



Controls on large woody debris distributions in Yellowstone streams
by James Lee Rasmussen

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in
Earth Sciences

Montana State University

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Abstract:

Woody debris affects the channel morphology of streams and can have profound effects on stream habitat. Despite knowledge of the effects of woody debris in streams, the controls on its distribution are poorly understood. This study examined 55 kilometers of the 2nd to 4th order segments in Soda Butte and Cache Creeks in Yellowstone National Park. A continuous 100-meter longitudinal sampling scheme was used to determine if there are basin-wide controls on woody debris.

Results of this study suggest that the streams in the study have only weak basin wide trends. Woody debris counts in the streams declined slightly with distance from the headwaters, but there appears to be no pattern to the agglomeration of wood into jams. Woody debris was found to have a minor but significantly positive effect on the number of riffles and pools. When wood counts from a burned and undisturbed stream were compared, the undisturbed stream had significantly higher amounts of woody debris.

This was in direct contrast to earlier research in the study area. The contrast can be attributed to recent high magnitude (MO year) floods, suggesting that floods are a major control on woody debris storage within the stream. The forest also plays a major role; a comparison of forested and non-forested segments of stream showed that forested segments had substantial and significantly higher quantities of wood.

Despite the failure to find strong basin-wide controls on woody debris, the study did call into question many methodological considerations, specifically the resolution of sampling required to study a stream. The results of this study suggest that most sampling schemes in stream research fail to capture the spatial variability in streams.

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IN YELLOWSTONE STREAMS

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and it is ready for submission to the College of Graduate Studies.

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ABSTRACT

Woody debris affects the channel morphology of streams and can have profound effects on stream habitat. Despite knowledge of the effects of woody debris in streams, the controls on its distribution are poorly understood. This study examined 55 kilometers of the 2nd to 4th order segments in Soda Butte and Cache Creeks in Yellowstone National Park. A continuous 100-meter longitudinal sampling scheme was used to determine if there are basin-wide controls on woody debris.

Results of this study suggest that the streams in the study have only weak basin wide trends. Woody debris counts in the streams declined slightly with distance from the headwaters, but there appears to be no pattern to the agglomeration of wood into jams. Woody debris was found to have a minor but significantly positive effect on the number of riffles and pools. When wood counts from a burned and undisturbed stream were compared, the undisturbed stream had significantly higher amounts of woody debris. This was in direct contrast to earlier research in the study area. The contrast can be attributed to recent high magnitude (>10 year) floods, suggesting that floods are a major control on woody debris storage within the stream. The forest also plays a major role; a comparison of forested and non-forested segments of stream showed that forested segments had substantial and significantly higher quantities of wood.

Despite the failure to find strong basin-wide controls on woody debris, the study did call into question many methodological considerations, specifically the resolution of sampling required to study a stream. The results of this study suggest that most sampling schemes in stream research fail to capture the spatial variability in streams.

CHAPTER 1

INTRODUCTION

Introduction

The objective of this study is to provide a greater understanding of wood distributions within burned and undisturbed watersheds and how these distributions relate to stream morphology. Large wood affects the channel morphology of streams by altering flow patterns and sediment storage. The effects of wood on stream morphology can be major; for example, a study of forested headwater streams in the Pacific Northwest found that 25 to 50% of the streambed was wood or sediment stabilized by wood (Anderson and Sedell, 1979). Wood can play a different but important role in the lower portions of watersheds, where woody debris may only be 4% of the substrate surface but contains 60% of the invertebrate biomass found in the stream (Benke *et al.*, 1985). Woody debris is also a factor in the formation of riffles and pools, which are important habitat for macro-invertebrates and fish. It has been shown that the greater the geomorphic complexity in the stream, the more favorable the stream's habitat (Robison and Beschta, 1990). Thus, woody debris and other roughness elements are directly tied to the composition of streams sediments, to stream morphology and to the quality of a stream's habitat. Understanding the distribution of wood in streams and the controls on that distribution are therefore critical to stream management.

Despite the extensive research on woody debris and its role within the fluvial system, there is still a need for better understanding of the spatial distribution of woody

debris and its relationship with stream morphologic units in streams of different size.

This objective of this study will be achieved by testing five hypotheses.

1. The count of woody debris stored in the stream and flood plain decreases with increasing channel width.
2. The amount of wood contact with the channel increases as the width of the channel increases.
3. Wood transport and agglomeration into jams increases as the width of the channel increases.
4. The influence of woody debris upon channel morphology increases with increased wood loading; increased woody debris density produces a corresponding increase in morphologic unit density.
5. Wildfires affect the delivery of large woody debris to the fluvial system; recently burned forested watersheds produce more woody debris than undisturbed forested watersheds.

Most studies have relied upon the intensive study of a few reaches and have assumed that these sites are representative of the entire stream. This study will explore woody debris using continuous field data collected in extensive longitudinal surveys across two mountain watersheds, thus including the natural variability intrinsic to all stream systems. The completeness of this approach also presents a unique opportunity to search for thresholds or natural breaks in the pattern of wood transport, agglomeration and deposition. Finally, an extensive data set provides a new opportunity to test existing hypotheses on woody debris distributions that were derived from less extensive studies.

Literature Review

Woody debris plays a major role in both the structure and function of the fluvial system. This review examines research about the impacts of wood on stream flow and morphology, downstream variations in these impacts, and woody debris as a system of supply, transport, and decay components.

The Influence of Woody Debris on Stream Flow and Morphology

Wood serves as an impediment to flow, acting to increase roughness, decreasing stream velocity, creating a higher water level upstream of the debris, and theoretically increasing the risk of flooding (Gippel *et al.*, 1996). Many early efforts to clear streams of woody debris were intended to reduce the risk of flood. A study of a test channel found that clearing of woody debris reduced the Manning's resistance coefficient an average of 39% (Dudley *et al.*, 1998), thus reducing flow velocities and increasing flood stages.

Although flood flows may be deeper due to wood, its role as an energy dissipater reduces the amount of energy available for sediment transport and stabilizes the bed of forested streams (Heede, 1972). A study of 1st to 5th order streams in 13 watersheds in the Oregon Coast Range found that log steps dissipated an average of 6% of the total potential energy of the streams (Marston, 1982). Other studies report that as much as 80% of stream energy is dissipated by log steps.

Because it dissipates energy that could be used for sediment transport, woody debris can be a major factor in reducing sediment transport and increasing sediment

storage in forested streams. Marston (1982) reported that the volume of sediment stored behind log steps in 3rd, 4th and 5th order streams in the Oregon Coast Range was 123% of the estimated mean annual sediment discharge for those streams. A similar study on a forested 3rd order stream in Vermont (Thompson, 1995) found that although woody debris steps accounted for only 22.2% of the elevation drop in the study, they accounted for up to 53% of the total sediment storage. Thompson also pointed out that woody debris is superior to bedrock knickpoints in sediment storage capability because of the larger storage area behind wood dams.

The formation of steps and local base levels by wood jams has recently been recognized by a study conducted by Massong and Montgomery (2000) in the Willapa River Basin in southwest Washington. They attempted to predict a bedrock or alluvial channel type from slope and drainage area data. In many of the alluvial reaches that were misclassified as bedrock they found a forced alluvial morphology upstream of wood jams and log steps. The woody debris had created a local base level and the reach immediately upstream of the wood obstruction had alluvium deposited as a veneer over the original bedrock channel.

In some instances wood can increase erosion, wood can deflect flow creating localized acceleration and vortex development (Abbe and Montgomery, 1996). A flume study by Cherry and Beschta (1989) found that wood angled upstream caused the greatest flow disturbance and instigated bank erosion by deflecting the flow toward the side of the flume; however, they found that wood oriented perpendicular to the direction of flow produced the largest amount of channel scour by volume.

Removal of woody debris can have drastic effects on sediment transport. The experimental removal of woody debris from a 2nd order stream in Southeast Alaska resulted in a 4-fold increase in bedload transport (Smith *et al.*, 1993a). The drastic increase in transport was attributed to destabilization of previously stored sediment and the loss of low energy backwater storage sites. Likewise Lisle (1995) reported that wood removal near Mt. St. Helens increased sediment transport as well as a substantially coarsening the channel bed as fines were flushed away.

Woody debris effects on sediment storage and transport create wood induced channel features such as pools. Pools have long been associated with large roughness elements like boulders and woody debris that deflect stream flow and cause localized bed scour. Recent studies have begun to differentiate between wood or boulder forced pools and rhythmically spaced free-form pools. Many types of forced pools are directly associated with woody debris. Beschta and Platts (1986) describe how forced flow under or around a log creates scour pools, while channel-spanning wood jams create dammed and backwater pools upstream of the jam and plunge pools immediately below the jam. Gurnell and Sweet (1998) point out that of the 10 pool types in the habitat unit classification system developed by Bisson *et al.* (1982), six are associated with woody debris.

The best evidence for woody debris acting as a pool-forming factor is the many studies that count the number of pools directly associated with woody debris in their study area. Studies report that woody debris is associated with 48% to 75% of the pools found in a wide range of streams (Robison and Beschta, 1990; Beechie and Sibley, 1997).

Other studies have used the spacing of pools to assess the role of wood in pool formation. Montgomery *et al.* (1995) found that pool spacing in Washington and Southeast Alaska is dependent upon large woody debris loading. Mean pool spacing in pool-riffle, plane-bed and forced pool-riffle channels decreased from 13 channel widths to less than 1 channel width as the wood loading increased. The rate of increase varied with channel width and slope, but in all cases an increase in wood loading yielded a decrease in the pool spacing.

Woody debris not only influences in-channel features but also has a profound effect on channel width. A study of a forested upland watershed in the western Cascade Range in Oregon found that, in all alluvial reaches, the reaches with woody debris had channels that were about 1.5 times wider than channels without wood (Nakamura and Swanson, 1993). This widening was attributed to anchored trees falling into the middle of the channel and deflecting flow toward the banks, causing bank erosion. This study also reported that wood-induced deflection increased lateral migration and the development of secondary channels in unconfined alluvial reaches of 4th order or higher streams. Robison and Beschta (1990) describe woody debris as a major factor in deflecting flow toward sites of bank failure in the streams of Chicagof Island, Alaska.

The role of wood in affecting channel planform is well supported in the literature. Beschta and Platts (1986) describe woody debris as contributing to planimetric sinuosity by thalweg deflection and to longitudinal sinuosity by forming steps. Studies of woody debris have also reported that jams provide a key ingredient in the formation of islands. Abbe and Montgomery (1996) used historical data from maps and aerial photographs from the Queets River of the Olympic Peninsula to chart the development of stable

forested islands from transient in-channel bars. They describe the process as follows; (1) in-channel bars collect woody debris at the upstream apex of the bar, (2) the formation of a stable bar apex jam changes the local hydraulics in the channel, creating zones of scour and deposition; (3) the original bar with the jam at its apex becomes a zone of stable deposition, building up a blanket of colonizing vegetation and (4) the vegetated bar eventually develops into a forested island.

Downstream Variations in the Role of Woody Debris

Studies of woody debris at the basin scale have found that the quantity and role of wood varies with position in the basin. The accepted maxim is that wood loading decreases with increasing drainage area and channel width (Bilby and Ward, 1989; Robison and Beschta, 1990; Nakamura and Swanson, 1993; Montgomery *et al.*, 1995). The impact of this wood on morphology varies with basin location. Woody debris is thought to have little effect in the small 1st to 2nd order streams high in the drainage basin because the pieces of wood are larger than the width of the small channels. Wood tends to be suspended above the channel and therefore does not play a large role in channel morphology or sediment capture (Bilby and Ward, 1989; Nakamura and Swanson, 1993). The impact of woody debris on channel morphology and sediment transport increases in streams with slightly wider channels. A wider channel allows fallen trees to interact more with the active channel. This trend continues until the channel width reaches a balance with wood length and the woody debris becomes more susceptible to transport (Bilby and Ward, 1989; Nakamura and Swanson, 1993). Bilby and Ward (1989) found that wood size and the volume of instream debris accumulation increased with increased

drainage area in a 2nd to 5th order stream flowing through an area of old growth timber in Washington. Although the size of the accumulations increased, the spatial frequency of woody debris decreased as drainage area increased.

Despite the minor role attributed to woody debris in smaller channels, the literature does report a number of important facts. Studies by Heede (1972), Marston (1982) and Wohl *et al.*, (1997) report on the substantial effects of woody debris in creating log steps and storing significant amounts of sediment in smaller upland streams. Bilby and Ward (1989) recorded the orientation of woody debris relative to the channel and found that in channels less than 7 meters wide, 40% of the woody debris was perpendicular to the axis of flow. This perpendicular orientation resulted in log steps being the most common woody debris form and plunge pools being the most common pool type associated with wood in the small channels. They also reported that 40% of the sediment storage in channels less than 7m in width could be directly associated to woody debris.

As the drainage basin area increases and wider channels are encountered, the orientation of woody debris is increasingly parallel to flow and the effect of wood on morphology is reduced. Bilby and Ward (1989) report that the wood piece orientation in channels greater than 10 meters wide is angled downstream into the flow over 40% of the time and parallel to the flow of the stream over 20% of the time. The most common type of pools associated with woody debris in this portion of the stream are scour pools formed by flow deflection. They also mention that storage behind wood accounts for less than 20% of the total sediment storage in the wider channel. Research by Robison and Beschta (1990) on five streams in Southeast Alaska confirms the trend from log steps and

plunge pools in the smallest streams to wood-deflected flow and scour pool formation in the larger streams.

The role of woody debris in the larger channels in the lower portion of the drainage basin is an understudied topic. Most literature reports that the effects of woody debris on rivers and large streams is greatly reduced, highly localized and usually associated with jams. Abbe and Montgomery (1996) describe the role of meander jams as bank protection, bar apex jams as protection for island formation, and the role of debris jams as historically being a factor in lake development, flood plain formation, and forced channel avulsion.

The Woody Debris System

Wood in streams can be viewed as an open system with wood input, transport and export components. Wood input processes are variable within the drainage network. Wood is entering the channel through a variety of mechanisms, including debris flows, tree fall and fluvial transport from upstream sources. Nakamura and Swanson (1993) reviewed the variety of processes that introduce wood into streams of the western Cascade Range of Oregon. They grouped the wood input process by the relative importance of that process in low (1st and 2nd), medium (3rd and 4th) and high (5th) order streams. Their study reported that treefall processes, specifically wind throw within the riparian zone, are ubiquitous within the drainage network and are a common source of wood to streams of all sizes. Mass wasting processes, specifically landslides, were most commonly associated with the input of woody debris in low order streams with steep narrow valleys. Debris flows were described as a more spatially variable input source

that played a major role in the delivery of woody debris to a 2nd order tributary and a 5th order stream within their study area. Medium order streams also received wood from mass wasting processes, mainly through streamside slides caused by incision. Higher order streams were associated with large amounts of woody debris delivered through bank erosion and treefall induced by lateral migration of the channel (Nakamura and Swanson, 1994). This statement is supported by a study of 2nd to 5th order streams in an old growth forest in Southeast Alaska, where 73% of the woody debris with an identifiable source was associated with bank erosion and wind throw (Murphy and Koski, 1989). An important aspect of wood input processes within the drainage basin is the recognition of how narrow a zone actually supplies wood to the channel. Murphy and Koski (1989) also found that nearly all of the wood in their streams originated within 30 meters of the channel.

The mobility of wood within the fluvial system can be best explained by the relationship between wood length and channel width. Wood is most mobile when its length is less than the bankfull width of the channel. Transported wood is on average smaller than wood that entered the channel locally (Nakamura and Swanson, 1994). The mobility of woody debris in a study of 2nd and 3rd order streams in northwest Wyoming was tied directly to the size of the debris (Young, 1994). Larger pieces were found to be the most stable, while smaller pieces had the highest mobility. Wood that was in contact with the water surface had a higher probability of movement than completely submerged wood. A study by Gregory (1991) in the Mackenzie River Basin of Oregon reported that in 1st to 7th order study streams no more than 10% of the woody debris moved per year

and that of the wood that was redistributed each year less than 15% was over 3 meters in length.

Wood is preferentially stored in areas where the transport capabilities of the stream are insufficient. Gurnell *et al.* (2000b) examined the retention of woody debris within the large Fiume Tagliamento basin in Italy. They explain the varying density of woody debris over 170 kilometers of stream within the basin by examining the processes that foster wood retention within the river system. The size, type and location of woody debris in the forested headwaters are predominantly a product of the character of the forest. The type of forest is very important in wood retention; a study of 2nd order streams in New Mexico reported that study reaches in coniferous forest had wood loadings 10 times higher than the reaches in aspen *Populus tremuloides* stands (Trotter, 1990). Regardless of forest type, in headwater streams wood is immobile and randomly distributed by treefall (Gurnell *et al.*, 2000b).

Wood in moderately sized streams is affected by forest character, but hydrologic character is the dominant factor in wood location; wood is more mobile, especially during floods, and it is more likely to be clustered into jams (Gurnell *et al.* 2000a). Woody debris in larger rivers, where the width of the channel is greater than the length of the trees, is most affected by the geomorphic character of the river. All wood in the larger rivers is transportable and wood can only be retained in specific locations where it is captured along the crest of bars, on the margins of islands, or piled against the outer bend of meanders (Gurnell *et al.* 2000a).

Channel planform also plays a role in wood loadings. Gurnell *et al.* (2000b) reported that single channel reaches in the Fiume Tagliamento retained an average of one

ton of wood per hectare, while reaches with multiple channels retained an average of six tons per hectare. Although braided channels have more surface area and therefore more potential to collect woody debris, the difference between the wood loadings of multiple and single channels is disproportionately high. Gregory's (1991) study of 1st to 7th order streams in Oregon found that although only 20% of the channel length was braided, 75% of the wood was located in these reaches. Piegay and Gurnell (1997) found in a wide range of streams in south England and southeast France that woody debris was preferentially stored in mobile channels of braided and wandering rivers. Nakamura and Swanson (1994) reported that in Lookout Creek, a 5th order stream in Oregon, reaches with multiple channels had almost twice the wood by volume that was found in single channel reaches. This study also found that the majority (61%) of the woody debris in the basin was retained on the floodplain and not in the active channel. Gregory (1991) reported that less than 30% of the woody debris found in the Mackenzie River Basin was located within the active channel.

Regardless of the location, wood retention is dependent upon the presence of large key members of wood. Removing large wood from channels reduces the number of possible wood retention sites. Kiem *et al.* (2000) found in their study of a 3rd order stream in the Oregon Coast Range that the addition of large key members resulted in a net increase in the total wood volume in the study area by between 86 and 155% over a 3-year period.

Wood that is retained in the drainage can have a very long residence time before decay removes it. Studies in North America have found that decay acts very slowly upon woody debris and is confined primarily to the surface of the wood, with little effect on

the interior of logs (Anderson *et al.*, 1978; Anderson and Sedell, 1979). Woody debris that is immersed in water is unable to support fungi, which are the principal agents in the terrestrial breakdown of wood. Wood in rivers is therefore limited to bacterial decomposition, which can act only upon a thin surface layer (Bilby, 2000). Anderson *et al.* (1978) reported that wood depletion by decay, abrasion and breakage is always faster on smaller pieces of debris. They also recognized the minor role that macroinvertebrates play in wood breakdown. Their study estimated that invertebrate fecal production in western Oregon streams was only 1 to 1.7% of the total volume of woody debris each year. This suggests that very little of the large wood (predominately conifer trees) found in streams of a temperate climates is susceptible to decay.

Gregory (1991) performed a dendrochronological analysis of nurse trees growing atop large woody debris and found that many of the woody debris supporting nurse trees were in place for up to 50 years. Smaller pieces of woody debris as well as many species of riparian trees are much more susceptible to breakdown and decay. Keim *et al.* (2000) reported that of the various species of woody debris placed in a 3rd order stream in the Oregon Coast Range, red alder (*Alnus rubra*) was initially the most effective at capturing small wood but was subject to rapid breakdown and decay when compared to larger conifer species. Their study reported that by the third year of the study, most of the alders were in a state of advanced decay and breakage. Despite the relatively rapid breakdown of some species of woody debris, most large wood is very resistant to breakdown and can be retained within the basin for an extremely long time, perhaps as long as centuries. Pieces of wood found in streams have been dated at over 1000 years old using dendrochronological and radioisotope methods (Bilby, 2000).

Human induced changes in land cover can change the rate of wood input, especially if the 30 meter buffer suggested by Murphy and Koski (1989) is violated. Even if a buffer zone between the drainage network and the developed basin is maintained, the removal of large wood key members for flood control or waterway navigation purposes can reduce the wood retention capacity of the stream.

The Effects of Fire on Woody Debris

The role of wildfires in changing both the forest cover and the hydrologic regime of streams within burned watersheds has been examined by a number of researchers. These studies primarily focused upon headwater streams of burned watersheds, which are the most heavily affected by fire-induced change (Minshall *et al.*, 1989; Minshall *et al.*, 1997). Studies in burned and unburned watersheds of the Yellowstone area in northwestern Wyoming (Lawrence, 1991; Young, 1994; Minshall *et al.*, 1997) reported that wood loadings were higher in the burned watersheds and that the overall mobility of woody debris was greater. Young (1994) found that woody debris in Jones Creek, a stream in a burned watershed adjacent to Yellowstone National Park, was 3 times as likely to move and moved over 4 times farther than woody debris in Crow Creek, an adjacent but undisturbed watershed. Minshall *et al.* (1989) studied wood retention in the headwater streams of Yellowstone National Park and created a hypothetical response model for woody debris in 1st through 3rd order streams after a wildfire.

Despite the efforts of many researchers, there are gaps in the current research on woody debris in areas affected by wildfires. Although the research covers a wide area, it is limited to a few study reaches in a large number of streams. Very little work has

focused upon extensive longitudinal surveys of large woody debris in an entire basin.

There is a need for greater understanding of the changing influence of woody debris from the transport-limited zone of the headwaters to the supply-limited zone in larger channels in both burned and undisturbed watersheds.

CHAPTER 2

STUDY AREA AND METHODS

Study Area

The study was conducted on Soda Butte Creek and Cache Creek, tributaries of the Lamar River in Yellowstone National Park (Figure 1). A ten-kilometer portion of Pebble Creek, a tributary of Soda Butte Creek was also included during the analysis portion of the study. These streams are excellent for a study of woody debris because wood has never been removed from the streams and the natural landcover of the area has not been directly modified by human action.

The study portions of Soda Butte and Cache Creeks flow southwestward from an elevation of over 2300 meters to approximately 2000 meters at their confluences with the Lamar River. The climate of the study area is montane; 75-85% of the precipitation is snow or rainfall on snowpack (Despain, 1987). The average annual peak flow for Soda Butte Creek is nearly 50 cubic meters/second (m^3/s), while the average annual flow is approximately $6 \text{ m}^3/\text{s}$. Cache Creek, although not gauged, has a similar runoff regime. In both Soda Butte Creek and Cache Creek, peak annual flows occur during late spring when the winter snow pack melts.

The upper portions of Soda Butte Creek are primarily subalpine forests containing Engelmann Spruce (*Picea engelmannii*), Sub-alpine fir (*Abies lasiocarpa*), and Douglas fir (*Pseudotsuga menziesii*). The lower portions vary between open meadow and forests that are primarily Lodgepole Pine (*Pinus contorta*). Soda Butte Creek also has extensive

meadows in the lower portion of its basin. The vegetation in Cache Creek was heavily burned by wildfire in 1988, so forest coverage is minimal.

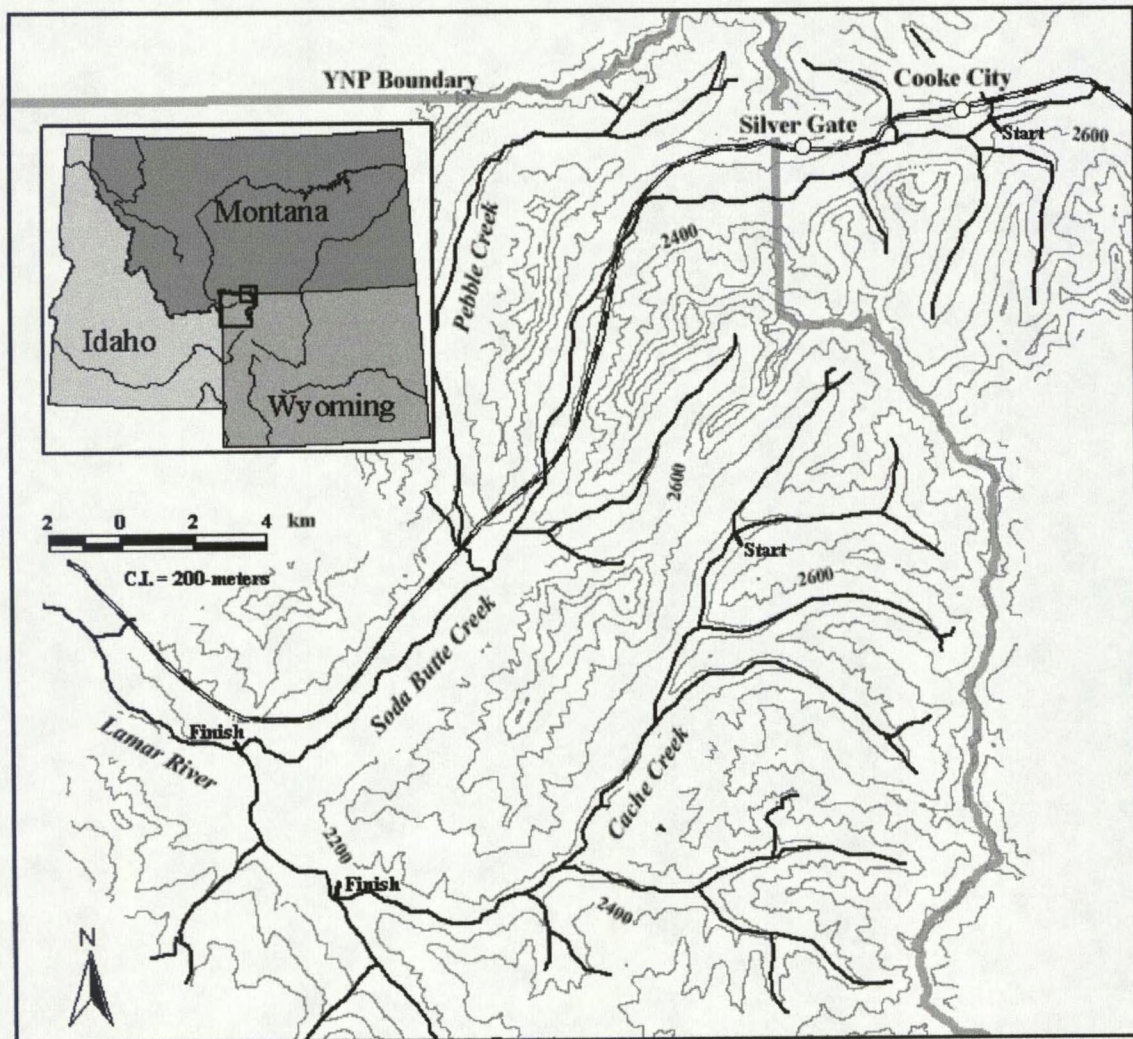


Figure 1. The study area with inset map.

Both streams exhibit the highly variable geomorphic character associated with mountain streams. The streams occupy valleys that are glacially modified but are confined in some reaches by mass wasted material from the steep valley walls. Dominant channel substrate sizes range from small cobbles to boulders, with Cache Creek being a

predominately cobble to small boulder-bed stream and Soda Butte Creek most commonly having a coarse gravel to cobble bed. Although each stream flows over a bedrock nick-point that is formed by the Mississippian Madison Limestone Group, the underlying geology is overwhelmingly friable volcanic clastic rock from the Eocene Absaroka Volcanic Super Group (Prostka *et al.*, 1975; Meyer, 2001).

Soda Butte Creek has been the subject of studies on trace metals in streams (Marcus *et al.*, 1996; Ladd *et al.*, 1998), on the remote sensing of streams (Wright *et al.*, 2000) and stream sediment studies (Marcus *et al.*, 1995). Cache Creek has been the site of a ten-year stream ecology project (Minshall, 1995). Both Soda Butte Creek and Cache Creek have also been the subject of woody debris studies (Marcus *et al.*, in press). Information collected during past studies provides an excellent resource to ongoing research. Together Soda Butte and Cache Creeks permit the study of streams over a variety of conditions at both the watershed and local reach scale.

Field Methods

Testing the research hypotheses required the collection of data on channel width, as well as surveys of the distributions of large woody debris throughout the watershed. Emphasis was placed on the 2nd, 3rd and 4th Horton-Strahler Ordered segments of streams on the USGS 7.5 minute quadrangles, where the streams are wide enough for wood transport.

I adopted a continuous longitudinal sampling scheme to capture the inherent variability of mountain streams and to discern if natural breaks exist in wood transport

and deposition. The extensive nature of this study required quick counts in order to complete the work within a summer field season.

The longitudinal distribution of wood was tallied within a 100-meter segment measured down the centerline of the stream with a sub-meter precision laser range finder. The 100-meter distance was used because longer segments proved difficult to measure accurately, while shorter segments would have required more time, restricting the extent of the study.

Each 100-meter segment was classified using a number of nominal categories adopted from the Montgomery and Buffington system (Montgomery and Buffington, 1993). The type of valley confinement, valley floor cover, channel control, channel planform, channel character, and a channel substrate estimate were recorded for each 100-meter segment. The categorization of each segment provided a basis for the comparison of segments and helped in identifying factors outside those in the research hypotheses that influence woody debris distributions.

Channel widths were measured using a tape, hand level and stadia rod. All width measurements used a field-observation-derived bankfull stage as their basis.

The survey portion of this study was two-fold. One team member was responsible for identifying and counting the in-stream morphologic units that would later be compared to the woody debris counts. This team member counted the number of Bisson habitat units (Bisson *et al.*, 1982) for each segment. The following morphologic units were counted; plunge pools, scour pools, backwater pools, runs, glides, high and low gradient riffles and steps.

