TFW Effectiveness Monitoring Report

ONION CREEK WATERSHED LARGE WOODY DEBRIS RECRUITMENT

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Abstract

A riparian survey was conducted in the Onion Creek Watershed, in Stevens County, Washington, to obtain baseline data and establish permanent plots that can be used to track future rates of large woody debris recruitment during "normal" years and episodic events.

A total of twelve permanent plots were established during summer of 1998 at three sites corresponding to mixed conifer, western redcedar, and mature western redcedar stands. Plots were 30 meters long and 50 meters wide centered on the creek. All three streams were small, (Type 3) with bankfull widths ranging from 2 to 3 meters. Average stream gradients ranged from 8% to 20%, and average site hillslopes ranged from 26% to 44%.

Standing wood, down wood, and instream wood were measured at each plot. Over 1250 standing trees and instream wood were marked with aluminum tags for future reference. Various information such as tree height, dbh, species, condition, and lean azimuth was recorded for standing trees. The size of down wood (pieces and trees with rootwads) was also recorded, along with the location and fall direction of trees. Instream wood was characterized and counted as well.

Overall, trees were predominantly western redcedar (60%), Grand fir, and western hemlock (fir and hemlock together making up 24%). Average stand densities ranged from 825 to 1055 stems/ha. The majority of the trees were small (<30cm dbh), with the greatest number of large trees in the mature redcedar stand. On average, the tallest trees were also located in the mature redcedar stand. Eight to 12% of the trees at a stand were either stressed or snags. Twelve to 20% of the trees in a stand were leaning, with 2% more leaning toward the creek than away. Trees were generally well distributed throughout the plots. The western redcedar stand had the most trees close to the creek; the mature redcedar had the most trees farther up the hillslope.

The most common species of down wood was western redcedar. There were about twice as many down pieces of wood than down trees with rootwads. The mixed conifer stand had the most down wood. Most of the down wood was small (<30 cm) in diameter and between 5 and 15 meters long. The down trees with rootwads were more decayed than the individual pieces. Most of the trees that fell originated away from the creek, between 10 and 20 meters slope distance. Of the down wood, 11% was recruited to bankfull, 7% was spanning, and 20% was suspended over the stream channels (however, much of this suspended wood was found in just two of the twelve plots).

Most instream wood was very small (<20 cm diameter). Accounting for all wood in the channel (bankfull, spanning, or suspended), recruitment was 1 piece/bankfull width. Most of these pieces were < 5 meters long. Almost all of the wood functioning to form pools was small or medium sized; most was small. The mixed conifer stand had the most wood recruited to the bankfull channel (1.1 pieces/bankfull width), and the redcedar stands had less than half that amount (0.30-0.45 pieces/bankfull width). No debris jams were found in the study plots.

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I. Introduction

I.A. Problem Statement

The capability to identify the density and size of trees needed in riparian areas to assure sufficient long-term recruitment of wood into stream channels is extremely important for developing riparian management objectives that are adequate to protect fish habitat. Currently, knowledge about all the recruitment mechanisms is incomplete. There is some limited information available on the loss of trees resulting from outbreaks of disease and pestilence. The Forest Service is currently gathering information on wood recruitment associated with the 1994 tires in Idaho. However, information on recruitment due to storm events is virtually non-existent. This monitoring program provides an opportunity to refine the understanding of wood recruitment processes.

I.B. Backaround

Wood is recruited to streams through a variety of mechanisms. One mechanism is through suppression, where smaller trees lose the battle with larger trees for nutrients and light. These trees die and typically fall. If they are close enough to a stream, they may recruit to the stream. This mechanism however, is unlikely to recruit large diameter wood to streams but may recruit sufficient wood to channels where small pieces are functional. Larger trees that grow old and die typically remain standing and decay in place, providing valuable wildlife habitat but little wood in streams. Recruitment of larger wood to streams is more likely to occur as a result of catastrophic events such as tire, wind storm, flood, ice storms, and outbreaks of pestilence or disease. Hence, recruitment of larger wood is expected to be an episodic process, much like mass wasting, occurring primarily during extreme or unusual events.

The ability to evaluate the adequacy of various riparian management strategies would be greatly enhanced if the rate at which these various recruitment mechanisms occurred was known. Many have proposed to evaluate the effectiveness of management strategies by monitoring before and after treatment situations or paired situations to compare recruitment rates. Due to the great deal of variability that the episodic nature of recruitment imparts to wood recruitment, before and after treatment situations are virtually impossible to control and require many years of before and after treatment data to adequately account for that variability. Paired studies have a greater probability of success since sites can be selected to assure identical weather conditions, Nevertheless, it will take decades of monitoring to characterize long term differences between treatments, during which time stand conditions will change dramatically, adding another complicating factor to the study which is difficult to control.

An alternate approach is to try to capture the recruitment rates out of various stand types and densities during “normal” years and episodic events. This information could then be used in conjunction with growth and yield models and probability of direction of fall approaches to estimate or model the total recruitment of wood over time to streams under various management approaches. Such an approach has the potential to help us arrive at answers regarding the adequacy of riparian management strategies much more quickly than a long-term monitoring program. Of course, a decade of uneventful years will hinder attempts to attain needed information in a timely fashion. Smaller magnitude events may, however, provide some insight regarding recruitment in huger events,

I.C. Characterization of the Onion Creek Watershed

In 1997, a Watershed Analysis was conducted in the Onion Creek WAU which provided an assessment of watershed conditions and established prescriptions for forest practices on state and private land (Raines et al., 1997).

The Onion Creek watershed is in many ways typical of northeast Washington. The basin lies within the range of the continental glaciers and drains into Lake Roosevelt on the Columbia River (Figure 1). Average annual precipitation is approximately 25 inches, most of which falls as snow. Peak runoff occurs during the spring snowmelt period. The topography of the basin is gently rolling with few steep slopes, however a 90 foot waterfall is present near the mouth of the creek, separating most of the basin's fish populations from Lake Roosevelt.

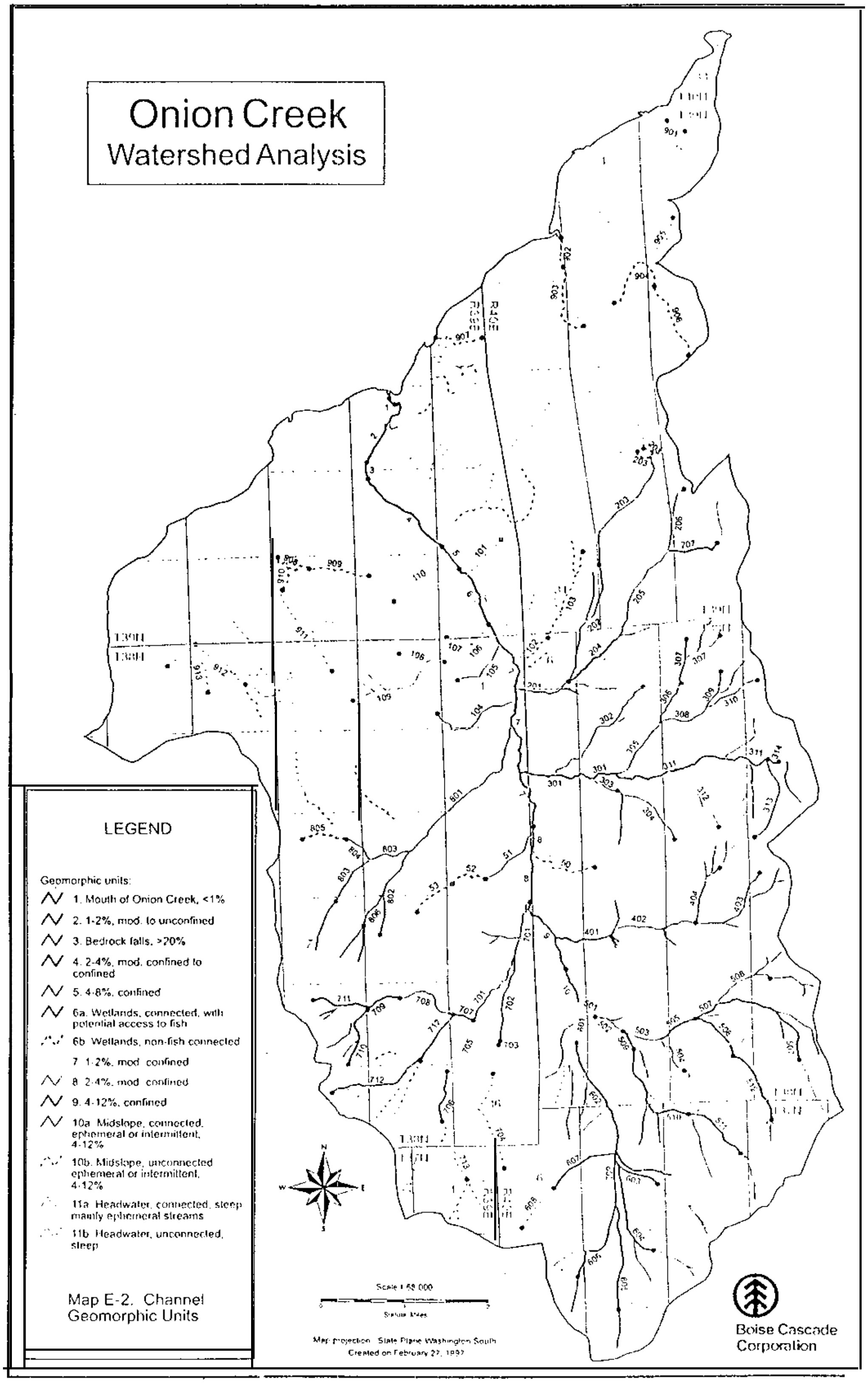
The dominant fish species in the basin is brook trout. Cutthroat are also present in portions of the basin. Bull trout, which reside in Lake Roosevelt, make limited use of the lower portion of the creek for spawning. That portion of the stream, however, has been highly modified; little good quality habitat is available.

The basin geology is dominated by highly weathered glaciated granitics. There are exposures of slate and other sedimentary rock formations intermingled with the granitics as a result of folding and erosion which surfaced the layers of rock laid down when the area was still oceanic. The area is near the southern terminus of the continental glaciers, hence, pockets of unconsolidated glacial deposits are scattered across the basin.

The area near the mouth of the stream was covered for a time by the old glacial Lake Columbia. In this area, there are extremely deep deposits of unconsolidated material, Water in this portion of the basin tends to go subsurface and several streams disappear altogether in this material. The water in these streams is presumed to enter Lake Roosevelt below the water line. Although Onion Creek drains approximately 37,000 acres, the summer low flow at the mouth is only 4 cubic feet per second. The stream is presumed to lose some amount of flow as it passes through the lake deposits although measurements taken in the basin during the Watershed Analysis did not identify any significant flow reduction in this area.

Many of the headwater streams in the basin also are dry most of the year. These headwater areas flow primarily during snowmelt and are dry once the snow is gone. In winter they are dry or frozen,

Figure 1. Location of the Onion Creek Watershed



Landslides are rare in the basin, occurring primarily in the glacial lake deposits on oversteep slopes. There have been no debris slides identified in the period of photo record, therefore, debris slides are not a significant recruitment mechanism. There have been at least two blowouts of mine tailings since 1960 that had significant effects on channel condition.

As the previous discussion might suggest, stream power in the basin is relatively low. Very small wood (< 20 cm dbh) functions well in many of the tributaries and branch size pieces function in the headwaters.

The dominant vegetation type in the basin is ponderosa pine. Stands of fir and Douglas fir are also present in some areas and mature cedar is found along portions of the lower mainstem. The upper portion of the basin is managed as commercial forest. The lower portion of the basin is in primarily large lot rural residential development. There is a small area of agricultural use near the mouth of the stream. Such multi-use basins are common in this portion of the state.

Most of the riparian areas in the Onion Creek basin can be characterized as part of the Western Hemlock/Cedar vegetation zone (Henderson et al 1989, 1992). Western redcedar/queen cup beadlily (THPL/CLUN) and cedar/ladyfern (THPL/ATFI) as characterized in Williams et al. (1995) are typical of the moist riparian sites along the mainstem Onion Creek. In addition to redcedar, these areas also contain western larch and Douglas fir with pockets of grand fir and Engelmann spruce. Paper birch, quaking aspen, and black cottonwood are also peppered throughout the mixed redcedar stands along the mainstem.

Western redcedar is also common along the major tributary drainages where soils are wet. Hemlock plant associations mostly occur on slopes adjacent to confined channels where drainage is good. In the upper Onion Creek sub-basin and the Van Stone Mine sub-basin, western larch and lodgepole pine are common in the riparian area.

The width of the riparian area from which trees can be recruited to the channel is wider than the true riparian vegetation zone; hence much of the potential recruitment is from stands best characterized as upland forest, Along the smaller tributaries, the width of the true riparian vegetation zone is very narrow and upland species are the primary species available for recruitment.

II. Project Description

In 1998, a monitoring project was initiated in the Onion Creek Watershed to help determine LWD recruitment rates during normal periods and episodic events. In the first phase of the project, which is described in this report, an inventory of existing riparian stands and instream wood was conducted to provide baseline data for tracking future changes. Funds provided by the TFW Monitoring Advisory Group, Northwest Indian Fisheries Commission (NWIFC), and Boise Cascade Corporation were utilized for establishing the plots and conducting the initial survey.

Boise Cascade Corporation will strive to find additional funding sources to continue the monitoring annually and following major disturbance events for a period of at least five years. At a minimum, the permanent plots will be revisited at least once during the five year review of the watershed analysis. The ability to capture episodic information will be contingent on the occurrence of such events. If no such events occur during the period of monitoring, there will be an opportunity to get improved information on recruitment during "normal" years as a function of stand type, slope, and density.

II.A. Goal and Objectives

The Onion Creek effectiveness monitoring project is designed to address the following general goal and objectives (Smith and Schuett-Hames, 1998), as well as project specific objectives.

