January 2016

Clear Creek Aquatic Habitat Condition Assessment and Fish Population Monitoring Report

Dear Reader:

Thank you for your interest in the Clear Creek Aquatic Habitat Condition Assessment and Fish Population Monitoring report. This document and associated data collection has been a partnership effort between the Nez Perce – Clearwater National Forests and the Clearwater Basin Collaborative under contract with Stillwater Sciences. The Clear Creek monitoring project was developed by the Selway-Middle Fork CFLRP Monitoring Advisory Committee, a third party group consisting of participants from the Clearwater Basin Collaborative, the Nez Perce-Clearwater National Forests and the Northern Region, the Rocky Mountain and Pacific Northwest Research Stations, the University of Idaho, and local members of the community. The purpose of the project is to provide an inventory of habitat conditions and document fish distribution and relative abundance in the Clear Creek watershed as a baseline for comparison to future surveys. The Clear Creek Assessment will provide the baseline for documenting any stream condition effects, both positive and negative, of the Clear Creek Integrated Restoration Project both in the short and long-term. Ultimately, information learned can be used to help improve the development and design of similar projects on the Forests.

Due to the support of the Idaho Soil and Water Conservation District, the project was extended to document aquatic conditions and fish distribution and relative abundance in the portion of Clear Creek that flows through private lands, referred to as Lower Clear Creek in the Assessment. This information is very valuable; however, it must be noted that permission to conduct the surveys on private lands was only granted within limited sections of Lower Clear Creek; thus, the data may not be representative of the entire reach.

The National Forests and the CBC have a strong commitment to both short and long-term monitoring and will continue similar efforts in Clear Creek and other areas.

For more information about the Clear Creek Aquatic Habitat Condition Assessment and Fish Population Monitoring, its uses, and/or future analyses, please contact Karen Smith, Nez Perce-Clearwater National Forests' Central Zone Fisheries Biologist, at 208-935-4252 or kasmith03@fs.fed.us.

Sincerely,

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FINAL REPORT ◦ DECEMBER 2015

Clear Creek Aquatic Habitat Condition Assessment and Fish Population Monitoring

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Cover photos (clockwise from upper left): measuring a potential barrier in Middle Fork Clear Creek (Reach 15); View of the Clear Creek Drainage, looking southwest from Crane Hill; *O. clarki* observed in upper mainstem of Clear Creek (Reach 35); Snorkeling in Middle Fork Clear Creek (Reach 31).

Table of Contents

Tables

Figures

Appendices

ACKNOWLEDGEMENTS

We would like to thank the Clearwater Basin Collaborative (CBC) and its co-chairs Alex Irby and Dale Harris, along with the Idaho Soil and Water Conservation District for recognizing the need for and benefit of base-line data collection and long term monitoring of the Clearwater River watershed. In particular, we would like to thank the following contributors for their support and involvement:

Tera King's stewardship of the project as CBC project coordinator has ensured the project's success through many scoping, contracting, and implementation phases. She provided input and local contacts both before and after field work began.

Karen Smith of the USDA Forest Service provided invaluable local knowledge and logistical support during project planning and implementation. She also assisted with equipment and permitting for electrofishing and was always available with advice and encouragement. Karen provided reports and existing information from previous studies in the watershed and reviewed and commented on the draft protocols, sampling framework, and this final report.

The Teats Family and J.K. Ranches provided access to much of the watershed through their property to conduct the study. Without their cooperation accessing our field sites would have been much more challenging.

We would also like to thank Dr. Colden Baxter who served as science advisor for the project. Dr. Baxter contributed to the study design and imparted valuable technical knowledge during development of the sampling framework and protocols. Dr. Baxter also reviewed an early draft of this report and improved the final version through his input.

Finally, we are grateful for the hard work and dedication of field crew members who made successful completion of this project possible. They worked long hours in difficult terrain and inclement weather to produce consistent and reliable results. Thank you Abel Brumo, Sam Rizza, Dylan Keel, Dakotah Smith, Martin Ventura, Eric Newhouse, and Chris Loomis.

EXCUTIVE SUMMARY

Introduction

The goal of the Aquatic Habitat Condition Assessment and Fish Population Monitoring project is to provide an inventory of habitat conditions, and document fish distribution and relative abundance in the Clear Creek watershed. Results from the assessment will serve as a baseline for comparison with future surveys.

The Clear Creek drainage contains approximately 65 miles of fish-bearing streams within Forest Service managed lands in the Nez Perce-Clearwater National Forests. Habitat and fish population surveys were conducted during the summer of 2015 on approximately 27 miles of stream that were considered highest priority by the USDA Forest Service within the Nez Perce-Clearwater National Forests. Habitat surveys were also expanded to include additional study reaches of mainstem Clear Creek on private land downstream of the National Forest boundary at the request of the Idaho Soil and Water Conservation District and in coordination with the CBC.

Methods

As part of a systematic framework for assessing fish habitat and channel conditions, the study area within the National Forest was initially stratified into 52 functional study reaches that were classified based on drainage area and channel gradient. The full Sampling Framework is described in Appendix A.

Field protocols for collecting fish population and habitat data were developed based on several existing protocols and fine-tuned for application to this effort. Detailed field and analytical protocols are provided in Appendix B.

Fish and habitat data were collected at two scales: reach-scale and habitat unit-scale. Long-term monitoring stations were also established for more intensive collection of fish population and habitat and channel data. Reach-scale data were collected less frequently than every habitat unit and include channel form and constraining features, riparian vegetation, fish distribution and abundance, and fish passage barrier identification and characterization. Habitat units (channel geomorphic units) are relatively homogeneous lengths of the stream that are classified by channel bed form, flow characteristics, and water surface slope. For this survey, habitat unit-scale data were collected at every habitat unit and included habitat type, channel dimensions, substrate composition, incidence of bank undercut and erosion, large woody debris abundance, and suitable spawning gravel abundance.

Two permanent monitoring stations were established to monitor stream channel physiography, stream discharge, stream bed surface substrate, cobble embeddedness, and air and water temperature. Fish population abundance was assessed through electrofishing at the two monitoring stations established by Stillwater, and at three additional monitoring stations previously established by the USDA Forest Service.

Results

Data analyses and summaries were generally reported at both the individual study reach and at the subwatershed scales. Subwatersheds included:

- Lower Mainstem Clear Creek (LMCC) from the National Forest Boundary to the confluence with Browns Spring Creek

- Upper Mainstem Clear Creek (UMCC) from the confluence of Browns Spring Creek to the end of the surveyed reaches. Note that while included in the discussion of UMCC, reaches 49 and 50 are on a tributary to upper Clear Creek, and are referred to as "Tailed Frog Creek"
- West Fork Clear Creek and Lost Mule Creek (West Fork)
- South Fork Clear Creek (South Fork)
- Middle Fork Clear Creek (Middle Fork)
- Pine Knob Creek (Pine Knob)
- Browns Spring Creek (Browns Spring)
- Privately-owned reaches downstream of the National Forest boundary on Lower Clear Creek (LCC)

Channel Classification
The 52 study reaches surveyed within the National Forest represented 11 reach types defined by contributing drainage area and channel gradient. The most prevalent reach type was 4–8% gradient and 5–25 km^2 drainage area, followed by 1–4% gradient and 25–100 km^2 drainage area. By stream length, 41% of the surveyed channel was 1–4% gradient, 47% was 4–8%, 11% was 8–20%, and <1% was greater than 20%. Six study reaches, all 1–4% gradient and >100 km^2, were identified by the Idaho Soil and Water Conservation District and CBC in lower Clear Creek based on private land access.

Reach scale characterization
A total of 78 transects were surveyed for channel form and constraint, stream bank surface type, embeddedness, riparian vegetation, and canopy cover within the National Forest study reaches. An additional 9 transects were surveyed within LCC

Channel form and constraint
The majority of reach-scale transects were on a single channel constrained by hillslopes in a narrow valley. However, in some locations, despite being relatively constrained by steep hillslopes, reaches had a complex network of either braided or anastomosing channels.

Bankfull widths at transects ranged from about 5 m in smaller streams such as West Fork Clear Creek and Pine Knob Creek to about 10 m in lower mainstem Clear Creek. Bankfull depths ranged from about 0.4 m in Pine Knob Creek to 0.8 m in lower mainstem Clear Creek. The ratio of bankfull width to bankfull depth ranged from 7.6 to 14.3 for subwatersheds within the National Forest, but was substantially greater in LCC at 29.4.

Floodprone widths ranged from about 8 m in West Fork to about 16 m in UMCC. The ratio of floodprone width to bankfull width ranged from 1.5 in LMCC to 2.8 in UMCC. Both UMCC and Browns Spring Creek had relatively expansive floodplains based on transect data. Stream bank surface types were primarily hillslopes, with some low terraces and floodplains. High terraces, rip-rap, roadbeds, and secondary channels were uncommon.

Cobble embeddedness
Average cobble embeddedness measured in riffles for subwatersheds in the National Forest ranged from 30% in Browns Spring to 37% in South Fork. Average cobble embeddedness in LCC was lower at 20%.

Riparian vegetation
The dominant vegetation type at surveyed transects within the National Forest was coniferous (44% of observations). Deciduous and mixed conifer/deciduous were also relatively abundant, including 22% of observations within National Forest transects. Shrubs was the most common vegetation type at transects in the South Fork subwatershed, and "no vegetation" was most common in LCC. The dominant tree size as measured by diameter at breast height (DBH) was fairly evenly distributed among the size categories. LMCC, UMCC and Browns Spring had the highest frequency of trees >50 cm DBH.

Canopy cover
Channel canopy cover within the National Forest was generally highest in smaller channels, with approximately 80% or greater canopy cover (combined channel center and margins). In larger channels, including LMCC and South Fork, combined canopy cover was moderate with 71% and 58% cover, respectively. Channel canopy cover in lower Clear Creek (LCC) downstream of the National Forest boundary was relatively low (28%).

Fish Distribution and Relative Abundance

A total of 199 pools were snorkeled, totaling nearly 1,400 m of stream. Whitefish, suckers, and dace were found primarily or exclusively downstream of the National Forest boundary. Juvenile coho salmon were found in mainstem Clear Creek up to the National Forest boundary. Sculpin were documented in lower mainstem Clear Creek, West Fork Clear Creek, Middle Fork Clear Creek, and LCC. Chinook salmon were observed in mainstem Clear Creek to just upstream of the Middle Fork confluence; in approximately the lower half of the surveyed reaches of South Fork Clear Creek; and in West Fork Clear Creek near the mouth.

Relative abundance of juvenile Chinook salmon was highest in LCC, at 186 fish/100 m and much lower in the LMCC and South Fork subwatersheds (28 and 7 fish/100 m, respectively). Relative abundance of juvenile Chinook salmon generally declined from downstream to upstream within LMCC and South Fork Clear Creek.

Steelhead/rainbow trout (*O. mykiss*), the most widely distributed species, were found to the upper end of surveyed reaches in West Fork Clear Creek (but not its tributary, Lost Mule Creek), South Fork Clear Creek, Middle Fork Clear Creek, and Pine Knob Creek. *O. mykiss* were restricted to the lower half of the Browns Spring Creek study area. In mainstem Clear Creek, *O. mykiss* were found throughout the LCC reaches to approximately two kilometers upstream of the Browns Spring Creek confluence. At the subwatershed scale, *O. mykiss* relative abundance as measured by linear density (fish/100 m) was highest in streams with larger channels: LCC and LMCC. However, conclusions about relative abundance were somewhat different when evaluated with areal density (fish/m^2), which showed higher relative abundance in streams with smaller channels compared with linear density.

Cutthroat trout were found primarily in smaller streams in the upper reaches of the study area: they were observed throughout surveyed reaches in Lost Mule, West Fork Clear Creek, Tailed Frog Creek and Browns Spring Creek. In mainstem Clear Creek, cutthroat trout were rare downstream of Browns Spring Creek, but found in higher numbers further upstream. At the subwatershed scale, relative abundance of all cutthroat trout was highest in Browns Springs, followed by UMCC, and West Fork. Unlike *O. mykiss* results, linear and areal densities of cutthroat trout generally painted a similar picture of relative abundance. The distribution and relative abundance of cutthroat trout and *O. mykiss* were negatively correlated to one another. Densities of cutthroat trout were generally highest in study reaches where *O. mykiss* were not present, such as the upper reaches of Browns Spring Creek.

Observation efficiency of snorkeling

Observation efficiency of snorkeling was investigated through multi-pass vs. single-pass snorkel surveys, limited comparison of electrofishing results with snorkel counts, and through comparison of daytime snorkel surveys with nighttime snorkeling. Result from these analyses indicate that day time snorkeling underestimated the total fish population. However, the goal of snorkel surveys was to provide estimates of a relative abundance and describe fish distribution across the study area, rather than provide an absolute estimate of abundance.

Fish passage barrier identification

A total of 28 potential barriers to fish migration were identified with the National Forest study area. Five of these locations were considered to be likely total barriers to passage of anadromous fish. The likely total barriers were each located in relatively small streams in the upper portions of the study area. Several other locations were documented that are not expected to be total barriers, but likely limit migration across a relatively wide range of stream flows. Photographs of each potential barrier along with GPS coordinates, site-specific measurements, more detailed descriptions, and rationale for qualitative designations of barrier status for each location are provided in Appendix E.

Habitat Unit-scale Characterization

Main and side channel length

Within the National Forest, large side channels comprised approximately 3% of the 40,100 m of main channel. Large side channel percentage was highest in the South Fork subwatershed at nearly 9% and lowest in LMCC at 1%. In LCC, large side channels made up over 10% of the 6,800 m of main channel. Small side channels were most abundant in Browns Spring Creek and least abundant in UMCC, comprising 10.6 percent and 0.2 percent of mainstem channel length, respectively.

Habitat type composition

The most prevalent habitat units by length and number in all subwatersheds were fast-water turbulent units (riffles, rapids, cascades, and falls), followed by fast-water non-turbulent units (often referred to as runs and glides) and slow-water units (pools and off-channel). Riffles were the most common fast-water turbulent habitat type and comprised the greatest relative length in all subwatersheds. For slow-water habitats, scour pools were the most abundant type in all subwatersheds, except West Fork Clear Creek, where plunge pools were most prevalent.

For subwatersheds within the National Forest, pool frequency ranged from nearly 12 pools/km in the Middle Fork to 27 pools/km in West Fork. Pool frequency within the National Forest ranged from 7 bankfull widths/pool in UMCC to 15 bankfull widths/pool in Middle Fork. There were fewer pools in LCC, which had 22 bankfull widths/pool. Pools deeper than 0.9 m (3 ft) were most abundant in the LMCC (23 pools) and South Fork subwatersheds (21 pools). UMCC, West fork, Pine Knob, and Browns Springs all had 3 or fewer pools >0.9 m deep, whereas none were observed in the Middle Fork. Fourteen pools >0.9 m deep were observed in LCC.

Channel dimensions

Mean length, mean wetted-width, and mean depth of habitat units were greatest in subwatersheds with the largest channels: LCC, followed by LMCC and South Fork.

Substrate composition

In general, cobble and/or boulder accounted for the greatest percent of streambed substrate, followed by gravels, sands/fines, and bedrock, respectively. Bedrock was relatively infrequent

(<5%) in all subwatersheds, with UMCC having the greatest prevalence (4.3%) relative to other substrate types. Percent of boulder substrate was highest in South Fork (35%), while percent of cobble substrate was highest in LCC (53%). Percent of coarse gravel was greatest in Pine Knob (27%) and fine gravel in UMCC (16%). UMCC, West Fork, Pine Knob, and LCC had the highest levels of bed surface fines, ranging from 3–5%.

Bank stability

In general, undercut and eroding banks were uncommon. Of 3,433 surveyed habitat units, 53 (1.5%) exhibited some degree of bank erosion and 130 (3.8%) had undercut banks (on one or both banks).

Large woody debris

Within the National Forest, LWD frequency was highest in the West Fork subwatershed (415 pieces/km) and lowest in LMCC (142 pieces/km). LWD frequency was substantially lower in LCC (111 pieces/km). LWD size frequency was dominated by smaller pieces of wood. Frequency of key LWD pieces (≥12 in diameter and ≥35 ft length) within the National Forest was highest in UMCC (44 key pieces/km), which was substantially higher than elsewhere. Key piece frequency was lowest in Middle Fork (5 key pieces/km). Total volume of LWD within the National Forest ranged from 113 m^3/km in Pine Knob to 438 m^3/km in UMCC. Most of the LWD volume in LMCC was observed in jams. LWD volume was substantially lower in LCC (32 m^3/km) compared with other subwatersheds.

The frequency of LWD jams within the National Forest was highest in the UMCC (4.7/km) and in West Fork (4.8 jams/km), and lowest in South Fork (1.6 jams/km). LWD jam frequency in LCC (0.1 jams/km) were substantially lower than observed on the National Forest. Total jam volume and jam volume per length of stream were greatest in the LMCC and UMCC subwatersheds and lowest in LCC.

Spawning gravel

Anadromous spawning gravel quantity within the National Forest rated as good or fair (combined), ranged from 12 m^2/km in the West Fork subwatershed to 121 m^2/km in LMCC. Anadromous spawning gravel quantity exceeded 50 m^2/km in the UMCC, LMCC, and South Fork subwatersheds, and was less than 25 m^2/km in West Fork and Pine Knob. Anadromous spawning gravel was far more abundant in LCC, with gravel quantity exceeding 500 m^2/km.

Long-term Monitoring Stations

Five long-term monitoring stations were established in the Clear Creek basin for more intensive monitoring of channel physiography and fish habitat and population data. Stillwater Sciences established two stations, one in mainstem Clear Creek near the National Forest boundary (LMCC) and the other in West Fork Clear Creek at its confluence with Clear Creek (WFCC). The three other long-term monitoring stations, established by the USDA Forest Service, were located in mainstem Clear Creek just upstream of the Middle Fork confluence (MMCC), South Fork Clear Creek approximately 2.5 km upstream of Clear Creek (SFCC), and Middle Fork Clear Creek near its confluence with Clear Creek (MFCC). The primary purpose of collecting data at monitoring stations was for comparing results to future monitoring.

Longitudinal and cross-section profiles

The LMCC monitoring station extends 500 ft downstream from the National Forest boundary. The elevational difference from the top to the bottom of the monitoring station was 2.8 m (9.2 ft), a gradient of 1.8%. Three cross sections were also monumented and surveyed. The WFCC monitoring station extends from the confluence upstream 500 ft. The elevational difference from the top to the bottom of the monitoring station was 8.6 m (28.4 ft), a 5.7% gradient. As with the LMCC station, three cross sections were monumented and surveyed.

Stream discharge

Stream discharge estimated from two measurements at both at the LMCC and WFCC monitoring stations was approximately 10 cfs and 0.6 cfs, respectively.

Stream bed surface substrate

One 300-particle pebble count was performed at the LMCC and WFCC monitoring stations. Results indicate that surface substrates at WFCC are generally finer than those observed at LMCC.

Cobble embeddedness

Average weighted cobble embeddedness at the LMCC and WFCC monitoring stations was 65.5% and 72.9% respectively.

Air and water temperature

Air and water temperature data loggers were installed at the LMCC and WFCC monitoring stations. The data loggers will be downloaded and maintained by the USDA Forest Service.

Fish abundance

Electrofishing was conducted at each of the five long-term monitoring stations. A total of 2,192 fish of eight species were captured. Juvenile *O. mykiss* and age-0 unidentified trout comprised over 73% of the total catch. A considerable number of juvenile Chinook salmon were captured at the LMCC monitoring station. Additionally, despite not being documented during reach-scale snorkel surveys, five juvenile Chinook salmon were captured during electrofishing in WFCC. Relatively low numbers of juvenile coho salmon were also documented at LMCC, but none were seen during snorkel surveys of Reach 1 (which encompasses LMCC). Other species captured included mountain whitefish, cutthroat trout, dace and sculpin. *O. mykiss* populations were estimated at each long-term monitoring station, but too few fish of other species were captured to allow for meaningful population estimates.

The total *O. mykiss* population (all ages) was highest at the LMCC monitoring station, followed closely by MMCC and SFCC. However, SFCC had the highest number of older and larger fish. Consistent with findings from snorkel surveys, very few older fish were present at WFCC.

1 INTRODUCTION

The Clearwater Resource Conservation and Development Council, Inc. (RC&D) is a non-profit organization that sponsors the Clearwater Basin Collaborative (CBC). The CBC is a collaborative effort involving of representatives from local and state governments, conservation groups, the timber products industry, the Nez Perce Tribe, motorized interests, sportsmen, and local citizens. The CBC's vision is to enhance and protect the ecological and economic health of the forests, rivers, and communities within the Clearwater Basin.

In March 2009, President Obama signed the Forest Landscape Restoration Act (FLRA) into law under Title IV of the Omnibus Public Lands Act of 2009, establishing the Collaborative Forest Landscape Restoration Program (CFLRP). The purpose of CFLRP is to implement and monitor collaborative, science-based ecosystem restoration of priority forest landscapes over a 10-year period. The Clearwater Basin's Selway - Middle Fork CFLRP Project is one of 23 selected nationwide for inclusion in this program.

This document summarizes the Clear Creek Aquatic Habitat Condition Assessment and Fish Population Monitoring Project, which is part of the Selway - Middle Fork CFLRP being managed by the CBC.

1.1 Background

The goal of the Aquatic Habitat Condition Assessment and Fish Population Monitoring project is to provide an inventory of habitat conditions, and document fish distribution and relative abundance in the Clear Creek watershed on the Nez Perce-Clearwater National Forests near Kooskia, Idaho. Results from the assessment will serve as a baseline for comparison with future surveys to evaluate habitat conditions and processes, water quality parameters, and fish population changes over time as a result of resource management in the basin. Of particular importance is the current spatial distribution and relative abundance of salmonid species in the basin. The locations of suitable habitat for steelhead and salmon spawning and rearing, the relative importance of the drainage and sub-watersheds for these species, and the existence of upstream barriers will inform resource management decisions within the watershed.

The specific project objectives include:

- Describe current stream channel and fish habitat conditions
- Identify potentially suitable salmon and steelhead spawning habitat
- Determine spatial distribution and relative abundance of salmonids
- Identify and evaluate potential barriers to fish migration
- Establish baseline datasets for determining impacts on aquatic habitat that can be attributed to the implementation of land management activities
- Establish and monument two permanent monitoring stations (in addition to three previously established) for the evaluation of potential changes to the physical habitat (e.g., spawning gravels), the physical processes (e.g., channel aggradation/degradation), and relevant water quality parameters (e.g., stream temperature).

1.2 Study Area

The Clear Creek drainage lies within the Middle Fork Clearwater River basin near the town of Kooskia, Idaho (Figure 1). Landforms in the study area are mostly steep dissected mountain slopes (58% of the area) and low and moderate relief rolling uplands (33%), with the remainder a mix of landform types (Clearwater RC&D Council 2015 - RFP). Geologically, the area has a dissected mosaic of plutonic, volcanic, and sedimentary rocks distributed throughout the basin. Within the study area, vegetation is dominated by coniferous forest, with nearly all areas dominated by grand fir. Additional detail on geology and vegetation is included in Appendix A.

The Clear Creek drainage contains at least of 359 kilometers (223 miles) of mainstem and tributary streams. Of these, approximately 105 kilometers (65 miles) are considered fish-bearing and occur on Forest Service managed lands within the Nez Perce-Clearwater National Forests. Within fish-bearing streams on National Forest lands, the USDA Forest Service defined reaches by survey priority (see Appendix A). Habitat and fish population surveys were conducted during the summer of 2015 on approximately 43 kilometers (27 miles) of stream (based on GIS) that were considered highest priority by the USDA Forest Service (Appendix A). Within the Nez Perce-Clearwater National Forests, the study area included reaches in mainstem Clear Creek and its tributaries (West Fork Clear Creek/Lost Mule Creek, South Fork Clear Creek, Middle Fork Clear Creek, Pine Knob Creek, and Browns Spring Creek) (Figure 1).

Westslope cutthroat trout occur widely throughout the area well into the headwaters of most streams. Snake River Basin steelhead trout (a threatened species listed under the federal Endangered Species Act) and unlisted Spring Chinook salmon occur in the Clearwater River basin. There are 56 kilometers (35 miles) of designated critical habitat for steelhead on National Forest lands in the Clear Creek drainage. Other fish species previously documented included mountain whitefish, sculpin, and dace.

The study area was expanded to include surveys of additional study reaches on private land in the Clear Creek basin downstream of the National Forest boundary (Lower Clear Creek, or LCC) at the request of the Idaho Soil and Water Conservation District, in coordination with the CBC (Figure 1). The focus of these surveys was to characterize habitat conditions in LCC in support of identifying enhancement opportunities. These surveys were conducted using the same survey protocols used for surveys on National Forest land.

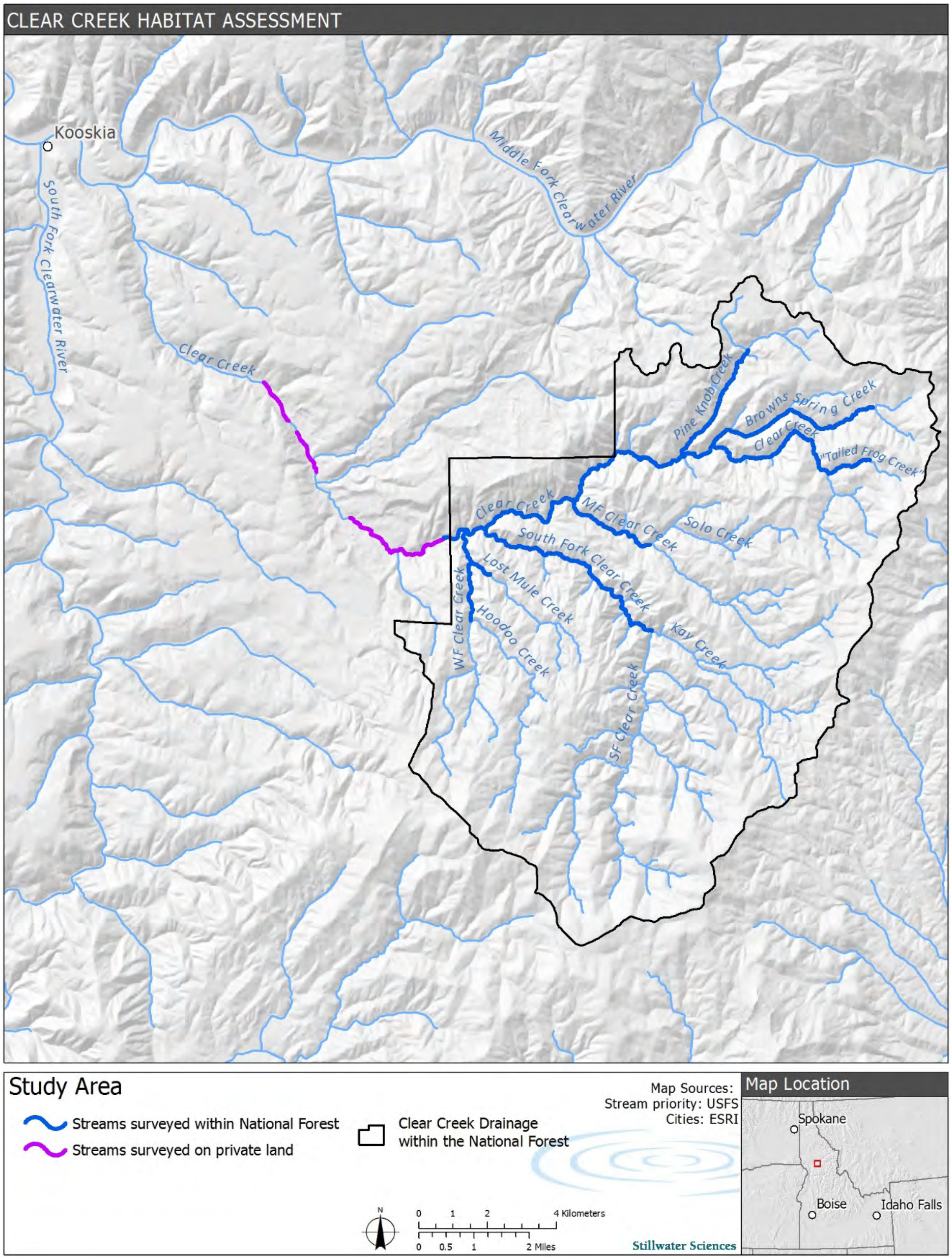

Figure 1. Streams surveyed in the Clear Creek study area, including streams within the Nez Perce-Clearwater National Forests and on private land in lower Clear Creek.

2 METHODS

2.1 Sampling Framework

A sampling framework was developed to guide fish distribution and aquatic habitat surveys and ensure that the data collected were sufficient to characterize habitat conditions and relative fish abundance, while implementing an efficient approach with available resources. The sampling framework is included as Appendix A, and is briefly summarized herein.

The study area was first stratified into functional reaches. A reach is a length of stream defined by one or more functional characteristics. In general, reaches are segments of stream with consistent valley width, channel gradient, and channel formation processes (geomorphology). Reaches are further defined by major changes in vegetation type, changes in land use, and location relative to major tributaries. Stratifying the channel network into functional reaches provides a valuable structure to guide field sampling and data interpretation at appropriate scales. The reach concept is that channel segments having similar controlling conditions and experiencing similar influences on the landscape will, typically, function similarly and provide similar habitat conditions for fish and aquatic species. In addition, reaches of the same type are expected to respond similarly to similar types and magnitudes of disturbance.

Drainage area and channel gradient were the primary parameters used to differentiate the study area into individual reaches. Drainage area thresholds are intended to differentiate between channels of varying size and position in the channel network (e.g., stream order). A range of potential drainage area thresholds were evaluated and the following four categories were selected to characterize relative differences in stream size at an appropriate scale for this assessment: <5 km^2, 5–25 km^2, 25–100 km^2, and >100 km^2.

Channel gradient categories follow those described by Montgomery and Buffington (1998), and include 0–1%, 1–4%, 4–8%, 8–20%, and >20%. These gradient categories relate to channel bed morphologies (i.e., pool-riffle, plane-bed/forced pool-riffle, step-pool, cascade), sediment characteristics, and response potential, and also correlate strongly with species habitat suitability and preferences (e.g., Chinook salmon are typically found in reaches with gradients <4%, whereas steelhead may use reaches having an average gradient of 8% or higher). For ease and clarity of reporting in some sections, reach gradient categories were consolidated into low gradient reaches (1–4%), moderate to moderately high gradient reaches (4–20%), and high gradient reaches (>20%).

2.2 Field Protocols

Field protocols were developed based on several existing protocols, including the Columbia Habitat Monitoring Program (CHaMP), the EPA Environmental Monitoring and Assessment Program (EMAP), the Washington Salmon Recovery Funding Board, and the Oregon Department of Fish and Wildlife (ODFW) Aquatic Inventories Project Methods for Stream Habitat Surveys Protocol. Data were collected using an iPad-based data collection platform (GeoOptix) supplied by Sitka Technologies. Use of iPads allowed field crews to collect and rapidly enter numerous types of data in the remote study area while not having to carry and organize a large amount of hard-copy datasheets. Further, built-in validation features of GeoOptix were designed to ensure that all data entry forms were complete and minimize data entry errors.

Fish and habitat data were collected at two scales: reach-scale and habitat unit-scale. The process by which reaches were identified for this project is described briefly above (Section 2.1) and detailed in Appendix A. For the purposes of reporting, reach-scale data are considered to be all data collected less frequently than every habitat unit. These data include channel form and constraining features, riparian vegetation, fish distribution and abundance, and fish passage barrier identification and characterization (Table 1). Reach-scale data were primarily collected at transects (except for fish distribution abundance, and passage barrier assessment). Transects were completed at least once per reach, or every approximately 500 m in longer reaches (Appendix A).

Habitat units (channel geomorphic units) are relatively homogeneous lengths of the stream that are classified by channel bed form, flow characteristics, and water surface slope. With some exceptions, habitat units are defined to be at least as long as the active channel is wide. Individual units are formed by the interaction of discharge and sediment load with channel resistance (roughness characteristics such as bedrock, boulders, and large woody debris). For the purposes of this survey, habitat unit-scale data are considered to be all data collected at every habitat unit, which includes habitat type, habitat unit dimensions (width, length, water depth), substrate composition, incidence of bank undercut and erosion, large woody debris abundance, and suitable spawning gravel abundance (Table 1).

In addition to reach-scale and habitat unit-scale data collection, two permanent monitoring stations were established for more intensive monitoring of stream channel physiography, stream discharge, stream bed surface substrate, cobble embeddedness, and air and water temperatures (Table 1). Fish population abundance was assessed through electrofishing at the two monitoring stations established by Stillwater, and at three additional monitoring stations previously established by the USDA Forest Service. Specific methodologies for collecting each of the reach-scale, habitat unit-scale, and monitoring station data element are described in detail in Appendix B.

Table 1. Data collected at each spatial scale.

Reach-scale	Habitat unit-scale	Long-term monitoring stations
• Channel form and constraint • Cobble embeddedness • Riparian vegetation • Canopy cover • Fish distribution and abundance (snorkel surveys) • Fish passage barriers	• Reach type classification • Habitat type classification • Channel dimensions • Substrate composition • Bank undercut and erosion • Large woody debris abundance • Spawning gravel	• Longitudinal and cross-section profiles • Discharge • Bed surface substrate • Cobble embeddedness • Air and water temperatures • Fish abundance (electrofishing)

Following review and acceptance of the protocols by the CBC and the USDA Forest Service, the CBC received a request from the Idaho Department of Fish and Game that the field crew also note the presence of freshwater mussels and amphibians. An additional field was added to the electronic snorkel survey forms to prompt crews to record mussel and amphibian presence in snorkeled pools. Mussels and amphibians were also noted in the comments section during habitat typing, but no systematic methods were applied to identify or quantify mussels and amphibians throughout the study area.

2.3 Analytical Methods

Analytical methods that required more involved analysis than simple mathematical calculations, such as reporting mean values for a reach, are described briefly with their accompanying results in the sections below. In addition, the field sampling protocol (Appendix B) has been updated to describe specific methods of data analysis/data manipulation such that it can serve as a stand-alone document for future data collection and analysis efforts.

3 RESULTS

3.1 Channel Classification

3.1.1 National Forest study reaches

The channels surveyed within the National Forest were divided into 52 study reaches representing 11 reach types (categorized by channel gradient and drainage area) (Table 2, Figure 2). The most prevalent reach type was reaches with 4–8% gradient and 5–25 km^2 drainage area (30% by length), followed closely by reaches with 1–4% gradient and 25–100 km^2 drainage area (27% by length). By stream length, 41% of the surveyed channel was 1–4% gradient, 47% was 4–8%, 11% was 8–20%, and <1% was greater than 20%. Only nine of the 52 reaches had >8% gradient. With the exception of 1,600 m of channel in Reaches 1 and 2 in lower mainstem Clear Creek, all channels had contributing drainage areas less than 100 km^2 (Figure 2). Study reaches in South Fork Clear Creek, mainstem Clear Creek from the South Fork confluence to Browns Spring Creek, and the lower reaches of the West Fork and Middle Fork had contributing drainage areas of 25–100 km^2. The remainder of the study reaches had drainage areas in the 5–25 km^2 category, excluding reaches in upper Browns Spring Creek, and Tailed Frog Creek.

Table 2. Reach length (m) by channel gradient and drainage area categories for study reaches within the National Forest.

Channel gradient	**Contributing drainage area category (km^2)**					
	<5	**5–25**	**25–100**	**>100**	**Total**	**% of channel length**
0–1%	--	--	--	--	0	**0**
1–4%	183	3,664	11,012	1,598	16,457	**41**
4–8%	1,488	12,002	6,267	--	19,013	**47**
8–20%	691	3,301	482	--	4,473	**11**
>20%	--	161	--	--	161	**<1**
Total	**2,361**	**19,127**	**17,761**	**1,598**	**40,104**	**100**

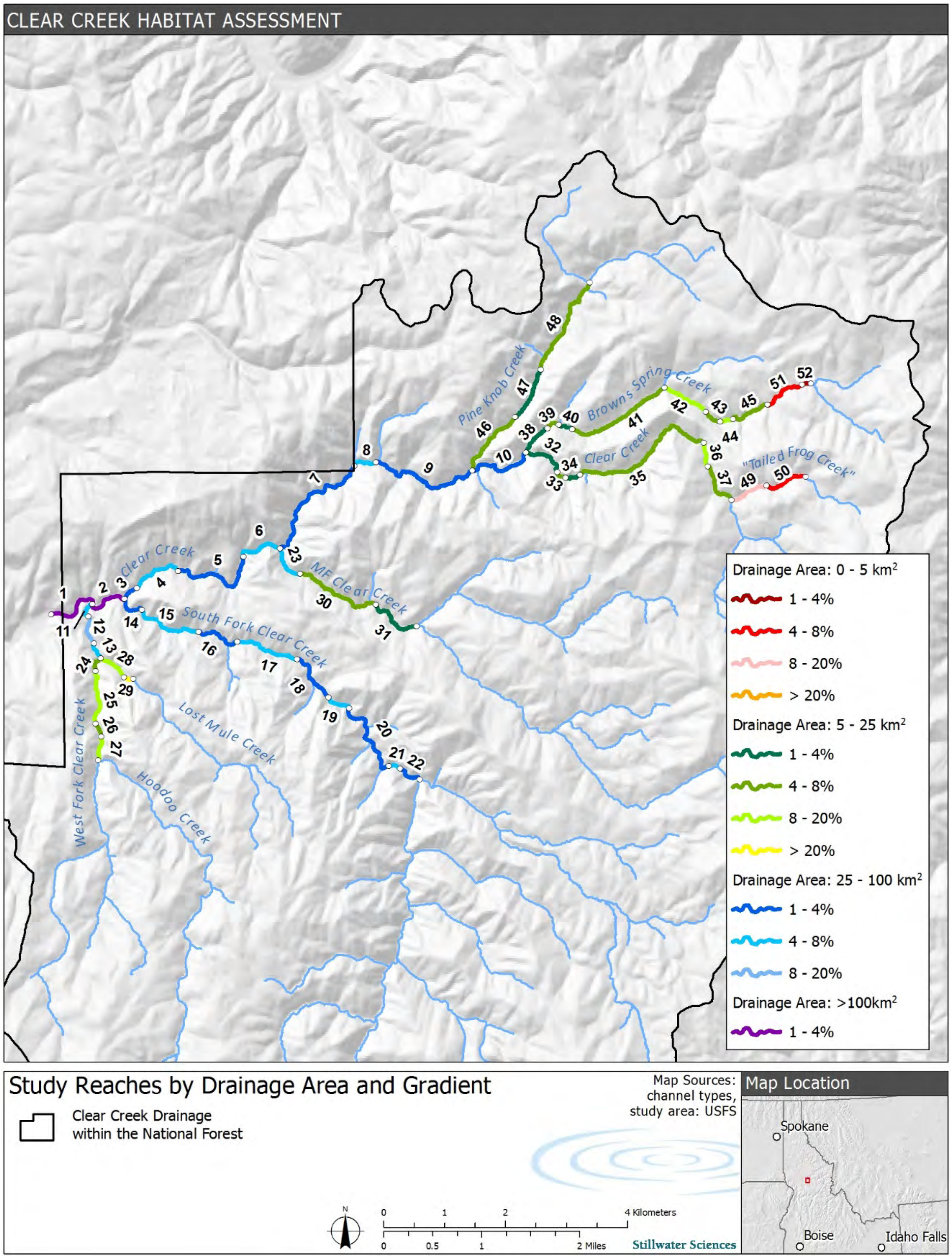

Figure 2. Distribution of study reaches as defined by channel gradient and drainage area for streams surveyed within the National Forest. Each study reach is associated with a unique reach identification number.

The location of study reach boundaries were initially identified using GIS; however, exact boundaries of the reaches were identified in the field based on observed channel characteristics, and located to coincide with a habitat unit boundary. Therefore, reach boundaries may have shifted from pre-identified reaches (Appendix A), and thus, their measured lengths are not exactly the same as those in Appendix A. Individual reach lengths as measured in the field ranged from 161 to 2,812 m and totaled over 40,000 m. The measured length of individual reaches is provided in Appendix C.

For data analysis and presentation, the study area was broken into eight subwatersheds including:

- Lower Mainstem Clear Creek (LMCC) from the National Forest Boundary to the confluence with Browns Spring Creek
- Upper Mainstem Clear Creek (UMCC) from the confluence of Browns Spring Creek to the end of the surveyed reaches. Note that while included in the discussion of UMCC, reaches 49 and 50 are on a tributary to the upper Clear Creek, referred to as “Tailed Frog Creek”
- West Fork Clear Creek and Lost Mule Creek (West Fork)
- South Fork Clear Creek (South Fork)
- Middle Fork Clear Creek (Middle Fork)
- Pine Knob Creek (Pine Knob)
- Browns Spring Creek (Browns Spring)
- Privately-owned reaches downstream of the National Forest boundary on Lower Clear Creek (LCC)

Overall, streams with smaller drainage areas were generally steeper than larger streams. Lower mainstem Clear Creek and South Fork, generally had lower-gradient reaches with larger drainage areas (Figure 2, Table 3). Middle Fork, Browns Spring, UMCC, and Pine Knob had smaller drainage areas and a mix of gradients, whereas West Fork had the highest gradients overall (Figure 2, Table 3).

Table 3. Number of reaches in each subwatershed by reach type.

Drainage area category	Gradient Category	LMCC	UMCC	West Fork	South Fork	Middle Fork	Pine Knob	Browns Spring	Total
<5	1–4%	--	--	1	--	--	--	--	**1**
	4–8%	--	1	--	--	--	--	1	**2**
	8–20%	--	1	--	--	--	--	--	**1**
5–25	1–4%	--	2	--	--	1	1	2	**6**
	4–8%	--	3	2	--	1	2	4	**12**
	8–20%	--	1	3	--	--	--	2	**6**
	>20%	--	--	1	--	--	--	--	**1**
25–100	1–4%	5	--	--	5	--	--	--	**10**
	4–8%	3	--	2	4	1	--	--	**10**
	8–20%	--	--	1	--	--	--	--	**1**
>100	1–4%	2	--	--	--	--	--	--	**2**
All Reaches		**10**	**8**	**10**	**9**	**3**	**3**	**9**	**52**

Reaches 1 and 2 have a substantially larger drainage area (both >140 km^2), and thus channel size, than the remainder of the reaches in LMCC (all <80 km^2) due to the contribution of South Fork Clear Creek, which has a drainage area of nearly 68 km^2 (Figure 2). Nonetheless, for analysis and reporting, these two reaches were included with the remainder of LMCC due to their relatively short combined length.

3.1.2 Lower Clear Creek study reaches

Six study reaches were identified by the Idaho Soil and Water Conservation District and CBC in lower Clear Creek (LCC) based on private land access (Figure 3). The reaches surveyed on lower Clear Creek included 6,804 m of mainstem channel and 775 m of side channel. Although reach types weren't specifically designated for these study reaches, drainage areas were >100 km^2, and channel gradients 1–4%.

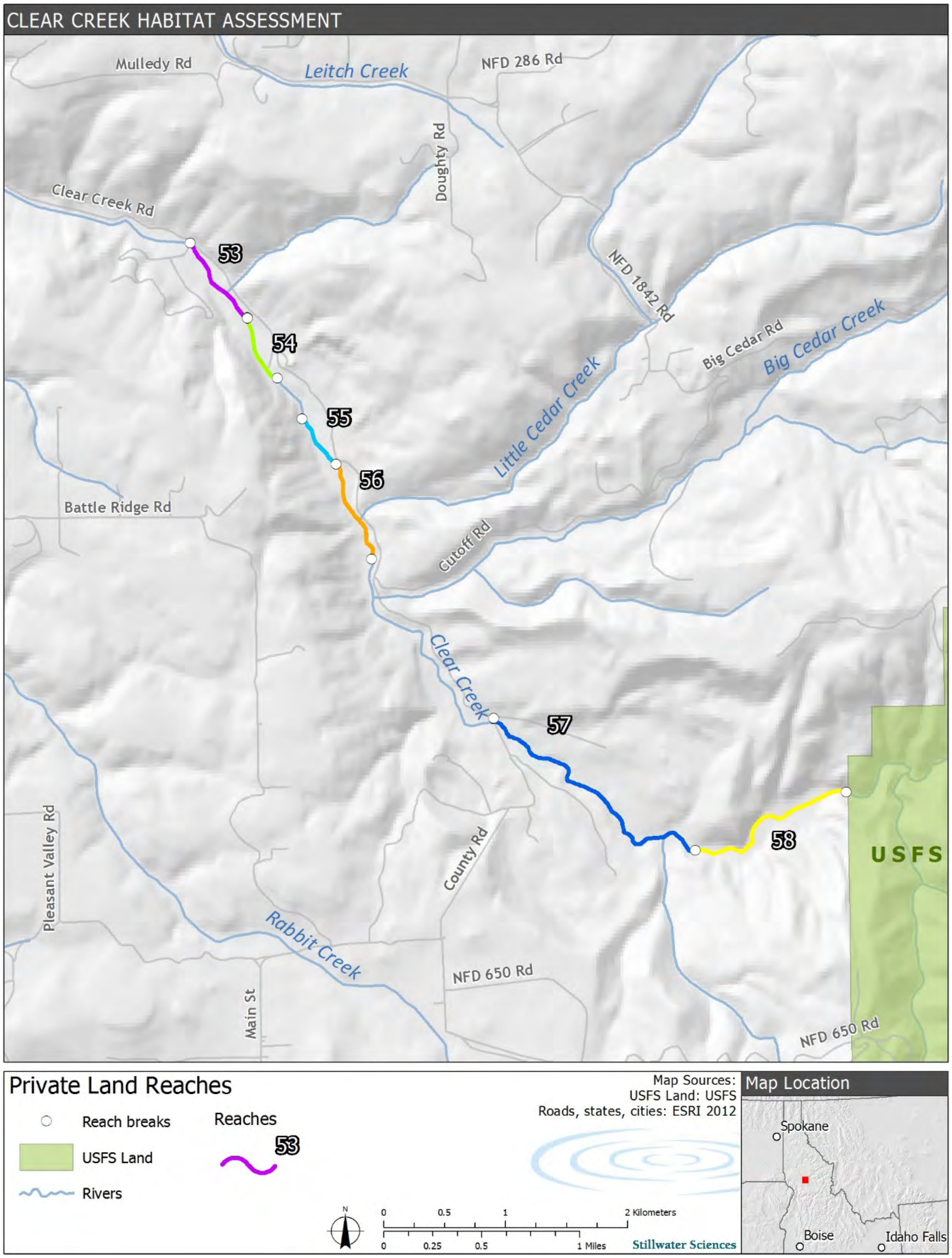

Figure 3. Distribution of study reaches for streams surveyed on private land in lower Clear Creek downstream of the National Forest boundary. Each study reach is associated with a unique reach identification number.