The second team member was responsible for categorizing and counting woody debris. Woody debris was categorized by a number of factors including size, location and associated morphology. The classification of woody debris was based upon a dichotomous key (Appendix A) created during a field methods validation on a variety of test reaches. This key was devised to describe as many different types of woody debris as possible with a minimal amount of subjectivity. Categories for woody debris were based upon earlier studies in the literature (Nakamura and Swanson, 1993; Davis *et al.*, 1997). The following woody debris counts were collected for each 100-meter segment; single logs, agglomerations of 2-5 logs (clusters), jams of > 6 logs, suspended wood, ramped wood, submerged wood, bar wood, bar top wood and partially buried wood. From these counts, the following wood counts were calculated for each segment; total wood counts, active (in channel only) wood counts and floodplain wood counts. Great effort was taken to reduce the level of subjectivity within the data. The field team tested and then practiced the routine of data collection in the weeks prior to the study and did not rotate in their duties once the study began.

The combined wood counts were calculated using a formula that was derived after observing the average number of logs in each type of wood agglomeration. The rules of the dichotomous key resulted in the average whole number size of jams being eight logs and the average whole number size of 2-5 log clusters being three logs. These figures were used in the following equation to calculate the total wood loading for each 100-meter segment of stream in the study.

$$\text{Total Wood} = 8(\text{Jam Count}) + 3(2\text{-}5 \text{ Count}) + \text{Single Log Count}.$$

This total count was broken down further into active channel counts by separating bar top wood and suspended wood from ramped, submerged and buried wood counts.

Statistical Considerations

A number of different statistical methods were employed in the attempt to resolve the five original research questions. The most important of the techniques was the analysis of regression coefficients to assess the possible relationship between channel width and woody debris counts. Although simple linear regression was not designed for count data, this technique is robust enough when used only to determine the presence of and direction of a relationship. This technique was also used to examine the relationship between woody debris counts and in channel morphologic unit counts. Each of these questions was backed up with results from a non-parametric Spearman's rank correlation.

The comparison of woody debris counts from Soda Butte Creek and Cache Creek was conducted using a non-parametric Wilcoxon Rank Sum Test, because the variance of the wood counts from Soda Butte Creek were much higher than the wood counts from Cache Creek. The test was run on two continuous 10-kilometer samples that were selected from each stream. The samples began where each stream changed to 3rd order on the USGS 7.5 minute quadrangles. The sample sites and sample size were selected to minimize any differences in basin area, slope or underlying geology between the two streams.

All of the research questions in this study utilized some form of count data. Count data is supposed to follow a Poisson Distribution. The count data from this study was displayed in a histogram and then compared to its Poisson Distribution using a chi-

square goodness of fit test. The actual wood counts were loosely Poisson distributed but the computed total counts were not, chi-square values exceeded 100 in each test. All of the wood counts had a much higher variance than would be expected from count data, but still displayed a single mode bell-shaped distribution where mean, median and mode were comparable.

Even with the highly variable nature of the wood counts there was some degree of spatial autocorrelation between the counts from neighboring segments. There was statistically significant positive autocorrelation ($p\text{-value} < 0.05$) in the counts from both Soda Butte and Cache Creek out to a distance of three lags or 300 meters. This was also true of the channel width measurements from each stream. Despite the minor level of spatial autocorrelation in both the wood counts and the channel metrics measurements, the data does lend itself to a variety of statistical methods.

CHAPTER 3

RESULTS AND DISCUSSION

Results

The following section presents the data collected in this study. The analysis was limited primarily to wood counts, morphologic unit counts and channel width measurements, so these variables receive the most attention.. However, the stream segment classification data and basin metric information were also a valuable contribution to the study, so they are included as well.

Basin Metrics and Segment Classification

Table 1 is a summary of the basin characteristics for Soda Butte and Cache Creeks. The table provides the range of channel elevation, channel slope and drainage basin area for the portions of the streams included in the study as well as the summary of the Montgomery and Buffington categories for each 100-meter stream segment in the study.

Table 1. Summary of study area information for Soda Butte and Cache Creeks.

	Soda Butte Creek	Cache Creek
Stream Metrics		
Elevation (m)	2298-2005	2355-2042
Slope (m/m)	0.003-0.045	0.009-0.060
Drainage Area (km ²)	46.66-266.93	41.62-211.47
Study Length (km)	35.1	19.1
Stream Order	3rd-4th	3rd-4th

Table 1 continued.

	Soda Butte Creek	Cache Creek
Valley Floor Cover		
% classified as Burned	0	87
% Forest	54.5	12.5
% Meadow	45.5	0.5
Valley Floor Width		
% classified as <2 channel widths	19.6	32.8
% 2-4 channel widths	30.4	62
% >4 channel widths	50	5.2
Channel Control		
% classified as Bedrock controlled	3.4	15.6
% Colluvial controlled	14.8	49.5
% Alluvial controlled	81.8	34.9
Channel Planform		
% classified as Braided	29.5	8.3
% Meandering (sinuosity >1.1)	40.1	76
% Straight	30.4	15.7
Channel Character		
% classified as Step/Pool	9.7	47.9
% Riffle/Pool	57.1	50.5
% Run/Glide	33.2	1.6
Channel Substrate D₅₀ Estimate		
% classified as Boulder	13.4	56.8
% Cobble	58.5	42.7
% Gravel	28.1	0.5

Woody Debris Counts

Table 2 is a summary of the woody debris data collected in the study area portions of both Soda Butte and Cache Creeks. The table includes both the total wood counts as well as the various counts for each category of woody debris in the dichotomous key.

The complete data for these counts is provided in Appendices B and C.

Table 2. Summary of woody debris data for Soda Butte and Cache Creeks.

	Soda Butte Creek	Cache Creek
Single Logs in Active Channel		
Sum	1014	421
Min/max	0/16	0/10
Mean	2.81	2.19
Variance	9.07	3.93
Clusters in Active Channel		
Sum	636	245
Min/max	0/8	0/6
Mean	1.76	1.28
Variance	3.83	1.43
Jams in Active Channel		
Sum	230	96
Min/max	0/6	0/4
Mean	0.64	0.50
Variance	1.10	0.65
Total Wood in Active Channel		
Sum	4762	1924
Min/max	0/67	0/37
Mean	13.19	10.02
Variance	167.12	49.28
Suspended Single Logs		
Sum	40	31
Min/max	0/4	0/2
Mean	0.11	0.16
Variance	0.19	0.19
Ramped Single Logs		
Sum	571	353
Min/max	0/14	0/8
Mean	1.58	1.84
Variance	3.66	3.30
Submerged Single Logs		
Sum	443	68
Min/max	0/8	0/3
Mean	1.23	0.35
Variance	3.01	0.42

Morphologic Unit Counts and Channel Metrics

The in-stream morphologic unit counts; channel width and depth measurements are displayed in the Table 3. The complete data for Soda Butte and Cache Creeks is also provided in Appendices B and C.

Table 3. Summary of morphologic unit counts, channel width and depth for Soda Butte and Cache Creeks.

	Soda Butte Creek	Cache Creek
Scour Pools		
Sum	442	55
Min/max	0/7	0/2
Mean	1.22	0.29
Variance	1.76	0.27
Plunge Pools		
Sum	185	366
Min/max	0/4	0/8
Mean	0.51	1.91
Variance	0.62	3.54
Total Pools		
Sum	627	421
Min/max	0/9	0/9
Mean	1.74	2.19
Variance	2.74	4.16
Backwater Pools		
Sum	217	85
Min/max	0/3	0/3
Mean	0.6	0.44
Variance	0.53	0.42
Runs		
Sum	332	125
Min/max	0/4	0/10
Mean	0.92	0.65
Variance	0.86	0.94

Table 3 continued.

	Soda Butte Creek	Cache Creek
Glides		
Sum	745	130
Min/max	0/8	0/3
Mean	2.06	0.68
Variance	2.01	0.49
LG Riffles		
Sum	778	181
Min/max	0/8	0/3
Mean	2.16	0.94
Variance	2.53	0.55
HG Riffles		
Sum	532	316
Min/max	0/9	0/10
Mean	1.47	1.65
Variance	1.71	1.17
Steps		
Sum	74	323
Min/max	0/4	0/8
Mean	0.2	1.68
Variance	0.36	4.28
Total Units		
Sum	3305	837
Min/max	1/27	1/12
Mean	9.16	4.36
Variance	24.32	3.29
Total Width all Channels (m)		
Min	4.3	7.9
Max	116.2	72.1
Mean	23.07	20.72
Variance	191.83	82.51
Max Depth (m)		
Min	0.25	0.7
Max	4.05	8.5
Mean	1.31	1.73
Variance	0.37	0.56

Discussion

Section 1: a priori hypotheses

The primary objective of this study was to provide greater understanding of wood distributions within burned and undisturbed watersheds and how these distributions relate to stream morphology by surveying woody debris at the basin scale. The study questioned the relationship between channel width and three factors in woody debris distributions; wood quantity, wood contact with the channel, and the agglomeration of wood into groups or jams. This study also investigated a possible relationship between woody debris and in-channel morphologic units. Finally, the study contrasted the woody debris counts in burned and undisturbed watersheds.

Hypothesis 1:

Channel Width and Quantity of Wood

The first hypothesis is that increasing channel width reduces the count of woody debris. This was tested by using a null hypothesis that channel width has no effect upon woody debris counts in the study. Figure 2 shows scatter plots and a least squares regression of the channel widths and woody debris counts for each stream. If the null hypothesis were true, the slope of the regression would not differ significantly from zero.

The regression equation for Soda Butte Creek has relatively little use as a predictor with an R^2 of 0.11 and a standard error of over 12 pieces of wood. However a T-test of the regression slope coefficient showed that it differed significantly from the null of zero, ($p < 0.01$), indicating that channel width has a weak but significant negative effect on woody debris counts in Soda Butte Creek. In Cache Creek the regression had

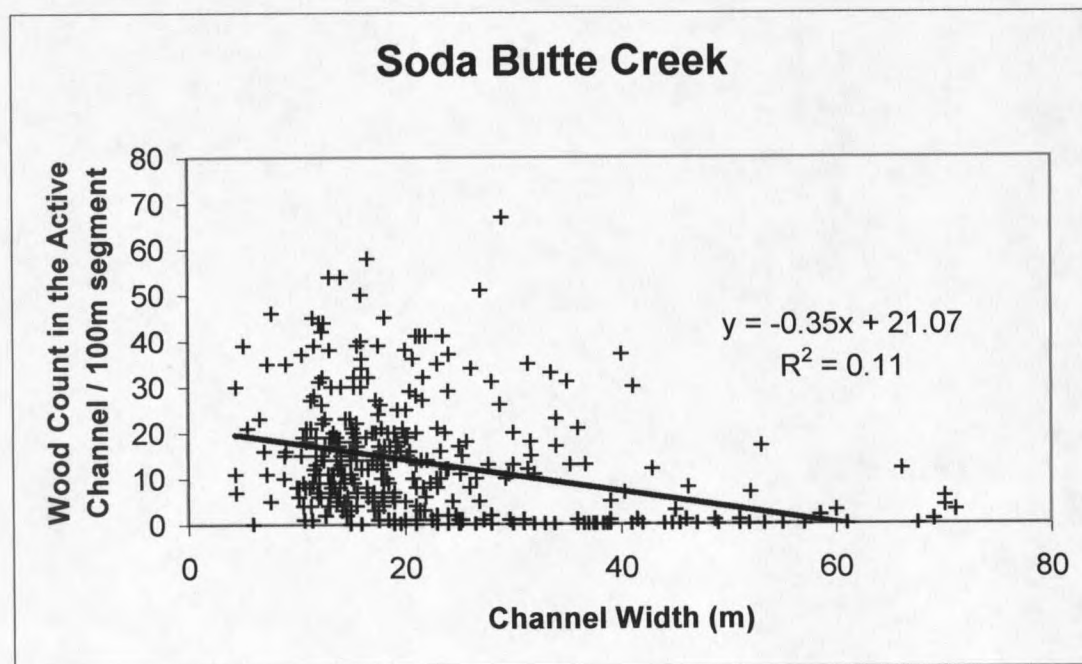
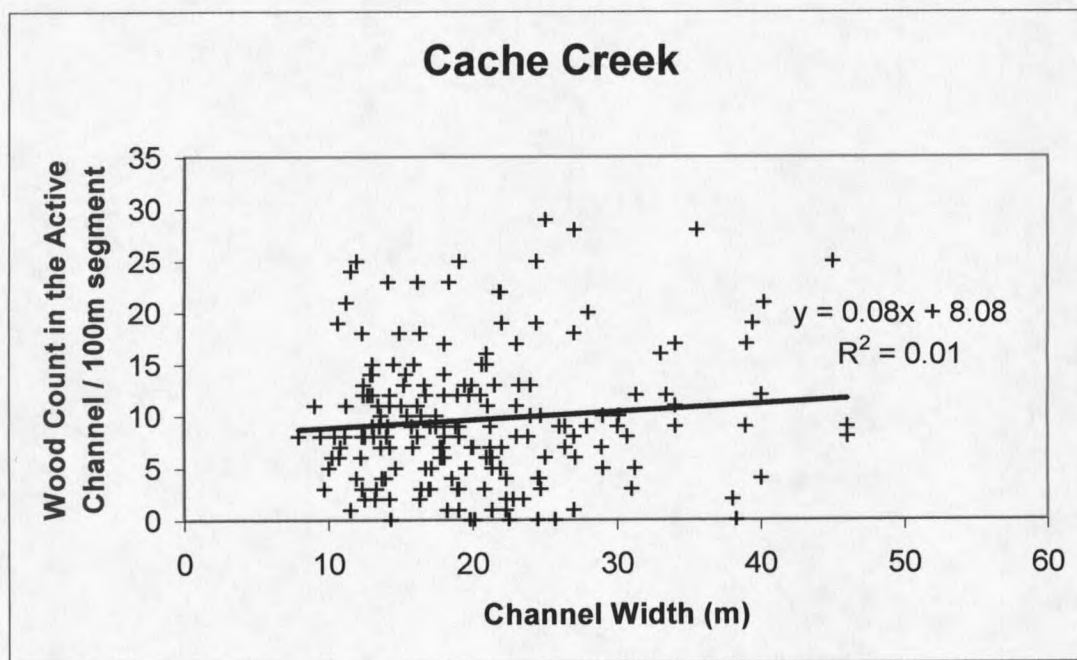


Figure 2. Scatter plots and regressions of Cache Creek and Soda Butte Creek wood counts versus channel width.

an R^2 of only 0.01, and the slope did not differ significantly from zero, ($p = 0.19$), suggesting that channel width has little effect on the wood counts in Cache Creek.

Hypothesis 2:

Channel Width and Wood Contact

The second research hypothesis evaluates the level of wood contact with the channel as a function of channel width. Simple physical reasoning supports the idea of woody debris interacting very little or none with smaller channels in the upper watershed, because fallen trees tend to span the channel. During data collection, woody debris was categorized into wood interaction classes. Each class represented a different level of wood contact with the channel. Log jams and other wood agglomerations could often be categorized in more than one class, so the data set for this hypothesis was restricted to single logs. Braided reaches were also excluded to simplify the determination of total channel width for each segment of stream. Figure 3 shows the percentage of total wood in each class as a function of channel width. Each width category had a sample size of roughly 25 segments.

If the hypothesis that the proportion of wood in contact with the channel increases in larger channels is true, the percentage of suspended woody debris should drop off with increasing channel width, while the submerged category of wood should become a progressively larger component of the woody debris. Although the graphs of Soda Butte and Cache Creeks do show a decrease in the percentage of woody debris characterized as suspended wood (Figure 3), the suspended category remains a component of the wood count in even the largest channel width categories, while the ramped and submerged categories remain in fairly constant proportions throughout the width categories,

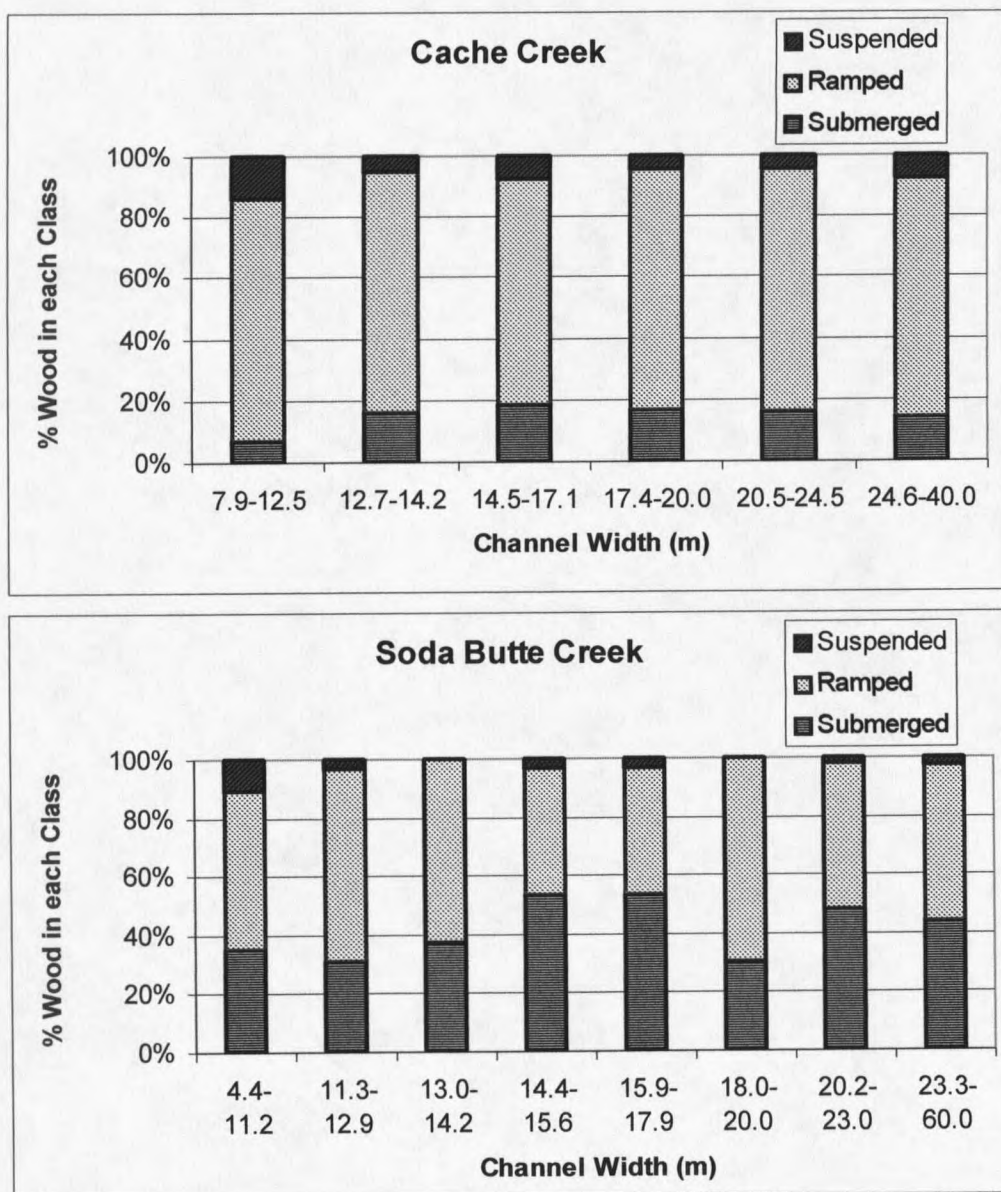


Figure 3. Cache Creek and Soda Butte Creek single log interaction for channel width categories, each class contains roughly 25 samples.

suggesting that channel width has little effect on the ramped and submerged categories of woody debris.

An analysis of variance for each category of wood showed a slight but significant variation ($p < 0.05$) in the between column means of the Suspended category of Soda Butte Creek (Table 4), while the other categories did not vary appreciably. The ANOVA for the Cache Creek wood also showed slight but significant variation in the between column means in the suspended category but the submerged and ramped categories had no measurable variation. The weak results of these tests do not provide support for the notion there is increased wood interaction with the channel with increasing channel width.

Hypothesis 3:

Channel Width and Wood Agglomeration

The third research hypothesis is that the size of wood agglomerations should increase with increasing channel width. During data collection, wood was grouped into three categories of wood agglomerations. Independent logs were categorized as single logs, while collections of greater than two but less than six logs were assigned to the cluster category, and woody debris agglomerations that were greater than 5 logs were grouped into one or more jams (Appendix A). Again, the data set for this hypothesis was limited to single strand channels.

Figure 4 shows the three agglomeration categories as a percentage of total wood on a bar graph with channel width categories of approximately 25 segments per category. If wood agglomerations increase in size as the channel width increases, the proportion of wood in jams should increase with increasing channel width. Figure 4 shows that this is

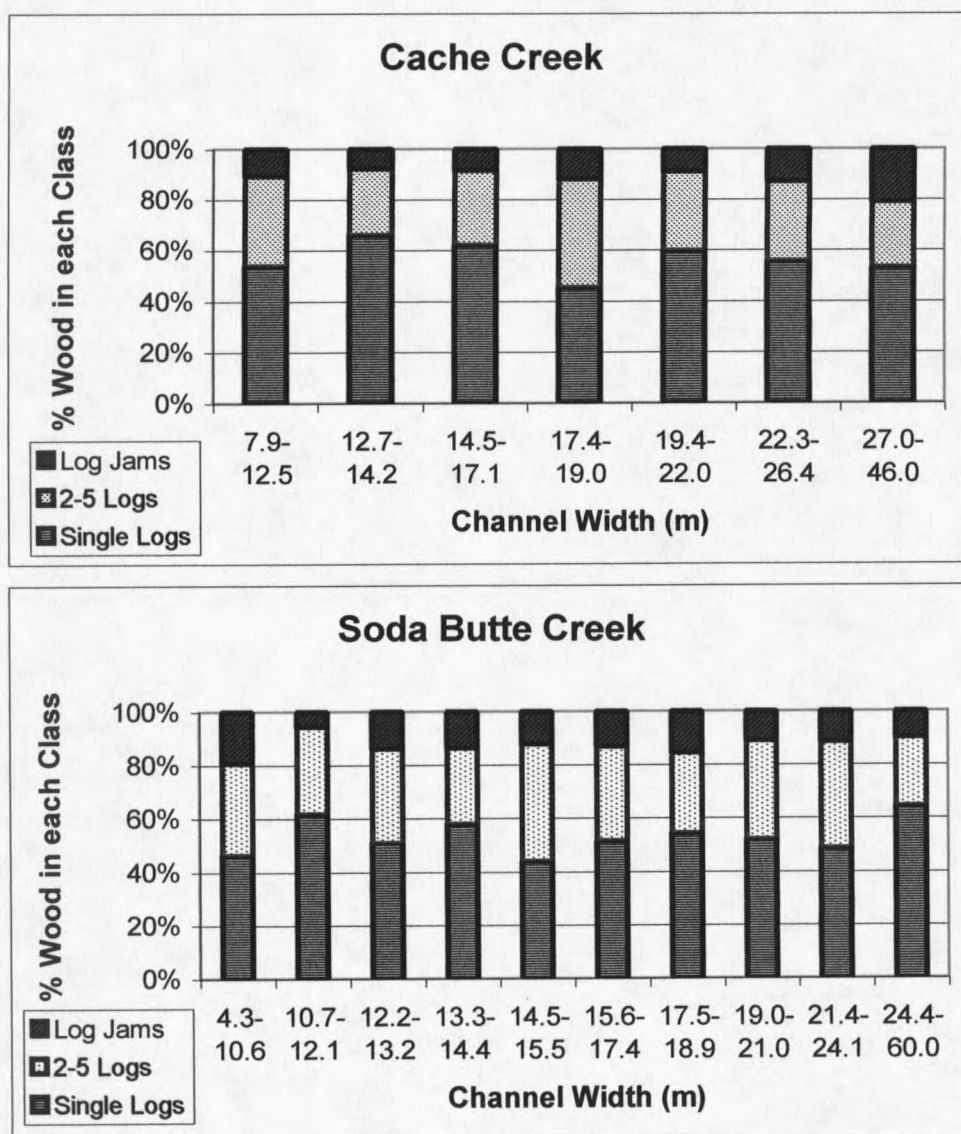


Figure 4. Cache Creek and Soda Butte Creek wood agglomeration for channel width categories, each category has roughly 25 samples.

not the case. Jams, clusters, and single logs remain in fairly constant proportions throughout the channel width categories.

An analysis of variance was conducted on the between column means of the channel width categories for each class of wood agglomeration (Table 4); the results of the ANOVA for Soda Butte Creek suggested that there was no difference between the means of each width category, with all p-values being greater than 0.32. The ANOVA for Cache Creek showed significant variation in the single log means ($p = 0.01$), but the other means had high F-ratios that were comparable to those in Soda Butte Creek. The results of the ANOVA's and the description of the agglomeration counts in the graphs suggest that channel width in the study area has little or no effect on wood agglomeration.

Table 4. Summary of ANOVA results for research hypotheses 2 and 3. F is the ratio of between category variance to within category variance.

	Cache Creek			Soda Butte Creek		
Hypothesis 2: Width and Wood Contact	n=143	F	p-value	n=206	F	p-value
Suspended Wood		2.93	0.02		3.86	0.05
Ramped Wood		0.48	0.75		3.31	0.02
Submerged Wood		1.42	0.23		1.84	0.12
Hypothesis 3: Width and Wood Agglomeration	n=169	F	p-value	n=231	F	p-value
Single Logs		3.70	0.01		0.59	0.67
2-5 Logs		0.95	0.44		1.17	0.32
Jams		0.93	0.45		0.37	0.83

Hypothesis 4:

Woody Debris and Channel Morphology

The fourth research hypothesis explores the widely accepted perception that channels with woody debris are more geomorphically complex than similar channels without woody debris (Beschta and Platts, 1986; Robison and Beschta, 1990; Smith *et al.*, 1993b). Specifically, does increased woody debris density result in a corresponding increase in the number of channel morphologic units?

Figure 5 depicts scatter plots and regressions of the counts of woody debris and morphologic units that were collected for each stream segment. The presence of the relationship was tested using a null hypothesis that woody debris had no effect on morphologic units. If the research hypothesis is correct, then the regression slope will be positive and significantly differ from zero.

The regression equation for Soda Butte Creek had an R^2 of 0.10 (Figure 5); while the results of the T-test of the regression coefficient suggest that the relationship is positive and differs significantly from zero ($p < 0.01$). Cache Creek had an R^2 of 0.04 (Figure 5), and the T-test of the regression coefficient implies that the relationship is slightly positive and differs significantly from zero ($p < 0.01$). Figure 6 shows a similar scatter plot for riffles and pools only. The plots for Soda Butte and Cache Creeks show that woody debris has a slight effect upon the count of riffles and pools in stream reaches. These results suggest that woody debris has a significant positive effect on the density of morphologic units and the level of geomorphic complexity in that segment.

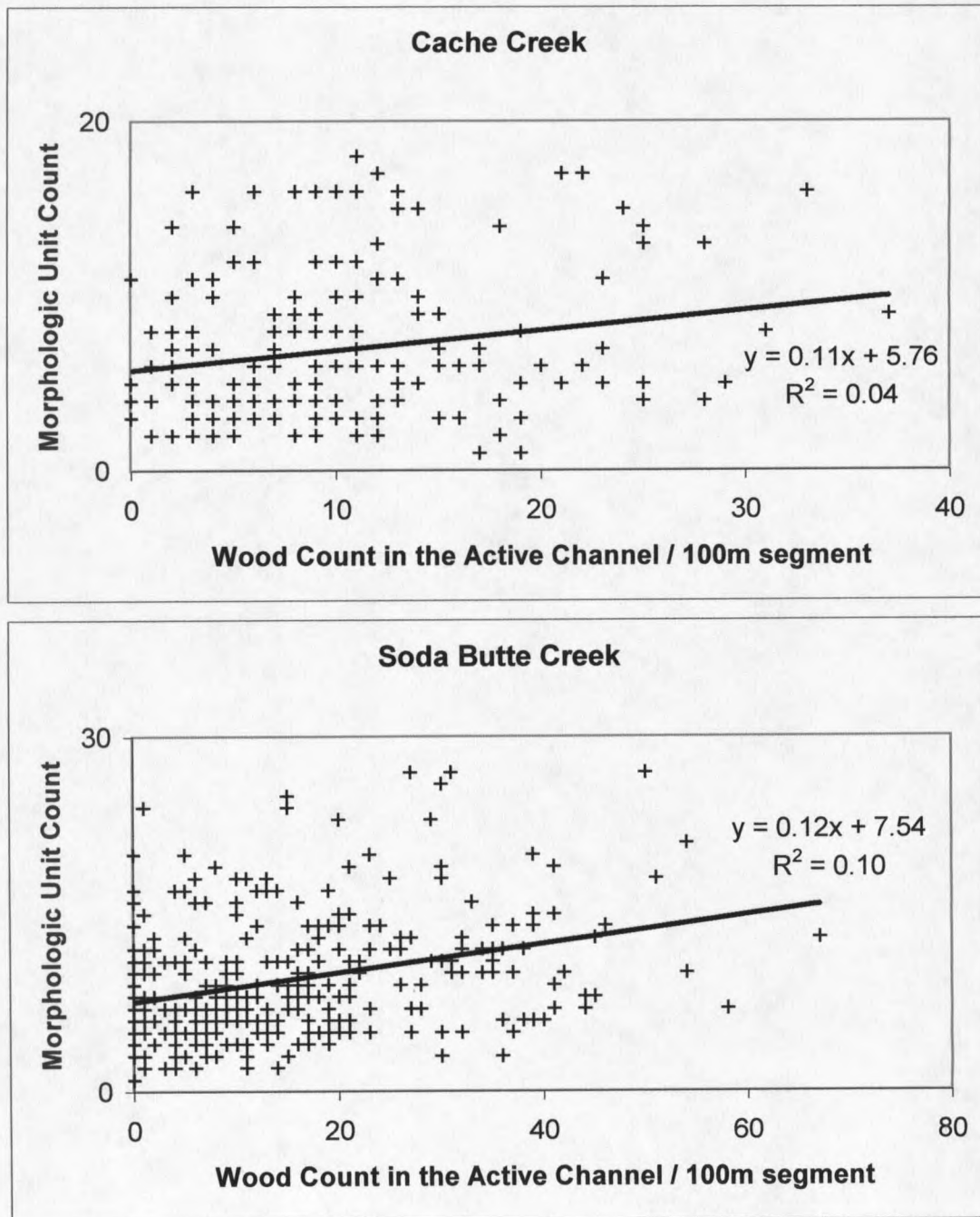


Figure 5. Scatter plot of Cache Creek and Soda Butte Creek wood counts and the number of morphologic units in 100-meter reaches.

