FISH HABITAT ASSESSMENT IN THE OREGON DEPARTMENT OF FORESTRY NORTH CASCADE STUDY AREA

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Project Description

A collaborative project between the Oregon Department of Forestry (ODF) and the Oregon Department of Fish and Wildlife (ODFW) was initiated to synthesize aquatic habitat and fisheries information for the North Cascade management areas to assist in the development of operational management plans, stream habitat restoration projects, habitat conservation planning, and watershed analysis. The project summarizes the condition of stream habitat, the distribution and abundance of salmonid fishes, and the potential for restoration. The ODFW Aquatic Inventories Project has conducted stream habitat surveys as part of its basin survey project and habitat assessment project under the Oregon Plan for Salmon and Watersheds. The goal of these surveys was to document the status and trends of stream conditions in coastal drainages. These surveys in conjunction with fish distribution, fish presence, potential barriers to passage, and past restoration activities form the basis of the analyses.

The North Cascade project area is composed of tributaries to the North Santiam and Pudding Rivers west of the Cascade Mountains in Oregon (Maps 1 and 2). The North Cascade project area, as delineated by ODF ownership, is comprised of segments of each drainage rather than watershed boundaries. There are seven ODF management areas in the project area: Butte Creek, Cedar Creek, Crabtree, Green Basin, Mad Creek, Rock Creek, and scattered areas. Table 1 and Map 3 display the surveyed streams in relation to the management areas and major rivers in the study area. Non-ODF land ownership in the watersheds includes federal, private industrial and private non-industrial (Map 4). The area delineated by ODF ownership is referred to as the North Cascade project area; the area delineated by ODFW for this aquatic assessment is termed the North Cascade study area. If information is presented for land off the project area, it is specifically stated.

The North Cascade study area is comprised of three level IV ecoregions as defined by Thorson et al. (2003) (Map 5): Cascades High, Cascades West (North, Central, South), and the Willamette Valley Plain/Foothill ecoregion. The project area is entirely within the Cascades West ecoregion.

GIS coverages – sources and scales

Three digitized maps layers were used for different features of this synthesis. The primary layer is the 1:100,000 USGS stream layer. It is a standardized and routed coverage, and has a unique latitude and longitude field associated with each stream (Hupperts 1998). Fish distribution and aquatic habitat data are joined to the 1:100,000 coverage. OWEB restoration sites are mapped at a 1:24,000 scale. The remaining resolution coverage was developed for Oregon Department of Forestry (ODF) at the 1:12,000 scale. We used this layer to display a generalized (no species information) map of salmonid distribution. Because of the different development processes, the data cannot be integrated across scales, but are displayed in the same projection.

Fish Distribution and Abundance

Several species of salmonids are present in the study area. Coho salmon (*Oncorhynchus kisutch*), fall and spring Chinook salmon (*O. tshawytscha*), and summer and winter steelhead (*O. mykiss*) are distributed throughout the basins (Maps 6, 7, and 8). Additionally, resident cutthroat trout (*O. clarki clarki*) (Map 9) and rainbow trout (*O. mykiss*) are present. Non-salmonid native species are present however the extent of their distribution is not known. ODFW Aquatic Inventory fish presence/absence distribution surveys were conducted in most streams within the project area from 1992 through 1996 (Map 10). In addition to rainbow and cutthroat trout, these surveys included the presence of Cottids (sculpin) and amphibians.

Winter steelhead and spring Chinook salmon are native to the Willamette watershed. Coho, fall Chinook salmon, and summer steelhead could not access the Willamette basin above Willamette Falls located in Oregon City as the falls were a natural barrier to these species prior to the construction of the first fish passage in 1885. The present ladder additions and modifications were completed in 1971. All three of these life histories were introduced and propagated under programs within ODFW. These programs, in conjunction with the fish ladder, extended the fish distribution of these species. The summer steelhead program still operates today which provides a sports fisheries within the basin. The coho and fall Chinook salmon observed in the Willamette basin are the natural prodigy of these earlier programs.

Most of the streams in the project area are accessible up to known barriers for all the aforementioned species but documentation of their distribution is incomplete or lacking.

ESA Designations

Spring Chinook salmon and winter steelhead are listed as threatened under the federal Endangered Species Act in the North Cascade study area (http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/). Others species are not listed at this time.

Historic Fish Distribution

Prior to the construction of the fish ladder at Willamette Falls spring Chinook salmon and winter steelhead were the only anadromous salmonids to extend into the study area. Resident cutthroat trout also extended into the study area. Non-salmonids native to the study area include Oregon chub, northern pikeminnow, dace, peamouth, chiselmouth, shiners, stickleback, suckers, sculpin, and sand rollers. Only Oregon chub are federally listed as endangered. Pacific Lamprey are also native to the Willamette River watershed and can be found in the study area.

Salmon and steelhead life history in the Willamette basin

Adult spring Chinook salmon begin returning in early April, peaking in June. These fish will spend the summer in the larger rivers seeking refuge in deep, cool pools. Peak spawning activity is observed mid September to mid October. Chinook salmon prefer to spawn in larger streams at the tail crest of pools and glides and tend to use larger substrate to build redds. As the fry emerge in early spring, some will migrate immediately to the estuary while others will remain in freshwater until early summer. After spending the summer and early fall in the estuary they will migrate to the ocean. Juvenile Chinook salmon can be found in the estuary most months of the year. Most Chinook salmon will remain in the ocean an average of 3 to 4 years. Upon return from the ocean, the adult fish often hold in the lower Willamette and Columbia Rivers. Habitat requirements for adult Chinook are clean, ample gravel for spawning, cold, clean, well-oxygenated water, and deep pools for cover. Juvenile Chinook need cool, clean water, pools, and large wood debris for cover while in their freshwater environment. Estuaries and associated wetlands provide vital nursery areas for the juvenile fish prior to their departure to the ocean.