General Goal

> ***To support adaptive management by evaluating the effectiveness of individual riparian forest practices and restoration measures in providing adequate levels of LWD and associatedfunctions on a site scale.***

General Objectives

> ***To improve interpretation of monitoring results by collecting regional data on tree growth, tree mortality, and L WD recruitment processes in riparian stands, and on the persistence, routing, andfunction of LWD in stream channels.***

Specific Project Objectives

- To establish permanent plots and collect baseline data that can be used to track future changes in LWD recruitment in order to:

    1. refine our understanding of wood recruitment for use in growth and yield models and probability of fall approaches used to estimate the recruitment over time,
    2. capture recruitment rates during normal years and episodic events as a function of stand type, slope, and density, and

3. address persistence of recruited wood in streams and the portion of wood recruitment that functions to form pools.

II.B. Monitoring Questions

1. ***Characterization***: What are the current characteristics of riparian stands and levels of LWD?
2. ***Tree fall rates***: What is the rate of tree fall during "normal" periods as a function of slope, stand type, and density? What is the rate of tree fall during various types of storm events (assuming they occur)?
3. ***Fall*** direction: What is the distribution of tree fall direction? Is the distribution different for trees rooted in the bank than for trees further from the stream? How does slope affect the distribution? How does the lean of a tree factor into the direction of fall?
4. *Functionality of recruited* wood: How do wood and stream size affect functionality?

This report summarizes the work completed in 1998 to establish riparian monitoring plots in the Onion Creek Watershed. The results of this work and the contents of this report characterize current stand conditions. Follow-up monitoring is needed before other questions can be answered.

III. Study Design

III.A. Introduction

The study design was based on riparian stand survey methods developed to monitor the effectiveness of riparian forest practices on a site scale as part of the TFW Effectiveness Monitoring and Evaluation Program (Smith, 1998). These methods were used to characterize timber stands and the current level of LWD recruitment.

III.B. Site Location

The Onion Creek Watershed is located in Stevens County in northeastern Washington, near the town of Northport (Figure 1). The Onion Creek Watershed (WAU 610105) is in Water Resource Inventory Area (WRIA) 61.

Study sites were located *along* stream segments that were assigned segment numbers during the Onion Creek Watershed Analysis (Raines, et al. 1997). The study sites, identified by stream segment numbers, can be located using the information provided below.

Table 1. Location of study sites in the Onion Creek Watershed

WAU #	*Site Description (stand type)*	*Stream Segment #*	*USGS Quadrangle Name*	*Location*	*¼ Section of Upstream Boundary*
610105	mixed conifer	602	Gillette Mtn.	T. 37 N., R. 40 E.	S. 5, NE ¼ of SW ¼
610105	western redcedar	512	Onion Creek	T. 38 N., R. 40 E.	s. 34, SW ¼ of SW ¼
610105	mature western redcedar	511	Gillette Mtn.	T. 37 N., R. 40 E.	S. 4, SE ¼ of NE ¼

IILC. Site Selection

All study sites were located on Boise Cascade property to ensure adequate plot protection and long-term accessibility for monitoring purposes. Sites were selected on Type 3 streams in areas containing mixed conifer, western redcedar, and mature western redcedar stands. The mature redcedar stand was known to contain older and larger trees than the redcedar stand. A western larch/Douglas-fir stand was also selected, it but could not be surveyed because of safety concerns.

A Boise Cascade forester utilized existing information about stand types, hillslopes, channel confinement, stand density, tree size, and local knowledge about access to select study sites. Limiting site selection to Type 3 streams on Boise Cascade property greatly reduced the pool of potential sites. Sites were selected to contain a range of hillslope gradients and stand densities to the extent possible; however, most of Boise's property is in the upper portion of the watershed, and streams there are generally small, steep, and confined.

III.D. Stream Information

Stream Segment 602 was in the upper reach of Onion Creek, and Segments 5 12 and 5 11 were tributaries to Onion Creek. These creeks were relatively small. Stream Segment 602 was the largest with an average bankfull width of almost 3 meters. The average flow in this segment was 4 cubic feet per second (cfs) in 1998, ranging from a high of 14 cfs and a low of 0.4 cfs. Segments 512 and 511 were smaller than segment 602; the average bankfull width was 2 meters at each. Plow measurements are not available for these two segments.

As characterized in the Onion Creek Watershed Analysis (Raines et al., 1997), the redcedar sites were located in stream segments characterized by relatively steep slopes (8-20%) and the mixed conifer stand had moderately steep slopes (4-8%). All three stream segments had confined channels. The average stream gradient was least in Segment 602 (8%) and greatest in Segment 5 11 (20%).

Table 2. Stream gradient and bankfull width at riparian plots in the Onion Creek Watershed

Segment 602 mixed conifer			*Segment 512 western redcedar*			*Segment 511 mature redcedar*		
Plot #	Stream Gradient (%)	Bankfull Width (m)	Plot #	stream Gradient (%)	Bankfull Width (m)	Plot #	Stream Gradient (%)	Bankfull Width (m)
2	10	3.2	2	21	2.1	0	12	1.6
6	5	2.8	6	10	1.5	1	16	1.9
10	9	2.7	10	12	2.2	5	27	2.4
13	8	2.8	13	13	2.1	9	24	2.0
Avg.	8	2.9	*Avg*	14	2.0	*Avg*	20	2.0

III.E. Plot Location

Thirty meter horizontal transects were marked following the direction of the stream in each stream segment. One of the first four upstream transects was selected randomly for survey, with subsequent transects selected every fourth transect after that. Plots were established at the mixed conifer site first, followed by the western redcedar and mature redcedar sites, respectively.

According to the original study design, four sites (or segments) were to be surveyed; however, the fourth site could not be surveyed for safety reasons. One plot was added to each of the existing segments after three plots had already been surveyed. Plots were not all equidistant within a segment for a combination of reasons, including the modification from four sites to three.

Particular information about plot locations within each segment is provided below:

Segment 602 An existing forest road was located in the upper portion of the site. A 30 meter unnumbered buffer was placed on each side of the road.

Segment 512 -The distance available for plot establishment was limited by a forest road upstream of the first plot (a 60 meter buffer was used to avoid the road) and a property line at the downstream end of the site.

Segment 511 – Plot establishment was complicated by the presence of a forest road and harvested area upstream and flagging for road construction near the middle of the site. A 160 meter buffer was created to allow for future road construction without interference with plots.

III.F. Plot Establishment

Plot boundary lines were established 25 meters perpendicular to transect lines on both sides of the stream. Resulting plots were 30 meters long and approximately 50 meters wide. Facing downstream, 30 x 25 meter right bank (RB) and left bank (LB) subplots were also delineated within each plot. The length of plot boundary lines varied slightly due to variations in hillslope, so the plot areas also differ somewhat. Hillslopes were calculated using a weighted average of slopes for each slope-break, with the floodplain excluded from calculations if the gradient of the first slope-break was <10%.

Table 3. Descriptive information for riparian plots in the Onion Creek Watershed

Segment #	*Plot #*	*Distance From Boundary* (m)*	*Subplot (RB, LB)*	*Hillslope (%)*	*Aspect*	*Plot Area (square meters)*
602	2	30	RB	36	W-NW	758
			LB	54	E-SE	720
602	6	240	RB	27	W	738
			LB	34	E	752
602	10	360	RB	31	W	746
			LB	55	E	744
602	13	450	RB	27	W	756
			LB	47	E	753
512	2	30	RB	31	W	723
			LB	42	E	744
512	6	150	RB	9	W-SW	752
			LB	29	E-NE	752
512	10	270	RB	33	SW	734
			LB	30	NE	782

*Distance from the upstream segment boundary to the upstream plot boundaries

Table 3. Continued

Segment #	Plot #	Distance From Boundary* (m)	Subplot (RB, LB)	Hillslope (%)	Aspect	Plot Area (square meters)
512	13	360	RB	11	W-SW	749
			LB	23	E-NE	749
511	0	0	RB	41	SW	734
			LB	46	NE	752
511	1	30	RB	46	SW	747
			LB	52	NE	749
511	5	310	RB	29	SW	761
			LB	43	NE	756
511	9	430	RB	47	S-SW	729
			LB	53	N-NE	755

*Distance from the upstream segment boundary to the upstream plot boundaries

The outside corners of each plot were permanently marked with rebar, and witness trees were marked at each plot. Witness tree information is provided in the database provided to NWIFC.

III.G. Methods

The following sections provide a brief description of monitoring methods used in this study. Detailed study methods can be found in the project monitoring plan (Schumaker et al., 1998).

III.G.1. *Standing Trees*

In each plot, survey information was collected for all standing trees ≥10 cm dbh and snags (≥10 cm dbh, ≥2 m tall, and standing ≥45° from the ground). Survey information included tree height, dbh, tree species, distance from the creek, condition, lean angle, and lean azimuth.

Over 1250 standing trees were tagged during the survey using aluminum tags nailed below chainsaw height on the side of the tree facing the stream. Using the hundredths place on the tag number, even numbered tags were used on the right bank subplots, and odd numbered tags were used on the left bank subplots; for example, #459 and #1473 are on a right bank; #329 and #1328 are on a left bank.

III.G.2. *Down Wood*

Two categories of down wood (<45° from the ground) were surveyed: trees with attached rootwads and individual broken pieces. Down trees with attached rootwads were included if more than 50% of the rootwad was in the plot, the length from the base of the tree to the top was at least 2 m, and its dbh was at least 10 cm. Individual broken pieces of trees were included if the midpoint of the piece was in the plot, the length of the piece was at least 2 m, and the diameter at the midpoint was at least 10 cm. When down trees or pieces reached or spanned the stream channel, Large Woody Debris (LWD) information was also collected and cross referenced by tree number. Survey information included decay class, diameter at the midpoint of pieces and base of trees, tree species, and recruitment to the bankfull channel.

III.G.3. *Instream Wood*

All pieces of wood in the stream greater than 2 m long and 10 cm diameter, measured at the middle of the piece, were inventoried (Schuett-Hames et al., 1994). Those pieces that extend up onto the bank of the stream were noted in the downed wood survey and also in the instream wood counts.

III.G.4. *Quality Assurance*

To ensure collection of consistently high quality field measurements, field crews were subject to unannounced inspections. An inspector was provided by Boise Cascade Corporation. The inspector periodically checked measurements taken by field crews and compared them to his/hers as a measure of accuracy. Field crews also periodically took duplicate measurements to document their precision. Data were within the following tolerances for average accuracy and precision:

Table 4. Quality of data collected during the survey in the Onion Creek Watershed

Measurement	*Tolerance ±*
Tree height	5% of height
Azimuth	2°
dbh	2 cm
Length	*0.3* m
Tree species	<5% error
Slopes	5%

The target guideline values are based on tolerances used in DNR's Forest Resource Inventory System (Washington State DNR, 1996) and recommendations from NWIFC and Boise Cascade Corporation. These values are believed to be adequate to meet the objectives of this study.

IV. Survey Results

This portion of the report summarizes site characterization information for standing, down, and instream wood. Results from the survey of standing wood are presented by stream segment/stand type, and characterization information is provided for each subplot. Subplots are not characterized individually for down wood and instream wood; instead, histograms are used to characterize results from all plots combined.

IV.A. Standing Trees

The following section summarizes the density, species composition, size, condition, height, lean, and distance from the stream information for standing trees in the Onion Creek riparian plots.

IV.A.1. *Density*

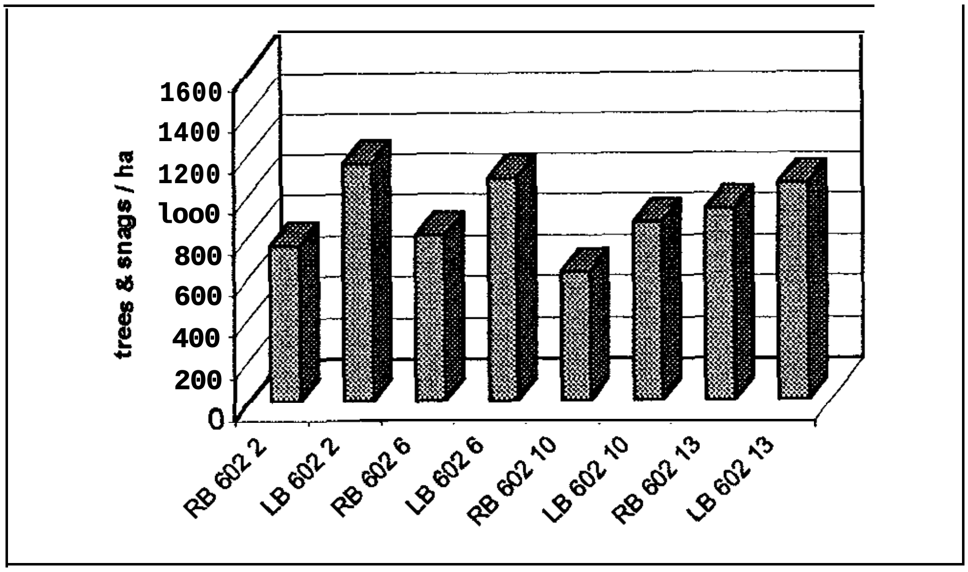
The density of standing trees (live trees and snags) ranged from 300 stems/ha to almost 1400 stems/ha within a subplot. Densities of 600 to 1000 stems/ha were most common. The western redcedar stand had the greatest density, and the mature redcedar stand had the lowest density.