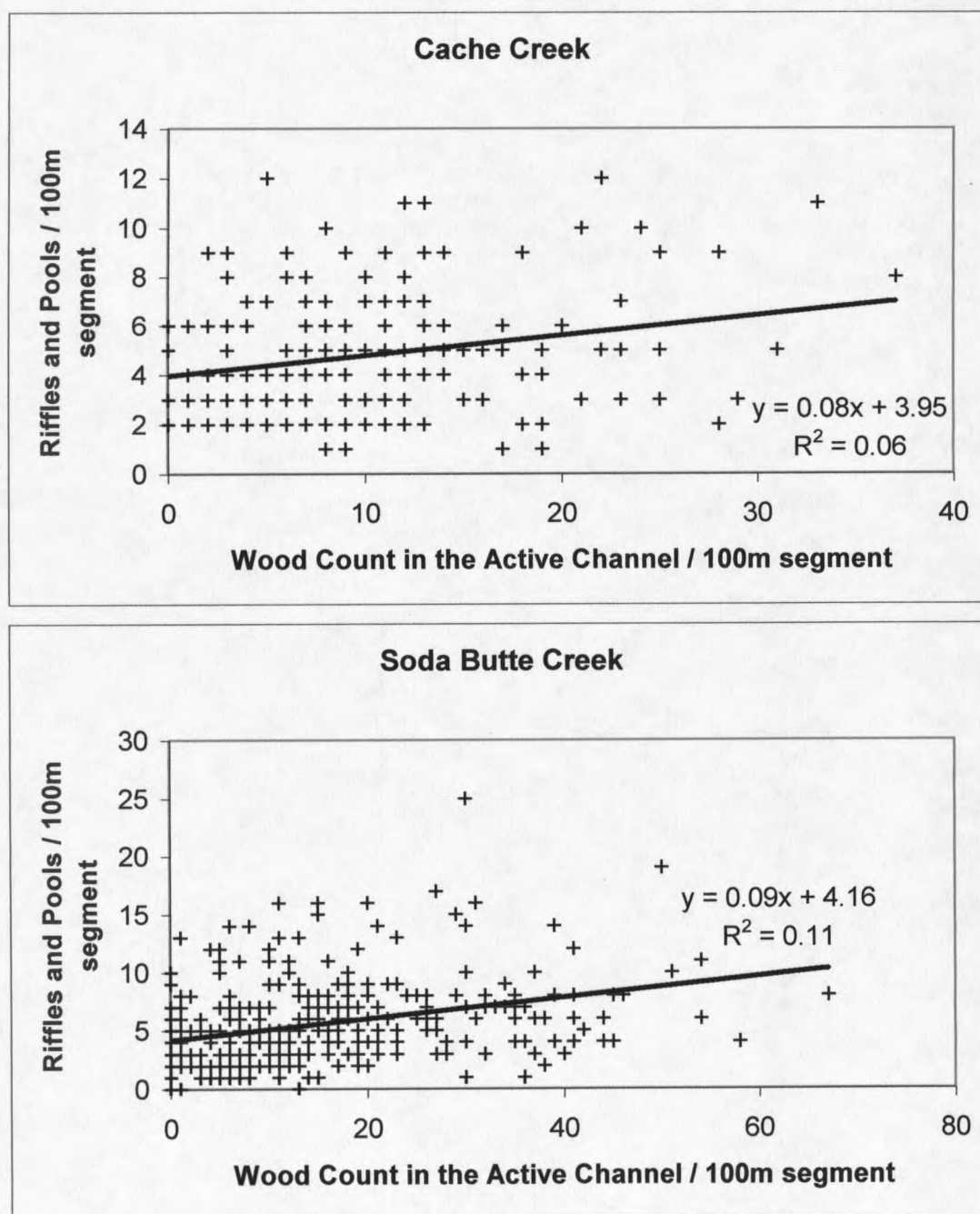


Figure 6. Scatter plot of Cache Creek and Soda Butte Creek wood counts and the number of riffles/pools in 100-meter reaches.

Hypothesis 5: Woody Debris in Burned and Undisturbed Streams

The final hypothesis of this study tests the assumption that the woody debris loadings in a stream from a burned basin are higher than the woody debris loadings from a similar sized stream in an undisturbed basin (Lawrence, 1991; Young, 1994; Minshall *et al.*, 1997). The null hypothesis for this question was that there was no significant difference in wood counts between the burned and control streams.

This hypothesis was tested using similar 10-kilometer samples from Soda Butte and Cache Creeks. Figure 7 shows a box plot of the wood loadings for Soda Butte and

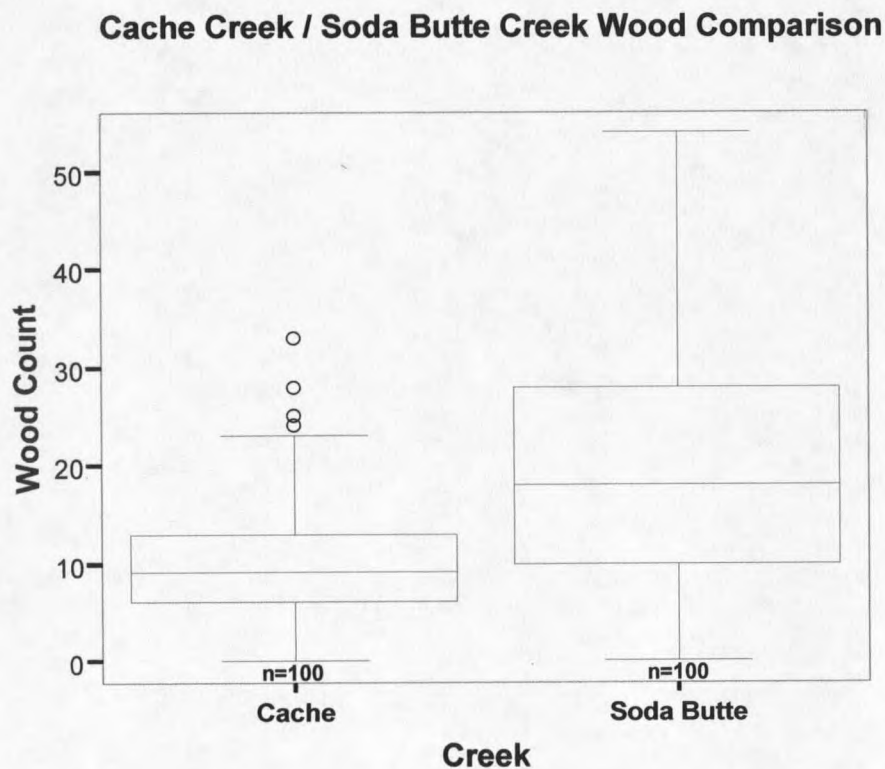


Figure 7. Box plot of Cache vs. Soda Butte Creek wood loadings. The centerline is the median; boxes denote quartiles and whiskers represent 1.5 times the interquartile range.

Table 5. Summary of statistical results for selected research hypotheses. Spearman's are non-parametric rank correlations; b is the slope of the regression; Z is the z score for the Wilcoxon rank statistic.

	Cache Creek	Soda Butte Creek
Hypothesis 1:		
n	192	361
R ²	0.01	0.11
b	0.08	-0.35
p-value	0.19	5.41E-11
Spearman's	0.04	-0.40
Hypothesis 4:		
Morphologic Units:		
n	192	361
R ²	0.04	0.10
b	0.11	0.12
p-value	0.006	4.20E-10
Spearman's	0.19	0.49
Riffles/Pools:		
n	192	361
R ²	0.06	0.11
b	0.08	0.09
p-value	0.001	7.67E-11
Spearman's	0.25	0.53
Hypothesis 5:		
n	200	same
Z	6.89	as
p-value	1.68E-10	Cache

Cache Creeks. The figure shows the undisturbed stream has higher wood loadings. The results of the Rank Sum Test provide statistical support for the observed trend (Table 5).

The 10-kilometer samples from Soda Butte Creek had significantly higher wood loadings

than the sample from Cache Creek ($p < 0.01$). The results of this test suggest that although the null hypothesis was rejected, and that the expected results in research hypothesis were the opposite of reality. Despite its undisturbed nature, Soda Butte Creek has significantly higher woody debris counts per segment than Cache Creek.

Section 2: a posteriori hypotheses

The results of the tests on the research hypotheses raise many interesting questions. Many of the expected trends were not evident in the data. This discussion will address both the absence of basin-wide trends in woody debris as well as other factors that potentially affect wood distributions. Finally, it will examine woody debris as a tool for stream restoration.

Hydraulic Controls on Wood

The objective of this study was to relate the basin-wide distribution of large woody debris to patterns and trends in hydrologic and geomorphic variables. The research hypotheses originated from previous literature, which is largely based on classic hydraulic geometry concepts that assume that streams change in a fairly regular and unidirectional manner with increasing drainage area, discharge or channel width.

The physical arguments for channel width affecting the distribution of woody debris are strongly supported by the literature (Nakamura & Swanson, 1993; Minshall *et al.*, 1997; Marcus *et al.*, in press). Wider channels present the stream with greater opportunities to transport woody debris; so wood loadings should vary in channels of differing width.

However, the results of the first three research hypotheses show that channel width has little effect on basin-wide trends in woody debris counts, accumulation into jams or channel interactions. Although data from Soda Butte Creek supported the first hypothesis on the relationship between woody debris loadings and channel widths (Figure 2), this can be attributed to other factors that will be addressed later. Likewise, the Analyses of Variance for hypotheses two and three found little significant variation in woody debris jams or channel interaction with width, which implies other factors are driving variations throughout the basin.

A study of this nature may have shown a closer relation between hydraulic variables and wood if it had focused upon a set of alluvial dominated streams, where geologic structure and relict geomorphology are likely to play a minor role. It is certain however, that in the mountainous basins of northeastern Yellowstone, hydraulic factors have very little control over the spatial distribution of large woody debris.

The Absence of Basin Wide Trends

The continuous data collected in this study calls into question the concept of uniform basin-wide trends and wood research that is based upon sample sites selected as "representative reaches". The spatial variability of the streams in this study defies almost any sampling scheme.

Before surveying the distribution of large woody debris at the basin scale, it is important to recognize that the streams in the study area are highly variable mountain streams that do not exhibit the relationships that the hydraulic geometry concept prescribes. Figures 8-9 provide scatter plots of drainage area and distance downstream

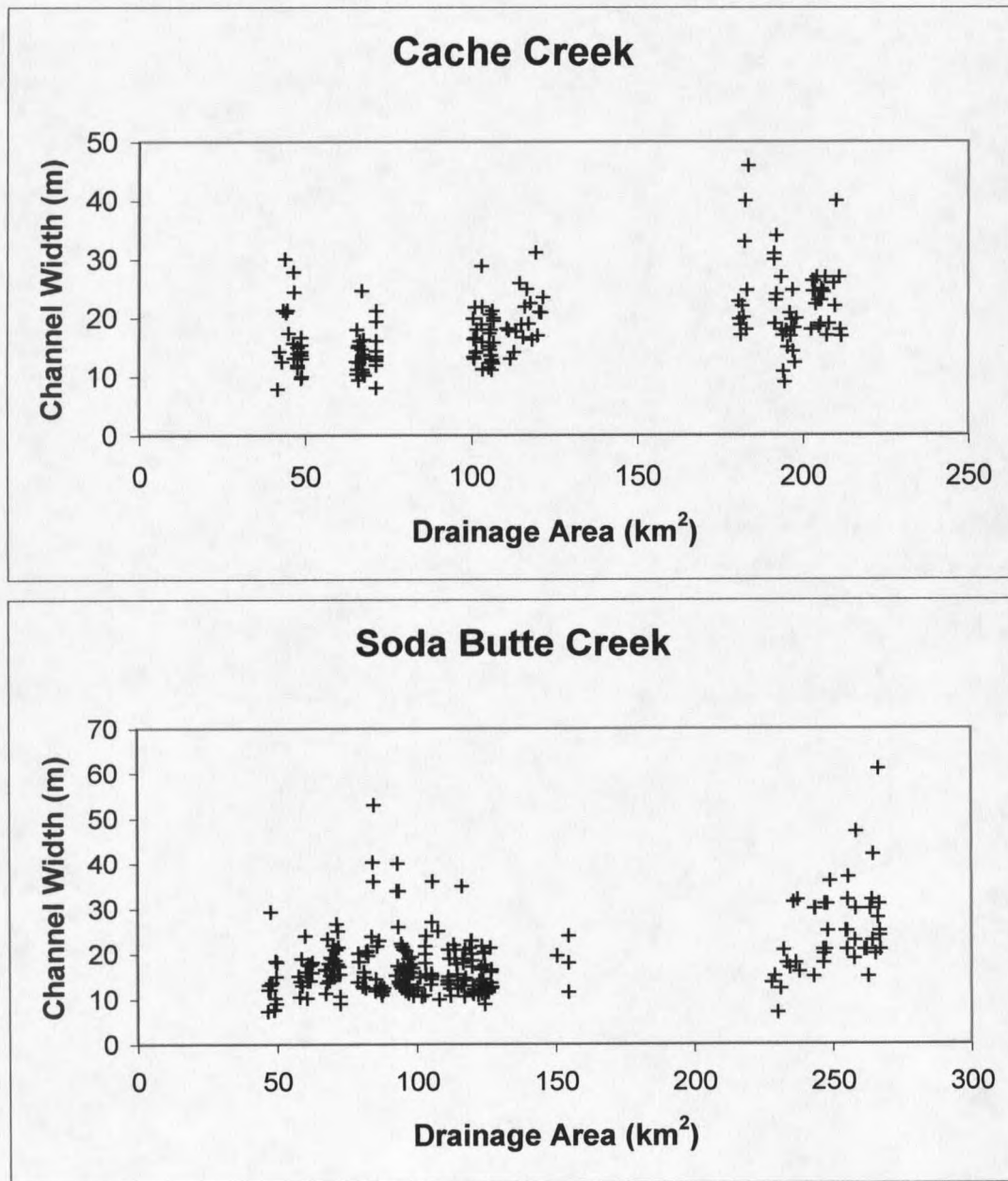


Figure 8. Scatter plots of Cache and Soda Butte Creek drainage area versus channel width.

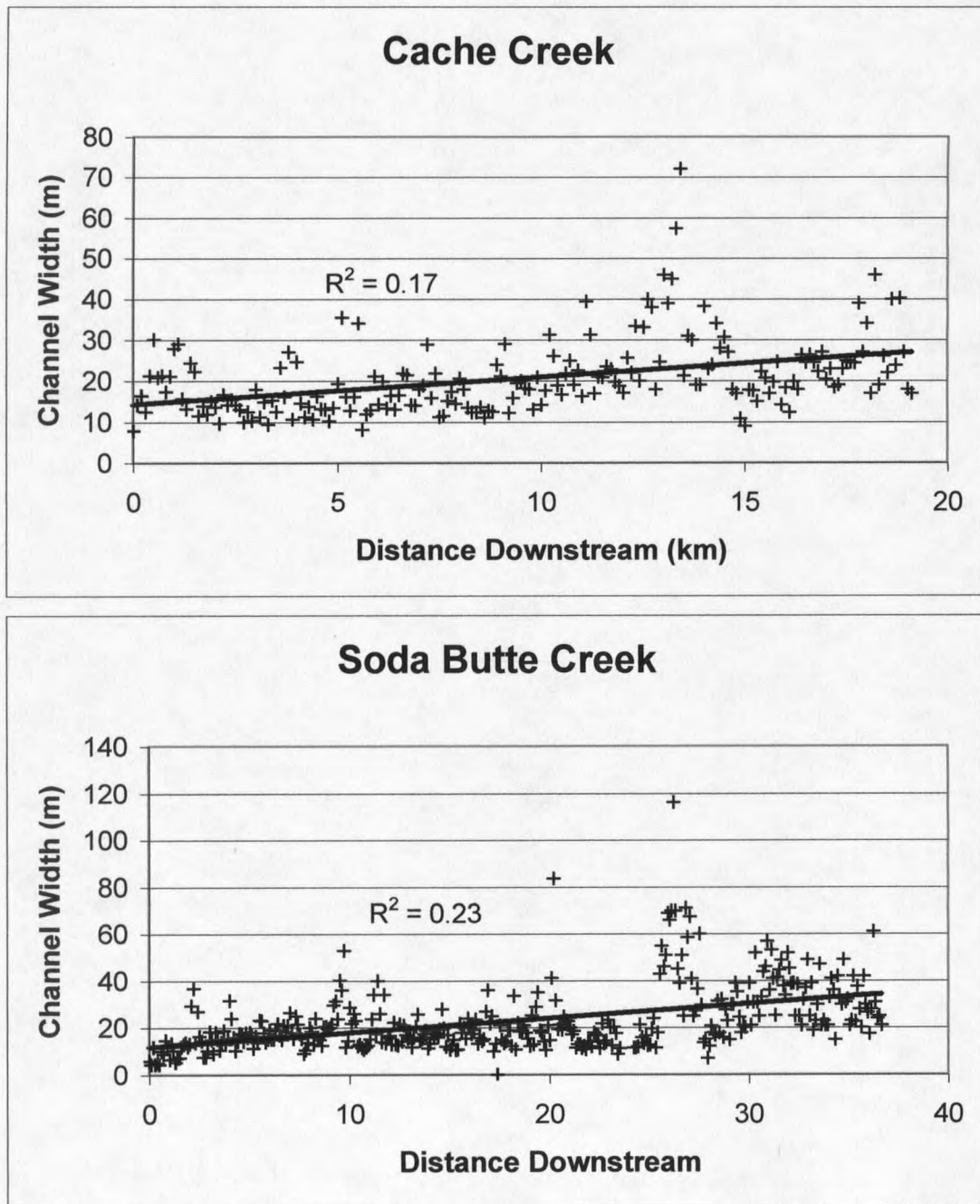


Figure 9. Scatter plots and regressions of Cache and Soda Butte Creek distance downstream versus channel width.

versus channel width. It is clear from these figures that there is only a weak relationship between position in the basin and channel width.

More importantly, this study raises questions about almost all basin-scale fluvial research to date, which is based on reach-scale sampling. It is clear that there is no "representative reach" for any of the segments in this study. The assumption that systematic downstream samples or sampling reaches of specific order or drainage area can capture the variability of any stream is not supported. A random sample would probably be just as effective in the streams of this study.

Other Controls on Wood

The lack of width controls on woody debris suggests that other processes must be controlling wood in the study streams. One possible explanation for the distributions is the role of supply, which is largely governed by the proximity of trees to the stream (Murphy and Koski, 1989). It is clear the surrounding forest plays an important role in supplying woody debris to each reach in the study area (Figure 10). The importance of tree fall from the forest becomes more apparent when a spatial buffer is created by removing the three downstream transition segments from each border between the broad zones of forested and non-forested stream (Figure 11). The rationale for removing three segments is derived from partial auto-correlation values for woody debris counts. In both Soda Butte and Cache Creeks wood loadings are positively auto-correlated to a distance of 300-meters. Figure 10 suggests that the presence or absence of forest along Soda Butte Creek is a much better predictor of wood loadings than channel width or drainage area, it is impossible to check Cache Creek for a similar pattern because the stream is

Soda Butte Creek

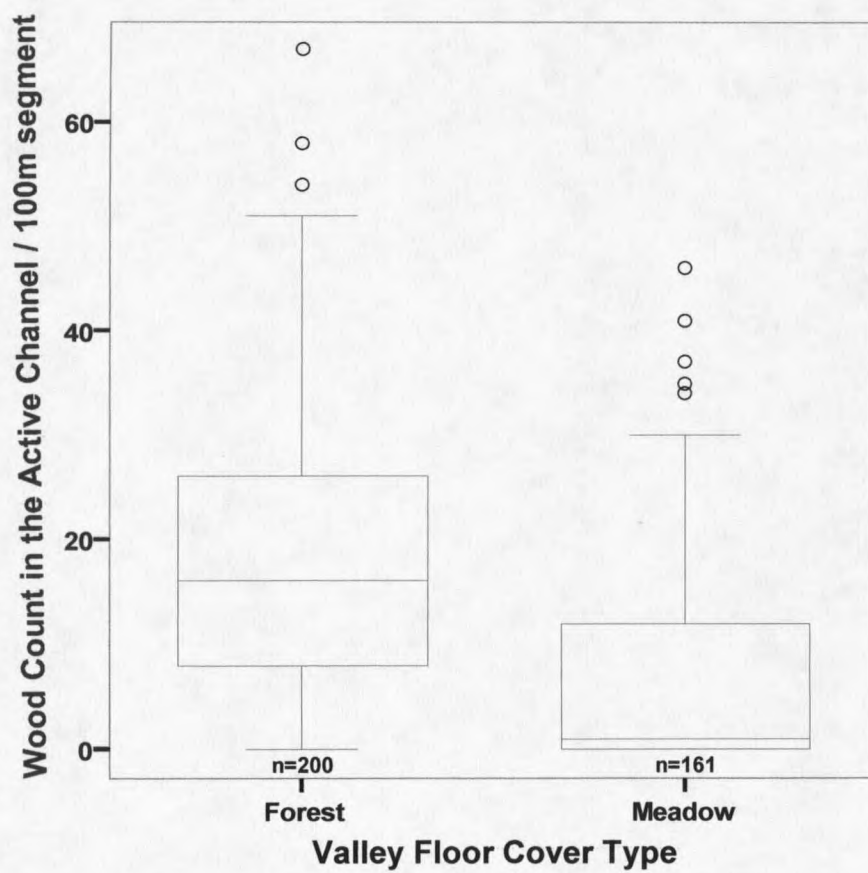


Figure 10. Box plot of Soda Butte Creek forest vs. non-forest segments.

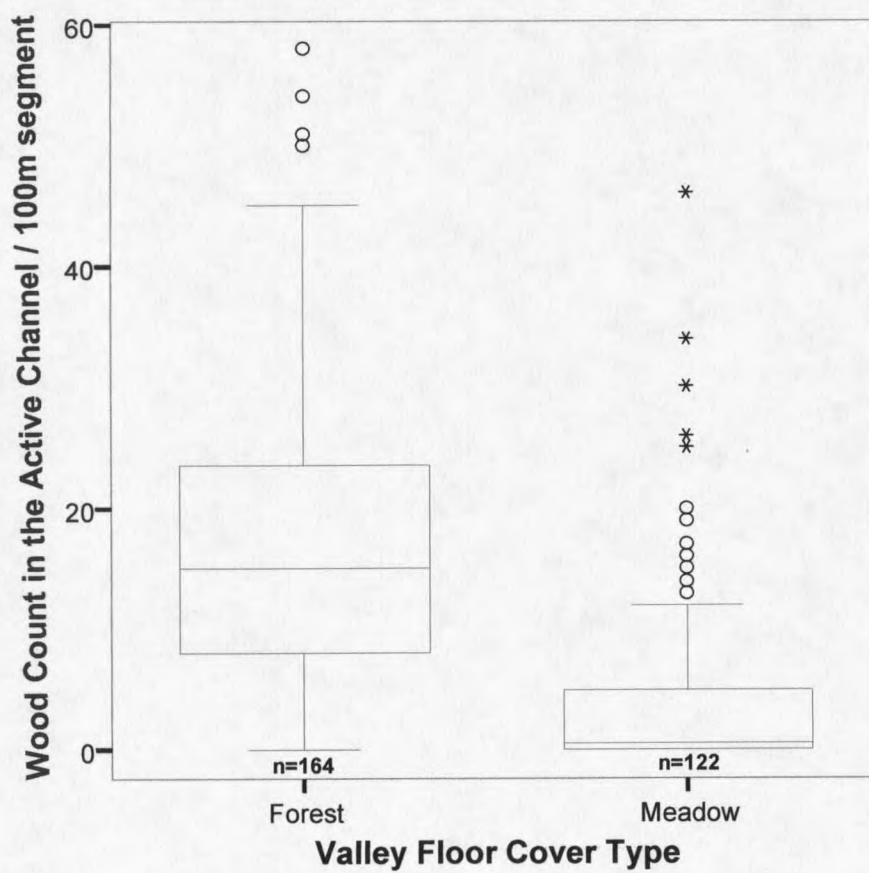
Soda Butte Creek (Buffered Segments)

Figure 11. Box plot of Soda Butte Creek forest vs. non-forest segments.

nearly 90% burned. The data from Soda Butte Creek suggests that stream bank forest is the dominant factor in the distribution of woody debris.

In addition to tree fall, streamside slides are a common source of woody debris. Murphy and Koski (1989) and Nakamura and Swanson (1993) suggest that in 2nd to 5th order channels with a strong colluvial influence, wood inputs through mass wasting are a major component of the overall woody debris present. A breakdown of alluvial and colluvial classified segments (Montgomery and Buffington, 1993) from Cache and Soda Butte Creek do not support these assertions (Figures 12 and 13). It is difficult to separate wood inputs through true mass wasting processes from wood that entered the channel from other means like tree fall, so total wood counts over a 100 meter segment are unlikely to provide clear evidence for elevated wood counts as a result of colluvial inputs.

Wildfire Controls on Woody Debris

The statistical comparison of Soda Butte Creek (undisturbed) and Cache Creek (burned) showed that Cache Creek had significantly lower wood levels than Soda Butte Creek (Figure 7). This is surprising because research conducted by Minshall *et al.* (1989) and Lawrence (1991) on Cache Creek and many other streams reported that initially there was a substantial increase in the pieces of woody debris in burned streams relative to undisturbed streams. Continued monitoring of many of the burned watersheds in Yellowstone, including Cache Creek, showed a significant loss of woody debris after the first few years. Despite the reduction of woody debris in burned streams following 1991, these streams still had higher wood loadings than the control streams used by Minshall *et al.* This trend was expected to continue until the supply of dead wood was expended,

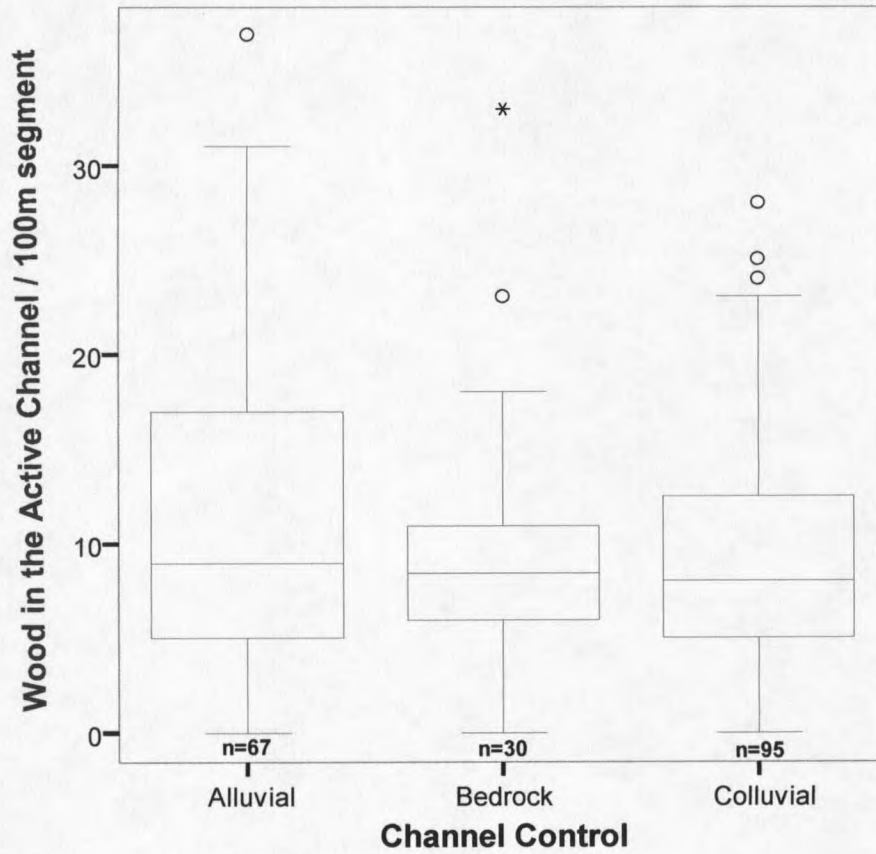
Cache Creek

Figure 12. Box plot of Cache Creek type of channel control and wood counts.