3.2 Reach-scale Characterization

A total of 78 transects were surveyed for channel form and constraint, stream bank surface type, embeddedness, riparian vegetation, and canopy cover within the National Forest study reaches. An additional 9 transects were surveyed within LCC (Table 4). At least one transect was surveyed in each study reach, with multiple transects surveyed approximately every 500 m reaches longer than 1,000 m. Reach 50 in UMCC was an exception, where a transect was not surveyed because the small, heavily braided, and densely vegetated channel hindered implementation of standard field survey protocols.

Table 4. Number of transects surveyed in each of the subwatersheds.

Subwatershed	# of Transects
LMCC	20
UMCC	11
West Fork	11
South Fork	12
Middle Fork	5
Pine Knob	7
Browns Spring	12
LCC	9
Total	**87**

3.2.1 Channel form and constraint

The Clear Creek study area within the National Forest consists primarily of wooded steep valleys. By contrast, the private land in LCC, downstream of the National Forest boundary, has much lower gradient, wider floodplains, more gravel and cobble, and abundant side channels. Overall, the majority of reach-scale transects (71%) indicated a single channel form constrained by hillslopes in a narrow valley (Table 5, Figure 4). However, in some locations, despite being relatively constrained by steep hillslopes, the stream morphology was a complex network of either braided or anastomosing channels. Figure 4 and 5 illustrate the number and percentage of transects by channel form and constraint overall and by subwatershed, respectively. Detailed data for all transects are included in Appendix D.

Table 5. Number of transects surveyed within channel form and constraint type categories, by subwatershed.

Subwatershed	Constraint type	Channel form		
		Single	Braided	Anastomosing
LMCC	Narrow Valley	19	--	--
	Valley Floor	1	--	--
	Unconstrained	--	--	--
UMCC	Narrow Valley	7	--	3
	Valley Floor	1	--	--
	Unconstrained	--	--	--
West Fork	Narrow Valley	9	--	1
	Valley Floor	--	--	--
	Unconstrained	--	1	--
South Fork	Narrow Valley	10	--	--
	Valley Floor	--	--	2
	Unconstrained	--	--	--
Middle Fork	Narrow Valley	4	--	--
	Valley Floor	1	--	--
	Unconstrained	--	--	--
Pine Knob	Narrow Valley	7	--	--
	Valley Floor	--	--	--
	Unconstrained	--	--	--
Browns Spring	Narrow Valley	4	--	1
	Valley Floor	3	--	3
	Unconstrained	--	1	--
Total for National Forest	**Narrow Valley**	**60**	**-**	**5**
	Valley Floor	**6**	**-**	**5**
	Unconstrained	**-**	**2**	**-**
LCC	Narrow Valley	2	--	--
	Valley Floor	4	1	2
	Unconstrained	--	--	--
Grand total	**Narrow Valley**	**62**	**--**	**5**
	Valley Floor	**10**	**1**	**7**
	Unconstrained	**--**	**2**	**--**

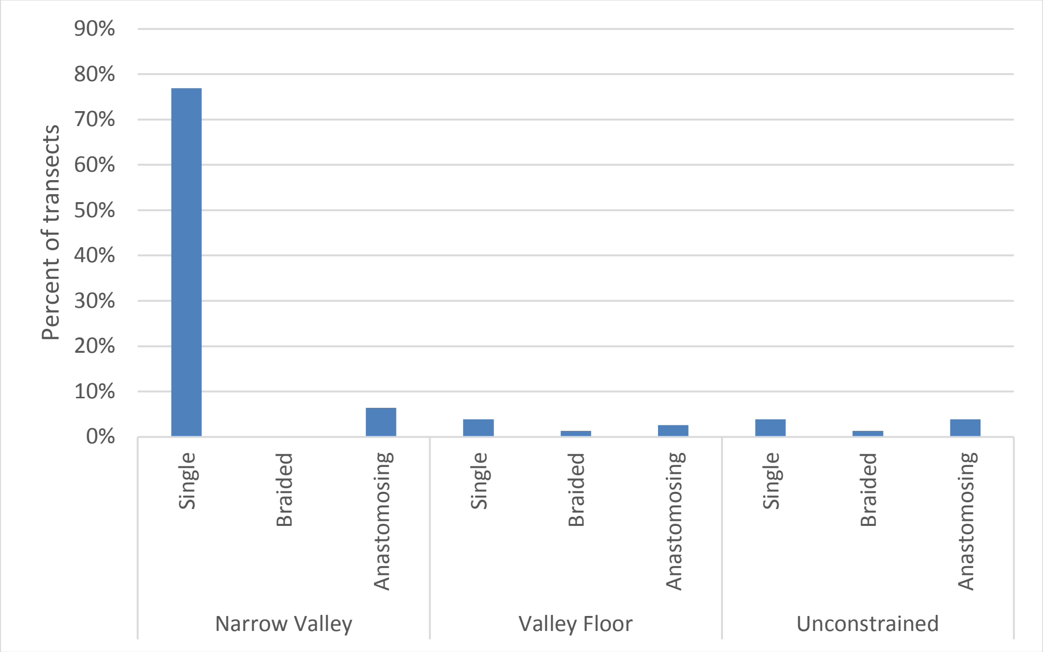

Figure 4. Percent of transects by channel form and constraint type.

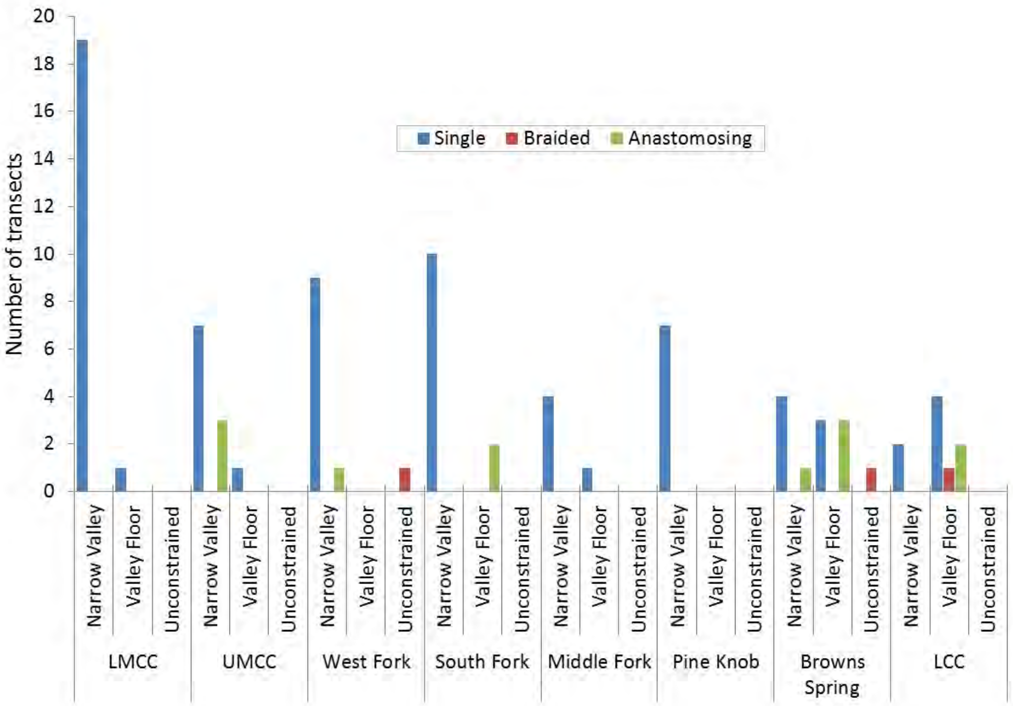

Figure 5. Number of transects by channel form and constraint type.

Characteristics of channel size were measured at reach-scale transects to provide an understanding of how channel dimensions vary among reaches and subwatersheds. Measured parameters included bankfull width and depth, and floodprone width (floodprone depth is based on bankfull depth measurement). Various metrics derived from channel dimensions provide useful tools for comparing physical processes and channel condition. Metrics reported include width-to-depth ratios; and width-to-width ratios.

Bankfull width and depth provide an indication of the extent of the common floods with recurrence interval of about 1.5–2 years, which have a strong influence on shaping channel form and conditions (Harrelson et al. 1994). Bankfull widths ranged from about 5 m in smaller watersheds such as West Fork Clear Creek and Pine Knob Creek, up to about 10 m in lower mainstem Clear Creek (Table 6). Bankfull depths ranged from about 0.4 m in Pine Knob Creek up to 0.8 m in lower mainstem Clear Creek. The ratio of bankfull width to bankfull depth, which provides a measure of channel constraint during common floods, ranged from 7.6 to 14.3 for subwatersheds within the National Forest (Table 6, Figure 6). The bankfull width to bankfull depth ratio was substantially greater in lower Clear Creek at 29.4.

Floodprone width provides an estimate of channel size during less frequent and more substantial flooding events. The ratio of floodprone width to bankfull width provides a measure of channel constraint during larger floods and indicates the relative extent of the adjacent floodplain. Floodprone widths ranged from about 8 m in West Fork to about 16 m in UMCC (Table 6). The ratio of floodprone width to bankfull width ranged from 1.5 in LMCC to 2.8 in UMCC. Based on the ratio of floodprone width to bankfull width measured at transects, both UMCC and Browns Spring had the most extensive floodplains relative to other subwatersheds (Table 6, Figure 6). It is notable that UMCC had the greatest constraint based on bankfull width to bankfull depth ratio, but the least constraint based on floodprone width to bankfull depth ratio.

Table 6. Channel dimensions, by subwatershed[1].

Variable	LMCC	UMCC	West Fork	South Fork	Middle Fork	Pine Knob	Browns Spring	LCC
Bankfull depth (m)	0.8	0.8	0.5	0.7	0.6	0.4	0.5	0.3
Bankfull width (m)	10.2	5.7	4.8	9.8	5.6	5.1	6.0	9.8
Floodprone width (m)	15.0	15.9	8.1	15.0	11.0	9.5	14.6	18.1
$\text{Width}_{\text{bf}}:\text{depth}_{\mathbf{bf}}$	12.8	7.6	9.5	14.3	9.8	12.4	12.9	29.4
$\text{Width}_{\text{fp}}:\text{width}_{\text{bf}}$	1.5	2.8	1.7	1.5	2.0	1.8	2.4	1.8

[1] Values are average values based on measurements at reach-scale transects.

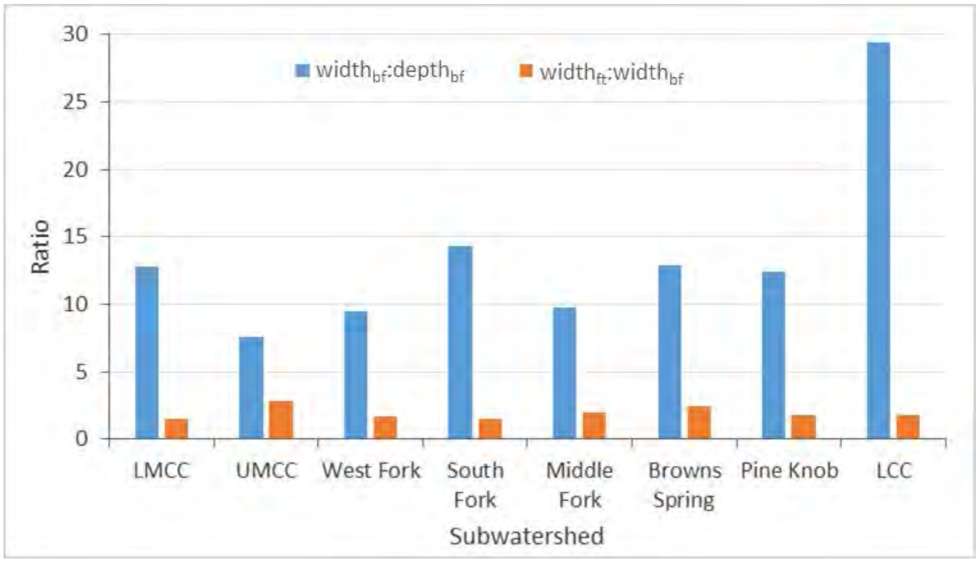

Figure 6. Ratio of bankfull width to bankfull depth and ratio of floodprone width to bankfull width measured at reach-scale transects within each subwatershed.

Stream banks were primarily formed by hillslopes, with some low terraces and floodplains. Uncommon banks types were high terraces, rip-rap, roadbeds, and secondary channels (Table 7).

Table 7. Number of transects by bank surface type.[1]

Subwatershed	Hillslope		Low terrace		Floodplain		High terrace		Rip rap		Roadbed		Secondary channel	
	RB	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**
LMCC	13	12	5	6	2	2	--	--	--	--	--	--	--	--
UMCC	7	8	4	1	1	2	--	1	--	--	--	--	--	--
West Fork	8	8	1	2	--	--	--	--	--	--	1	1	1	--
South Fork	8	6	--	2	2	2	1	2	1	--	--	--	--	--
Middle Fork	2	5	2	--	1	--	--	--	--	--	--	--	--	--
Pine Knob	2	6	4	--	1	1	--	--	--	--	--	--	--	--
Browns Spring	7	4	2	--	3	7	--	1	--	--	--	--	--	--
LCC	1	--	1	3	6	5	--	--	1	1	--	--	--	--
Totals	**48**	**49**	**19**	**14**	**16**	**19**	**1**	**4**	**2**	**1**	**1**	**1**	**1**	**--**

[1] RB = right bank and LB = left bank (looking downstream)

3.2.2 Cobble embeddedness

Average cobble embeddedness measured in riffles for subwatersheds in the National Forest ranged from 30% in Browns Spring Creek to 37% in South Fork Clear Creek (Figure 7). Average cobble embeddedness on private lands in lower Clear Creek was generally lower at 20%.

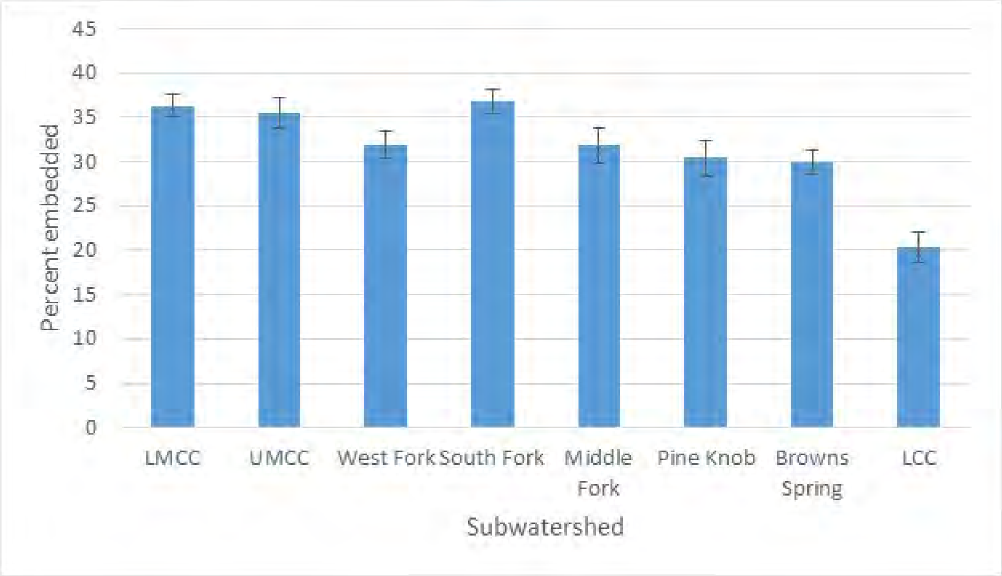

Figure 7. Average embeddedness for reach-scale transects for all subwatersheds. Error bars indicate the standard error.

Embeddedness, or average embeddedness for reaches with more than one transect, for each reach is illustrated in Figure 8. Most of the reaches surveyed within the National Forest had embeddedness of 30–40%. Embeddedness of most of the remainder was 20–30%, with a handful of short reaches being 40–50% embedded. The private lands of LCC were generally less embedded and more variable, ranging from 1–10% embedded up to 20–30% embedded.

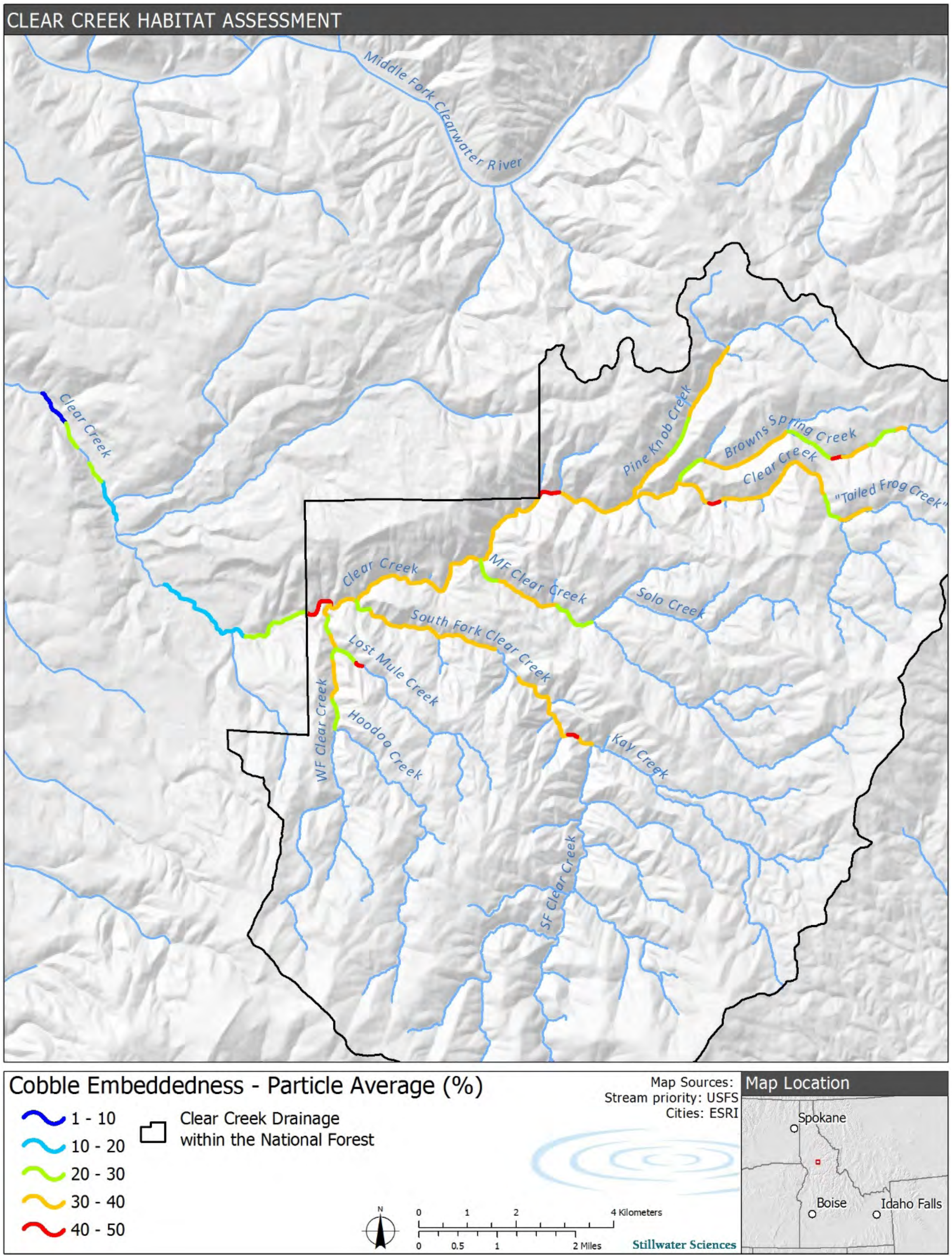

Figure 8. Average cobble embeddedness by study reach.

3.2.3 Riparian vegetation

All riparian vegetation data collected at reach-scale transects are presented in Appendix D. The dominant riparian vegetation at most of the transects surveyed within the National Forest was coniferous (44% of observations) (Table 8). Deciduous and mixed conifer/deciduous vegetation types were also relatively abundant at transects, including 22% of observations within the National Forest. At the subwatershed level, coniferous and mixed conifer/deciduous vegetation were generally most common. Shrubs was the most common vegetation type at transects in the South Fork subwatershed, and “no vegetation” was most common in lower Clear Creek (Tables 8 and 9).

Table 8. Dominant vegetation type at transects[1], by subwatershed.

Dominant vegetation	LMCC	UMCC	West Fork	South Fork	Middle Fork	Pine Knob	Browns Spring	LCC	Total
Coniferous	14	15	8	6	3	10	13	1	**70**
Deciduous	10	7	--	2	2	1	3	4	**29**
Mixed Conifer/Deciduous	3	2	10	6	3	--	4	1	**29**
Shrubs	10	--	1	10	2	1	1	1	**26**
Annual grasses	1	--	--	--	--	--	--	1	**2**
Perennial grasses	2	--	1	--	--	2	3	4	**12**
No vegetation	--	--	--	--	--	--	--	6	**6**
Total	**40**	**24**	**20**	**24**	**10**	**14**	**24**	**18**	**174**

[1] The number of transect observations includes one observation for each bank (left bank and right bank) such that each transect has two observations.

The dominant tree size as measured by diameter at breast height (DBH) was fairly evenly distributed among the size categories. LMCC, UMCC and Browns Spring had the highest frequency of trees >50 cm DBH.

Table 9. Dominant tree size at transects[1], by subwatershed.

Dominant vegetation DBH	LMCC	UMCC	West Fork	South Fork	Middle Fork	Pine Knob	Browns Spring	LCC	Total
0–3 cm	7	--	1	3	2	3	5	11	**32**
3–15 cm	14	6	1	11	3	--	2	3	**40**
15–30 cm	7	3	11	5	3	2	3	3	**37**
30–50 cm	2	1	6	3	--	4	2	1	**19**
50–90 cm	6	7	--	2	2	5	10	--	**32**
> 90 cm	4	7	1	--	--	--	2	--	**14**
Total	**40**	**24**	**20**	**24**	**10**	**14**	**24**	**18**	**174**

[1] The number of transect observations includes one observation for each bank (left bank and right bank) such that each transect has two observations.

3.2.4 Canopy cover

Measures of canopy cover indicate the amount of stream shading, and the potential for solar irradiation to warm stream water temperatures, in addition to a rough measure of potential inputs of riparian biomass. Canopy cover was measured at three locations in the stream channel (stream center, left margin, right margin), and two locations in the riparian zone 5 m from the stream bank on each side of the stream (left bank, right bank).

Channel canopy cover within the National Forest was generally high in the smaller tributary channels, with approximately 80% or greater canopy cover based on combined channel center and margin measurements (Table 10). In larger channels including LMCC and South Fork, combined canopy cover was moderate with 71% and 58% cover, respectively. Channel canopy cover in lower Clear Creek (LCC) downstream of the National Forest boundary was relatively low (28%) based on combined channel center and margin measurements.

Within the National Forest, canopy cover measured in the center of the channel ranged from 44% in South Fork Clear Creek to 93% in Pine Knob Creek (Table 10, Figures 9 and 10). Canopy cover measured at stream margins was higher, as would be expected, ranging from 85% in South Fork Clear Creek to 95% in Pine Knob Creek. The most downstream study reach within the National Forest study area (Reach 1) was among the reaches with the least canopy cover (20–40%).

Table 10. Canopy cover at transects, by subwatershed.

Canopy cover metric	LMCC	UMCC	West Fork	South Fork	Middle Fork	Pine Knob	Browns Spring	LCC
Channel center (%)	64	82	83	44	74	93	76	23
Channel margins (%)	85	92	86	85	92	95	87	38
Channel center and margins (%)	71	85	84	58	80	93	79	28
Riparian zone (%)	82	85	85	72	89	94	86	37

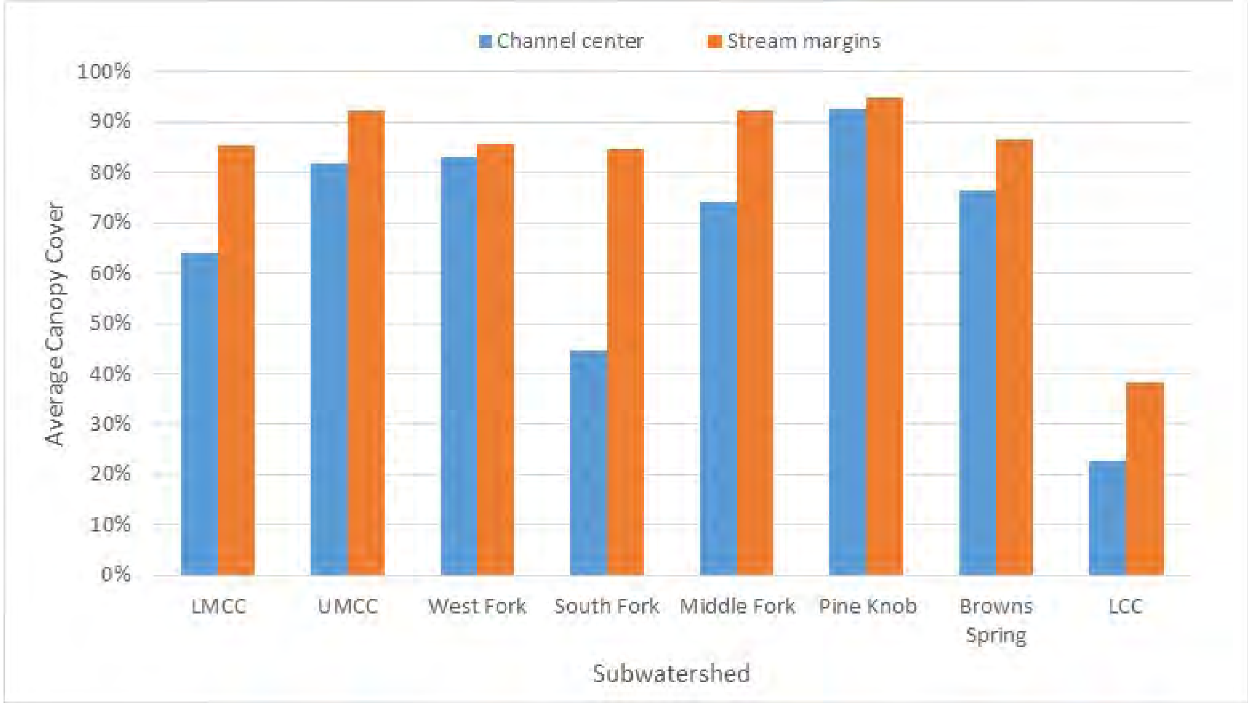

Figure 9. Average canopy cover in the channel center and stream margins, by subwatershed.

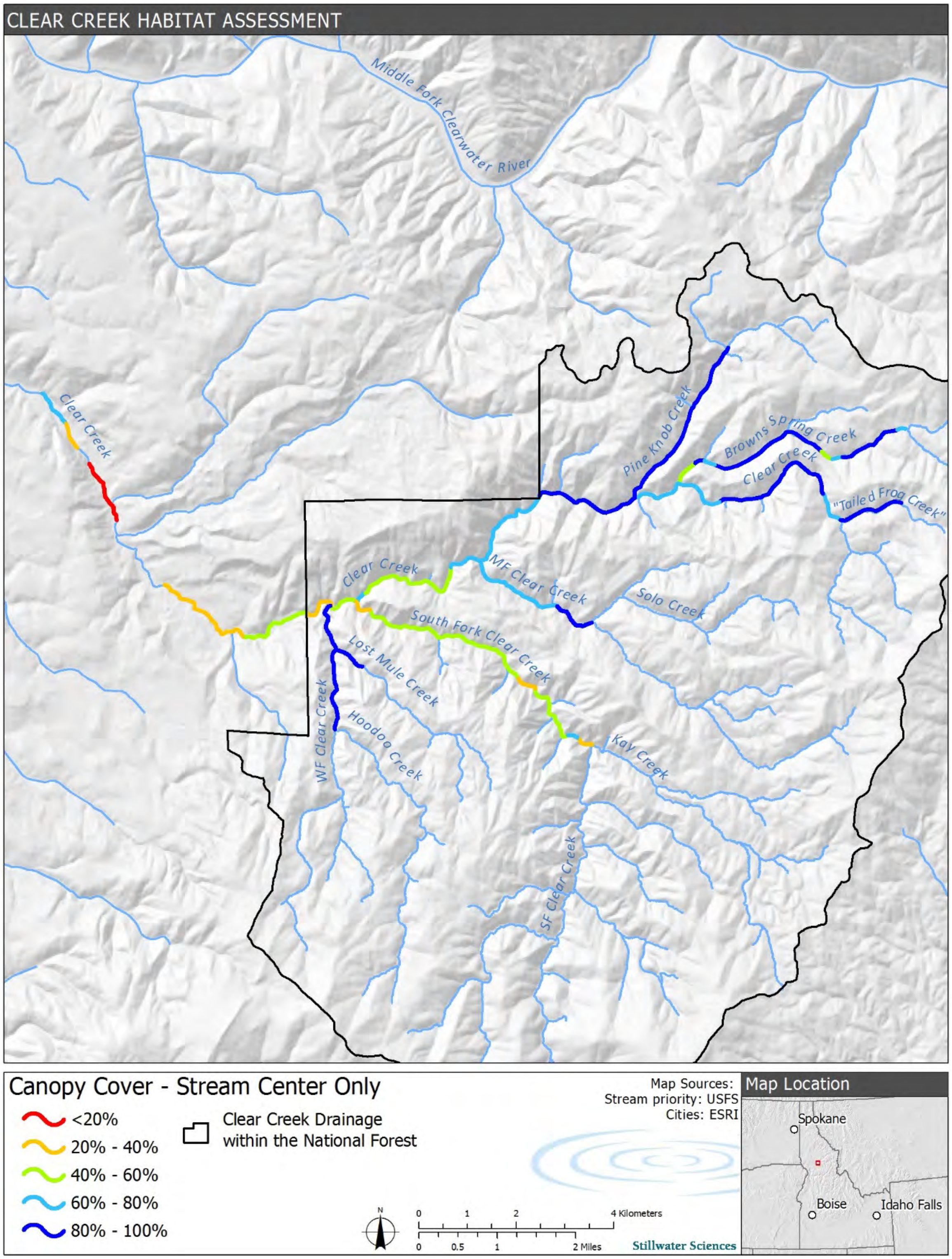

Figure 10. Average canopy cover measured in the center of the stream channel, by study reach.

Riparian canopy cover within the National Forest was typically higher than channel canopy cover, and relatively high overall, ranging from 72% for South Fork Clear Creek transects to 94% for Pine Knob Creek (Table 10, Figure 11). Riparian canopy cover measured at transects in private lands (LCC) was the lowest of all subwatersheds, at 37%.

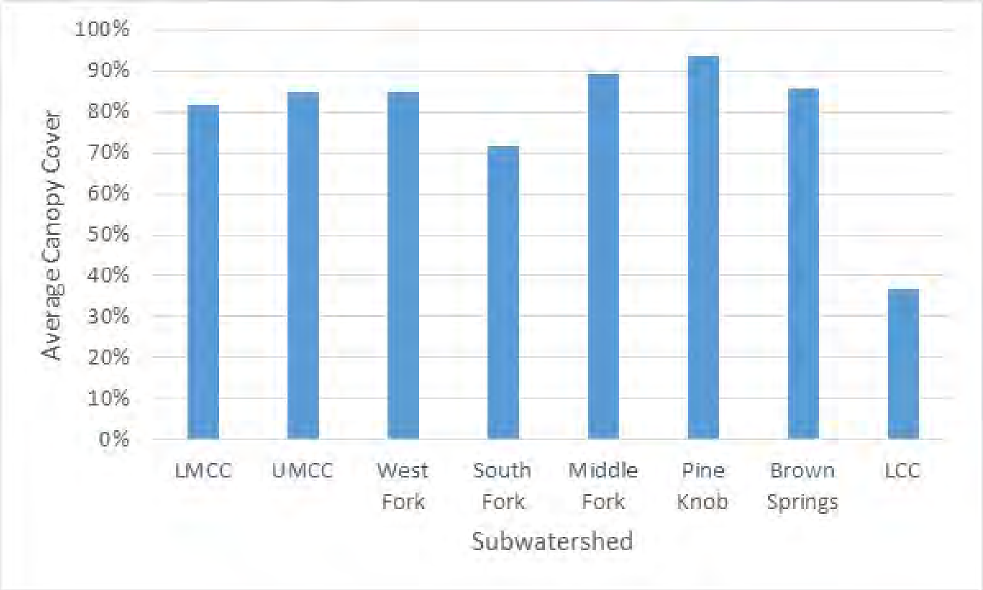

Figure 11. Average riparian canopy cover by subwatershed.

3.3 Fish Distribution and Relative Abundance

During snorkel surveys of study reaches, 199 pools were sampled, totaling nearly 1,400 m of stream (Table 11). Snorkel surveys were conducted in every reach surveyed, with the following exceptions:

- Reaches 29 (Lost Mule Creek) and 50 ("Tailed Frog Creek") were not snorkeled due to small channel size and shallow stream depths. Visual surveys of these small and clear streams were conducted from above the water to assess fish presence.
- Reach 55 (on private land in LCC) was not snorkeled because no pools were identified.

Table 11. Number, length, and area of pools sampled using snorkel surveys, by subwatershed.

Subwatershed	Number of pools snorkeled	Total length snorkeled (m)	Total area snorkeled (m^2)
LMCC	26	220	1,365
UMCC	50	245	883
West Fork	27	118	333
South Fork	28	295	1,675
Middle Fork	7	39	136
Pine Knob	19	92	278
Browns Spring	27	121	372
LCC	15	249	1,575
Total	**199**	**1,378**	**6,618**

Distribution of salmonids based on the results of snorkel surveys, electrofishing, and visual observations is shown in Figure 12 and described in more detail in the sub-sections that follow. Relative abundance of each salmonid species—based on single pass snorkel surveys of pools—is also summarize at the subwatershed and study reach scales. Additionally, observations of non-salmonid fish species, amphibians, and mussels are also summarized. Abundance estimates from electrofishing of the five monitoring stations are provided in Section 3.5.6.

Relative abundance of each species is reported as both linear density (fish/100 m) and areal density (fish/m^2), since each metric may lead to different conclusions. Linear density provides a measure of relative abundance per unit length of stream without taking into account the overall area surveyed. This metric can be useful for understanding production potential of a given reach of stream and for evaluating relative importance of different parts of the watershed for a given fish population. Areal density, a measure of relative abundance per unit area of stream surveyed, provides a better metric for assessing relative habitat capacity compared with linear density.

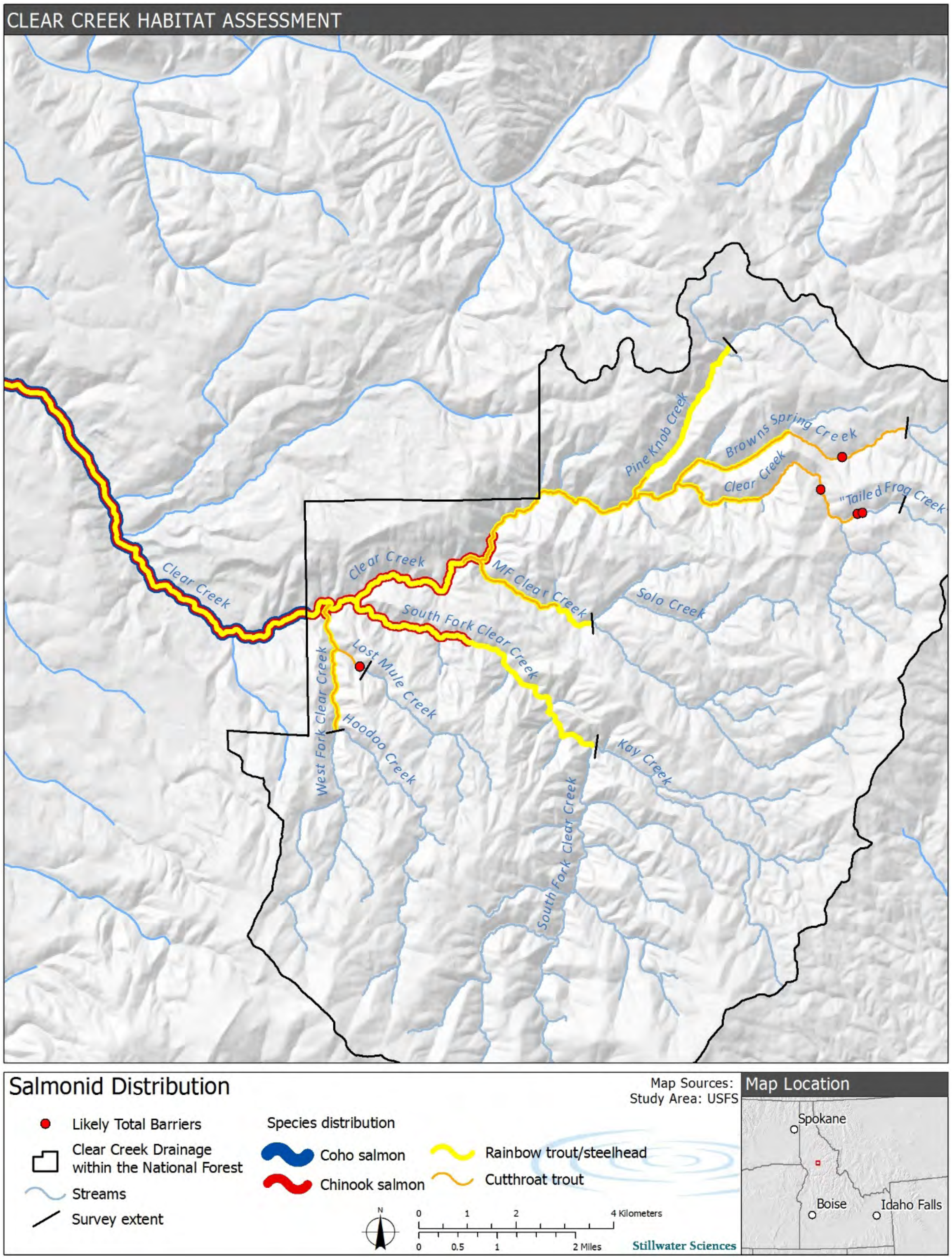

Figure 12. Observed and assumed distributions of salmonid species[1] based on snorkel surveys and electrofishing at monitoring stations.[2]

[1] Distribution includes adult and juvenile life stages.

[2] Distributions of anadromous species are assumed to extend downstream from the uppermost observation

3.3.1 Coho salmon

Within the National Forest, juvenile coho salmon were documented during electrofishing of the LMCC monitoring station (see Section 3.5.6 below) at the downstream end of Reach 1. Juvenile coho salmon were also observed in Reaches 53, 57, and 58 during snorkel surveys in LCC (Figure 12). No adult coho were observed. Both migratory adult and juvenile coho salmon pass through the entire mainstem of Clear Creek from the National Forest boundary to the confluence with the Clearwater River.

Juvenile coho salmon observed during snorkel surveys in lower Clear Creek.

Relative abundance of juvenile coho salmon based on snorkel surveys was highest in Reach 57, at nearly 240 fish/100 m, followed by Reaches 53 (33 fish/100 m) and 58 (26 fish/100 m).

3.3.2 Chinook salmon

Adult and juvenile Chinook salmon observed during snorkel surveys in lower Clear Creek.

Adult Chinook salmon were documented in mainstem Clear Creek from the National Forest boundary upstream to approximately 600 m above the Middle Fork Clear Creek confluence (Reach 7). However, juvenile Chinook salmon were only observed upstream through the lower half of Reach 5. In West Fork Clear Creek, Chinook salmon were observed upstream to the beginning of Reach 12, approximately 320 m from the confluence. In addition to small numbers of juvenile Chinook salmon being documented by snorkel surveys, five individuals were captured while electrofishing the West Fork monitoring station (Section 3.5.6). In South Fork Clear Creek, juvenile Chinook salmon were observed upstream to approximately halfway through Reach 17 (approximately one-half of the surveyed distance in South Fork Clear Creek), but adults were only observed as far upstream as the upper end of Reach 15 (approximately one-third of the surveyed distance). Chinook salmon were not documented in any of the other Clear Creek tributaries surveyed. One surveyor reported a possible sighting of a single juvenile during night snorkeling in lower Browns Spring Creek. However, based on the distribution of other Chinook salmon observations in the Clear Creek drainage, this sighting is questionable, and is thus not included on distribution or relative abundance maps. In LCC, juvenile Chinook salmon were observed in all reaches surveyed, while adults were only observed in Reaches 54, 56, 57, and 58, wherever there were sufficient holding pools.

Relative abundance of juvenile Chinook salmon was by far the highest in LCC, at 186 fish/100 m (Table 12). In the LMCC and South Fork subwatersheds (within the documented distribution of the species), mean densities of juvenile Chinook salmon were much lower: 28 and 7 fish/100 m, respectively. Relative abundance of juvenile Chinook salmon in LMCC generally declined from downstream to upstream, with linear densities of 91 fish/100 m in Reach 1, 40–60 fish/100 m in

Reaches 2 and 3, 14 fish/100 m in Reach 4 and 11 fish/100 m in Reach 5 (Figure 13). In South Fork Clear Creek, juvenile Chinook salmon were observed in Reach 14 at a density of 25 fish/100 m. Densities in Reaches 15, 16, and 17 were considerably lower at 2, 7, and 10 fish/100 m, respectively. Areal densities (fish/m^2) showed similar trends in Chinook salmon relative abundance as liner densities (Table 12).

Table 12. Linear and areal densities of juvenile and adult Chinook salmon based on single-pass snorkel surveys, by subwatershed.[1]

Subwatershed	Number counted		Linear density (fish/100 m)		Areal density (fish/m^2)	
	Juvenile	Adult	Juvenile	Adult	Juvenile	Adult
LMCC	23	5	28.3	3.6	0.048	0.007
UMCC	0	0	-	-	-	-
West Fork	0	0	-	-	-	-
South Fork	13	3	7.0	1.6	0.012	0.003
Middle Fork	0	0	-	-	-	-
Pine Knob	0	0	-	-	-	-
Browns Spring	0	0	-	-	-	-
LCC	462	18	185.7	7.2	0.293	0.011
All Reaches	**498**	**26**	**44.1**	**2.3**	**0.096**	**0.005**

[1] To allow for more meaningful comparisons between subwatersheds, densities in LMCC and South Fork only include pools snorkeled in the study reaches located downstream of the documented upper distributions of juvenile and adult Chinook.

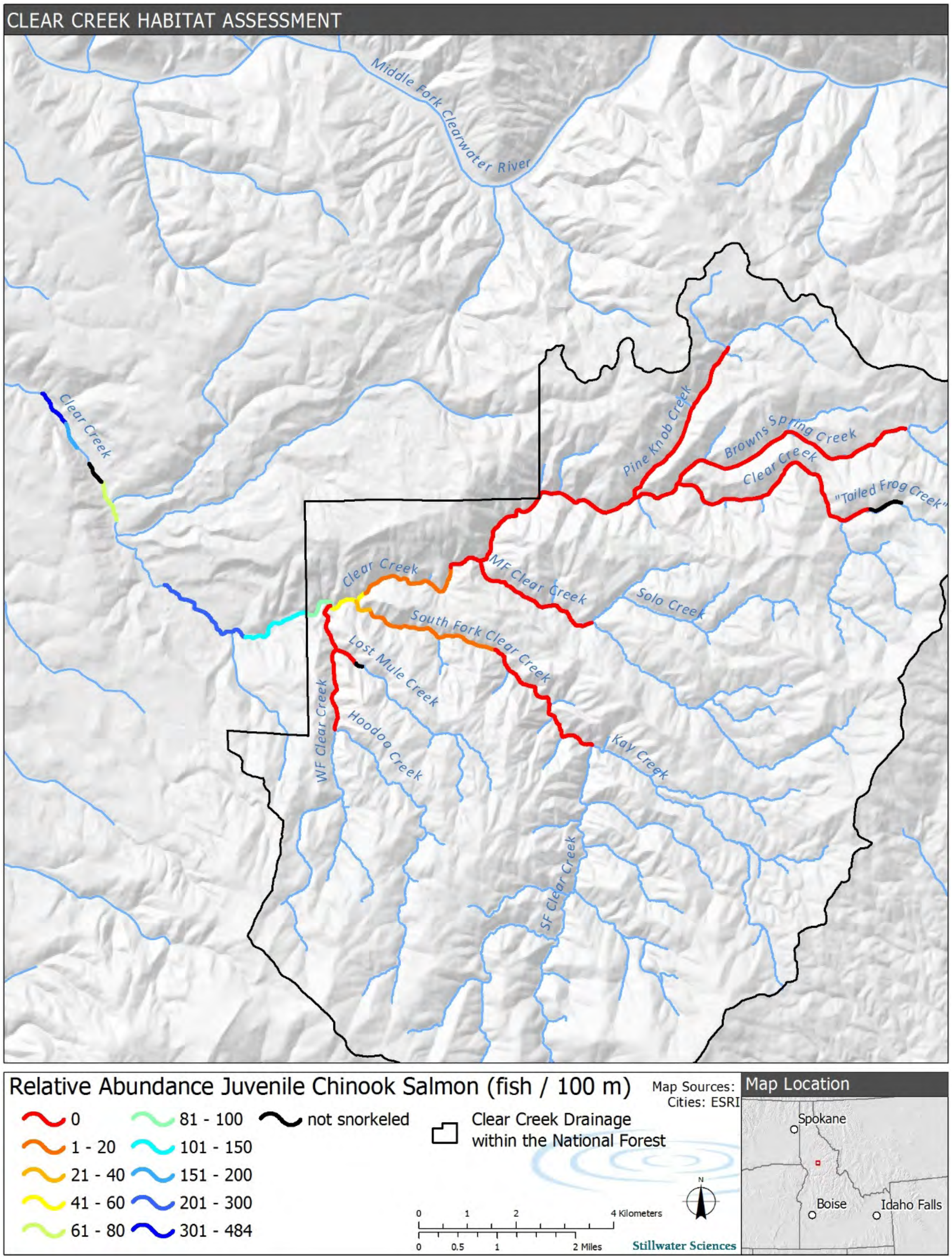

Figure 13. Linear density of juvenile Chinook salmon by study reach based on single-pass snorkel surveys.

3.3.3 *O. mykiss*

Juvenile *O. mykiss* captured during electrofishing surveys in Clear Creek.

Resident rainbow trout and steelhead *(O. mykiss)* was the most widely distributed salmonid species in the Clear Creek study area (Figure 12). Within the National Forest, juvenile *O. mykiss* were observed in the mainstem and all major tributaries surveyed. In mainstem Clear Creek, they were observed from the National Forest boundary upstream to the middle of Reach 35 (above the confluence of Browns Spring Creek). In general, however, *O. mykiss* densities in the mainstem dropped considerably upstream of the Browns Spring Creek confluence (upstream end of Reach 10), which coincided with an increase in cutthroat trout densities, a pattern described further below. The upper end of *O. mykiss* distribution appeared to be coincident with a series of seasonal barriers in Reach 36 (see Section 3.3.8). In West Fork Clear Creek, *O. mykiss* were documented from the confluence, upstream to the end of the study area; however, they were not documented in Lost Mule Creek, a small tributary to the West Fork. Likewise, in South Fork Clear Creek, Middle Fork Clear Creek, and Pine Knob Creek, *O. mykiss* were documented in all reaches surveyed (Figure 12). In Browns Spring Creek, *O. mykiss* were found upstream to the lower end of Reach 42.