Table 5. Stand density (stems per hectare) at three study sites in the Onion Creek Watershed

Stand	*Mixed conifer*	*Western redcedar*	*Mature redcedar*
Mean Density (standard deviation)	904 (182)	1055 (196)	826 (286)

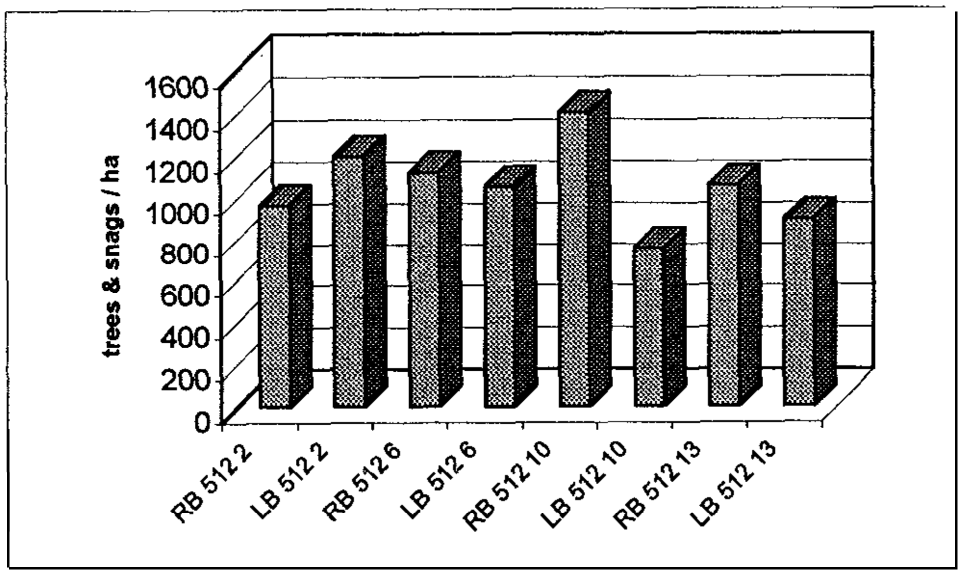
Of the three stands surveyed, the mixed conifer stand had an intermediate density of standing trees; densities ranged between 600 stems/ha and 1100 stems/ha. Left bank subplots had greater tree densities than right bank subplots in this stream segment.

Figure 2. Density of standing trees (live trees & snags) in mired conifer subplots



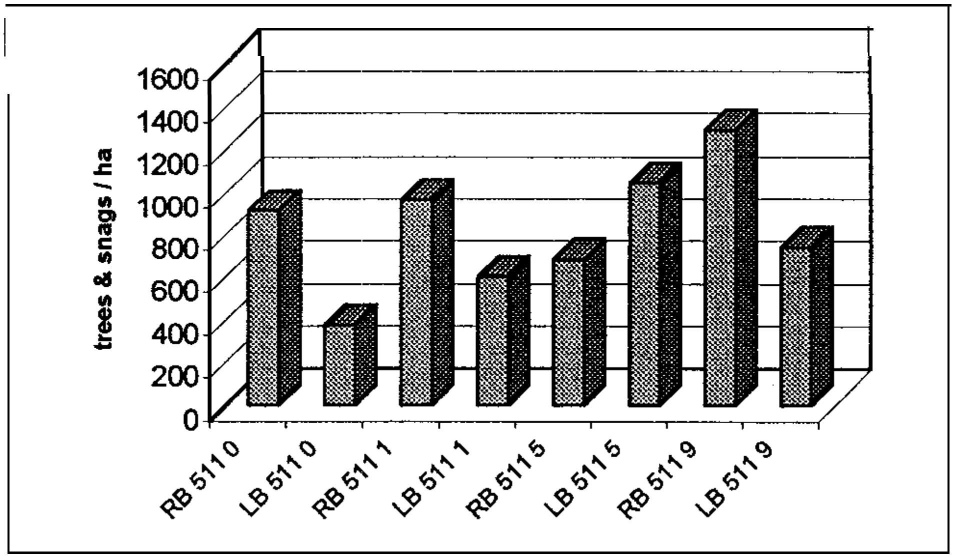
The density of standing trees in the western redcedar stand ranged fiom 700 stems/ha to over 1300 stems/ha, with all but one subplot over 800 stems/ha.

Figure 3. Density of standing trees (live trees & snags) in western redcedar subplots



The mature redcedar stand had the lowest tree density. Subplot densities ranged from 300 stems/ha to over 1200 stems/ha, with half of the subplots near or less than 600 stems/ha. This site also had the greatest variability in densities between subplots.

Figure 4. Density of standing trees (live trees & snags) in mature redcedar subplots



IV.A.2. *Species Composition*

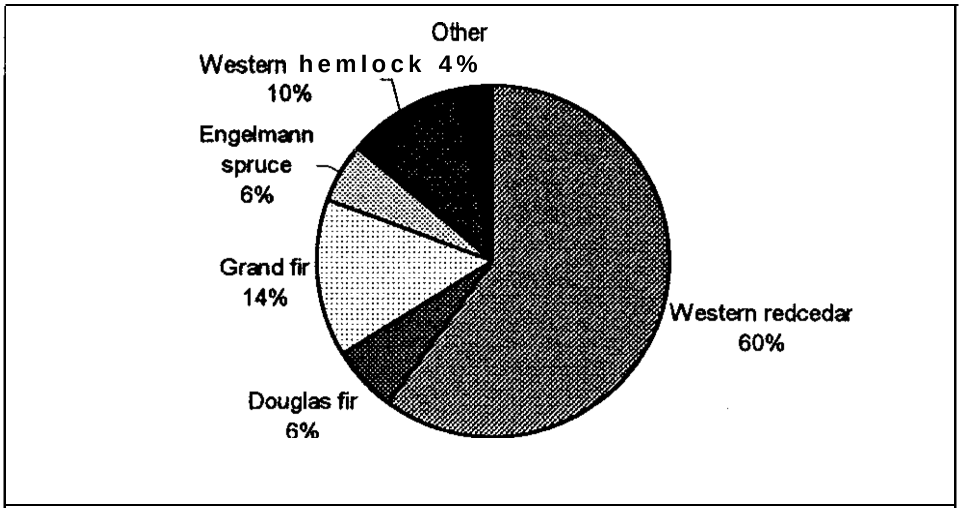
Most of the plots surveyed were predominantly comprised of western redcedar. The most common species were western redcedar, western hemlock, grand fir, Douglas-fir, and Engelmann spruce. Other species included western white pine, western larch, lodgepole pine, and subalpine fir. Each stand generally reflected the expectations of species composition when sites were selected.

Table 6. Species composition of three riparian stands in the Onion Creek Watershed

Type	*Mixed Conifer*	*Western redcedar*	*Mature redcedar*
Western redcedar	51%	63%	66%
Grand fir	9%	25%	10%
Western hemlock	22%	2%	6%
Douglas fir	7%	4%	6%
Engelmann spruce	4%	4%	9%
Others	7%	2%	3%

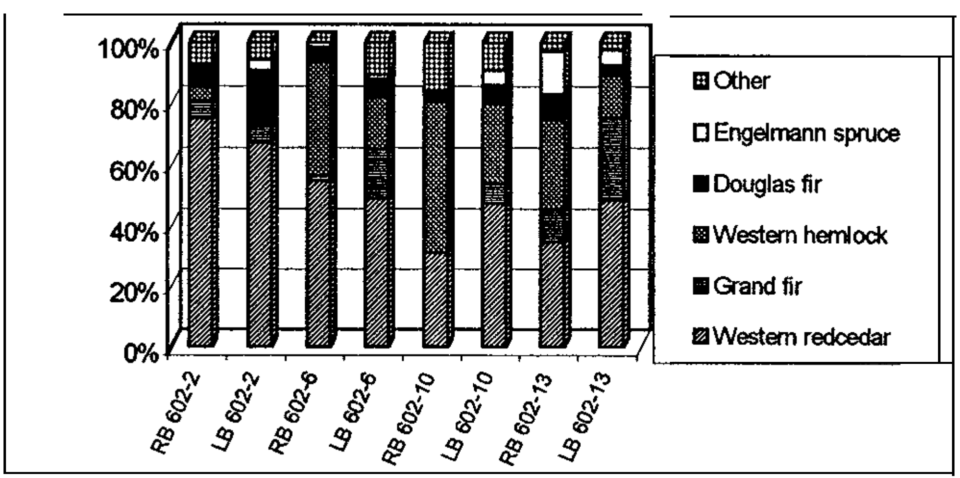
When considering all the plots surveyed in this study, 84 percent of the trees were comprised of western redcedar (60%), grand fir (14%) and western hemlock (10%).

Figure 5. Species composition of all trees surveyed in the Onion Creek Watershed



Plots in the mixed conifer stand, stream Segment 602, were predominantly comprised of western redcedar and western hemlock. Over 60% of the trees in plot 2 were western redcedar. Plots 6, 10, and 13 had subplots generally having 20% to 50% hemlock. The mixed conifer stand had the greatest proportion of species other than redcedar compared to the western redcedar stands.

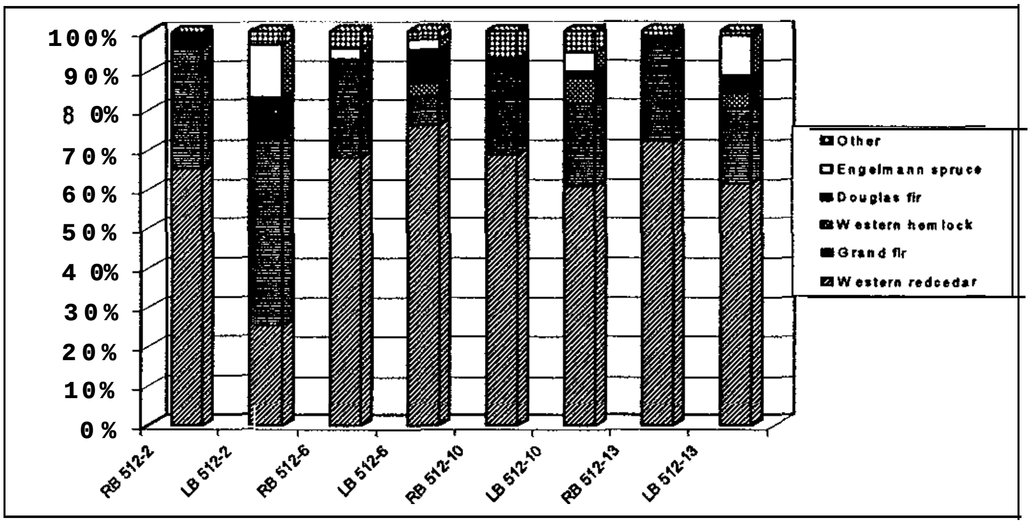
Figure 6. Species composition of mired conifer stand subplots



Plots in the western redcedar stand, 512, were predominantly comprised of western redcedar and grand fir. Western redcedar generally made up 60% of the trees and grand fir about 25%. Plot 5 12-2 was an exception, having the lowest proportion of redcedar of all subplots (approximately 20%).

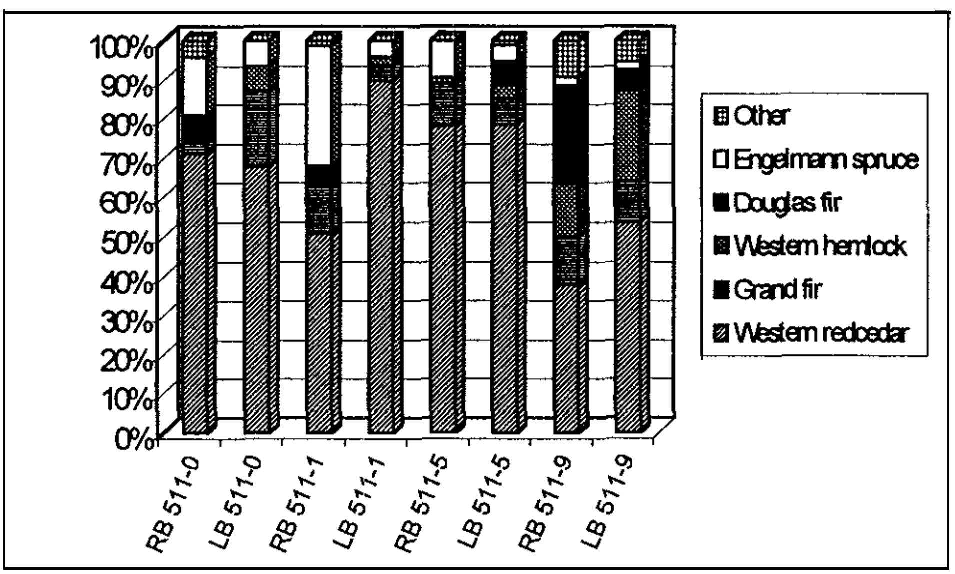
Plots in the western redcedar stand, 512, were predominantly comprised of western redcedar and grand fir. Western redcedar generally made up 60% of the trees and grand fir about 25%. Plot 512-2 was an exception, having the lowest proportion of redcedar of all subplots (approximately 20%).

Figure 7. Species composition of each western redcedar stand subplots



Plots in the mature redcedar stand were predominantly redcedar, with a smaller proportion of Engelmann spruce, grand fir, Douglas-fir, and western hemlock included, depending on the plot. The greatest proportion of Engelmann spruce and western hemlock was in plots 1 and 9, respectively.

Figure 8. Species composition of mature redcedar stand subplots



I.V.A.3. Tree Size (dbh)

Tree sizes are characterized below using tables and histograms to describe the size distribution. Tree size is characterized by the following classes based on dbh: small (<30cm), medium (30-50 cm), and large (>50 cm).

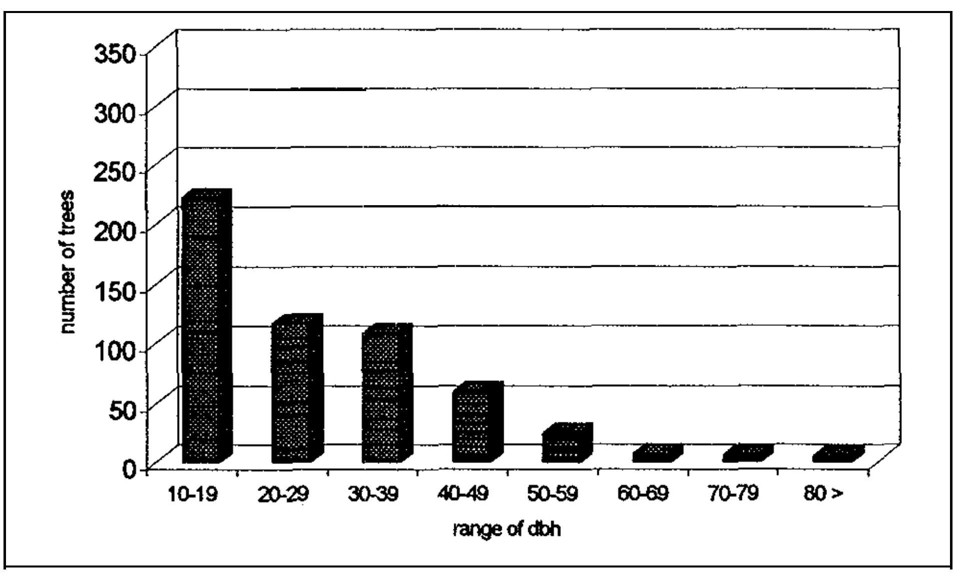
The greatest number of trees were small (70%), with a successively decreasing abundance as size class increases. Most trees had a dbh between 10 and 20 cm As expected, the mature redcedar stand had the most large trees.