Winter steelhead return to their natal streams from November to April after spending from 1 to 3 years in the ocean. Unlike other Pacific salmonids, steelhead are iteroparous and may survive after spawning to return to the ocean and repeat the cycle. Spawning occurs in the early spring, and when the fry emerge they remain close by or occasionally migrate to the upper or lower reaches of streams and rivers. Like other salmon species, juveniles and adults rely on streams, rivers, and marine habitat during their lifecycle. Juveniles usually stay in their freshwater environment for two years before migrating to the ocean in the spring. Habitat requirements include clean, ample gravel for spawning, cold, clean, well oxygenated water, deep pools and large wood debris for cover.

Cutthroat trout in the study area may exhibit two main life history strategies; a fluvial form that migrates to small streams from the mainstem river to spawn, and a resident form that both resides and spawns in small streams. Resident cutthroat trout are found throughout the study area below natural barriers. Specifically resident cutthroat tend to be found in the upper headwater reaches of the tributaries. In freshwater, adult cutthroat typically reside in large pools while the young reside in riffles.

Pacific lamprey are anadromous. Mating pairs construct a nest by digging, using rapid vibrations of their tails and by moving stones using their suction mouths. Adults die within days of spawning and the young (ammocoetes) hatch in 2-3 weeks. The juveniles swim to backwater or eddy areas of low stream velocity where sediments are soft and rich in dead plant materials. They burrow into the muddy bottom where they filter the mud and water, eating microscopic plants (mostly diatoms) and animals. The juvenile lamprey will stay burrowed in the mud for 4 to 6 years and stay in the same habitat, rarely migrating within the stream system. They metamorphose into adults averaging 4.5 inches long. Lamprey migrate to the ocean in late winter during periods of high water. After 2 to 3 years in the ocean they will return to freshwater to spawn.

Habitat Survey Approach and Methods

ODFW Aquatic habitat surveys were conducted in the North Cascade project area drainages from 1995 – 1998 (Map 10; Table 1). Due to the small number of surveyed reaches on ODF land within the project area, summaries reflect individual reaches unless otherwise stated.

The habitat surveys describe the channel morphology, riparian characteristics, and features and quality of instream habitat during summer flow, following methods described in Moore et al. (1999) (http://osu.orst.edu/Dept/ODFW/freshwater/inventory/publicatn.htm). Each habitat unit is an area of relatively homogeneous slope, depth, and flow pattern representing different channel forming processes. The units are classified into 22 hierarchically-organized types of pools, glides, riffles, rapids, steps, and cascades, as well as slow-water and off-channel pool habitat. Length, width, and depth were either estimated or measured for each habitat unit. In addition, water surface slope, woody debris, shade, cover, and bank stability were recorded. Substrate characteristics were visually estimated at every habitat unit. Estimates of percent silt, sand, and gravel in low gradient (1-2%) riffles were used to describe gravel quantity and quality. The surveys also provided an inventory of site-specific features including barriers to fish passage (e.g., falls or culverts), mass hillside failures, and beaver activity.

Riparian transects describe tree type and size, canopy closure, and ground cover associated with the floodplain, terraces, and hillslopes adjacent to the stream. Each transect measures 5 meters in width and extends 30 meters perpendicular to each side of the stream channel. The number and size of the trees recorded are extrapolated from these transects and summarized as the number of trees expected every 305 meters of stream length.

Descriptions of channel and valley morphology followed methods developed at Oregon State University and described in detail in Moore et al. (1999). Valley and channel morphology defined the stream configuration and level of constraint that local landforms such as hillslopes or terraces imposed upon the stream channel (Gregory et al. 1989; Moore and Gregory 1989). The channel was described as hillslope constrained, terrace constrained, or unconstrained. Channel dimensions included active (or bankfull) channel width and depth, floodprone width and height, and terrace widths and height. These descriptions of channel morphology have equivalents within the OWEB and Rosgen channel typing system (Rosgen 1994).

Two survey designs were used within the North Cascade project area. Surveys conducted in 1995 – 1996 followed a basins, or census, survey design. The basins survey followed methodology proposed by Hankin (1984) and Hankin and Reeves (1988). The sampling design is based on a continuous walking survey generally from the mouth or confluence of a stream to the upper reaches. Each stream is stratified into a series of long sections called reaches and into short habitat units within each reach. A stream reach is a length of stream defined by some functional characteristic. This may be a change in valley and channel form, an entering tributary, major changes in vegetation type, or changes in land use or ownership. Within a watershed, field crews survey major streams and a selection of small tributaries. The methodology provides flexibility of scale, allowing information to be summarized at the level of microhabitat, associations of habitat, portions or reaches of streams, watersheds, and subunits within regions. The continuous-survey approach provides field-based estimates of habitat conditions throughout a stream, describe habitat and hydrologic relationships among streams or landscape features, and permit stream-wide estimates of fish distribution and abundance.

The second survey design referred to as Oregon Plan surveys (OR Plan). This survey design was intended to provide estimates of habitat conditions across a broad geographic region. To accomplish this, we randomly selected sites in 1998 in drainages throughout the Willamette basin. Of the total sites surveyed to date, two sites fell within the North Cascade project area. Field protocol was similar to the basins surveys except that sites were 500 meters to 1,000 meters in length and some of the sites are designated to be resurveyed on a rotational design of one, three, and nine year intervals. The randomly selected sites were combined with the basins survey reaches to describe aquatic conditions in the study area and are included in the summaries reported here.