Soda Butte Creek

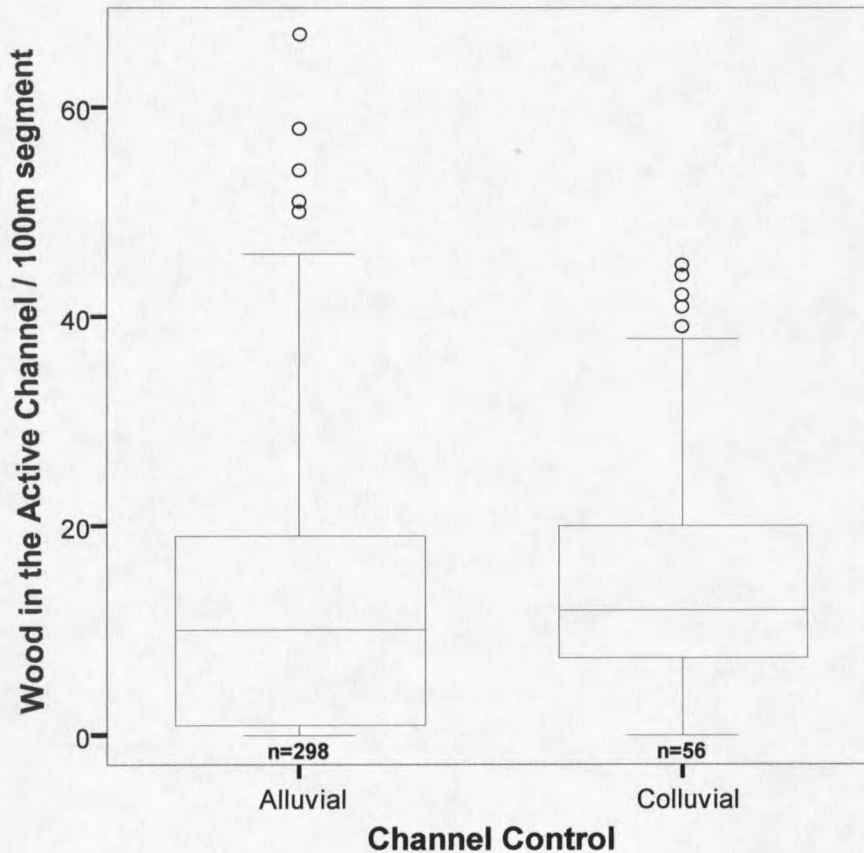


Figure 13. Box plot of Soda Butte Creek type of channel control and wood counts.

after which the levels of woody debris would remain lower than pre-fire levels until the surrounding forest matured (Minshall *et al.*, 1997).

Although the postulated response of the wood system after wildfire seems reasonable and is backed by some empirical evidence, results from this study conclusively show that the undisturbed stream has higher wood loadings than the burned stream. This could be a product of differences in methodology; the selection of the study

sites (specifically the control stream used by the previous investigators), or it is possible that woody debris levels have dropped appreciably in Cache Creek since 1995.

Differences in methodology could explain the contrasting results, although the methods for counting woody debris were very similar, previous studies counted each piece of woody debris at a number of sample sites, while this study counted only agglomerations of woody debris for the entire stream.

Another difference between the studies was the selection of a control stream. Earlier studies used nearby Pebble Creek and not Soda Butte Creek as the control stream (Minshall *et al.*, 1989; Minshall *et al.*, 1997). This issue was resolved for this study by collecting additional data for Pebble Creek in summer 2000. Table 6 and Figure 14 display wood counts and supplemental data for Cache, Soda Butte and Pebble Creeks. The box plot clearly shows that the 10-kilometer sample from Pebble Creek has much higher wood loadings than Cache Creek.

The best explanation for the contrast between studies is that fire-induced changes in the hydrology of Cache Creek have increased wood transport rates to a level high enough to offset the increase in wood delivery. Both basins have experienced three high magnitude (>10 year) floods in 1995, 96 and 97 (Marcus *et al.*, 2001). Previous studies suggest that deforested basins experience an increase in the peak annual discharge and the magnitude of floods in the stream relative to its pre-fire conditions (Bolin and Ward, 1987; Minshall and Brock 1991). There is evidence that the wood has been flushed out of Cache Creek since 1996 (Minshall, Pers. Com., 2001). This could explain the low wood levels in Cache Creek relative to Soda Butte Creek.

Table 6. Summary of information for 10-kilometer samples from Soda Butte, Cache and Pebble Creeks.

	Soda Butte Creek	Cache Creek	Pebble Creek
Stream Metrics			
Elevation (m)	2298-2214	2354-2150	2355-2115
Average Slope (m/m)	0.0084	0.0206	0.0268
Drainage Area (km ²)	46.67-93.20	41.62-112.20	n/a
Study Length (km)	10	10	10
Stream Order (@ 1:24000)	3rd	3rd	3rd
Valley Floor Cover			
% classified as Burned	0	99	0
% Forest	59	1	99
% Meadow	41	0	1
Valley Floor Width			
% classified as <2 channel widths	17	52	61
% 2-4 channel widths	23	48	35
% >4 channel widths	60	0	4
Channel Control			
% classified as Bedrock controlled	1	23	17
% Colluvial controlled	13	77	29
% Alluvial controlled	86	0	54
Channel Planform			
% classified as Braided	14	6	9
% Meandering (sinuosity >1.1)	57	65	50
% Straight	29	29	71
Channel Character			
% classified as Step/Pool	10	83	46
% Riffle/Pool	74	17	54
% Run/Glide	16	0	0
Channel Substrate D₅₀ Estimate			
% classified as Boulder	13	97	52
% Cobble	59	3	48
% Gravel	28	0	0

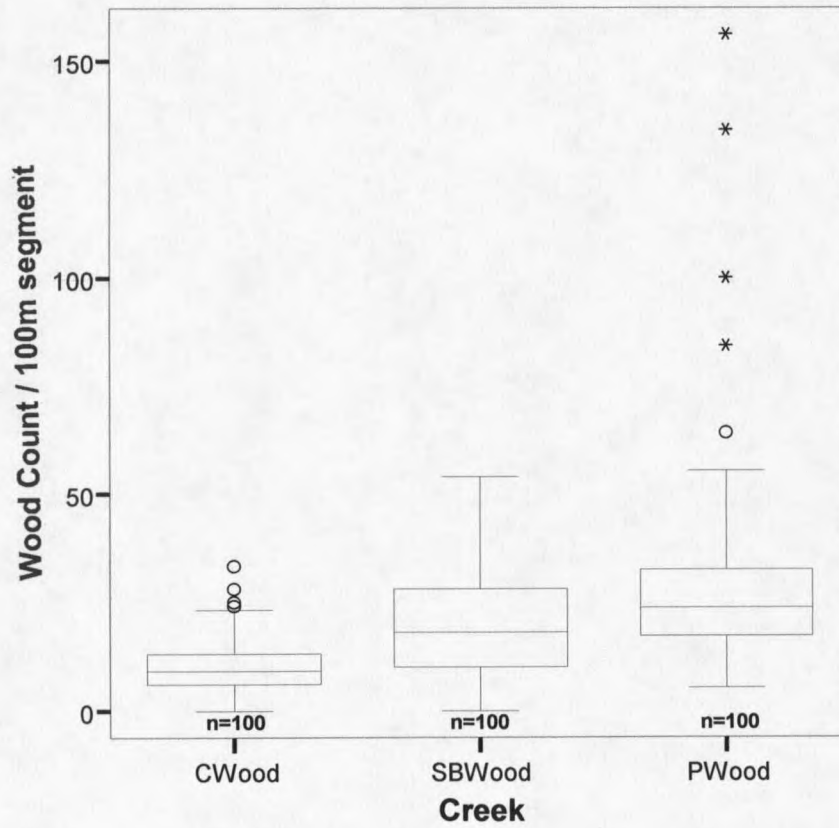
Cache / Soda Butte / Pebble Creek Wood Comparison

Figure 14. Cache, Soda Butte and Pebble Creek wood comparison.

Studying the Woody Debris System

The disparity in wood counts between this study and earlier work also stems from a differing focus. Earlier work was concerned with fire effects on the forest. Wildfire affects the rate of woody debris input to the stream. This study looked at the wood storage within the stream, which is a function of wood input from the forest and export through the downstream transport. Studies of the woody debris need to recognize the interrelations between input, transport and export components of the system. Fluctuations in the rate of input (wildfire) and in the rate of export (floods) are pushing change at different times (Figure 15). It appears that the timing of a study relative to fire, flooding or large mass-wasting events makes all the difference. Recognition of change over time as well as space is essential for understanding the variability of wood locations within the stream.

Wood as a Tool for Stream Restoration

Because wood stabilizes the stream channel, reduces sediment transport, increases the retention of organic matter (Smith *et al.*, 1993a, 1993b; Trotter 1990), and provides habitat for macroinvertebrates and fish (Anderson and Sedell, 1979; Keller and Tally, 1979; Benke *et al.*, 1985), wood has recently become the focus of stream restoration efforts. Research that explores the distribution of woody debris in streams from areas preserved as wilderness can provide valuable information on what type and how much woody debris is needed to restore streams to a "natural state."

It is clear from this study that the largest pieces of woody debris serve to capture smaller pieces that would otherwise be transported downstream. This project recorded

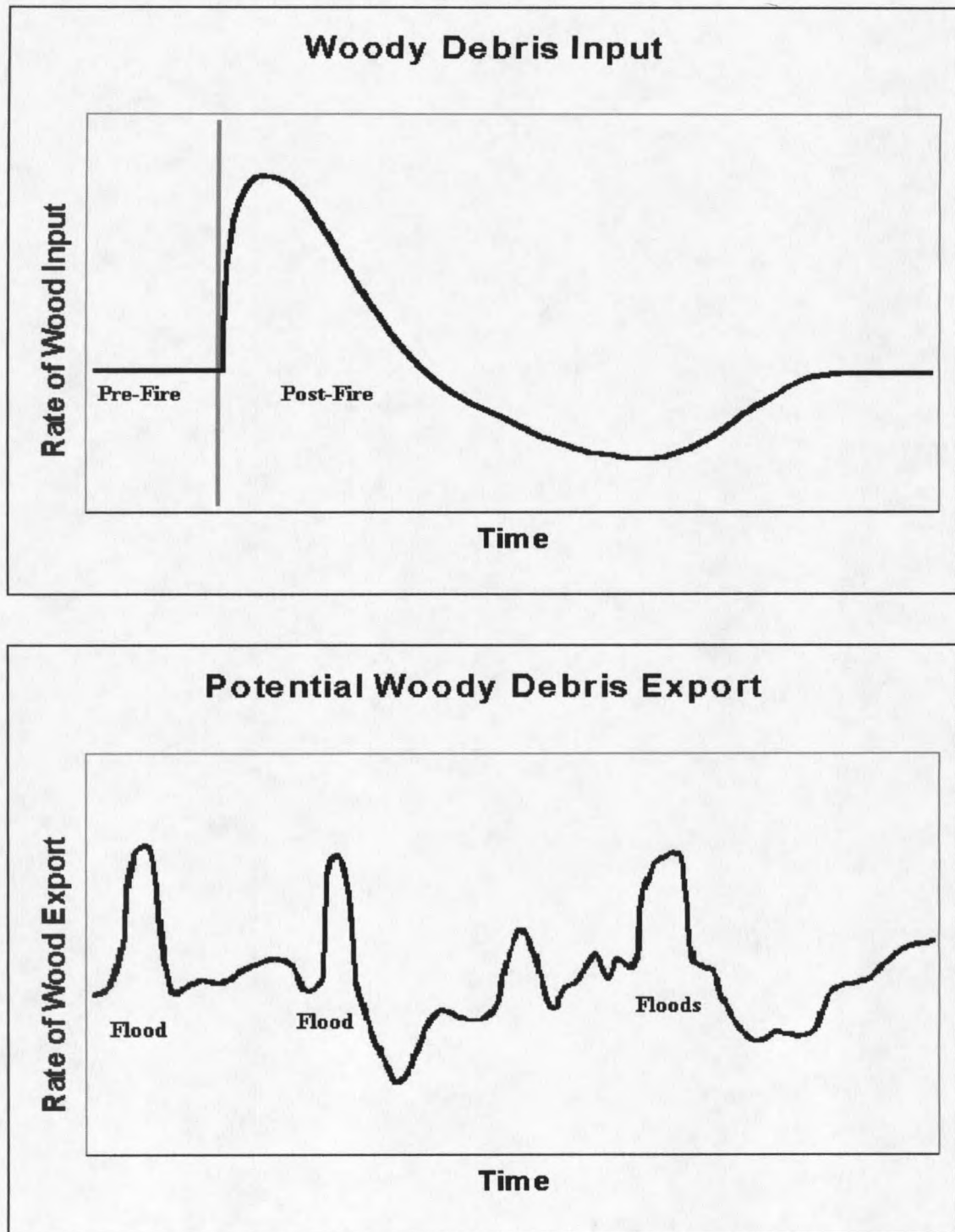


Figure 15. Hypothetical graphs of woody debris input to the stream from the forest and export from the stream through floods (After Minshall *et al.*, 1989).

the largest member size of each log agglomeration; in both Soda Butte and Cache Creeks, Jam key member size was overwhelmingly greater than six meters in length (Figure 16). It is likely that smaller pieces of wood do not provide the stability needed for jam formation during the stream's annual peak discharge that is also the time of maximum wood transport. Restoration efforts that use woody debris should focus on placing larger pieces of wood to increase small wood retention and improve habitat.

The results of this study suggest that woody debris loadings are positively correlated with the density of pools and other morphologic units. This is in line with the bulk of the literature concerning wood effects on geomorphology. It is worth pointing out that the regression relating woody debris to pools varied substantially between streams. Soda Butte Creek with its predominately riffle/pool morphology had an R^2 of 0.21 while the step/pool-dominated Cache Creek had an R^2 of only 0.03 (Figure 17). Although both regressions were statistically significant, the data suggests that woody debris could have a positive effect on the morphology of riffle/pool streams.

It is also clear that woody debris is not distributed in a predictable fashion throughout a stream. The amount of woody debris per reach varies significantly with a number of factors, most notably with the vegetation type of the valley floor (Figure 9). Analysis of the woody debris and morphologic units relationship suggests that woody debris plays only a minor role in creating in-channel habitat units. Woody debris affects the habitat of a stream and introduced wood can yield improvements, but it is likely that there are thresholds involved as the woody debris spacing approaches the hydraulic pool spacing of the stream. More wood is probably better for habitat complexity, but further research is needed to explore possible thresholds.

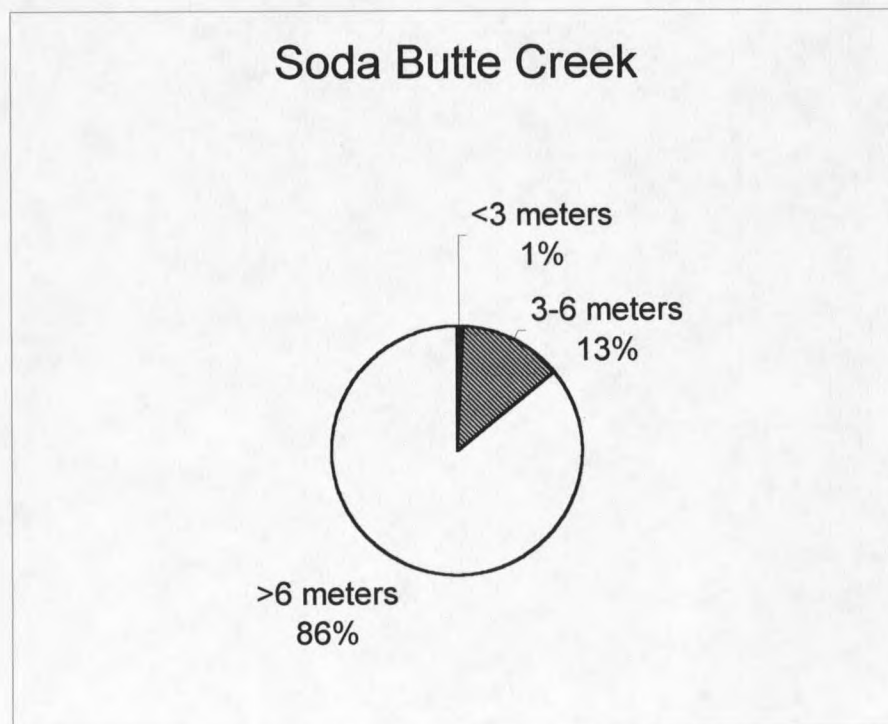
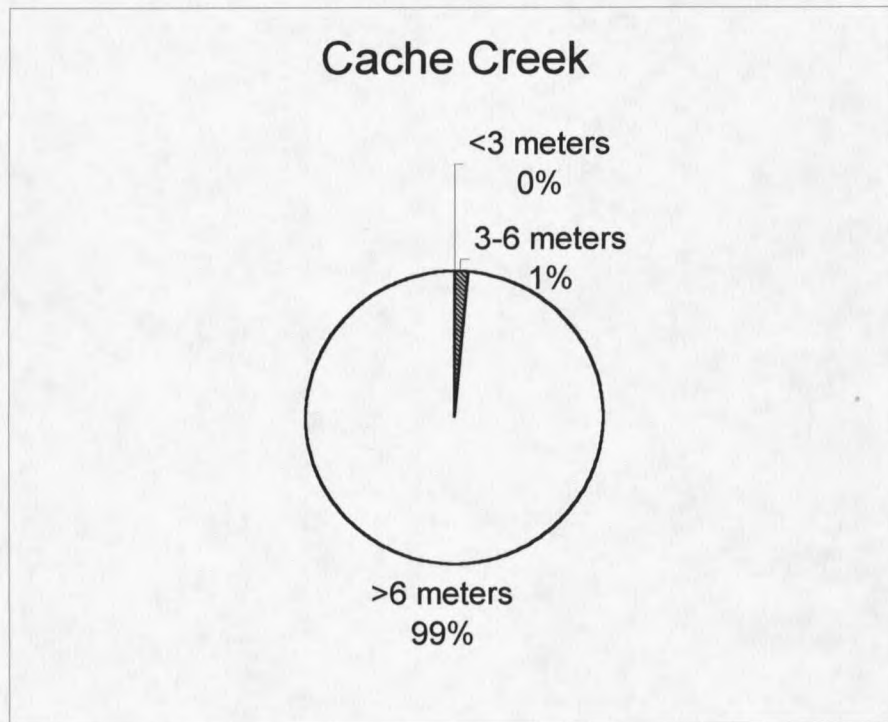


Figure 16. Cache Creek and Soda Butte Creek jam size.

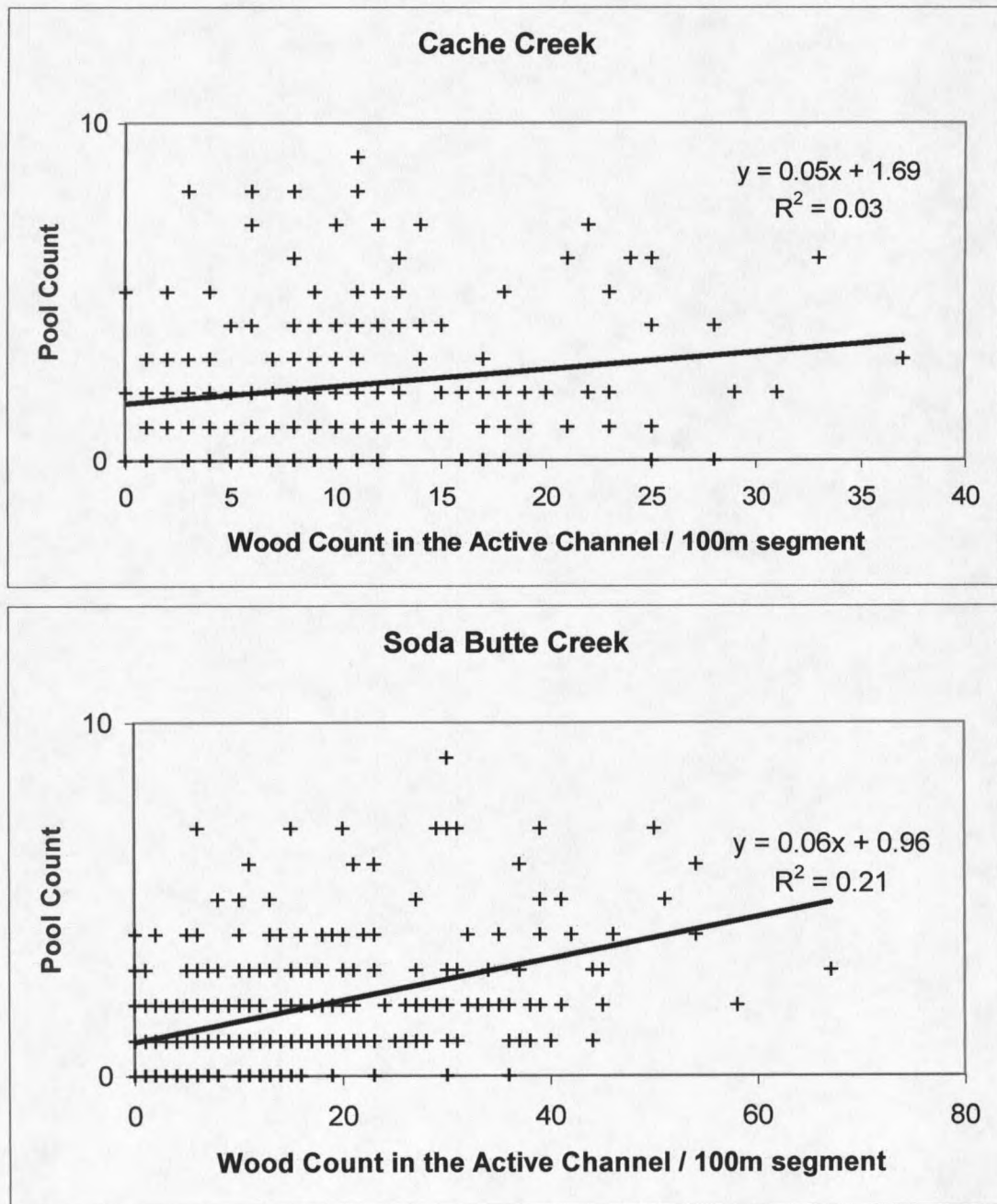


Figure 17. Scatter plots and regressions of Cache Creek and Soda Butte Creek wood versus pools.

The results of this study suggest that from the stream management standpoint the focus should be on the surrounding vegetation rather than the in-stream wood dynamics. Human induced changes in land cover may severely reduce the rate of wood input to many streams. This study indicates that the key to managing streams for habitat is in managing the riparian zone. An important product of this research has been the recognition of the importance of surrounding vegetation in woody debris variability. Forests along the channel margin are the main source of woody debris and are therefore essential for a diverse stream habitat. Deliberate wood placement in streams can provide a temporary improvement, but maintaining habitat quality in a sustainable fashion will require the preservation of a stable riparian zone.

Modeling Woody Debris

This study attempted to model woody debris counts using a number of multiple regressions. The most successful attempt at predicting amounts of woody debris utilized three variables selected in a step-wise regression. The model included total bankfull channel width, total bankfull channel depth and the categorical variable channel planform braided.

$$\text{Wood Count} = 0.882 + (0.942 \times \text{Channel Width}) + (7.016 \times \text{Channel Depth}) + (15.204 \times \text{Braided Planform})$$

The results of the regression models were tested against observed data using a root mean square error to assess its validity. The model was an inadequate predictor of wood loadings, the regression equation had an R^2 of only 0.32 and the root mean square error of the model was 15.76. These results translate into an average error of 12 pieces of large

wood per 100 meters. The test of the model reveals serious shortcomings. The R^2 of 0.32 implies that the model explains less than a third of the total variance in wood loadings. A regression equation that included every possible wood predictive variable that was available in the data had an R^2 of only 0.48 and violated a number of statistical assumptions regarding variable collinearity. This suggests that woody debris distributions are affected by many factors outside the scope of this study. The data collected was predominately stream focused and probably ignored a number of important geomorphic and forest variables. It also suggests that modeling woody debris counts in future research will require large and complex regression models.

CHAPTER 4

SUMMARY AND CONCLUSIONS

Suggestions for Future Research

The relationship between large woody debris and geomorphic complexity has been poorly established and needs to be addressed in a number of geomorphically different streams. Also a more rigorous examination of the nature of the relationship between wood and stream units is needed. Specifically, the possible existence of a threshold as the woody debris spacing approaches the hydraulic spacing of riffles and pools should be explored.

The long-term effect of wildfires on woody debris inputs also requires further examination. Woody debris data from the Lamar River and South Cache Creek, another burned stream, were collected in summer 2001. The new data sets should allow a greater understanding of downstream transport and export of wood in burned and undisturbed streams in Yellowstone. However, the only certain way to resolve this question is to obtain pre-fire wood loadings for burned streams.

Understanding in wood research should advance with the recognition that woody debris is part of a system that operates across the sensitive interplay between forest, hydrologic and hydraulic processes at a variety of spatial and temporal scales. The relationship between woody debris input, transport and export is exceedingly complicated and therefore will require more elaborate means of study that are able to evaluate the effects of change in one portion of the system relative to the other components.

Conclusions

This study showed a clear relation between the count of woody debris in stream segments and the number of morphologic units, specifically pools in the segment. These results support the existing assumptions in the literature about the effects of woody debris on stream morphology. The data also suggests that woody debris may have a greater effect on lower gradient riffle/pool morphology streams than higher gradient step/pool streams. This could have serious implications for stream and streamside management. It is evident that wood debris has an effect on the morphology and habitat of streams, it is still unclear if woody debris distributions have a discernable trend or pattern that can be used as a template in restoration projects.

The evidence from this study suggests that hydraulic variables are only a minor control on the distribution of large woody debris. Neither of the two streams in this study displayed clear basin-wide trends that would suggest that channel width or drainage area are key factors in woody debris deposition. It appears that the forest vegetation is the principal control on the spatial location of wood in streams. Forest segments of stream showed a consistently higher wood loading than non-forested segments.

Despite evidence that forest processes dominate the distribution of woody debris, the results of this study show that recently burned drainage basins have less woody debris in the stream network than unburned basins. The relatively undisturbed Soda Butte Creek averaged twice the woody debris per 100-meter reach than the neighboring but burned Cache Creek. It is likely that this effect is a result of the post-fire flood regime in the study area. This suggests that the timing and size of floods are a decisive factor in

woody debris variation, but more extensive study across time and space is required to test this hypothesis.

Finally, the results of this study raise a number of questions about fluvial research that is limited to a reach-based data gathering approach. It is clear that longitudinal surveys provide a substantially richer understanding of the stream system. Traditional sampling schemes are incapable of capturing the spatial variability in streams. New techniques and technologies are needed to achieve a more complete understanding of the fluvial system.

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APPENDICES

APPENDIX A

WOOD DICHOTOMOUS KEYS

Wood in the Study Key

1. Is the wood or agglomeration of wood resting in the floodplain as defined by stable vegetation or confined by active stream steepened valley walls? If yes, then 2. If no, then ignore the wood.
2. Is the wood or agglomeration of wood a collection of small branches or shrubs greater than one cubic meter in volume? If yes, then include in the study. If no, then 3.
3. Is the wood or agglomeration of wood containing a log or root ball at least 25 centimeters in diameter at its thickest point and at least one meter long? If yes, then include the wood in the study. If no, then 4.
4. Is the wood or agglomeration of wood containing a log or root ball at least 10 centimeters in diameter at its thickest point and at least 2 meters long? If yes, then include the wood in the study. If no then ignore the wood.

Wood Type Key

1. Is the wood or agglomeration of wood a collection of small branches or shrubs greater than one cubic meter in volume? If yes, then record wood in vegetation snag type category. If no, then 2.
2. Is the wood or agglomeration of wood a single log or root ball not in contact with any other wood that is of a size large enough to be included in the study? If yes, then record the wood in the single log type category. If no then 3.
3. Is the agglomeration of wood in contact with less than 6 wood members that are of a size large enough to be included in the study? If yes then record the wood in the cluster category. If no then 4.
4. Is the agglomeration of wood a collection of greater than 20 wood members that are of a size large enough to be included in the study? If no, then record the collection as a one jam in the jam type category? If yes, then 5.
5. Is the large jam of greater than 20 members clearly a result of multiple transport episodes and easily divisible along natural breaks (example: two large jams 10 meters apart, one jam high atop a bar and the other in the channel, connected by only a single log)? If yes, then record each jam separately in the jam type category. If no then record as a one large jam.

Wood Size Key

1. Is the long axis of the wood or agglomeration of wood less than three meters in length? If yes, then record the wood in the less than three meters size category. If no, then 2.
2. Is the long axis of the wood or agglomeration of wood greater than six meters in length? If no, then record the wood in the 3-6 meters size category. If yes, then record the wood in the greater than six meters size category.

Wood Location Key

1. Is the wood or agglomeration of wood more than two-thirds buried in alluvium? If yes, then record the wood in the buried location category. If no, then 2.
2. Is the wood or agglomeration of wood completely submerged in the stream but not in the aforementioned buried category? If yes, then record the wood in the submerged location category. If no, then 3.
3. Is the wood or agglomeration of wood dry and suspended above the channel? If yes, then record the wood in the suspended location category? If no then 4.
4. Is the wood or agglomeration of wood completely dry and resting level upon a bar? If yes, then record the wood in the bar location category? If no, then record the wood in the ramped location category.

Wood Morphologic Unit Key

1. Is the wood or agglomeration of wood recorded in the bar location category? If yes, then 2. If no, then 3.
2. Is the wood or agglomeration of wood resting on a completely detached bar? If yes, then record the wood in the in-channel bar category. If no, then record the wood in the side-channel bar category.
3. Is the wood or agglomeration of wood dry (not in contact with the stream)? If yes, then record in the side channel bank category. If no, then record the wood in the morphologic unit category that it is ramped into or buried or submerged in.

APPENDIX B

SODA BUTTE CREEK DATA

Table 7. Woody debris and channel measurement data for Soda Butte Creek.

