the 1987 Bland Mountain Fire on the Roseburg District, BLM is one area lacking connectivity in the LSR. This would be an area to treat young (early and mid seral age) stands within the LSR. Stands burned in the fire and replanted are between five and ten years old and are approaching precommercial thinning size.

3. Within the provincial radius of spotted owl activity centers (1.3 miles) maintain and promote spotted owl habitat so that all sites have at least 40 percent of the circle in suitable spotted owl habitat.

Analyze existing suitable habitat around owl sites, as well as other factors like productivity of the sites, connectivity of the suitable habitat to other suitable habitat in the vicinity, and location of the site on the landscape. This information can form the basis for creating a priority list of owl sites. The list can be used to determine which owl sites require active management to increase habitat within the home range or increase connectivity of habitat by manipulating forest stands to accelerate the development of young forest stands with late-successional/old-growth stand characteristics. The treatment or type of stand manipulation may differ based on the particular factor deficient near individual owl sites (see Appendix D).

Knowledge of the owl sites involved and the associated owl and forestry data is important for the reasons listed below.

a. Stand manipulation within the LSR still requires "may affect" determinations under the ESA of 1973 as amended. Whether the impact is negative, positive, or neutral, on the spotted owl or critical habitat, a "may affect" determination must be done by the BLM or Forest Service prior to project implementation. This can be done with knowledge about the owl sites, home range, current forest stand ages, and distribution of stands on the landscape.

b. Each owl site should be evaluated. What is good for one site may not be good for another site. Evaluation should be conducted primarily by wildlife biologists but should include input from silviculturists to ensure that proper methods and prescriptions are developed and that goals can be achieved.

c. Goals of the forest stand manipulation should be tied to and based on the analysis of the data previously discussed.

An example of a priority list for the South Umpqua River/Galesville LSR is given in Appendix D, Table D-1. Table D-1 provides ranking of the sites by occupancy, acres, history, and other data useful in evaluating each site. Table D-2 displays the acres and percent of suitable habitat present within the 1.3 mile radius around each owl site.

Specific areas identified under this criteria include twenty-five owl sites which contain less than 30 percent suitable habitat within 1.3 miles. This is at least 10 percent below the threshold considered important by the USFWS. These sites should be considered first for evaluation following the guidelines listed above.

4. Integration of the three previous criteria.

After evaluating all three landscape criteria, it appears there are a few areas which may be high priority for treatment because they meet more than one of the identified needs. These areas are:

- the Bland Mountain fire in the Roseburg District, BLM,

- the central portion of the Medford BLM part of the LSR, and
- the owl sites below the 30 percent suitable habitat level and in or near an area identified under landscape-level criteria one or two listed above.

VII. Fire Management Plan

A. Wildfire Suppression and Management

The objective of fire and fuels management in the LSR is to maintain late-successional habitat by reducing the risks of high intensity, stand replacing wildfires. Suppression methods would seek to minimize impacts on LSOG habitat. Wildfires in the LSR should be aggressively attacked to keep fires to the smallest possible size. Suppression tactics should consider public and firefighting personnel safety as a primary concern.

In order to minimize disturbance due to wildfire suppression activities, the following practices should be implemented:

- Design fuel treatment and fire suppression strategies, practices, and activities to meet aquatic conservation strategy objectives.
- Avoid building control lines in riparian reserves.
- Where possible, use existing roads and natural fuel breaks for control lines.
- Construct firelines only wide and deep enough to check fire spread.
- Use burning-out as a fire suppression tool.
- Consider rapidly extinguishing smoldering coarse woody debris and duff.
- Minimize impacts of suppression activities near spotted owl nest sites.
- Locate incident bases, heliports and other facilities using an interdisciplinary team with the objective of minimizing disturbance to forested stands and other identified special sites such as special status plant locations.
- Avoid locating incident bases, camps, helibases, staging areas, and helispots within riparian reserves.
- Use existing campsites whenever possible.
- Locate and manage water drafting sites to minimize adverse effects on riparian habitat and water quality.

- Retardant, foam, or other additives should not be applied to open water or at spotted owl nest sites.

- Fire rehabilitation measures would be employed to minimize erosion and sedimentation into streams.

- Establish conifer forests as quickly as possible on suitable sites.

- There should be a post-fire evaluation to determine whether the goals of the LSR were met during suppression activities and to identify necessary changes in management direction.