Analysis

Habitat data were summarized at the reach (basins surveys) or site (OR Plan surveys) scale to describe channel morphology, habitat structure, sediment supply and quality, riparian forest connectivity and health, and in-stream habitat complexity. Individual attributes include:

Channel morphology	Channel dimensions
	Channel constraint features, if any
	Gradient
	Percent secondary channels
	Floodplain connectivity
Pool habitat	Percent pool
	Percent slow, backwater, and off-channel pools
	Deep Pools (>1m deep)
	Complex pools (contain > 3 pieces large wood)
Large Wood	Pieces of large wood (>0.15 diameter and >3m length)
	Volume of large wood (m^3)
	Key pieces of wood (>0.6m diameter and >12m length)
Substrate	Percent fines, gravel, cobble, boulder, bedrock
	Percent fines and gravel in low gradient riffles
Riparian	Shade
	Density of conifer trees, by size category
	Density of hardwood trees, by size category

Results are presented in tables and as frequency distribution graphs and in GIS coverages. Values were standardized as a percent or by reach length. Habitat attributes were expressed as reach or site averages or displayed at the habitat unit level. Information from a reference database was used to provide a standard point of comparison. The basins and OR Plan surveys were integrated into coverages in a Geographical Information System (Jones et al 2001). The basins surveys were routed and displayed at the channel reach and habitat unit scales, and the random surveys were displayed as points with reach summary data.

Individual stream survey reports for the streams in the North Cascade project area are available from the Aquatic Inventories Project in Corvallis. Metadata for the GIS coverages is available online at http://oregonstate.edu/Dept/ODFW/freshwater/inventory/index.htm. An interpretation guide for aquatic habitat data is available online at http://oregonstate.edu/Dept/ODFW/freshwater/inventory/index.htm

West Cascade Reference conditions

Reference values (Table 3) were derived from streams in areas with low impact from human activities (e.g. wilderness or roadless area, late successional forest or mature forest). A total of 68 reference sites, surveyed between 1991 and 2003, were selected within the West Cascade ecoregion. Each site was inspected using USGS 7.5 minute topographic maps for human-caused stressors such as roads, development, and forest management. A summary of reference site characteristics follows:

Attribute	**Value**
Number of Reaches or Sites	68
Distance Surveyed - Total (km)	111
Reach or Site Length (m)	
Mean (median)	1632 (1081)
Range	227 - 11997
Active Channel Width (m)	
Mean (median)	7.7 (6.5)
Range	1.5 – 23.3
Gradient (%)	
Mean (median)	9.3 (7.5)
Range	1.3 – 30.9
Ownership	primarily federal
Ecoregion	West Cascades

While few of the sites were completely absent of human influence, we assumed that the reference sites represented a natural range of conditions. The range of data for each reference stream variable was subdivided into quartiles, 0-25%, 25-75%, and 75-100%. The value within each of the three quartiles was labeled as either low, moderate, or high. Thus, we considered that the 25th and 75th quartile breakpoints represented the values we considered low or high within a natural context. The middle 50% quartile was considered a moderate or average level. We used these values not to predict historic conditions in the North Cascade project area, but to more broadly represent the potential range of historic conditions in the project area, and to provide a point of comparison for the subsequent analysis.

Aquatic Habitat Conditions

Aquatic Habitat overview

The ODFW Aquatic Inventories Project has conducted aquatic habitat surveys in the North Cascade project area since 1995. There are approximately 33 kilometers of surveyed stream habitat associated with 10 identified reaches within the project area (Map 11). Table 1 lists the streams surveyed. Table 5 provides all the stream reaches and habitat conditions for the selected attributes within the project area. Most of the streams surveyed in the project area were small to moderate sized tributaries, based on active channel width. The active channel width (bankfull width) on the surveyed streams ranged from 2.0 – 17.2m (average of 10m and a median of 9m). The gradient ranged from 3.2 – 15.0% (9.0% average and median).

Thirteen core habitat attributes considered important for successful spawning, rearing, and survival throughout various fish life history stages were analyzed. These core attributes are the amount of pool habitat, quantity of deep pools per kilometer, percent of slackwater habitat, percent of secondary channel area, percent of fines and gravel substrate found in riffle units, percent bedrock substrate, large wood pieces, volume, and key pieces, shade, and large conifers in the riparian zone. The values derived from these core attributes are compared to the high and low reference values of the reference stream reaches and conditions. Reference sites provide a general context and range of stream attributes of minimally human-influenced sites. They are intended to provide a point of comparison to view the relative differences between streams and reaches within a drainage network. Reference values are not meant to be prescriptive, that is, to indicate the value each reach of stream must attain.

Relationship of fish populations to aquatic habitat

The surveys described components and processes that contribute to the structure and productivity of a stream and fish community. The Aquatic Inventories Project selected attributes to describe important indicators of sediment supply and quality, instream habitat complexity, and riparian forest community. These variables were summarized for reaches and sites on ODF lands within the North Cascade project area in Tables 2 and 5. As mentioned earlier, we also used cumulative frequency distribution graphs to examine the survey data on ODF lands (Figures 1 through 8). The frequency distribution graphs are useful for determining medians and percentile values and for comparing the differences in distribution of values between multiple strata. These graphs also illustrate the habitat values with comparison to West Cascade Reference conditions. Those reaches meeting or exceeding the high reference values are displayed in Maps 12-15. Individual habitat units are displayed for complex pools, beaver pools, spawning gravel, and secondary channels (Map 16).

The response of salmonid fishes to the character of aquatic habitat varies by life stage and time of year. Adult fish seek deep pools for holding areas while preparing to spawn and need gravel and cobble substrate that is free of fine materials to build redds and deposit eggs. Furthermore the redds require a steady flow of oxygenated water to allow the eggs and alevins to mature. Increasing amounts of fine sediments (<2mm) increases the mortality of eggs in the gravel (Everest et al. 1987). The amount of silts and fines associated with riffles is an indicator of embeddedness in spawning areas. A high percentage of fine sediment can settle (embed) in the interstitial spaces of the gravel and armor it such that it is difficult for spawning fish to dig an adequate redd (nest) and prevent oxygenated water from reaching the eggs. Fine sediment values less than 19% are desirable (Table 3). The median value among the project areas was moderate at 16% (Table 4). Reaches which met or exceeded the high reference value are displayed on Map 12.