Distance (km)	Single Logs	Clusters	Jams	Buried	Bar	Submerged	Suspended	Ramped	Total Wood	Total Width (m)	Max Depth (m)
0	0	0	0	0	0	0	0	0	0	6.00	0.48
0.1	1	2	0	0	0	0	1	1	7	4.40	0.78
0.2	0	1	1	0	0	0	0	0	11	11.70	1.05
0.3	0	1	1	1	1	0	0	0	11	4.30	0.50
0.4	3	4	3	0	0	1	0	2	39	5.10	0.60
0.5	4	6	1	0	1	4	3	0	30	4.40	0.75
0.6	2	2	0	0	0	1	2	1	8	10.00	0.70
0.7	7	1	0	0	3	6	2	1	10	8.85	0.50
0.8	2	0	0	0	0	2	0	0	2	14.60	1.10
0.9	3	1	0	0	1	0	0	3	6	12.00	0.72
1	5	6	0	0	1	2	0	3	23	6.60	0.70
1.1	6	2	1	2	0	5	0	1	20	13.40	1.00
1.2	3	4	0	1	0	0	0	3	15	10.40	0.55
1.3	2	1	2	0	0	0	0	2	21	5.45	1.20
1.4	2	3	0	1	0	0	0	2	11	7.20	0.55
1.5	0	1	4	0	2	0	0	0	35	7.30	1.52
1.6	0	3	0	0	6	0	0	0	9	12.10	0.55
1.7	0	1	2	0	12	0	0	0	19	13.10	0.70
1.8	1	1	1	0	9	0	0	1	12	13.80	1.15
1.9	0	1	1	0	3	0	0	0	11	12.10	1.00
2	0	1	1	0	14	0	0	0	11	13.25	0.80
2.1	2	0	1	0	16	0	0	2	10	29.30	1.15
2.2	2	1	1	0	9	0	2	2	13	36.70	1.25
2.3	2	1	0	0	43	1	0	1	5	13.70	1.05
2.4	2	1	0	1	14	1	0	1	5	26.90	2.10
2.5	5	2	1	0	1	5	0	0	19	16.40	1.38
2.6	2	1	0	0	0	2	0	0	5	14.40	1.66
2.7	2	1	0	0	0	2	0	0	5	7.60	1.05
2.8	3	1	5	1	15	1	0	2	46	7.70	0.70
2.9	0	2	0	1	8	0	0	0	6	10.20	0.75
3	4	0	2	0	3	1	0	3	20	18.40	1.05
3.1	3	0	0	0	3	2	0	1	3	15.00	1.15
3.2	2	2	1	2	6	2	0	0	16	9.00	1.05
3.3	3	6	3	0	6	0	0	3	45	18.10	1.25
3.4	1	4	1	0	8	1	1	0	21	15.10	0.95
3.5	4	3	3	1	0	1	0	3	37	10.50	1.10
3.6	3	2	1	4	2	2	0	1	17	13.90	0.95
3.7	3	1	0	4	12	0	0	3	6	18.90	1.50

3.8	1	7	4	0	9	1	0	0	54	13.00	1.15
3.9	8	5	2	0	5	8	0	0	39	15.55	1.65
4	3	5	0	1	5	3	0	0	18	31.60	2.45
4.1	7	2	2	2	1	3	0	4	29	24.00	0.85
4.2	0	0	0	4	1	0	0	0	0	16.00	0.65
4.3	0	0	1	0	2	0	0	0	8	10.20	1.75
4.4	5	3	2	2	5	5	0	0	30	14.10	0.95
4.5	1	3	2	0	1	1	0	0	26	17.70	0.60
4.6	1	2	4	4	1	0	0	1	39	17.50	0.70
4.7	1	7	4	3	1	1	0	0	54	14.10	0.70
4.8	2	0	1	4	1	2	0	0	10	17.80	1.70
4.9	11	5	3	5	5	8	0	3	50	15.90	1.05
5	6	1	1	1	7	4	0	2	17	18.10	1.05
5.1	7	3	2	2	5	7	0	0	32	16.60	1.10
5.2	1	4	1	1	4	0	0	1	21	11.30	1.25
5.3	2	2	0	2	10	1	0	1	8	16.45	0.65
5.4	2	3	1	4	5	0	0	2	19	13.70	0.70
5.5	2	2	1	5	1	1	0	1	16	23.30	1.10
5.6	1	4	1	0	5	1	0	0	21	23.00	1.60
5.7	0	2	0	1	2	0	0	0	6	17.90	1.05
5.8	2	2	0	0	13	0	0	2	8	14.00	0.95
5.9	1	1	2	0	3	1	0	0	20	15.20	0.85
6	6	4	0	0	3	4	0	2	18	19.20	1.25
6.1	0	0	4	2	3	0	0	0	32	15.30	0.60
6.2	1	0	1	2	2	1	0	0	9	15.30	0.75
6.3	3	3	1	1	8	3	0	0	20	19.00	0.25
6.4	2	5	3	3	2	2	0	0	41	21.90	0.40
6.5	6	0	0	2	5	4	0	2	6	17.00	0.60
6.6	11	1	0	1	1	7	0	4	14	15.00	0.80
6.7	4	0	0	1	1	4	0	0	4	21.00	1.00
6.8	1	0	0	1	2	1	0	0	1	18.50	1.20
6.9	8	0	0	1	0	4	0	4	8	21.00	1.50
7	4	2	0	0	0	1	1	3	10	26.60	0.75
7.1	5	0	1	0	4	2	0	3	13	17.80	1.60
7.2	1	7	0	0	0	0	0	1	22	15.50	1.00
7.3	5	2	0	1	2	3	0	2	11	25.10	0.75
7.4	6	0	1	1	4	2	0	4	14	21.50	1.05
7.5	4	5	1	5	3	3	1	1	27	17.30	1.40
7.6	10	3	0	1	1	6	2	4	19	15.50	1.00
7.7	7	4	2	3	2	4	0	3	35	9.00	1.35
7.8	3	0	2	0	3	1	1	2	19	10.60	0.75
7.9	3	1	0	2	1	0	0	3	6	13.80	1.25
8	1	2	1	0	4	1	0	0	15	20.20	0.70
8.1	7	1	0	0	1	1	0	6	10	18.30	0.75
8.2	1	1	0	2	4	1	0	0	4	12.90	0.90
8.3	3	6	2	2	6	0	0	3	37	24.05	1.35

8.4	6	4	2	0	0	2	0	4	34	16.00	0.75
8.5	5	1	1	0	3	0	0	5	16	14.90	0.96
8.6	3	1	2	1	0	1	0	2	22	12.40	1.30
8.7	1	4	2	0	6	0	0	1	29	20.40	0.80
8.8	1	3	0	0	8	0	0	1	10	20.70	0.60
8.9	5	1	1	0	7	1	0	4	16	19.60	1.20
9	3	2	2	1	7	1	0	2	25	20.05	2.15
9.1	4	5	1	4	6	4	0	0	27	21.60	1.80
9.2	2	3	0	1	1	2	0	0	11	29.60	1.82
9.3	13	2	2	2	0	5	0	8	35	31.40	1.65
9.4	3	3	0	2	5	1	0	2	12	23.80	0.95
9.5	1	2	0	0	20	1	0	0	7	40.30	0.75
9.6	1	0	0	0	4	0	0	1	1	36.00	1.45
9.7	0	3	1	3	4	0	0	0	17	53.00	1.60
9.8	4	5	0	0	1	1	0	3	19	11.80	0.80
9.9	2	7	0	0	4	0	0	2	23	14.50	0.75
10	2	0	3	3	4	0	0	2	26	28.80	1.40
10.1	3	7	1	0	1	2	0	1	32	21.70	0.90
10.2	9	3	2	0	1	5	0	4	34	26.10	2.10
10.3	4	5	2	2	2	1	0	3	35	23.00	1.00
10.4	5	7	2	0	0	0	0	5	42	12.30	0.90
10.5	8	2	3	2	1	3	0	5	38	13.00	1.65
10.6	12	0	0	0	0	3	0	9	12	11.60	1.40
10.7	4	5	0	0	0	0	0	4	19	10.90	0.90
10.8	6	3	0	0	0	2	0	4	15	11.80	1.65
10.9	3	1	1	0	0	1	0	2	14	12.50	1.20
11	1	3	1	0	6	1	0	0	18	15.30	1.40
11.1	6	2	1	1	1	5	1	1	20	23.70	1.25
11.2	0	5	1	3	4	0	0	0	23	34.00	1.30
11.3	2	1	1	0	6	0	1	2	13	17.40	1.49
11.4	10	1	3	1	4	5	0	5	37	40.00	1.60
11.5	2	2	0	0	3	1	0	1	8	26.00	1.55
11.6	12	2	0	2	6	8	0	4	18	13.90	0.95
11.7	3	2	1	0	6	2	0	1	17	34.00	1.00
11.8	5	1	0	2	2	0	0	5	8	13.50	1.05
11.9	1	2	0	1	0	0	0	1	7	15.60	1.75
12	3	3	0	0	0	0	0	3	12	16.60	0.75
12.1	5	4	0	2	3	0	0	5	17	13.00	1.05
12.2	6	1	0	0	0	4	0	2	9	22.30	1.30
12.3	3	0	1	0	2	0	0	3	11	12.90	1.10
12.4	2	2	3	2	2	1	0	1	32	12.40	1.70
12.5	6	7	0	0	1	4	0	2	27	21.60	0.93
12.6	10	1	0	0	1	5	0	5	13	14.10	1.05
12.7	6	2	2	0	1	3	0	3	28	21.00	1.15
12.8	6	2	1	2	0	2	0	4	20	17.00	0.93
12.9	5	1	1	3	3	3	0	2	16	15.40	1.25

13	9	7	0	1	0	3	0	6	30	15.90	1.15
13.1	10	1	0	0	4	3	0	7	13	11.80	1.10
13.2	3	3	3	3	6	1	0	2	36	16.00	0.75
13.3	5	5	2	1	1	1	1	4	36	20.70	1.50
13.4	6	4	0	1	5	2	2	4	18	25.70	1.95
13.5	6	1	0	0	2	2	0	4	9	14.40	0.90
13.6	4	6	1	0	7	1	0	3	30	15.30	1.25
13.7	0	4	1	1	5	0	0	0	20	17.30	0.65
13.8	8	2	0	1	2	4	0	4	14	19.00	0.60
13.9	10	3	1	1	1	6	0	4	27	11.30	0.60
14	6	8	0	0	0	3	0	3	30	13.20	1.05
14.1	3	2	1	2	4	3	0	0	17	17.60	0.95
14.2	0	0	0	0	4	0	0	0	0	16.00	1.55
14.3	4	4	0	0	0	4	0	0	16	17.70	1.10
14.4	4	4	3	0	2	3	0	1	40	15.90	0.75
14.5	5	4	0	0	5	3	0	2	17	19.30	1.85
14.6	6	3	2	3	6	3	0	3	31	28.00	1.51
14.7	7	2	1	1	5	6	0	1	21	19.80	1.80
14.8	1	2	0	2	4	0	0	1	7	11.90	1.20
14.9	2	1	0	0	0	1	0	1	5	17.00	1.15
15	5	1	0	0	0	1	0	4	8	10.80	1.00
15.1	11	4	0	0	1	7	0	4	23	12.60	1.00
15.2	2	7	0	0	0	0	0	2	23	14.90	1.05
15.3	6	1	0	0	0	1	0	5	9	10.60	1.05
15.4	4	2	1	0	3	2	0	2	18	10.90	1.00
15.5	0	1	0	0	2	0	0	0	3	21.80	0.85
15.6	3	4	0	0	7	0	0	3	15	18.00	1.00
15.7	1	6	0	1	4	0	0	1	19	20.00	1.40
15.8	1	1	0	0	5	0	0	1	4	15.50	1.25
15.9	2	0	0	0	7	1	0	1	2	24.00	1.25
16	7	5	2	1	6	5	0	2	38	20.00	2.05
16.1	5	1	2	2	7	2	1	3	24	17.50	2.10
16.2	1	5	0	0	2	0	0	1	16	19.20	2.40
16.3	5	4	3	1	0	1	0	4	41	23.50	2.10
16.4	7	4	0	1	1	4	0	3	19	13.20	1.35
16.5	5	4	0	0	3	2	0	3	17	15.60	1.00
16.6	5	2	0	2	1	4	0	1	11	14.40	1.55
16.7	2	2	1	0	3	1	0	1	16	15.10	0.95
16.8	10	3	4	0	2	5	0	5	51	27.00	0.55
16.9	13	0	1	0	3	8	0	5	21	36.00	1.10
17	6	0	0	0	3	3	1	3	6	21.90	1.40
17.1	3	2	1	1	0	2	0	1	17	25.00	1.60
17.2	5	1	0	0	0	2	0	3	8	10.00	1.60
17.3	2	2	0	0	0	0	0	2	8	13.20	1.56
17.4	3	0	1	1	6	1	0	2	11	10.00	1.25
17.5	2	5	3	2	1	1	0	1	41	21.00	1.75

17.6	2	3	0	0	2	0	0	2	11	15.00	1.30
17.7	3	0	1	0	0	0	0	3	11	13.40	1.10
17.8	3	0	0	0	1	0	0	3	3	14.20	1.15
17.9	2	1	0	0	0	0	0	2	5	19.00	0.90
18	4	1	0	0	1	2	0	2	7	19.00	1.00
18.1	9	2	0	1	4	4	0	5	15	12.30	1.50
18.2	10	5	1	1	2	7	1	3	33	33.50	2.55
18.3	1	0	0	0	1	0	0	1	1	10.70	1.10
18.4	0	2	1	0	3	0	0	0	14	22.00	1.85
18.5	1	0	1	1	0	0	0	1	9	18.50	1.90
18.6	1	0	0	0	0	0	0	1	1	19.00	0.80
18.7	1	1	2	0	2	0	0	1	20	21.00	2.10
18.8	4	3	1	0	5	2	0	2	21	17.80	1.20
18.9	0	2	1	0	4	0	0	0	14	15.50	1.55
19	6	4	1	1	8	2	1	4	26	12.30	1.20
19.1	6	3	0	1	7	1	0	5	15	25.30	2.45
19.2	4	1	0	3	10	2	0	2	7	13.00	0.85
19.3	4	5	6	0	2	2	0	2	67	29.00	2.05
19.4	6	3	2	0	1	2	0	4	31	35.00	1.50
19.5	1	2	0	0	1	1	0	0	7	19.00	1.40
19.6	4	1	0	0	1	1	0	3	7	18.00	1.10
19.7	3	0	1	0	3	0	0	3	11	14.20	1.25
19.8	1	1	0	1	5	1	0	0	4	10.60	1.55
19.9	4	3	0	0	3	1	0	3	13	21.00	0.90
20	0	2	0	0	3	0	0	0	6	14.70	1.80
20.1	9	7	0	1	5	1	1	8	30	41.10	1.80
20.2	5	4	0	0	3	1	1	4	17	83.50	1.25
20.3	6	3	0	1	7	4	0	2	15	31.70	1.85
20.4	3	2	2	0	7	0	0	3	25	19.30	1.45
20.5	0	1	0	0	14	0	0	0	3	21.40	0.60
20.6	3	1	1	0	13	1	0	2	14	19.10	1.35
20.7	2	0	0	0	7	2	0	0	2	24.70	0.80
20.8	2	0	0	0	1	1	0	1	2	23.00	0.70
20.9	7	1	0	0	4	1	0	6	10	22.90	0.90
21	5	0	0	1	1	1	0	4	5	20.00	0.75
21.1	0	1	0	0	3	0	0	0	3	17.20	0.80
21.2	3	2	1	0	4	0	0	3	17	18.60	0.75
21.3	0	4	2	0	3	0	0	0	28	11.60	0.95
21.4	1	1	0	0	1	0	0	1	4	13.00	0.90
21.5	3	2	0	0	5	0	0	3	9	13.00	0.85
21.6	8	0	0	0	3	2	0	6	8	11.20	1.30
21.7	0	2	0	0	4	0	0	0	6	12.20	1.20
21.8	3	6	0	1	6	0	1	3	21	10.90	1.45
21.9	3	4	0	0	5	1	0	2	15	14.10	0.85
22	6	0	0	0	2	2	0	4	6	13.90	0.55
22.1	1	2	3	0	2	0	0	1	31	12.10	1.15

22.2	3	1	0	0	2	0	0	3	6	17.90	1.40
22.3	7	0	0	0	2	3	0	4	7	17.10	0.75
22.4	3	1	0	0	3	3	0	0	6	16.60	0.70
22.5	1	1	0	0	1	0	0	1	4	11.30	1.00
22.6	5	1	0	0	0	2	0	3	8	21.70	0.70
22.7	0	1	2	0	4	0	0	0	19	13.30	0.65
22.8	1	1	0	0	1	1	0	0	4	14.40	0.90
22.9	1	3	0	2	5	1	0	0	10	23.30	1.15
23	4	5	0	0	6	3	0	1	19	20.20	0.60
23.1	8	3	0	0	1	1	1	7	17	12.60	1.00
23.2	2	2	1	1	1	0	0	2	16	20.40	1.10
23.3	1	0	0	0	5	1	1	0	1	17.60	1.05
23.4	7	0	1	0	3	2	0	5	15	8.90	2.00
23.5	1	0	0	0	2	0	3	1	1	11.40	1.30
24.2	13	6	1	0	4	4	0	9	39	11.60	0.60
24.3	16	7	1	2	1	2	0	14	45	11.50	0.90
24.4	13	5	2	0	1	7	0	6	44	12.10	0.80
24.5	9	8	1	1	2	4	0	5	41	21.40	0.65
24.6	4	8	1	1	5	2	1	2	36	16.00	1.10
24.7	4	2	1	0	3	2	0	2	18	13.60	0.85
24.8	1	3	6	0	2	0	0	1	58	16.60	0.80
24.9	3	3	4	0	0	2	0	1	44	12.50	1.05
25	2	0	0	0	1	1	0	1	2	12.70	1.40
25.1	0	0	0	1	5	0	0	0	0	19.60	0.45
25.2	1	1	1	0	8	1	0	0	12	24.00	0.60
25.3	3	2	0	0	7	0	1	3	9	11.50	1.10
25.4	2	0	1	1	16	0	0	2	10	18.00	0.70
25.5	3	3	0	0	19	0	0	3	12	42.90	1.70
25.6	0	0	0	1	32	0	0	0	0	55.00	3.45
25.7	0	0	1	2	21	0	0	0	8	46.20	3.10
25.8	1	0	0	3	21	1	0	0	1	51.00	2.90
25.9	1	0	0	1	23	0	0	1	1	69.00	3.10
26	1	1	1	3	45	0	0	1	12	66.00	3.60
26.1	3	1	0	3	46	0	0	3	6	70.00	4.05
26.2	2	1	0	0	20	0	0	2	5	70.00	3.10
26.3	1	1	0	0	21	0	0	1	4	70.00	2.20
26.4	0	1	0	1	13	0	0	0	3	45.00	1.00
26.5	0	0	0	1	7	0	0	0	0	39.00	1.30
26.6	0	0	0	1	17	0	0	0	0	51.00	2.45
26.7	0	0	0	0	1	0	0	0	0	25.00	1.75
26.8	3	0	0	0	8	1	0	2	3	71.00	1.35
26.9	2	0	0	0	12	0	0	2	2	58.50	1.40
27	0	0	0	0	7	0	0	0	0	67.50	2.25
27.1	0	0	0	0	8	0	0	0	0	41.00	2.80
27.2	0	0	0	1	7	0	0	0	0	25.10	1.35
27.3	1	0	0	1	10	0	0	1	1	27.30	1.55

27.4	0	0	0	0	11	0	0	0	0	36.60	2.10
27.5	3	0	0	0	3	1	0	2	3	60.00	3.40
27.6	1	0	0	1	3	1	0	0	1	29.70	1.25
27.7	0	2	1	3	5	0	0	0	14	13.70	0.80
27.8	1	3	0	2	4	1	0	0	10	15.10	0.90
27.9	2	2	1	2	4	2	1	0	16	7.00	1.35
28	1	3	2	0	0	0	0	1	26	12.30	1.55
28.1	1	3	0	1	0	0	0	1	10	20.80	0.90
28.2	3	3	0	0	1	1	0	2	12	18.00	1.20
28.3	8	2	0	0	0	4	0	4	14	17.00	1.40
28.4	3	3	0	0	0	0	0	3	12	31.40	1.25
28.5	1	1	0	0	0	0	0	1	4	18.00	2.05
28.6	2	3	0	0	0	1	0	1	11	32.00	0.90
28.7	1	1	1	0	1	0	0	1	12	16.00	1.35
28.8	2	1	1	0	0	1	0	1	13	27.70	2.20
28.9	2	2	0	0	0	0	0	2	8	23.00	2.05
29	0	1	1	0	5	0	0	0	11	15.00	1.25
29.1	2	1	1	0	6	2	4	0	13	30.00	0.80
29.2	3	3	1	1	3	1	0	2	20	30.00	0.80
29.3	2	1	0	0	1	1	0	1	5	39.00	2.75
29.4	5	0	1	0	4	1	0	4	13	35.30	1.75
29.5	2	1	0	0	2	1	0	1	5	24.40	2.20
29.6	2	1	0	0	0	0	0	2	5	18.00	1.10
29.7	1	0	0	0	0	1	0	0	1	21.00	0.95
29.8	1	0	0	0	1	0	0	1	1	20.00	1.05
29.9	0	0	0	0	9	0	0	0	0	31.00	1.60
30	1	0	0	0	2	1	0	0	1	39.00	2.50
30.1	0	0	0	0	0	0	0	0	0	21.00	1.45
30.2	1	0	0	0	8	1	0	0	1	31.00	1.45
30.3	1	2	0	0	7	1	0	0	7	52.00	1.65
30.4	0	0	0	0	14	0	0	0	0	31.00	1.35
30.5	0	0	0	7	8	0	0	0	0	25.00	1.30
30.6	0	0	0	0	23	0	0	0	0	33.00	2.15
30.7	0	0	0	1	7	0	0	0	0	44.00	1.85
30.8	1	0	0	0	8	1	0	0	1	46.00	1.05
30.9	0	0	0	0	15	0	0	0	0	57.00	2.50
31	0	0	0	1	11	0	0	0	0	36.00	0.75
31.1	0	0	0	2	14	0	0	0	0	53.30	1.70
31.2	0	0	0	3	13	0	0	0	0	41.00	1.55
31.3	1	0	0	1	17	1	0	0	1	25.30	1.60
31.4	1	0	0	0	18	0	0	1	1	41.50	2.40
31.5	0	0	0	0	3	0	0	0	0	44.70	2.70
31.6	1	0	0	0	6	1	0	0	1	48.70	4.00
31.7	0	0	0	0	5	0	0	0	0	37.70	2.90
31.8	0	0	0	0	3	0	0	0	0	33.90	2.60
31.9	0	0	0	0	11	0	0	0	0	51.90	2.35

[illegible]

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36.6 0 0 0 0 0 0 0 0 0 21.00 0.95

Table 8. Basin metrics and channel morphology data for Soda Butte Creek.

Distance (km)	Slope (m/m)	Elevation (m)	DA (km ²)	Scour Pool	Plunge Pool	Backwater	Run	Glide	LG Riffle	HG Riffle	Step	Total Pool	Total Units
0	0.0457	2322.58	10.16	0	0	0	0	0	0	0	1	0	1
0.1	0.0203	2318.00	10.34	0	2	0	0	0	0	0	3	2	5
0.2	0.0203	2315.97	10.52	1	2	0	0	0	0	0	4	3	7
0.3	0.0203	2313.93	15.41	3	0	0	0	1	7	6	1	3	18
0.4	0.0203	2311.90	15.58	2	3	0	0	0	6	3	1	5	15
0.5	0.0203	2309.87	15.76	7	2	1	0	0	7	9	0	9	26
0.6	0.0203	2307.83	15.94	4	1	2	1	2	3	6	0	5	19
0.7	0.0102	2305.80	16.12	3	1	1	1	2	4	3	0	4	15
0.8	0.0102	2304.78	16.30	3	1	1	0	3	2	2	0	4	12
0.9	0.0102	2303.77	16.48	5	2	1	0	3	3	4	0	7	18
1	0.0102	2302.75	16.65	3	3	2	3	2	4	3	0	6	20
1.1	0.0102	2301.73	16.83	6	1	2	2	3	6	3	0	7	23
1.2	0.0102	2300.72	17.01	4	3	3	2	3	5	4	0	7	24
1.3	0.0102	2299.70	17.19	4	2	1	1	3	5	3	0	6	19
1.4	0.0102	2298.68	17.37	2	4	0	1	4	3	4	0	6	18
1.5	0.0102	2297.67	46.67	2	0	2	1	3	0	2	0	2	10
1.6	0.0102	2296.65	46.84	2	0	2	0	2	3	1	0	2	10
1.7	0.0102	2295.63	47.02	1	0	1	0	1	2	2	0	1	7
1.8	0.0102	2294.62	47.20	1	2	1	1	1	3	5	0	3	14
1.9	0.0087	2293.60	47.38	0	0	0	1	1	1	0	0	0	3
2	0.0087	2292.73	47.56	0	0	2	1	0	3	2	0	0	8
2.1	0.0087	2291.86	47.74	3	1	2	3	1	6	2	0	4	18
2.2	0.0087	2290.99	47.91	4	1	2	1	2	4	4	0	5	18
2.3	0.0087	2290.11	48.09	3	0	0	0	3	2	2	0	3	10
2.4	0.0087	2289.24	48.27	2	2	2	2	4	4	4	0	4	20
2.5	0.0087	2288.37	48.45	3	1	1	0	4	4	4	0	4	17
2.6	0.0087	2287.50	48.63	3	1	1	0	2	5	1	0	4	13
2.7	0.0087	2286.63	48.81	4	0	2	0	1	3	0	0	4	10
2.8	0.0087	2285.76	48.98	3	1	1	1	4	2	2	0	4	14
2.9	0.0087	2284.89	49.16	3	0	0	0	2	2	1	0	3	8
3	0.0087	2284.01	49.34	1	2	2	2	2	4	2	0	3	15
3.1	0.0087	2283.14	49.52	1	0	1	0	1	2	0	0	1	5
3.2	0.0057	2282.27	49.70	3	1	0	1	2	2	1	0	4	10
3.3	0.0030	2281.71	49.88	1	2	1	2	1	4	1	1	3	13
3.4	0.0111	2281.40	57.58	2	0	0	2	1	4	1	1	2	11
3.5	0.0111	2280.29	57.96	3	0	0	1	3	3	0	0	3	10
3.6	0.0111	2279.18	58.28	2	1	1	1	1	3	1	0	3	10
3.7	0.0111	2278.07	58.61	4	0	2	1	2	2	1	0	4	12
3.8	0.0111	2276.96	58.93	2	2	1	1	2	1	1	0	4	10

3.9	0.0111	2275.85	59.25	3	1	2	1	3	3	1	0	4	14
4	0.0111	2274.75	59.57	2	1	1	2	1	3	1	0	3	11
4.1	0.0111	2273.64	59.90	5	2	2	2	4	4	4	0	7	23
4.2	0.0111	2272.53	60.22	2	0	1	1	3	3	1	0	2	11
4.3	0.0111	2271.42	60.54	3	0	0	1	3	1	1	0	3	9
4.4	0.0111	2270.31	60.87	7	0	0	1	4	5	2	0	7	19
4.5	0.0081	2269.20	61.19	2	0	1	1	2	4	2	0	2	12
4.6	0.0081	2268.39	61.51	6	1	1	2	3	4	3	0	7	20
4.7	0.0081	2267.57	61.83	4	2	2	3	5	3	2	0	6	21
4.8	0.0081	2266.76	62.16	5	0	2	2	3	4	2	0	5	18
4.9	0.0081	2265.95	62.48	5	2	0	1	7	8	4	0	7	27
5	0.0081	2265.13	62.69	1	1	1	0	1	4	0	0	2	8
5.1	0.0081	2264.32	67.10	3	1	1	1	0	3	1	0	4	10
5.2	0.0081	2263.51	67.31	1	0	0	1	1	1	1	0	1	5
5.3	0.0081	2262.69	67.53	0	1	1	0	1	2	0	0	1	5
5.4	0.0081	2261.88	67.74	2	0	2	0	1	1	1	0	2	7
5.5	0.0081	2261.07	67.96	1	2	1	0	3	3	2	0	3	12
5.6	0.0081	2260.25	68.17	1	0	1	1	1	0	2	0	1	6
5.7	0.0081	2259.44	68.38	1	0	0	0	3	1	1	0	1	6
5.8	0.0081	2258.63	68.60	1	1	0	1	2	1	1	0	2	7
5.9	0.0081	2257.81	68.81	1	1	2	2	2	1	3	0	2	12
6	0.0068	2257.00	69.02	3	0	0	1	3	4	3	0	3	14
6.1	0.0068	2256.32	69.24	1	1	0	0	5	3	2	0	2	12
6.2	0.0068	2255.64	69.45	2	0	0	1	3	4	1	0	2	11
6.3	0.0068	2254.97	69.67	2	0	1	0	1	2	2	0	2	8
6.4	0.0068	2254.29	69.88	5	0	0	1	6	4	3	0	5	19
6.5	0.0068	2253.61	70.09	2	0	2	3	3	4	2	0	2	16
6.6	0.0068	2252.93	70.31	3	1	1	3	5	3	1	0	4	17
6.7	0.0068	2252.26	70.52	2	0	1	2	3	2	1	0	2	11
6.8	0.0068	2251.58	70.74	1	1	2	3	3	1	0	0	2	11
6.9	0.0068	2250.90	70.95	1	0	0	1	0	1	0	0	1	3
7	0.0068	2250.22	71.16	3	1	1	3	3	3	2	0	4	16
7.1	0.0068	2249.54	71.38	2	1	1	1	3	2	1	0	3	11
7.2	0.0068	2248.87	71.59	1	0	1	1	2	4	1	0	1	10
7.3	0.0068	2248.19	71.80	1	0	1	1	1	2	1	0	1	7
7.4	0.0068	2247.51	72.02	1	1	1	2	0	2	2	0	2	9
7.5	0.0068	2246.83	72.23	2	1	2	2	3	1	2	0	3	13
7.6	0.0068	2246.16	72.45	1	0	0	1	1	1	1	1	1	6
7.7	0.0068	2245.48	72.60	3	1	0	2	2	1	2	0	4	11
7.8	0.0094	2244.80	72.66	2	0	0	2	2	2	1	0	2	9
7.9	0.0094	2243.86	78.86	0	0	0	1	0	2	1	0	0	4
8	0.0094	2242.92	79.07	0	2	0	3	0	2	4	0	2	11
8.1	0.0094	2241.98	79.28	0	2	0	2	0	1	4	1	2	10
8.2	0.0094	2241.05	80.52	1	1	0	0	1	1	2	0	2	6
8.3	0.0094	2240.11	80.80	3	3	1	0	3	0	4	0	6	14
8.4	0.0094	2239.17	81.08	1	1	0	0	1	4	3	0	2	10