Table 7. Tree size, by diameter class, for each stand type The number of trees in each class is given in parentheses

Size Class	*Small*		*Medium*			*Large*		
dbh (cm)	***10-19***	***20-29***	***30-39***	***40-49***	***50-59***	***60-69***	***70-79***	***>80***
Mixed ***Conifer***	41% (221)	21% (116)	20% (107)	11% (59)	4% (24)	1% (6)	1% (5)	1% (4)
Western redcedar	54% (340)	25% (156)	11% (68)	5% (29)	1% (8)	1% (7)	1% (9)	2% (13)
Mature Redcedar	45% (220)	22% (106)	11% (55)	8% (37)	4% (18)	3% (13)	3% (17)	5% (27)
Average for all stands	70%		21%			9%		

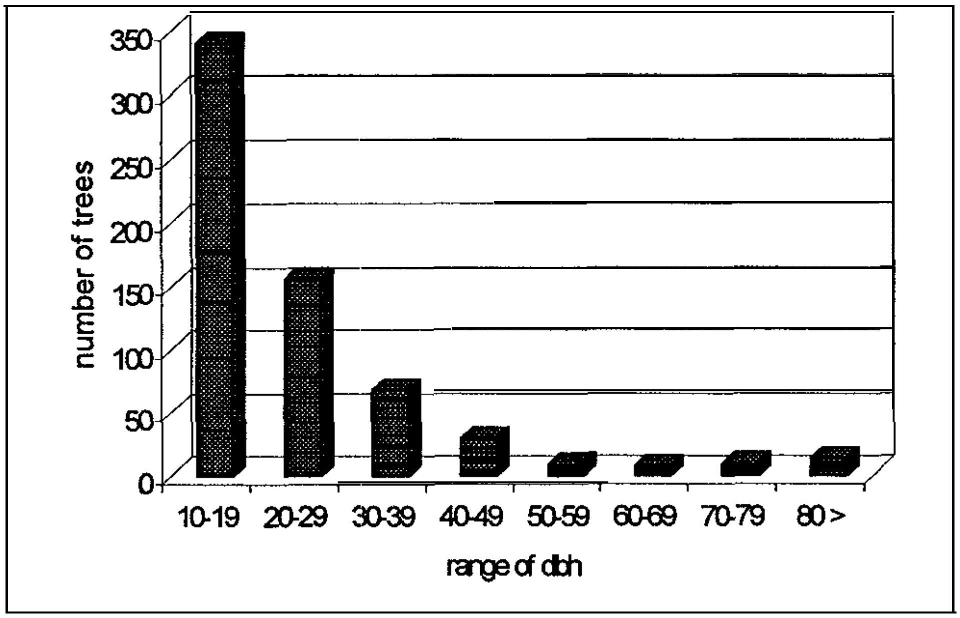
The mixed conifer stand had an intermediate number of large trees. About 62% of the trees were small. This segment had the greatest number of medium trees in the 30-39 cm range, this was twice as many as in other segments

Figure 9. Sii distribution of trees in the mired conifer stand.



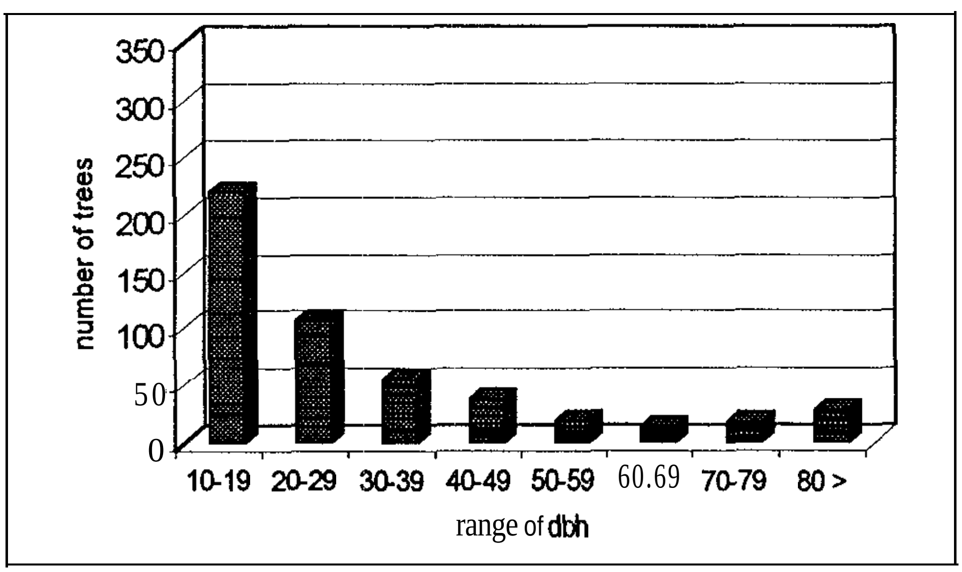
The western redcedar stand had the fewest large trees compared to other segments. This stand had the greatest proportion of small trees (79%) and the most small trees.

Figure 10. Size distribution of trees in the western redcedar stand



The mature redcedar stand had the greatest number and proportion of large trees. The proportion of small trees at this site (67%) was similar to that of the mixed conifer stand.

Figure 11. Sii distribution of trees in the mature redcedar stand



I.V.A.4. *Condition*

The condition of standing trees is summarized by the number and percent of snags and stressed trees. The most snags were located in the mixed conifer and mature **redcedar** stands, generally between 5 and 14 per subplot. Overall, the greatest number of stressed trees was located in the mixed conifer stand, although the subplots with the most stressed trees were located in the western **redcedar** stands. There were generally more snags than stressed trees.

Table 8. Tree condition by stand type

Stand	*Stressed trees*	*Snags*
Mixed Conifer	4% (41)	8% (71)
Western redcedar	**3% (32)**	**3% (32)**
Mature redcedar	4% (37)	7% **(64)**

Figure 12 Number of snags and stressed trees in tbe mixed conifer stand subplots

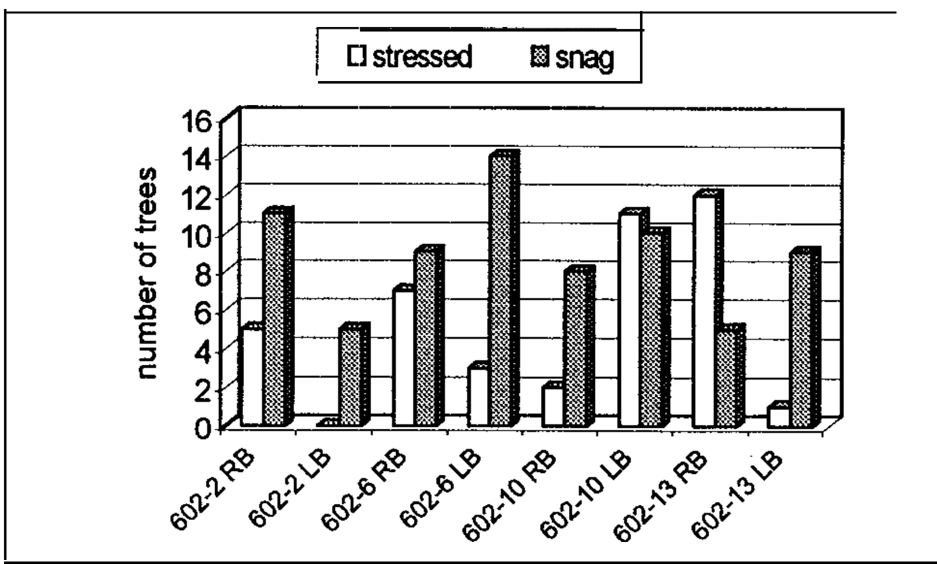


Figure 13. Number of snags and stressed trees in the western redcedar stand subplots

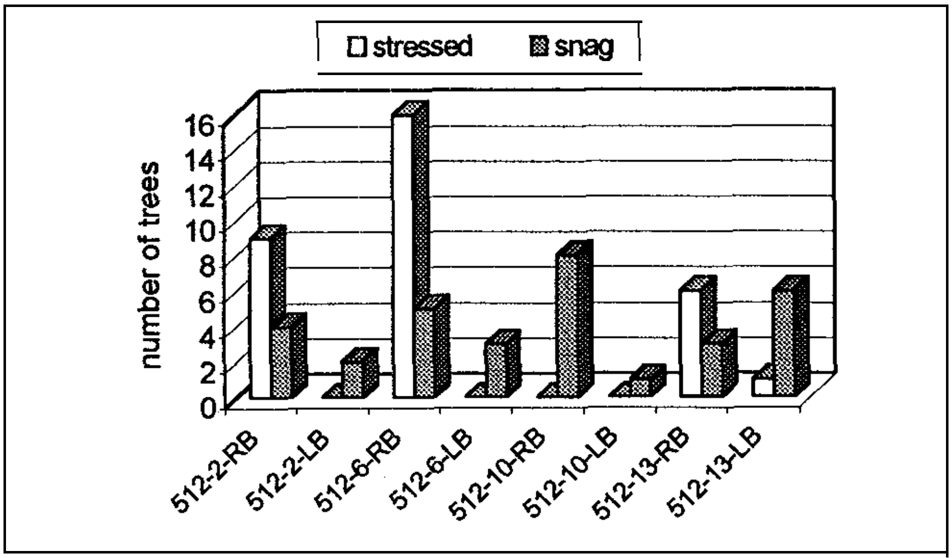
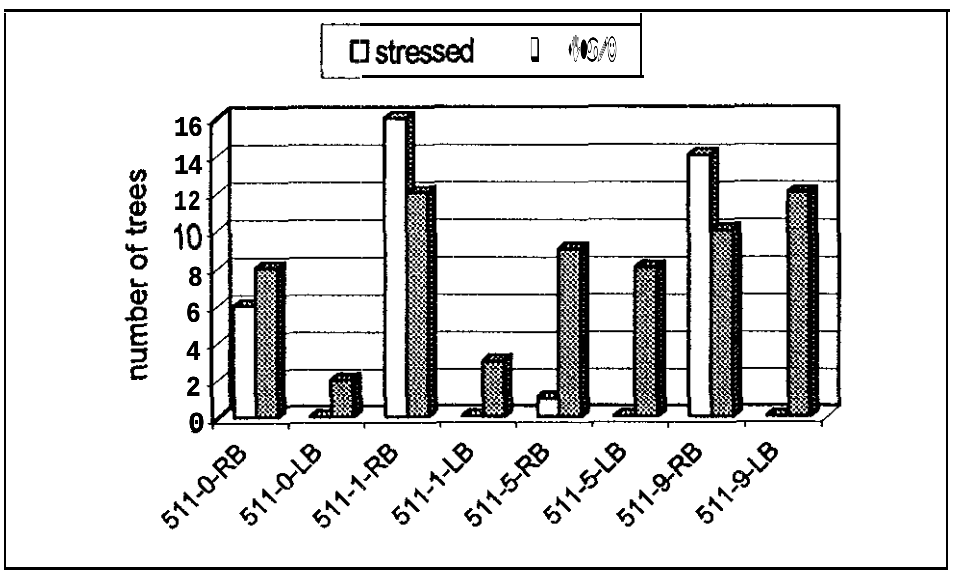


Figure 14. Number of snags and stressed trees in the mature redcedar stand subplots



I.V.A.5. *Tree Height*

Tree height was measured on 20% of the live standing trees in each subplot. The average tree height at a subplot was generally between 15 and 25 meters, Average tree height was the greatest in the mature redcedar stand, with most plots averaging 20 to 25 meters. This stand also has the greatest variability between subplots. The mixed conifer stand tree heights averaged 20.2 meters, ranging from 17 to 21 meters. Tree heights were very similar between subplots in the western redcedar stand.