After emergence in the spring, salmonid fry typically remain in freshwater for a few weeks to two years before migrating to the ocean, depending on species. Edge cover and backwater habitats are particularly important to the survival of fry in the spring, though less so as they grow and move into larger pools during the summer. The distribution of juvenile salmonids is limited primarily by the availability of pool habitat, food resources, and acceptable water quality. Complex off-channel habitats are also important in these large stream reaches during the winter. Large wood is an important structural component contributing to the complexity of these preferred habitats (Sedell 1984). Juvenile steelhead and cutthroat trout are more opportunistic in regards to habitat type, residing in pools, riffles, rapids, and cascades. Additionally, pools provide resting places and over-wintering habitat for fish. Deep pools, those greater than or equal to 1 meter deep, provide temperature refugia and provide year-round cover.

The median value of the amount of available pool habitat in the North Cascade project area was moderate (11%). Overall, all reaches met or exceeded the moderate reference value. The project area had a median value of 4.0 for deep pools in relation to the habitat reference value (high value is more than 4 pools per kilometer greater than 1 meter deep) (Table 4, Figure 4, Map 13). Slackwater pools include backwater habitat, dammed pool, and beaver ponds. A high level is greater than 0.5% of total available habitat; the North Cascade project area exceeded the reference values with a median value of 8% (Table 4).

Instream wood serves many functions in a stream channel. The wood helps to scour deep pools, provide cover and nutrients, trap sediment, and provide cover from predators. Wood acts as an obstacle at higher flows, forcing the stream to cut new channels, to scour new pools, and to create undercut banks. Channel morphology and amount of secondary channel indicate relatively high connectivity to the floodplain. Secondary channels increase the potential habitat available to fishes, particularly to juveniles. Often the habitat has slower moving water than the primary channel. It provides over-wintering and summer rearing habitat for juvenile fish. A high level of secondary channels is 4% or more of the total channel area. The mean and median values for the North Cascade project area were 6.2% and 5.2% respectively. Reaches which met or exceeded the high reference value are displayed in Map 15.

Riparian vegetation is indirectly an important component of fish habitat. The riparian trees stabilize the bank, are a recruitment source of woody debris, buffer against flood impacts, and provide shade. Stabilized stream banks are more likely to develop undercut banks, which serve as important cover for fish and are less likely to contribute fine sediments. With the exception of the Coal Creek (8W-171) reach, the canopy cover (shade) in all reaches rated moderate in relation to the reference conditions. There were very few conifers observed in the riparian zones of any of the reaches (Tables 4 and 5, Figure 6). No reaches within the North Cascade project area exceeded the high reference value. This is a limiting factor for recruitment of large wood (greater than 60 cm dbh) into the channel and thus a limiting factor for increasing pool and channel complexity. Although all trees are important and contribute to the river system, conifers are particularly important as they tend to grow larger than deciduous trees; therefore, they remain in the river system longer before deteriorating and provide greater hydraulic function.

Habitat reach summaries

Pudding River drainage: Coal Creek (8W-171): Approximately 500 meters of Coal Creek were surveyed in 1998 in conjunction with the Oregon Plan sampling frame work. The reach was hillslope-constrained in a narrow valley with an average gradient of 9.0. The site exceeded the high reference value for shade; it met the low reference value for percent bedrock. Most other habitat parameters were at the moderate level. The reach exceeded the high level of fine sediment in riffle units with a score of 29% (>19% is considered high). An ODFW fish presence / absence survey was not conducted at this site, though the habitat crew noted cutthroat trout.

North Santiam drainage: Rock Creek (8W-145): Almost 1000 meters were surveyed in 1998. The reach was constrained by steep hillslopes in a narrow valley; the gradient averaged 6.0. The reach exceeded the high reference value for percent of area in secondary channels (6.2%; high was >4%) and percent deep pools (17%; high was >4 pools). It rated low for the number of keypieces and volume of large wood/100 meters. The remainder of the reach attributes was at the moderate level. The crew identified two potential barriers to upstream fish migration – a step-over-boulder 2.3m high and a cascade-over-boulder at 733 and 847 meters, respectively, from the survey start. In 1992, ODFW conducted a fish presence / absence survey on this stretch of stream. Cutthroat trout, rainbow trout, and sculpin were noted.

A basin survey was conducted on Rock Creek in 1995. Three reaches were designated, totaling over 15 kilometers. Reach 1 began at the confluence with the North Fork Santiam River and extended 6,486 meters. Two-thirds of the reach is on ODF property. The channel was unconstrained with multiple terraces in a wide valley floor. The reach exceeded the high reference value for percent slackwater pools and percent secondary channel area and exceeded the low level for bedrock. Large wood volume and key pieces were lower than the low reference value. The remaining habitat attributes were moderate. The reach lacked beaver ponds, yet did have a few units with complex pools. Three fish presence / absence surveys were conducted on this reach; trout and sculpin were recorded. A couple of tributaries to the reach were also surveyed at this time for fish presence and yielded either zero fish or trout species. The aforementioned survey, Rock Creek (8W-145), was contained within this reach. Reach two extended 2,343 meters to end at East Rock Creek. The reach was constrained by steep hillslopes and averaged 5% gradient. This reach met or exceeded the high reference value for percent secondary channels, percent slackwater pools, number of deep pools, and number of pieces of large wood. It exceeded the low level for bedrock. The remainder of the habitat attributes met the moderate level. This reach had many habitat units with complex pools, some spawning gravel and secondary channels. There were no beaver ponds. A fish presence/absence survey was not conducted on this portion of the stream. Tributaries of the reach were surveyed and yielded either no fish or trout species. The final reach was 6729 meters in length. The reach was constrained by moderately sloped hillslopes in a narrow valley. The reach exceeded the high reference value for percent slackwater pools and percent secondary channel area and exceeded the low level for bedrock. Key pieces were lower than the low reference value. The remaining habitat attributes were moderate. At the habitat unit level, there were secondary channel and spawning gravel, few complex pools, and no beaver ponds. Fish presence / absence surveys were conducted on the reach and its tributaries; some surveys yielded fish (sculpin and trout) and others did not.