8.5	0.0094	2238.23	81.37	0	0	1	0	0	2	1	0	0	4
8.6	0.0094	2237.29	81.65	2	2	0	0	2	3	2	0	4	11
8.7	0.0094	2236.35	81.93	0	2	2	0	1	4	2	0	2	11
8.8	0.0094	2235.42	82.21	0	1	0	1	3	3	3	0	1	11
8.9	0.0094	2234.48	82.49	1	3	1	1	3	5	2	0	4	16
9	0.0094	2233.54	82.78	1	0	1	3	6	4	3	0	1	18
9.1	0.0094	2232.60	83.06	3	2	0	3	7	6	6	0	5	27
9.2	0.0094	2231.66	83.34	2	0	0	2	2	5	2	0	2	13
9.3	0.0094	2230.72	83.62	2	2	0	3	2	3	1	1	4	14
9.4	0.0094	2229.78	83.91	2	1	1	2	4	5	2	0	3	17
9.5	0.0094	2228.85	84.19	2	1	1	2	2	4	4	0	3	16
9.6	0.0094	2227.91	84.47	2	1	1	3	1	2	2	0	3	12
9.7	0.0094	2226.97	84.75	2	1	1	4	0	0	1	0	3	9
9.8	0.0094	2226.03	85.03	4	0	1	3	3	2	1	0	4	14
9.9	0.0094	2225.09	85.32	4	0	1	1	3	4	1	0	4	14
10	0.0094	2224.15	85.60	1	1	1	1	4	5	0	0	2	13
10.1	0.0094	2223.22	85.88	3	1	1	0	5	3	0	0	4	13
10.2	0.0094	2222.28	86.16	0	3	2	0	3	4	0	0	3	12
10.3	0.0094	2221.34	86.44	3	1	1	2	3	1	1	0	4	12
10.4	0.0061	2220.40	86.73	2	2	1	1	1	0	1	2	4	10
10.5	0.0061	2219.79	87.01	0	1	0	2	0	0	1	2	1	6
10.6	0.0061	2219.18	87.29	0	0	0	0	0	1	1	3	0	5
10.7	0.0061	2218.57	87.57	0	1	0	0	0	0	1	2	1	4
10.8	0.0061	2217.96	87.86	0	0	0	1	0	0	1	1	0	3
10.9	0.0061	2217.35	88.14	1	1	0	0	2	1	1	0	2	6
11	0.0061	2216.74	92.58	3	1	0	1	3	0	5	0	4	13
11.1	0.0061	2216.13	92.74	2	1	0	1	4	3	3	0	3	14
11.2	0.0061	2215.52	92.89	2	1	0	3	3	0	2	1	3	12
11.3	0.0061	2214.91	93.05	3	1	0	0	2	1	0	0	4	7
11.4	0.0061	2214.30	93.20	1	0	2	0	0	2	0	0	1	5
11.5	0.0061	2213.69	93.36	1	0	1	0	2	2	1	0	1	7
11.6	0.0061	2213.08	93.52	1	0	0	0	2	3	2	0	1	8
11.7	0.0061	2212.47	93.67	3	0	0	0	1	3	3	0	3	10
11.8	0.0061	2211.86	93.83	1	0	0	0	2	2	1	0	1	6
11.9	0.0061	2211.25	93.98	1	0	1	0	1	3	1	0	1	7
12	0.0061	2210.64	94.14	0	0	1	1	1	2	1	0	0	6
12.1	0.0061	2210.03	94.29	0	2	0	0	3	0	0	0	2	5
12.2	0.0061	2209.42	94.45	2	0	0	0	3	2	1	0	2	8
12.3	0.0061	2208.81	94.61	2	0	0	0	2	2	1	0	2	7
12.4	0.0076	2208.20	94.76	2	0	1	0	1	1	0	0	2	5
12.5	0.0076	2207.44	94.92	1	1	0	1	1	3	0	0	2	7
12.6	0.0076	2206.68	95.07	0	0	2	1	2	0	0	0	0	5
12.7	0.0076	2205.91	95.23	1	1	3	2	1	1	0	0	2	9
12.8	0.0076	2205.15	95.39	2	2	1	1	2	1	3	0	4	12
12.9	0.0076	2204.39	95.54	1	3	1	2	1	0	1	0	4	9
13	0.0076	2203.63	95.70	2	1	0	3	5	3	4	0	3	18

13.1	0.0076	2202.86	95.85	1	0	0	1	1	1	0	0	1	4
13.2	0.0076	2202.10	96.01	0	1	0	1	1	2	1	0	1	6
13.3	0.0076	2201.34	96.16	2	0	1	2	2	3	2	0	2	12
13.4	0.0076	2200.58	96.32	0	2	1	1	2	3	2	0	2	11
13.5	0.0076	2199.81	96.48	1	0	0	2	2	2	2	0	1	9
13.6	0.0076	2199.05	96.63	2	0	0	0	1	2	0	0	2	5
13.7	0.0076	2198.29	96.79	1	0	0	1	1	2	1	0	1	6
13.8	0.0076	2197.53	96.94	2	0	0	1	2	3	1	0	2	9
13.9	0.0076	2196.76	97.10	0	1	0	0	2	2	0	0	1	5
14	0.0094	2196.00	97.26	0	0	0	1	1	1	0	0	0	3
14.1	0.0094	2195.06	97.41	3	0	1	1	3	2	0	0	3	10
14.2	0.0094	2194.12	97.57	1	0	1	1	1	2	1	0	1	7
14.3	0.0094	2193.18	97.72	1	1	1	1	2	1	1	0	2	8
14.4	0.0094	2192.25	97.88	1	0	1	0	2	1	1	0	1	6
14.5	0.0094	2191.31	98.03	2	1	0	2	4	3	0	0	3	12
14.6	0.0094	2190.37	98.19	5	2	2	3	5	5	4	1	7	27
14.7	0.0094	2189.43	98.35	2	1	1	4	2	1	3	1	3	15
14.8	0.0094	2188.49	98.50	0	0	0	1	1	1	0	1	0	4
14.9	0.0094	2187.55	98.66	0	0	0	1	1	0	1	2	0	5
15	0.0094	2186.62	98.81	0	0	0	0	1	2	0	0	0	3
15.1	0.0094	2185.68	100.32	1	0	0	1	1	2	0	0	1	5
15.2	0.0094	2184.74	101.08	0	0	1	1	1	2	2	0	0	7
15.3	0.0076	2183.80	101.84	0	1	0	0	2	2	1	0	1	6
15.4	0.0076	2183.04	102.91	0	1	0	2	2	3	4	2	1	14
15.5	0.0076	2182.28	103.00	0	0	0	1	1	3	2	0	0	7
15.6	0.0076	2181.51	103.09	1	0	1	2	1	3	3	0	1	11
15.7	0.0076	2180.75	103.18	2	0	0	1	1	1	2	0	2	7
15.8	0.0076	2179.99	103.27	0	1	0	1	1	2	1	1	1	7
15.9	0.0076	2179.23	103.36	0	0	1	1	3	3	2	0	0	10
16	0.0076	2178.46	103.45	1	1	2	1	3	1	3	0	2	12
16.1	0.0076	2177.70	103.54	1	1	1	2	3	2	4	0	2	14
16.2	0.0076	2176.94	103.63	0	1	2	0	2	1	2	0	1	8
16.3	0.0076	2176.18	104.95	1	1	0	1	2	1	1	0	2	7
16.4	0.0076	2175.41	105.06	1	0	1	1	1	1	0	0	1	5
16.5	0.0076	2174.65	105.18	1	0	1	0	1	1	0	0	1	4
16.6	0.0076	2173.89	105.29	1	0	2	1	1	1	0	0	1	6
16.7	0.0076	2173.13	105.40	2	0	2	0	1	2	0	0	2	7
16.8	0.0076	2172.36	105.51	3	2	2	1	3	4	1	2	5	18
16.9	0.0102	2171.60	105.62	2	0	1	1	2	1	1	0	2	8
17	0.0102	2170.58	107.07	2	0	0	1	1	2	2	0	2	8
17.1	0.0102	2169.57	107.58	3	0	1	3	2	1	2	2	3	14
17.2	0.0102	2168.55	108.09	0	2	1	1	1	1	1	1	2	8
17.3	0.0102	2167.53	111.09	0	0	0	1	1	1	0	0	0	3
17.4	0.0102	2166.52	111.20	0	0	0	1	1	1	1	0	0	4
17.5	0.0102	2165.50	111.31	0	2	1	1	4	4	2	1	2	15
17.6	0.0102	2164.48	111.41	1	0	0	1	2	1	1	1	1	7

17.7	0.0102	2163.47	111.52	0	0	0	1	0	1	0	0	0	2
17.8	0.0102	2162.45	111.63	0	0	0	1	0	1	0	0	0	2
17.9	0.0102	2161.43	111.73	1	0	0	0	1	1	0	0	1	3
18	0.0102	2160.42	111.84	0	2	0	0	2	3	2	0	2	9
18.1	0.0076	2159.40	111.95	1	1	1	1	1	2	2	0	2	9
18.2	0.0076	2158.64	112.05	0	2	0	2	6	1	4	1	2	16
18.3	0.0076	2157.88	112.16	0	0	1	1	2	1	1	0	0	6
18.4	0.0076	2157.11	113.21	0	2	1	1	2	0	5	0	2	11
18.5	0.0076	2156.35	113.48	0	1	1	0	1	1	0	0	1	4
18.6	0.0076	2155.59	113.75	0	0	0	1	0	1	1	0	0	3
18.7	0.0076	2154.83	114.02	1	0	1	1	1	0	1	0	1	5
18.8	0.0076	2154.06	114.30	1	1	0	1	2	1	2	1	2	9
18.9	0.0076	2153.30	114.57	2	0	0	1	1	0	1	0	2	5
19	0.0076	2152.54	114.84	1	0	0	1	3	1	3	0	1	9
19.1	0.0076	2151.78	115.83	0	1	0	1	3	3	3	0	1	11
19.2	0.0076	2151.01	116.03	1	0	1	1	2	1	1	0	1	7
19.3	0.0076	2150.25	116.22	3	0	1	1	3	3	2	0	3	13
19.4	0.0076	2149.49	116.42	2	1	1	2	2	2	1	0	3	11
19.5	0.0076	2148.73	116.61	1	0	0	0	0	1	1	0	1	3
19.6	0.0076	2147.96	116.80	0	0	1	2	1	1	1	0	0	6
19.7	0.0068	2147.20	117.00	0	0	0	0	1	0	1	0	0	2
19.8	0.0068	2146.52	117.19	0	0	2	1	0	1	1	0	0	5
19.9	0.0068	2145.84	117.39	1	0	0	2	0	1	1	1	1	6
20	0.0068	2145.17	117.58	0	0	0	0	1	0	1	0	0	2
20.1	0.0068	2144.49	117.78	1	0	1	0	3	6	0	0	1	11
20.2	0.0068	2143.81	118.87	0	3	1	0	3	3	1	3	3	14
20.3	0.0068	2143.13	118.99	2	1	0	1	8	8	4	1	3	25
20.4	0.0068	2142.46	119.11	1	0	0	2	4	3	2	0	1	12
20.5	0.0068	2141.78	119.23	0	0	0	0	2	3	2	0	0	7
20.6	0.0068	2141.10	119.34	1	0	0	0	2	1	1	0	1	5
20.7	0.0068	2140.42	119.46	1	0	0	0	3	2	2	0	1	8
20.8	0.0068	2139.74	119.58	2	0	1	0	4	3	3	0	2	13
20.9	0.0068	2139.07	119.70	1	0	0	0	2	3	1	0	1	7
21	0.0068	2138.39	119.82	0	0	2	0	2	2	1	0	0	7
21.1	0.0068	2137.71	119.94	0	0	0	0	3	2	0	0	0	5
21.2	0.0068	2137.03	120.05	1	1	0	0	2	2	2	0	2	8
21.3	0.0068	2136.36	120.17	1	0	0	0	3	1	2	0	1	7
21.4	0.0068	2135.68	120.29	0	0	0	0	0	2	3	0	0	5
21.5	0.0102	2135.00	120.41	0	1	0	0	3	1	2	0	1	7
21.6	0.0102	2133.98	120.53	0	2	0	0	0	2	3	0	2	7
21.7	0.0102	2132.97	120.65	1	0	0	0	2	2	3	0	1	8
21.8	0.0102	2131.95	122.06	1	0	0	0	1	1	2	1	1	6
21.9	0.0102	2130.93	122.63	1	0	0	0	2	3	1	0	1	7
22	0.0102	2129.92	122.76	0	0	0	0	1	2	2	0	0	5
22.1	0.0102	2128.90	122.89	1	0	1	1	2	3	2	0	1	10
22.2	0.0102	2127.88	123.02	0	0	0	0	2	0	2	0	0	4

22.3	0.0102	2126.87	123.15	1	0	0	0	1	2	2	0	1	6
22.4	0.0102	2125.85	123.28	0	0	1	0	2	1	2	0	0	6
22.5	0.0102	2124.83	123.41	0	0	0	0	2	2	0	0	0	4
22.6	0.0102	2123.82	123.54	0	0	1	0	1	2	2	0	0	6
22.7	0.0122	2122.80	123.67	0	0	0	0	4	1	2	0	0	7
22.8	0.0122	2121.58	123.80	0	0	0	0	1	0	1	0	0	2
22.9	0.0122	2120.36	123.94	0	0	1	0	2	2	1	0	0	6
23	0.0122	2119.14	124.07	1	0	0	0	1	2	1	0	1	5
23.1	0.0122	2117.92	124.20	0	1	0	0	2	2	1	0	1	6
23.2	0.0122	2116.70	124.33	1	1	0	0	4	1	2	0	2	9
23.3	0.0122	2115.48	124.46	1	0	0	1	1	1	2	0	1	6
23.4	0.0122	2114.26	124.59	1	1	0	1	2	1	2	0	2	8
23.5	0.0122	2113.04	124.72	1	0	0	1	1	0	1	1	1	5
24.2	0.0122	2098.40	125.64	2	0	0	0	2	0	2	0	2	6
24.3	0.0122	2097.18	125.77	2	0	1	0	3	1	1	0	2	8
24.4	0.0122	2095.96	125.90	1	0	0	0	3	3	0	0	1	7
24.5	0.0122	2094.74	126.50	2	0	0	0	3	3	1	0	2	9
24.6	0.0122	2093.52	126.62	0	0	0	0	2	1	0	0	0	3
24.7	0.0122	2092.30	126.75	1	0	0	0	2	2	0	0	1	5
24.8	0.0122	2091.08	126.87	2	0	1	2	0	2	0	0	2	7
24.9	0.0122	2089.86	126.99	3	0	1	0	1	2	1	0	3	8
25	0.0122	2088.64	127.11	0	1	0	0	2	1	0	0	1	4
25.1	0.0122	2087.42	150.57	0	0	0	0	2	1	1	0	0	4
25.2	0.0076	2086.20	154.59	1	0	0	0	2	1	2	0	1	6
25.3	0.0076	2085.44	154.67	1	0	0	0	1	3	1	0	1	6
25.4	0.0076	2084.68	154.76	0	0	0	0	2	2	0	0	0	4
25.5	0.0076	2083.91	154.84	0	0	1	0	3	2	2	0	0	8
25.6	0.0076	2083.15	154.92	1	0	0	1	2	2	2	0	1	8
25.7	0.0076	2082.39	155.00	1	1	0	0	2	2	1	0	2	7
25.8	0.0076	2081.63	155.09	0	0	0	0	2	4	1	0	0	7
25.9	0.0076	2080.86	155.17	0	0	0	0	1	1	1	0	0	3
26	0.0076	2080.10	155.25	0	1	0	0	4	3	1	0	1	9
26.1	0.0076	2079.34	155.33	0	3	0	0	0	3	1	0	3	7
26.2	0.0076	2078.58	155.42	1	1	0	1	5	6	3	0	2	17
26.3	0.0076	2077.81	155.50	1	0	0	0	5	7	4	0	1	17
26.4	0.0076	2077.05	155.58	2	0	0	0	1	2	2	0	2	7
26.5	0.0076	2076.29	155.66	1	1	1	0	4	5	2	0	2	14
26.6	0.0076	2075.53	155.75	0	1	1	0	4	3	3	0	1	12
26.7	0.0076	2074.76	155.83	0	0	1	0	2	1	0	0	0	4
26.8	0.0081	2074.00	218.67	1	0	1	0	5	3	1	0	1	11
26.9	0.0081	2073.19	219.49	0	0	2	0	1	2	1	0	0	6
27	0.0081	2072.37	220.30	2	0	1	2	1	2	1	0	2	9
27.1	0.0081	2071.56	221.12	2	0	0	0	1	0	0	0	2	3
27.2	0.0081	2070.75	221.94	2	0	1	0	2	1	1	0	2	7
27.3	0.0081	2069.93	222.76	3	0	1	1	2	2	1	0	3	10
27.4	0.0081	2069.12	223.58	4	0	1	1	2	2	0	0	4	10

27.5	0.0081	2068.31	224.40	2	0	0	1	3	1	0	0	2	7
27.6	0.0081	2067.49	225.22	1	0	1	1	2	1	1	0	1	7
27.7	0.0081	2066.68	227.78	0	0	0	0	1	1	0	0	0	2
27.8	0.0081	2065.87	228.87	3	0	0	3	1	1	0	0	3	8
27.9	0.0081	2065.05	229.96	4	0	0	3	0	0	0	0	4	7
28	0.0081	2064.24	231.05	2	0	2	1	3	4	0	0	2	12
28.1	0.0081	2063.43	232.14	0	0	0	0	1	1	3	3	0	8
28.2	0.0081	2062.61	233.23	0	0	0	0	0	0	3	3	0	6
28.3	0.0305	2061.80	234.32	0	0	0	0	0	0	3	3	0	6
28.4	0.0305	2058.75	235.77	1	1	0	1	1	0	2	2	2	8
28.5	0.0305	2055.70	236.45	0	1	0	0	0	0	1	1	1	3
28.6	0.0305	2052.65	237.13	0	1	0	1	1	0	3	2	1	8
28.7	0.0068	2049.60	237.82	0	1	0	0	2	1	3	1	1	8
28.8	0.0068	2048.92	242.86	0	0	0	0	3	4	4	0	0	11
28.9	0.0068	2048.24	242.99	0	0	0	2	0	0	2	1	0	5
29	0.0068	2047.57	243.12	0	1	0	0	1	0	1	1	1	4
29.1	0.0068	2046.89	243.25	0	0	1	1	1	1	2	0	0	6
29.2	0.0068	2046.21	243.39	0	2	0	2	4	0	2	2	2	12
29.3	0.0068	2045.53	245.88	0	0	0	1	4	5	0	0	0	10
29.4	0.0068	2044.86	246.06	1	0	0	2	6	4	4	0	1	17
29.5	0.0068	2044.18	246.24	0	1	0	3	3	0	2	2	1	11
29.6	0.0068	2043.50	246.41	0	0	0	0	2	1	0	0	0	3
29.7	0.0068	2042.82	246.59	0	0	1	0	2	2	0	0	0	5
29.8	0.0068	2042.14	246.76	0	0	1	1	1	1	2	0	0	6
29.9	0.0068	2041.47	246.94	1	0	0	1	2	1	1	0	1	6
30	0.0068	2040.79	247.12	0	0	0	1	1	1	2	0	0	5
30.1	0.0068	2040.11	247.29	0	0	0	1	2	1	0	0	0	4
30.2	0.0068	2039.43	247.47	0	0	0	0	2	2	1	0	0	5
30.3	0.0068	2038.76	247.64	1	0	0	1	4	2	3	0	1	11
30.4	0.0068	2038.08	247.82	1	0	0	0	2	1	1	0	1	5
30.5	0.0064	2037.40	248.00	0	0	1	0	1	1	0	0	0	3
30.6	0.0064	2036.76	248.17	0	0	1	1	1	2	1	0	0	6
30.7	0.0064	2036.12	248.35	1	0	0	2	2	2	1	0	1	8
30.8	0.0064	2035.47	248.52	0	0	3	1	3	4	4	0	0	15
30.9	0.0064	2034.83	248.70	0	0	0	2	2	4	1	0	0	9
31	0.0064	2034.19	248.88	0	0	0	2	2	2	1	0	0	7
31.1	0.0064	2033.55	249.05	0	0	1	1	1	1	0	0	0	4
31.2	0.0064	2032.91	249.23	0	0	1	1	1	2	0	0	0	5
31.3	0.0064	2032.26	249.40	2	0	1	1	3	3	1	0	2	11
31.4	0.0064	2031.62	252.32	0	0	1	1	2	2	1	0	0	7
31.5	0.0064	2030.98	252.37	3	0	0	2	6	5	1	0	3	17
31.6	0.0064	2030.34	252.41	1	0	1	2	8	8	4	0	1	24
31.7	0.0064	2029.69	252.46	0	0	0	1	4	5	0	0	0	10
31.8	0.0064	2029.05	252.50	1	0	2	0	3	4	0	0	1	10
31.9	0.0064	2028.41	253.99	0	0	0	1	4	2	1	0	0	8
32	0.0064	2027.77	254.14	1	1	3	1	3	5	3	0	2	17

32.1	0.0064	2027.13	254.28	0	1	0	2	4	2	1	0	1	10
32.2	0.0064	2026.48	254.43	0	1	1	0	2	1	0	0	1	5
32.3	0.0064	2025.84	254.57	0	0	1	0	1	0	0	0	0	2
32.4	0.0061	2025.20	254.72	0	0	1	2	2	1	2	0	0	8
32.5	0.0061	2024.59	254.87	0	0	0	1	2	2	1	0	0	6
32.6	0.0061	2023.98	255.01	0	0	0	0	1	0	0	0	0	1
32.7	0.0061	2023.37	255.16	1	0	1	1	2	4	1	0	1	10
32.8	0.0061	2022.76	255.31	0	1	1	1	1	1	1	0	1	6
32.9	0.0061	2022.15	255.45	2	0	2	1	1	2	0	0	2	8
33	0.0061	2021.54	257.01	2	0	1	0	2	2	0	0	2	7
33.1	0.0061	2020.93	257.25	1	1	0	2	2	4	1	0	2	11
33.2	0.0061	2020.32	257.48	0	0	0	0	2	1	0	0	0	3
33.3	0.0061	2019.71	257.71	0	0	0	1	2	1	1	0	0	5
33.4	0.0061	2019.10	257.95	1	0	1	1	2	1	1	0	1	7
33.5	0.0061	2018.49	258.18	1	0	1	1	1	2	2	0	1	8
33.6	0.0061	2017.88	261.32	0	0	1	2	0	2	0	0	0	5
33.7	0.0061	2017.27	261.51	0	0	1	0	2	2	1	1	0	7
33.8	0.0061	2016.66	261.70	1	0	1	1	0	1	0	0	1	4
33.9	0.0061	2016.05	261.89	1	0	0	1	2	0	1	1	1	6
34	0.0061	2015.44	262.07	0	0	0	1	5	4	0	0	0	10
34.1	0.0061	2014.83	262.26	0	0	0	2	4	4	2	0	0	12
34.2	0.0061	2014.22	262.45	3	0	0	1	3	2	1	0	3	10
34.3	0.0061	2013.61	262.63	1	0	0	1	2	2	2	1	1	9
34.4	0.0038	2013.00	262.82	1	1	0	3	4	4	3	0	2	16
34.5	0.0038	2012.62	263.01	1	0	0	3	1	3	0	0	1	8
34.6	0.0038	2012.24	263.19	0	0	0	0	1	0	0	0	0	1
34.7	0.0038	2011.86	263.38	0	0	2	1	3	2	1	0	0	9
34.8	0.0038	2011.48	263.57	1	0	0	1	4	3	1	0	1	10
34.9	0.0038	2011.09	263.76	0	0	1	3	2	2	2	0	0	10
35	0.0038	2010.71	263.94	2	0	0	1	3	2	1	0	2	9
35.1	0.0038	2010.33	264.13	0	0	1	0	2	1	0	0	0	4
35.2	0.0038	2009.95	264.32	0	0	0	1	2	3	2	0	0	8
35.3	0.0038	2009.57	264.50	1	0	0	0	3	3	0	0	1	7
35.4	0.0038	2009.19	264.69	1	0	1	1	3	4	0	0	1	10
35.5	0.0038	2008.81	264.88	1	0	0	1	2	1	1	0	1	6
35.6	0.0038	2008.43	265.06	0	0	1	0	1	0	0	0	0	2
35.7	0.0038	2008.04	265.25	1	0	1	2	3	3	2	0	1	12
35.8	0.0038	2007.66	265.44	2	0	1	3	4	3	1	0	2	14
35.9	0.0038	2007.28	265.63	1	0	1	1	1	1	0	0	1	5
36	0.0038	2006.90	265.81	1	0	1	1	1	1	0	0	1	5
36.1	0.0038	2006.52	266.00	1	0	3	3	5	7	1	0	1	20
36.2	0.0038	2006.14	266.19	0	0	0	1	1	2	0	0	0	4
36.3	0.0038	2005.76	266.37	2	0	0	3	2	0	1	0	2	8
36.4	0.0038	2005.38	266.56	0	0	0	2	2	2	1	0	0	7
36.5	0.0038	2004.99	266.75	0	0	0	1	2	1	1	0	0	5
36.6	0.0038	2004.61	266.93	0	0	0	1	1	1	1	0	0	4

APPENDIX C

CACHE CREEK DATA

Table 9. Woody debris and channel measurement data for Cache Creek.

Distance (km)	Single Logs	Clusters	Jams	Buried	Bar	Submerged	Suspended	Ramped	Total Wood	Total Width (m)	Max Depth (m)
0	2	2	0	0	1	0	0	2	8	7.90	1.65
0.1	1	1	1	0	5	1	0	0	12	14.20	8.50
0.2	3	0	0	0	8	1	0	2	3	16.40	1.70
0.3	2	0	0	0	2	0	0	2	2	12.50	1.15
0.4	1	0	0	0	9	0	0	1	1	21.30	1.00
0.5	7	1	0	0	5	0	0	7	10	30.10	1.45
0.6	0	2	0	0	1	0	0	0	6	20.90	0.90
0.7	0	2	0	0	2	0	1	0	6	21.30	1.15
0.8	2	0	1	0	12	0	1	2	10	17.40	0.95
0.9	1	2	0	0	4	1	0	0	7	21.20	1.50
1	3	2	0	0	2	2	0	1	9	27.90	1.70
1.1	2	1	0	0	2	0	0	2	5	29.00	2.70
1.2	3	2	0	0	9	2	0	1	9	15.70	0.80
1.3	2	2	0	0	10	2	0	0	8	13.10	1.60
1.4	5	4	1	1	11	0	0	5	25	24.40	1.15
1.5	2	0	0	0	1	1	0	1	2	22.30	1.70
1.6	4	4	1	0	1	0	0	4	24	11.50	1.10
1.7	1	1	0	0	2	1	0	0	4	13.90	1.35
1.8	0	3	2	0	0	0	1	0	25	11.90	0.90
1.9	2	3	0	0	2	1	0	1	11	15.00	1.50
2	4	2	0	0	0	0	1	4	10	13.60	1.40
2.1	3	0	0	0	0	0	0	3	3	9.70	1.55
2.2	4	0	1	1	2	1	0	3	12	16.70	1.35
2.3	1	2	2	0	2	0	0	1	23	14.10	1.25
2.4	2	0	1	0	3	0	0	2	10	15.40	1.40
2.5	4	1	0	0	3	0	0	4	7	14.20	1.30
2.6	3	1	1	0	4	0	0	3	14	13.00	0.85
2.7	2	1	0	0	2	0	2	2	5	10.00	0.95
2.8	8	0	0	0	1	1	1	7	8	12.50	0.70
2.9	2	2	0	0	2	0	0	2	8	10.40	1.25
3	3	1	0	0	2	0	1	3	6	18.00	1.05
3.1	4	3	1	0	1	2	0	2	21	11.20	1.45
3.2	4	2	1	0	1	1	2	3	18	14.90	1.15
3.3	5	1	0	0	0	0	0	5	8	9.40	1.15
3.4	5	3	0	0	2	1	0	4	14	15.30	1.15
3.5	2	1	1	0	3	0	0	2	13	12.40	0.90
3.6	2	1	1	0	3	0	0	2	13	23.20	2.05
3.7	4	1	2	0	1	2	0	2	23	16.10	1.75

3.8	0	2	0	0	7	0	1	0	6	27.10	1.85
3.9	0	1	2	0	6	0	1	0	19	10.60	1.85
4	1	1	0	0	3	0	0	1	4	24.60	1.35
4.1	2	1	0	0	4	1	0	1	5	14.60	1.35
4.2	3	0	1	0	2	1	0	2	11	11.20	1.65
4.3	1	1	0	0	1	0	1	1	4	13.70	1.75
4.4	3	1	0	0	0	0	0	3	6	10.70	1.00
4.5	2	0	0	0	1	0	0	2	2	16.30	1.45
4.6	2	0	0	0	7	1	0	1	2	13.20	1.65
4.7	1	0	1	0	2	0	0	1	9	13.00	1.60
4.8	0	2	0	0	2	0	0	0	6	10.20	1.35
4.9	3	0	1	0	2	1	0	2	11	13.40	1.70
5	2	1	1	0	1	0	0	2	13	19.40	1.45
5.1	0	4	2	0	3	0	0	0	28	35.50	2.15
5.2	0	0	1	0	6	0	1	0	8	16.10	1.50
5.3	1	1	1	1	8	0	2	1	12	12.70	2.05
5.4	2	3	0	1	4	0	0	2	11	16.10	1.10
5.5	0	1	1	0	1	0	1	0	11	34.00	4.80
5.6	1	0	4	0	0	0	1	1	33	8.10	1.70
5.7	4	0	0	0	1	0	0	4	4	11.90	1.95
5.8	5	3	0	0	0	0	0	5	14	12.90	1.15
5.9	0	3	0	0	3	0	0	0	9	21.20	1.25
6	0	0	0	0	1	0	0	0	0	14.30	0.85
6.1	4	1	0	0	2	0	0	4	7	19.90	1.50
6.2	3	0	0	0	1	0	0	3	3	13.30	1.50
6.3	4	2	0	0	1	0	2	4	10	16.40	1.65
6.4	3	4	0	0	2	1	0	2	15	13.00	1.85
6.5	10	1	0	0	2	3	1	7	13	16.60	1.40
6.6	8	2	1	0	1	2	1	6	22	21.80	1.75
6.7	4	3	0	0	0	2	0	2	13	21.50	2.70
6.8	5	2	0	0	0	0	0	5	11	14.20	1.20
6.9	5	1	0	0	0	1	0	4	8	14.00	1.10
7	0	3	1	0	3	0	0	0	17	18.00	1.45
7.1	0	1	0	3	2	0	0	0	3	18.90	1.70
7.2	4	1	0	0	2	0	0	4	7	28.90	1.50
7.3	9	2	0	0	1	1	0	8	15	15.90	1.30
7.4	5	0	0	0	0	0	0	5	5	21.90	2.15
7.5	5	2	0	0	0	0	0	5	11	11.20	1.70
7.6	1	0	0	0	0	0	0	1	1	11.50	1.85
7.7	4	3	0	0	2	0	0	4	13	15.20	1.70
7.8	3	2	0	0	0	1	1	2	9	17.40	1.85
7.9	1	2	1	0	2	0	0	1	15	14.50	1.55
8	1	2	1	0	0	0	0	1	15	20.60	2.05
8.1	2	2	0	0	1	0	0	2	8	18.00	2.35
8.2	6	1	0	0	3	3	0	3	9	13.50	1.75
8.3	0	1	0	0	0	0	0	0	3	12.30	1.75