At the subwatershed scale, relative abundance as measured by linear density (fish/100 m) was highest where stream channels were largest: in LCC and LMCC (Table 12). However, relative abundance as measured by areal density (fish/m^2) was relatively higher in subwatersheds with smaller channels (e.g., Pine Knob Creek) compared with linear density (Table 12). This result can be explained by the relatively smaller channel widths (and thus greater length to width ratio) founds in smaller streams compared with larger streams.

The largest size class of *O. mykiss* (>150 mm) was most abundant in larger channels (Figure 14). Regardless of the density metric used, the LMCC and LCC subwatersheds had the highest relative abundance of *O. mykiss* larger than 150 mm. Few individuals larger than 150 mm were observed in the Middle Fork, and none were observed in the West Fork. LCC had the highest linear densities of fish in the 100–150 mm size class (presumably age-1; see Section 3.5.6); however Pine Knob Creek had the highest areal densities of this size class (Figure 14).

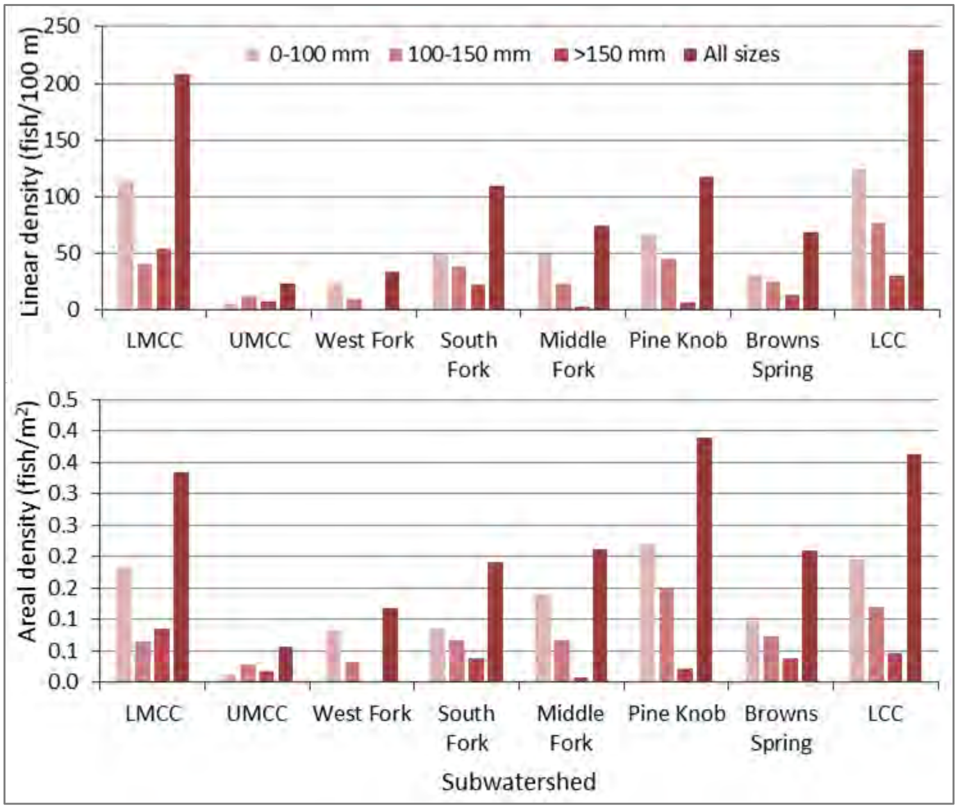

Figure 14. Linear (top) and areal (bottom) densities of juvenile *O. mykiss* size-classes, by subwatershed. Note: To allow for more meaningful comparisons between subwatersheds, densities in UMCC and Browns Springs only include pools snorkeled in the study reaches located downstream of the documented upper distribution of the species.

Figure 15 shows linear density of *O. mykiss* larger than 100 mm by study reach. *O. mykiss* linear density varied considerably between and within study reaches, but was generally highest in reaches within the LCC and LMCC subwatersheds. As with subwatershed results, conclusions about relative abundance of *O. mykiss* as measured by areal density (fish/m^2) were somewhat different than linear density (Figure 16). Reaches of Browns Spring Creek, Pine Knob Creek, and South Fork Clear Creek had relatively higher areal densities than linear densities, suggesting these reaches had relatively high habitat capacity (Figure 16).

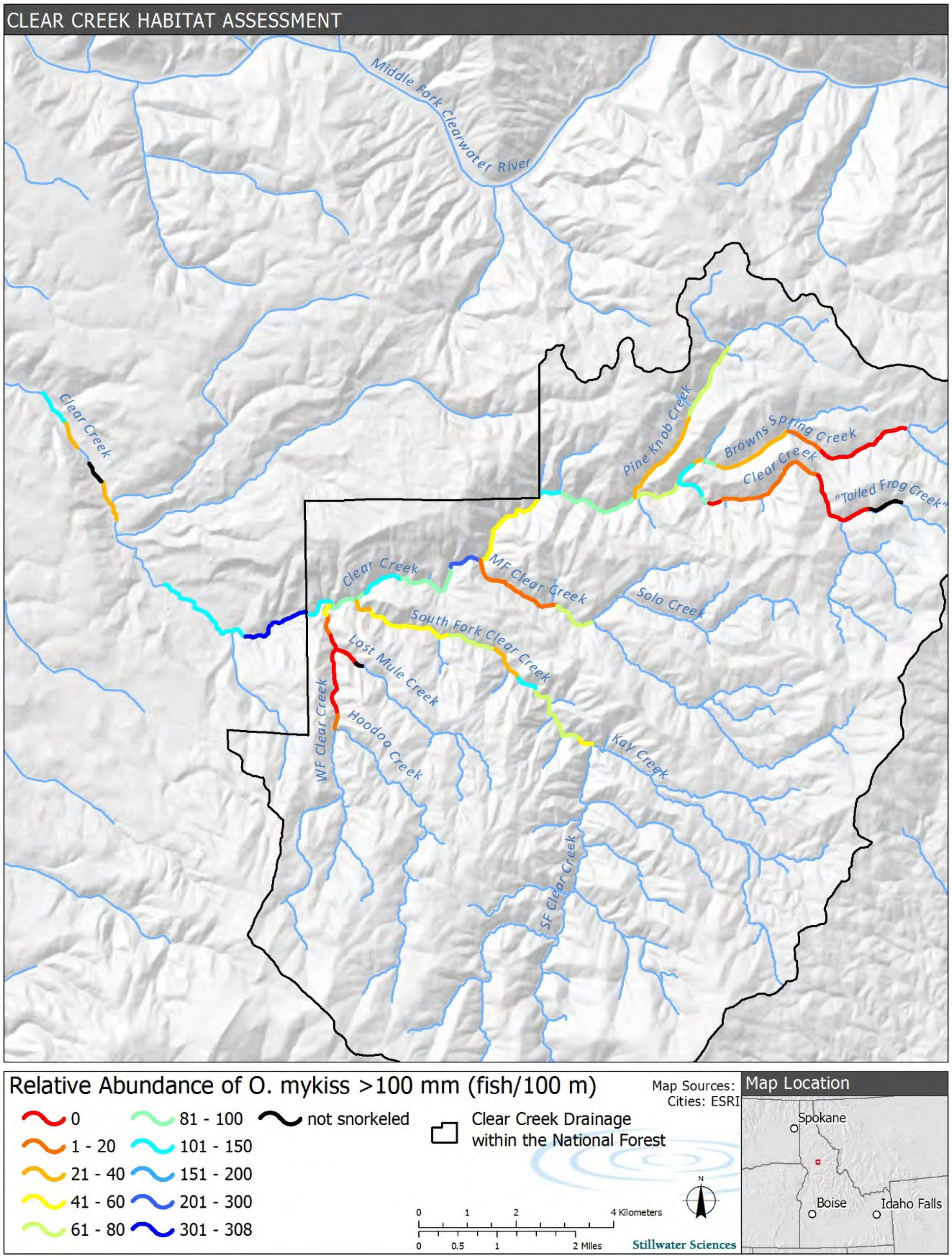

Figure 15. Linear density of *O. mykiss* >100 mm by study reach based on single-pass snorkel surveys.

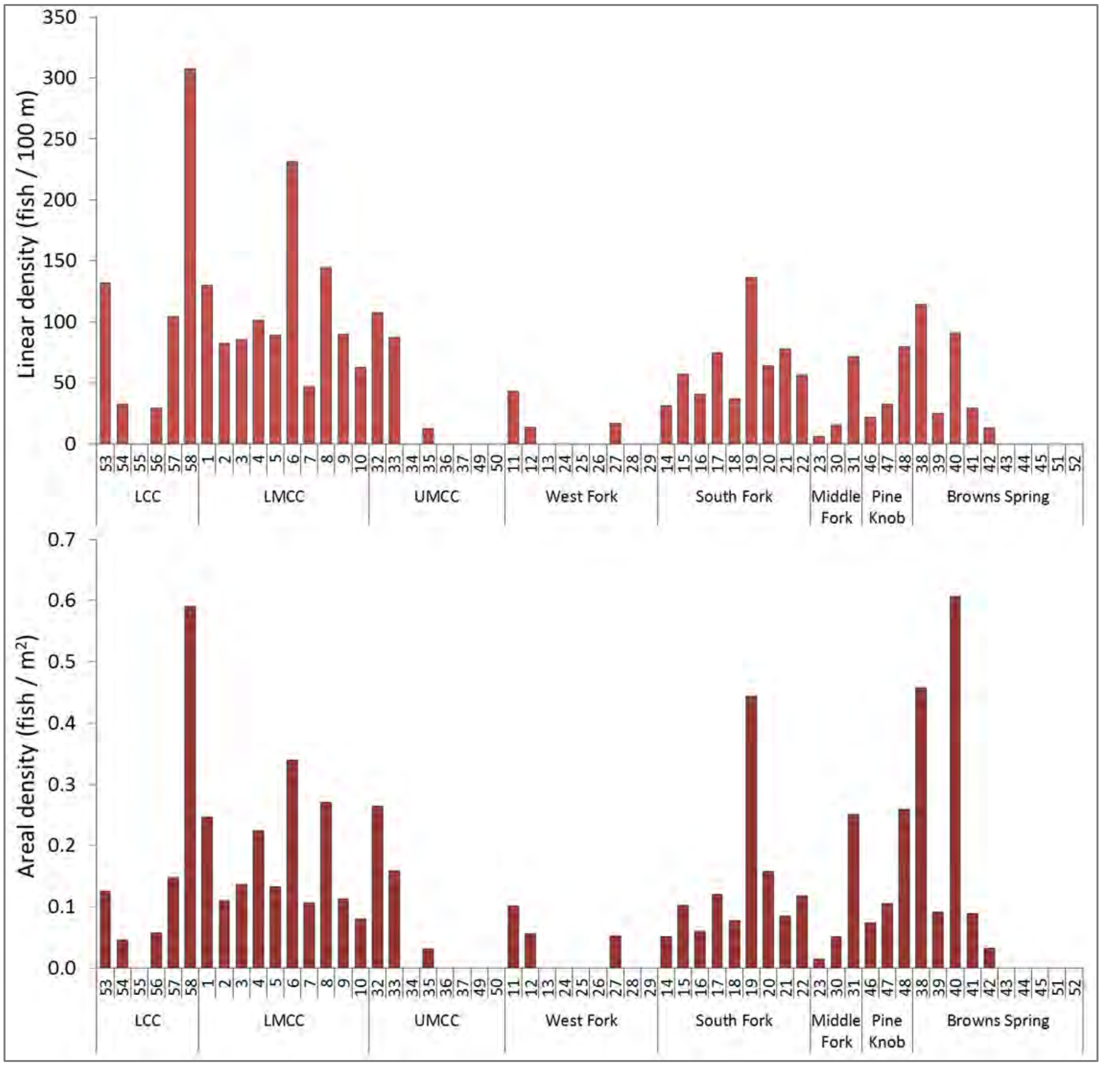

Figure 16. Linear (top) and areal (bottom) densities of juvenile *O. mykiss* >100 mm, by study reach and subwatershed.

To help understand observed patterns in fish relative abundance across the study area, it is useful to view results in the context of stream size and gradient. Figure 17 presents relative abundance (fish/m^2) of *O. mykiss* larger than 100 mm in each study reach ordered by drainage area and channel gradient categories. To assist with interpretation, reaches are color coded by subwatershed. In general, for smaller channels (0–25 km^2) within a sub-watershed, *O. mykiss* density (fish >100 m) was higher in lower gradient reaches. However, for larger channels, densities were similar between gradients categories, and in the case of LMCC, densities were generally higher in steeper reaches.

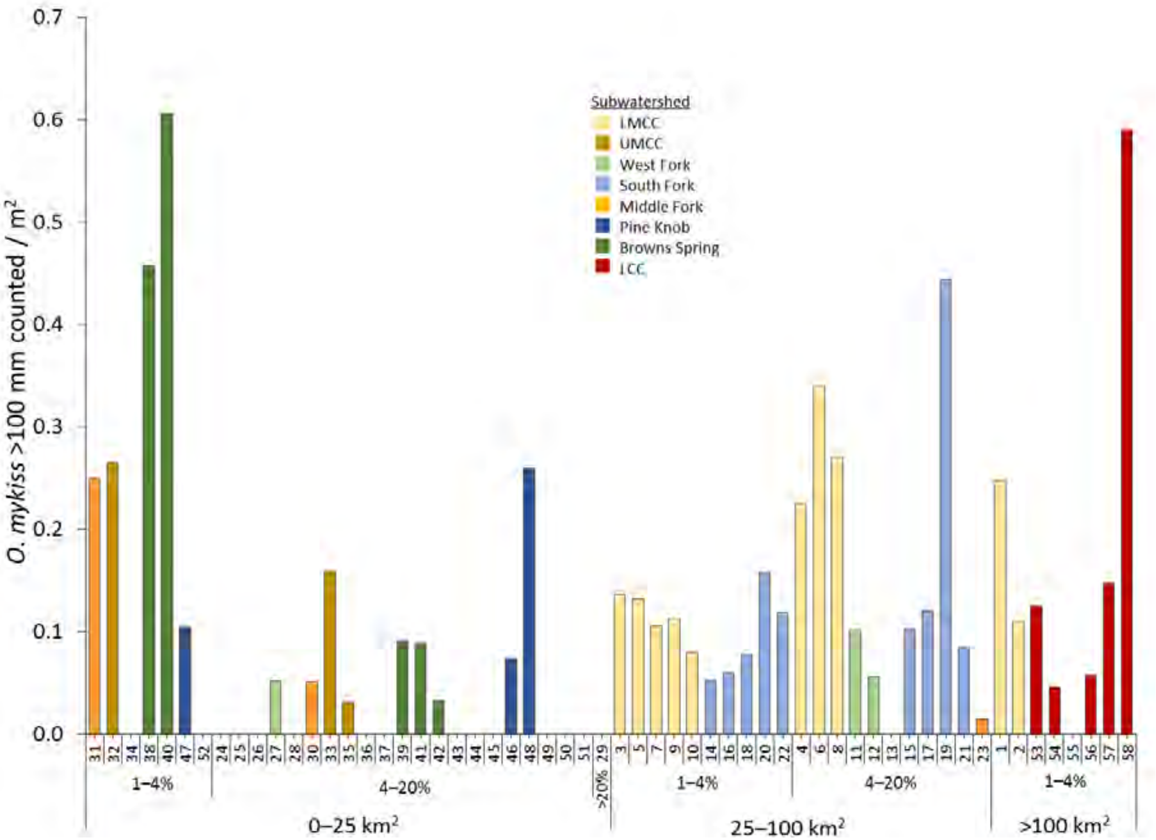

Figure 17. Areal density (fish/m^2) of *O. mykiss* >100 mm in each study reach, by drainage area and channel gradient categories.

3.3.4 Cutthroat trout

Cutthroat trout observed during snorkel surveys in upper Clear Creek.

Cutthroat trout were distributed primarily in the upper reaches of the mainstem Clear Creek and its tributaries (Figure 12). In mainstem Clear Creek, cutthroat trout were observed from just downstream of the Middle Fork confluence (Reach 6) upstream to the highest mainstem reach (Reach 37). They were also documented in the lower reach of "Tailed Frog Creek" (Reach 49). Cutthroat trout were not observed upstream of a series of likely total barriers to fish migration documented in Reach 49 (Section 3.3.8). Notably, cutthroat trout were patchily distributed and found in very low densities in mainstream Clear Creek downstream of Reach 35 (mid-portion of UMCC), with densities increasing considerably upstream of the documented upper distribution of *O. mykiss*. In West Fork Clear Creek, cutthroat trout were documented from the confluence upstream to the end of the study area and also in Lost Mule Creek at least as far upstream as the upper half of Reach 28. A single trout of unknown species, but presumably cutthroat trout, was observed in Lost Mule Creek near the upper end of Reach 29, just below a likely complete barrier to fish migration (Section 3.3.8). In South Fork Clear Creek, no cutthroat trout were documented during snorkel surveys of the study reaches or electrofishing of the monitoring station (located at the upper end of Reach 16). All of the 230 individual fish captured (and closely inspected) during electrofishing in the South Fork were clearly *O. mykiss*. In Middle Fork Clear Creek, cutthroat trout were found from the confluence upstream to the lower end of Reach 31 (uppermost reach on Middle Fork). They were not detected in limited snorkeling upstream of that point, but are expected to be present throughout Reach 31 and likely upstream of the study area boundary. In Pine Knob Creek, cutthroat trout were not detected during systematic snorkel surveys, but one individual was definitively documented in Reach 46 (lowest reach on Pine Knob) during limited night snorkeling (Section 3.3.7). Due to difficulties distinguishing smaller size classes of cutthroat trout from *O. mykiss* it is possible that cutthroat trout were more widely distributed within Pine Knob Creek than indicated by snorkel surveys. In Browns Spring Creek, cutthroat trout were observed throughout the study area.

At the subwatershed scale, relative abundance of all size classes of cutthroat trout was highest in Browns Springs, followed by UMCC, and West Fork (Figure 18). In general, and unlike *O. mykiss* results, linear and areal densities of cutthroat trout show a similar pattern of cutthroat trout relative abundance at the subwatershed scale. This finding is largely due to cutthroat trout being found only in relatively small streams with similar channel dimensions.

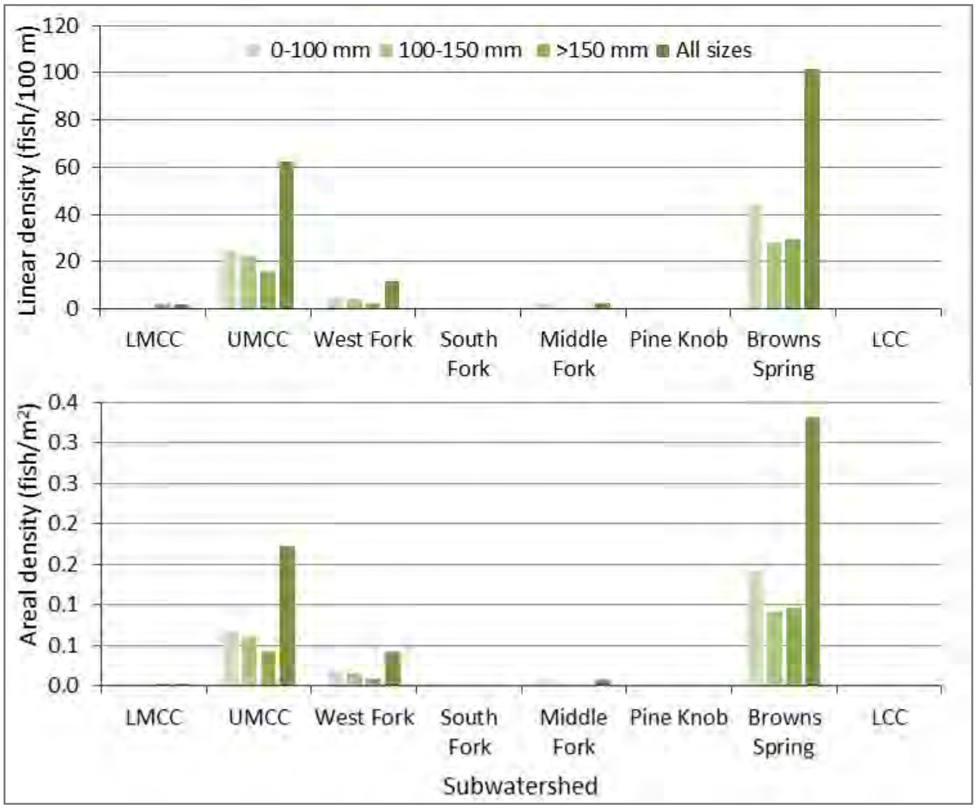

Figure 18. Linear and areal densities of cutthroat trout by size-class in each subwatershed. Note: To allow for more meaningful comparisons between subwatersheds, densities in LMCC only include pools snorkeled in the study reaches located upstream of the documented lower distribution of the species in Clear Creek.

At the reach scale, relative abundance of cutthroat trout (>100 mm) was by far highest in upper Browns Spring Creek (Reaches 45, 50, 51, and 52), followed by reaches in the upper mainstem Clear Creek (Figures 19 and 20). As with subwatershed results, areal density results generally indicate similar patterns in relative abundance compared with linear density (Figure 20). Regardless of metric, relative abundance was highest in upper Browns Spring Creek.

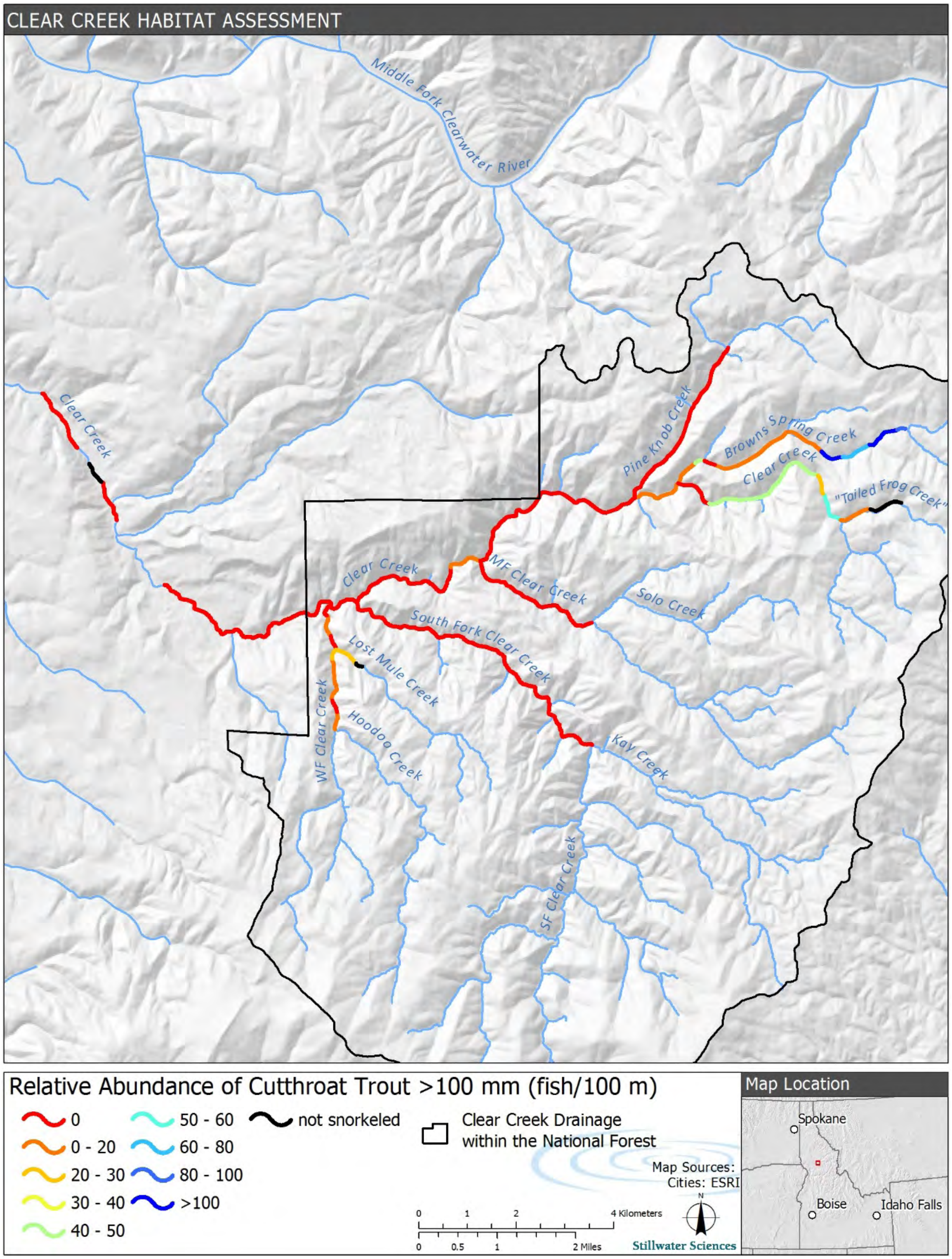

Figure 19. Linear density of cutthroat trout >100 mm by study reach based on single-pass snorkel surveys.

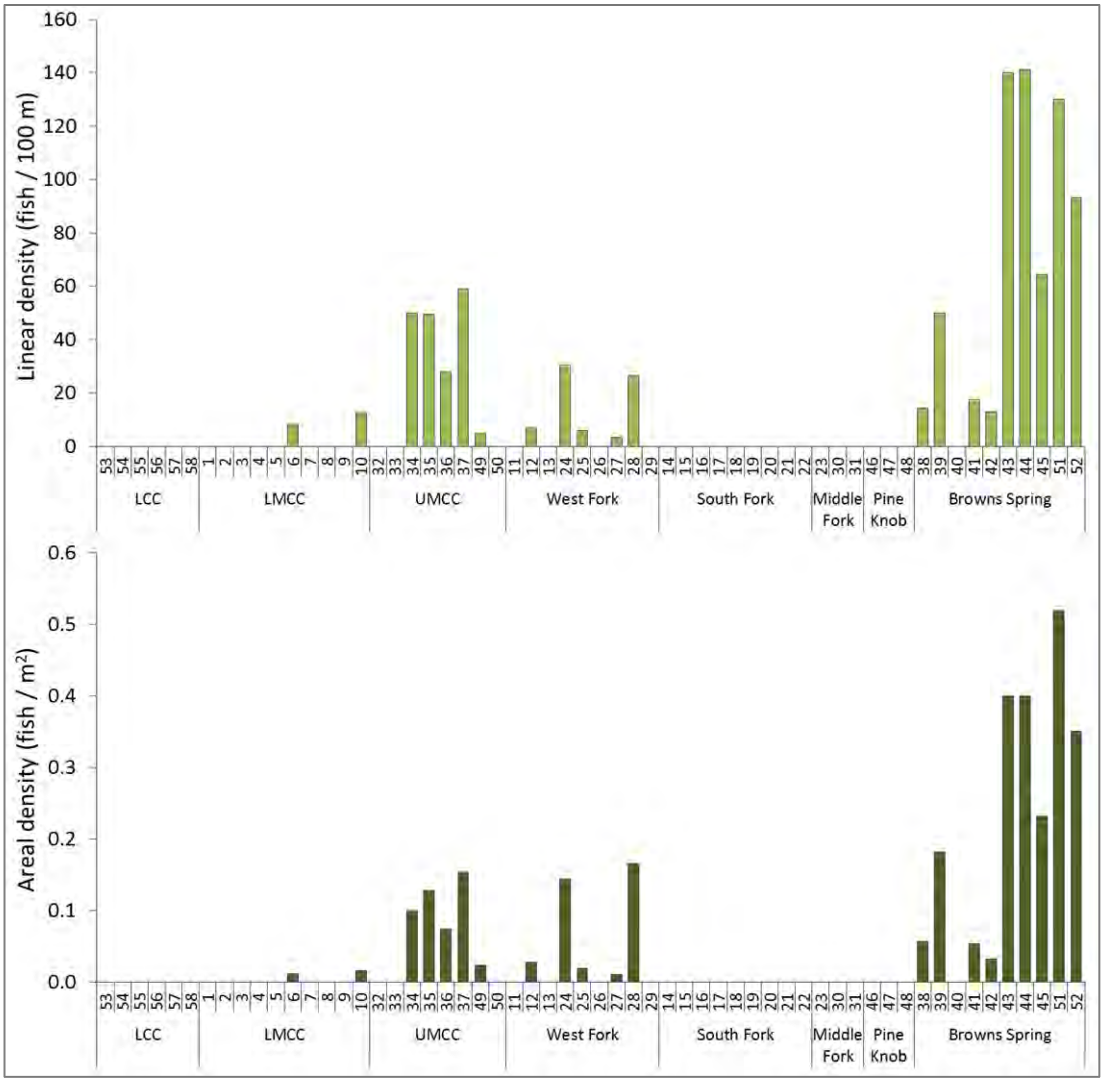

Figure 20. Comparison of linear (top) and areal (bottom) densities of cutthroat trout >100 mm, by study reach and subwatershed.

Figure 21 presents relative abundance (fish/m^2) of cutthroat trout >100 mm in each study reach, by drainage area and channel gradient categories. Cutthroat trout were most abundant in channels with contributing drainage area <25 km^2, with few fish observed in channels with larger contributing drainage area. Within subwatersheds where cutthroat trout were found, relative abundance patterns did not appear driven by channel gradient of study reaches. Rather, channel size and subwatershed appear to be stronger factors. This pattern was likely shaped by the distribution of *O. mykiss* and other factors such as water temperatures and large woody debris frequency within each reach.

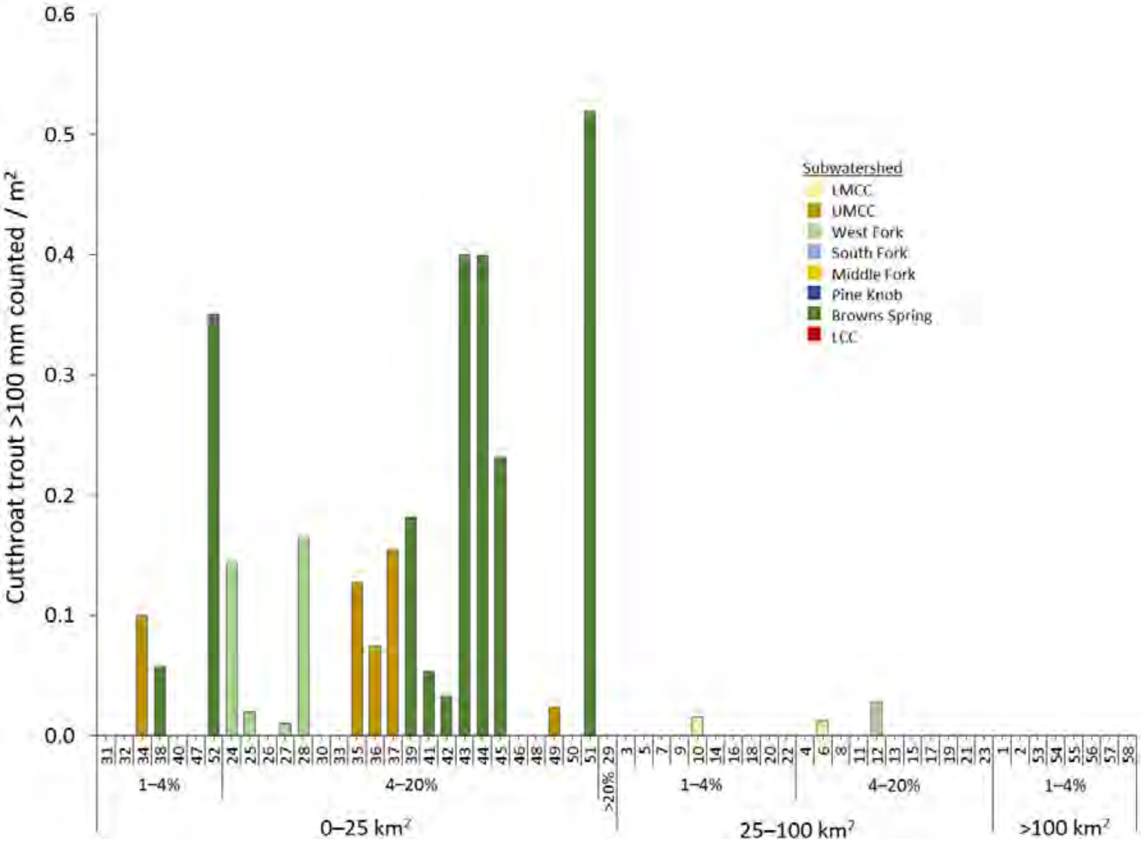

Figure 21. Areal density (fish/m^2) of cutthroat trout >100 mm in each study reach, by drainage area and channel gradient categories.

The distribution and relative abundance of cutthroat trout and *O. mykiss* were negatively correlated to one another (Figure 22). Densities of cutthroat trout were generally highest in study reaches where *O. mykiss* were not observed, such as the upper reaches of Browns Spring Creek (Reaches 43, 44, 45, 51, and 52) (Figure 22).

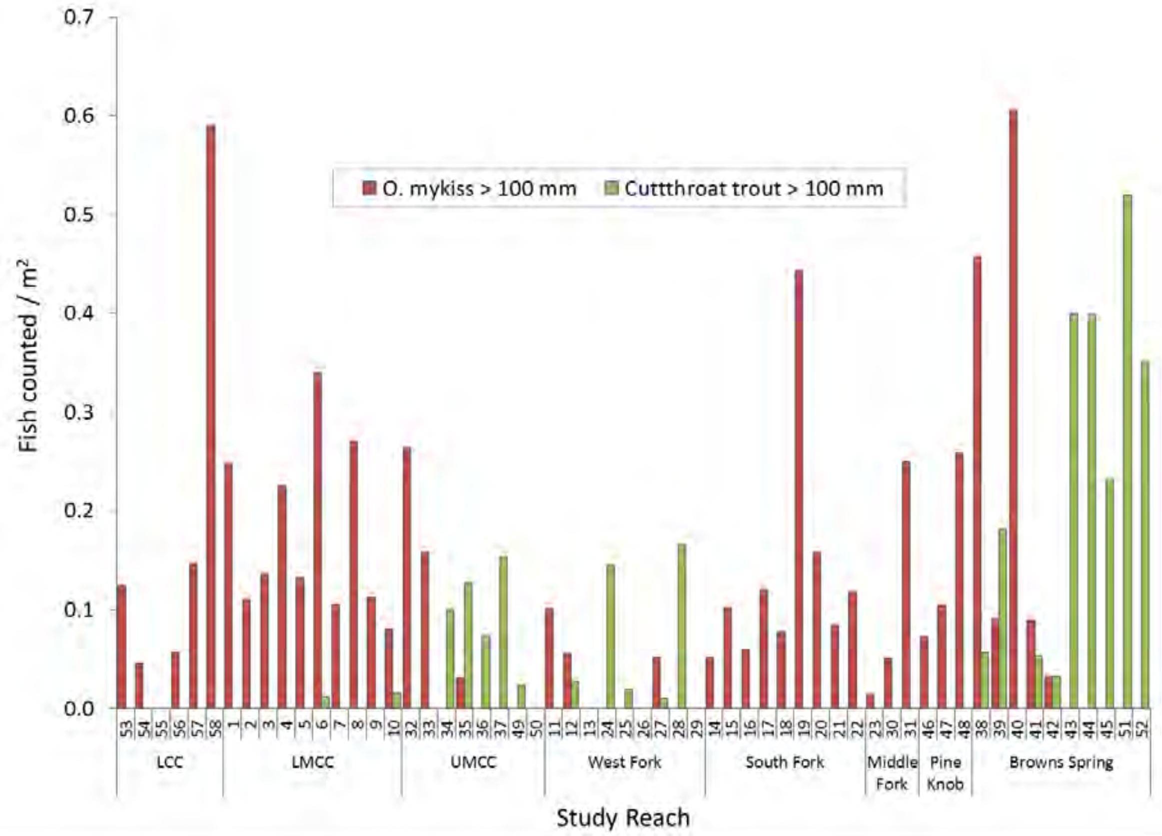

Figure 22. Relative abundance (fish/m^2) of cutthroat trout and *O. mykiss* within each subwatershed, by study reach.

3.3.5 Non-salmonid fish species

Four genera of non-salmonid fishes were observed in the study area during snorkel surveys, or captured during electrofishing (Table 13).

Mountain whitefish had a relatively restricted distribution in Clear Creek (Table 13). Mountain whitefish, primarily larger adults, were documented in the low-gradient reaches of mainstem Clear Creek, including the lowermost reach of LMCC (Reach 1) and the three LCC reaches immediately downstream (Reaches 56, 57, and 58). Mountain whitefish were not observed in Clear Creek upstream of Reach 1, in any tributaries, or in the LCC surveyed downstream of Reach 56.

Table 13. Study reaches where non-salmonids were documented during snorkeling and electrofishing surveys.

Species		Study reaches where detected
Common name	**Scientific name**	
Mountain whitefish	*Prosopium williamsoni*	1[e], 56[s], 57[s], 58[s]
Dace	*Rhinichthys* spp.	1[es], 2[s], 6[s], 7[s], 53[s], 54[s], 56[s], 57[s], 58[s]
Sculpin	*Cottus* spp.	1[e], 7[e], 11[e], 12[s], 23[e], 56[s], 58[s]
Sucker	*Catostomus* spp.	53[s], 57[s]

[e] Indicates species was documented in reach during electrofishing of monitoring stations.
[s] Indicates species was documented in reach during snorkel surveys.

Dace species were observed in the low- to moderate-gradient reaches of LMCC and in each of the private land reaches in LCC (Table 13). Dace were not documented in mainstem Clear Creek between Reaches 2 and 6, upstream of Reach 7, or in any of the tributaries. Dace were not tallied by species, but observations made during electrofishing and snorkeling in lower mainstem Clear Creek indicate the presence of both speckled dace (*Rhinichthys osculus*) and longnose dace (*Rhinichthys cataractae*).

Speckled dace observed during snorkel surveys in Lower Clear Creek.

Longnose dace captured during electrofishing survey in lower Clear Creek.

Only small numbers of sculpin were observed during snorkel surveys. Sculpin were documented in LMCC (Reaches 1 and 7), West Fork Clear Creek (Reaches 11 and 12), Middle Fork Clear Creek (Reach 23), and LCC (Reaches 56 and 58). Sculpin were not detected by snorkel surveys in reaches 1, 7, and 23, but large numbers were captured during electrofishing of monitoring stations in these reaches. Sculpin were not captured during electrofishing of the South Fork monitoring station (in Reach 16). Sculpin are susceptible to electrofishing, so their absence from the electrofishing catch suggests that they are rare or absent in South Fork Clear Creek in Reach 16.

Sculpin species captured during electrofishing survey in lower Clear Creek.

A lack of sightings during snorkel surveys in areas where sculpin were clearly present (based on electrofishing results) indicates very low observation efficiency of sculpin during snorkel surveys. Thus, sculpin are likely much more widely distributed than indicated by the snorkel surveys and limited electrofishing. It is unclear whether they are present in downstream study reaches in the South Fork (Reaches 14 and 15) but it is possible that the series of waterfalls in Reach 15 (and historically the 10-ft vertical drop that was dynamited in 1991; see Sections 3.3.8 and 4.3 below) represent a barrier to sculpin dispersal upstream.

Based on the collection locations, it is likely that the sculpin captured were Paiute Sculpin *(Cottus beldingi*), but could also be a newly described species, *Cottus schitsuumsh*. Sculpin taxonomy is currently in flux. Several sculpin samples were collected and will be submitted to Michael Young of the USDA Forest Service Rocky Mounty Research Station for genetic testing.

Finally, several suckers (*Catostomus* spp.) of unknown species were observed during snorkel surveys in Reaches 53 and 57. These fish ranged in length from 150 to 300 mm.

3.3.6 Amphibian and mussel observations

At the request of Idaho Fish and Game, observations of amphibians and mussels during snorkel surveys were recorded. In addition, field crews made incidental notes of amphibian and mussel observations during habitat typing. Adult and tadpole Rocky Mountain tailed frogs (*Ascaphus montanus*) were the primary frog species observed, in addition to Columbia spotted frogs (*Rana luteiventris*) and bullfrogs (*Rana catesbeiana*) (observed only in LCC). Adult and larval Idaho giant salamander (*Dicamptodon aterrimus*) were also observed. Mussels (not identified to species) were observed, primarily on private land downstream of the National Forest boundary, where there were some very extensive mussel beds. Table 14 includes all mussel and amphibian observations compiled by the field crews.

Columbia spotted frog observed in UMCC.

Rocky Mountain tailed frog adult and metamorphosing juvenile.

Idaho giant salamander post-metamorph observed during night snorkeling in Pine Knob Creek (Reach 46).

Idaho giant salamander larvae observed during night snorkeling in Reach 45.

Mussel bed observed in Reach 57.

Table 14. Mussel and amphibian observations from snorkel and habitat surveys.

Subwatershed	Species and life stages observed	Study reaches detected
LMCC	Freshwater mussels	2
	Unknown frog sp.	2
UMCC	Giant salamander sp. (larval form)	35
	Rocky Mountain tailed frog (tadpole)	35
	Rocky Mountain tailed frog (adult)	35
"Tailed Frog Creek" (UMCC)	Giant salamander sp. (larval form)	49, 50
	Rocky Mountain tailed frog (tadpole)	49, 50
	Rocky Mountain tailed frog (adult)	49, 50
South Fork	Columbia spotted frog	16
	Unknown frog	18
West Fork	Idaho giant salamander (larval form)	25, 26
Pine Knob	Idaho giant salamander (larval form)	45, 46
	Idaho giant salamander (post-metamorph)	46
Brown Springs	Rocky Mountain tailed frog (tadpole)	42, 44

Subwatershed	Species and life stages observed	Study reaches detected
	Rocky Mountain tailed frog (adult)	45, 51
	Giant salamander sp. (larval form)	45, 51
LCC	Freshwater mussels	57, 58
	Bull Frog	53, 57

3.3.7 Observation efficiency of snorkeling

Single-pass daytime snorkel counts are expected to provide a reliable measure of relative abundance between study reaches, but most likely underestimate the number of fish actually present in each pool snorkeled. We evaluated observation efficiency during the daytime by sampling every fifth pool snorkeled with three snorkel passes. Additionally, we evaluated the extent to which daytime snorkel counts underestimate the number of fish present by (1) comparing fish counted in pools sampled by daytime snorkeling with estimates from electrofishing the same pools, and (2) by comparing fish densities (fish/100 m) in pools sampled by daytime snorkeling with densities from snorkeling the same pools at night.

Multi-pass snorkeling

Multi-pass snorkel counts were performed on a subset (approximately 20%) of pools sampled using single-pass methods to provide insight into observation efficiency of single-pass snorkeling. For field application, every fifth pool snorkeled with a single-pass was sampled with two additional passes, for a total of three passes. The three-pass approach allows the trout population to be estimated using a bounded-count estimator counts (Robson and Whitlock 1964, Regier and Robson 1966, Overton 1971, Routledge 1982). Habitat-specific estimates were calculated from three-pass counts for cutthroat trout and *O. mykiss* by size class for each pool in which they were present, and compared with single-pass counts.

Field observations indicated that in smaller streams the assumption of independence between snorkel passes may not be met, since larger trout would often be flushed by divers on the first pass and would not be observed on the second and third passes. For this reason, streams were stratified into “large” and “small” categories to assess whether differences based on stream size were apparent. Streams with contributing drainage areas >25 km^2, including pools within the LMCC and South Fork subwatersheds, were categorized as “large”. Streams with contributing drainage areas <25 km^2, including pools within the UMCC, West Fork, Middle Fork, Pine Knob, and Browns Spring subwatersheds, were categorized as “small”.

Multi-pass dives were conducted in 26 pools, six of which were in streams categorized as "large" and six of which were in streams categorized as "small". For each species/size class, Pass 1 counts typically spanned the range of 0–100% of bounded counts estimates (Table 15). On average, depending on size class, Pass 1 counts detected 73–82% of the cutthroat trout and 48–65% of the *O. mykiss* estimated from bounded counts. For *O. mykiss*, observation efficiency appeared to be lower in smaller streams compared with larger streams for the two larger size classes (100–150 and >150 mm), but not for fish <100 mm. No cutthroat trout were observed during multi-pass snorkeling in large streams. Overall, these analyses support the hypothesis that single-pass snorkel counts underestimate the number of fish actually present within pools.

Table 15. Percentage of bounded count estimates counted in Pass 1 for individual pools where multi-pass snorkeling was conducted. N = number of pools where at least one individual was counted for each species/size category.

Species	Size class (mm)	Small streams[1]				Large streams[2]				All streams			
		N	Min	Max	Mean	N	Min	Max	Mean	N	Min	Max	Mean
Cutthroat trout	0–100	7	40%	100%	82%	0	n/a	n/a	n/a	7	40%	100%	82%
	100–150	7	0%	100%	73%	0	n/a	n/a	n/a	7	0%	100%	73%
	>150	4	50%	100%	75%	0	n/a	n/a	n/a	4	50%	100%	75%
O. mykiss	0–100	9	0%	100%	61%	5	0%	100%	63%	14	0%	100%	62%
	100–150	8	0%	100%	43%	5	0%	100%	57%	13	0%	100%	48%
	>150	3	0%	75%	42%	6	50%	100%	77%	9	0%	100%	65%

[1] Pools in streams with contributing drainage area <25 km^2
[2] Pools in streams with contributing drainage area >25 km^2

Electrofishing comparison with snorkel counts

During electrofishing surveys of monitoring stations, three pools (one each in West Fork Clear Creek [WFCC], Middle Fork Clear Creek [MFCC], and mainstem Clear Creek above the Middle Fork (MMCC]) were snorkeled and immediately afterwards, block-netted and sampled using electrofishing. Multiple-pass depletion estimates from electrofishing were compared with single-pass snorkel counts and estimates from multi-pass snorkeling for pools at WFCC and MFCC where three snorkel passes were conducted. Abundance estimates from electrofishing were developed using the Zippin estimator, and a bounded counts estimator was used for multi-pass snorkel estimates. *O. mykiss* was the only species for which there were enough individuals captured to conduct abundance estimates. For the other species, presence/absence and total number captured or observed were used to help understand differences between the two methods.