Mad Creek: Three reaches were surveyed on this stream in 1996, totaling 7320 meters. The reaches are hillslope-constrained in a narrow valley. Reach 1 was 4379 meters in length and averaged 7 percent gradient. The landuses were timber harvest and large timber. The reach exceeded the high reference value for percent secondary channel area, percent slackwater pools, and number of pieces of wood. With the exception of key pieces of wood, remaining attributes were at the moderate level. Habitat units in this reach included complex pools and secondary channels, though there were no beaver ponds. The crew noted a potential barrier to fish passage; a step-over-bedrock 8.5m high. No fish presence / absence surveys were conducted in the reach. Reach 2 was 1214 meters long, had 9.6 percent gradient, and was mainly large timber landuse type. It exceeded the high reference value for percent slackwater pools, deep pools, and the large wood categories (pieces, volume, and key pieces). It was higher than the high level for bedrock (47%; >35% is high). Reach 2 had spawning gravel and complex pools, as seen at the unit level. No fish presence / absence survey was conducted in the reach. Reach 3 was 1727 meters long. It exceeded the high reference value for percent slack water pools. The amount of bedrock exceeded the high reference value (48%; >35% is high); the amount of gravel in riffles was lower than the low reference value (23%; <25% is low). Otherwise, the levels were in the moderate range. This reach had secondary channels, though lacked adequate spawning gravel, complex pools, or beaver ponds at the habitat unit level. A fish presence / absence survey was conducted, though no fish were found at the time of the survey.

Sevenmile Creek: This single reach survey began at the confluence with North Santiam River and continued 5251 meters upstream. Approximately half of the survey is on ODF land. Overall, the creek met the moderate level for habitat parameter reference values. The stream exceeded the high level for percent secondary channel area, percent gravel in riffle units, percent slackwater pools, and number of pieces of large wood. It surpassed the high level of silt in riffle units (25%; >19% is high); it was lower than the low level for key pieces of large wood (0.6 pieces; <1 is low). The survey was conducted post-1996. Several landslides were observed throughout the survey. Some of the small tributaries sluiced out and contributed substantial bedload to the creek. At the habitat unit level, there were complex pools, spawning gravel and secondary channels. There were three fish presence / absence surveys conducted on the ODF portion of the reach. Two of the three yielded no fish at the time of the surveys and one yielded amphibians.

Sardine Creek: One reach 3200 meters long and constrained by hillslopes in a narrow valley was surveyed on ODF land. The gradient averaged 13%. The reach exceeded the high reference values for percent secondary channel area, percent gravel in riffles, percent slackwater pools, and number of deep pools. It had low values for shade (75%; <80% is low), wood volume (22.4%; low is <23%) and for key pieces of large wood (0.6 pieces; <1 is low). The remainder of the attributes was in the moderate range. Complex pools and secondary channels were present at the habitat unit level. The crew noted two falls (13 and 15 meters high) as potential barriers to fish. A fish presence / absence survey was conducted at four sites. Trout and sculpin were found at the time of the surveys.

Flood surveys

ODFW Aquatic Inventories Project surveyed a selection of stream reaches following the large flood event that occurred during February 1996 (Jones et al. 1998). Due to the structure of the sampling, none of the randomly selected flood survey sites were within the ODF North Cascade project area.

Barriers

Barriers and potential barriers to anadromous and resident fish exist in most riverine systems due either to human-caused or natural processes. A barrier, which includes culverts, dams, velocity barriers, natural falls, lack of sufficient water flow, etc., is defined as an impediment to the movement of any fish at any life stage. The North Cascade project area has 11 recorded barriers, as determined by Streamnet (Map 17 and Table 6). These barriers are located both within and outside known fish distribution. Fish distribution may extend beyond a partial barrier because the barrier may be specific to a species or life stage, or at a particular time of year (Map 18).

The Streamnet barrier database incorporated the culvert inventory database; therefore, culverts in the dataset are those which do not meet acceptable fish passage criteria, not necessarily those which prevent all fish at all times. Of the 11 listed barriers, 2 are culverts. These barriers are rated as to the degree, or lack thereof, of fish passage. One is thought to be nonblocking; one has unknown passage ability. Movement may be prevented due to high velocity of water through the culvert, incorrectly sized culvert, culvert deterioration, or debris blocking the culvert. The remaining 9 are natural waterfalls, both named and unnamed, and are described below. Data are not available to assess fish presence above all of the potential barriers (Table 11).

There are three named falls in the North Cascade project area. Abiqua Falls is located on Abiqua Creek. The height of the Falls is about 30 meters. Approximately 3000 meters of ODF land upstream of the Falls is potentially blocked to anadromous fish. Butte Creek Falls, on Butte Creek, is approximately 30 meters high and potentially blocks 12 kilometers of fish passage. Shellburg Falls, on Stout Creek, is approximately 30 meters high and potentially blocks 2000 meters of fish passage on state land. The amount of aquatic habitat with restricted access or passage problems in the North Cascade project area based on Streamnet barrier data may total 33 kilometers. Information as to species and life stage affected is not available in the database.

Conducting field surveys to improve documentation is recommended, because passage is unknown at some of the falls.

For those where anadromous fish distribution is mapped, fish use ends at or below each of the listed barriers (Map 18). The Aquatic Inventories Project fish presence / absence surveys were designed to assess the status and distribution of fishes at the time of the survey. Their data reveal that resident rainbow trout, cutthroat trout, lamprey, and sculpin may be present above some natural barriers. No anadromous fish were noted during these surveys.