Some natural fires may be allowed to burn under prescribed conditions. This decision would be based on additional analysis and planning. An approved prescribed natural fire plan would need to be completed before a fire is allowed to play its natural role. A plan would include guidelines based on risk, protection of key habitats, human use areas, and the ability to keep the fire in the prescribed area. The interspersion of private lands and proximity of residences in the valley floor limits the possibilities for using prescribed natural fires.

B. Prescribed Fire

Prescribed fire is recognized as a valuable tool to meet LSR objectives, especially in southwest Oregon where fire is such an integral part of ecosystem functions. The interspersion of private lands and proximity of residences in the valley floor impacts the use of prescribed fires. Fire suppression during the past 80 years and the subsequent fuel buildup also affects the use of prescribed fires to reduce the fuel buildup. Prescribed fires may be used:

- to prepare the site for planting conifers to achieve necessary stocking. This treatment may be called for in past harvest units where reforestation has not been successful, due to competing vegetation. It also may be appropriate in partial cut or naturally open stands to initiate a conifer understory to develop into a multi-layer canopy.

- to underburn an older stand in order to reduce excessive brush, prepare for underplanting, create small "natural" gaps, and increase stand diversity.

- to underburn an older stand to reduce fuels in order to create a fuel break to reduce the potential for a wide spread, high intensity fire which could remove a large acreage of late-successional habitat.

Prescribed fire operations would implement the same suppression guidelines as wildfire suppression activities to minimize adverse impacts to late-successional habitat. Prescribed burn projects and prescriptions would be designed to contribute to attainment of aquatic conservation strategy objectives.

VIII. Implementation

This section is intended to give some idea when the BLM and USFS intend to implement management actions in the near future. Currently foreseeable actions are discussed in light of this LSR assessment. It is clear that conditions are constantly changing and this section should not be read as a complete listing of proposed management actions. The actual implementation of proposed management actions are also based on the availability of funds. As with the entire document, this section should be continually updated as new management direction arises or needs change.

The watershed analysis documents for areas within the LSR also contain goals, objectives and some recommended management activities for a variety of resource management needs. Watershed Analysis for areas within the LSR should be completed before projects are implemented.

Implementation of treatments within the LSR may be based on the appropriate treatment criteria developed to identify possible project, treatment, and status quo (no change) areas. This list included topics like connectivity of mature and late-successional blocks to other similar blocks, evaluation of the blocks and their relationship to topography, identify obvious areas of attention (previous points of catastrophic events i.e., Bland Mountain Fire), and evaluation of spotted owl sites by determining suitable habitat present, where it is located, and its connectivity to other suitable habitat.

Map 4 shows one area in the southern portion of the LSR, within the Glendale Resource Area, where LSOG habitat is scarce. But this area does have extensive stands of 50-80 year old stands, some of which currently provide spotted owl habitat (Map 7). Map 5 shows stands which are possible priorities for thinning, pruning, small gap creation and other management actions which could accelerate the development of suitable LSOG forest habitat. Currently some of these treatments are tentatively proposed to be implemented within the first three years after the approval of this assessment.

Other projects identified, such as the campground Medford BLM proposes to build adjacent to Galesville Reservoir, would not be based on the priority criteria developed but when a project is identified. This campground project is expected to be initiated in fiscal year (FY) 1996.

Some other projects may be implemented on a when needed basis, such as a large scale (greater than 40 acres) salvage project after a catastrophic event or road construction. Still other projects or activities may be ongoing, such as special forest product harvesting and plantation maintenance. Additional projects may be implemented after more information is gathered.

IX. Monitoring and Evaluation Plan

Monitoring is an essential part of natural resource management to provide information on the relative success of management strategies. Monitoring should be conducted at multiple levels and scales. Monitoring should occur at the project level and at a broader scale throughout the LSR. Monitoring should be conducted in a manner that allows localized information to be compiled and considered in a broader regional context. Future monitoring requirements driven by Regional concerns may be added later.

The monitoring plans for the Medford and Roseburg RMPs and the Umpqua Forest Plan are tiered to the Monitoring and Evaluation Plan for the SEIS ROD, which has not been completed yet. As components of the Monitoring and Evaluation Plan are completed or refined, the RMPs, the Forest Plan and this monitoring plan would be updated to conform to the regional plan. Monitoring should follow the guidelines or directions set forth in the following documents:

1. Standards and Guidelines (S&Gs) in the SEIS ROD,

2. management actions/direction in the Medford and Roseburg District Resource Management Plans, and the Standards and Guidelines in the Umpqua National Forest Plan,

3. treatment recommendations in the LSR assessment,

4. management concerns raised during watershed analysis, and

5. mitigation measures included in project NEPA analysis.