Table 9. Average tree height at riparian stands in tbe Onion Creek Watershed

	Mixed conifer	*Western redcedar*	*Mature western redcedar*
Average Tree Height (m)	20.2	17.1	21.6

Figure 15. Average tree height at mixed conifer stand subplots

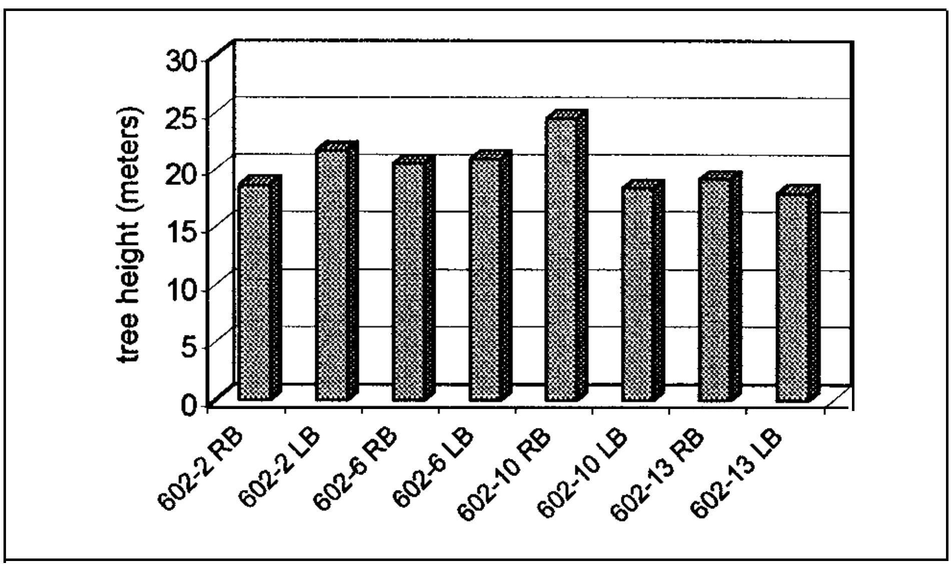


Figure 16. Average tree height at western redcedar subplots

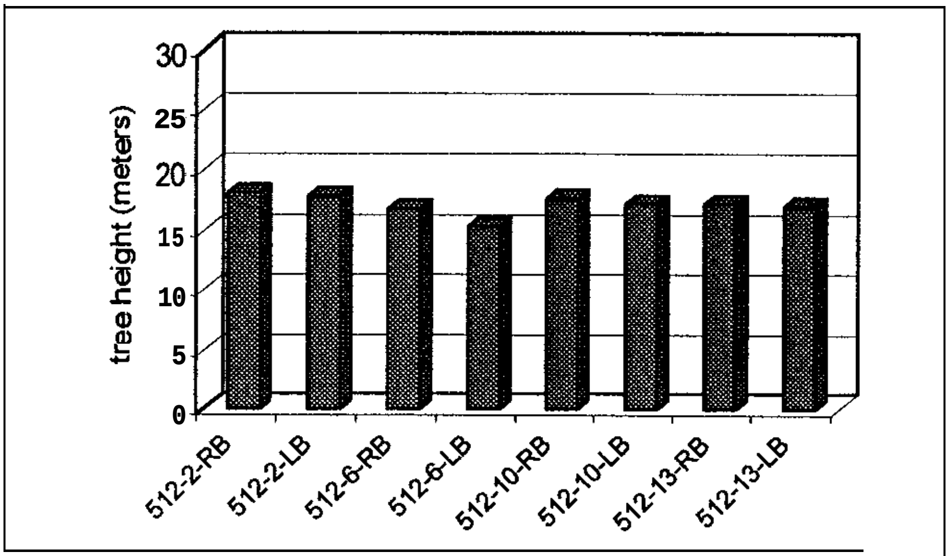
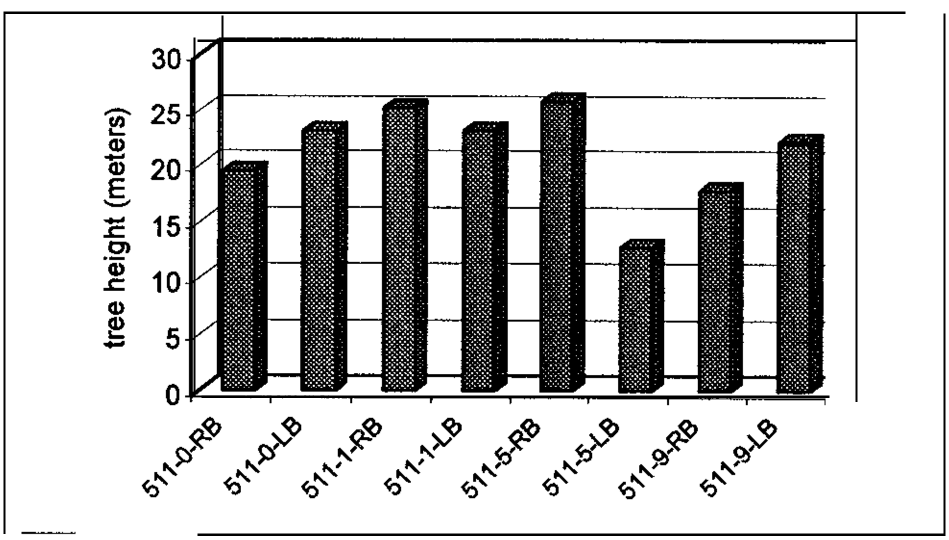


Figure 17. Average tree height at mature redcedar subplots



IV.A.6. *Leaning Trees*

Lean angle was determined by the angle formed between the top of the tree and its base. Trees in the mixed conifer plots had the greatest average lean angle, ranging from 10% to 22%. Average lean angles were similar in the western redcedar and mature redcedar plots, ranging from 7% to 13%.

Table 10. Percent of trees leaning away from and toward the creek at each riparian stand

Trees Leaning	*Mixed conifer*	*Western redcedar*	*Mature redcedar*
Toward *Creek*	8%	7%	11%
Away from *creek*	6%	5%	9%
Not leaning	86%	88%	80%

Between 12% and 20% of the standing trees were leaning at each stand. Slightly more trees were leaning toward the creek than away in each stand. Almost every plot had at least three trees leaning toward the creek and generally less than eight. The greatest number of leaning trees was located in the mature redcedar stand.

Figure 18. Number of trees leaning toward and away from the creek in the mixed conifer stand

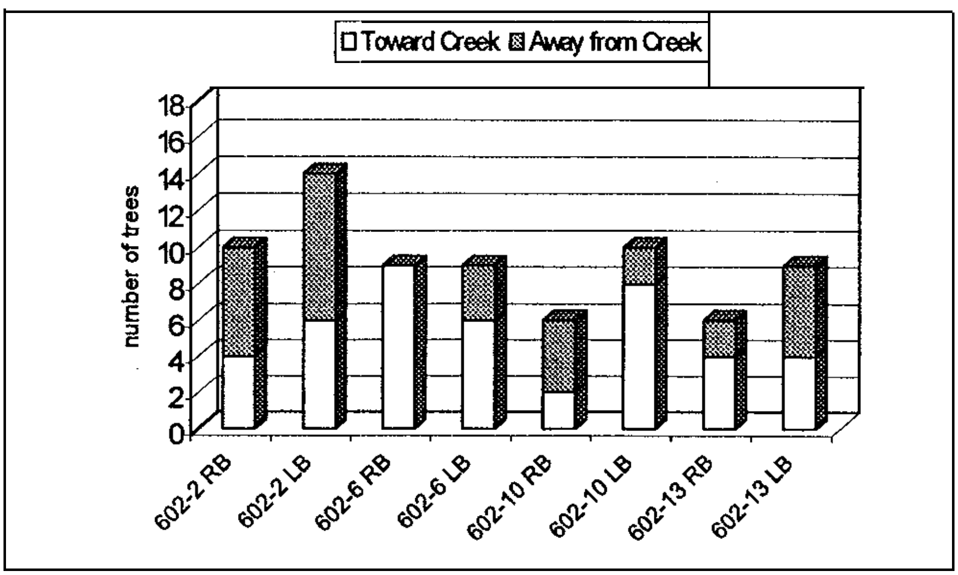


Figure 19. Number of trees leaning toward and away from the creek in the western redcedar stand

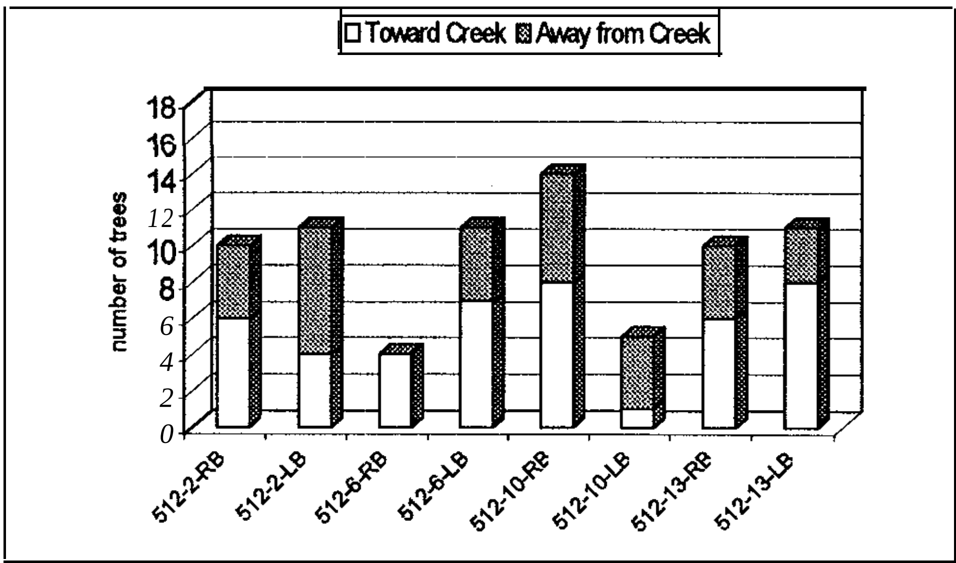
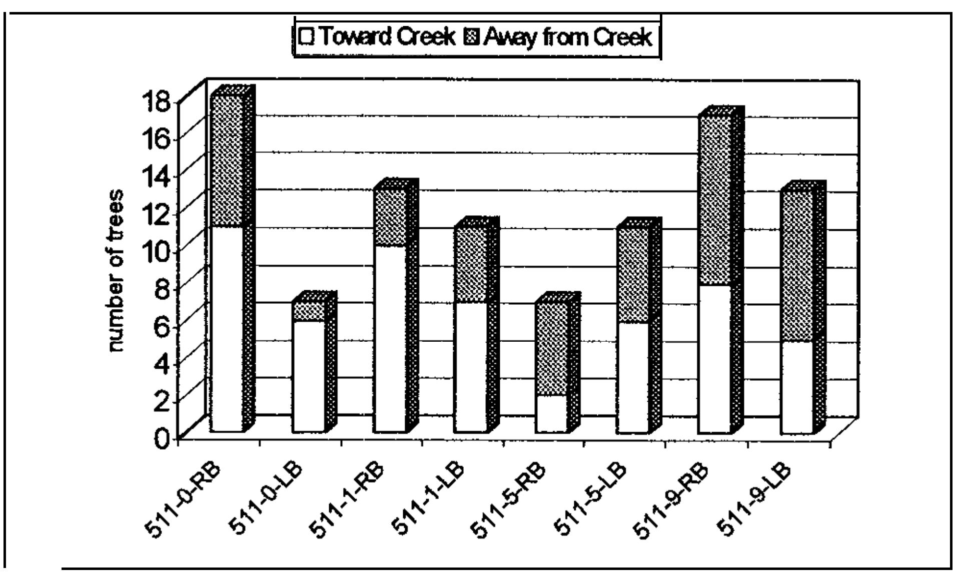


Figure 20. Number of trees leaning toward and away from the creek in the mature redcedar stand



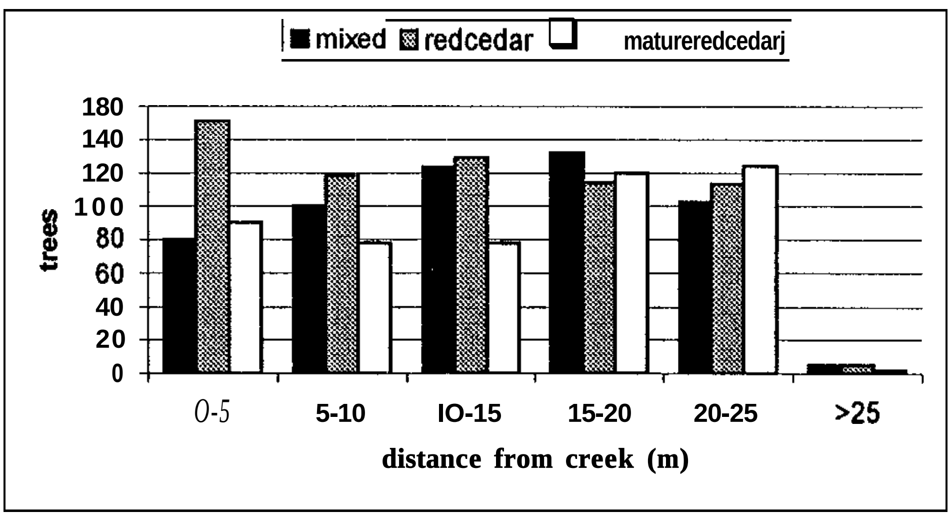
IV.A.7. *Distance from Stream*

Each standing tree was recorded at a certain distance from the creek. Trees were distributed relatively evenly over the plots; the greatest difference between distance classes was only 9%. The western redcedar stand had the greatest proportion within 5 meters of the creek. The mixed conifer stand had the greatest proportion of trees between 10 and 20 meters. The mature redcedar had the greatest proportion of trees in the 20 to 25 meter range.

Table 11. Distribution of standing trees at various distances from tbe creek in each stand

Distance (m)	Mixed conifer	Western redcedar	Mature redcedar
0-5	15%	24%	18%
5-10	18%	19%	18%
IO-15	23%	20%	18%
15-20	24%	18%	24%
20-25	19%	18%	25%
25+	1%	1%	<1%

Figure 21. Tbe number of trees located at various distances from the creek in each stand

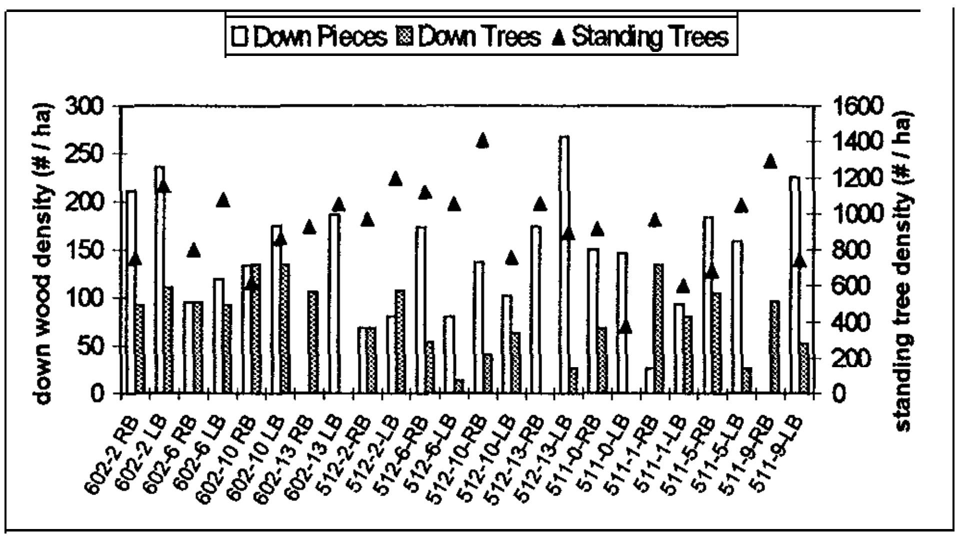


IV.B. Down Wood

IV.B. 1. *Density*

The density of down wood was determined for each subplot, and results arc presented in Figure 22. Overall, there were almost twice as many individual pieces of down wood as there were down trees with attached rootwads, with 134 pieces/ha and 71 down trees/ha, respectively. The density of down trees with rootwads in a subplot ranged from 0 to 134 trees/ha, while the density of down pieces ranged from 0 to 267 pieces/ha. The highest density of down wood was in the mixed conifer stand, and the lowest density was in the western redcedar stand. There was no correlation between the density of standing wood and the density of down wood in subplots.