Additionally, aquatic habitat survey crews documented many potential barriers to migratory fish. They identified natural steps up to 15.0 meters high on ODF land (Map 19). Crews labeled two natural features as potential barriers. These were steps-over-boulder located on Sardine Creek and were 13 and 15 meters high. The sites did not correspond with those in the Streamnet database. Crews identified nine steps, ranging from 2.0 – 8.5 meters high, which have the potential to impede fish.

Restoration

Restoration is a technique and process used in an attempt to improve stream habitat in the short term and to achieve long-term recovery goals. The goals of restoration range from improving spawning and rearing habitat to improving natural stream processes. Treatment projects focus on improving summer and winter rearing for juvenile salmonids, improving spawning habitat, increasing channel complexity and connectivity, increasing nutrients in the stream, reducing sedimentation and bank erosion, and replanting native streamside vegetation. The quality of existing pools could be increased by recruitment of gravel, addition of wood pieces, or increased shade levels. Monitoring is a critical aspect of the restoration effort, as it is important to gauge whether the methods employed helped to achieve the desired effects. Achieving noticeable response may take several high flow events; biological response could take longer.

Since 1998, fifteen instream projects funded by OWEB have been completed on ODF lands (Table 8, Map 20) in the North Cascade project area. The projects on ODF lands focused on instream enhancement, road/drainage improvements, and passage issues. Eight projects placed large wood in the stream; four improved the road and drainage system, and seven improved fish passage.

Implementing restoration enhancement projects/techniques after the habitat survey makes sense. Not only does the habitat survey provide a baseline from which to see potential impacts from the restoration projects, but it also allows for comparisons to the reference values. These values guide habitat biologists who protect and enhance reaches with high quality habitat. If high quality habitat is not available, then those reaches with high potential for better quality habitat should be selected. Overall, the North Cascade project area meets the moderate to high reference value, so finding area of quality habitat to enhance should be a smooth procedure.

Of the fifteen projects, Mad Creek reach 1 (Project Number 980312) was conducted after the habitat survey. The reach met the moderate or high reference value for most every parameter. The additional wood will increase the large wood pieces, volume, and key pieces, help to scour deep pools, and recruit gravel. The projects goals were to improve the complexity of the channel and spawning habitat and to increase the number of pools through the placement of large wood. A site visit would verify whether or not the project has impacted the stream and has met the original goals.

Summary of Fish Populations and Aquatic Habitat Conditions in the Oregon Department of Forestry North Cascade Study Area

Fish distribution

What fish species are documented in the watershed?

- Coho salmon, fall and spring Chinook salmon, winter and summer steelhead, cutthroat, and rainbow trout are present in the North Cascade basin. The occurrence and distribution of other native species is known to include cottids and amphibians.

Are any of these species currently state- or federally-listed as endangered, threatened, or candidates?

- Spring Chinook salmon and winter steelhead are listed as threatened under the federal Endangered Species Act in the North Cascade study area (http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/).

Are there any fish species that historically occurred in the watershed that no longer occur there? Map potential historical fish distribution.

- No species have been extirpated from the North Cascade study area.
- We believe current distribution is similar to historical distribution.

Which salmonid species are native to the watershed, and which have been introduced?

- Spring Chinook salmon and winter steelhead are native to the watershed. Fall Chinook salmon, coho, and summer steelhead have been introduced with the advent of the fish ladder. Cutthroat trout and rainbow trout are native.

Are there potential interactions between native and introduced species?

- Interactions between native and introduced fish may occur, since the run times have become more similar overtime than when the species were originally introduced.

Current habitat conditions

Show current condition of key habitat characteristics.

- Habitat surveys were conducted from 1995 – 1998 (Map 3).
- Habitat characteristics are listed in Table 5, graphed in Figures 1 through 8, and examples mapped in Maps 17 - 22.

Compare to reference streams for each characteristic.

- Reference sites provide a general context and range of stream attributes of minimally human-influenced sites, and are intended to provide a point of comparison to view the relative differences between streams and reaches within a drainage network. Reference values are not meant to be prescriptive, that is, to indicate the value each reach of stream must attain.
- Key reference values are presented in Tables 3-5 and individual stream reaches are compared to the West Cascade reference values in Table 5, Figures 1-8, and Maps 17-20.

- Within the North Cascade project area, most of the median values for 13 habitat attributes are in the moderate level.
  - Percent pools: The median value for the project area was moderate (11.0%). All ten reaches met the moderate reference value level.
  - Deep pools/km: The median value for the project area was high (4.0/km). Four of the ten reaches met or exceeded the high reference value level.
  - Percent slackwater pools: The median value for the project area was at the high (8.0%) level; eight individual reaches met or exceeded the high reference value level.
  - Percent secondary channel area: The median value for the project area was high at 5.2%; seven of the ten reaches met or exceeded the high reference value level.
  - Percent fines in riffle units: The median value for the project area was moderate at 16%; eight of the ten reaches were at moderate levels.
  - Percent gravel in riffle units: The median value for the project area was moderate at 35%. One reach exceeded the high reference value level; seven of the ten reaches were within the moderate reference value level.
  - Percent bedrock: The median value for the project area was 15%. Four of the ten reaches met or exceeded the low reference value level.
  - Pieces lwd/100m: The median value for the project area was moderate (15); four of the ten reaches met or exceeded the high reference value level.
  - Volume lwd/100m: The median value for the project area was moderate at 26.0. One of the ten reaches exceeded the high reference value level; six reach values were at the moderate level.
  - Key pieces lwd/100m: The median value was 1.0 which was moderate. One reach exceeded the high reference value level; one reach met the moderate reference value level.
  - Number of conifers >50cm dbh/305m: The median value for the project area was moderate at 41.0. Nine reaches met the moderate reference value level.
  - Number of conifers >90cm dbh/305m: The project area median value was low (0.0). One reach met the moderate level.
  - Percent shade: The median value for the project area (84.0%) was at the moderate level. One reach exceeded the high reference value level; eight reaches met the moderate level.