Three types of monitoring (implementation, effectiveness, and validation) described in the SEIS ROD should be integrated in monitoring projects and/or activities within this LSR. Implementation, effectiveness, and validation monitoring encompass the multiple levels of monitoring. The goal of implementation monitoring is to determine if the plan is being implemented correctly. Effectiveness monitoring should determine if the objectives of the plan are being achieved. Validation monitoring is to determine if the objectives are being met for the right reasons (based on the right assumptions).

Implementation monitoring for the BLM should answer two primary questions pertaining to Late-Successional Reserves from the Medford and Roseburg RMPs. A third item to monitor is included in the Medford RMP.

1. What activities were conducted or authorized within the LSR and how were they compatible with objectives of the LSR plan? Were activities consistent with SEIS ROD S&Gs, the LSR Assessment, and/or Medford RMP management direction, Roseburg RMP management direction, Umpqua

National Forest Plan S&Gs and REO review requirements?

2. What is the status of development and implementation of plans to eliminate or control non-native species which adversely impact late-successional objectives?

3. What land acquisitions occurred, or are under way to improve the area, distribution, and quality of Late-Successional Reserves?

Additional questions for the Roseburg District to address, due to the Tier 1 Key Watershed designation of the upper South Umpqua River would be those concerned with fish habitat. These items would include:

1. Are at-risk fish species and stocks being identified?

2. Are fish habitat restoration and enhancement activities being designed and implemented which contribute to attainment of Aquatic Conservation Strategy objectives?

3. Are potential adverse impacts to fish habitat and fish stocks being identified?

Effectiveness monitoring should determine how successfully projects or activities have achieved the objectives, goals, and/or desired future conditions in the LSR. Some key items to consider may include:

1. Is a functional, interacting, late-successional ecosystem maintained where adequate, and restored where inadequate?

2. Did silvicultural treatments benefit the creation and maintenance of late successional conditions?

3. What is the relationship between levels of management intervention and the health and maintenance of late-successional and old-growth ecosystems?

4. Are desired habitat conditions for the northern spotted owl and for other late-successional forest associated species maintained where adequate and restored where inadequate?

5. Are desired habitat conditions for listed, sensitive, and at-risk fish populations maintained where adequate or restored where inadequate?

6. Are landscape level recommendations being met?

7. Is the health of Riparian Reserves improving?

8. Are management actions designed to rehabilitate riparian reserves effective?

Indicators for assessing these conditions and trends include:

- land use data
- seral development across the LSR
- locations and concentrations of disease and insect infestations
- fuel amounts by category
- riparian and stream habitat condition by stream class
- water quality
- retention of snags and down woody debris

Validation monitoring assesses the accuracy of underlying management assumptions. Most validation and some effectiveness monitoring would be conducted through formal research. Existing research projects may be integrated to answer the validation monitoring question.

New information gained through research, other watershed assessments, or outside sources should be evaluated to determine whether changes or adjustments to recommendations should be made to this LSR assessment, including the monitoring plan. In addition, the Medford and Roseburg BLM RMPs are scheduled to be formally evaluated at the end of every third year after implementation of the RMPs begins, until the preparations of new plans that would supersede the RMPs begins. The formal evaluation of the RMPs is to determine whether there is significant cause for an amendment or revision of the plans. This evaluation and/or revisions to the plans may affect this LSR assessment, causing the need to revise this assessment. The LSR assessment may also need to be revised at other times when it has been determined that additional information is needed or that a change needs to be made concerning existing information.

Because this LSR crosses BLM district boundaries and involves two federal agencies, a periodic review should be conducted to evaluate management activities and future plans. This review should involve all three parties.

X. Data Gaps

Some data gaps were identified during this assessment which are important for long term management of this area. These data gaps include:

- an inventory of modified older stands to determine which stands may not be functioning as LSOG habitat,
- an analysis of block sizes for LSOG habitat and interior habitat blocks,
- stream habitat surveys for some streams that may need habitat improvement, and
- possible areas for land exchanges for consolidating ownership.

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