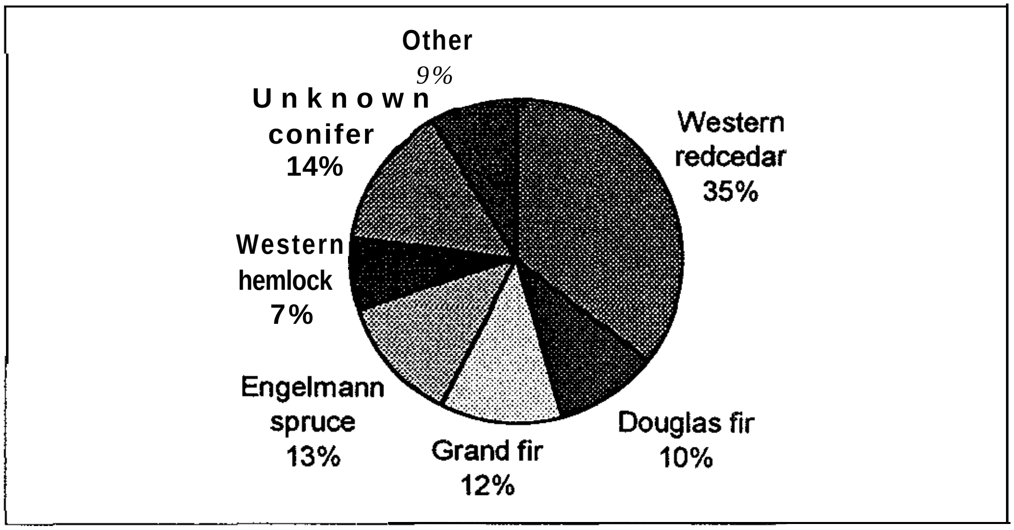
Figure 22. Density of down wood pieces, down trees with rootwads, and standing trees in subplots in the Onion Creek Watershed



IV.B.2. *Species Composition*

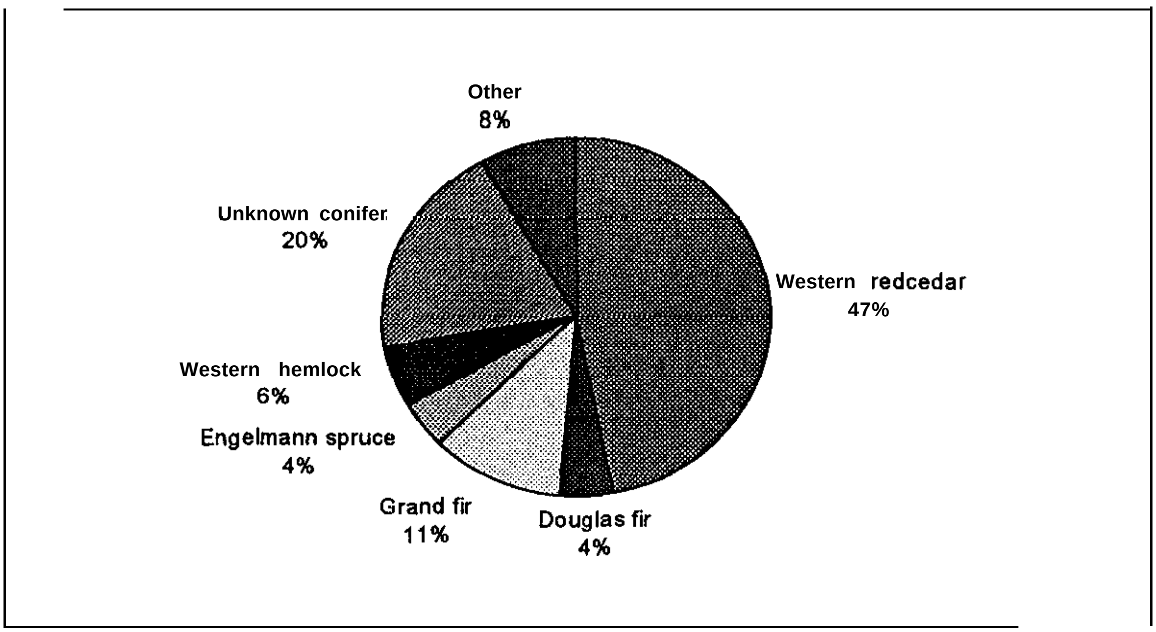
The most common species of down trees with rootwads was western redcedar (35%). Several other species comprised similar proportions (10-13%) of the down wood, including Douglas fir, grand fir, and Engelmann spruce.

Figure 23. Species composition of down trees with rootwads surveyed in the Onion Creek Watershed



The most common species of down pieces was western redcedar (47%), followed by grand fir (11%). Due to the difficulty of identifying pieces of down wood, 20% of the wood was recorded as an unknown conifer.

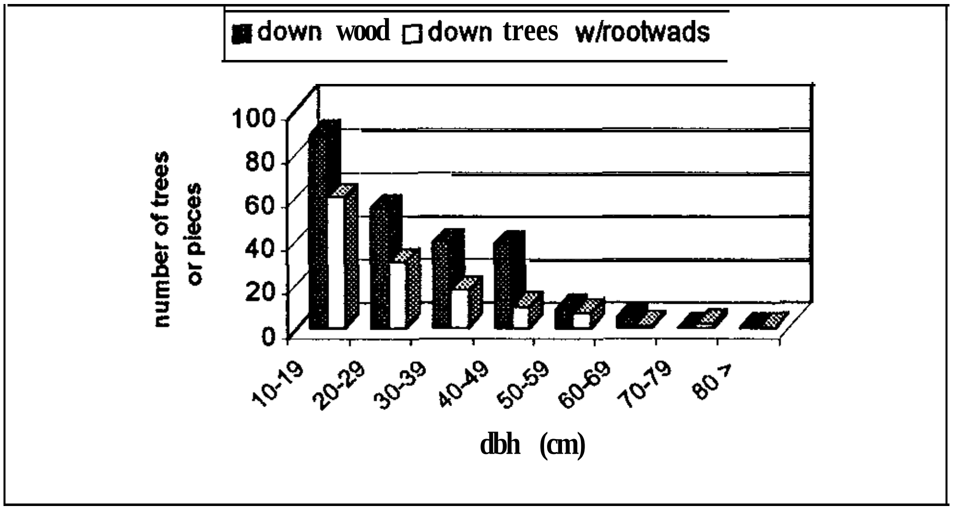
Figure 24. Species composition of down wood pieces surveyed in the Onion Creek Watershed



IV.B.3. Tree Size

Most of the down wood was small in diameter. Ranging from 10-29 cm dbh, (two-thirds of these trees were in the 10-19 cm dbh range). The **relatively large** number of small down trees was consistent with the larger proportion of small standing trees. Only 10 down trees with rootwads, or 8%, were >50 cm dbh, and only 14 down pieces, or 6%, were >50 cm dbh.

Figure 25. Number of down wood pieces and down trees with rootwads in various size classes surveyed in the Onion Creek Watershed



The **average** size of down pieces and trees was less than 30 cm in all three stands.

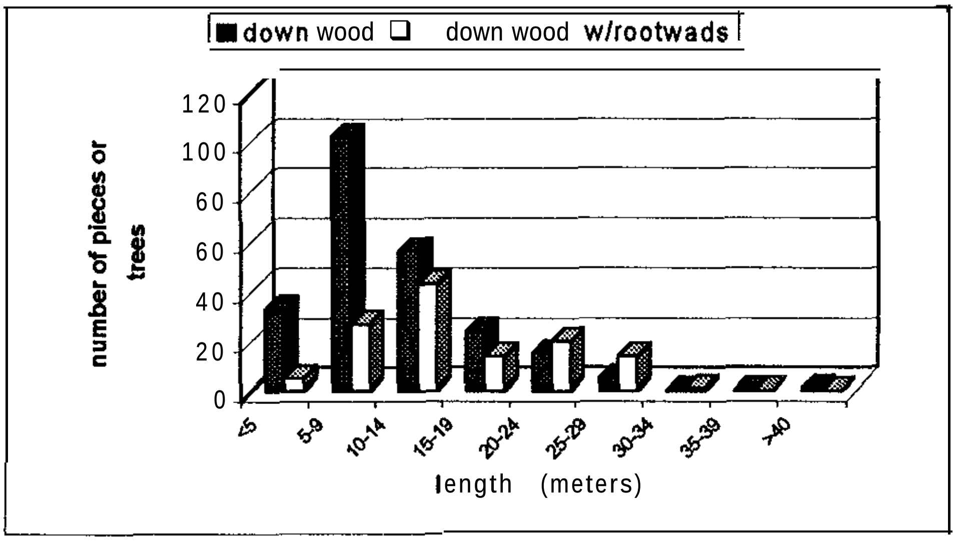
Table 12. Average size of down *trees* and down pieces surveyed in the Onion Creek Watershed

Average wood size (cm)	*Mixed conifer*	*Western redcedar*	*Mature redcedar*
Down trees	27	24	24
Down pieces	25	29	28

IV.B.4. *Length*

Most of the down pieces of wood or trees with rootwads were between 5 and 15 meters long. Pieces of down wood were generally shorter than trees with rootwads.

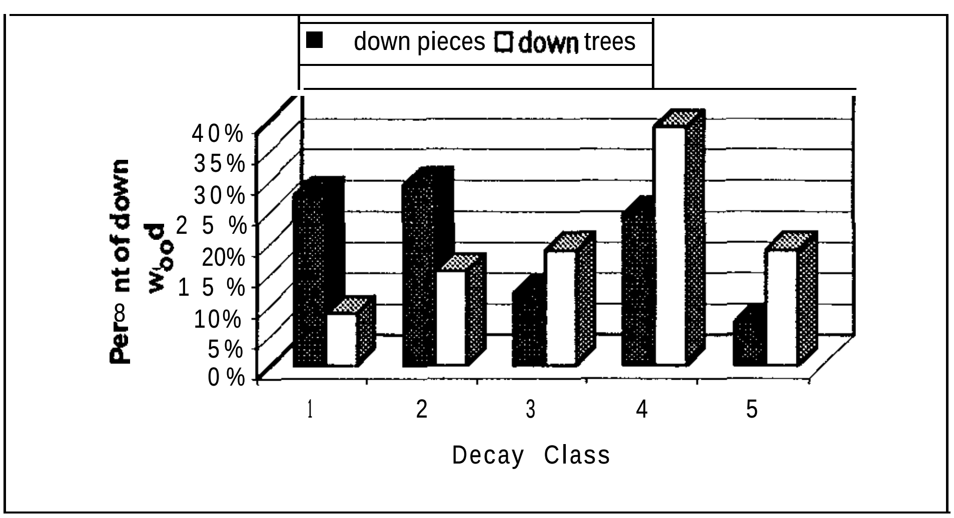
Figure 26. Number of down wood pieces and trees with rootwads in various length classes



IV.B.5. *Decay Class*

A decay class ranging between 1 and 5 (5 being the most decayed) was assigned to down wood. The distribution of trees in these classes was different for trees with rootwads than for individual pieces of down wood. Trees with rootwads were more decayed (often class 4) compared to down wood pieces which were more often in classes 1 and 2.

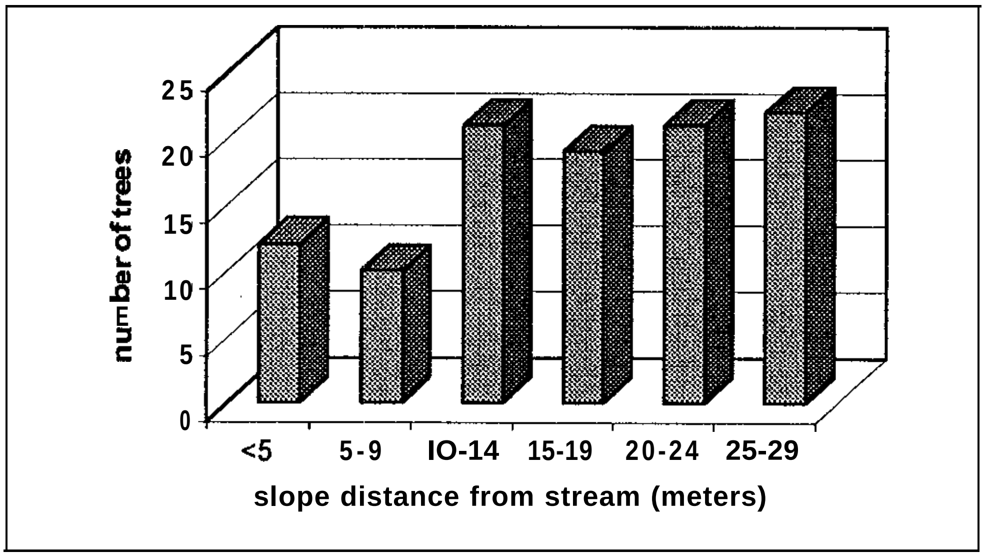
Figure 27. Percent of down trees with rootwads and down pieces of a given decay claws



IV.B.6. *Distance from Stream*

For down trees with attached rootwads, the distance from the base of the tree to the stream was measured. The majority of trees that fell were located away from the stream, primarily between 10 and 29 meters away. About an equal number of fallen trees came from across this range of distances.