8.4	0	6	0	0	0	0	2	0	18	12.30	1.50
8.5	4	1	0	0	1	1	0	3	7	13.60	1.40
8.6	2	2	0	0	0	0	1	2	8	11.10	1.60
8.7	3	3	0	0	0	0	0	3	12	12.80	0.95
8.8	3	3	0	0	0	1	0	2	12	12.40	1.35
8.9	4	2	0	0	3	0	0	4	10	24.00	2.85
9	6	0	0	0	2	2	0	4	6	21.20	2.30
9.1	2	0	1	0	8	0	0	2	10	29.00	1.65
9.2	3	1	0	0	2	0	0	3	6	12.20	1.90
9.3	1	2	0	0	0	1	0	0	7	15.80	1.50
9.4	2	1	0	0	4	0	0	2	5	19.50	1.65
9.5	4	1	0	0	4	0	0	4	7	20.00	1.80
9.6	1	0	0	0	2	0	0	1	1	18.20	1.80
9.7	1	2	0	0	1	0	0	1	7	17.90	1.50
9.8	4	0	1	1	6	0	0	4	12	13.00	2.05
9.9	1	2	1	0	2	0	0	1	15	20.90	2.85
10	6	1	0	0	1	0	0	6	9	14.10	2.30
10.1	1	2	0	0	1	1	0	0	7	17.70	1.95
10.2	0	4	0	0	5	0	0	0	12	31.30	2.75
10.3	6	1	0	0	0	0	0	6	9	26.00	1.85
10.4	3	3	0	0	1	0	0	3	12	18.90	1.10
10.5	5	0	0	0	0	0	0	5	5	16.70	1.05
10.6	0	2	2	0	1	0	0	0	22	21.90	1.80
10.7	1	4	2	0	0	1	0	0	29	25.00	1.35
10.8	3	2	2	0	5	1	0	2	25	19.00	1.85
10.9	0	0	0	0	3	0	0	0	0	22.50	2.65
11	4	2	1	0	5	0	0	4	18	16.30	1.45
11.1	0	1	2	0	3	0	1	0	19	39.40	1.90
11.2	5	0	0	0	0	0	0	5	5	31.20	1.60
11.3	1	0	1	0	1	0	0	1	9	17.00	1.40
11.4	0	1	1	0	10	0	0	0	11	21.00	1.05
11.5	5	1	1	0	0	0	0	5	16	20.90	0.95
11.6	2	0	0	0	1	0	1	2	2	23.50	1.55
11.7	2	0	0	0	1	0	0	2	2	22.80	1.80
11.8	0	0	0	0	4	0	0	0	0	19.80	1.80
11.9	1	0	1	0	2	0	0	1	9	18.80	2.10
12	2	1	0	0	8	0	0	2	5	17.10	1.65
12.1	0	0	0	0	5	0	0	0	0	25.70	2.75
12.2	5	2	1	0	0	2	0	3	19	22.00	1.90
12.3	3	3	0	0	2	1	0	2	12	33.40	2.95
12.4	0	0	0	0	1	0	0	0	0	20.10	1.90
12.5	0	0	2	0	6	0	0	0	16	33.00	1.60
12.6	1	1	0	0	2	0	0	1	4	40.00	1.85
12.7	2	0	0	0	0	1	0	1	2	38.00	3.55
12.8	3	3	0	0	0	1	0	2	12	18.00	2.15
12.9	2	0	1	0	2	0	1	2	10	24.70	1.55

13	0	0	1	0	0	0	0	0	8	46.00	1.65
13.1	3	2	0	0	1	1	0	2	9	38.90	2.40
13.2	1	0	3	0	0	0	0	1	25	45.00	3.15
13.3	4	1	3	0	3	0	0	4	31	57.50	3.10
13.4	2	1	4	0	6	2	0	0	37	72.10	3.35
13.5	2	1	0	0	1	0	0	2	5	21.30	2.40
13.6	3	0	0	0	0	0	0	3	3	31.00	1.30
13.7	3	2	0	1	0	0	0	3	9	30.00	0.95
13.8	1	0	1	0	3	0	0	1	9	19.00	1.35
13.9	1	0	0	0	4	1	0	0	1	19.00	1.80
14	0	0	0	0	5	0	0	0	0	38.30	2.35
14.1	0	0	1	0	2	0	0	0	8	23.00	2.50
14.2	2	1	1	0	1	0	0	2	13	24.00	2.00
14.3	1	0	2	0	3	0	0	1	17	34.00	2.50
14.4	4	0	2	0	3	1	0	3	20	28.00	2.70
14.5	0	0	1	0	0	0	0	0	8	30.70	1.50
14.6	2	0	2	0	0	0	0	2	18	27.00	1.75
14.7	3	2	0	0	1	1	0	2	9	18.00	1.50
14.8	0	1	0	0	0	0	0	0	3	17.00	2.30
14.9	1	2	0	0	0	0	1	1	7	10.80	1.70
15	2	3	0	0	0	0	0	2	11	9.00	2.35
15.1	0	2	0	0	0	0	0	0	6	17.80	1.40
15.2	0	2	0	0	3	0	0	0	6	17.70	1.25
15.3	0	1	1	0	1	0	0	0	11	15.00	1.20
15.4	1	1	0	0	1	0	0	1	4	22.30	1.85
15.5	0	1	0	1	0	0	0	0	3	20.80	1.10
15.6	0	1	0	1	2	0	0	0	3	16.90	1.55
15.7	6	2	0	0	3	0	0	6	12	19.70	1.35
15.8	3	0	0	0	2	1	0	2	3	24.70	1.35
15.9	2	0	0	0	6	0	0	2	2	14.20	2.00
16	4	1	2	1	3	1	0	3	23	18.30	0.90
16.1	2	2	0	0	3	1	0	1	8	12.30	1.70
16.2	7	2	0	0	0	0	0	7	13	19.90	1.45
16.3	2	4	0	0	0	2	0	0	14	18.00	0.95
16.4	0	3	0	1	4	0	0	0	9	26.40	2.45
16.5	1	1	0	0	4	0	0	1	4	24.50	1.50
16.6	1	2	0	0	4	0	0	1	7	26.40	2.25
16.7	4	0	0	0	1	0	0	4	4	24.50	1.40
16.8	1	0	0	0	1	0	0	1	1	22.30	1.35
16.9	0	0	1	0	3	0	0	0	8	27.00	1.55
17	1	1	1	0	9	0	0	1	12	20.50	2.10
17.1	1	0	2	1	3	0	0	1	17	23.00	1.45
17.2	1	1	0	0	0	1	0	0	4	18.50	2.05
17.3	3	0	0	0	0	1	0	2	3	19.00	2.25
17.4	2	3	0	0	0	1	0	1	11	23.00	1.65
17.5	0	2	0	0	0	0	0	0	6	25.00	1.65

17.6	0	0	0	0	18	0	0	0	0	24.50	1.70
17.7	0	1	2	0	5	0	0	0	19	24.40	1.40
17.8	1	0	2	0	5	0	0	1	17	39.00	1.80
17.9	1	1	3	0	5	0	0	1	28	27.00	1.60
18	1	0	1	0	2	0	0	1	9	34.00	1.60
18.1	0	1	0	0	1	0	0	0	3	17.00	1.60
18.2	0	3	0	0	2	0	0	0	9	46.00	1.90
18.3	0	0	1	0	2	0	0	0	8	19.00	1.55
18.4	1	0	1	0	6	0	0	1	9	26.00	1.55
18.5	4	1	0	1	6	0	0	4	7	22.00	1.30
18.6	3	3	0	1	4	2	1	1	12	40.00	1.90
18.7	2	2	0	0	0	0	0	2	8	23.80	2.10
18.8	1	4	1	1	4	0	0	1	21	40.20	2.90
18.9	1	0	0	1	10	1	0	0	1	27.00	1.20
19	0	3	1	0	0	0	0	0	17	18.00	2.15
19.1	0	1	0	0	8	0	0	0	3	16.90	1.70

Table 10. Basin metrics and channel morphology data for Cache Creek.

Distance (km)	Slope (m/m)	Elevation (m)	DA (km ²)	Scour Pool	Plunge Pool	Backwater	Run	Glide	LG Riffle	HG Riffle	Step	Total Pool	Total Units
0	0.0203	2354.60	41.62	0	1	2	0	1	2	2	2	1	7
0.1	0.0203	2352.57	42.03	0	5	0	0	2	2	0	6	5	4
0.2	0.0203	2350.53	42.45	0	2	0	0	0	1	0	4	2	1
0.3	0.0203	2348.50	42.86	0	2	2	0	0	1	0	2	2	3
0.4	0.0203	2346.47	43.27	0	3	1	0	1	0	0	4	3	2
0.5	0.0203	2344.43	43.69	0	4	1	0	0	1	3	3	4	5
0.6	0.0203	2342.40	44.10	0	1	0	0	1	0	2	1	1	3
0.7	0.0203	2340.37	44.51	1	0	0	0	0	1	3	1	1	4
0.8	0.0203	2338.33	44.93	0	0	0	0	0	0	2	2	0	2
0.9	0.0203	2336.30	45.34	1	2	0	0	1	0	2	3	3	3
1	0.0203	2334.27	46.32	0	1	0	1	1	0	3	2	1	5
1.1	0.0203	2332.23	46.34	0	1	1	0	0	1	1	1	1	3
1.2	0.0203	2330.20	46.37	0	5	2	1	0	1	3	5	5	7
1.3	0.0203	2328.17	46.39	0	3	1	0	1	1	1	3	3	4
1.4	0.0203	2326.13	46.41	1	3	1	0	0	3	2	3	4	6
1.5	0.0203	2324.10	47.49	0	5	0	0	0	2	2	5	5	4
1.6	0.0203	2322.07	47.52	2	4	0	0	0	2	2	5	6	4
1.7	0.0203	2320.03	47.55	1	1	2	0	0	2	0	1	2	4
1.8	0.0122	2318.00	47.58	2	4	1	0	1	0	3	4	6	5
1.9	0.0122	2316.78	47.61	1	8	1	0	0	0	0	8	9	1
2	0.0122	2315.56	48.60	0	7	1	0	0	0	1	7	7	2
2.1	0.0122	2314.34	48.63	2	6	1	0	0	0	1	6	8	2
2.2	0.0122	2313.12	48.65	2	2	1	0	1	2	2	2	4	6
2.3	0.0122	2311.90	48.68	1	4	0	0	1	1	1	4	5	3
2.4	0.0122	2310.68	48.70	0	3	0	1	0	1	3	3	3	5
2.5	0.0122	2309.46	48.73	0	3	0	0	1	1	1	3	3	3
2.6	0.0122	2308.24	48.75	0	4	0	1	0	1	1	4	4	3
2.7	0.0122	2307.02	48.78	0	4	1	0	2	2	1	4	4	6
2.8	0.0174	2305.80	65.17	1	7	0	0	2	1	1	6	8	4
2.9	0.0174	2304.06	65.30	0	4	0	0	0	1	2	3	4	3
3	0.0174	2302.31	65.43	1	7	0	0	1	0	0	8	8	1
3.1	0.0174	2300.57	65.56	0	6	1	1	0	2	2	6	6	6
3.2	0.0174	2298.83	65.69	0	5	0	0	0	1	3	5	5	4
3.3	0.0174	2297.09	65.82	0	6	0	0	0	2	2	6	6	4
3.4	0.0174	2295.34	65.95	1	6	0	0	1	0	2	6	7	3
3.5	0.0203	2293.60	66.08	1	4	1	0	0	0	1	4	5	2
3.6	0.0203	2291.57	66.21	0	6	0	0	0	1	2	6	6	3
3.7	0.0203	2289.53	66.34	0	2	1	0	0	1	2	1	2	4
3.8	0.0203	2287.50	66.46	1	3	0	1	1	2	3	3	4	7

3.9	0.0203	2285.47	66.59	1	1	1	1	1	1	2	2	2	6
4	0.0203	2283.43	66.72	0	2	1	0	1	0	2	2	2	4
4.1	0.0305	2281.40	66.85	0	0	0	0	1	1	1	0	0	3
4.2	0.0305	2278.35	66.98	0	3	0	0	1	1	3	3	3	5
4.3	0.0305	2275.30	67.11	0	3	1	0	1	0	3	3	3	5
4.4	0.0305	2272.25	67.24	0	2	0	0	0	2	1	1	2	3
4.5	0.0610	2269.20	67.37	0	1	1	1	0	3	2	1	1	7
4.6	0.0610	2263.10	67.50	0	1	1	0	1	1	2	1	1	5
4.7	0.0305	2257.00	67.63	0	4	2	0	0	1	1	4	4	4
4.8	0.0305	2253.95	67.76	1	6	0	0	0	0	2	7	7	2
4.9	0.0305	2250.90	71.08	1	7	0	0	0	0	1	7	8	1
5	0.0305	2247.85	71.09	1	5	0	0	0	1	4	5	6	5
5.1	0.0203	2244.80	71.09	0	4	0	1	0	1	4	4	4	6
5.2	0.0203	2242.77	71.10	0	4	0	1	1	0	2	4	4	4
5.3	0.0203	2240.73	71.11	1	6	0	0	1	1	3	6	7	5
5.4	0.0203	2238.70	71.11	0	3	0	1	0	0	2	3	3	3
5.5	0.0203	2236.67	71.12	0	5	0	0	0	0	1	6	5	1
5.6	0.0203	2234.63	71.12	0	6	0	1	2	0	5	5	6	8
5.7	0.0305	2232.60	71.13	0	5	0	1	0	0	2	4	5	3
5.8	0.0305	2229.55	71.14	0	3	1	1	0	0	1	4	3	3
5.9	0.0305	2226.50	71.14	0	3	0	0	0	0	2	4	3	2
6	0.0305	2223.45	71.15	0	5	0	1	1	0	1	5	5	3
6.1	0.0305	2220.40	100.44	0	3	1	1	0	0	1	4	3	3
6.2	0.0305	2217.35	100.56	0	3	0	0	1	1	2	5	3	4
6.3	0.0305	2214.30	100.67	0	2	0	1	0	1	2	3	2	4
6.4	0.0305	2211.25	100.79	1	1	1	1	1	1	2	1	2	6
6.5	0.0153	2208.20	100.90	0	1	1	1	0	0	1	1	1	3
6.6	0.0152	2206.68	101.02	1	6	0	0	0	1	4	5	7	5
6.7	0.0153	2205.15	101.13	0	2	0	1	1	1	1	2	2	4
6.8	0.0153	2203.63	101.25	0	3	0	0	0	0	2	3	3	2
6.9	0.0153	2202.10	101.36	0	2	1	0	1	1	3	2	2	6
7	0.0153	2200.58	101.48	1	2	0	0	0	0	2	2	3	2
7.1	0.0152	2199.05	102.92	0	2	0	1	0	0	1	2	2	2
7.2	0.0153	2197.53	103.00	0	2	0	0	0	2	3	2	2	5
7.3	0.0244	2196.00	103.09	0	1	0	1	1	0	2	0	1	4
7.4	0.0244	2193.56	103.17	0	2	0	1	0	0	10	2	2	11
7.5	0.0244	2191.12	103.25	0	2	0	2	3	1	1	2	2	7
7.6	0.0244	2188.68	105.19	0	1	0	10	0	1	1	1	1	12
7.7	0.0244	2186.24	105.27	0	4	0	1	1	0	3	4	4	5
7.8	0.0203	2183.80	105.34	0	3	0	0	0	0	2	3	3	2
7.9	0.0203	2181.77	105.42	0	2	0	0	1	1	2	2	2	4
8	0.0203	2179.73	105.50	0	2	0	1	1	0	3	1	2	5
8.1	0.0203	2177.70	105.58	0	4	0	1	0	0	2	3	4	3
8.2	0.0203	2175.67	105.65	0	2	0	2	0	0	2	2	2	4
8.3	0.0203	2173.63	105.73	0	1	0	0	0	1	2	0	1	3
8.4	0.0153	2171.60	105.81	0	2	0	0	0	0	2	0	2	2

8.5	0.0153	2170.08	105.89	0	3	0	0	0	1	4	1	3	5
8.6	0.0152	2168.55	105.96	0	1	0	1	0	1	2	0	1	4
8.7	0.0153	2167.03	106.04	0	2	0	0	0	1	2	1	2	3
8.8	0.0153	2165.50	106.12	0	0	0	2	0	0	2	0	0	4
8.9	0.0153	2163.98	106.20	0	1	1	1	1	1	1	0	1	5
9	0.0153	2162.45	106.27	0	1	0	2	0	0	1	2	1	3
9.1	0.0152	2160.93	106.35	0	2	0	0	1	1	2	1	2	4
9.2	0.0136	2159.40	106.43	0	0	0	0	1	1	1	1	0	3
9.3	0.0136	2158.04	106.51	0	0	0	0	1	2	1	0	0	4
9.4	0.0136	2156.69	106.58	0	0	0	0	1	1	2	0	0	4
9.5	0.0136	2155.33	106.66	0	3	0	0	1	0	2	2	3	3
9.6	0.0136	2153.98	110.57	0	0	0	1	0	1	1	0	0	3
9.7	0.0136	2152.62	111.11	0	3	0	1	1	1	2	2	3	5
9.8	0.0136	2151.27	111.65	0	2	0	0	1	1	2	1	2	4
9.9	0.0136	2149.91	112.20	1	3	0	0	0	0	1	4	4	1
10	0.0136	2148.56	112.74	0	1	0	1	0	1	1	3	1	3
10.1	0.0153	2147.20	113.28	1	1	0	0	0	2	1	2	2	3
10.2	0.0152	2145.68	113.82	0	0	1	0	0	1	2	0	0	4
10.3	0.0153	2144.15	114.37	0	1	0	0	1	1	2	1	1	4
10.4	0.0153	2142.63	114.91	0	0	0	1	1	2	1	0	0	5
10.5	0.0153	2141.10	115.45	0	0	1	0	0	2	1	0	0	4
10.6	0.0153	2139.58	115.99	1	1	0	2	2	1	2	1	2	7
10.7	0.0152	2138.05	116.54	0	2	0	3	2	0	1	2	2	6
10.8	0.0153	2136.53	117.08	0	1	0	1	1	1	3	0	1	6
10.9	0.0153	2135.00	117.62	0	0	1	1	1	1	2	0	0	6
11	0.0153	2133.48	118.16	0	0	0	1	1	0	2	0	0	4
11.1	0.0153	2131.95	118.71	0	1	1	0	0	1	2	0	1	4
11.2	0.0152	2130.43	119.25	1	0	0	1	0	1	1	0	1	3
11.3	0.0153	2128.90	119.79	0	1	1	1	2	1	1	0	1	6
11.4	0.0153	2127.38	120.33	0	0	0	1	2	1	2	0	0	6
11.5	0.0153	2125.85	120.88	0	0	0	1	1	2	1	0	0	5
11.6	0.0153	2124.33	121.42	0	1	1	0	0	1	1	1	1	3
11.7	0.0136	2122.80	180.50	0	3	0	1	0	1	2	4	3	4
11.8	0.0136	2121.44	180.71	0	0	0	0	1	2	1	1	0	4
11.9	0.0136	2120.09	180.93	0	0	0	0	1	2	1	0	0	4
12	0.0136	2118.73	181.14	0	0	0	1	2	1	2	0	0	6
12.1	0.0136	2117.38	181.36	0	0	0	1	1	2	1	0	0	5
12.2	0.0136	2116.02	181.57	0	0	1	2	3	0	2	0	0	8
12.3	0.0136	2114.67	181.79	1	1	1	1	2	2	1	0	2	7
12.4	0.0136	2113.31	182.00	0	0	1	0	1	1	1	0	0	4
12.5	0.0136	2111.96	182.21	1	1	1	1	0	1	2	0	2	5
12.6	0.0122	2110.60	182.43	1	0	0	2	1	0	1	0	1	4
12.7	0.0122	2109.38	182.64	0	1	2	0	0	1	2	0	1	5
12.8	0.0122	2108.16	182.86	0	0	0	1	1	1	1	0	0	4
12.9	0.0122	2106.94	183.07	0	0	0	1	1	2	1	0	0	5
13	0.0122	2105.72	183.29	0	0	1	1	1	2	2	0	0	7

13.1	0.0122	2104.50	190.51	0	0	1	1	0	1	1	1	0	4
13.2	0.0122	2103.28	190.64	0	0	1	0	0	2	1	0	0	4
13.3	0.0122	2102.06	190.76	1	1	3	2	3	1	2	0	2	11
13.4	0.0122	2100.84	190.89	1	2	1	0	2	3	2	0	3	8
13.5	0.0122	2099.62	191.01	1	0	1	1	1	1	2	0	1	6
13.6	0.0102	2098.40	191.14	0	0	0	1	1	1	1	0	0	4
13.7	0.0102	2097.38	191.27	0	0	1	1	0	0	2	0	0	4
13.8	0.0102	2096.37	191.39	0	1	0	2	1	1	0	0	1	4
13.9	0.0102	2095.35	191.52	0	1	0	1	1	0	1	0	1	3
14	0.0102	2094.33	191.64	0	2	0	1	2	1	2	0	2	6
14.1	0.0102	2093.32	191.77	0	0	0	1	1	0	2	0	0	4
14.2	0.0102	2092.30	191.95	1	1	0	0	1	1	2	0	2	4
14.3	0.0102	2091.28	191.95	2	1	1	2	0	1	1	0	3	5
14.4	0.0102	2090.27	191.96	1	1	0	0	2	2	2	0	2	6
14.5	0.0102	2089.25	193.02	1	1	0	1	0	1	1	1	2	3
14.6	0.0102	2088.23	193.31	1	0	0	0	1	2	1	0	1	4
14.7	0.0102	2087.22	193.60	0	1	0	0	1	1	2	1	1	4
14.8	0.0102	2086.20	193.88	1	2	1	1	1	0	2	2	3	5
14.9	0.0102	2085.18	194.17	0	3	0	3	0	0	0	3	3	3
15	0.0102	2084.17	194.46	0	1	0	0	1	1	0	0	1	2
15.1	0.0102	2083.15	194.74	1	0	0	0	1	1	2	0	1	4
15.2	0.0102	2082.13	195.03	1	1	0	0	1	1	2	0	2	4
15.3	0.0102	2081.12	195.32	2	2	0	1	1	1	2	0	4	5
15.4	0.0102	2080.10	195.60	0	0	0	1	0	3	1	0	0	5
15.5	0.0102	2079.08	195.89	1	1	0	0	0	1	2	0	2	3
15.6	0.0102	2078.07	196.18	0	3	0	2	1	2	3	0	3	8
15.7	0.0102	2077.05	196.46	0	2	1	2	1	1	2	0	2	7
15.8	0.0102	2076.03	196.75	0	1	0	1	1	1	2	0	1	5
15.9	0.0102	2075.02	197.04	1	0	0	0	1	1	0	0	1	2
16	0.0122	2074.00	197.32	0	1	2	0	0	1	1	0	1	4
16.1	0.0122	2072.78	197.61	1	3	1	2	1	0	3	0	4	7
16.2	0.0122	2071.56	197.90	0	1	1	0	0	2	1	0	1	4
16.3	0.0122	2070.34	202.46	1	0	0	1	1	2	2	0	1	6
16.4	0.0122	2069.12	202.72	0	1	0	2	1	1	2	0	1	6
16.5	0.0122	2067.90	202.98	0	1	0	0	1	1	1	0	1	3
16.6	0.0122	2066.68	203.24	0	0	1	1	1	1	1	0	0	5
16.7	0.0122	2065.46	203.50	0	0	1	0	0	1	1	0	0	3
16.8	0.0122	2064.24	203.76	0	1	0	0	0	1	2	0	1	3
16.9	0.0122	2063.02	204.02	0	1	0	1	1	2	1	0	1	5
17	0.0094	2061.80	204.29	0	0	2	0	0	1	1	0	0	4
17.1	0.0094	2060.86	204.55	0	2	1	1	1	1	2	0	2	6
17.2	0.0094	2059.92	204.81	0	1	1	0	1	1	0	0	1	3
17.3	0.0094	2058.98	205.07	0	2	0	1	1	1	2	0	2	5
17.4	0.0094	2058.05	205.33	0	1	0	2	2	0	1	0	1	5
17.5	0.0094	2057.11	205.59	0	1	1	1	1	0	1	0	1	4
17.6	0.0094	2056.17	205.85	0	0	2	2	2	2	1	0	0	9

17.7	0.0094	2055.23	206.11	0	0	0	1	1	1	0	0	0	3
17.8	0.0094	2054.29	206.37	0	1	0	1	2	2	3	0	1	8
17.9	0.0094	2053.35	206.64	0	0	2	1	1	1	1	0	0	6
18	0.0094	2052.42	206.90	0	0	2	1	0	0	1	0	0	4
18.1	0.0094	2051.48	207.16	0	1	0	2	2	2	1	0	1	7
18.2	0.0094	2050.54	207.42	0	1	0	1	1	1	1	0	1	4
18.3	0.0095	2049.60	207.68	0	0	1	0	0	1	0	0	0	2
18.4	0.0095	2048.65	209.13	0	1	1	0	1	1	1	0	1	4
18.5	0.0095	2047.69	209.46	0	1	1	1	0	1	1	0	1	4
18.6	0.0095	2046.74	209.80	0	1	2	1	1	2	1	0	1	7
18.7	0.0095	2045.79	210.13	0	0	1	1	1	1	0	0	0	4
18.8	0.0095	2044.83	210.47	1	0	2	0	1	1	1	0	1	5
18.9	0.0095	2043.88	210.80	1	1	0	1	0	2	2	0	2	5
19	0.0095	2042.93	211.14	0	0	0	0	0	1	0	0	0	1
19.1	0.0095	2041.98	211.47	1	0	1	1	1	1	0	0	1	4

APPENDIX D

STREAM SEGMENT CLASSIFICATIONS

Table 11. Stream segment classification data for Cache and Soda Butte Creeks.