What stream reaches have high, moderate, and low levels of key pieces of large wood (>24-in) in the channel?

- Key pieces/100m: The median value for the project area was 1.0 which was at the moderate level. One reach, Mad Creek reach 2, exceeded the high reference value level. Rock Creek reach 2 met the moderate reference value. The remaining reaches were at the low reference value.

How many miles of fish-bearing or potentially fish-bearing streams are blocked by culverts, and where are these blockages?

- Of the 11 listed barriers on ODF land, 2 are culverts. These barriers are rated as to the degree, or lack thereof, of fish passage. RecordId 4217 is thought to be nonblocking; RecordId 3707 has unknown passage ability. It is possible that other barriers not noted are present.

- The amount of aquatic habitat with restricted access in the North Cascade project area based on Streamnet barrier data is approximately 33 kilometers. Documentation as to the species and life stage affected by each barrier is limited. Field surveys to improve documentation is recommended. As five of the seven structures potentially limiting fish distribution are natural falls, attention should be directed towards the culvert issues as well as provide adequate habitat downstream of these falls.

Are there watersheds where the current level of instream wood is a limiting factor for achieving properly functioning aquatic systems?

- Several reaches in the North Cascade project area meet the high large woody debris reference level for number of pieces and volume per 100m (Tables 5 and 6B and Map 19). Key pieces of wood were low overall, though two reaches exceeded the low level. Additional large wood would increase the opportunity for complex instream habitat, scouring of deep pools, and sediment sorting in most of the reaches.
- Reach two of Mad Creek met the high reference value level for number of pieces, volume, and key pieces of lwd/100m.
- Sardine Creek and Rock Creek reach 1 met the low level for both wood volume and key pieces. Rock Creek reach 1 was also low for the number of deep pools. These particular reaches would benefit from the addition of large wood.

Analyze restoration potential

Which reaches have the most potential to increase fish populations?

- Due to the lack of mapped intrinsic potential for this area, habitat surveys, site visits, and knowledge of the area will guide biologists to choose reaches with high quality habitat to enhance the habitat and to protect fish productivity.
- Due to the amount of unknown habitat quality and availability, improving fish populations and production is difficult to determine. Fish use is not mapped for all the streams on ODF property.
- A long term strategy to grow large conifer trees in the riparian area will improve conditions across the project areas and increase complexity of stream habitat for fish production as the trees naturally recruit to the channel. Although alders along the streamside serve important functions, large riparian conifers are necessary as well for their size and persistence in the system. In addition to riparian plantings, large wood in the stream would help to retain gravel.
- Site selection will require an in-depth analysis of the unit level GIS and Oregon Plan site data coupled with field verification. Habitat complexity and floodplain connectivity requires the placement of large wood in selected stream segment to create complex pool and channel breaching opportunities. Taking advantage of the existing secondary channels will accelerate the process.
- Reduction of fine sediment will require additional information to determine source, transport, and storage of sediment in the basin. The data available through the stream surveys only identify areas collecting excessive amounts of fine sediment.
- Site verification prior to restoration planning is necessary because some of the surveys are 10 years old and proper implementation depends on current site-specific factors.

Which reaches have the most potential to meet or exceed reference value levels?

- All of the reaches have the potential to meet many of the reference value conditions over time. Restoration and protection strategies can expedite the opportunity to improve aquatic habitat complexity, sediment, and riparian structure in the North Cascade project area.

What is the magnitude of possible additional habitat with restoration of access?

- The two culverts potentially blocking upstream passage of fish should be examined. Surveys are needed to determine the condition of the culvert, the ability of fish of many sizes and life stages and types to pass, and to document the quantity and quality of habitat for salmonid species above the culverts.
- The amount of aquatic habitat with restricted access or passage problems in the North Cascade project area based on Streamnet barrier data may total 33 kilometers. Information as to species and life stage affected is not available in the database. Conducting field surveys to improve documentation is recommended, because passage is unknown at most of the sites. Either fish use is not mapped for many of the sites with potential barriers or fish use ends at or below the potential barrier; therefore it is difficult to project the magnitude of restoring access.

What is the relative priority of barriers for removal, replacement, or repair?

- The ODF and Streamnet barrier databases do not provide a lot of detail. Site checks are necessary to verify the nature and extent of the passage issues.

Describe the types and locations of potential enhancement projects.

- More habitat surveys are necessary to asses and determine the quality of the available habitat.
- Due to the lack of mapped intrinsic potential for this area and habitat surveys, site visits and knowledge of the area will guide biologists to choose reaches with high quality habitat to enhance the habitat and to protect fish productivity.
- Looking broadly at the North Cascade project area, reference values for riparian conifers, large woody debris, and gravel substrate were on the lower end of the moderate range. Fine sediment was on the high end of the moderate range. Efforts to improve these attributes would be beneficial.
- Many streams on ODF land would benefit from the addition of large woody debris, which would entrap substrate, scour deep pools, and provide cover for fish. Examples include Rock Creek reach 1, Sardine Creek, Mad Creek reach 3, Sevenmile Creek.
- Enhancement activities can be more effective when a watershed approach is utilized. For example, rather than constructing one or two habitat structures in each of ten widely scattered locations, constructing these same structures in one watershed can enhance a longer continuous section of stream. With riparian plantings and the removal of a passage barrier, a whole stream could be improved.
- Priorities related to fish habitat are discussed above – improving habitat complexity, floodplain connectivity, scouring of pool habitat, and reduction of fine sediment, and retention of spawning gravel.