Figure 28. Number of down trees with rootwads located within a given distance from the creeks surveyed in the Onion Creek Watershed



IV.B.7. *Direction of Tree Fall*

The azimuth of fall for trees with attached rootwads was determined at each plot. Generally, more trees fell toward the creek than away. Fall toward or away was defined as fall within an area 178° wide toward or away from the bankfull channel.

Table 13. Number and percent of trees with rootwads that fell toward or away the bankfull channel in timber stands in the Onion Creek Watershed

Direction of fall	*Mixed Conifer*	*Western redcedar*	*Mature redcedar*
Toward	46	12	32
Away	11	16	10
Percent toward	81%	43%	76%

IV.B.8. *Recruitment*

Table 14 gives the percent of down wood that was recruited to the bankfull channel, suspended over the channel, or spanning the channel. The number of down trees that were recruited was small; most of the individual pieces and trees with rootwads were not recruited.

Table 14. Recruitment of down wood surveyed in the Onion Creek Watershed

Type of Recruitment	*Percent of down trees w/ rootwads*	*Percent of down wood pieces*
Recruited to bankfull	*4%*	*7%*
Suspended	*3%*	*4%*
Spanning	16%	*4%*

The larger proportion of down trees spanning the channel is due, in part, to several spanning logs in subplots 602-6 and 5 11-S.

The wood recruited to the bankfull channel averaged between 33 and 35 cm diameter at the midpoint or dbh for pieces and trees, respectively. Most of the recruited pieces were either unknown species or redcedar. Most down trees with rootwads were not identified due to their level of decay.

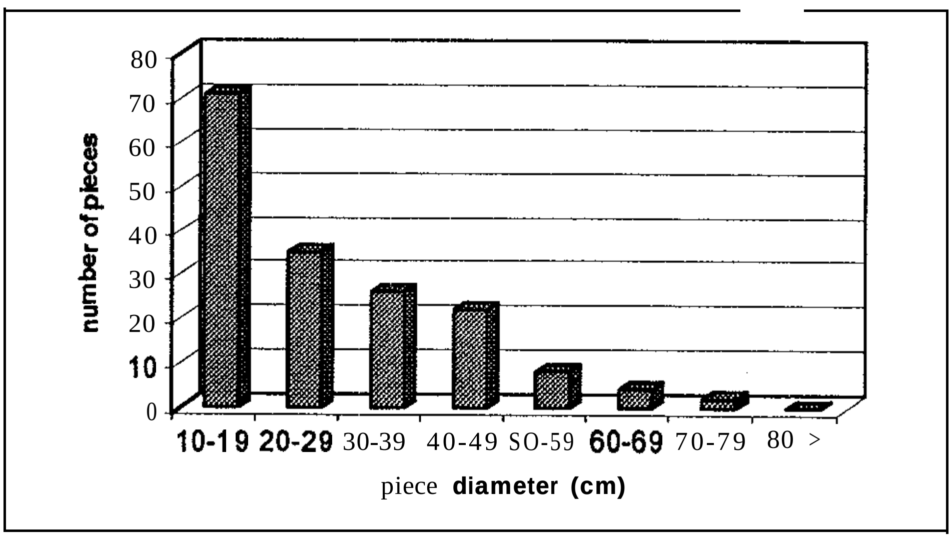
IV.C. Instream Wood

Qualifying pieces of instream wood were associated with the location of the piece in the channel. The system used to describe the location consists of four zones. Our methods account for three zones: 1, 2, and 3+4. Zone 1 encompasses the wetted channel. Zone 2 is the area above the wetted channel but within the bankfull channel. Zone 3 is the area extending above the bankfull channel but within the horizontal perimeter of the bankfull channel. Zone 4 is the upland area to the left or right of (i.e. outside of) the bankfull channel; including the riparian area and hillslopes.

IV.C.1. *Diameter & Density*

Most of the instream wood was very small in diameter (10-19 cm). The histogram of instream wood diameter looks similar to the histogram for down wood *on* the hillslopes. Overall, there were just over 150 qualifying pieces of LWD in all 12 plots; this corresponds to an average of 0.42 pieces of LWD/ meter of stream length or 0.96 pieces of LWD/ bankfull width.

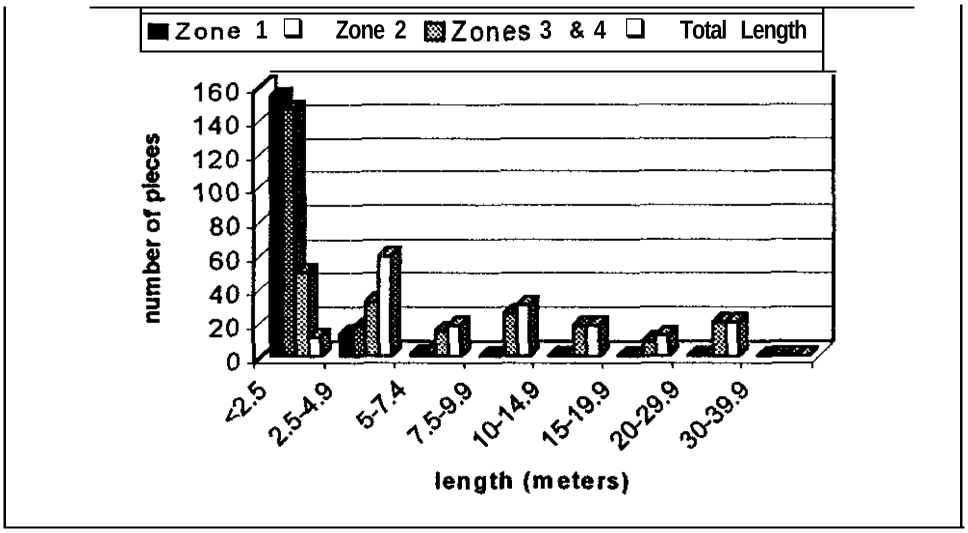
Figure 29. Diameter of LWD in surveyed in the Onion Creek Watershed



IV.C.2. *Length*

Most pieces of LWD were between 2.5 and 5 meters in total length. The vast majority of wood that was recruited to the bankfull channel had less than 2.5 meters of length in the channel; the rest of the wood extended outside the bankfull channel. Many pieces were between 5 and 7.5 meters total length.

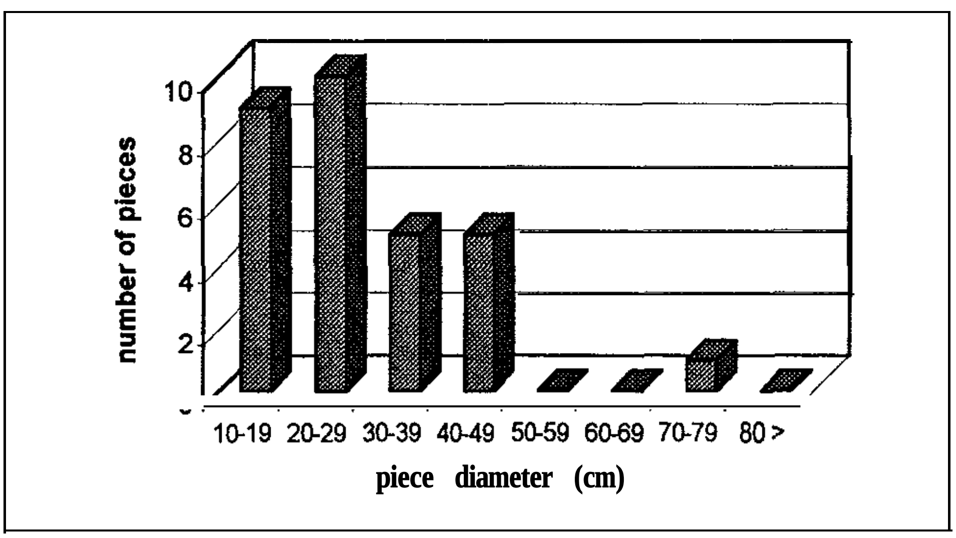
Figure 30. Total length of LWD and length of pieces within each channel zone surveyed in the Onion Creek Watershed



IV.C.3, *Functioning Wood*

Small diameter wood was found functioning at Onion Creek sites. Of all pieces recruited, 18% were functioning to form pools. Of the wood that was functioning to form pools, about twice as many of those pieces were small rather than large, ranging from 10-29 cm diameter. About half of the pieces were oriented perpendicular to the direction of flow.

Figure31. Diameter of LWD functioning to form pools in stream segments surveyed in the Onion Creek Watershed



IV.C.4 Volume of Wood Recruited to Bankfull Channel.

The volume of wood recruited to the bankfull channel varied significantly between **the mixed** conifer stand and the redcedar stands. Almost twice as much wood was in the channel at the mixed stand.

Table 15. Volume of wood and number of pieces within the bankfull channel at timber stands surveyed in the Onion Creek Watershed

Stand	*Wood volume (m3)*	*Number of Pieces*	*Pieces per bankfull width*
Mixed conifer	131	47	1.14
Western ***redcedar***	77	27	0.45
Mature redcedar	60	18	0.30

The number of pieces in the bankfull channel per bankfull width varied significantly between plots. The greatest number of pieces in the bankfull channel were in the mixed conifer stand and the least in the mature redcedar stand.

IV.C.5. Debris Jams

Debris jams are defined as 10 or more qualifying pieces in contact with each other. Each must be totally or partially in Zones 1, 2, or 3.

No qualifying debris jams were found in study plots surveyed in the Onion Creek Watershed.

V. Changes in Riparian Stands After One Year

Stevens County Conservation District technicians revisited each riparian stand to document any changes that occurred following the initial survey completed in September 1998. The follow up survey was conducted in October/November 1999. There were no major disturbance events during this time.

V.A. Standing Trees

Natural conditions resulted in very few changes in riparian plots in the Onion Creek Watershed (Table 15). Only four trees in the mixed conifer stand and five trees in the mature western redcedar stand changed. At the mixed conifer stand, two snags and one stressed tree were leaning more than before, and the top broke out of one tree, creating a new snag. The three leaning trees lean almost directly toward the creek, although, two of the three are located more than 15 meters horizontal distance from the creek. At the mature redcedar site, three fir trees died and two trees were leaning approximately 30° more than before. Four of the five trees with a change are located more than 15 meters horizontal distance from the creek.

Table 16. Number of standing trees in Onion Creek Watershed riparian plots that changed between September 1998 and November 1999.

Type of change	*Mixed Conifer*	*Western redcedar*	*Mature redcedar*
New down wood	0	37	0
New Lean angle	3	1	2
Tree died	0	0	3
Tag/tree missing	0	55	0
Tree harvested	0	83	0
Other	1#	0	0
Total	4	176	5

#broken top created new snag.

Several categories of change were noted during the follow-up survey:

- ***Harvested:*** tree cut, stump remained, tag found, and log gone.
- ***Missing:*** tag could not be located; tree cut below tag level and harvested, taken to slash pile, or pushed over with tag buried.
- Down *wood*: tree on the ground; pushed over with equipment, fell over with no sign of pushing, or cut and left.
- ***Other:*** leaning more than before, broken top, or tree died.

One standing tree was found without a tag number in the mixed conifer stand, and two trees in the mature redcedar stand had tag numbers but no data recorded in the 1998 survey.

Many changes were found at the western redcedar stand; all of the changes were the direct or indirect result of harvesting activities during winter of 1998/99 (Table 17). This unplanned encroachment into the riparian plots impacted over 175 trees in the stand (between 34 to 52 trees at each plot). Between 50% and 53% of the trees impacted in Plots 2, 6, and 13 and almost 80% of the trees impacted in Plot 10 were located 15 meters or more from the creek.

Table 17. Number of standing trees impacted by harvesting activities at the western redcedar stand in the Onion Creek Watershed

Type of change	*Plot 2*	*Plot 6*	*Plot 10*	*Plot 13*
Tree harvested	20	24	16	23
Tag/tree missing	13	2	26	14
New down wood	15	8	10	4
Other	0	0	0	1
Total	48	34	52	42

V.B. Recruited Wood

Two small pieces of wood were recruited as LWD to the bankfull channel during the year following the Onion Creek survey. The total volume of newly recruited wood was approximately 0.12 m^3. Both pieces were in the mixed conifer stand, which had the most instream wood during the 1998 survey. Both pieces came from suspended wood, and they were significantly decayed (Class 4 and 5). Neither piece functioned to form pools upon recruitment,

Table 18. Wood recruited to the bankfull channel between September 1998 and November 1999 at timber stands surveyed in the Onion Creek Watershed

Source of Recruitment	*Mixed Conifer*	*Western redcedar*	*Mature redcedar*
Suspended wood	2	0	0
***Spanning** wood*	*0*	*0*	*0*
***Standing** trees*	*0*	*0*	*0*
Total			

VI. Discussion

The riparian survey conducted in the Onion Creek Watershed provided permanent plots and baseline data that can be used to track future rates of large woody debris recruitment during "normal" years and episodic events. The data presented in this report represent the riparian conditions from which future changes can be observed.

These sites were located on small streams having bankfull widths of less than 3 meters, Hillslopes were generally steep, but a range of stand densities and stream gradients was represented. The three sites selected for survey were initially identified as mixed conifer, western redcedar, and mature western redcedar stand. Stand characterization following the survey showed that each site was predominantly western redcedar while the mixed conifer stand had the greatest proportion of other species. Most of the trees surveyed were small (<30 cm dbh).

As expected, the mature redcedar stand was different from the redcedar stand. It had the largest and tallest trees. It had the lowest density of stems per hectare and the greatest proportion of trees located away from the stream. The mature redcedar stand had the steepest hillslope and the most leaning trees, but it had the fewest pieces of instream wood per bankfull width.