Cache Creek Data				
Distance Downstream (km)	Valley Confinement	Valley Floor Cover	Channel Planform	Channel Control
0	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
0.1	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
0.2	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
0.3	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
0.4	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
0.5	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
0.6	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
0.7	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
0.8	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
0.9	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
1	2-4 chan. widths	Burned/Deadfall	Braided	Colluvial
1.1	2-4 chan. widths	Burned/Deadfall	Braided	Colluvial
1.2	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
1.3	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
1.4	<2 chan. widths	Burned/Deadfall	Braided	Colluvial
1.5	<2 chan. widths	Burned/Deadfall	Single	Colluvial
1.6	<2 chan. widths	Burned/Deadfall	Single	Colluvial
1.7	<2 chan. widths	Burned/Deadfall	Single	Colluvial
1.8	<2 chan. widths	Burned/Deadfall	Single	Colluvial
1.9	<2 chan. widths	Burned/Deadfall	Single	Colluvial
2	<2 chan. widths	Burned/Deadfall	Single	Colluvial
2.1	<2 chan. widths	Burned/Deadfall	Single	Bedrock
2.2	<2 chan. widths	Burned/Deadfall	Single	Bedrock
2.3	<2 chan. widths	Burned/Deadfall	Single	Bedrock
2.4	<2 chan. widths	Burned/Deadfall	Single	Colluvial
2.5	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
2.6	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
2.7	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
2.8	<2 chan. widths	Burned/Deadfall	Single	Colluvial
2.9	<2 chan. widths	Burned/Deadfall	Single	Colluvial
3	<2 chan. widths	Burned/Deadfall	Single	Bedrock
3.1	<2 chan. widths	Burned/Deadfall	Single	Colluvial
3.2	<2 chan. widths	Burned/Deadfall	Single	Colluvial
3.3	<2 chan. widths	Burned/Deadfall	Single	Bedrock
3.4	<2 chan. widths	Burned/Deadfall	Single	Bedrock
3.5	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
3.6	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
3.7	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
3.8	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
3.9	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
4	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
4.1	<2 chan. widths	Burned/Deadfall	Single	Colluvial

4.2	<2 chan. widths	Burned/Deadfall	Single	Colluvial
4.3	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
4.4	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
4.5	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
4.6	<2 chan. widths	Burned/Deadfall	Single	Colluvial
4.7	<2 chan. widths	Burned/Deadfall	Single	Bedrock
4.8	<2 chan. widths	Burned/Deadfall	Single	Bedrock
4.9	<2 chan. widths	Burned/Deadfall	Single	Bedrock
5	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
5.1	2-4 chan. widths	Burned/Deadfall	Braided	Colluvial
5.2	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
5.3	2-4 chan. widths	Burned/Deadfall	Single	Bedrock
5.4	<2 chan. widths	Burned/Deadfall	Single	Bedrock
5.5	<2 chan. widths	Burned/Deadfall	Single	Bedrock
5.6	<2 chan. widths	Burned/Deadfall	Single	Bedrock
5.7	<2 chan. widths	Burned/Deadfall	Single	Bedrock
5.8	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
5.9	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
6	<2 chan. widths	Burned/Deadfall	Single	Bedrock
6.1	<2 chan. widths	Burned/Deadfall	Single	Colluvial
6.2	<2 chan. widths	Burned/Deadfall	Single	Colluvial
6.3	<2 chan. widths	Burned/Deadfall	Single	Colluvial
6.4	<2 chan. widths	Burned/Deadfall	Single	Colluvial
6.5	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
6.6	<2 chan. widths	Burned/Deadfall	Single	Colluvial
6.7	<2 chan. widths	Burned/Deadfall	Single	Colluvial
6.8	<2 chan. widths	Burned/Deadfall	Single	Colluvial
6.9	<2 chan. widths	Burned/Deadfall	Single	Colluvial
7	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
7.1	<2 chan. widths	Burned/Deadfall	Single	Colluvial
7.2	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
7.3	<2 chan. widths	Burned/Deadfall	Single	Colluvial
7.4	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
7.5	<2 chan. widths	Burned/Deadfall	Single	Colluvial
7.6	<2 chan. widths	Burned/Deadfall	Single	Colluvial
7.7	<2 chan. widths	Burned/Deadfall	Single	Colluvial
7.8	<2 chan. widths	Burned/Deadfall	Single	Colluvial
7.9	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
8	<2 chan. widths	Burned/Deadfall	Single	Bedrock
8.1	<2 chan. widths	Burned/Deadfall	Single	Bedrock
8.2	<2 chan. widths	Burned/Deadfall	Single	Bedrock
8.3	<2 chan. widths	Forest	Single	Bedrock
8.4	<2 chan. widths	Burned/Deadfall	Single	Bedrock
8.5	<2 chan. widths	Burned/Deadfall	Single	Bedrock
8.6	<2 chan. widths	Burned/Deadfall	Single	Colluvial
8.7	2-4 chan. widths	Burned/Deadfall	Single	Colluvial

8.8	2-4 chan. widths	Burned/Deadfall	Braided	Colluvial
8.9	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
9	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
9.1	2-4 chan. widths	Burned/Deadfall	Braided	Bedrock
9.2	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
9.3	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
9.4	<2 chan. widths	Burned/Deadfall	Single	Colluvial
9.5	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
9.6	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
9.7	<2 chan. widths	Burned/Deadfall	Single	Bedrock
9.8	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
9.9	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
10	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
10.1	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
10.2	2-4 chan. widths	Burned/Deadfall	Braided	Colluvial
10.3	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
10.4	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
10.5	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
10.6	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
10.7	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
10.8	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
10.9	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
11	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
11.1	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
11.2	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
11.3	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
11.4	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
11.5	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
11.6	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
11.7	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
11.8	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
11.9	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
12	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
12.1	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
12.2	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
12.3	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
12.4	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
12.5	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
12.6	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
12.7	>4 chan. widths	Burned/Deadfall	Single	Alluvial
12.8	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
12.9	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
13	>4 chan. widths	Burned/Deadfall	Single	Alluvial
13.1	>4 chan. widths	Burned/Deadfall	Single	Alluvial
13.2	2-4 chan. widths	Burned/Deadfall	Braided	Alluvial
13.3	2-4 chan. Widths	Burned/Deadfall	Braided	Alluvial

13.4	2-4 chan. widths	Burned/Deadfall	Braided	Alluvial
13.5	2-4 chan. widths	Burned/Deadfall	Braided	Alluvial
13.6	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
13.7	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
13.8	>4 chan. widths	Burned/Deadfall	Single	Alluvial
13.9	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
14	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
14.1	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
14.2	>4 chan. widths	Burned/Deadfall	Single	Alluvial
14.3	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
14.4	>4 chan. widths	Burned/Deadfall	Single	Alluvial
14.5	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
14.6	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
14.7	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
14.8	<2 chan. widths	Burned/Deadfall	Single	Bedrock
14.9	<2 chan. widths	Burned/Deadfall	Single	Bedrock
15	<2 chan. widths	Burned/Deadfall	Single	Bedrock
15.1	<2 chan. widths	Burned/Deadfall	Single	Bedrock
15.2	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
15.3	<2 chan. widths	Burned/Deadfall	Single	Colluvial
15.4	<2 chan. widths	Burned/Deadfall	Single	Alluvial
15.5	<2 chan. widths	Burned/Deadfall	Single	Bedrock
15.6	<2 chan. widths	Burned/Deadfall	Single	Bedrock
15.7	2-4 chan. widths	Meadow	Single	Alluvial
15.8	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
15.9	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
16	<2 chan. widths	Burned/Deadfall	Single	Colluvial
16.1	2-4 chan. widths	Forest	Single	Colluvial
16.2	2-4 chan. widths	Forest	Single	Colluvial
16.3	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
16.4	2-4 chan. widths	Forest	Single	Alluvial
16.5	2-4 chan. widths	Forest	Single	Alluvial
16.6	2-4 chan. widths	Burned/Deadfall	Single	Colluvial
16.7	2-4 chan. widths	Forest	Single	Colluvial
16.8	2-4 chan. widths	Forest	Single	Alluvial
16.9	2-4 chan. widths	Forest	Single	Alluvial
17	2-4 chan. widths	Forest	Single	Alluvial
17.1	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
17.2	2-4 chan. widths	Forest	Single	Alluvial
17.3	<2 chan. widths	Burned/Deadfall	Single	Colluvial
17.4	<2 chan. widths	Forest	Single	Bedrock
17.5	>4 chan. widths	Forest	Single	Alluvial
17.6	>4 chan. widths	Forest	Single	Alluvial
17.7	>4 chan. widths	Forest	Braided	Alluvial
17.8	>4 chan. widths	Forest	Braided	Alluvial
17.9	2-4 chan. widths	Forest	Single	Alluvial

18	2-4 chan. widths	Burned/Deadfall	Braided	Alluvial
18.1	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
18.2	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
18.3	2-4 chan. widths	Burned/Deadfall	Single	Alluvial
18.4	2-4 chan. widths	Forest	Single	Alluvial
18.5	2-4 chan. widths	Forest	Single	Alluvial
18.6	2-4 chan. widths	Forest	Single	Alluvial
18.7	2-4 chan. widths	Forest	Braided	Alluvial
18.8	2-4 chan. widths	Forest	Braided	Alluvial
18.9	2-4 chan. widths	Forest	Single	Alluvial
19	2-4 chan. widths	Forest	Single	Alluvial
19.1	2-4 chan. widths	Forest	Single	Alluvial

Soda Butte Creek Data

Distance Downstream (km) Valley Confinement Valley Floor Cover Channel Planform Channel Control

0	<2 chan. widths	Forest	Single	Colluvial
0.1	<2 chan. widths	Forest	Single	Colluvial
0.2	2-4 chan. widths	Forest	Single	Colluvial
0.3	2-4 chan. widths	Forest	Single	Alluvial
0.4	<2 chan. widths	Forest	Single	Colluvial
0.5	2-4 chan. widths	Forest	Single	Alluvial
0.6	2-4 chan. widths	Forest	Single	Alluvial
0.7	2-4 chan. widths	Forest	Single	Alluvial
0.8	2-4 chan. widths	Forest	Single	Bedrock
0.9	2-4 chan. widths	Forest	Single	Alluvial
1	>4 chan. widths	Forest	Single	Alluvial
1.1	>4 chan. widths	Forest	Single	Alluvial
1.2	2-4 chan. widths	Forest	Single	Alluvial
1.3	>4 chan. widths	Forest	Single	Alluvial
1.4	>4 chan. widths	Meadow	Single	Alluvial
1.5	>4 chan. widths	Meadow	Single	Alluvial
1.6	>4 chan. widths	Meadow	Single	Alluvial
1.7	>4 chan. widths	Meadow	Single	Alluvial
1.8	>4 chan. widths	Meadow	Single	Alluvial
1.9	>4 chan. widths	Meadow	Single	Alluvial
2	>4 chan. widths	Meadow	Single	Alluvial
2.1	>4 chan. widths	Meadow	Braided	Alluvial
2.2	>4 chan. widths	Meadow	Braided	Alluvial
2.3	>4 chan. widths	Meadow	Braided	Alluvial
2.4	>4 chan. widths	Meadow	Braided	Alluvial
2.5	>4 chan. widths	Meadow	Braided	Alluvial
2.6	>4 chan. widths	Meadow	Single	Alluvial
2.7	>4 chan. widths	Meadow	Single	Alluvial
2.8	>4 chan. widths	Meadow	Single	Alluvial
2.9	>4 chan. widths	Meadow	Single	Alluvial
3	>4 chan. widths	Meadow	Single	Alluvial

3.1	>4 chan. widths	Meadow	Single	Alluvial
3.2	>4 chan. widths	Meadow	Single	Alluvial
3.3	<2 chan. widths	Forest	Single	Colluvial
3.4	2-4 chan. widths	Forest	Single	Alluvial
3.5	2-4 chan. Widths	Forest	Single	Alluvial
3.6	2-4 chan. widths	Forest	Single	Alluvial
3.7	>4 chan. widths	Forest	Single	Alluvial
3.8	>4 chan. widths	Forest	Single	Alluvial
3.9	>4 chan. widths	Forest	Single	Alluvial
4	>4 chan. widths	Forest	Braided	Alluvial
4.1	>4 chan. widths	Meadow	Braided	Alluvial
4.2	>4 chan. widths	Meadow	Single	Alluvial
4.3	>4 chan. widths	Meadow	Single	Alluvial
4.4	>4 chan. widths	Meadow	Single	Alluvial
4.5	2-4 chan. widths	Forest	Single	Alluvial
4.6	2-4 chan. widths	Forest	Single	Alluvial
4.7	>4 chan. widths	Forest	Single	Alluvial
4.8	2-4 chan. widths	Forest	Single	Alluvial
4.9	2-4 chan. widths	Forest	Single	Alluvial
5	2-4 chan. widths	Forest	Single	Alluvial
5.1	2-4 chan. widths	Forest	Single	Alluvial
5.2	2-4 chan. widths	Forest	Single	Alluvial
5.3	2-4 chan. widths	Forest	Single	Alluvial
5.4	2-4 chan. widths	Forest	Single	Alluvial
5.5	2-4 chan. widths	Meadow	Single	Alluvial
5.6	2-4 chan. widths	Forest	Single	Alluvial
5.7	2-4 chan. widths	Forest	Single	Alluvial
5.8	>4 chan. widths	Forest	Single	Alluvial
5.9	>4 chan. widths	Forest	Single	Alluvial
6	>4 chan. widths	Meadow	Single	Alluvial
6.1	>4 chan. widths	Forest	Single	Alluvial
6.2	>4 chan. widths	Forest	Single	Alluvial
6.3	>4 chan. widths	Forest	Single	Alluvial
6.4	>4 chan. widths	Meadow	Single	Alluvial
6.5	>4 chan. widths	Meadow	Single	Alluvial
6.6	>4 chan. widths	Meadow	Single	Alluvial
6.7	>4 chan. widths	Meadow	Single	Alluvial
6.8	>4 chan. widths	Meadow	Single	Alluvial
6.9	>4 chan. widths	Meadow	Single	Alluvial
7	>4 chan. widths	Meadow	Single	Alluvial
7.1	2-4 chan. widths	Meadow	Single	Alluvial
7.2	<2 chan. widths	Forest	Single	Alluvial
7.3	2-4 chan. widths	Forest	Single	Alluvial
7.4	2-4 chan. widths	Forest	Single	Alluvial
7.5	<2 chan. widths	Forest	Single	Alluvial
7.6	<2 chan. widths	Forest	Single	Alluvial

7.7	<2 chan. widths	Forest	Single	Alluvial
7.8	<2 chan. widths	Forest	Single	Colluvial
7.9	<2 chan. widths	Forest	Single	Colluvial
8	<2 chan. widths	Forest	Single	Colluvial
8.1	<2 chan. widths	Forest	Single	Colluvial
8.2	2-4 chan. widths	Forest	Single	Alluvial
8.3	<2 chan. widths	Forest	Single	Colluvial
8.4	<2 chan. widths	Forest	Single	Bedrock
8.5	<2 chan. widths	Forest	Single	Colluvial
8.6	2-4 chan. widths	Forest	Single	Colluvial
8.7	>4 chan. widths	Forest	Single	Alluvial
8.8	2-4 chan. widths	Forest	Braided	Alluvial
8.9	>4 chan. widths	Forest	Single	Alluvial
9	>4 chan. widths	Forest	Braided	Alluvial
9.1	>4 chan. widths	Forest	Braided	Alluvial
9.2	>4 chan. widths	Forest	Braided	Alluvial
9.3	>4 chan. widths	Forest	Single	Alluvial
9.4	>4 chan. widths	Meadow	Braided	Alluvial
9.5	>4 chan. widths	Meadow	Single	Alluvial
9.6	>4 chan. widths	Meadow	Single	Alluvial
9.7	>4 chan. widths	Meadow	Single	Alluvial
9.8	>4 chan. widths	Forest	Single	Alluvial
9.9	>4 chan. widths	Forest	Single	Alluvial
10	>4 chan. widths	Forest	Braided	Alluvial
10.1	>4 chan. widths	Forest	Single	Alluvial
10.2	>4 chan. widths	Meadow	Single	Alluvial
10.3	2-4 chan. widths	Forest	Single	Alluvial
10.4	<2 chan. widths	Forest	Single	Colluvial
10.5	<2 chan. widths	Forest	Single	Colluvial
10.6	<2 chan. widths	Forest	Single	Colluvial
10.7	<2 chan. widths	Forest	Single	Colluvial
10.8	<2 chan. widths	Forest	Single	Colluvial
10.9	2-4 chan. widths	Forest	Single	Alluvial
11	>4 chan. widths	Meadow	Single	Alluvial
11.1	>4 chan. widths	Meadow	Braided	Alluvial
11.2	>4 chan. widths	Forest	Single	Alluvial
11.3	>4 chan. widths	Meadow	Single	Alluvial
11.4	>4 chan. widths	Meadow	Single	Alluvial
11.5	>4 chan. widths	Forest	Single	Alluvial
11.6	>4 chan. widths	Forest	Braided	Alluvial
11.7	2-4 chan. widths	Forest	Braided	Alluvial
11.8	2-4 chan. widths	Forest	Single	Alluvial
11.9	2-4 chan. widths	Forest	Single	Colluvial
12	<2 chan. widths	Forest	Single	Colluvial
12.1	<2 chan. widths	Forest	Single	Alluvial
12.2	2-4 chan. widths	Forest	Single	Alluvial

12.3	2-4 chan. widths	Forest	Single	Alluvial
12.4	2-4 chan. widths	Forest	Single	Alluvial
12.5	2-4 chan. widths	Forest	Single	Alluvial
12.6	2-4 chan. widths	Forest	Single	Alluvial
12.7	2-4 chan. widths	Forest	Single	Alluvial
12.8	2-4 chan. widths	Forest	Single	Alluvial
12.9	2-4 chan. widths	Forest	Single	Alluvial
13	<2 chan. widths	Forest	Single	Alluvial
13.1	2-4 chan. widths	Forest	Single	Alluvial
13.2	2-4 chan. widths	Forest	Single	Alluvial
13.3	<2 chan. widths	Forest	Single	Alluvial
13.4	<2 chan. widths	Forest	Single	Alluvial
13.5	2-4 chan. widths	Forest	Single	Alluvial
13.6	2-4 chan. widths	Forest	Single	Alluvial
13.7	<2 chan. widths	Forest	Single	Alluvial
13.8	<2 chan. widths	Forest	Single	Alluvial
13.9	<2 chan. widths	Forest	Single	Alluvial
14	>4 chan. widths	Forest	Single	Alluvial
14.1	>4 chan. widths	Forest	Single	Alluvial
14.2	2-4 chan. widths	Forest	Single	Alluvial
14.3	2-4 chan. widths	Forest	Single	Alluvial
14.4	2-4 chan. widths	Forest	Single	Alluvial
14.5	2-4 chan. widths	Forest	Braided	Alluvial
14.6	2-4 chan. widths	Forest	Braided	Alluvial
14.7	2-4 chan. widths	Forest	Braided	Alluvial
14.8	2-4 chan. widths	Forest	Single	Alluvial
14.9	<2 chan. widths	Forest	Single	Colluvial
15	<2 chan. widths	Forest	Single	Colluvial
15.1	<2 chan. widths	Forest	Single	Colluvial
15.2	<2 chan. widths	Forest	Single	Colluvial
15.3	<2 chan. widths	Forest	Single	Colluvial
15.4	2-4 chan. widths	Forest	Braided	Colluvial
15.5	2-4 chan. widths	Forest	Single	Colluvial
15.6	2-4 chan. widths	Forest	Single	Alluvial
15.7	>4 chan. widths	Forest	Single	Alluvial
15.8	>4 chan. widths	Forest	Single	Alluvial
15.9	>4 chan. widths	Forest	Single	Alluvial
16	>4 chan. widths	Forest	Braided	Alluvial
16.1	2-4 chan. widths	Forest	Braided	Alluvial
16.2	<2 chan. widths	Forest	Single	Alluvial
16.3	2-4 chan. widths	Forest	Single	Alluvial
16.4	<2 chan. widths	Forest	Single	Alluvial
16.5	2-4 chan. widths	Forest	Single	Alluvial
16.6	2-4 chan. widths	Forest	Single	Alluvial
16.7	2-4 chan. widths	Forest	Single	Alluvial
16.8	2-4 chan. widths	Forest	Braided	Alluvial

16.9	2-4 chan. widths	Forest	Single	Alluvial
17	2-4 chan. widths	Forest	Single	Alluvial
17.1	2-4 chan. widths	Forest	Single	Alluvial
17.2	2-4 chan. widths	Forest	Single	Alluvial
17.3	2-4 chan. widths	Forest	Single	Alluvial
17.4	2-4 chan. widths	Forest	Single	Alluvial
17.5	2-4 chan. widths	Forest	Single	Alluvial
17.6	<2 chan. widths	Forest	Single	Alluvial
17.7	<2 chan. widths	Forest	Single	Colluvial
17.8	<2 chan. widths	Forest	Single	Colluvial
17.9	2-4 chan. widths	Forest	Single	Colluvial
18	2-4 chan. widths	Forest	Single	Alluvial
18.1	2-4 chan. widths	Forest	Single	Alluvial
18.2	2-4 chan. widths	Forest	Braided	Alluvial
18.3	2-4 chan. widths	Forest	Single	Alluvial
18.4	2-4 chan. widths	Forest	Single	Alluvial
18.5	2-4 chan. widths	Forest	Single	Alluvial
18.6	2-4 chan. widths	Forest	Single	Alluvial
18.7	2-4 chan. widths	Meadow	Single	Alluvial
18.8	2-4 chan. widths	Meadow	Braided	Alluvial
18.9	2-4 chan. widths	Meadow	Single	Alluvial
19	2-4 chan. widths	Meadow	Braided	Alluvial
19.1	2-4 chan. widths	Meadow	Braided	Alluvial
19.2	2-4 chan. widths	Meadow	Single	Alluvial
19.3	2-4 chan. widths	Forest	Braided	Alluvial
19.4	2-4 chan. widths	Forest	Single	Alluvial
19.5	2-4 chan. widths	Meadow	Single	Alluvial
19.6	2-4 chan. widths	Meadow	Single	Alluvial
19.7	2-4 chan. widths	Forest	Single	Alluvial
19.8	2-4 chan. widths	Meadow	Single	Alluvial
19.9	2-4 chan. widths	Meadow	Single	Alluvial
20	2-4 chan. widths	Forest	Single	Alluvial
20.1	>4 chan. widths	Meadow	Braided	Alluvial
20.2	>4 chan. widths	Meadow	Braided	Alluvial
20.3	>4 chan. widths	Meadow	Braided	Alluvial
20.4	>4 chan. widths	Meadow	Single	Alluvial
20.5	>4 chan. widths	Meadow	Single	Alluvial
20.6	>4 chan. widths	Meadow	Single	Alluvial
20.7	>4 chan. widths	Meadow	Single	Alluvial
20.8	>4 chan. widths	Meadow	Single	Alluvial
20.9	2-4 chan. widths	Forest	Single	Colluvial
21	2-4 chan. widths	Forest	Single	Colluvial
21.1	2-4 chan. widths	Forest	Single	Alluvial
21.2	<2 chan. widths	Forest	Single	Colluvial
21.3	<2 chan. widths	Forest	Single	Colluvial
21.4	<2 chan. widths	Forest	Single	Colluvial

21.5	<2 chan. widths	Forest	Single	Colluvial
21.6	<2 chan. widths	Forest	Single	Colluvial
21.7	<2 chan. widths	Forest	Single	Colluvial
21.8	<2 chan. widths	Forest	Single	Colluvial
21.9	<2 chan. widths	Forest	Single	Colluvial
22	2-4 chan. widths	Forest	Single	Alluvial
22.1	2-4 chan. widths	Forest	Braided	Alluvial
22.2	2-4 chan. widths	Forest	Single	Alluvial
22.3	2-4 chan. widths	Forest	Single	Alluvial
22.4	2-4 chan. widths	Forest	Single	Alluvial
22.5	2-4 chan. widths	Forest	Single	Alluvial
22.6	2-4 chan. widths	Forest	Single	Alluvial
22.7	>4 chan. widths	Meadow	Single	Alluvial
22.8	>4 chan. widths	Meadow	Single	Alluvial
22.9	>4 chan. widths	Meadow	Single	Alluvial
23	>4 chan. widths	Meadow	Single	Alluvial
23.1	2-4 chan. widths	Forest	Single	Alluvial
23.2	<2 chan. widths	Forest	Braided	Alluvial
23.3	2-4 chan. widths	Forest	Single	Alluvial
23.4	<2 chan. widths	Forest	Single	Bedrock
23.5	<2 chan. widths	Forest	Single	Bedrock
24.2	<2 chan. widths	Forest	Single	Bedrock
24.3	<2 chan. widths	Forest	Single	Colluvial
24.4	<2 chan. widths	Forest	Single	Colluvial
24.5	<2 chan. widths	Forest	Single	Colluvial
24.6	<2 chan. widths	Forest	Single	Colluvial
24.7	<2 chan. widths	Forest	Single	Colluvial
24.8	2-4 chan. widths	Forest	Single	Alluvial
24.9	2-4 chan. widths	Forest	Single	Alluvial
25	>4 chan. widths	Forest	Single	Alluvial
25.1	>4 chan. widths	Forest	Single	Alluvial
25.2	>4 chan. widths	Meadow	Single	Alluvial
25.3	>4 chan. widths	Meadow	Single	Alluvial
25.4	<2 chan. widths	Forest	Single	Alluvial
25.5	>4 chan. widths	Meadow	Braided	Alluvial
25.6	>4 chan. widths	Meadow	Braided	Alluvial
25.7	>4 chan. widths	Meadow	Braided	Alluvial
25.8	>4 chan. widths	Meadow	Braided	Alluvial
25.9	>4 chan. widths	Meadow	Braided	Alluvial
26	>4 chan. widths	Meadow	Braided	Alluvial
26.1	>4 chan. widths	Meadow	Braided	Alluvial
26.2	>4 chan. widths	Meadow	Braided	Alluvial
26.3	>4 chan. widths	Meadow	Braided	Alluvial
26.4	>4 chan. widths	Meadow	Braided	Alluvial
26.5	>4 chan. widths	Meadow	Braided	Alluvial
26.6	2-4 chan. widths	Meadow	Braided	Alluvial

26.7	2-4 chan. widths	Meadow	Braided	Alluvial
26.8	2-4 chan. widths	Meadow	Braided	Alluvial
26.9	<2 chan. widths	Meadow	Braided	Alluvial
27	>4 chan. widths	Meadow	Single	Alluvial
27.1	>4 chan. widths	Meadow	Single	Alluvial
27.2	>4 chan. widths	Meadow	Single	Alluvial
27.3	>4 chan. widths	Meadow	Single	Alluvial
27.4	>4 chan. widths	Meadow	Single	Alluvial
27.5	>4 chan. widths	Meadow	Single	Bedrock
27.6	>4 chan. widths	Meadow	Single	Alluvial
27.7	>4 chan. widths	Meadow	Single	Alluvial
27.8	>4 chan. widths	Meadow	Single	Alluvial
27.9	>4 chan. widths	Meadow	Single	Alluvial
28	>4 chan. widths	Meadow	Single	Alluvial
28.1	<2 chan. widths	Forest	Single	Colluvial
28.2	<2 chan. widths	Forest	Single	Colluvial
28.3	<2 chan. widths	Forest	Single	Colluvial
28.4	<2 chan. widths	Forest	Single	Colluvial
28.5	<2 chan. widths	Forest	Single	Colluvial
28.6	2-4 chan. widths	Forest	Braided	Colluvial
28.7	2-4 chan. widths	Forest	Braided	Colluvial
28.8	<2 chan. widths	Forest	Braided	Colluvial
28.9	<2 chan. widths	Forest	Braided	Colluvial
29	<2 chan. widths	Forest	Single	Colluvial
29.1	2-4 chan. widths	Forest	Braided	Alluvial
29.2	>4 chan. widths	Forest	Braided	Alluvial
29.3	>4 chan. widths	Forest	Braided	Alluvial
29.4	2-4 chan. widths	Forest	Braided	Alluvial
29.5	<2 chan. widths	Forest	Single	Colluvial
29.6	2-4 chan. widths	Forest	Single	Colluvial
29.7	>4 chan. widths	Forest	Single	Alluvial
29.8	>4 chan. widths	Meadow	Braided	Alluvial
29.9	>4 chan. widths	Meadow	Braided	Alluvial
30	>4 chan. widths	Meadow	Single	Alluvial
30.1	>4 chan. widths	Meadow	Single	Alluvial
30.2	>4 chan. widths	Meadow	Braided	Alluvial
30.3	>4 chan. widths	Meadow	Braided	Alluvial
30.4	>4 chan. widths	Meadow	Single	Alluvial
30.5	>4 chan. widths	Meadow	Braided	Alluvial
30.6	>4 chan. widths	Meadow	Braided	Alluvial
30.7	>4 chan. widths	Meadow	Braided	Alluvial
30.8	>4 chan. widths	Meadow	Braided	Alluvial
30.9	>4 chan. widths	Meadow	Braided	Alluvial
31	>4 chan. widths	Meadow	Braided	Alluvial
31.1	>4 chan. widths	Meadow	Braided	Alluvial
31.2	>4 chan. widths	Meadow	Braided	Alluvial

31.3	>4 chan. widths	Meadow	Braided	Alluvial
31.4	>4 chan. widths	Meadow	Braided	Alluvial
31.5	>4 chan. widths	Meadow	Braided	Alluvial
31.6	>4 chan. widths	Meadow	Braided	Alluvial
31.7	>4 chan. widths	Meadow	Braided	Alluvial
31.8	>4 chan. widths	Meadow	Braided	Alluvial
31.9	>4 chan. widths	Meadow	Braided	Alluvial
32	>4 chan. widths	Meadow	Braided	Alluvial
32.1	>4 chan. widths	Meadow	Braided	Alluvial
32.2	>4 chan. widths	Meadow	Braided	Alluvial
32.3	>4 chan. widths	Meadow	Braided	Alluvial
32.4	>4 chan. widths	Meadow	Braided	Alluvial
32.5	>4 chan. widths	Meadow	Braided	Alluvial
32.6	>4 chan. widths	Meadow	Single	Alluvial
32.7	>4 chan. widths	Meadow	Braided	Alluvial
32.8	>4 chan. widths	Meadow	Single	Alluvial
32.9	>4 chan. widths	Meadow	Braided	Alluvial
33	>4 chan. widths	Meadow	Braided	Alluvial
33.1	>4 chan. widths	Meadow	Braided	Alluvial
33.2	>4 chan. widths	Meadow	Single	Alluvial
33.3	>4 chan. widths	Meadow	Single	Alluvial
33.4	>4 chan. widths	Meadow	Single	Alluvial
33.5	>4 chan. widths	Meadow	Single	Alluvial
33.6	>4 chan. widths	Meadow	Braided	Alluvial
33.7	>4 chan. widths	Meadow	Braided	Alluvial
33.8	<2 chan. widths	Meadow	Single	Bedrock
33.9	2-4 chan. widths	Meadow	Single	Alluvial
34	>4 chan. widths	Meadow	Braided	Alluvial
34.1	>4 chan. widths	Meadow	Braided	Alluvial
34.2	>4 chan. widths	Meadow	Braided	Alluvial
34.3	>4 chan. widths	Meadow	Braided	Alluvial
34.4	>4 chan. widths	Meadow	Braided	Alluvial
34.5	>4 chan. widths	Meadow	Braided	Alluvial
34.6	>4 chan. widths	Meadow	Single	Alluvial
34.7	>4 chan. widths	Meadow	Braided	Alluvial
34.8	>4 chan. widths	Meadow	Braided	Alluvial
34.9	>4 chan. widths	Meadow	Single	Alluvial
35	>4 chan. widths	Meadow	Braided	Alluvial
35.1	>4 chan. widths	Meadow	Single	Alluvial
35.2	>4 chan. widths	Meadow	Single	Alluvial
35.3	>4 chan. widths	Meadow	Single	Alluvial
35.4	>4 chan. widths	Meadow	Braided	Alluvial
35.5	>4 chan. widths	Meadow	Braided	Alluvial
35.6	>4 chan. widths	Meadow	Braided	Alluvial
35.7	>4 chan. widths	Meadow	Braided	Alluvial
35.8	>4 chan. widths	Meadow	Braided	Alluvial

35.9	>4 chan. widths	Meadow	Braided	Alluvial
36	>4 chan. widths	Meadow	Braided	Alluvial
36.1	>4 chan. widths	Meadow	Braided	Alluvial
36.2	>4 chan. widths	Meadow	Single	Alluvial
36.3	>4 chan. widths	Meadow	Single	Alluvial
36.4	>4 chan. widths	Meadow	Single	Alluvial
36.5	>4 chan. widths	Meadow	Single	Alluvial
36.6	>4 chan. widths	Meadow	Single	Alluvial

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