A comparison of results from electrofishing to snorkeling is presented in Table 16. Across all locations and species, more individuals were captured by electrofishing than observed by single-pass snorkeling, except for a single juvenile Chinook salmon that was detected by both methods in the pool at WFCC. For *O. mykiss*, the population estimates from electrofishing was nearly twice as high as single-pass snorkel counts for the MMCC monitoring station, but only about 15% higher for the WFCC monitoring station. Too few fish were captured to conduct an estimate at the MFCC monitoring station, but seven times more juvenile *O. mykiss* were captured by electrofishing compared with single-pass snorkeling.

Cutthroat were not observed during snorkeling at any of the monitoring stations, but one individual was captured by electrofishing at both the MFCC and MMCC monitoring stations. It is possible that these fish were seen, but misidentified as *O. mykiss* or assigned to the “unknown trout” category (which is included with *O. mykiss* for this analysis). Cutthroat and *O. mykiss* can be difficult to discern while snorkeling, especially if they are small and moving quickly. As a caveat, visibility at the MMCC monitoring station was relatively poor due to turbidity resulting from electrofishing the monitoring station upstream, which may have lowered the observation efficiency of snorkeling there. At each monitoring station, sculpin were detected during electrofishing, but not by snorkeling, supporting the conclusion that snorkel surveys cannot be used to accurately describe sculpin abundance or distribution.

Table 16. Comparison of abundance estimates using snorkeling vs. electrofishing.

Monitoring station ID	Species	Electrofishing		Snorkeling			
		Number captured	Abundance estimate[1] (95% CI)	Number observed			Abundance estimate[2] (95% CI)
				Pass 1	Pass 2	Pass 3	
MMCC	*O. mykiss*	57	57 (±1)	31	32	37	42 (±10)
	Cutthroat	1	n/a	0	0	0	n/a
	Sculpin	8	n/a	0	0	0	n/a
MFCC	*O. mykiss*[3]	7	n/a	1	1	2	3 (±1)
	Sculpin	2	n/a	0	0	0	n/a
WFCC	*O. mykiss*	13	14 (±3)	12	n/a	n/a	n/a
	Chinook	1	n/a	1	n/a	n/a	n/a
	Cutthroat	1	n/a	0	n/a	n/a	n/a
	Sculpin	3	n/a	0	n/a	n/a	n/a

[1] Calculated using Zippin estimator
[2] Calculated using bounded count estimator
[3] All *O. mykiss* were over 100 mm

Day-night comparison

Daytime snorkel counts are generally expected to underestimate actual fish abundance and also have the potential to miss rare, cryptic, or more nocturnal species. In some cases, nighttime surveys will result species or life stages being detected that are missed during daytime surveys (Thurow 1994, Thurow et al. 2006). Because of the logistical challenges and safety issues of working during both day and night in the remote study area, snorkel surveys were performed during daylight and concurrently with reach-and habitat unit-scale surveys. However, in order to inform the potential extent of differences between day and night snorkeling results, on 5 August 2015, we snorkeled a total of 26 pools in Reaches 9, 10, 32, 38 and 46 at night (Table 17). For each study reach, fish densities (fish/100 m) from pools snorkeled at night were compared with fish densities from pools snorkeled during the day. These day-night comparisons were made for *O. mykiss* and cutthroat trout, since no other species were observed in these study reaches. As with other snorkel analyses, unidentified trout observed at night (all 0–50 mm length) were considered *O. mykiss* for these analyses since *O. mykiss* was the predominant species in these reaches.

Table 17. Number and total length of pools snorkeled during day and night for study reaches where night snorkel surveys were conducted.

Stream	Study reach	Day		Night	
		Pools snorkeled	**Total length snorkeled (m)**	**Pools snorkeled**	**Total length snorkeled (m)**
Clear Creek	9	5	48	8	50
Clear Creek	10	3	16	4	20
Clear Creek	32	1	3	1	5
Browns Spring	38	2	7	6	25
Pine Knob	46	6	32	7	32
Total		**17**	**106**	**26**	**132**

O. mykiss densities from nighttime snorkeling were consistently higher than daytime densities for all study reaches and size classes, with the exception of fish >150 mm in Reach 32, where only 1 pool was snorkeled (Table 18). Across all reaches (all pools combined) and size-classes, *O. mykiss* densities observed during the day averaged 44% of densities observed at night, supporting the expectation that daytime snorkel surveys underestimate actual fish abundance.

Table 18. Comparison of observed *O. mykiss* densities between day and night snorkel surveys, by reach and size class.

Study reach	***O. mykiss* densities (fish / 100 m)**								**Percent of night densities observed during day**			
	Day				**Night**							
	0–100 mm	**100–150 mm**	**>150 mm**	**All sizes**	**0–100 mm**	**100–150 mm**	**>150 mm**	**All sizes**	**0–100 mm**	**100–150 mm**	**>150 mm**	**All sizes**
9	77	0	90	167	87	166	129	382	89%	0%	69%	44%
10	19	25	38	81	93	195	73	361	20%	13%	51%	23%
32	0	0	107	107	160	60	40	260	0%	0%	268%	41%
38	71	57	57	185	115	64	71	250	62%	90%	80%	74%
46	62	19	3	83	60	63	25	149	103%	29%	12%	56%
Total[1]	**61**	**13**	**54**	**128**	**90**	**122**	**81**	**293**	**68%**	**11%**	**66%**	**44%**

[1] Density for all surveyed pools combined

Cutthroat densities from nighttime snorkeling observations were also generally much higher than from daytime observations (Table 19). Cutthroat trout were not observed in Reaches 32 and 46 during daytime surveys, but were documented in both reaches at night. In Reach 46, nighttime snorkeling resulted in the only observation of cutthroat trout in Pine Knob Creek. In the reaches where cutthroat were documented during both day and night (Reaches 10 and 38), densities from daytime observations were less than 50% of densities from nighttime observations for all size classes combined. As with *O. mykiss*, these results support the expectation that daytime snorkel surveys underestimate actual fish abundance.

Table 19. Comparison of observed cutthroat trout densities between day and night snorkel surveys, by reach and size class.

Study reach	Cutthroat trout densities (fish / 100 m)								Percent of night densities observed during day			
	Day				Night							
	0–100 mm	100–150 mm	>150 mm	All sizes	0–100 mm	100–150 mm	>150 mm	All sizes	0–100 mm	100–150 mm	>150 mm	All sizes
9	0	0	0	0	0	0	0	0	n/a	n/a	n/a	n/a
10	0	0	12	12	5	15	10	29	0%	0%	128%	43%
32	0	0	0	0	20	40	60	120	0%	0%	0%	0%
38	29	14	0	43	28	36	24	87	103%	40%	0%	49%
46	0	0	0	0	0	0	3	3	n/a	n/a	0%	0%
Total	**2**	**1**	**2**	**5**	**7**	**11**	**9**	**27**	**28%**	**9%**	**21%**	**18%**

3.3.8 Fish passage barrier identification

Definitively identifying barriers to fish passage can be challenging with a single point-in-time observation. Investigators in such a case are observing a potential barrier at a single stream flow and are projecting conditions at other stream flows based on site-specific features and professional judgement. Thus, except in the case of clearly impassable waterfalls, determining whether a waterfall or other obstruction is actually a barrier to fish passage is a judgement call. These and other considerations related to fish passage designations are discussed further in Section 4.3. With those caveats in mind, the methodology for identifying potential barriers is presented in Appendix B. In general, based on field measurements and observations and evidence from fish distribution, potential barriers (PB) were judged to be in one of four categories:

- *Seasonal barrier—low*: feature likely represents a migration barrier at some flows (e.g., low summer flow) and is likely passable at a relatively wide range of stream flows.
- *Seasonal barrier—moderate*: feature likely represents a migration barrier over a wider range of flows than seasonal barrier—low, but still likely passable at some flows.
- *Seasonal barrier—high*: feature likely represents a migration barrier at a relatively wide range of stream flows and thus is passable at a relatively narrow range of stream flows (e.g., winter high flows).
- *Likely total barrier*: feature is expected to be a total barrier to fish migration across all stream flows.

A total of 28 potential barriers to fish migration were identified during surveys of study reaches within the National Forest (Table 20, Figure 23). Photographs of each potential barrier along with GPS coordinates, site-specific measurements, more detailed descriptions, and rationale for qualitative designations of barrier status for each location are provided in Appendix E. A synopsis of fish passage barriers documented in each stream surveyed is provided in the following sections.

Table 20. Potential barriers to fish migration documented during surveys of study reaches within the National Forest.

Potential barrier ID[1]	Stream meter[2]	Barrier type/s	Salmonid species documented upstream[3]	Barrier designation
Clear Creek				
6.1	4,590	Physical, hydraulic	CS, OM, CT	Seasonal barrier—low
35.1	13,175	Physical, hydraulic	CT	Seasonal barrier—high
36.1	15,085	Physical, hydraulic	CT	Seasonal barrier—high
36.2	15,098	Physical, hydraulic	CT	Seasonal barrier—high
36.3	15,128	Physical, hydraulic	CT	Seasonal barrier—moderate
36.4	15,365	Physical, hydraulic	CT	Seasonal barrier—high
36.5	15,383	Physical, hydraulic	CT	Likely total barrier
36.6	15,437	Hydraulic	CT	Seasonal barrier—high
"Tailed Frog Creek"				
49.1	76	Physical, hydraulic	None	Likely total barrier
49.2	95	Physical, hydraulic	None	Likely total barrier
49.3	102	Physical, hydraulic	None	Seasonal barrier—low
West Fork Clear Creek				
12.1	645	Physical	OM, CT	Seasonal barrier—high
25.1	1,422	Physical, hydraulic	OM, CT	Seasonal barrier—high
27.1	2,626	Physical	OM, CT	Seasonal barrier—high
27.2	2,722	Physical	OM, CT	Seasonal barrier—low
27.3	2,731	Physical	OM, CT	Seasonal barrier—moderate
Lost Mule Creek				
29.1	613	Physical, hydraulic	None	Likely total barrier
South Fork Clear Creek				
15.1	1,245	Physical	CS, OM	Seasonal barrier—low
15.2	1,337	Physical	CS, OM	Seasonal barrier—moderate
15.3	1,586	Physical	CS, OM	Seasonal barrier—moderate
15.4	1,636	Physical	CS, OM	Seasonal barrier—low
15.5	1,663	Physical	CS, OM	Seasonal barrier—high
17.1	3,196	Physical	OM	Seasonal barrier—high[4]
19.1	4,554	Physical	OM	Seasonal barrier—low
Pine Knob Creek				
48.1	2,979	Physical	OM	Seasonal barrier—high
Browns Spring Creek				
42.1	3,627	Physical	CT	Seasonal barrier—low
44.1	4,135	Physical, hydraulic	CT	Seasonal barrier—high
44.2	4,211	Physical, hydraulic	CT	Likely total barrier

[1] Each barrier is numbered sequentially within each reach. For example, potential barrier 15.1 is the first potential barrier in Reach 15, followed sequentially by potential barrier 15.2.

[2] Stream meters listed are from the confluence with the mainstem, except for mainstem Clear Creek, which starts at Reach 1 near the USDA Forest Service Boundary.

[3] CS = Chinook salmon, OM = steelhead/rainbow, CT = cutthroat trout

[4] This potential barrier was located just upstream of the documented upper distribution to Chinook salmon in the South Fork and therefore may constitute a total barrier to that species.

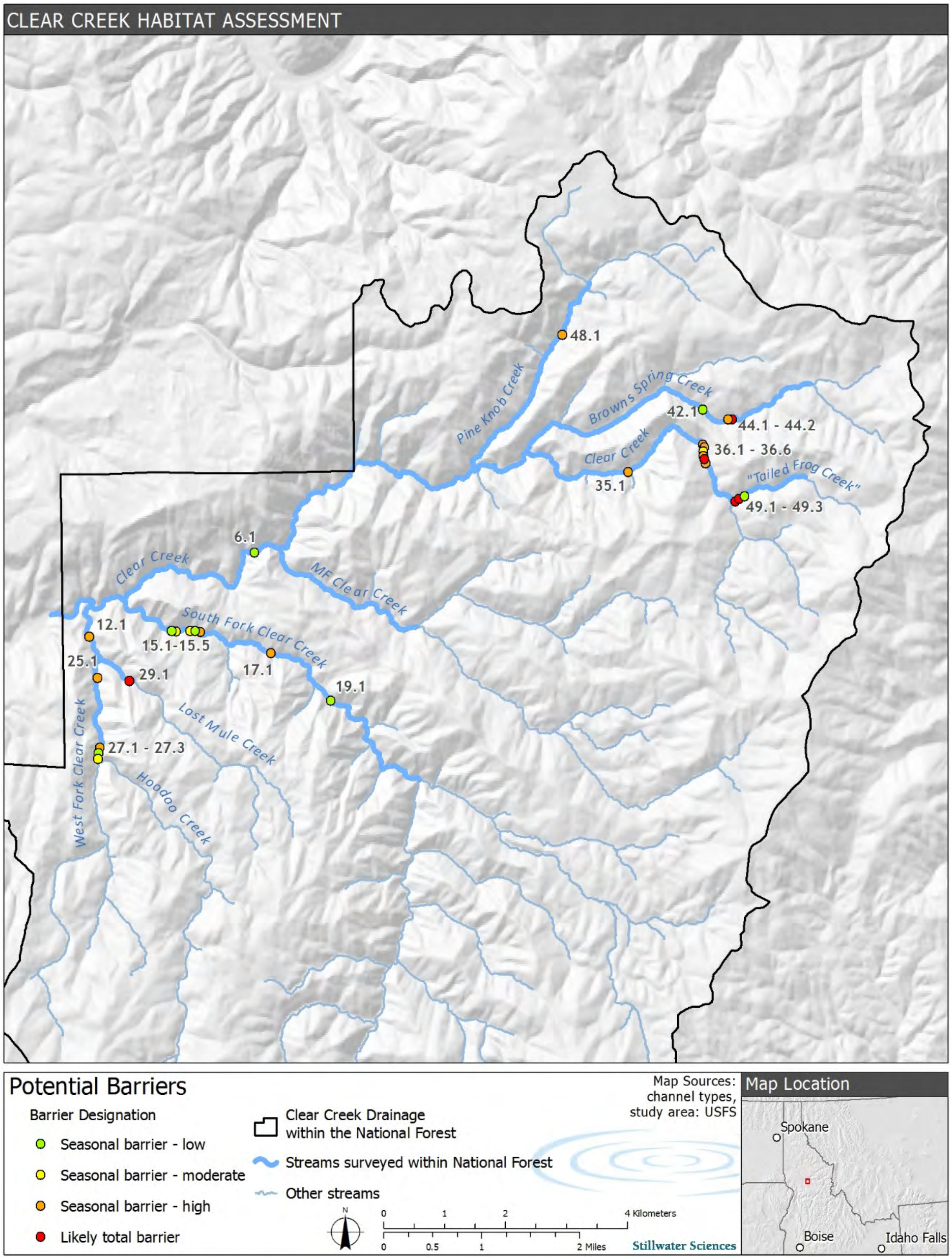

Figure 23. Locations of potential barriers to fish migration documented during surveys of study reaches within the National Forest. Numbers associated with potential barrier locations represent the potential barrier ID, which is based on the reach number.

Mainstem Clear Creek and "Tailed Frog Creek"

In mainstem Clear Creek, eight potential barriers were documented in the surveyed reaches (Figure 23). With the exception of a potential barrier in Reach 6 (PB 6.1, immediately downstream of the Middle Fork confluence), these features were all located in the mid-section of UMCC, within high-gradient sections of Reaches 35 and 36 (Figure 23). Presence of both adult Chinook salmon and *O. mykiss* upstream of PB 6.1 indicate that it is at most a barrier to fish passage at low stream flows. The next potential barrier upstream, PB 35.1, appears to be the first major obstacle to anadromous fish migration in mainstream Clear Creek. Since it coincides with the upper-most documented extent of *O. mykiss*, this feature may constitute a total barrier. Even if PB 35.1 is not a total barrier to anadromy, the presence of six other potential barriers—one of which (PB 36.5) is likely a total barrier—in the next 2,300 m of channel is expected to prevent upstream passage of anadromous fish through this section of Clear Creek. Despite these numerous migration barriers, cutthroat trout were found in relatively high densities in mainstem Clear Creek throughout Reaches 35 and 36 (Figure 19). However, in the small tributary to upper Clear Creek referred to as "Tailed Frog Creek", cutthroat trout were only found in the lower 75 m below PB 49.1, a likely total barrier.

West Fork Clear Creek and Lost Mule Creek

Five potential barriers were documented in West Fork Clear Creek (Figure 23). The downstream-most feature, PB 12.1, is expected to present a passage barrier to anadromous fish across a wide range of flows due to the combination of jump height and jump distance. However, there is a potential alternative passage route at higher flows, and it is possible that flow could backwater enough to allow passage at moderate to high flows. Notably, Chinook salmon were observed downstream, but not upstream of this feature, suggesting that it may prevent their passage. Presence of significant numbers of *O. mykiss* upstream suggests that either a population of resident rainbow trout exists, or steelhead can pass these features at some range of flows. The next potential barrier in the West Fork, PB 25.1, is nearly 800 m upstream. This feature is likely a significant passage obstacle across a wide range of stream flows and is expected to be a total barrier to anadromy at low flows. Three additional potential barriers were documented in a 100-m high-gradient section of Reach 27. Notably, *O. mykiss*, along with cutthroat trout, were documented upstream of each of these features, suggesting that either a population of resident rainbow trout exists, or steelhead can pass these features at some flows.

In the Lost Mule Creek study reaches, a likely total barrier, PB 29.1, was documented approximately 600 m upstream from the confluence with West Fork Clear Creek. In support of the physical evidence that this feature blocks passage (Appendix E), no fish were documented in the short distance surveyed upstream of this feature through Reach 29.

South Fork Clear Creek

In South Fork Clear Creek, seven potential barriers to fish migration were documented in the surveyed reaches (Figure 23, Appendix E). Five of these features were in an approximately 400-m high-gradient section of Reach 15, starting 1,200 m from the confluence with mainstem Clear Creek (Figure 23). All of these potential barriers were classified as seasonal and are expected to inhibit fish passage to varying degrees across a range of stream flows. In support of these designations, both Chinook salmon and *O. mykiss* were observed upstream of these potential barrier locations (Figures 12 and 23). The next potential barrier upstream, PB 17.1, appears to be a barrier to fish passage at lower flows due to the lack of a jump pool immediately below the drop (which plunges onto boulders), and the presence of a cascade below the drop. This feature coincides with the documented upper distribution of Chinook salmon and therefore could be a total barrier to the species. *O. mykiss*, on the other hand, were found in high numbers upstream (and cutthroat trout were not documented), suggesting that either a population of resident *O. mykiss* exists, or steelhead can pass this features at some range of flows. The only other potential barrier documented in the South Fork Clear Creek surveyed reaches, PB 19.1, was categorized as a seasonal barrier and is not expected to block passage of anadromous salmonids at moderate stream flows.

Middle Fork Clear Creek

No potential barriers were documented in the surveyed reaches of Middle Fork Clear Creek. However, the extremely braided nature of Reach 30 could impede upstream migration of large fish such as adult salmon and steelhead, particularly during low stream flows.

Pine Knob Creek

Only one potential barrier, PB 49.1, was documented in the surveyed reaches of Pine Knob Creek. At low flows this feature is expected to be a total barrier to fish migration. At higher flows it is possible that fish can navigate through the feature, but more extensive fish passage surveys and analysis would be required to determine this. *O. mykiss* were documented upstream of this feature, suggesting that either a population of resident *O. mykiss* exists, or steelhead can pass this feature at some flows.

Browns Spring Creek

Three potential barriers were documented in Browns Spring Creek. The most downstream, PB 42.1, appears to present a low-flow barrier to fish passage, but is not expected to impede passage at moderate to higher flows. *O. mykiss* were documented downstream, but not documented upstream of this feature. However, in this case it appears that upper distribution of the species may be controlled by factors other than migration barriers. Two additional potential barriers were documented farther upstream in Reach 44. The more upstream barrier, PB 44.2, appears to present a total barrier to anadromous fish passage. High densities of cutthroat trout were observed upstream of this feature.

3.4 Habitat Unit-scale Characterization

Habitat unit-scale assessments (habitat typing, channel dimensions, substrate compositions, bank stability, large woody debris (LWD) counts, and spawning gravel assessment) were conducted on all surveyed study reaches, with the following exceptions. Approximately 750 m of Reach 30 in Middle Fork Clear Creek was not specifically habitat-typed or otherwise assessed due to difficulties accessing and locating the main channel and following standard protocols in the extremely braided and complex reach, which was characterized by dense, and in places impassable, alder thickets. The majority of the accessible and visible habitat units within this braided section were designated as riffles. The crew later attempted to access this area from upstream via Reach 31. However, they again encountered extremely braided and densely vegetated sections of channel. The sections of Reach 30 that weren't assessed in detail appeared to contain primarily braided riffles and single-channel rapids with large amounts of LWD.

Field crews were able to conduct standard surveys for the majority of Reach 31, but two approximately 50-m sections were inaccessible due to extremely dense and impassable vegetation, and therefore dominant habitat unit types and lengths were estimated.

Side channels can be an important habitat element for spawning, rearing, and refuge habitat. Side channels also tend to provide habitat complexity. Large and small side channels were present to varying degrees in all the subwatersheds. The differentiating features between large and small side channels are described in Appendix B.

3.4.1 Main and side channel length

Within the National Forest, there were 1,154 m of large side channels versus 40,104 m of main channel (2.9%). Large side channels were present in 22 of 52 reaches within the National Forest and four of six reaches in LCC. As a percentage of main channel length, large side channels within the National Forest were most abundant in South Fork (8.8% of main channel length) (Figure 24). No large side channels were identified in Middle Fork or Pine Knob Creeks. LCC had the most large side channels (as a percentage of main channel length) study-wide (Figure 24).

Small side channels within the National Forest were most abundant in Browns Spring Creek and least abundant in upper mainstem Clear Creek, comprising 10.6 percent and 0.2 percent of mainstem channel length, respectively (Figure 24). On private lands in lower Clear Creek, small side channels were more abundant than elsewhere, comprising 15.5% of mainstem channel length.

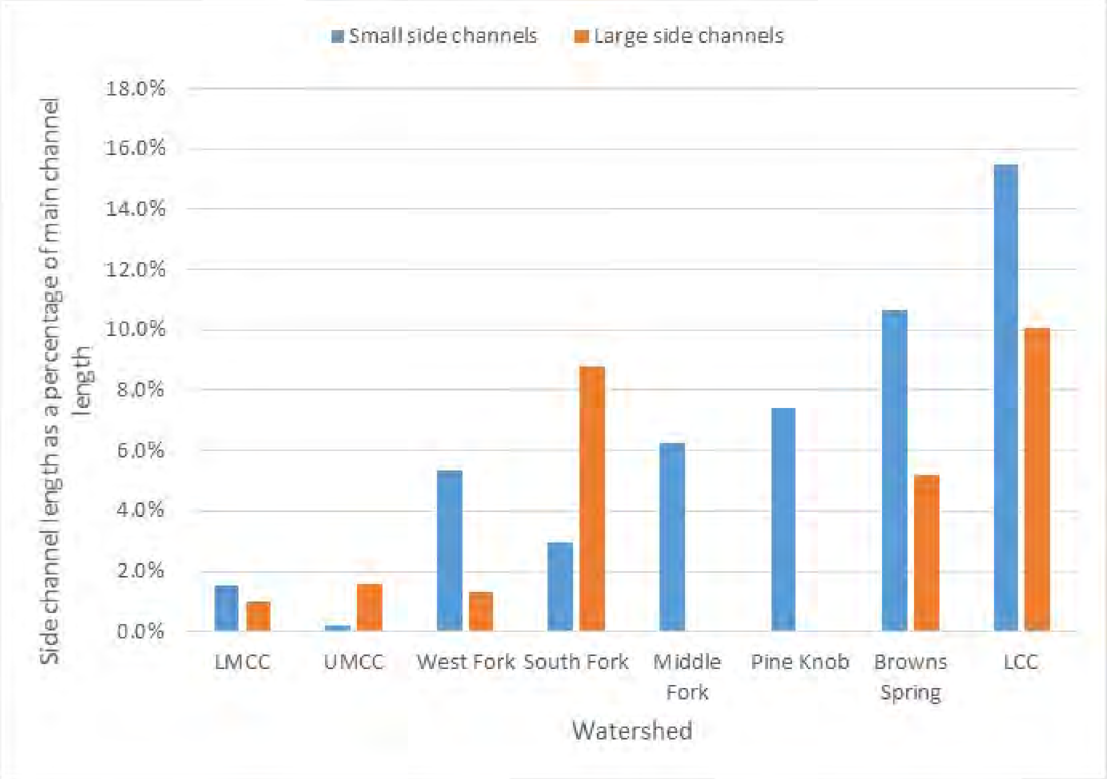

Figure 24. Length of small and large side channels as a percentage of total main channel length, by subwatershed.

3.4.2 Habitat type composition

Stream habitat was delineated by habitat unit type (e.g., riffle, pool) in the main channel and in all large side channels. Length and average width of small side channels were measured, but habitat units were not delineated within small side channels. The most prevalent habitat units by length and number in all subwatersheds were fast-water turbulent units (riffles, rapids, cascades, and falls), followed by fast-water non-turbulent units (runs and glides), followed by slow-water units (pools), and then off-channel units (Table 21, Figure 25).

Table 21. Length of each habitat type, by subwatershed.[1]

Tier I habitat type	**Tier II habitat type**	**Length of habitat unit types (m)**								
		LMCC	**UMCC**	**West Fork**	**South Fork**	**Middle Fork**	**Browns Spring**	**Pine Knob**	**LCC**	**Total**
Fast-water turbulent	Cascade	250	112	182	124	40	99	40	-	**846**
	Falls	-	43	8	17	-	2	-	-	**68**
	Rapid	2,880	1,532	1,934	1,441	455	747	1,348	161	**10,498**
	Riffle	4,969	3,524	223	3,596	1,141	3,884	1,196	4,702	**23,236**
Subtotal		**8,099**	**5,211**	**2,346**	**5,178**	**1,635**	**4,732**	**2,584**	**4,863**	34,648
Fast-water non-turbulent	Run/glide	1,827	946	793	1,346	369	933	1,159	1,983	**9,355**
Subtotal		**1,827**	**946**	**793**	**1,346**	**369**	**933**	**1,159**	**1,983**	9,355
Slow-water	Dam pool	10	40	9	19	-	37	-	73	**189**
	Plunge pool	221	327	290	313	53	219	106	-	**1,528**
	Scour pool	916	394	115	437	89	245	219	556	**2,971**
	Off-channel	-	42	182	-	-	-	-	13	**237**
Subtotal		**1,147**	**761**	**413**	**768**	**143**	**501**	**325**	**629**	4,687
Grand total		**11,073**	**6,961**	**3,734**	**7,292**	**2,147**	**6,166**	**4,068**	**7,488**	48,928

[1] Length includes habitat units within large side channels.

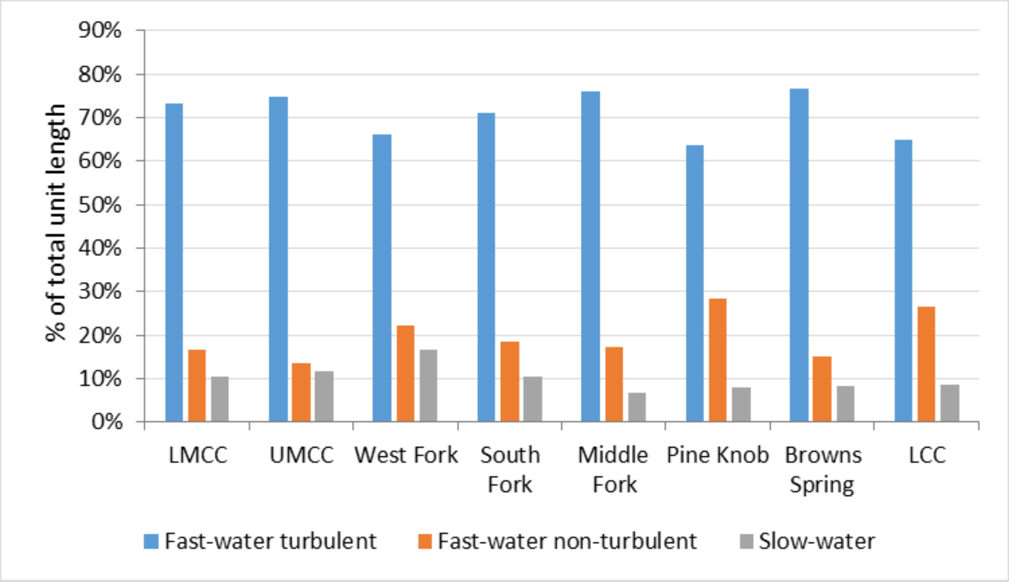

Figure 25. Tier 1 habitat type composition, by subwatershed.

For fast-water turbulent habitats (riffles, cascades, rapids, and falls), riffles were the most common unit type and comprise the greatest relative length in all subwatersheds (Figure 26). West Fork Clear Creek had the greatest relative length of cascade and rapid habitats. The higher average channel gradient in West Fork Clear Creek compared with other subwatersheds is likely responsible for the notable difference in habitat composition compared with other subwatersheds. Composition of fast-water turbulent habitat types in LCC was notably different compared with other subwatersheds, with riffles comprising nearly all of the fast-water habitat, and no cascades or falls were observed. Similarly, these differences in habitat composition are likely the result of differences in channel gradient.

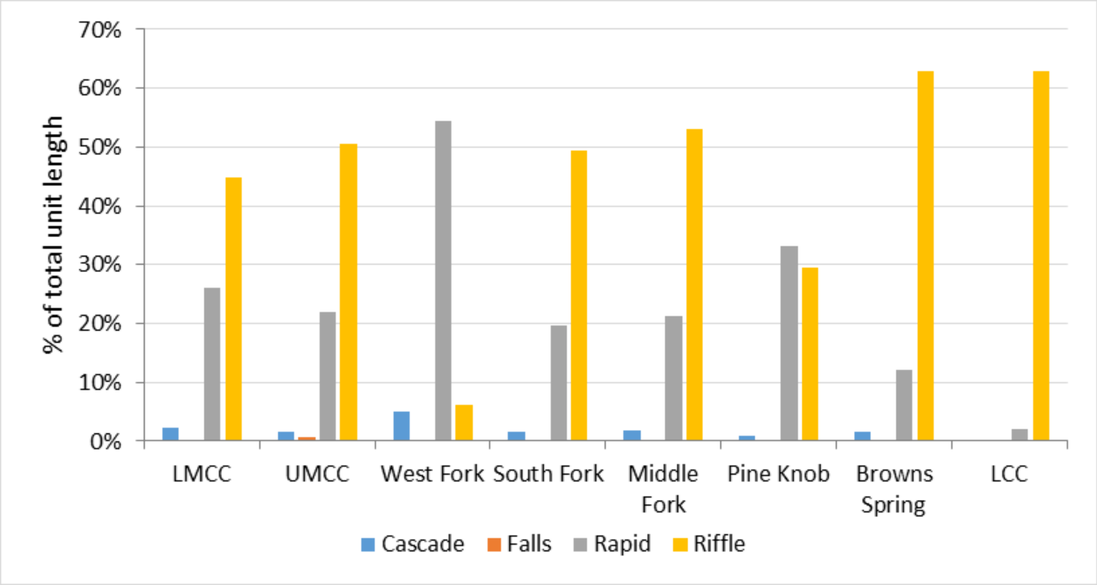

Figure 26. Percent of total stream length of Tier II fast-water turbulent habitat types, by subwatershed.

For slow-water habitats (i.e., pools), scour pools were the most abundant Tier II habitat type in all subwatersheds, except West Fork Clear Creek, where plunge pools were more prevalent (Figure 27). In LCC, most pool were scour pools, and plunge pools were not observed. Again, these differences are likely due to differences in channel gradient.

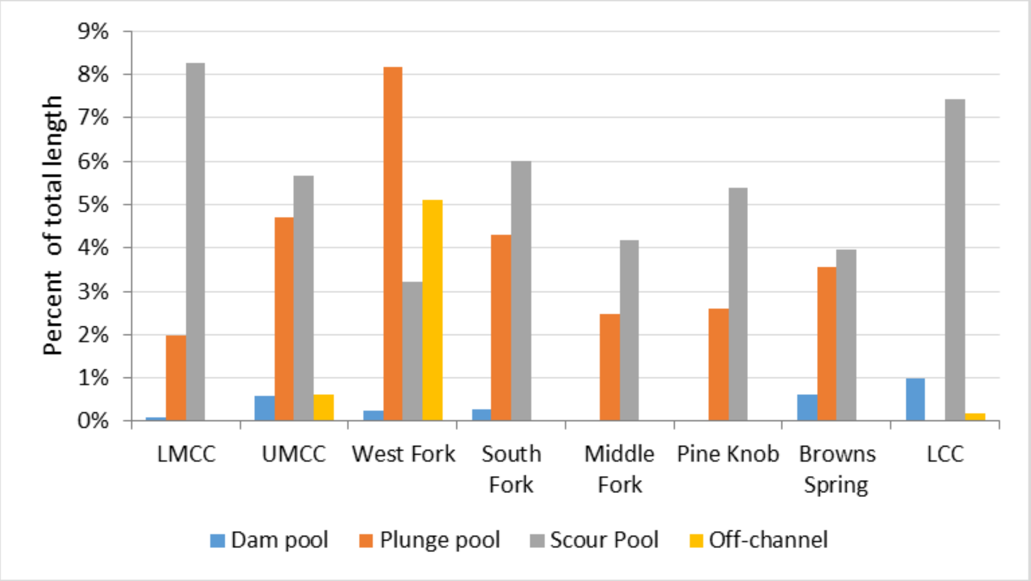

Figure 27. Percent of total stream length of Tier II slow-water habitat types, by subwatershed.

Pool habitats are particularly important habitats for salmonids, and can be degraded or lost as a result of land management activities (Montgomery et al. 1995). Pools can offer shallow, low-velocity habitat preferred by fry, and deeper habitats used by juveniles and adult for rearing. Deep pools can offer holding habitat for anadromous salmonids and can also be important for spawning, as spawning habitat in close proximity to holding habitat and cover tends to be preferred.

Pool frequency, or the number of pools per unit length of stream, is a useful metric for assessing the relative quantity of pool habitat. For subwatersheds within the National Forest, pool frequency ranged from 11.5 pools/km in LMCC to 26.8 pools/km in West Fork (Figure 28).

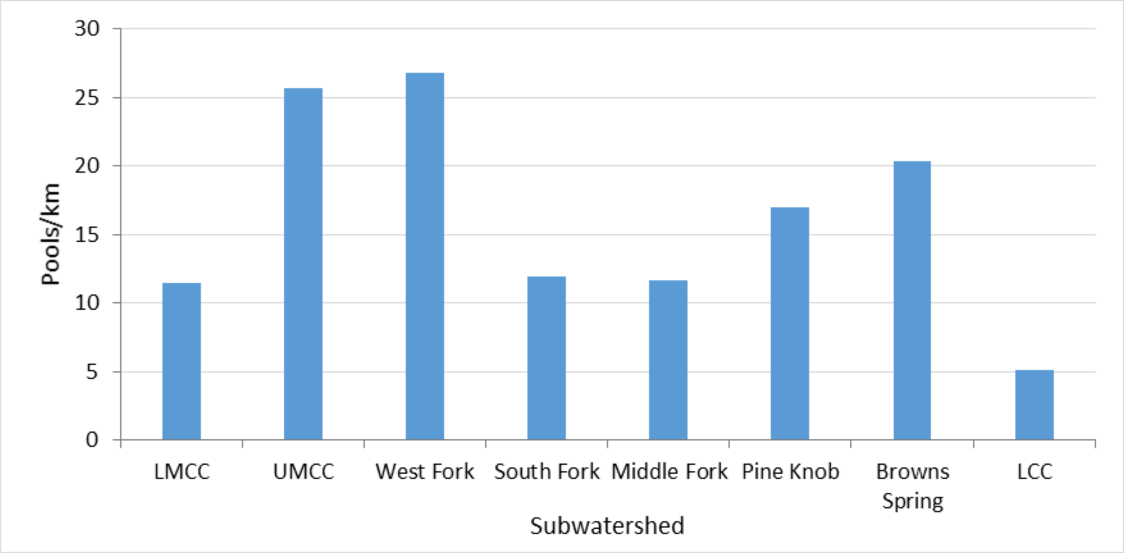

Figure 28. Pool frequency (pools per kilometer), by subwatershed.

Another useful and commonly used metric for reporting the relative abundance of pools is channel widths per pool, since this measure is scaled to channel size and relates directly to physical processes and reach type (i.e., channel gradient and channel constraint) (Montgomery et al. 1995). Pool frequency within the National Forest ranged from 7 bankfull widths/pool in upper mainstem Clear Creek to 15 bankfull widths/pool in Middle Fork Clear Creek (Figure 29). There were fewer pools in LCC, where there was 22 bankfull widths/pool. Of the subwatersheds within the National Forest, Middle Fork Clear Creek stands out as having relatively low pool abundance.

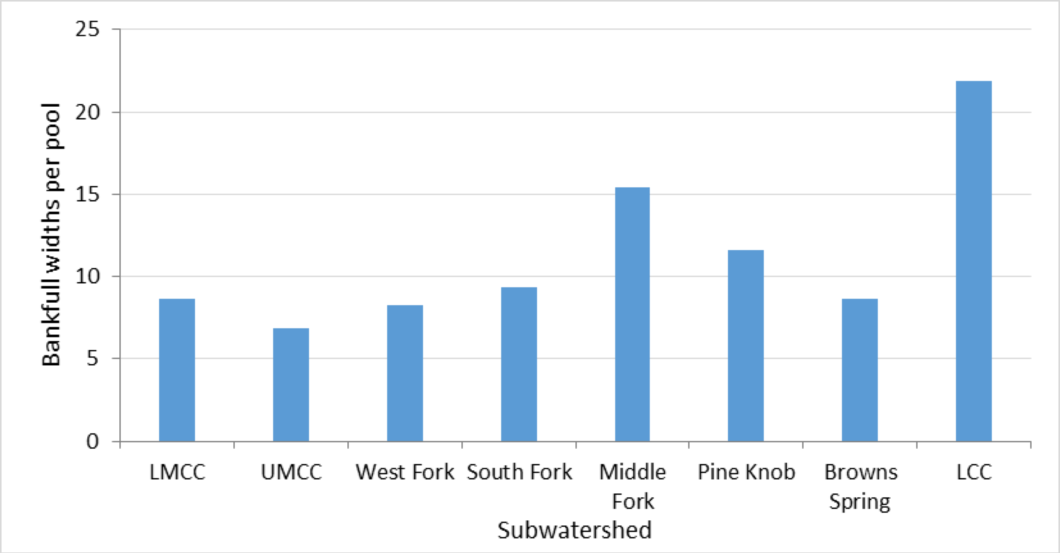

Figure 29. Pool frequency (bankfull widths per pool), by subwatershed.

At the reach scale, the majority of channels within the National Forest had pool frequency of 2–10 bankfull widths/pool (Figure 30). Only one reach (Reach 12) in West Fork Clear Creek had higher pool density (<2 bankfull widths/pool), and South Fork Clear Creek and West Fork Clear Creek each have two or more reaches with lower pool density (between 10 and 30 bankfull widths/pool). The private lands in LCC had the lowest pool density overall (15–30 bankfull widths/pool), and high between-reach variability. However, while pools were less frequent in LCC, they were typically larger and deeper.

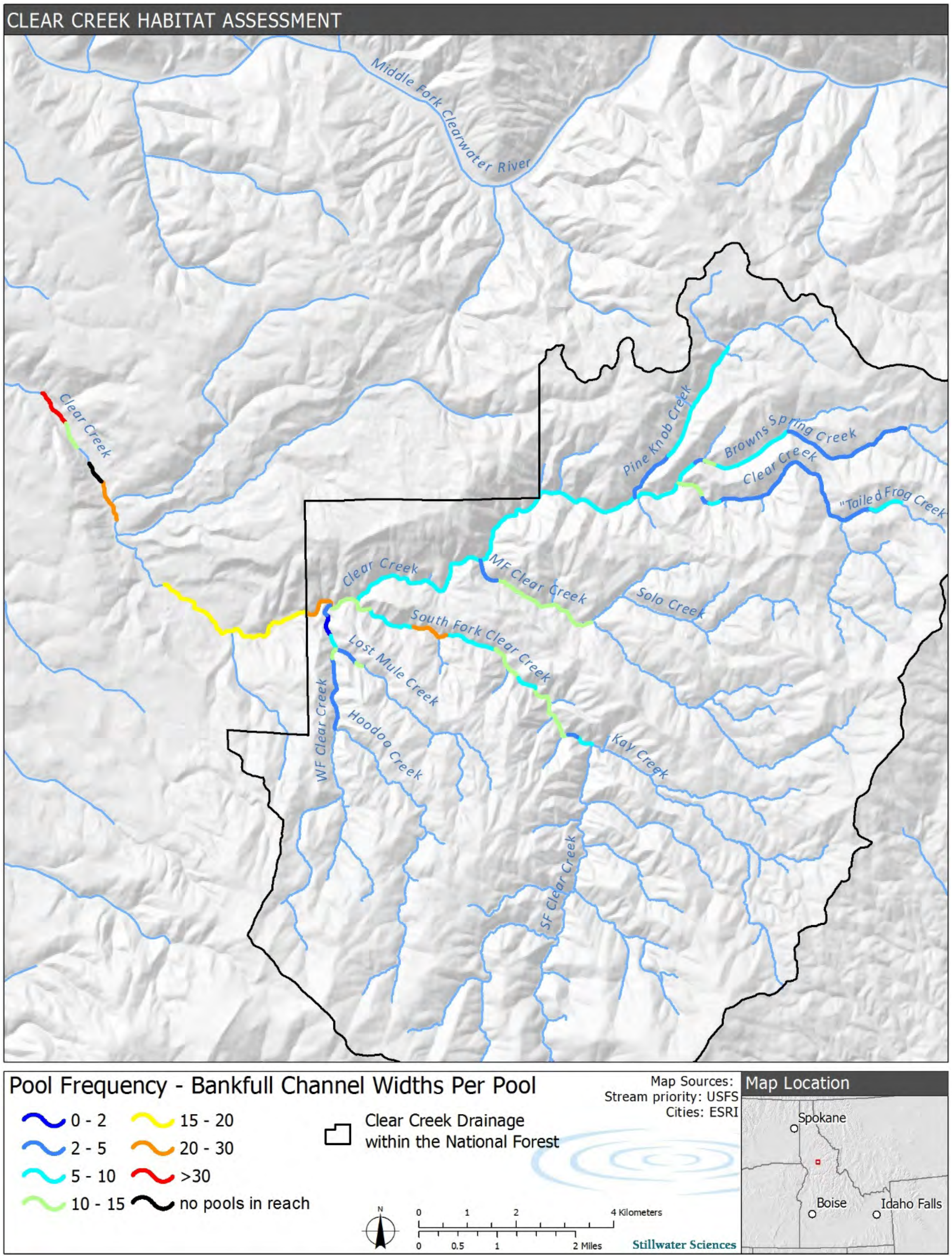

Figure 30. Pool frequency (bankfull widths per pool), by study reach.

Pools with sufficient depth to provide adult holding and rearing habitat are an important habitat element for salmonids. Within the National Forest, the LMCC and South Fork subwatersheds had the most pools deeper than 0.9 m (3 ft): 23 and 21 pools, respectively (Figure 31). The UMCC, West fork, Pine Knob, and Browns Springs subwatersheds all had 3 or fewer pools >0.9 m deep, whereas no pools deep pools were observed in the Middle Fork. Fourteen pools >0.9 m deep were observed in LCC. Overall, the frequency of pools >0.9 m deep ranged from 0 pools/km in the Middle Fork to 2.9 pools/km in the South Fork.

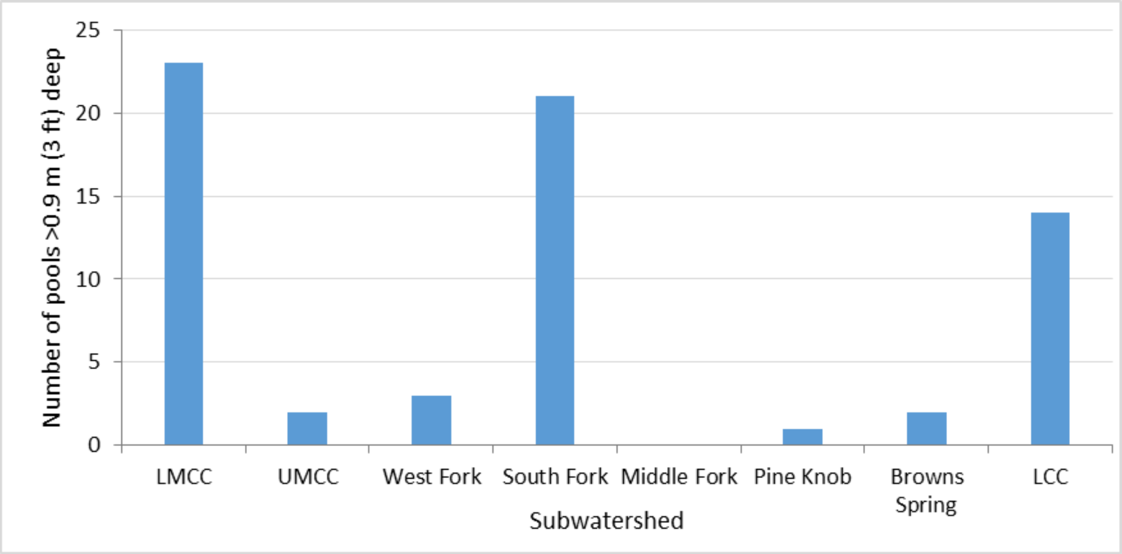

Figure 31. Number of pools >0.9 m (3 ft) deep, by subwatershed.

3.4.3 Channel dimensions

Characteristics of habitat units were measured to provide an understanding of how habitat conditions vary among reaches and subwatersheds. Parameters estimated for all habitat units include length, mean wetted-width, and mean depth at the thalweg. Mean length, mean wetted-width, and mean depth of habitat units were greatest in subwatersheds with the largest channels: LCC, followed by LMCC and South Fork (Table 22).

Table 22. Channel dimensions for habitat units by subwatershed.