Overall, the species composition of down wood was generally reflective of the standing wood. Most of the down wood was western redcedar; however, there was a greater proportion of Douglas fir and Engelmann spruce down than standing. Twelve to 20% of the trees were leaning; slightly more leaned toward the creek than away.

Most of the trees that fell originated more than 10 meters from the creeks. Of the down wood, 11% was recruited to the bankfull channel. As with standing trees, most instream wood was small in diameter and less than 5 meters long. This small wood functioned well to form pools in the Type 3 streams surveyed. The mixed conifer stand had the most wood recruited to the bankfull channel (1.1 pieces/ bankfull width); the redcedar stands had less than half that amount (.30-.45 pieces/bankfull width).

Follow-up survey of each plot one year after the initial survey resulted in few changes caused by natural conditions. At two stands, a few trees died and several had greater lean angles. Changes at the other stand resulted from timber harvesting activities. Over 175 standing trees were impacted; about 20% became down wood, and 80% were harvested or presumed harvested (missing).

If funding is available, plots will be revisited following disturbance events in the future. Disturbance events are generally defined as any event (wind, rain, snow storm, tire, heavy snow load, etc.) that is believed to have a high probability of causing tree fall.

Events that may cause mass mortality of trees include fire, disease, and insect damage. When a tree dies and the cause of death is apparent, that cause will be recorded. Local foresters can help with determining cause of death. Mass mortality situations cause trees to fall sooner in time than if they were healthy, but this time could be 10 years after the tree dies. These trees will be identified and tracked over time in the same manner healthy trees are tracked.

Several measurements will be taken when plots are revisited. Any tagged trees that have fallen will be identified by tag number and location. The angle of fall relative to the stream will be measured. If the tree fell into the stream, the mean diameter and length of the portion of the tree that is in the stream will be measured following the LWD survey methods used in this study (Schuett-Hames et al., 1994). Wood that falls into the channel from outside the plot will also be measured and noted if it qualifies under the methods provided above.

VII. References

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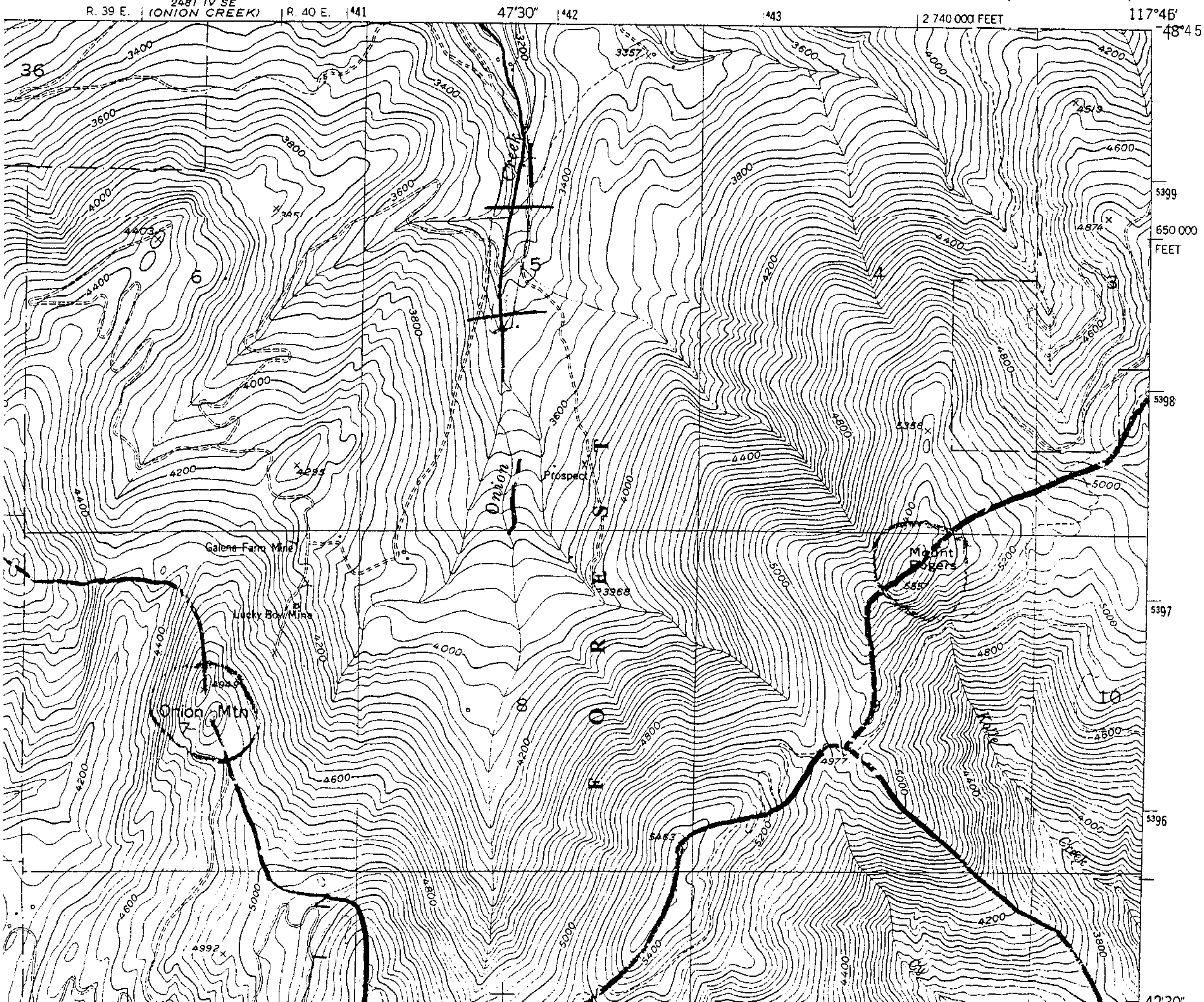
Appendix

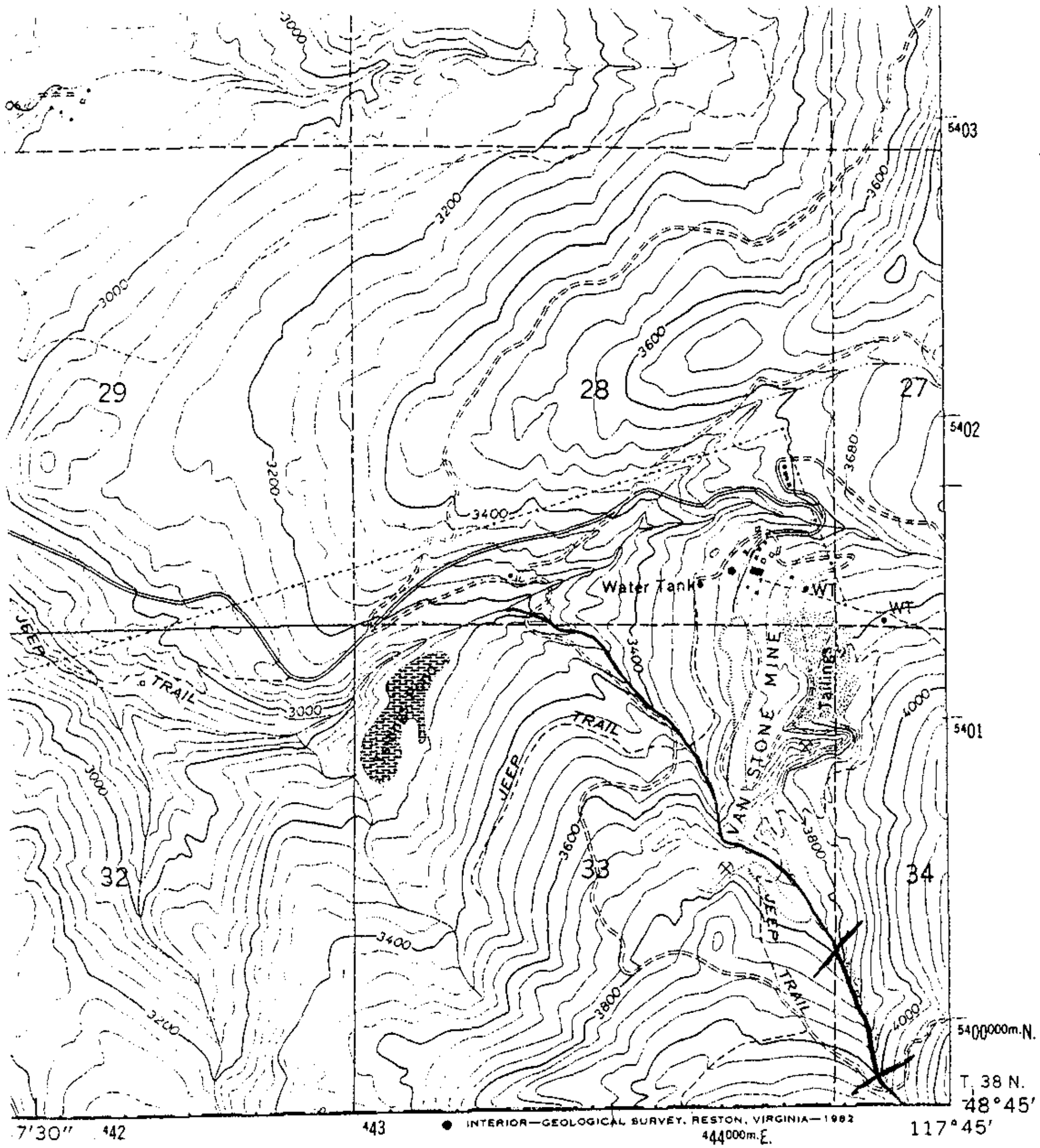
Gillette Mtn. GILLETTE MTN. QUADRANGLE
WASHINGTON-STEVENS CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

2481 I S (SPIRIT)

15



segment 602



segment 512

(ALADDIN)
2481 II NW

ROAD CLASSIFICATION

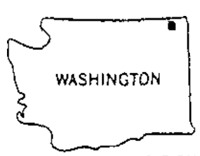
1 MILE

Primary highway, all weather, hard surface

Light-duty road, all weather, improved surface

Unimproved road, fair or dry weather

0 State Route



QUADRANGLE LOCATION

ONION CREEK, WASH.

N4845—W11745/7.5

1969

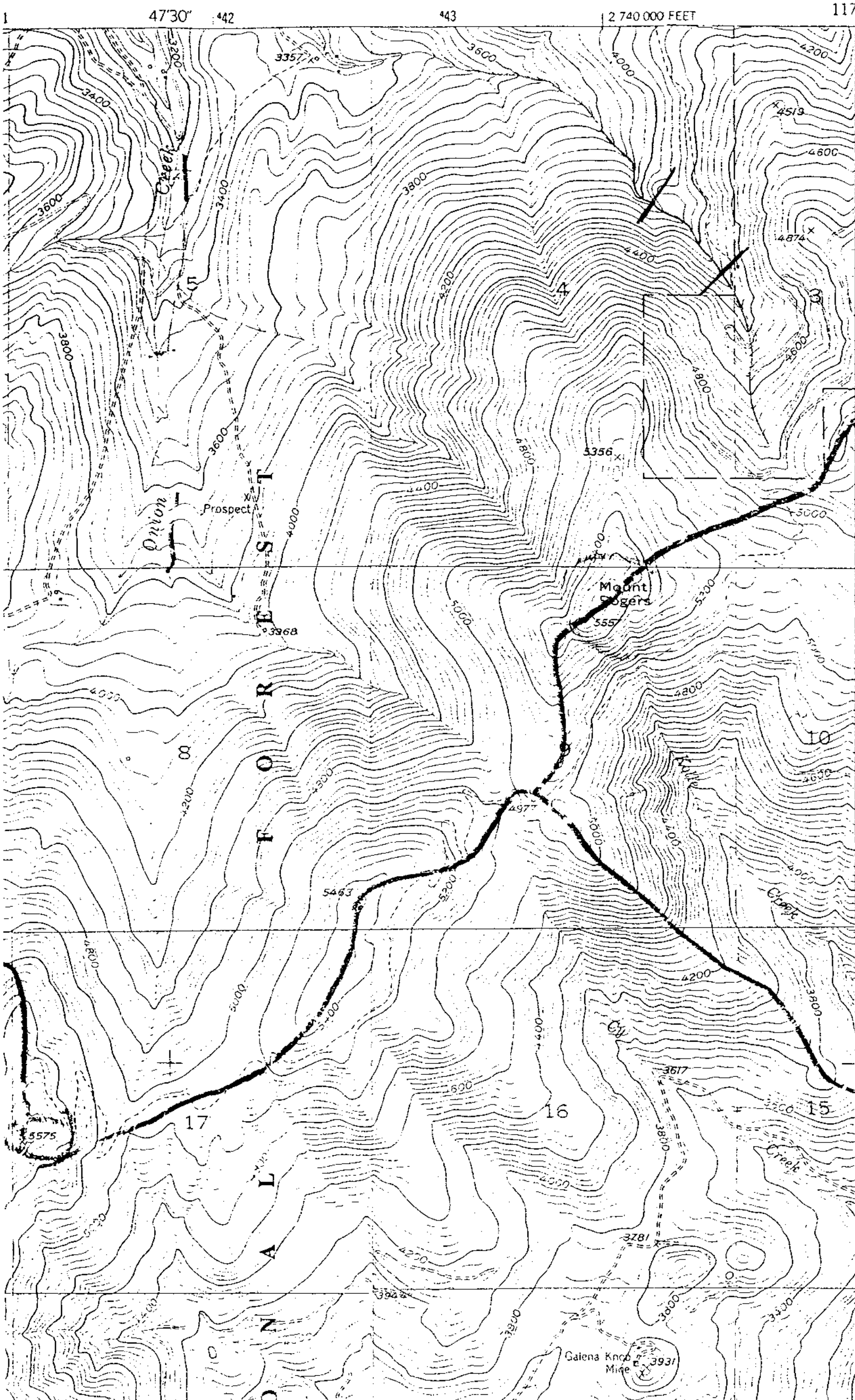
22092

76

WASHINGTON–STEVENS CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

2481 (SPIR

15



Segment 511