Subwatershed	N[1]	Length (m)			Mean wetted-width (m)			Mean depth (m)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
LMCC	586	3.0	92.8	18.7	0.9	32.2	5.8	0.1	8.7	0.4
UMCC	644	0.8	67.0	10.6	0.8	15.0	3.5	0.0	10.1	0.2
West Fork	362	1.8	86.8	9.7	0.8	6.0	2.7	0.0	0.6	0.2
South Fork	382	2.0	86.0	17.5	1.3	11.7	5.2	0.2	3.2	0.4
Middle Fork	163	3.2	45.1	13.2	2.1	6.7	3.5	0.1	0.5	0.2
Pine Knob	356	2.3	54.7	11.4	1.2	7.3	2.6	0.1	1.3	0.2
Browns Spring	472	1.5	90.0	12.4	0.5	8.4	2.7	0.1	1.1	0.2
LCC	188	4.5	184.0	36.2	2.2	14.0	7.2	0.2	1.2	0.4
Total	**3,153**	**0.8**	**184.0**	**14.9**	**0.5**	**32.2**	**4.0**	**0.0**	**10.1**	**0.3**

[1] Number of habitat units for which dimensions were measured.

3.4.4 Substrate composition

Bed substrates are an important habitat element for a host of aquatic species, and the relative abundance of substrate size classes can be a strong indicator of habitat conditions related to spawning, incubation, rearing, foraging, and refuge. The areal proportion (expressed as a percent) of each of seven substrate types was visually estimated in the field for each habitat unit. Percent composition was calculated as the length-averaged contributing area for all habitat units within each subwatershed. In general, within the study area cobble and/or boulder substrates accounted for the greatest area, followed by gravels, sands/fines, and bedrock, respectively (Table 23, Figure 32). Bedrock was relatively infrequent (<5%) in all subwatersheds, with upper mainstem Clear Creek having the greatest prevalence (4.3%) relative to other substrate types. Percent of boulder substrate was highest in South Fork Clear Creek (35%), while percent of cobble substrate was highest in Lower Clear Cleek (53%). Percent of coarse gravel was greatest in Pine Knob (27%) and fine gravel in UMCC (16%). UMCC, West Fork, Pine Knob, and LCC subwatersheds had the highest levels of bed surface fines at 4%, 5%, 3%, and 4%, respectively.

Table 23. Substrate composition, by subwatershed.[1]

Substrate category	**Substrate composition (%)**								
	LMCC	**UMCC**	**West Fork**	**South Fork**	**Middle Fork**	**Pine Knob**	**Browns Spring**	**All National Forest reaches**	**LCC**
Bedrock	1.5	4	4	3	0.1	0.5	1.6	2	1
Boulder	28	22	22	35	14	10	24	24	10
Cobble	34	22	26	33	27	38	34	31	53
Coarse gravel	13	17	17	12	23	27	17	16	15
Fine gravel	10	16	9	6	13	10	12	11	8
Sand	13	15	17	12	23	12	11	14	9
Fines	0.6	4	5	0.4	1	3	1	2	5

[1] Values are the length-averaged areal extent of the bed surface in each substrate category expressed as a percent.

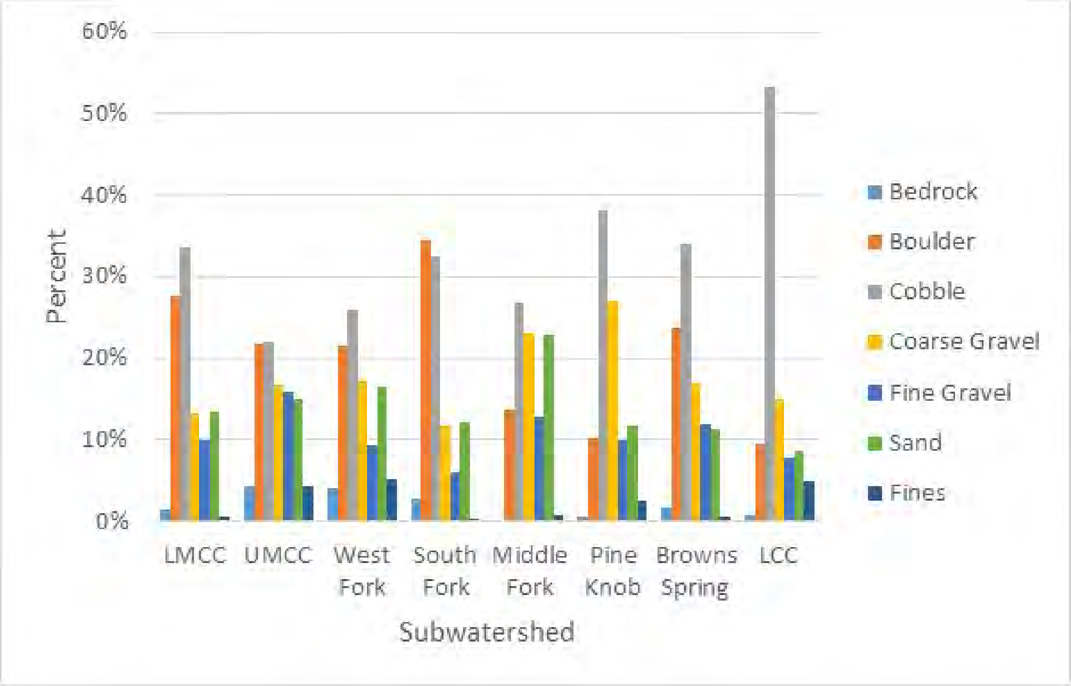

Figure 32. Substrate composition by subwatershed. Values are the length-averaged areal extent of the bed surface in each substrate category expressed as a percent.

Boulder and cobble substrates can provide important foraging and refuge habitat for aquatic vertebrates, and their abundance was relatively high in all subwatersheds, with combined (boulder/cobble) range of about 40–65% of bed surface area (Figure 33). Within the National Forest, the greatest proportion of cobble and boulder substrates were present in lower mainstem Clear Creek (61%), South Fork Clear Creek (67%), and Browns Spring Creek (58%) (Figure 33).

Cobble and gravel substrates are used by fish for foraging, and in the absence of fine sediment, promote benthic macroinvertebrate production. Within the National Forest, the greatest proportion of gravel and cobble substrates were present in Pine Knob Creek (75%) and the lowest proportion was in South Fork Clear Creek (50%).

Gravels are also important substrates for spawning and invertebrate production. Within the National Forest, gravels (coarse and fine) were prevalent in Pine Knob Creek (37%) and Middle Fork Clear Creek (36%), and least prevalent in South Fork Clear Creek (18%), based on percent surface area (Figure 33). Note that this is different than the actual quantity of available gravels, which is strongly correlated to channel size and gradient. A separate and more detailed assessment of spawning habitat quantity and quality is presented in Section 3.4.7.

Sand and fines (silt and clay) can embed larger particles, reducing the quality of spawning gravels and conditions for incubation, as well as conditions for benthic macroinvertebrate production. The area of bed substrates classified as sand and fines was greatest in in the Middle Fork Clear Creek (24%) and West Fork Clear Creek (22%), and lowest in Browns Spring Creek (12%) and South Fork Clear Creek (13%) (Figure 33).

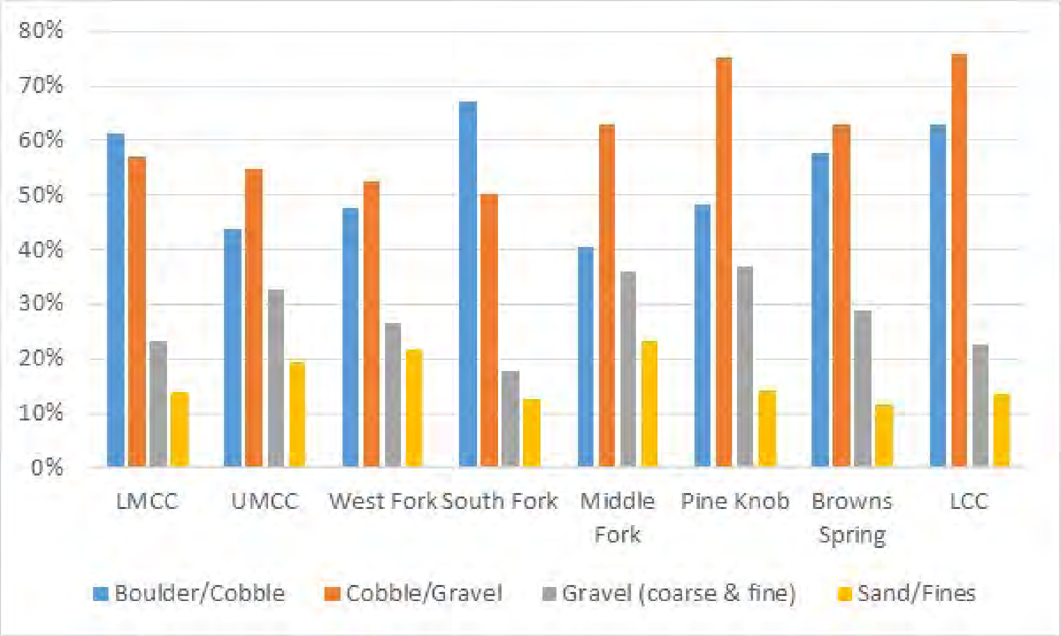

Figure 33. Substrate composition for combined substrate categories, by subwatershed. Values are the length-averaged area extent of the bed surface in substrate categories expressed as a percent.

Most study reaches were classified as having 10–20% of the bed surface comprised of sand and fine substrates (Figure 34). This included most of the study reaches surveyed in mainstem Clear Creek, South Fork Clear Creek, and upper reaches of Pine Knob Creek and Browns Spring Creek. Middle Fork Clear Creek and West Fork Clear Creek had notably higher abundance of sand and fines, generally averaging of 20–30%, with the exception of a small area at the very upstream, steepest portion of Lost Mule Creek which had low (<10%) sand and fines. Abundance of sand and fines in upper Clear Creek were variable by reach. Only a few short sections of Clear, Lost Mule and Browns Spring creeks had <10% of the bed surface comprised of sand and fines. Reaches surveyed on private lands in LCC had <20% of the bed surface comprised of sand and fines, with two of the five reaches (roughly one-third by length) having <10% sand and fines.

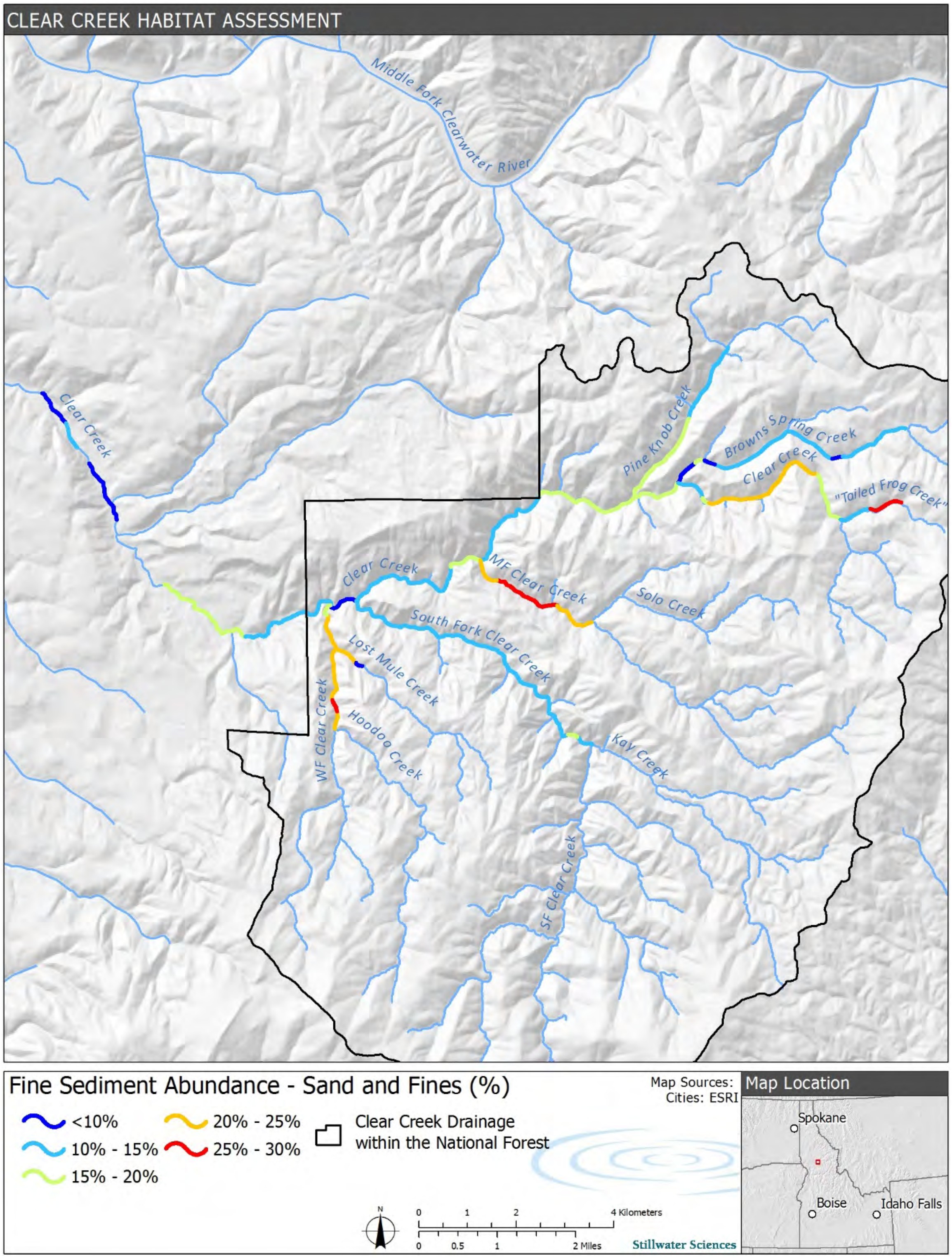

Figure 34. Percent of sand and fines (combined), by study reach.

The abundance of bed surface fines within reach classifications is variable both between and within reach types (Figure 35). Fines are most abundant in Reach 28, a relatively small (0–25 km^2) reach with moderate gradient (4–20%). Reaches with moderate drainage areas (25–100 km^2) generally appear to have lower fines, with the exception of reaches in West Fork. Overall, it appears that abundance of bed surface fines is correlated strongly with location (i.e., subwatershed).

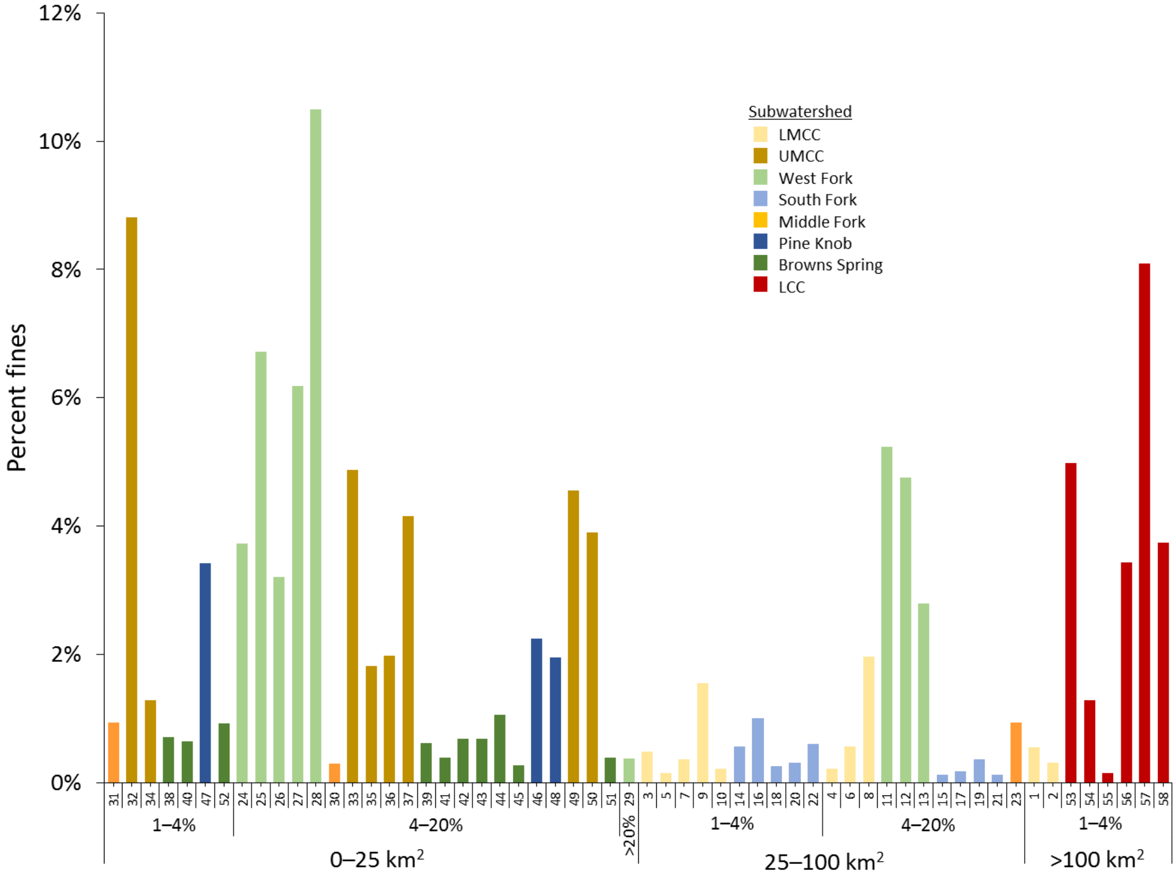

Figure 35. Percent of fines by study reach within drainage area and channel gradient categories.

3.4.5 Bank stability

Unstable stream banks can be a major contributor of fine sediment to streams, and can lead to reduced habitat quality through fine sediments infiltrating into coarser substrates and increasing substrate embeddedness, as well as through the loss of bank vegetation and habitat complexity. The extent of unstable banks can be directly affected by land management activities. Bank stability ratings included the extent of both undercut and eroding banks within each habitat unit, considering the left and right banks separately. In general, undercut and eroding banks were uncommon. Of 3,433 delineated habitat units, 53 (1.5%) exhibited some degree of bank erosion (on one or both banks), and 130 (3.8%) had some undercut banks (on one or both banks).

For surveyed reaches on the National Forest, the amount total channel length (main channel and large side channels) classified as eroding banks or undercut banks ranged from 0.0 to 0.21%, and

0.14% to 1.07%, respectively (Table 24). Bank erosion and undercut bank prevalence were much higher on the private lands in lower Clear Creek, at 5.13% and 2.43%, respectively (Table 24).

Table 24. Length of eroding and undercut banks, by subwatershed.

Subwatershed	Length (m) of eroding banks			% of total channel length with eroding banks	Length (m) of undercut banks			% of total channel length with undercut banks
	Left bank	Right bank	Total		Left bank	Right bank	Total	
LMCC	27	8	35	0.16%	14	48	62	0.28%
UMCC	11	8	19	0.13%	4	19	23	0.16%
West Fork	0	4	4	0.05%	12	28	41	0.57%
South Fork	2	1	2	0.02%	25	8	33	0.23%
Middle Fork	2	0	2	0.04%	3	3	6	0.14%
Browns Spring	17	8	26	0.21%	49	83	132	1.07%
Pine Knob	0	0	0	0.00%	21	32	53	0.65%
LCC	396	372	768	5.13%	154	210	364	2.43%

3.4.6 Large woody debris

Large wood is a critical stream habitat component in forested watersheds such as Clear Creek. Large wood promotes scour and pool formation, provides instream cover and habitat complexity elements, and sorts, stores, and regulates sediment in streams. Data collected on large woody debris (LWD) during stream surveys included a tally of LWD pieces (≥6 in diameter and ≥10 ft length) within the bankfull channel prism. Pieces were classified as either mostly wet or dry depending on the location of each piece. LWD pieces forming jams containing five or more pieces were recorded separately. Additional detail regarding the methodology for identifying key pieces of LWD is presented in Appendix B.

Within the National Forest, LWD frequency was greatest in West Fork Clear Creek (415 pieces/km) and lowest in LMCC (142 pieces/km) (Table 25, Figure 36). LWD frequency was substantially lower on private lands in lower Clear Creek (111 pieces/km). LWD size frequency was dominated by smaller pieces of wood (Figure 37). Reaches in LMCC and LCC had the lowest prevalence of LWD in the study area. Highest amounts were found in the West Fork, UMCC, and Browns Spring (Figure 38).

Table 25. Large woody debris frequency and volume, by subwatershed.

Variable	LMCC	UMCC	West Fork	South Fork	Middle Fork	Browns Spring	Pine Knob	LCC
LWD piece count								
Wet	852	1564	992	782	442	478	1216	594
Dry	706	714	462	666	156	126	662	164
Total	**1558**	**2278**	**1454**	**1448**	**598**	**604**	**1878**	**758**
LWD piece frequency (pieces/km)								
Wet	77.7	228.2	282.9	116.7	205.9	117.5	207.5	87.3
Dry	64.4	104.2	131.8	99.3	72.7	31.0	113.0	24.1
Total	**142.1**	**332.4**	**414.7**	**216.0**	**278.5**	**148.5**	**320.5**	**111.4**
Key LWD piece frequency (key pieces/km)								
Wet	4.1	25.1	8.5	3.7	4.8	6.4	8.9	0.4
Dry	7.4	19.1	7.5	5.1	0.0	3.1	8.4	0.5
Total	**11.5**	**44.2**	**16.0**	**8.8**	**4.8**	**9.5**	**17.3**	**0.8**
LWD volume (m^3/km)								
Wet	93.4	186.5	169.0	45.3	165.4	69.0	90.2	19.8
Dry	109.4	251.0	155.4	68.3	80.2	44.1	82.6	12.4
Total	**202.8**	**437.5**	**324.4**	**113.6**	**245.6**	**113.1**	**172.8**	**32.3**

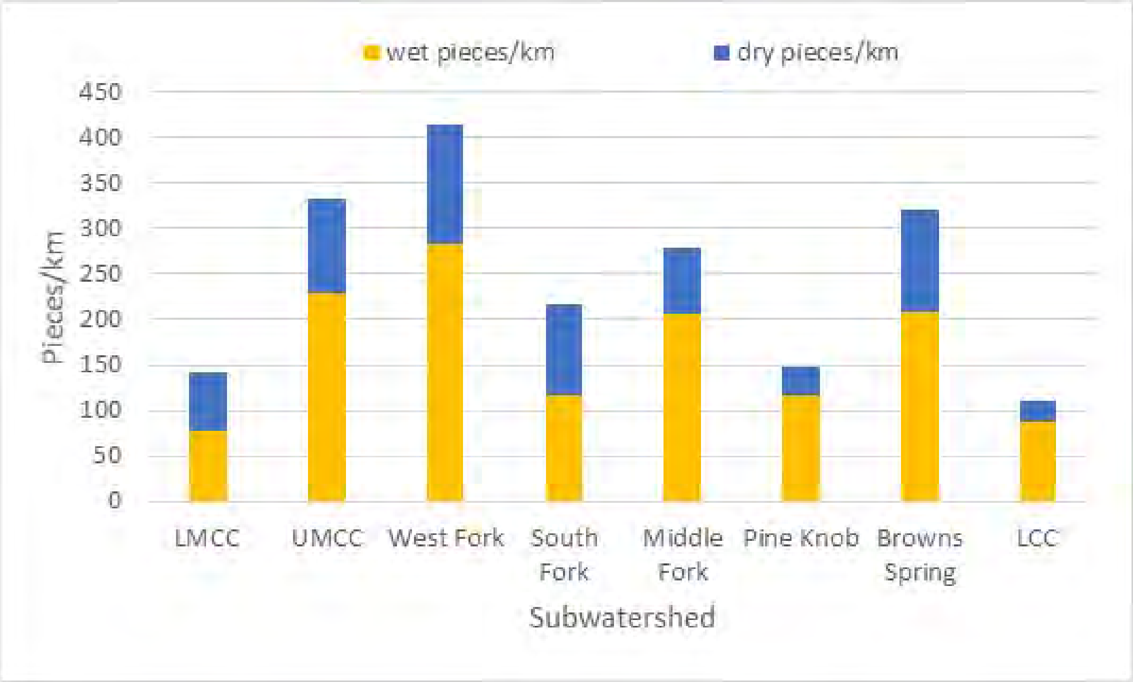

Figure 36. LWD frequency (pieces/km), by subwatershed. Note that channel length includes main channel only.

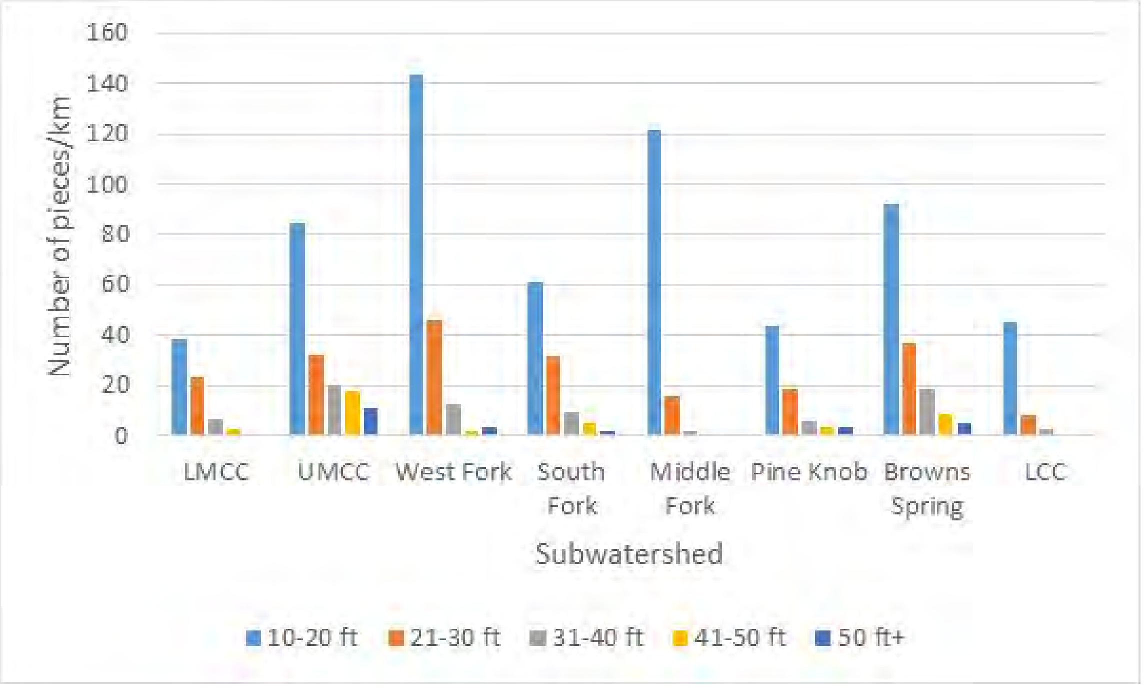

Figure 37. LWD frequency (pieces/km), by length category and subwatershed. Note that wood in jams is included for South Fork and Browns Spring subwatersheds only. Channel length includes main channel only (side channel length not included).

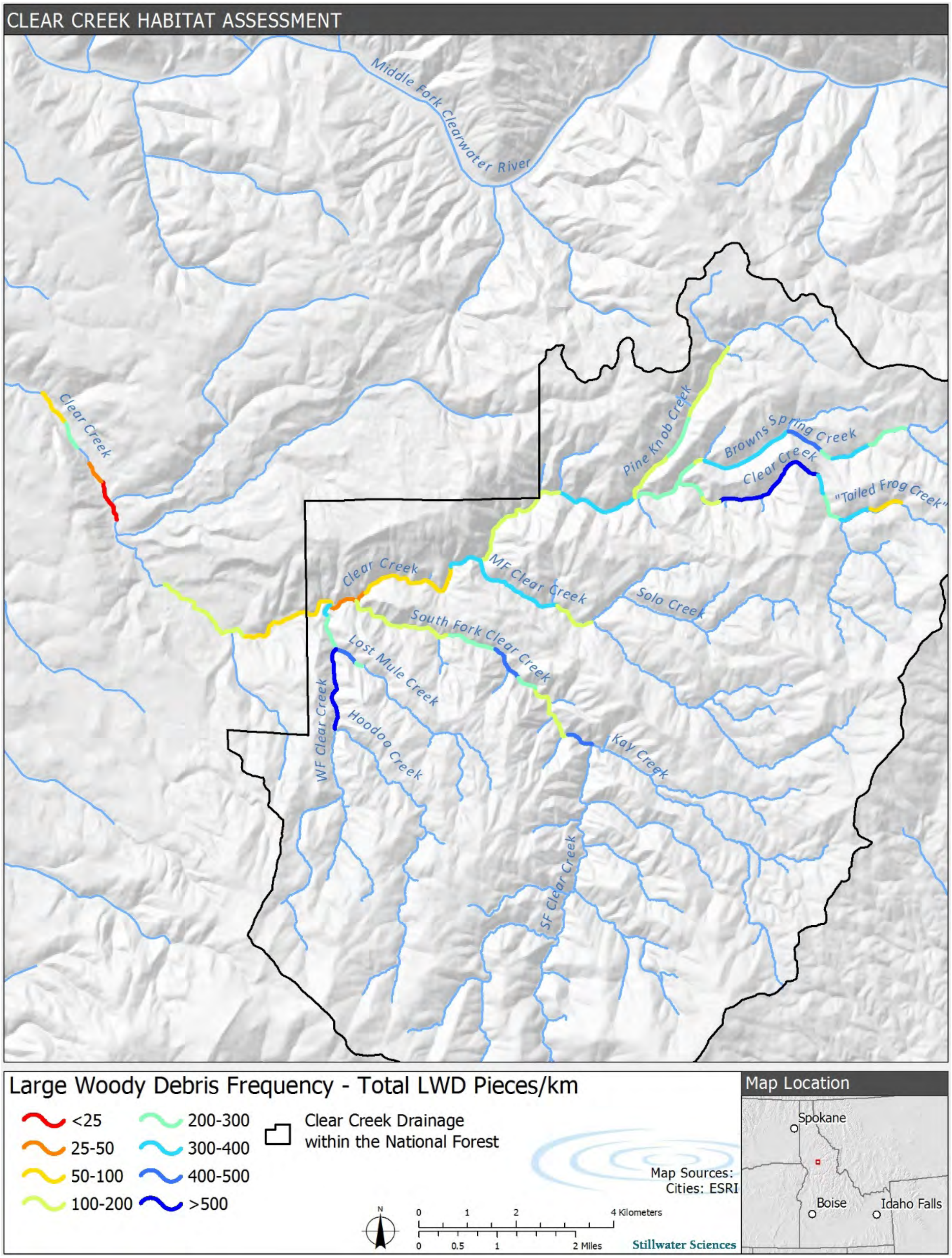

Figure 38. LWD frequency (pieces/km), by study reach. Note that channel length includes main channel only (side channel length not included).

Key LWD pieces (≥12 in diameter and ≥35 ft length) are pieces most likely to influence channel form through scour, sediment storage and sorting, and retaining other pieces of LWD. Key piece frequency (wet and dry, not including jams) within the National Forest was highest in upper mainstem Clear Creek (44.2 key pieces/km), which was substantially higher than elsewhere. Key piece frequency was lowest in Middle Fork Clear Creek (4.8 key pieces/km), where nearly all key pieces were classified as wet (Table 25, Figure 39). Key piece frequency was lowest on private lands in lower Clear Creek (0.8 key pieces/km) compared with other subwatersheds.

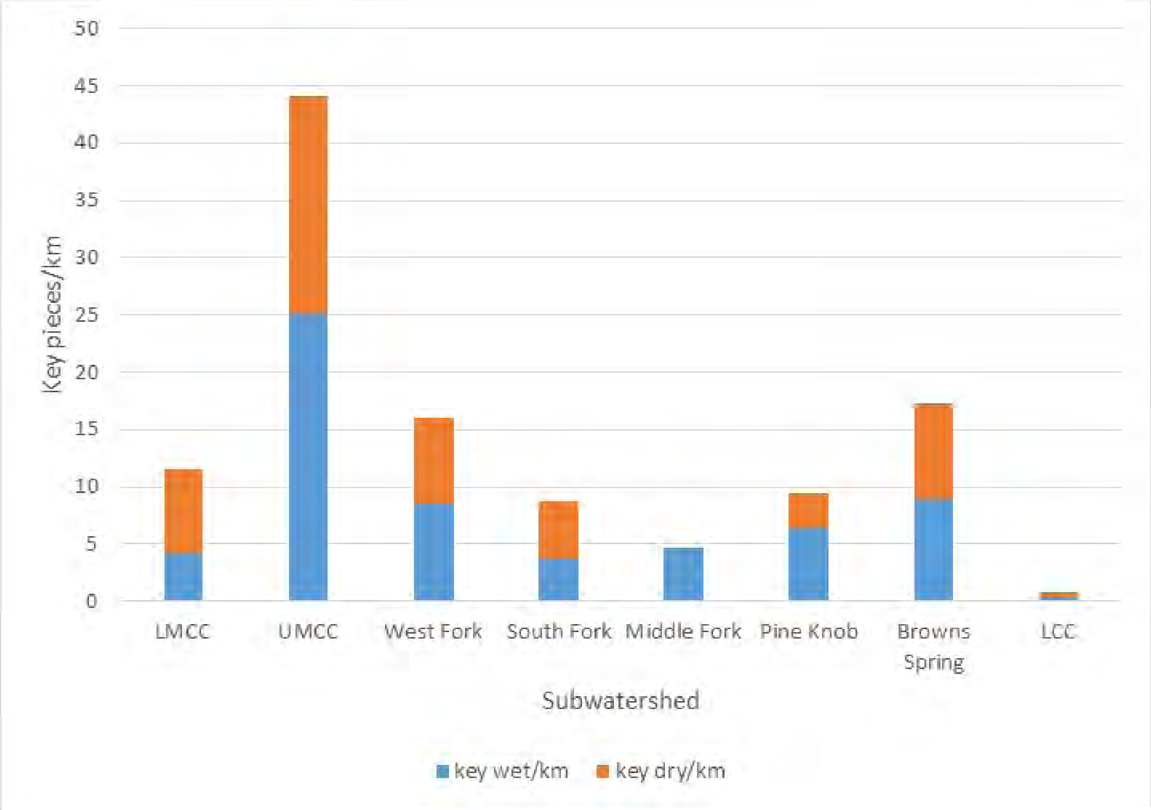

Figure 39. LWD frequency (pieces/km) of key pieces (>35 feet long and >12 inches in diameter), by subwatershed.

Most of the reaches surveyed had less than 15 key pieces/km, with most of the watershed in the <5 key pieces and 5–10 key pieces categories (Figure 40). Reach 35 in UMCC and Reach 25 in the South Fork had notably higher wood loading (>35 key pieces/km). Browns Spring Creek also had relatively higher wood loading, with most study reaches having between 10 and 30 key pieces.

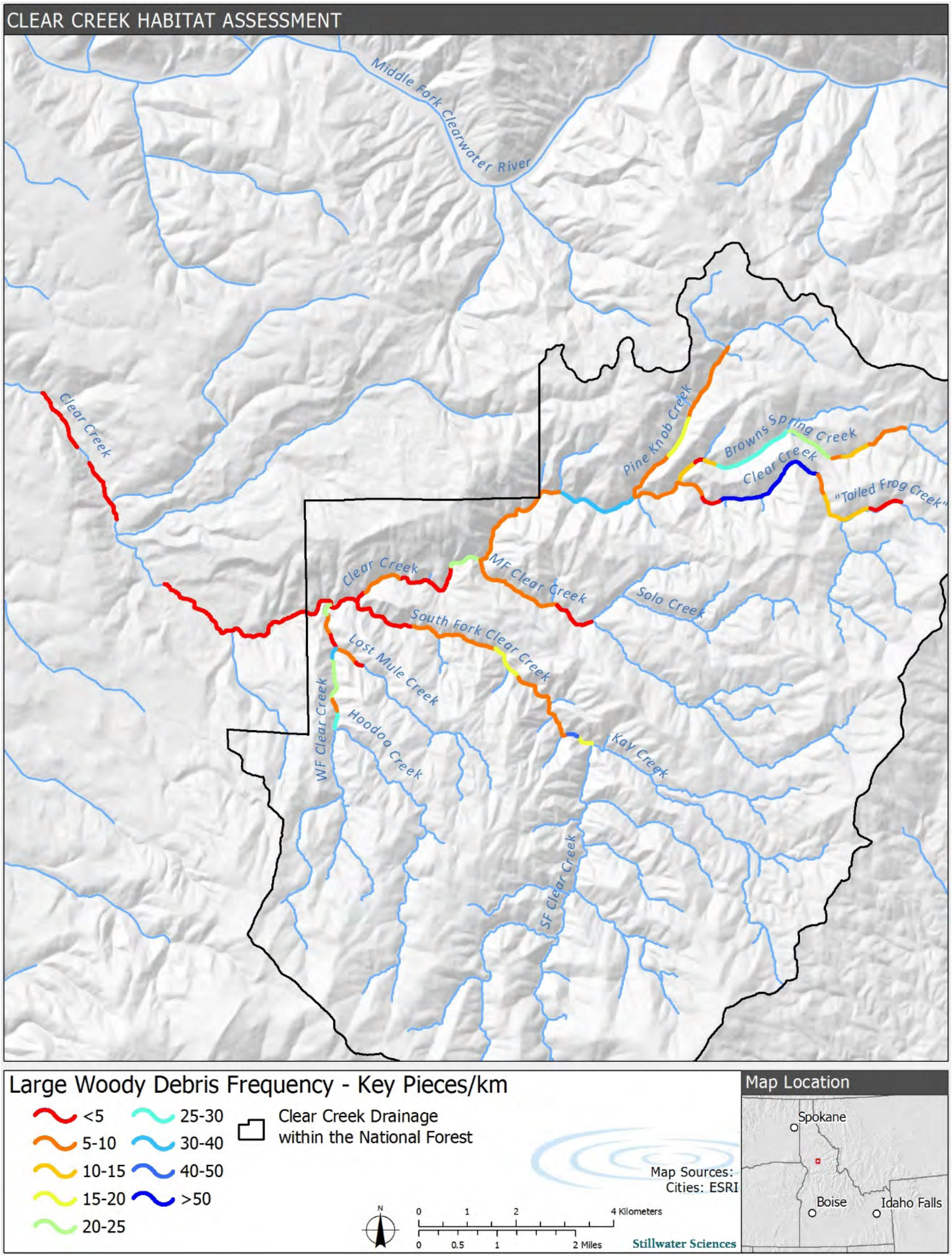

Figure 40. LWD frequency (pieces/km) of key pieces (>35 feet long and >12 inches in diameter), by study reach.

Total volume of LWD within the National Forest ranged from 113 m^3/km in Pine Knob Creek to 438 m^3/km in upper mainstem Clear Creek (Table 25, Figure 41). Upper mainstem Clear Creek had substantially more LWD volume than other subwatersheds within the National Forest. Most of the LWD volume in lower mainstem Clear Creek was observed in jams. LWD volume was substantially lower on private lands in lower Clear Creek (32 m^3/km) compared with other subwatersheds (Table 25). At the reach level, LWD volume was greatest in West Fork Clear Creek (including Lost Mule Creek), the upper portion of LMCC, the lowest reach of the Middle Fork, and UMCC (Figure 42).

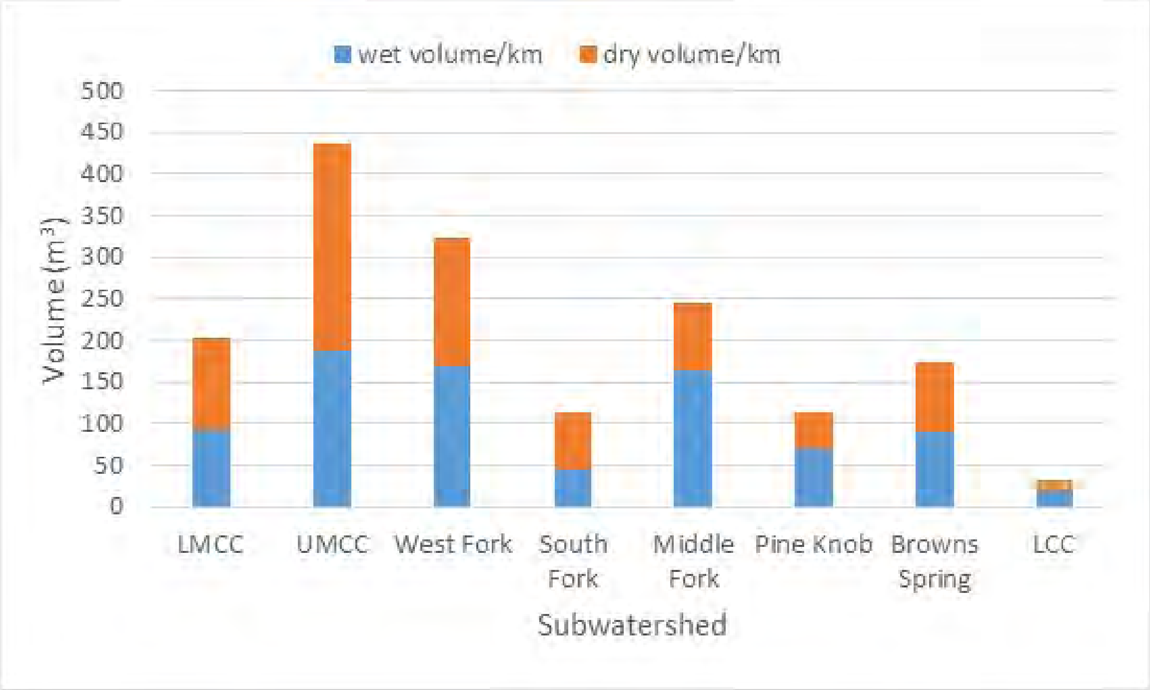

Figure 41. LWD volume (m^3/km), by subwatershed.

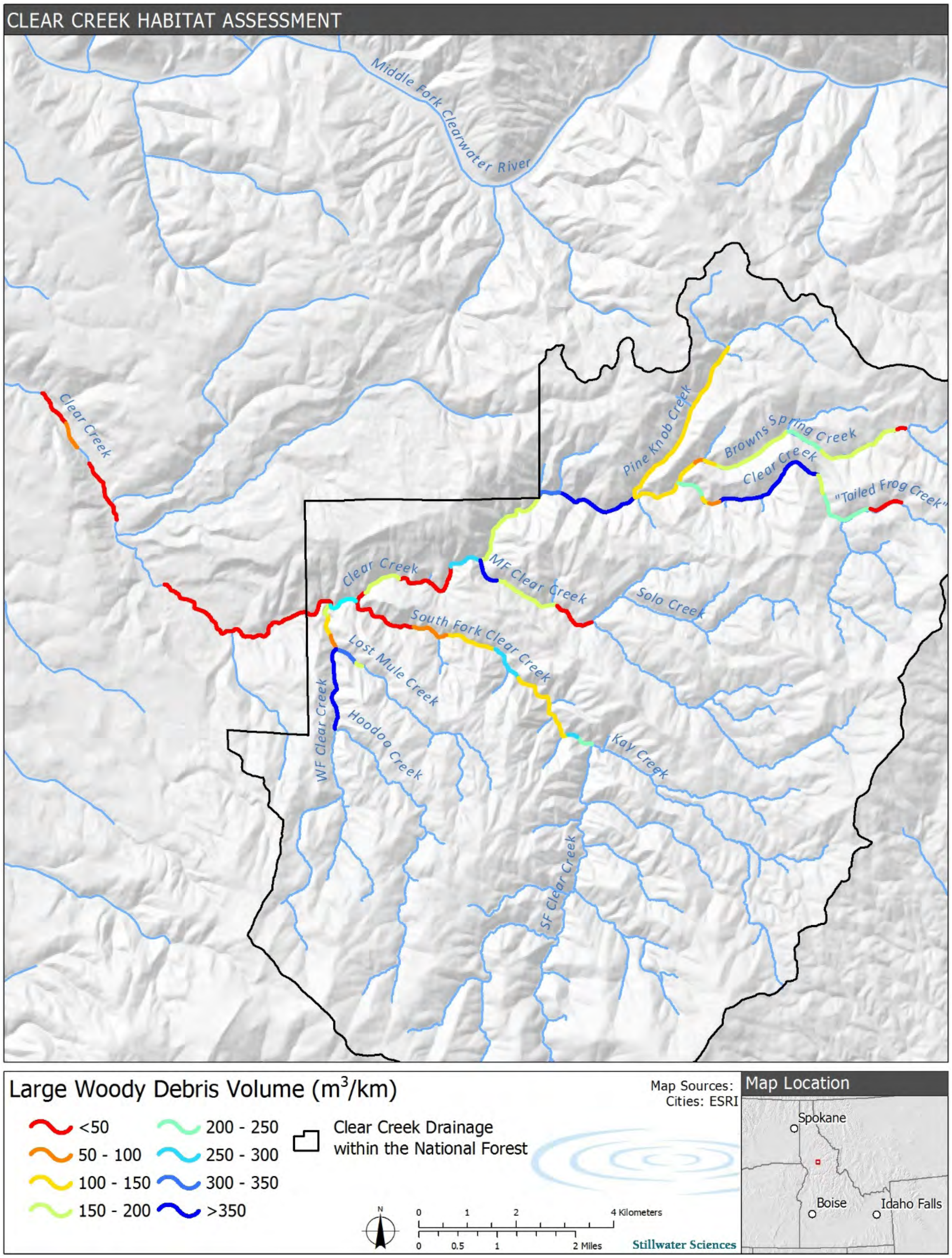

Figure 42. LWD volume (m^3/km), by study reach.

LWD volume within reach classifications is variable both between and within reach types (Figure 43), with the exception being the lowest gradient reaches with the largest drainage areas, which consistently have the lowest amount of LWD. This is not unexpected, as these reaches have higher potential to transport LWD downstream, may have historically been cleared of instream wood and large riparian tress, or were affected by wildfires in the early 1900s. Most reaches in West Fork Clear Creek have consistently high volumes of LWD, whereas the reaches within other subwatersheds are variable. Overall, it appears that abundance of LWD is not strongly correlated with gradient and drainage area except for low-gradient, high drainage area reaches.

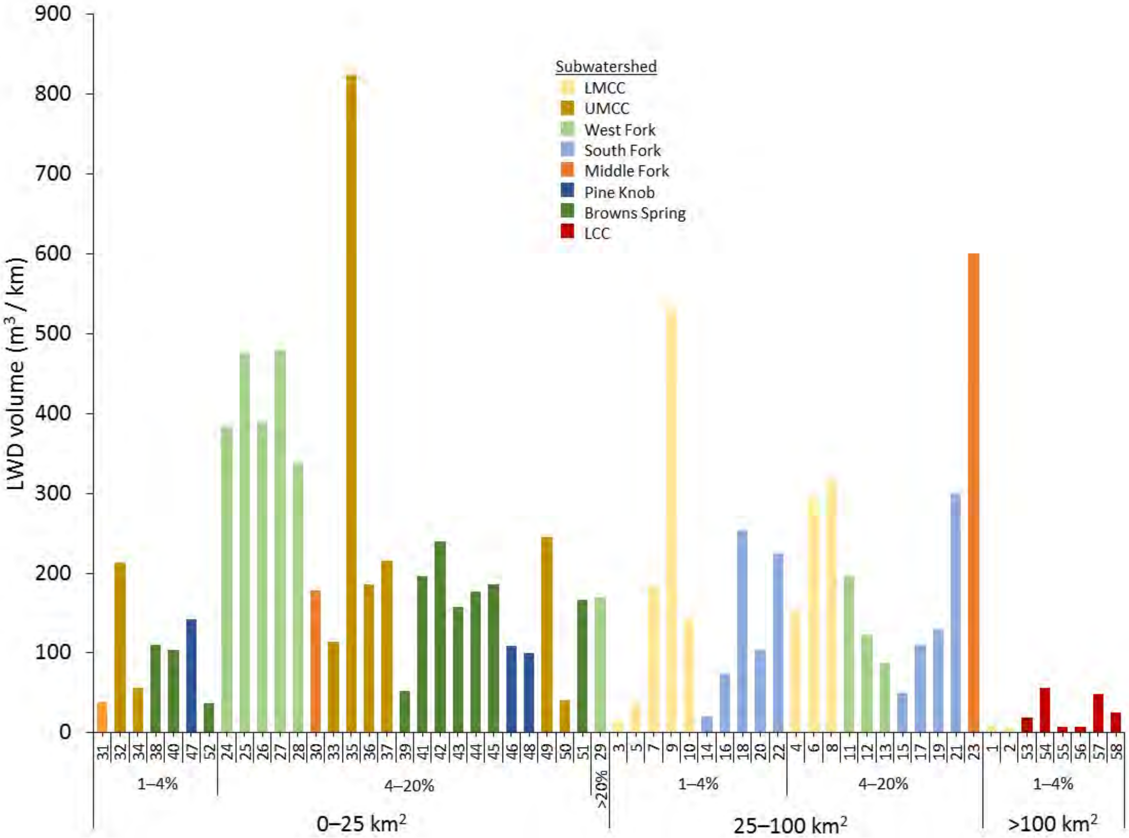

Figure 43. LWD volume (m^3/km), by study reach for drainage area and channel gradient categories.

Log jams (accumulations with at least five pieces of qualifying wood) were also tallied and measured (the number and volume of wet, dry and key pieces found in jams are included in the above tallies as well). Total jam volume and jam volume per length of stream were greatest in the LMCC and UMCC subwatersheds and lowest in LCC (Table 26). The frequency of LWD jams within the National Forest was highest in the UMCC (4.7/km) and in West Fork (4.8 jams/km), with the lowest in South Fork (1.6 jams/km) (Figure 42). LWD jam frequency on the private lands in Lower Clear Creek (0.1 jams/km) were substantially lower than observed on the National Forest. Log jams in lower mainstem and upper mainstem Clear Creek were larger compared with those in West Fork, resulting in a larger relative volume contribution in mainstem reaches within the National Forest (Table 26, Figure 44).

Table 26. Number, piece counts, and volume of LWD jams, by subwatershed.

Variable	LMCC	UMCC	West Fork	South Fork	Middle Fork	Browns Spring	Pine Knob	LCC
Number of jams with 5–10 pieces	14	25	13	8	4	13	8	-
Number of jams with 10–50 pieces	11	7	4	3	2	2	-	1
Number of jams with 50–100 pieces	1	-	-	-	-	-	-	-
Total number of jams	26	32	17	11	6	15	8	1
Total jam volume (m^3)	2,395	1,435	225	408	444	635	47	17
Jam volume per unit length (m^3/km)	205	209	58	56	133	102	11	2

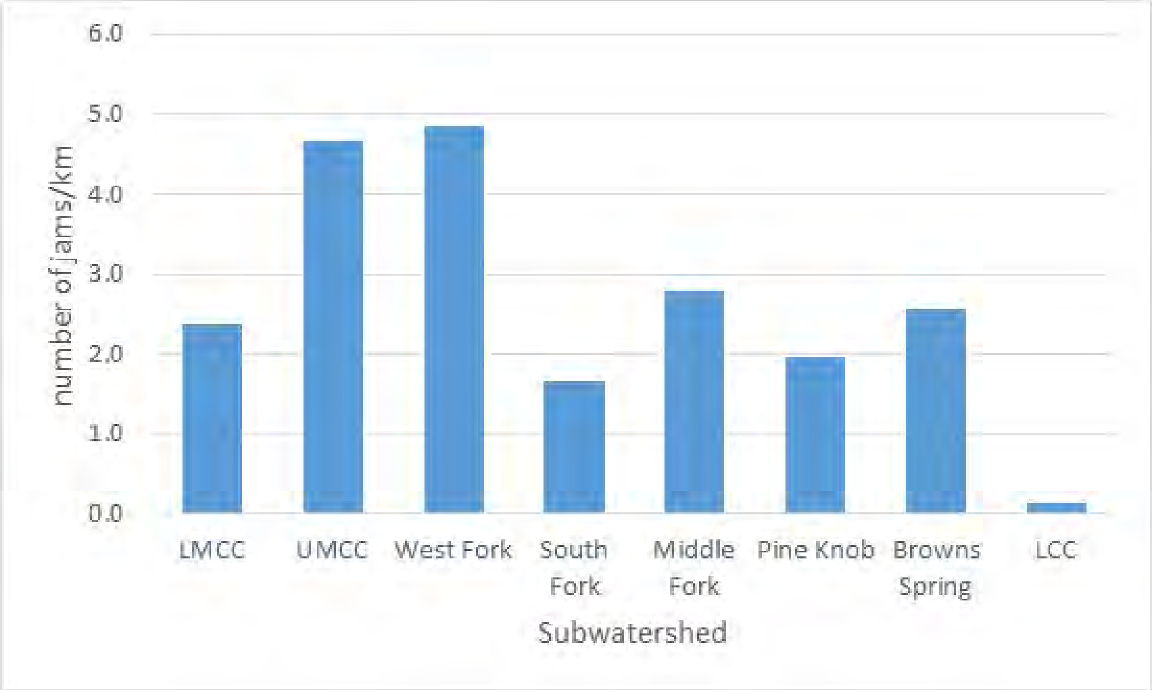

Figure 44. Number of log jams per stream kilometer, by subwatershed.

3.4.7 Spawning gravel

The quantity and quality of suitable spawning gravel was assessed in each habitat unit surveyed. Suitable gravels for anadromous and resident salmonids were delineated separately based on gravel size criteria. Suitable gravel patches on the stream margin that were dry at the time of the surveys, but expected to be inundated at moderate winter and spring stream flows (based on professional judgement) were included along with wet gravels in suitable gravel area estimates for each habitat unit. These dry (at the time of the survey) patches are more likely to be used by steelhead or coho salmon, as they generally spawn when stream flows are higher compared with Chinook salmon, which generally spawn during lower flows. Spawning gravel quality within potentially suitable spawning patches was classified as good, fair, or poor based on patch and substrate particle characteristics. Detailed methodologies for assessing spawning gravel quantity and quality are described in Appendix B.

Anadromous spawning gravel quantity within the National Forest rated as good or fair (combined), ranged from 12 m^2/km in the West Fork to 121 m^2/km in Lower Mainstem Clear Creek (Table 27, Figure 45). Anadromous spawning gravel quantity exceeded 50 m^2/km in the upper mainstem, lower mainstem, and South Fork subwatersheds, and was less than 25 m^2/km in the West Fork and Pine Knob subwatersheds. Anadromous spawning gravel was far more abundant on private land in lower Clear Creek, with gravel quantity exceeding 500 m^2/km (Table 27, Figure 46).

Table 27. Spawning gravel quantity and quality, by subwatershed.[1]

Quality rating	LM`CC	UMCC	West Fork	South Fork	Middle Fork	Pine Knob	Browns Spring	LCC
Anadromous patches (patches/km)								
Good	17	4	3	18	6	3	15	22
Fair	27	16	4	18	12	5	14	12
Poor	7	2	0	7	1	0	1	3
Total	**51**	**22**	**7**	**43**	**20**	**8**	**30**	**37**
Anadromous spawning gravel area (m^2/km)								
Good	77	12	5	31	15	10	20	229
Fair	43	40	7	36	19	8	17	249
Poor	10	3	0	9	1	0	1	111
Total	**130**	**55**	**12**	**76**	**35**	**19**	**39**	**589**
Resident patches (patches/km)								
Good	21	16	4	26	6	5	44	12
Fair	37	40	4	22	13	7	30	6
Poor	8	2	0	4	1	0	1	1
Total	**66**	**58**	**8**	**53**	**20**	**12**	**75**	**18**
Resident spawning gravel area (m^2/km)								
Good	52	40	6	16	15	14	23	80
Fair	47	59	7	8	19	9	9	22
Poor	6	2	0	1	1	0	0	3
Total	**104**	**100**	**13**	**26**	**35**	**22**	**32**	**105**

[1] Includes both wet and dry suitable gravels.

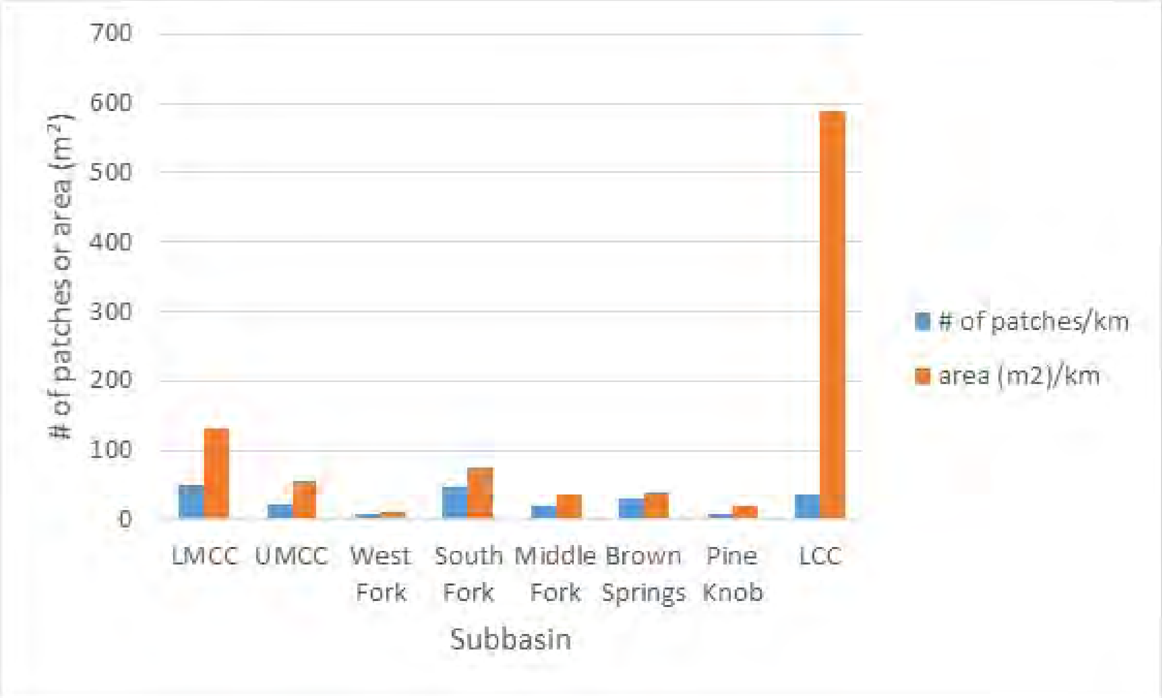

Figure 45. Anadromous salmonid spawning gravel patch frequency and total area (includes good, fair, and poor), by subwatershed.

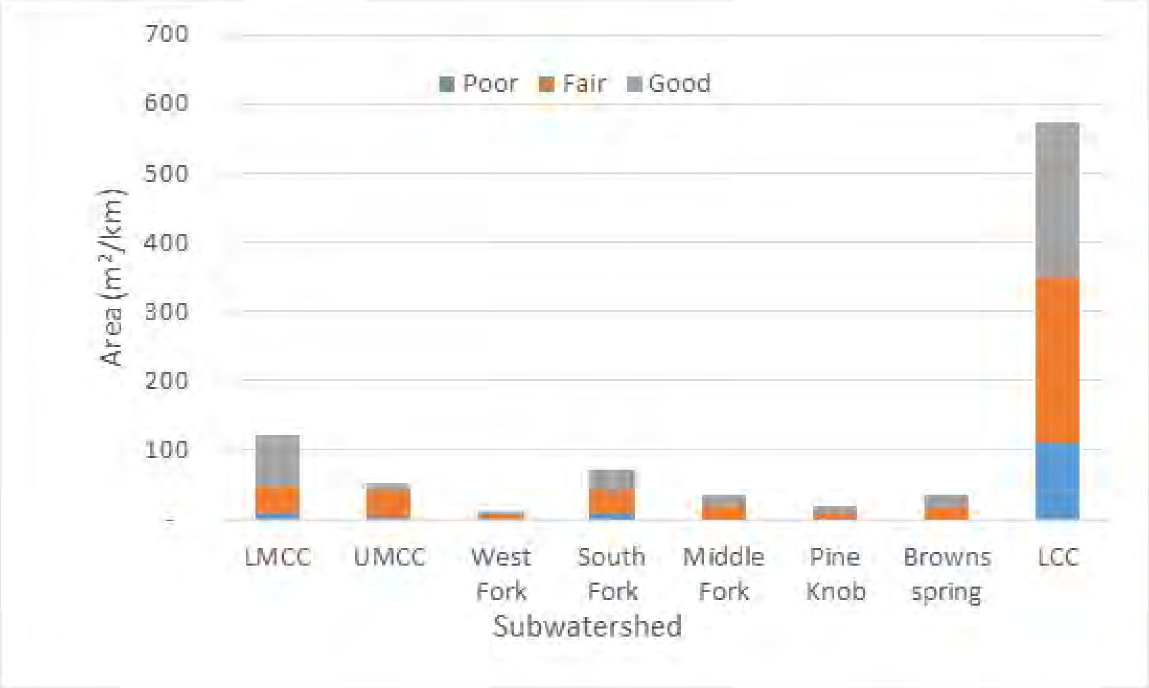

Figure 46. Anadromous salmonid spawning gravel (wet gravel only) quantity (m^2/km), by subwatershed.

Spawning gravels that were dry at the time of the surveys made up a very small percentage of the total suitable spawning gravel identified. Figure 47 illustrates anadromous spawning gravels identified as wet and dry.

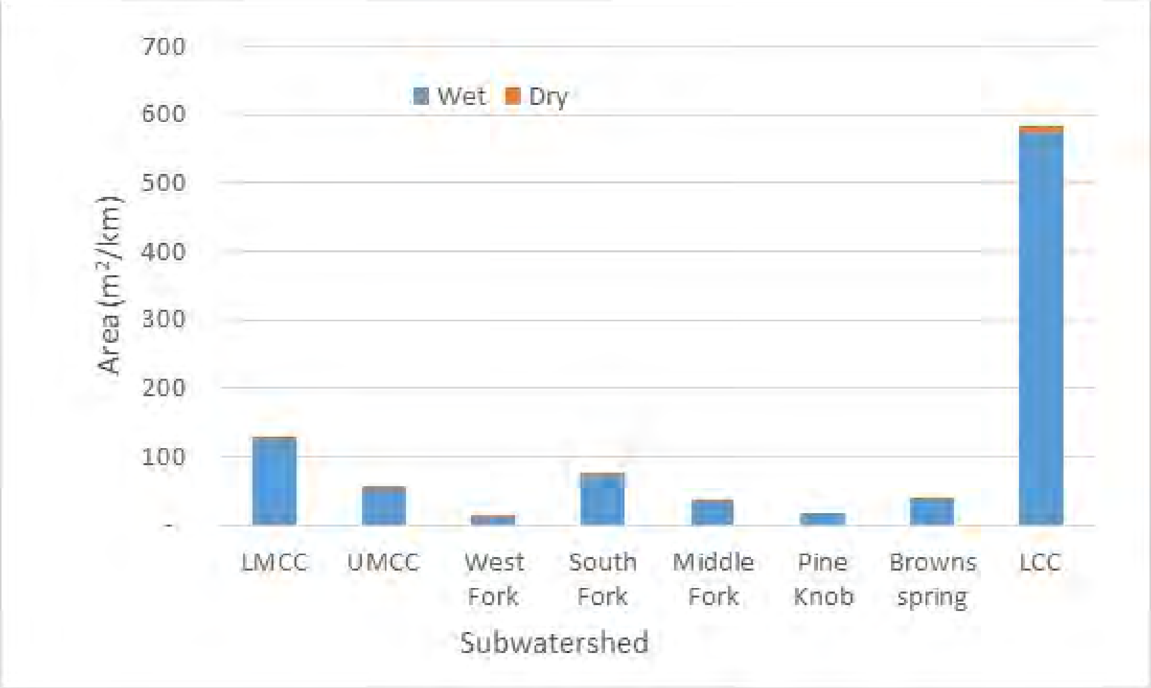

Figure 47. Total area of wet and dry suitable anadromous spawning gravel (m^2/km), by subwatershed.

Anadromous spawning gravel quantity rated as good or fair (combined) was generally less than 150 m^2/km for most of the reaches surveyed within the National Forest, and greater than 150 m^2/km for reaches on private land in lower Clear Creek. Reaches 9 and 10 in lower mainstem Clear Creek and Reach 34 in upper mainstem Clear Creek had the greatest spawning gravel area per unit length (200–250 m^2/km) in the National Forest (Figure 48).

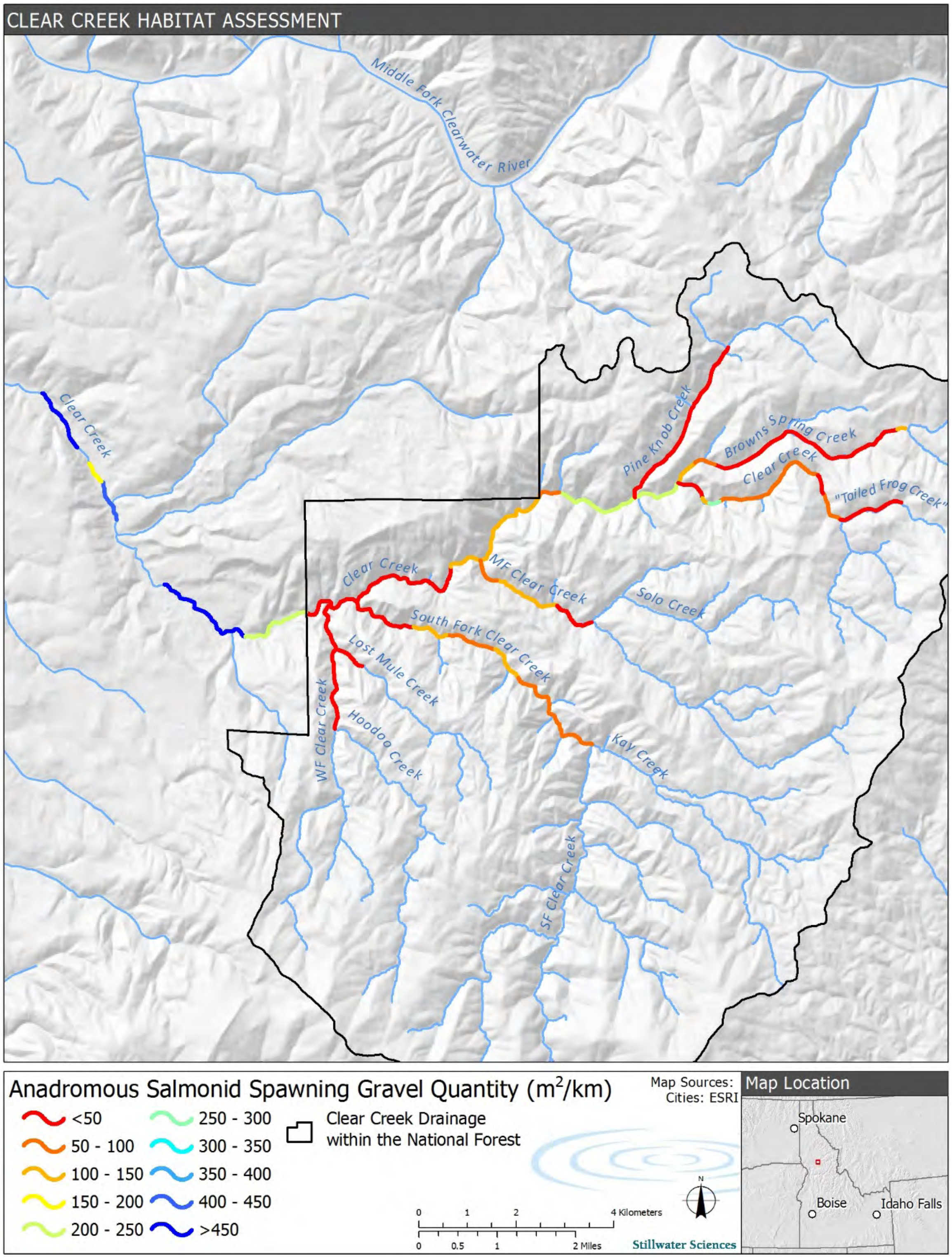

Figure 48. Anadromous spawning gravel quantity (m^2/km) rated good and fair, by study reach.

The abundance of good and fair spawning gravels within reach classifications is variable both between and within reach types (Figure 49). Spawning gravels were by far most abundant in

LCC, which had the lowest gradient and largest drainage area, but this association did not translate to other reaches of the same type (in LCC). In general, drainage area and gradient did not appear to have a strong influence on the abundance of spawning gravels within a subwatershed.

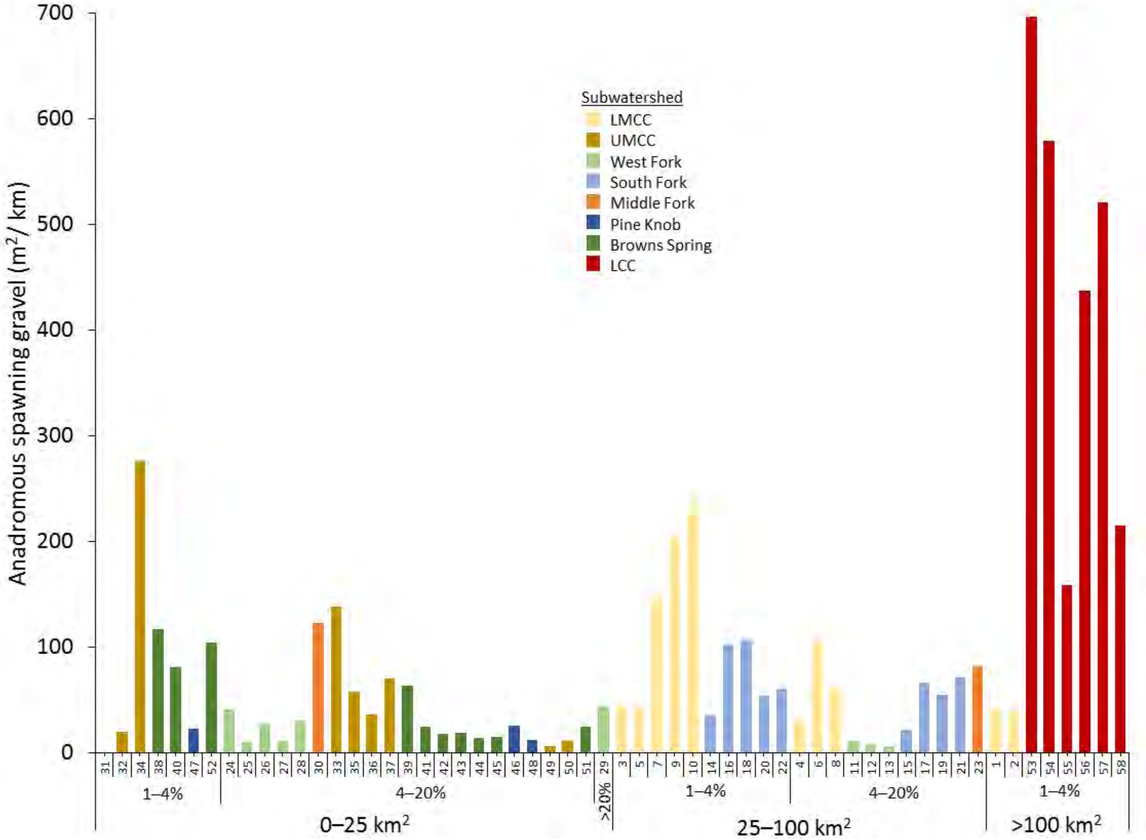

Figure 49. Anadromous spawning gravel quantity (m^2/km) rated good and fair (combined) by study reach ordered by drainage area and channel gradient categories.

Resident spawning gravels within the National Forest rated as good and fair (combined) ranged from 13 m^2/km West Fork Clear Creek to 98 m^2/km in Lower Mainstem Clear Creek (Table 27, Figure 50). Resident spawning gravel quantity exceeded 50 m^2/km in the upper mainstem and lower mainstem subwatersheds, and was less than 25 m^2/km in the West Fork, South Fork, and Pine Knob subwatersheds. Resident spawning gravel abundance on private land in lower Clear Creek was 93 m^2/km, slightly lower than observed in the lower mainstem and upper mainstem subwatersheds (Table 27, Figure 51).

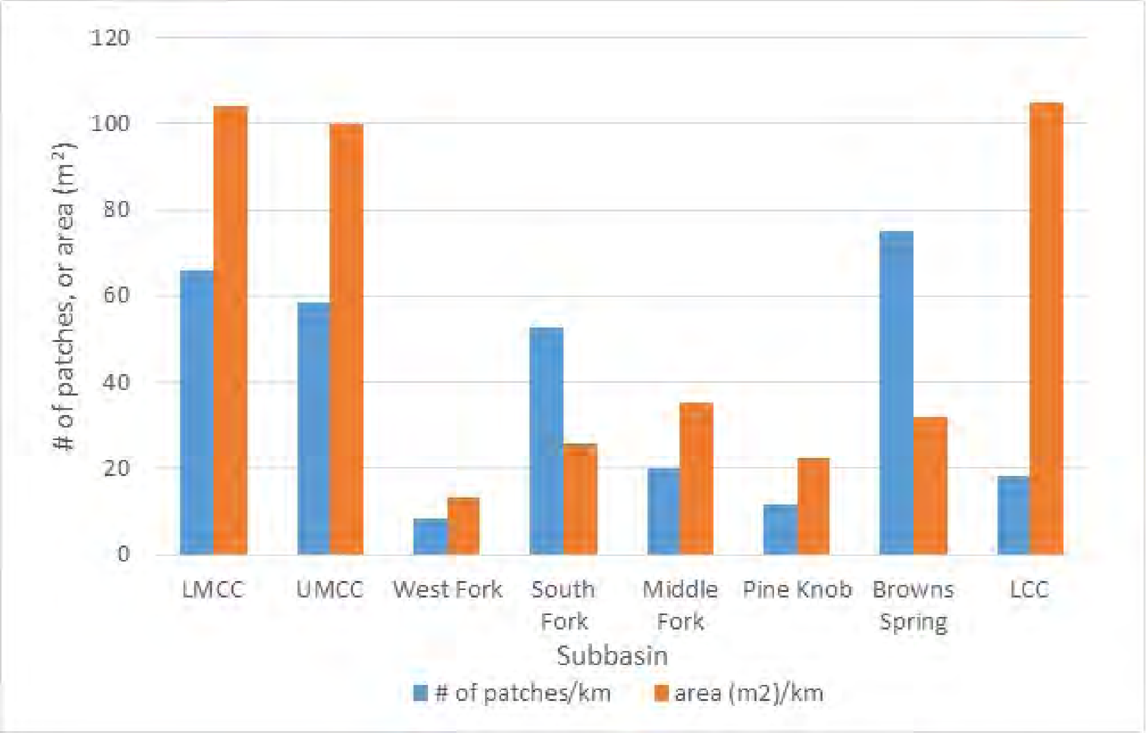

Figure 50. Resident salmonid spawning gravel patch frequency (patches/km) and total area (m^2) (good, fair, and poor), by subwatershed.

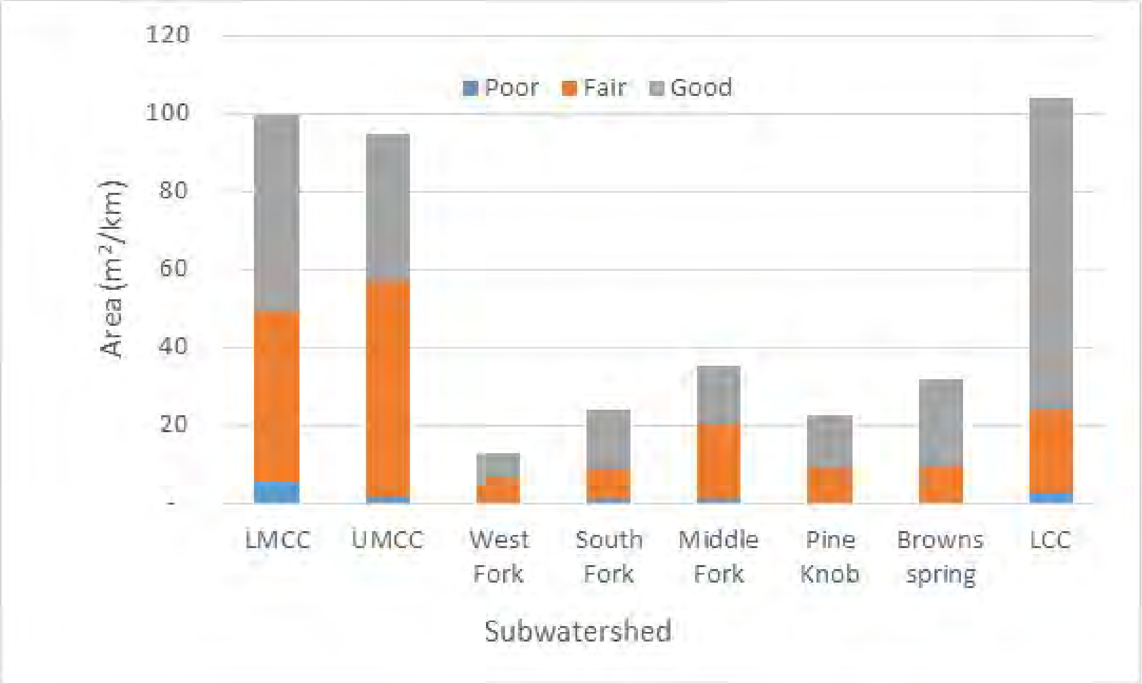

Figure 51. Resident salmonid spawning gravel quantity (m^2/km), by subwatershed.

Resident spawning gravel quantity rated good and fair (combined), was generally less than 200 m^2/km for most of the reaches surveyed in the study area. Reaches 33 and 34 in upper mainstem Clear Creek had greatest gravel area per unit length (>300 m^2/km) in the study area (Figure 52).

As with anadromous spawning gravels, gravels that were dry at the time of the survey were a small percentage of the total identified spawning gravels (Figure 53).

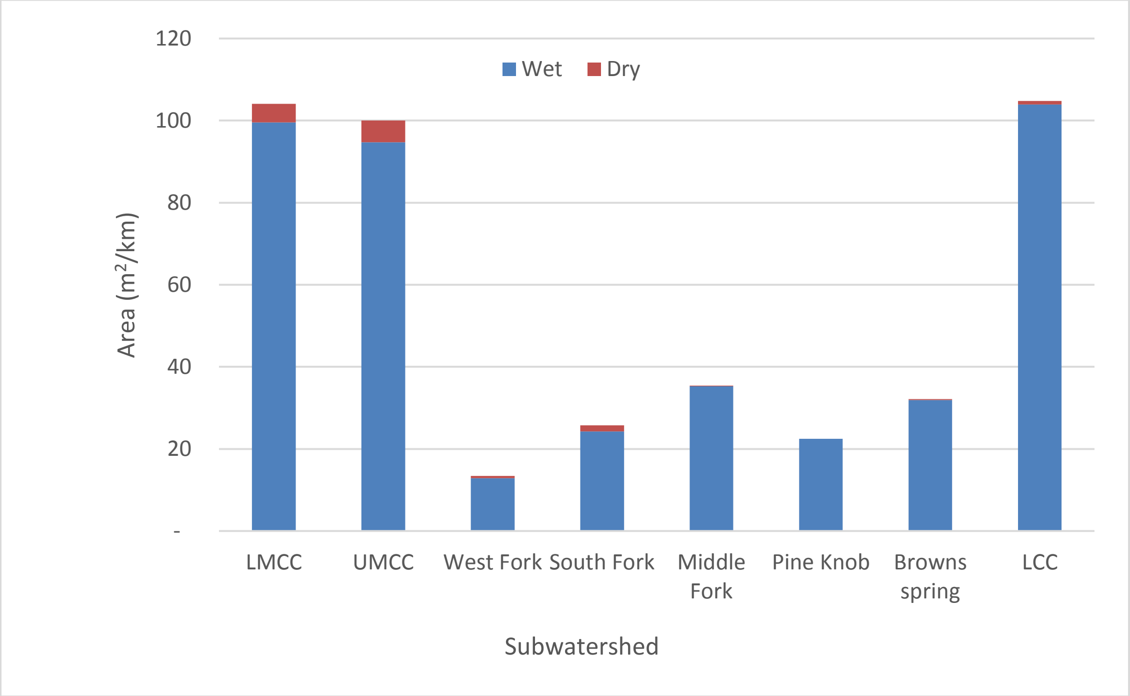

Figure 52. Resident salmonid spawning gravel area (m^2/km) (wet and dry), by subwatershed.

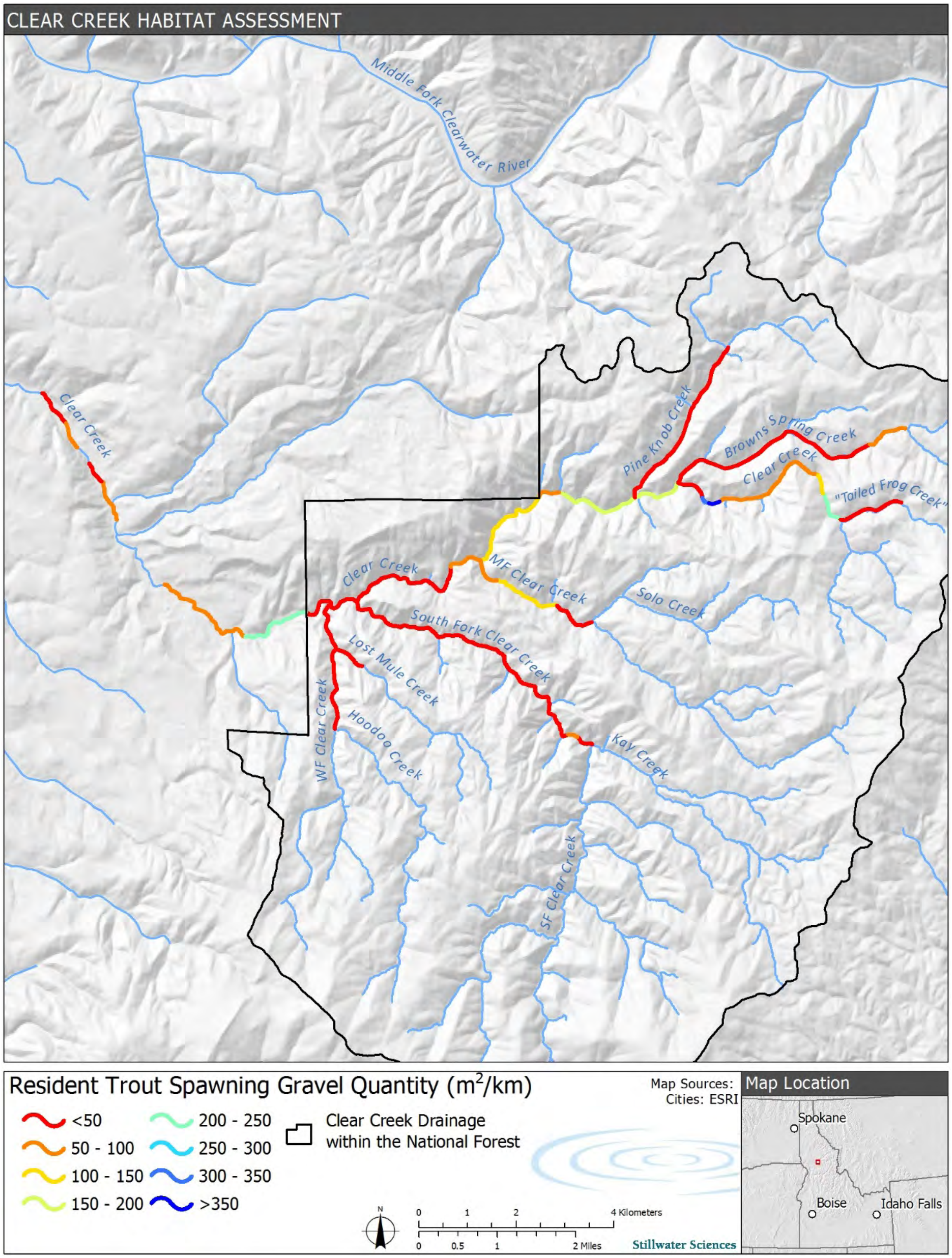

Figure 53. Resident salmonid spawning gravel quantity (m^2/km) rated good and fair, by study reach.

The abundance of good and fair spawning gravels within reach classifications is variable both between and within reach types (Figure 54). Resident spawning gravels were most abundant in UMCC, regardless of gradient and drainage area. In general, drainage area and gradient did not appear to have a strong influence on the abundance of resident spawning gravels.

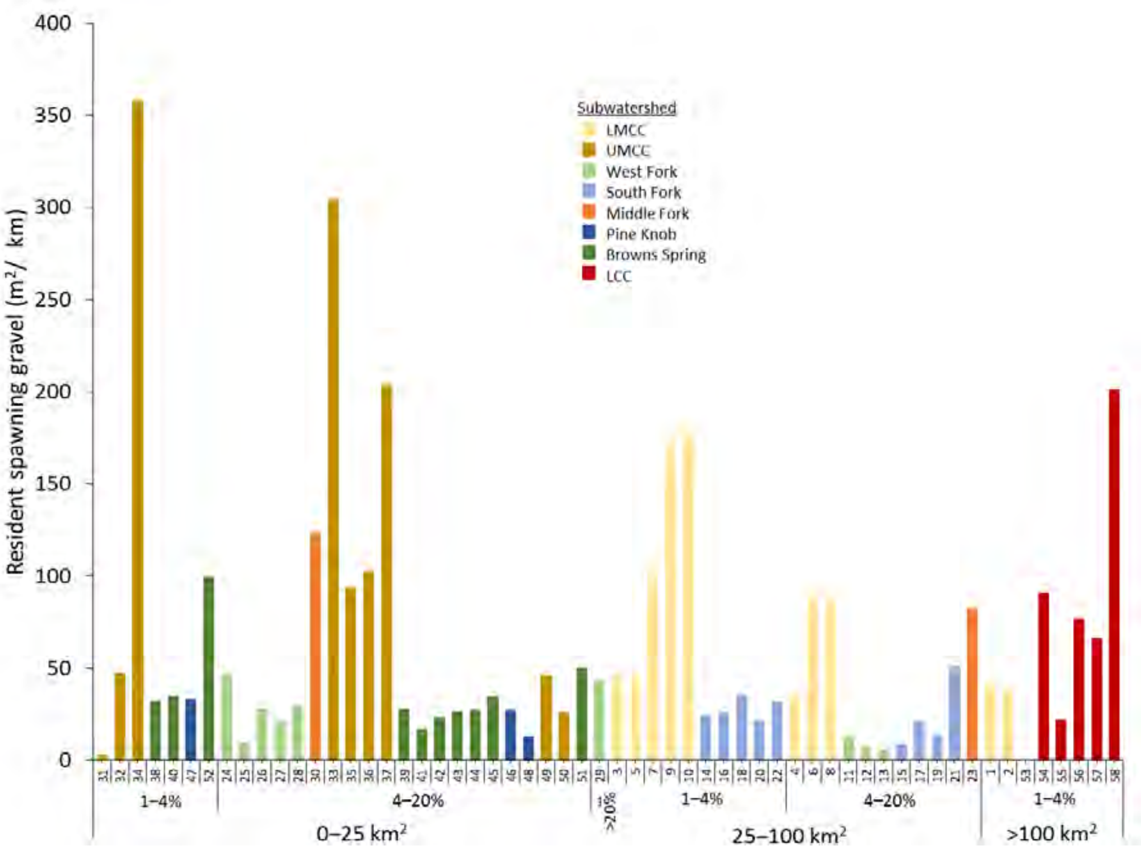

Figure 54. Resident salmonid spawning gravel quantity (m^2/km) rated good and fair (combined), by study reach ordered by drainage area and channel gradient categories.

3.5 Long-term Monitoring Stations

Five long-term monitoring stations were established in the Clear Creek basin. Stillwater Sciences established two long-term monitoring stations, one near the National Forest boundary and the other in West Fork Clear Creek at its confluence with Clear Creek (Figure 55). Each station was permanently monumented, and was approximately 152 m (500 ft) in length. The three other long-term monitoring stations were established by the USDA Forest Service. Monitoring station locations and station IDs include:

- Lower mainstem Clear Creek at the National Forest boundary (LMCC)
- Middle mainstem Clear Creek immediately upstream of its confluence with Middle Fork Clear Creek (MMCC)
- West Fork Clear Creek near its confluence with Clear Creek (WFCC)
- South Fork Clear Creek (SFCC)
- Middle Fork Clear Creek (MFCC)

Table 28 presents the study reach number, contributing drainage area, and gradient for each of the monitoring stations.

Table 28. Landscape characteristics of the long-term monitoring stations.

Monitoring station	Study reach #	Contributing drainage area (km^2)	Channel gradient (%)
LMCC	1	172	1.6
MMCC	7	47	2.8
WFCC	11	26	5.9
SFCC	16	64	3.1
MFCC	23	25	5.3

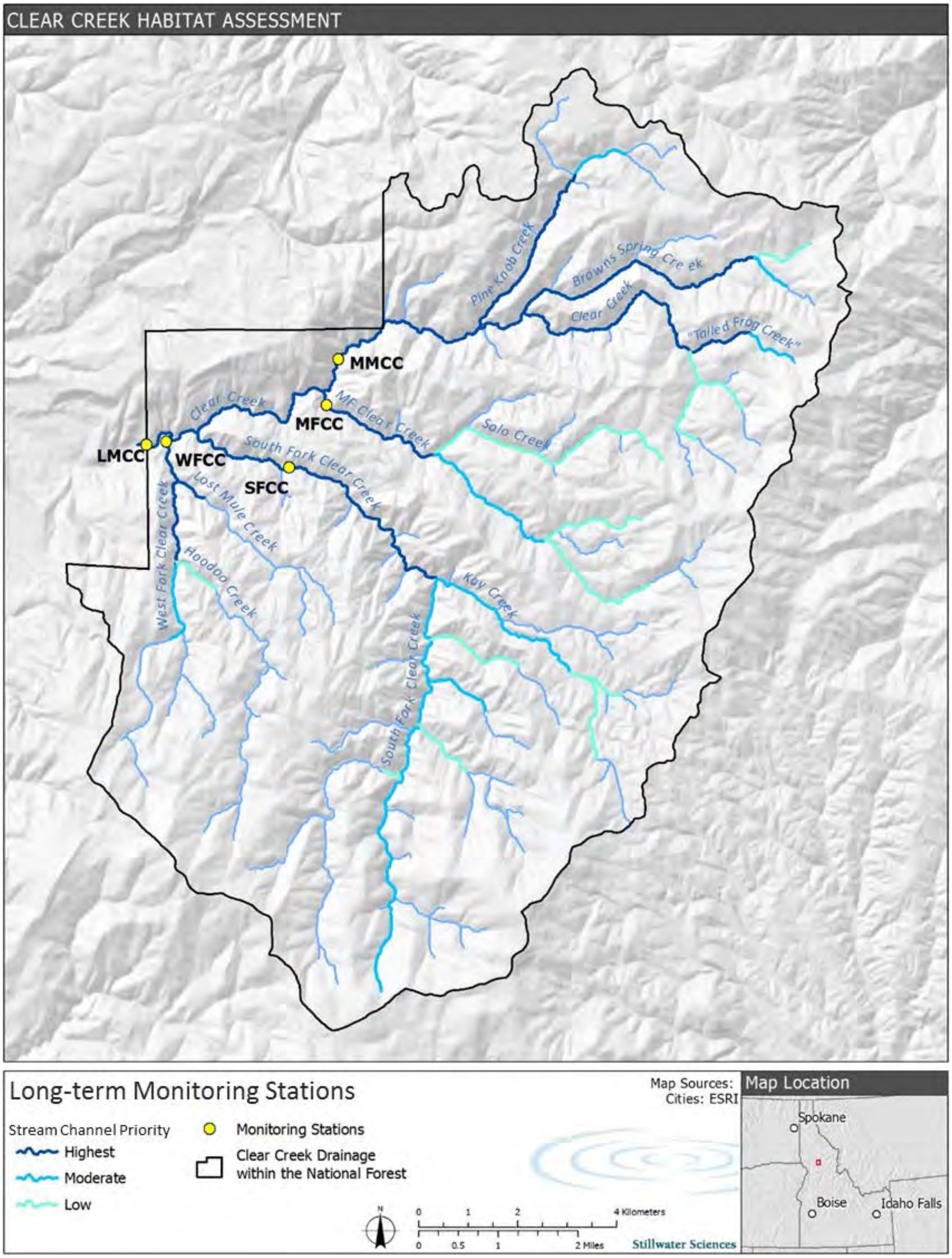

Figure 55. Long-term monitoring station locations.

Due to the hot summer and stream flows, water temperatures at the LMCC monitoring station at were in excess of 20ºC the end of reach-level field surveys (when electrofishing was scheduled to be conducted). This is greater than the 18ºC threshold above which the National Marine Fisheries Service (NMFS) does not allow electrofishing to occur under their scientific collection permits. Water temperature in West Fork Clear Creek remained at or below 18ºC, and Stillwater Sciences conducted electrofishing at the West Fork Clear Creek monitoring station during the originally scheduled field effort. Additional electrofishing surveys were delayed until water temperatures decreased to below 18°C. Since fish population monitoring using electrofishing had not previously been conducted at the three long-term monitoring stations established by the USDA Forest Service, electrofishing surveys were performed by Stillwater Sciences at the four remaining monitoring stations once water temperatures decreased to <18°C.

Profile surveying, discharge measurements, pebble counts, and embeddedness measurement of LMCC occurred on 10 August 2015. Pebble counts and embeddedness measurements of the West Fork monitoring station occurred on 10 August 2015. Profile surveying and discharge measurements were conducted on West Fork on 11 August 2015.

3.5.1 Longitudinal and cross-section profiles

Lower Mainstem Clear Creek

The monitoring station on lower mainstem Clear Creek (LMCC) was established immediately downstream of the National Forest boundary (with the upstream end of the 152 m (500 ft) monitoring station being adjacent to the Clearwater National Forest boundary marker). The channel within the LMCC long-term monitoring station is morphologically comparable to the Clear Creek channel immediately upstream within the National Forestry boundary.

The LMCC monitoring station in the lower mainstem extends 152 m (500 ft) downstream from the National Forest boundary. The downstream end is marked by a rebar stake driven into the right bank and flagged. The benchmark established is a large spike driven into the base of a multi-trunked aspen tree on river right near the downstream end of the monitoring station. The benchmark tree also has the temperature data loggers attached to it. Cross-section transects were established (and marked on each bank with rebar stakes) 33.5 m (110 ft), 82 m (269 ft), and 109 m (359 ft) upstream of the downstream end of the monitoring station.

The longitudinal profile was developed based on elevations surveyed in the thalweg relative to the benchmark (arbitrarily assigned an elevation of 100.00 ft). The elevational difference from the top to the bottom of the monitoring station was 2.8 m (9.2 ft), a gradient of 1.8% (Figure 56). The deepest area on the longitudinal transect was a pool at station 13.7 m (45 ft) (from the downstream end) with an elevation of 93.9 ft (or 0.8 ft lower than the downstream end).

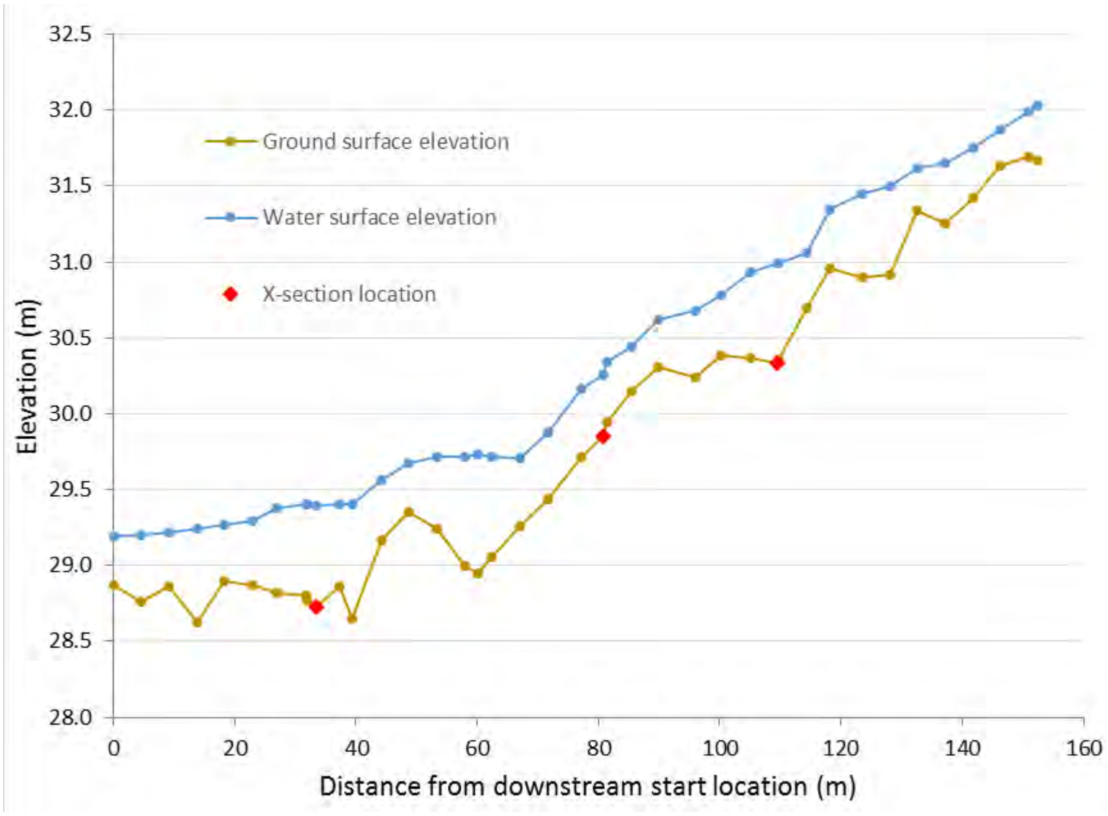

Figure 56. Longitudinal profile of the LMCC monitoring station.

Because of the prevalence of boulders within the station, it was difficult to select cross-section locations with gently sloping banks that would be more sensitive to erosion or other long-term changes than would banks armored with boulders. Cross-sectional profiles were surveyed at locations to capture dominant breaks in bed topography (Figures 57–59). On average, bankfull width at the LMCC monitoring station was 10.4 m (34.2 ft), with a bankfull depth of 0.9 m (3.0 ft), and a corresponding width:depth ratio of 11.4 (Table 29). Wetted-width averaged 7.9 m (25.8 ft).

Table 29. Channel cross-section characteristics at the LMCC long-term monitoring station.

Cross-section transect	Bankfull width m (ft)	Bankfull depth m (ft)	Width:depth	Wetted-width m (ft)
1	12.5 (41.1)	1.0 (3.3)	12.5	10.8 (35.4)
2	8.4 (27.5)	0.7 (2.3)	12.2	5.4 (17.8)
3	10.4 (34.2)	1.0 (3.3)	10.5	7.4 (24.3)
Average	**10.4 (34.2)**	**0.9 (3.0)**	**11.4**	**7.9 (25.8)**

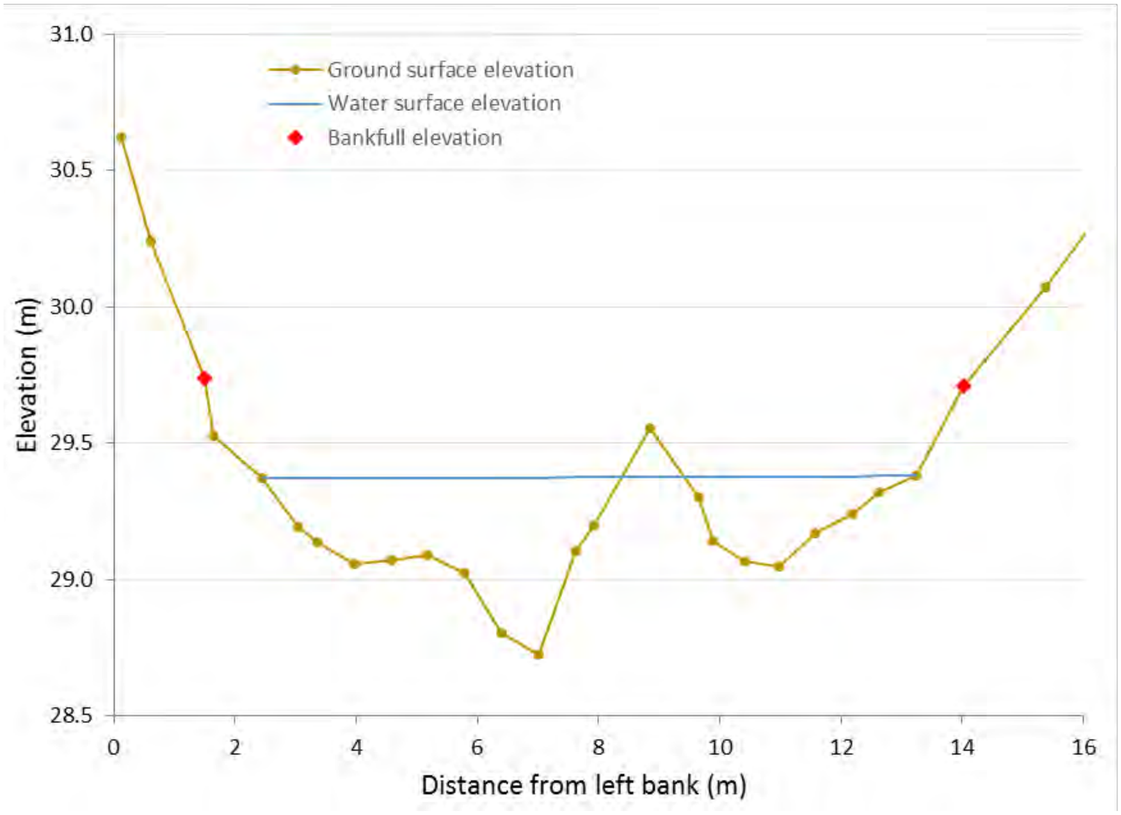

Figure 57. Cross-section profile at Transect 1 for the LMCC monitoring station.

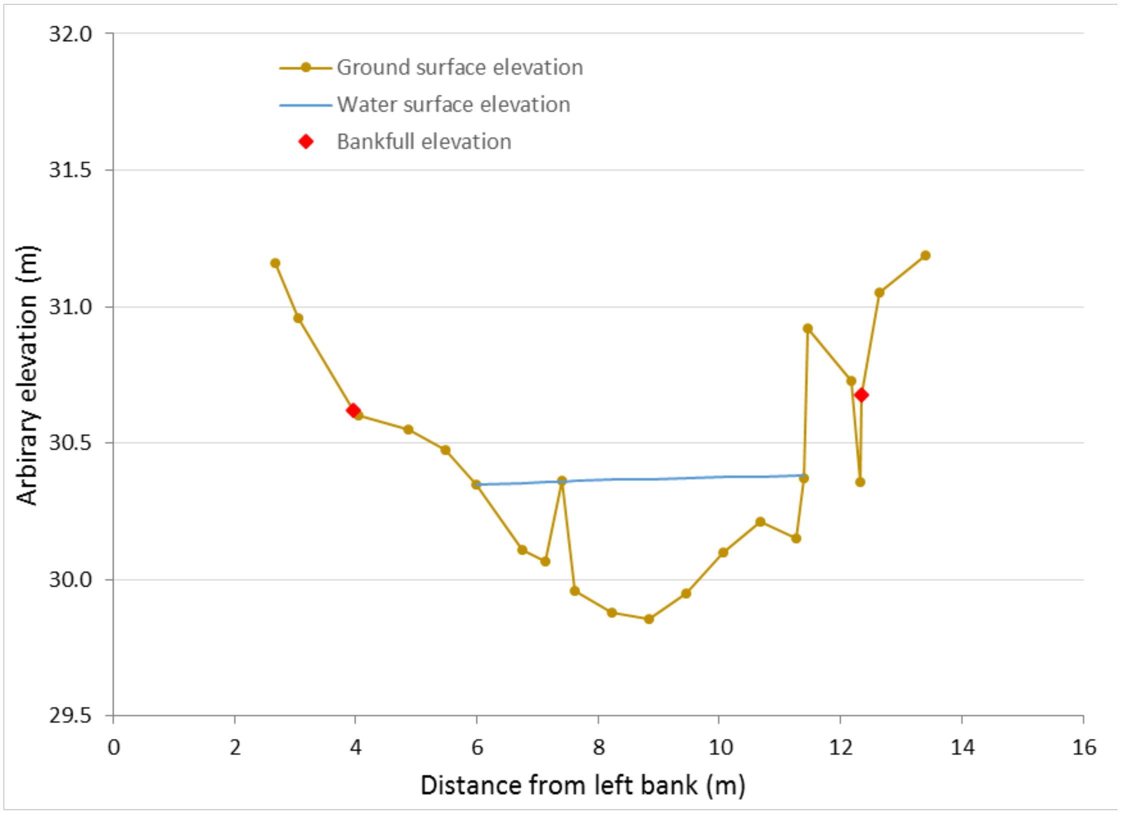

Figure 58. Cross-section profile at Transect 2 for the LMCC monitoring station.

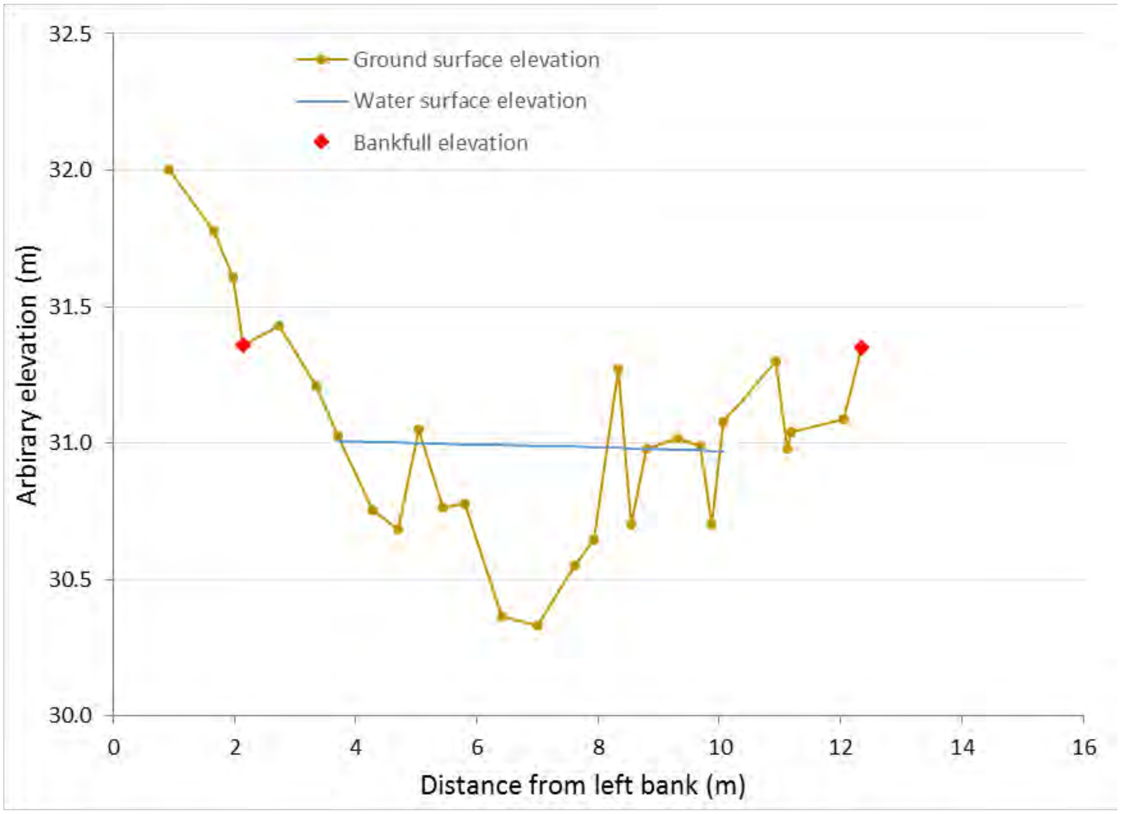

Figure 59. Cross-section profile at Transect 3 for the LMCC monitoring station.

West Fork Clear Creek (WFCC)

The monitoring station in West Fork Clear Creek (WFCC) extends from the head of a pool at the creek confluence, to 152 m (500 ft) upstream. The downstream end is marked by a rebar stake driven into the left bank and flagged. The benchmark established is a large spike driven into the base of an alder tree on river right approximately 33.6 m (110 ft) from the downstream end of the monitoring station. The elevational difference from the top to the bottom of the monitoring station was 8.6 m (28.4 ft), or a 5.7% gradient (Figure 60). The deepest area on the longitudinal transect was a pool at station 2.1 m (7 ft) (from the downstream end) with an elevation of 26.1 m (85.5 ft) [or 0.27 m (0.9 ft) lower than the downstream end].

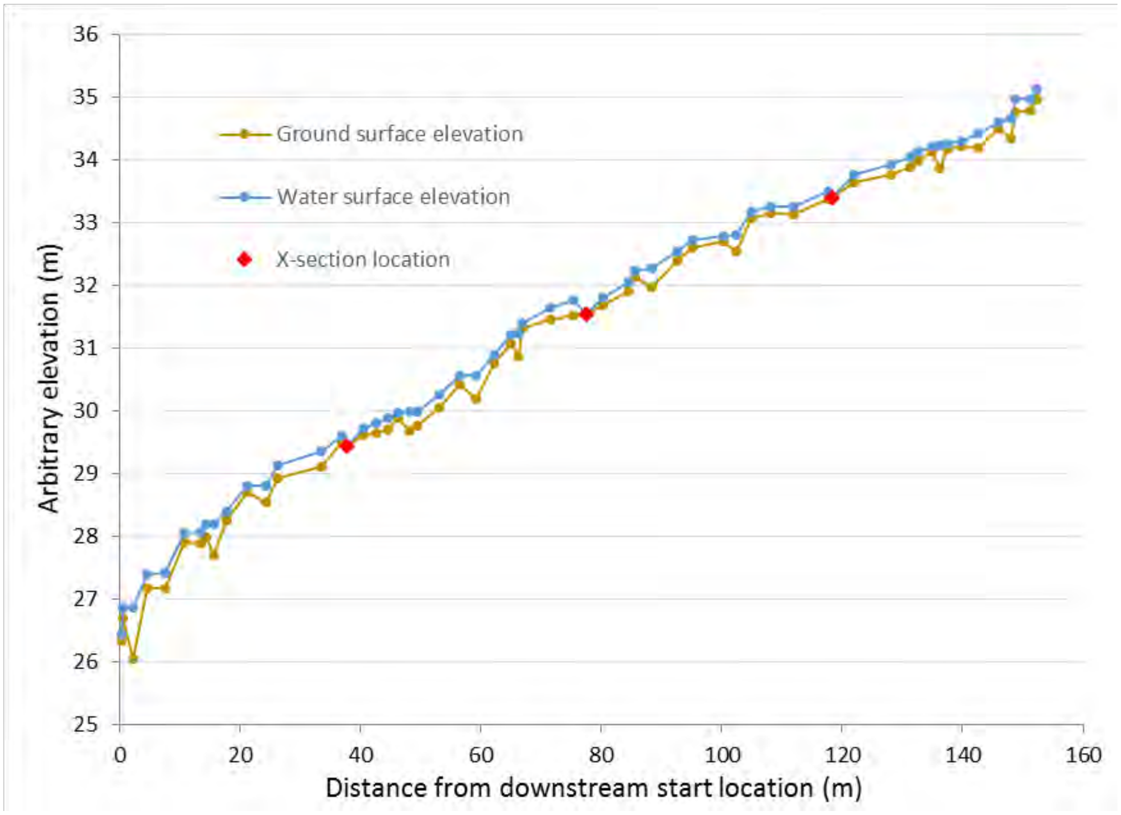

Figure 60. Longitudinal profile of the WFCC monitoring station.

The channel at the WFCC station was much smaller, less confined, and less boulder-dominated than the LMCC station. As a result, channel cross-sections were selected with more gently sloping banks. Cross-section transects were established (and marked on each bank with rebar stakes and flagging) at 38 m (124 ft), 77 m (254 ft), and 116 m (379 ft) from the downstream end of the monitoring station. On average, bankfull width at the West Fork monitoring station was 4.0 m (13.0 ft), with a bankfull depth of 0.5 m (1.6 ft), and a corresponding width:depth ratio of 8.1. Wetted-width averaged 2.3 m (7.5 ft) (Table 30). Figures 61–63 illustrate WFCC cross-sections.

Table 30. Cross-sectional characteristics at the WFCC long-term monitoring station.

Cross-section transect	Bankfull width m (ft)	Bankfull depth m (ft)	Width:depth m (ft)	Wetted-width m (ft)
1	3.3 (10.7)	0.4 (1.2)	8.7	2.3 (7.5)
2	4.5 (14.6)	0.5 (1.7)	8.7	2.1 (7.0)
3	4.2 (13.8)	0.5 (1.8)	7.7	2.4 (8.0)
Average	**4.0 (13.0)**	**0.5 (1.6)**	**8.1**	**2.3 (7.5)**

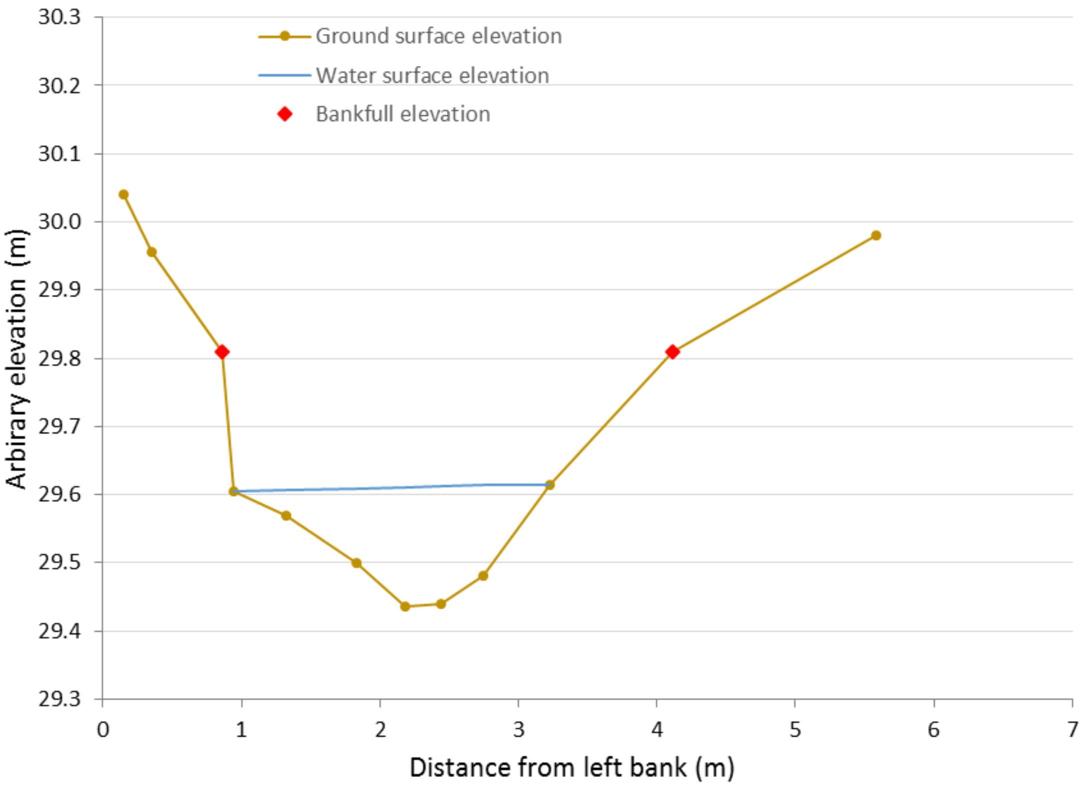

Figure 61. Cross-section profile at Transect 1 for the WFCC monitoring station.

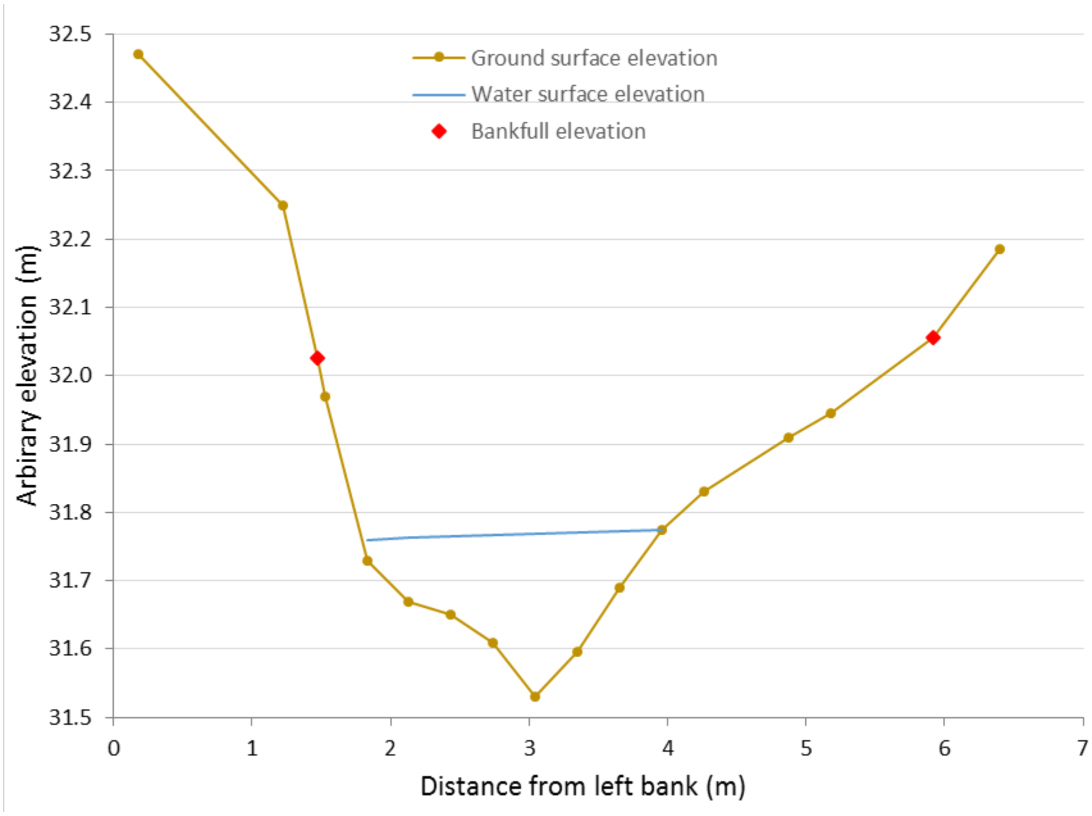

Figure 62. Cross-section profile at Transect 2 for the WFCC monitoring station.

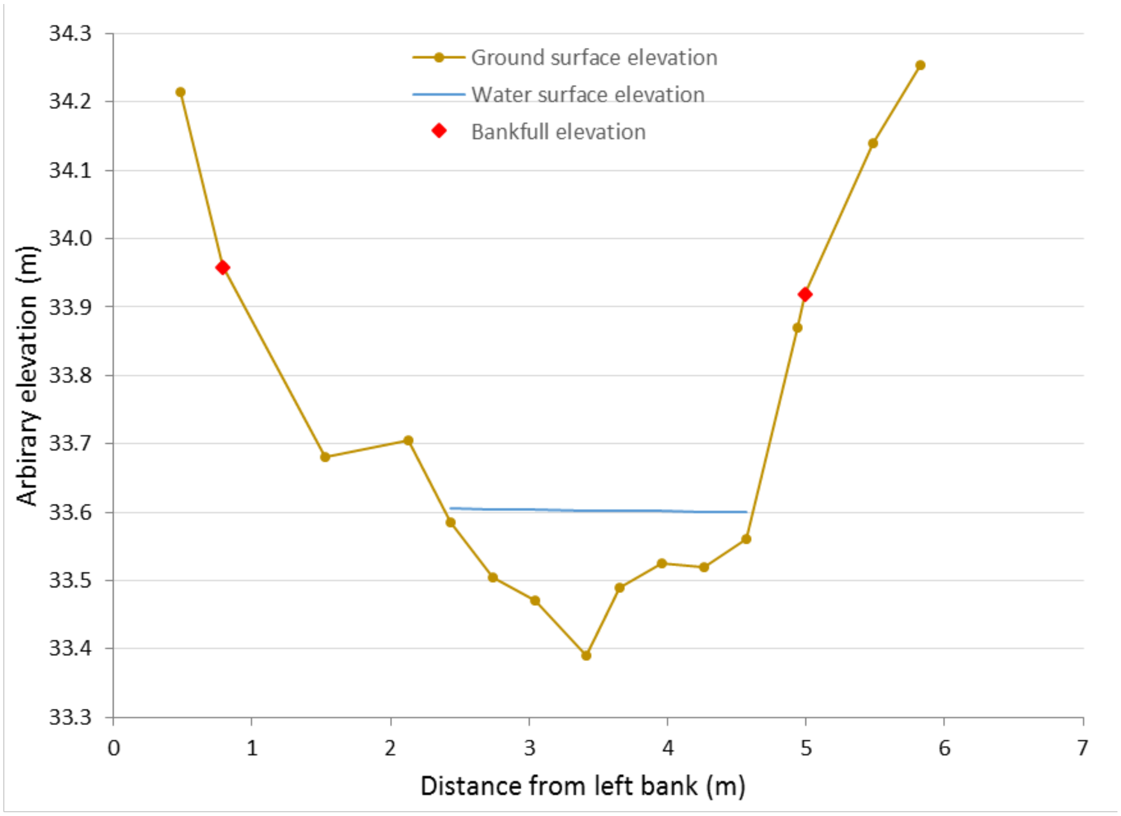

Figure 63. Cross-section profile at Transect 3 for the WFCC monitoring station.

3.5.2 Stream discharge

Stream discharge (in cubic feet per second [cfs]) was measured twice at each of the two long-term monitoring stations with a calibrated Marsh-McBirney Flo-mate model 2000. Stream discharge measured at the lower mainstem Clear Creek and West Fork monitoring stations was approximately 10 cfs and 0.6 cfs, respectively (Table 31). As a rule of thumb, multiple discharge measurements at the same location within about 10% of each other are considered to be within the margin of error of the methodology. Measurements for West Fork Clear Creek slightly exceeded this rule-of-thumb; however, discharge measurements at very low flows (e.g., <1 cfs) can be more difficult to accurately measure within this margin of error.

Table 31. Discharge (in cfs) measurements collected at monitoring stations.

Monitoring station	Measurement 1 (cfs)	Measurement 2 (cfs)	% difference	Average discharge (cfs)
LMCC	10.13	9.45	7%	9.79
WFCC	0.60	0.53	12%	0.57

Discharge measurements are most useful to compare the relative size of streams. And, although they are very “snapshot” in nature, stream discharge is also a useful data point to compare streams year-to-year during summer low flows.

3.5.3 Stream bed surface substrate

One 300-particle pebble count was performed at each of the two monitoring stations (LMCC and WFCC) using methods described in Appendix B. The pebble counts were spread over the entire station, but were separated into four sub-sections defined by the upstream and downstream boundaries of the monitoring station and the three cross-sections (T1–T4 from downstream to upstream). Cumulative particle size distributions are presented for each sub-section within the monitoring station and for the station as a whole for the two stations (Figure 64 and 65). Results indicate that surface substrates at the monitoring station in West Fork Clear Creek are generally finer than those observed at the monitoring station in lower mainstem Clear Creek, particularly as evidenced by d16 and d50 metrics. The sub-section pebble counts indicate greater variability in gravel-sized particles (2–64 mm) at the monitoring station in the lower mainstem Clear Creek compared with the monitoring station West Fork Clear Creek (Figure 64 and 65).

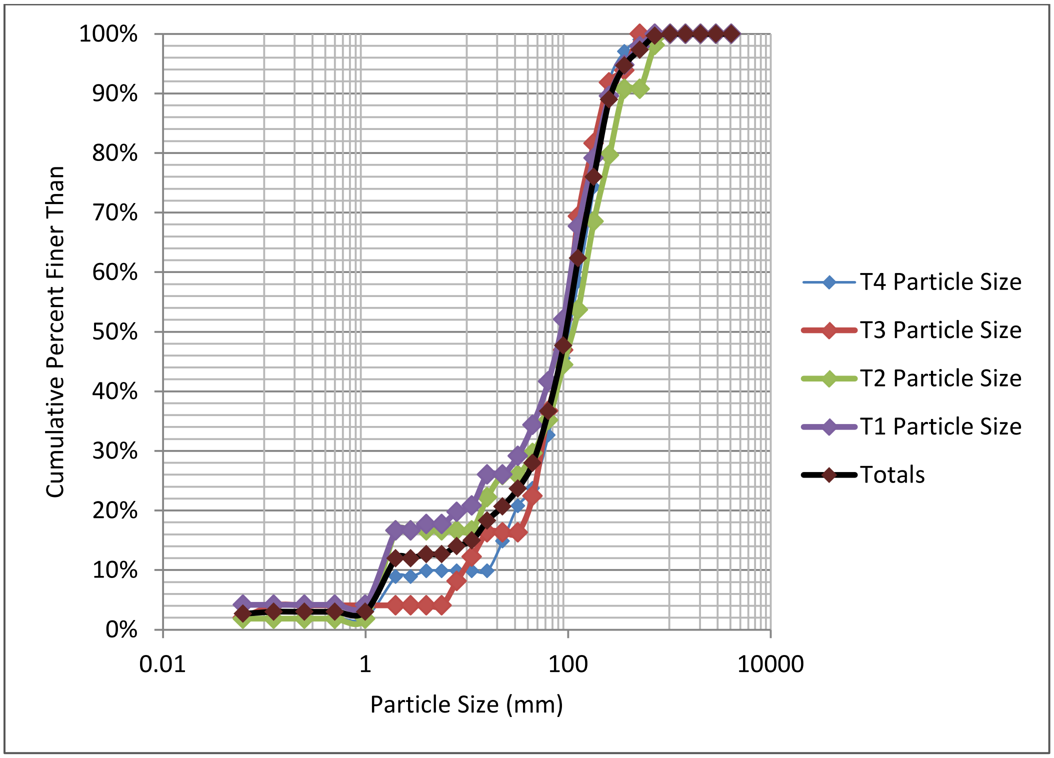

Figure 64. Cumulative substrate particle size distribution at the LMCC monitoring station.

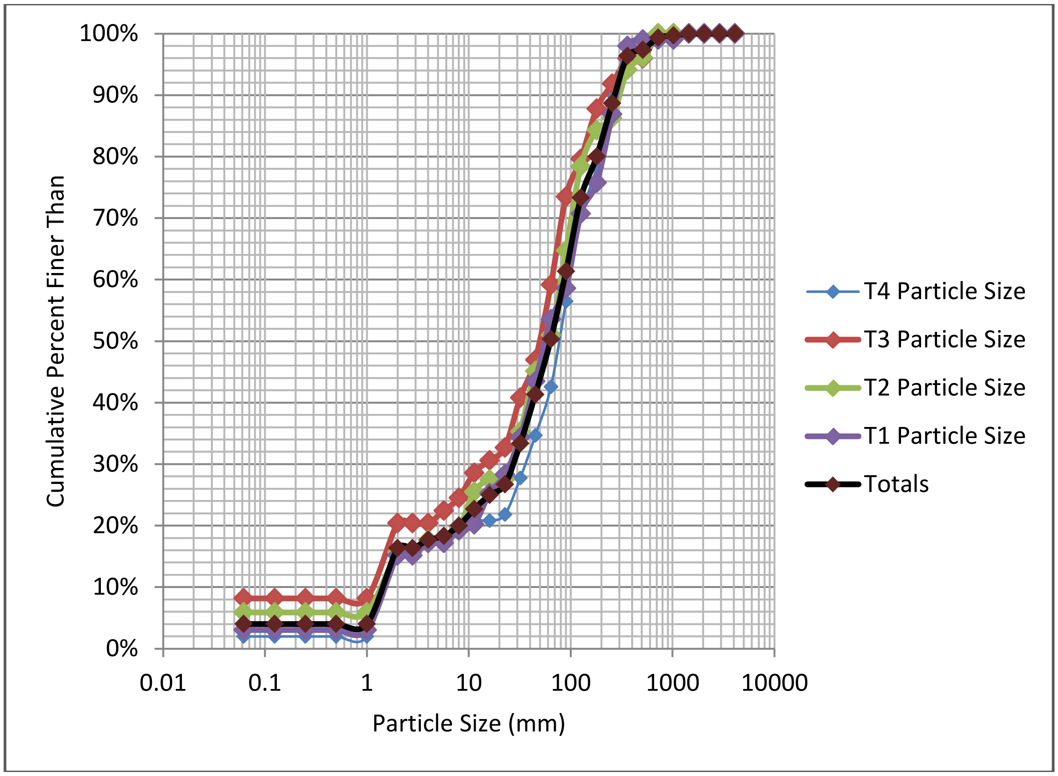

Figure 65. Cumulative substrate particle size distribution at the WFCC monitoring station.

Table 32 shows particle size metrics for the two monitoring stations. The d16, d50, and d84 metrics are typically used as representative grain sizes for sediment: d50 is the median grain size and while d16 and d84 are inversely analogous, with d84 representing the 84th percentile (only 16% of all pebbles measured were larger than the d84 particle size), while d16 represents the 16th percentile. D50 is a useful metric for describing "average" bed particle size. The d16 and d84 provide an indication of whether the particle distribution may be skewed to coarse or fine particles. In this case these metrics indicate that bed substrates were substantially finer at WFCC compared with LMCC.

Table 32. Representative grain sizes for the LMCC and WFCC monitoring stations.

Monitoring station	d16		d50		d84	
	mm	inches	mm	inches	mm	inches
LMCC	13	0.5	96	3.8	227	8.9
WFCC	2	0.08	63	2.5	215	8.5

3.5.4 Cobble embeddedness

Cobble embeddedness was assessed differently at the long-term monitoring stations than it was at the reach-scale transects. Rather than simply estimating the embeddedness of 20 cobble-sized particles, a 60-cm hoop was placed in three locations (at the 25%, 50% and 75% distances across the stream) at three transects, and embeddedness was assessed within the hoop. Weighted embeddedness takes into account the percentage of the total hoop area that is covered by fines.

The data collection and analysis methodologies are described in Appendix B. Because of the different methodologies, the embeddedness at the long-term monitoring stations is not directly comparable with the embeddedness estimates from the reach-scale transects. Tables 33 and 34 illustrate the embeddedness for the LMCC and WFCC monitoring stations.

Table 33. Embeddedness in the LMCC monitoring station.

Transect	Hoop placement	% of hoop area covered by fines	% embedded	% weighted embeddedness
1	25%	100	100	100
	50%	12.5	51.4	57.5
	75%	16.7	71.0	75.9
2	25%	0.0	35.0	35.0
	50%	0.0	63.5	63.5
	75%	0.0	35.0	35.0
3	25%	29.2	54.2	67.5
	50%	0.0	64.9	64.9
	75%	77.1	56.8	90.1
Average		**26.2**	**59.1**	**65.5**
Standard deviation		**33.3**	**17.7**	**19.6**

Table 34. Embeddedness in the WFCC monitoring station.

Transect	Hoop placement	% of hoop area covered by fines	% embedded	% weighted embeddedness
1	25%	10.0	44.0	49.6
	50%	5.0	62.6	64.5
	75%	27.1	74.0	81.0
2	25%	62.5	81.4	93.0
	50%	15.0	73.7	77.6
	75%	20.8	77.0	81.8
3	25%	14.6	70.4	74.7
	50%	31.3	61.2	73.3
	75%	0.0	60.2	60.7
Average		**20.7**	**67.2**	**72.9**
Standard deviation		**16.6**	**10.2**	**11.6**

3.5.5 Air and water temperature

Air and water temperature data loggers were installed at the LMCC and WFCC monitoring stations. The data loggers will be downloaded and maintained by the USDA Forest Service. Air and water temperature data are not summarized in this document. Launch data, UTM coordinates, and location descriptions and photos of the loggers are presented below.

Lower Mainstem Clear Creek

- Launch date/time: 11 July 2015at 11:00am
- UTM Coordinates : 11 T 0590517 E, 5099328 N

- Location description: The loggers were placed in or near a pool located approximately 50 m upstream of the Reach 1 boundary (Figure 66). The water temperature logger was cabled between two large boulders on river-right (looking downstream). The air temperature logger was tied to a branch in an adjacent alder on the right bank, approximately 3 m downstream on of the water temperature logger. Both loggers are flagged with pink flagging and small aluminum tags.

Figure 66. Location of air and water temperature loggers at the LMCC monitoring station.

West Fork Clear Creek

- Launch date/time: 11 July 2015at 12:20pm
- UTM Coordinates : 11 T 0591101 E, 5099474 N
- Location description: The loggers were placed in or near the first pool upstream from the confluence with mainstem Clear Creek (Figure 67). The water temperature logger was cabled between two large boulders on river-left edge of first pool The air temperature logger was tied into the branch of an alder on the left bank edge of the pool, approximately 6 ft above the water surface. Both loggers are flagged with pink flagging and small aluminum tags. Both loggers are across from a large stump on right bank with existing large aluminum tag nailed in. Note also that there was evidence of an older water temperature logger cable deployed in the same location as the new logger.

Figure 67. Location of air and water temperature loggers at the WFCC monitoring station.

3.5.6 Fish abundance

Electrofishing was conducted at each of the five long-term monitoring stations. West Fork Clear Creek was sampled on 11 August 2015, and the four other monitoring stations were sampled from 15 September to 18 September 2015. All monitoring stations were blocked with nets at their upstream and downstream boundaries. Three to four thorough electrofishing passes were made from downstream to upstream. Because of difficulties maneuvering within West Fork Clear Creek, it was electrofished in three sections. Detailed electrofishing protocols are described in Appendix B.

Small, young of the year trout (age-0) that were less than about 70 mm in length were difficult to identify definitively as either rainbow trout/steelhead (*O. mykiss*) or cutthroat trout (*Oncorhynchus clarki*). These were classified in the field as "unidentified trout." However, due to the relative rarity (when compared with *O. mykiss*) of cutthroat trout in the watershed (see Section 3.3 above), it is likely that the majority of the unidentified trout were *O. mykiss*. Therefore, unidentified trout were included with *O. mykiss* in population estimates and other analyses (see below).

The electrofishing totals include two pools that were adjacent to, but sampled separately from, the WFCC and MMCC long-term monitoring stations. These pools were first snorkeled and then electrofished to compare the results of the two methods (see Section 3.3.7). Fish collected by electrofishing in these two pools were not included in the length-frequency analysis or the population estimates for the long-term monitoring stations.

A total of 2,192 fish of eight species were captured at all monitoring stations combined (Table 35). The most abundant species at each monitoring station was *O. mykiss* (and unidentified trout, analyzed with *O. mykiss*). Juvenile *O. mykiss* and age-0 unidentified trout comprised over 73% of the total catch. A considerable number of juvenile Chinook salmon were captured at the LMCC monitoring station. Additionally, despite not being documented during reach-scale snorkel surveys (Section 3.3), five juvenile Chinook salmon were captured during electrofishing in WFCC. Relatively low numbers of juvenile coho salmon were also documented at LMCC, but none were seen during snorkel surveys of Reach 1 (which encompasses the station). All whitefish captured were large adults, which is consistent with observations from snorkel surveys (Section

3.3.5). Large numbers of sculpin were captured at all monitoring stations except SFCC, despite not being detected by snorkel surveys in the surrounding reaches (except for 1 individual seen in Reach 12 of West Fork Clear Creek).

Table 35. Number of fish captured by electrofishing at each monitoring station.

Common name	Species	Number captured (all sizes combined)					
		LMCC	MMCC	WFCC	SFCC	MFCC	Total
Mountain whitefish	*Prosopium williamsoni*	4	0	0	0	0	**4**
Chinook salmon[1]	*Oncorhynchus tshawytscha*	95	0	5	0	0	**100**
Coho salmon[1]	*Oncorhynchus kisutch*	13	0	0	0	0	**13**
Rainbow trout/steelhead	*Oncorhynchus mykiss*	245	147	32	230	124	**778**
Cutthroat trout	*Oncorhynchus clarkii*	0	3	17	0	0	**20**
Unidentified trout	*Oncorhynchus* spp.	154	252	277	135	10	**828**
Dace[2]	*Rhinichthys* spp.	25	0	0	0	0	**25**
Sculpin[3]	*Cottus* spp.	201	52	142	0	29	**424**
Total		**737**	**454**	**473**	**365**	**163**	**2,192**

[1] Only juvenile Chinook and coho salmon were captured by electrofishing.
[2] Small numbers of both speckled and long-nosed dace were collected.
[3] Sculpin appeared to primarily Paiute sculpin (*Cottus beldingi*).

Length-frequency histograms were constructed to illustrate the size and age structures of the *O. mykiss* populations at each monitoring station. Due to the remote nature of the monitoring stations, the time required to electrofish, and the limited amount of daylight, some fish were sub-sampled and not individually measured in order to manage sampling time. This was done primarily on age-0 *O. mykiss* and unidentified trout <70 mm long. For the purposes of constructing the length-frequency histograms, these unmeasured fish were assigned to length bins (41–50 mm, 51–60 mm, and 61–70 mm) based on the proportion of the measured fish that fell within each bin. Although there is some apparent variability in size-at-age of juvenile *O. mykiss* between monitoring stations, cluster analyses of length-frequency histograms generally support the following age classes: age-0 (<90 mm), age-1 (90–150 mm), and age-2 and older (>150 mm). Figures 68–72 illustrate the length-frequency distribution of juvenile *O. mykiss* at each monitoring station.

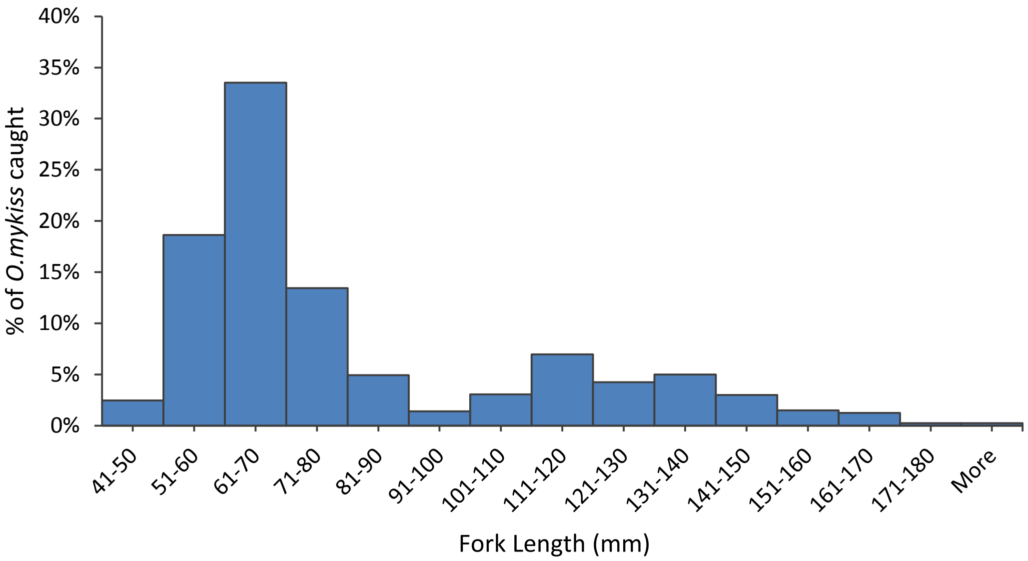

Figure 68. Length-frequency histogram of *O. mykiss* (and unidentified trout) at the LMCC monitoring station.

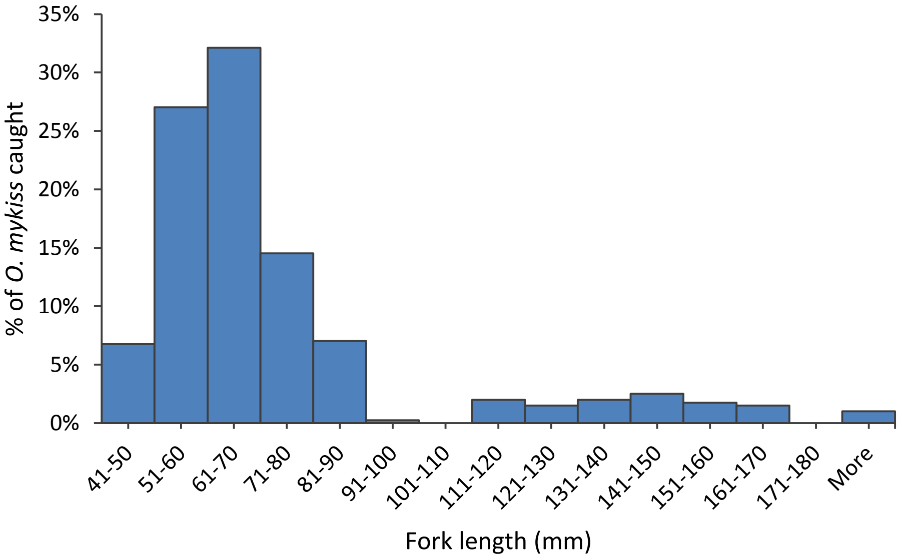

Figure 69. Length frequency histogram of *O. mykiss* (and unidentified trout) at the MMCC monitoring station.

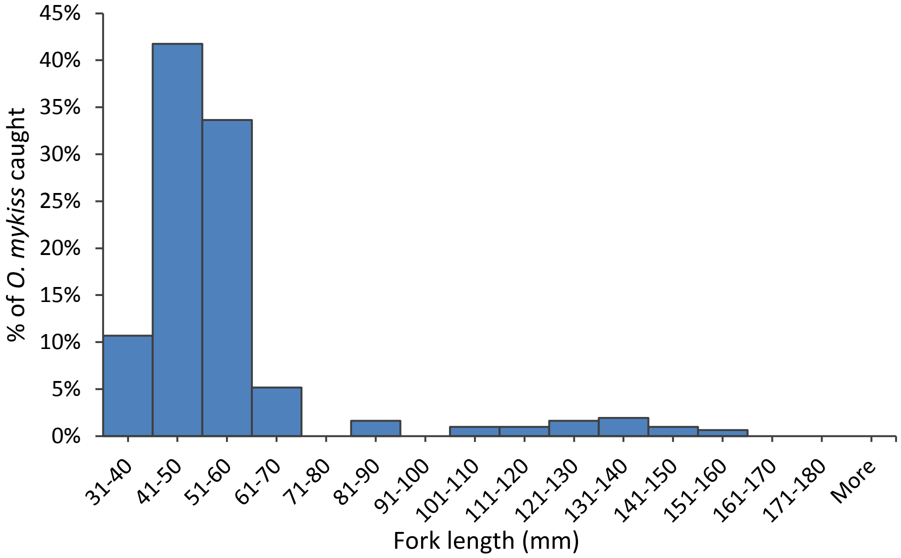

Figure 70. Length frequency histogram of *O. mykiss* (and unidentified trout) at the WFCC monitoring station.

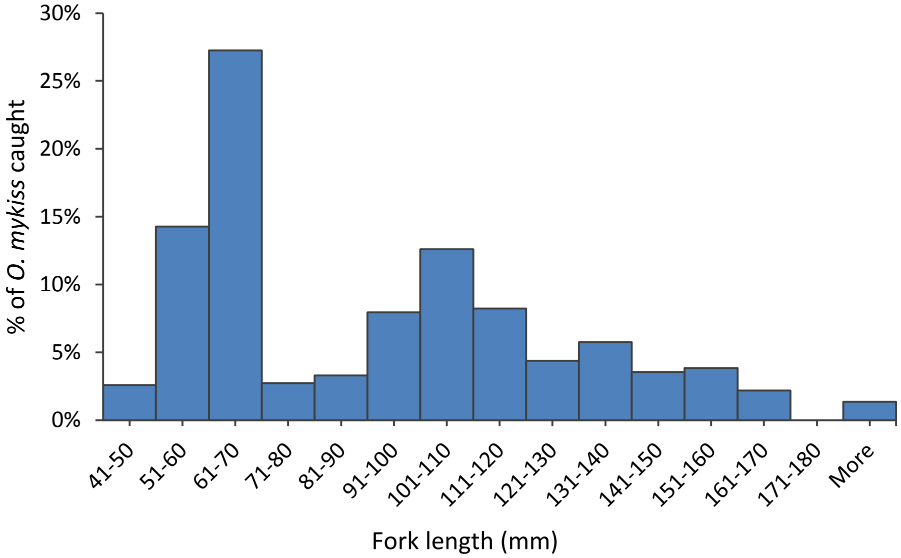

Figure 71. Length frequency histogram of *O. mykiss* (and unidentified trout) at the SFCC monitoring station.

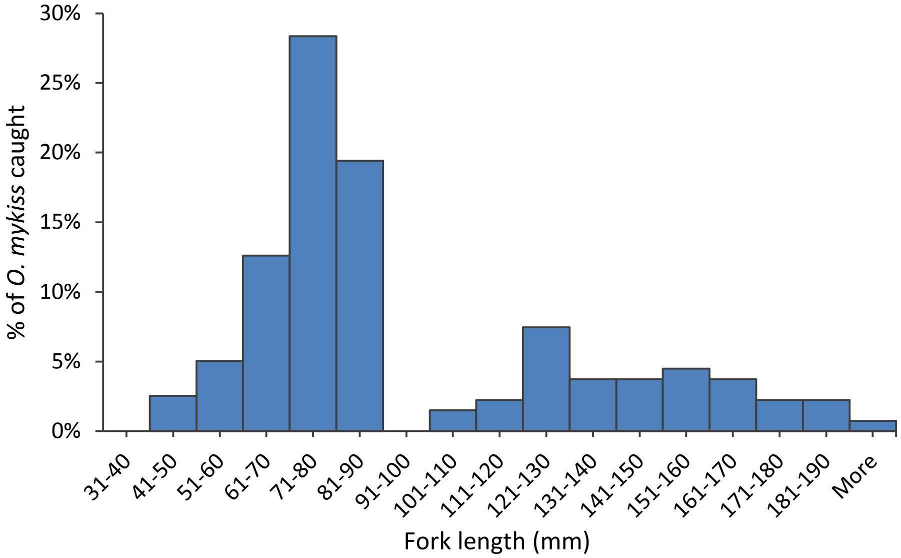

Figure 72. Length frequency histogram of *O. mykiss* (and unidentified trout) at the MFCC monitoring station.

O. mykiss populations were estimated at each long-term monitoring station using the Zippin methodology described by Platts et al. (1983). Separate estimates were made for the population as a whole, (including age-0 fish; <90 mm), age-1 and older fish (90 mm and longer), and age-2 and older fish (150 mm and longer). Too few fish of other species were captured at most monitoring stations to allow for population estimates to be conducted.

The total *O. mykiss* population (including age-0 fish) was highest at the LMCC station, followed closely by MMCC and SFCC (Figure 73). However, SFCC had the highest number of older and larger fish. In contrast, and similar to snorkel survey results, very few older fish were present at the WFCC station.

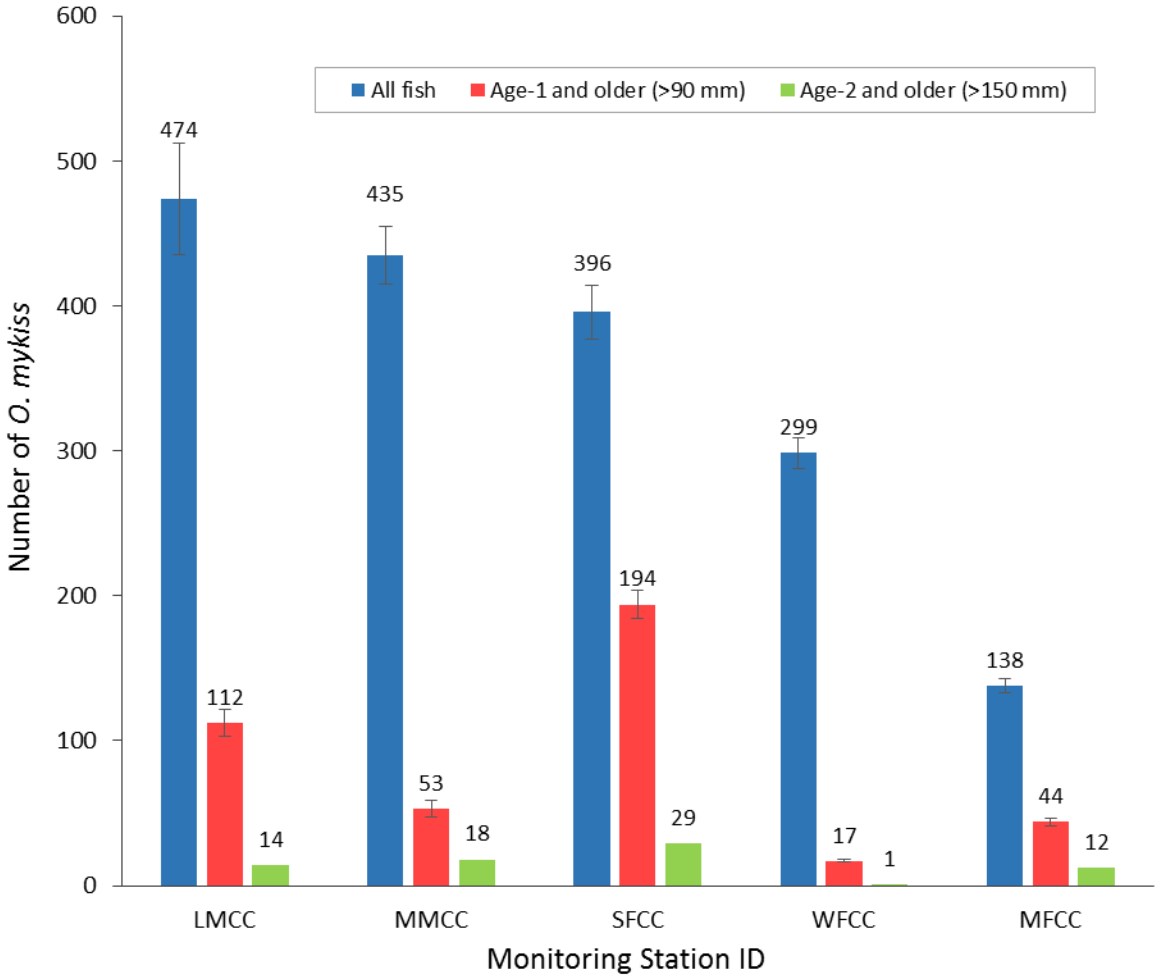

Figure 73. *O. mykiss* population estimates for long-term monitoring stations. Numbers above each bar are the estimated populations (includes unidentified age-0 trout) and error bars indicate 95% confidence intervals for each estimate.

4 DISCUSSION

4.1 Channel Classification

The channel classification approach was intended to stratify the channel network into functional reaches, and provide a structure to guide field sampling and data interpretation at appropriate scales. Based on field observations, the reach types and boundaries identified using GIS prior to field surveys generally matched the expected characteristics when surveyed in the field. Reach boundary locations were adjusted in the field based on site-specific characteristics and to correspond with a habitat unit boundary, but reaches did not need to be removed or reclassified based on field observations. In general, field crews considered the reach classifications and boundary locations to be quite accurate and helpful for stratifying the channel network.

In steep terrain, streams generally have a concave longitudinal profile, with channel gradient decreasing as contributing drainage area increases. This pattern was generally true for reaches surveyed within the Clear Creek basin, with a few exceptions. Of particular interest are reaches having relatively low gradients (<4%) and small contributing drainage area (i.e., <25 km^2). These reaches may provide particularly valuable fish habitat amidst reaches with less habitat potential based on stream size and gradient. Reach 31 in Middle Fork Clear Creek, Reaches 32 and 34 in upper mainstem Clear Creek, Reaches 38 and 40 in Browns Spring Creek, and Reach 47 in Pine Knob Creek are in relatively small channels (drainage area of 5–25 km^2) and low gradient (1–4%). Of these, Reaches 31, 32, 38, and 40, had a high relative abundance of *O. mykiss* (>80 fish/100 m) for small streams. In upper Browns Spring Creek, Reach 51 has a very small contributing drainage areas (<5 km^2), but has among the highest cutthroat trout densities of all study reaches, which is likely due in part its low gradient and proximity to excellent trout spawning and rearing habitats. Reaches 43, 45, and 51 were higher gradient (4–8%), but still had the highest cutthroat trout densities in the entire study area. This section of Browns Spring Creek had a relatively high frequency of LWD, including numerous, large channel-spanning logs that created channel complexity and locally low-gradient spawning and rearing habitats with high densities of trout.

These findings generally support the utility of the reach classification scheme used for this assessment, and its potential applicability for use in the future efforts.

4.2 Reach-scale Characterization

4.2.1 Channel form and constraint

Based on the channel classification and topography, and knowing *a priori* that most of the National Forest study area was composed of steep, forested terrain, we expected that stream channels would be primarily single-channel and constrained by steep hillslopes in narrow valleys. Although this was generally true, in some locations within the National Forest, a relatively complex network of either braided or anastomosing channels were common. In most cases, these complex reaches appeared to be related to past large-scale geomorphic events such as landslides and debris flows that filled the valley bottom with sediment deposits and resulted in a relatively wide floodplain within steep, narrow valleys. Examples of these complex channels were found in Browns Spring Creek, upper mainstem Clear Creek, South Fork Clear Creek, and West Fork Clear Creek. Such complex channels can be important to salmonids as they provide physical habitat diversity that improves habitat quality and quantity for a range of species and life-stages throughout the year.

By contrast, the lower-gradient reaches on private land in lower Clear Creek downstream of the National Forest boundary are relatively unconfined, with more abundant side channels and an extensive floodplain.

4.2.2 Embeddedness

The level of embeddedness of stream cobbles with finer substrates is important both for spawning and rearing of salmonids and for production of aquatic invertebrates (Rowe et al. 2003). High embeddedness can be caused by the underlying geology of the watershed, or by fine sediment inputs due to land management activities (e.g., road building) or natural disturbance (e.g., landslides). For this study, we generally considered embeddedness less than 30% as “good”. Mean embeddedness by subwatershed on National Forest lands was consistently within a range of approximately 30–36% (embeddedness on the private lands of Lower Clear Creek was lower at approximately 20%); however, embeddedness was highly variable from reach to reach. Reaches with less than 30% embeddedness were not common, and were distributed throughout the study area, occurring in UMCC and all tributaries other than the South Fork.

Embeddedness for the northern and middle Rockies ecoregion in Idaho has been reported to average 12% (Grafe 2002), indicating that embeddedness in the study area was higher than other streams evaluated in the same ecoregion in Idaho. Previous studies have identified high embeddedness as a potential problem in the Clear Creek basin (Appendix F), likely caused in part by the existing road system (USDA Forest Service 2014). Although embeddedness has potentially improved since these earlier studies, reducing management-related fine sediment inputs could improve conditions for fish and aquatic species in the Clear Creek basin by reducing substrate embeddedness. Much of the observed embeddedness was caused by medium to coarse sand and embeddedness by fine silt was relatively rare. This observation is notable, since sands have higher permeability and therefore are less likely to negatively impact developing embryos (Spence et al. 1996, Rowe et al. 2003).

4.2.3 Riparian vegetation

Riparian vegetation provides important functions to streams that benefit salmonids and their habitat (Maser et al. 1988). Trees (especially large conifers) provide LWD to streams when they fall or are carried by landslides, and LWD in streams creates pools, retains sediment, and provides fish habitat structure and complexity. Other riparian functions include: bank stabilization, flood plain development, nutrient inputs from falling leaves, and stream shade for moderating water temperature (discussed below).

Riparian vegetation varied extensively across and within study reaches within the study area, with the largest conifers found in mainstem Clear Creek, West Fork, and Browns Spring. Deciduous-dominated reaches were most common in mainstem Clear Creek, where alders were a predominant riparian tree. The observed variation in dominant riparian vegetation types between subwatersheds can be attributed in part to natural differences related to aspect, underlying geology, elevation, and moisture (USDA Forest Service 2014). Additionally fires of varying intensity have played a large role in creating and maintaining differences in vegetation types within the watershed. Notably, large fires that occurred in 1870 and 1931 burned nearly half of the Clear Creek drainage, altering riparian vegetation age-structure and species composition in some areas including large parts of the South Fork subwatershed (USDA Forest Service 2014). These fires likely explain the overall dominance of shrubs at transects surveyed in the South Fork subwatershed. Past timber harvest activities likely had minimal direct impact on observed riparian species composition since streamside buffers were maintained on the larger streams surveyed for this project (USDA Forest Service 2014). At transects surveyed in the LCC subwatershed, “no vegetation” was most common riparian designation, comprising one-third of the designations. This finding is likely due in part to cattle grazing and human activities along these private land reaches.

4.2.4 Canopy cover

Canopy cover, measured as an indicator of stream shade, is important in moderating water temperature and is heavily influenced by past disturbances and management actions (especially fire and timber harvest) (OWEB, 1999). Providing shade to a stream is one of the most important mechanisms that mitigates potential negative effects of land management on stream temperature. Unsurprisingly, canopy cover was highest in the upper reaches of the study area, which had smaller channels, as well as larger, older trees.

Mean canopy cover for the northern and middle Rockies ecoregion in Idaho was reported to be 48% (Grafe 2002). Mean canopy cover for study reaches within the National Forest ranged from

58% to 93%, indicating higher than average canopy cover in the study area compared with other streams in the ecoregion. Applying scoring criteria (scale of 1–10) for percent canopy cover used by Grafe (2002) to subwatersheds in the Clear Creek basin gives relatively high ratings for all subwatersheds except LCC (Table 36).

Table 36. Canopy cover scores for subwatersheds based on Grafe (2002).

Subwatershed	LMCC	UMCC	West Fork	South Fork	Middle Fork	Pine Knob	Browns Spring	LCC
Canopy cover score (1–10)	9	10	10	8	10	10	10	6

In Oregon, benchmarks for canopy cover in the Columbia Plateau, Northern Basin and Range, and Snake River Plains indicate that “good” canopy cover is anything greater than 47% (Hubler 2007), “poor” canopy cover is anything <1%. For the Blue Mountains Ecoregion in central Oregon, “good” canopy cover includes anything greater than 22%, and “poor” canopy cover is anything less than 3%. In the Clear Creek study area, all reaches within the National Forest had >20% canopy cover, and all but four reaches had canopy cover >47%, and thus would be classified as having “good” canopy cover using the most stringent rule-of thumb. In LCC, on the other hand, three of the five reaches had <40% canopy cover and one reach had <20% canopy cover.

The ODFW Aquatic Inventory methodology (ODFW, 2014) rates shade for streams <12 m in width of northeast Oregon as “desirable” if they are > 60%. By this metric, most reaches in upper mainstem and tributary subbasins would be rated as “desirable”, with the exception of LMCC, South Fork, and LCC.

4.3 Fish Distribution and Relative Abundance

Results from summer 2015 fish population surveys indicate widespread use of the study area by salmonid species, with species distribution patterns in Clear Creek largely similar to those of streams with similar characteristics (size, elevation, gradient, and forest cover) in the Middle Fork Clearwater River drainage (Grafe 2002). Chinook and coho salmon were found primarily in larger, lower-gradient reaches, *O. mykiss* were most widely distributed, and cutthroat trout were generally restricted to smaller streams in the upper reaches of the study area where *O. mykiss* were absent or found in relatively low numbers.

Notably, this study detected Chinook salmon upstream of two physical features considered to be total barriers by previous evaluations: one in mainstem Clear Creek and one in South Fork Clear Creek. Paradis et al. (1988) described a series of features in the mainstem just downstream of the Middle Fork confluence as a complete barrier to Chinook salmon since “the bedrock falls and cascades are too high and have inadequate plunge and landing pools….” However, the current assessment did not locate a total barrier in this vicinity (Reach 6), and an adult Chinook salmon was observed 600 m upstream of the Middle Fork Clear Creek confluence. In South Fork Clear Creek, Paradis et al. (1988) also identified a total barrier to fish migration described as a 10-ft drop onto bedrock and a “definite migration barrier to both Chinook and steelhead.” According to GIS metadata provided by USDA Forest Service, this feature, located in the in the vicinity of the upstream end of Reach 15, was blasted in 1991 to provide fish passage. The current assessment indicates that anadromous fish can now pass this feature, as evidenced by age-0 Chinook salmon documented well upstream in South Fork Clear Creek.

Our results indicated that cutthroat trout were restricted primarily to the uppermost study reaches and smaller channels in the Clear Creek drainage, with highest densities observed in locations upstream of *O. mykiss* presence. In general, results of this study did not indicate a strong relationship between cutthroat trout densities and channel gradient of study reaches within each subwatershed. This finding may be explained in part by the relatively high frequencies of LWD in the reaches where cutthroat trout were found. For example, field observations from Browns Spring Creek documented numerous, large channel-spanning logs and jams in high gradient reaches that trapped sediment upstream, raising the stream bed and lowering channel gradient. These log “dams” created a “stair-step” channel morphology with locally low-gradient sections of stream (containing excellent spawning and rearing habitats and high densities of trout) interspersed with short vertical drops over the dams.

Because of the difficulties of differentiating cutthroat trout from *O. mykiss* during snorkel surveys—especially smaller individuals—it is possible that cutthroat trout were present in low numbers in some locations where they were not detected by snorkeling, such as the upper study reaches of South Fork Clear Creek. However, a variety of evidence supports findings from snorkel surveys that cutthroat trout were not present in South Fork Clear Creek. First, no cutthroat trout were captured during electrofishing of the SFCC long-term monitoring station located in Reach 16. Second, cutthroat trout were either not detected or rare in mainstem Clear Creek study reaches where the channel was as large as South Fork study reaches. In the mainstem, cutthroat trout were exceedingly rare downstream of Reach 34, where the contributing drainage area is <15 km^2 and wetted-width averaged approximately 3.2 m (10.5 ft). For comparison, surveys in South Fork Clear Creek ended at the Kay Creek confluence (Reach 22), where the contributing drainage area was still >50 km^2 and wetted-width averaged approximately 4.3 m (14.1 ft). Assuming that stream size and presence of *O. mykiss* are among the drivers of cutthroat trout distribution in the watershed (as suggested by mainstem Clear Creek results), it is not surprising that the species was not detected in the South Fork study reaches, where *O. mykiss* were found in relatively high densities. Supporting this finding, a previous fish survey found that *O. mykiss* predominated in South Fork Clear Creek upstream to the Kay Creek confluence, while cutthroat became the dominant species upstream of the Kay Creek confluence (Appendix F, Paradis et al. 1988). Additional fish distribution surveys in South Fork Clear Creek upstream of Kay Creek would be valuable for understanding the patterns in distribution of these two species.

Notably, species distributions reported here are from surveys conducted in the summer and in a year with relatively low snowpack and stream flows. Fish distributions within a watershed are expected to vary seasonally and annually. For example, in years with higher flows and spring snowmelt, salmon and steelhead may migrate farther upstream and spawn in smaller channels, and in some cases they may be better able to pass seasonal barriers that restrict their upper distribution in low-flow years. Similarly, water temperature can be a major driver of the seasonal migrations and thus distributions of cold water species, with individual fish moving within a watershed to reaches with more thermally optimal temperatures (behavioral thermoregulation) (Behnke 1992, Sauter et al. 2001, Grafe 2002).

Similarly, changes in water temperatures can influence observed fish densities by mediating changes in habitat use. Juvenile salmonids are generally more abundant in pools habitats, but they also occupy riffles and other fastwater habitats, which were not snorkeled for this assessment.

Changes in the environmental conditions and ecological interactions amongst species can mediate the relative use of riffle versus pool habitats by juvenile salmonids (e.g., Smith and Li 1983, Fausch 1984, Piccollo et al. 2014). For example, when streams warm during summer months it is common to observe a shift toward greater use of riffle habitats and other fast water habitats, especially by certain species such as *O. mykiss* (Smith and Li 1983). This shift is presumed to be related to changes in energetically optimal conditions. When water temperature or competition from other fish increase beyond a certain point, some species or life stages may need to occupy faster water with higher prey availability (e.g., invertebrate drift rates) to meet increasing metabolic demand (Smith and Li 1983). Thus, it is important to assess results of pool-only snorkel surveys in this context, understanding that apparent changes in relative fish densities within pools could be driven in part by shifts in the distribution of fish between pools and riffles (rather than true population changes).

Analyses of multi-pass snorkeling, snorkel counts versus electrofishing estimates, and daytime versus nighttime snorkel counts (Section 3.3.7) indicated that single-pass daytime snorkel counts underestimate the number of fish actually present snorkeled pools. However, the purpose of the snorkel surveys was not to establish a population estimate, but rather to determine upstream distribution by species and inform relative abundance between locations in the watershed. Because multiple, spatially-stratified pools were snorkeled in each reach and snorkeling methodology was consistent across all locations, relative abundance of fish observed can be consistently compared from pool to pool, reach to reach, and subwatershed to subwatershed.

As discussed above, the fish passage barrier assessment, in combination with fish distribution surveys, refined our understanding of present-day impediments to fish passage in the Clear Creek basin. This assessment documented five potential barriers within the study area considered to be likely total barriers that limit the upper distribution of anadromous fish. Each of these likely total barriers were located in the upper portions of the watershed, with four of the five located in small to relatively small tributaries (Lost Mule, Browns Spring, and Tailed Frog creeks). Several additional obstacles were documented that are not expected to be total barriers but likely limit migration barrier across a relatively wide range of stream flows. Additionally, a number of features were encountered and assessed in the field that were determined not to be significant obstacles to fish passage and thus were not included here. Numerous large or channel-spanning wood jams that appeared to impede fish passage to some degree were documented, but were not reported here per data collection protocols, since they do not constitute permanent barriers.

Importantly, barrier designations were based on relatively rapid and qualitative field assessments of often complex features during a period of low stream flow and therefore generally should not be viewed as definitive. Numerous factors may influence whether a particular location is passable by a given fish at a given time. These factors include swimming and jumping ability of the species, fish size and condition, stream flow, and water year type (wet versus dry). Moreover, ability of fish to pass certain obstacles, particularly those in higher-gradient reaches, may be mediated by complex channel and sediment dynamics associated with large woody debris in the vicinity of the obstacle, and therefore passage success at these features can change over time. For example, channel-spanning logs that have fallen on existing vertical drops can raise the stream bed upstream, creating more significant drops and requiring higher jumps. Conversely, large fallen logs or wood jams downstream of a barrier may facilitate passage by causing backwatering of vertical drops or raising the bed elevation, which could facilitate passage by lessening jump heights, increasing water depths, and decreasing velocity. To more definitively designate passage status at each location, more exhaustive surveys (using auto-levels) and analyses (hydraulic modelling at each location in relation to species-specific swimming and jumping abilities) are needed. Nonetheless, this assessment provides a baseline inventory of potential barrier locations and provides insight into the degree to which they currently influence fish passage.

4.4 Habitat Unit-scale Characterization

4.4.1 Habitat type composition

The quality and quantity of salmonid habitat is often discussed in terms of pool prevalance (Montgomery et al. 1995). Pools provide important habitat for different life stages and species of salmonids and are used for holding, spawning (in pool tailouts), rearing, and high-flow refugia. Pool frequency and qualtity can also be affected by upstream management activities. Good salmonid habitat is characterized by a diversity of pool types, including lateral scour pools and those formed by large wood.

In Oregon, benchmark values for "desirable" salmonid habitat conditions are >35% of the stream area comprised of pool habitat, and pool frequency of at least one pool every five to eight channel widths (ODFW 2014). "Undesirable" salmonid habitat conditions includes streams with <10% of total area in pools, and pool frequency >20 channel widths per pool. Based on these benchmark values, none of the subwatersheds surveyed meet the "desirable" benchmarks for percent of stream area comprised of pool habitat. Middle Fork, Pine Knob, Browns Spring and LCC are all in the "undesirable" category. (Table 37). For the pool frequency benchmark, UMCC is the only subwatershed that meets the threshold for "desirable" conditions, and LCC is the only subwatershed that would be classified as having "undesirable" conditions (Table 37).

Table 37. Channel dimensions and pool frequency, by subwatershed.

Variable	LMCC	UMCC	West Fork	South Fork	Middle Fork	Browns Spring	Pine Knob	LCC
Wetted-width in meters (ft)	30.2 (18.8)	18.3 (11.4)	14.3 (8.9)	26.1 (16.2)	18.3 (11.4)	13.5 (8.4)	13.5 (8.4)	35.7 (22.2)
% pools	10	11	13	11	7	9	9	7
Pools/km (mile)	11.6 (18.5)	25.6 (41.3)	26.7 (43.1)	11.9 (19.2)	11.6 (18.7)	20.3 (32.7)	16.9 (27.3)	5.1 (8.3)
Channel widths/pool	8.6	6.9	8.3	9.3	15.4	8.6	11.6	21.8

The USDA Forest Service interim riparian management objectives (RMOs) (Quigley et al. 1997) call for 96 pools per mile in streams 10 feet in wetted-width, and 56 pools per mile in streams 20 ft in wetted-width. Based on these thresholds, the number of pools per mile is well below the USDA Forest Service interim RMOs threshold in all subwatersheds (Table 37).

Deep pool habitat is another important habitat component, particularly as adult holding habitat for anadromous salmonids. Pools deeper than 0.9 m (3 ft) were rare within the subwatersheds with smaller channels, but considerable numbers of deep pools were present in the LMCC, South Fork, and LCC subwatersheds.

Previous surveys have evaluated pool habitat in the Clear Creek basin. Murphy and Metzger (1962) noted that Pine Knob and South Fork both had numerous good resting pools. However, only the South Fork had particularly good deep pool habitat based on the current surveys. Johnson (1984) identified a lack of pool habitat in all surveyed creeks, which is generally consistent with the findings of the current surveys that indicate pool habitat is below established benchmarks. The generally low incidence of deep pools may be the result of low wood loading, high sediment supply, or other factors.

4.4.2 Channel dimensions

Measures of channel dimensions provide indicators of stream size and condition. The width-to-depth ratio is a metric that can indicate the loss of pools, accelerated streambank erosion rates, high sediment supply and channel aggradation, channel over-widening due to direct mechanical impacts, and other causes. The Oregon benchmark values for width-to-depth ratio (bankfull width to bankfull depth) on the east side of the Cascades are <10 for the "desirable" condition and >30 for the "undesirable" condition (Foster et al. 2001). Based on these thresholds, UMCC, West Fork, and Middle Fork would be classified as "desirable", and no subwatersheds would be classified as "undesirable"; however, LCC had an average width-to-depth ratio of 29.4, very close to the "undesirable" classification threshold. These metrics indicate that subwatersheds in the study area were generally relatively close to "desirable" conditions, and conditions could likely improve in subwatersheds not currently meeting the "desirable" conditions threshold. Conditions in lower Clear Creek may benefit from addressing conditions that could reduce width-to-depth ratio such as improving bank stability and promoting pool formation.

The USDA Forest Service interim RMOs (Quigley et al. 1997) define width-to-depth ratio based on average wetted-width and depth, with a benchmark ratio value of <10. Using this RMO metric, no subwatersheds within the National Forest meet the RMO benchmark for width-to-depth ratio (range 12.0–16.0).

4.4.3 Substrate composition

Substrate metrics frequently reported include percentage of gravels and cobbles (discussed below in relation to spawning gravels) and percent of sand and fines. Sand and fines can fill the interstices of gravels, reducing their suitability as spawning and rearing habitat. The mean percent sands and fines (d50 < 2 mm) in the Northern and Middle Rockies ecoregions of Idaho was 16.8% (Grafe 2002). Benchmark values in Oregon for the Columbia Plateau, Northern Basin and Range, and Snake River Plains are <30% for "good" conditions and >71% for poor conditions. For the Blue Mountains, <22% indicates "good" conditions and >31% indicates poor conditions (Hubler 2007).

Within surveyed reaches, the percent sand and fines ranged from 11.8% in Browns Spring to 23.5% in the Middle Fork. Subwatersheds with lower average percent fines compared with the mean for their ecoregion in Idaho included LMCC, South Fork, Browns Spring, Pine Knob, and LCC. All subwatersheds, with the exception of Middle Fork, had lower percent fines than the 22% "good" benchmark in Oregon for the Blue Mountains. Subwatersheds with reaches having relatively high concentrations of sand and fines included the Middle Fork, West Fork, and UMCC.

Grafe (2002) provides scoring criteria for % sand and fines on a scale of 1–10. Scores for each subwatershed indicate substrate conditions based on abundance of sand and fines as fair (Table 38).

Table 38. Sand and fines scores (1-10) for each subwatershed (from Grafe 2002).

Subwatershed	LMCC	UMCC	West Fork	South Fork	Middle Fork	Pine Knob	Browns Spring	LCC
Sand and fines score (1–10)	6	5	4	6	4	6	6	6

4.4.4 Bank stability

Stream banks in surveyed reaches were generally classified as stable, with little evidence of erosion or undercutting, except in LCC. The USDA Forest Service has interim RMOs for bank stability (>80% of banks to be stable) and lower bank angle (>75% of banks with <90 angle) for non-forested systems only, and all subwatersheds easily meet these benchmarks based on assessment of bank erosion.

4.4.5 Large woody debris

Key benefits of instream LWD include:

- Creating of pools for adult salmonid holding and juvenile rearing habitat.
- Increasing overall hydraulic complexity and roughness along the streambank.
- Providing refuge habitat juvenile and adult fish at a wide range of stream flows, including summer low flow and high-flow events.
- Providing food sources and habitat for aquatic insects and wildlife along shorelines.
- Helping to stabilize shorelines and reduce excessive erosion.
- Trapping and retaining sediment.

Overall, the comparison of data from reaches surveyed in Clear Creek with various regional metrics of desirable LWD levels, indicate that conditions within the study area are variable, with some subwatersheds and reaches having relatively “good” LWD conditions, and others having relatively “fair” conditions that would benefit from additional LWD.

The USDA Forest Service interim RMOs for LWD in Idaho streams (Quigley et al. 1997) are for >12 key pieces per km (>20 key pieces per mi), with key pieces defined as >35 feet length and >12 inches diameter—the size used to classify “key” pieces for this assessment. LWD key piece frequency (wet, dry, and jam key pieces) within subwatersheds in the National Forest ranged from 5 key pieces/km in the Middle Fork to 44 key pieces/km in UMCC. UMCC was the only subwatershed achieving the RMO of >12 key pieces/km, while LCC had the lowest key piece frequency of all subwatersheds, at less than 1 key piece/km (Figure 74).

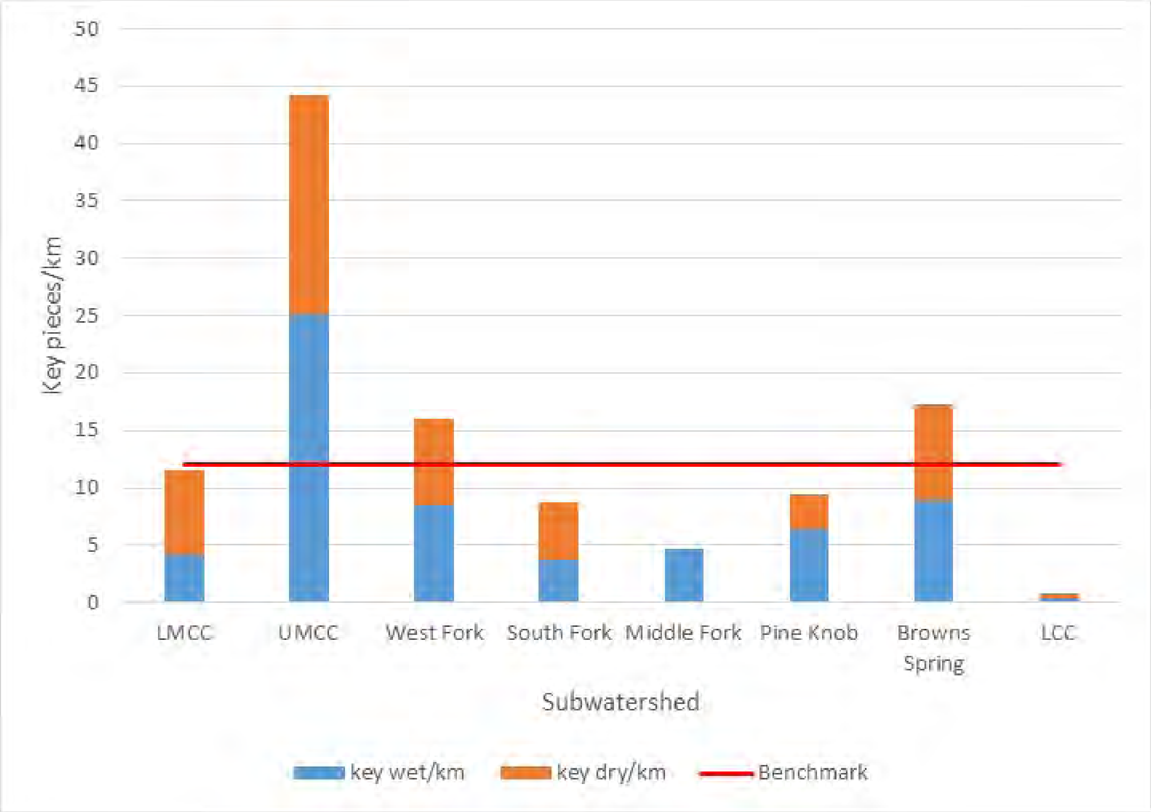

Figure 74. LWD frequency of key pieces (>35 feet long and >12 inches in diameter), by subwatershed. The indicated benchmark is the interim Riparian Management Objective of 12 key pieces/km (20 key pieces/mile).

Oregon benchmarks (Foster et al. 2001) for LWD piece frequency (for pieces >15 cm diameter and >3 m length) are defined as follows:

- >200 pieces/km is "desirable"
- <100 pieces/km is "undesirable".

Within subwatersheds in the National Forest, LWD piece frequency (all qualifying sizes and including wet, dry and jams), ranged from 142 pieces/km in LMCC to 415 pieces/km in West Fork. LCC had a frequency of 111 pieces/km. When compared with Oregon benchmarks, all subwatersheds would be classified as "desirable", except for LMCC, LCC, and Browns Spring. All subwatersheds had enough wood that they would not be classified as "undesirable".

Oregon benchmarks for LWD volume per channel length are defined as follows:

- >300 m^3/km of stream is "desirable"
- <300 m^3/km of stream is "undesirable"

LWD volume within the National Forest ranged from 113 m^3/km to 438 m^3/km. Based on Oregon benchmarks, LWD volume would be classified as "desirable" in UMCC and West Fork, and as "undesirable" in South Fork, Browns Spring, and Pine Knob subwatersheds. LCC had the lowest LWD volume of all subwatersheds and would be classified as "undesirable".

For the northern and middle Rockies ecoregion in Idaho, Grafe (2002) reported that the mean number of pieces of LWD was 296 pieces/km of stream. LMCC, South Fork, Middle Fork, Browns Spring, and LCC had LWD frequencies below the average reported by Grafe (2002) for the region. Additionally, a 1–10 scoring criteria for LWD piece frequency provided by Grafe (2002) indicates relatively poor to fair LWD conditions for the subwatersheds surveyed (Table 39).

Table 39. Large organic debris scores (1-10) for each subwatershed (from Grafe 2002).

Subwatershed	LMCC	UMCC	West Fork	South Fork	Middle Fork	Pine Knob	Browns Spring	LCC
Large organic debris score (1–10)	4	6	7	5	6	6	4	3

4.4.6 Spawning gravel

The amount of spawning gravel appeared to be more closely correlated with subwatershed than with reach type. LCC had the greatest amount of anadromous spawning gravels, followed by LMCC and South Fork. The areas with the most anadromous spawning gravel tended to be lower in the system, which would generally be expected. A lack of spawning gravel has historically been identified as a limiting factor in the Clear Creek watershed (Appendix F). However, this survey identified significantly more anadromous spawning gravel than Paradis (1988), with 129 m^2/km in the Clear Creek mainstem versus 4.9 m^2/km (Paradis 1988); and 70 m^2/km in the South Fork, versus 7.7 m^2/km (Paradis 1988). West Fork Clear Creek had similar amounts in the two surveys with 12 m^2/km in this survey and 12.4 m^2/km historically (Paradis 1988). However, the methodology employed by Paradis (1988) for identifying spawning gravel is not specified.

Resident spawning gravel was more evenly distributed throughout the study area, with LCC, LMCC, and UMCC having similar amounts, and the rest of the subwatersheds having lesser, but similar amounts. Resident cutthroat are concentrated in the upper watershed, where there is generally less spawning gravel area relative to larger channels. However, field observations indicate that ample high quality, ideally sized gravel in the upper reaches, thus, spawning gravel is unlikely to limit trout populations there

Based on the amount of spawning gravels present, and general observations, it is unlikely that the amount and quality of spawning gravels are limiting fish populations.

4.5 Long-term Monitoring Stations

The long-term monitoring stations were established to evaluate whether there are measureable adverse effects to aquatic habitat that are attributable to implementation of the Clear Creek Restoration Project. Specifically, changes to the physical habitat (e.g., spawning gravels), the physical processes (e.g., channel aggradation), and relevant water quality parameters (e.g., stream temperature). Additional monitoring within the basic framework will be used to isolate the effects of management actions from natural variations in streamflow (e.g., high runoff events associated with greater winter snowfall) and stream temperatures (i.e. higher stream temperatures associated with an unseasonably warm summer).

As described above, Stillwater Sciences performed channel geometry measurements and fish habitat surveys at the LMCC and WFCC monitoring stations, and collected fish abundance data at all five monitoring stations. Results of these surveys—along with channel and habitat data collected by USDA Forest Service at the MMCC, SFCC, and MFCC stations—will serve as a baseline for comparison with results of future surveys that are repeated at these monitoring stations following implementation of management activities in the Clear Creek basin within the National Forest.

When evaluating long-term monitoring data, it is important to place each monitoring station in the geomorphic context, taking into account channel size, gradient, confinement, and substrate characteristics, since these can affect how conditions (channel, habitat, and fish) are likely to respond to potential upstream management activities. For example, LMCC is located in a reach with relatively large drainage area 172 km^2) and low gradient (1.6%) and thus the channel there may respond differently compared with MFCC, which is located in a reach with a relatively small drainage area (25 km^2) and higher gradient (5.3%).

Comparing longitudinal and cross-section profiles with future surveys will be used to detect whether substantial changes in channel condition are evident, such as pool filling or scour, changes in local channel gradient, and streambed aggradation or degradation within a given monitoring station.

Results of stream bed surface analyses can be compared with future surveys to detect changes in the particle size distribution at each monitoring station that may result from changes in sediment dynamics (e.g., sediment supply, transport, and storage).

Average embeddedness estimated at the LMCC and WFCC long-term monitoring stations was considerably higher than the embeddedness estimated at reach-scale transects, and was generally greater than established benchmarks for sediment impairment. However, embeddedness at the long-term monitoring stations is not directly comparable to the embeddedness estimates from the reach-scale transects due to difference in methodologies. The main impetus for assessing embeddedness at long-term monitoring stations is to assess trends over time in relation to management actions in the basin.

Results from continuous air and water temperature data loggers are not summarized in this document, but will ultimately be used to document conditions and assess whether differences in temperature changes are evident that may be the result of either local management activities or changes in regional climate patterns.

The point-in-time discharge estimates collected at the long-term monitoring stations are informative metrics for interpreting monitoring data by allowing comparisons of relative stream-size and habitat availability from year-to-year based on differences in stream flows during the times when monitoring data are collected.

Fish population estimates conducted based on electrofishing at each monitoring station will allow abundance, age-structure, and presence/absence of each species to be compared with future surveys. Results of electrofishing surveys also provide a valuable means for reality-checking conclusions about relative abundance and distribution based on reach-level fish surveys conducted with snorkeling. Population estimates from electrofishing monitoring stations are not directly comparable with relative abundance estimates from reach-level snorkel surveys due to different methods and inclusion of non-pool habitats in electrofishing. However, electrofishing allowed detection of cryptic species such as sculpin and also documented cutthroat trout in reaches where they were not documented by snorkeling.

5 CONCLUSIONS

Results from this assessment provide a contemporary description of fish distribution, relative abundance, and habitat conditions within the Clear Creek watershed that can be used to help evaluate impacts of planned resource management activities. Results of the assessment also allow fish habitat conditions (quantity and quality) and relative abundance to be compared between specific study reaches and subwatersheds in the Clear Creek basin. Additionally, many of the standard metrics reported allow comparisons to be made between Clear Creek and similar watersheds, both within the Selway – Middlefork CFLRP boundary, the Clearwater River Basin as a whole, and beyond within the larger region. This regional comparison will help managers understand the relative condition of the Clear Creek basin and make conservation and management decisions at the landscape scale.

To reiterate, the specific project objectives included:

- Describe current stream channel and fish habitat conditions
- Identify potentially suitable salmon and steelhead spawning habitat
- Determine spatial distribution and relative abundance of salmonids
- Identify and evaluate potential barriers to fish migration
- Establish baseline datasets for determining impacts on aquatic habitat that can be attributed to the implementation of land management activities
- Establish and monument two permanent monitoring stations (in addition to three previously established) for the evaluation of potential changes to the physical habitat (e.g., spawning gravels), the physical processes (e.g., channel aggradation/degradation), and relevant water quality parameters (e.g., stream temperature).

With regard to these objectives, the study accomplished the following:

Stream channel and fish habitat conditions were characterized on the basis of their morphology (channel unit mapping); LWD abundance, size and distribution; size and composition of riparian vegetation; degree of canopy closure; stream channel form and constraining features; bank stability; substrate composition; and the embeddedness of cobbles.

Spawning habitat was evaluated for quality, and the amount of available gravels was tallied for both resident and anadromous salmonids in each of 52 pre-identified reaches in the National Forest and in an additional six reaches on private land.

The spatial distribution and relative abundance of all fish species was determined through snorkel surveys. The results were presented graphically in this report and were provided along with specific GPS coordinates to the CBC. The absolute abundance of existing fish populations were documented through multi-pass electrofishing at five long-term monitoring stations. Potential barriers were assessed and photographed and their locations were documented using GPS.

This project resulted in an extensive dataset of conditions as they were in summer 2015, prior to the initiation of planned future management actions. These data provide a very valuable snapshot and serve as a baseline to which future conditions can be compared. Had this data not been collected, future efforts to assess the basin would have been completely lacking in historical context. The systematic way in which the data were collected and analyzed, along with the specific protocols attached hereto, will insure easy apples-to-apples comparison of future conditions to those that existed prior to the implementation of management actions.

Two long-term monitoring stations were established and stream morphology was documented through the construction of longitudinal and cross-section profiles. Embeddedness was assessed, discharge was measured, and pebble counts were conducted. Temperature data loggers were installed and will be maintained by the USDA Forest Service.

In addition to the stated objectives, the project was expanded to collect additional valuable data. This included electrofishing the three long-term monitoring stations that were not initially in the scope; recording amphibian and mussel observations; and the collection of baseline data on private lands downstream of the national forest boundary. The concurrent data collection on private lands provided a valuable comparison and contrast to conditions within the national forest. In addition to serving as a comparison to the data collected within the national forest, the results of the surveys on private lands will be used to inform fish habitat enhancement projects.

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