- Riparian plantings that increase the number, size, and species of conifer trees in the riparian zone would benefit floodplain connectivity and increase shade levels and long-term large wood recruitment. Riparian enhancement for larger and greater mix of conifer species will again require site visits to identify appropriate floodplain and terrace sites within the North Cascade project area.

Describe confidence level in restoration analysis.

- The aquatic surveys, between 1995 and 1996, described the overall conditions within each reach at the time of the survey. Restoration recommendations were based on existing habitat surveys (although selected attributes of the habitat data may be out of date for this use), channel and valley configuration, and digital elevation models. Because successful restoration depends on site-specific characteristics, we recommend: 1) site visits prior to final planning, 2) analysis of habitat data (available in GIS and database) at the habitat unit scale, 3) re-examination of gradient and valley form, 4) more comprehensive road and barrier information, and 5) more detailed description of riparian conditions.

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Tables, Figures, and Maps

Table 1. ODFW surveyed streams listed by basin and ODF management area.

Basin	ODF management area	ODFW surveyed stream
North Santiam River	Green Basin	Sardine Creek
	Mad Creek	Mad Creek
		Sevenmile Creek
	Rock Creek	Rock Creek
		Rock Creek (8W-145)
Pudding River	Butte Creek	Coal Creek (8W-171)

Table 2. Comparison of reach length, active channel width, gradient, ownership, ecoregions, and geology between West Cascade reference surveys and ODF North Cascade project area.

Attribute	West Cascade Reference Reaches	North Cascade project area	North Cascade project area streams: Sardine Creek	Sevenmile Creek	Mad Creek	Rock Creek	Rock Creek (W-145)	Coal Creek (W-171)
Number of Reaches or Sites	68	10	1	1	3	3	1	1
Distance Surveyed - Total (km)	111km	32.8km	3200m	5251m	7320m	15,558m	942m	505m
Active Channel Width (meters):								
Mean (Median)	7.7m (6.5m)	10m (9m)	8.4m	10.4m	7.6m (8.5m)	12.7m (14.3m)	15m	2m
Range	1.5 - 23.3m	2.0 - 17.2m			5.0 - 9.2m	6.7 - 17.2		
Gradient (%):								
Mean (median)	9.3 (7.5)	9m (9m)	9	13.1	10.5 (9.6)	5.9 (4.9)	6	9
Range	1.3 - 30.9m	3.2 - 15.0			6.9 - 15	3.2 - 9.6		
Ownership	Primarily federal	state	state	state and private	primarily state	primarily state	state	state
Ecoregions	100% Cascade	100% Cascade	100% Cascade	100% Cascade	100% Cascade	100% Cascade	100% Cascade	100% Cascade

Table 3. West Cascade Reference values and descriptions.

Parameter	Definition	Low value	High value
percent pools	percent primary channel area represented by pool habitat	<7%	>24%
deep pools/km	pools > 1m deep per kilometer of primary channel	0	>4
percent slackwater pools	percent primary channel area - slackwater pool habitat (beaver pond, backwater, alcoves, isolated pools).	0	>0.5%
percent secondary channels	percent total channel area represented by secondary channels	0	>4%
percent fines in riffles	visual estimate of substrate composed of <2mm diameter particles	>19%	0
percent gravel in riffles	visual estimate of substrate composed of 2-64mm diameter particles	<25%	>49%
percent bedrock in stream	visual estimate of substrate composed of solid bedrock	>35%	<13%
pieces lwd/100m	# pieces of wood > 0.15m diameter X 3m length per 100 meters primary stream length	<7	>21
volume lwd/100m	volume (m3) of wood > 0.15m diameter X 3m length per 100 meters primary stream length	<23	>68
key pieces lwd/100m	# pieces of wood > 60 cm diameter X > 12 meters long per 100 meters primary stream length	<1	>4
# conifers > 50 cm dbh	number of conifer trees larger than 50 cm dbh within 30m both sides of stream per 305m of primary stream length	0	>284
# conifers > 90 cm dbh	number of conifer trees larger than 90 cm dbh within 30m both sides of stream per 305m of primary stream length	0	>151
percent shade	percent of 180 degree sky; includes topographic and tree shade	<80%	>92%

Table 4. Habitat survey reach values and habitat parameter values relative to West Cascade Reference Conditions.

Parameter	Habitat Reference Value	ODF North Cascade Project Area 32.8 km n = 10 mean	median
percent pools	Low <7%		
	Moderate	13%	11%
	High >24%		
deep pools/km	Low 0		
	Moderate		
	High >4	5	4
% slackwater pools	Low 0		
	Moderate		
	High >0.5%	10%	8%
% secondary channel area (m2)	Low 0		
	Moderate		
	High >4	6.2%	5.2%
% fines in riffles	High >19%		
	Moderate	16%	16%
	Low 0%		
% gravel in riffles	Low <25%		
	Moderate	35%	35%
	High >49%		
% bedrock	High >35%		
	Moderate	20%	15%
	Low <13%		
pieces LWD/100m	Low <7%		
	Moderate	19	15
	High >21		
volume LWD/100m	Low <23		
	Moderate	34	26
	High >68		
key pieces/100m	Low <1.0		
	Moderate	1	1
	High >4		
# conifers >50cm dbh	Low 0		
	Moderate	66	41
	High >284		
# conifers >90cm dbh	Low 0		0
	Moderate	3	
	High >151		
% shade	Low <80%		
	Moderate	85%	84%
	High >92%		

Table 5. Summaries of summer habitat reaches surveyed within the North Cascade project area. Figures in bold met or exceeded the high West Cascade Reference values.

NORTH CASCADES PROJECT AREA
REACH SUMMARY

STREAM	SURVEY DATE	REACH LENGTH (m)	% AREA IN SIDE CHANNELS	GRADIENT %	VWI	*VALLEY FORM	*CHANNEL FORM	*LAND USE DOM	*LAND USE SUB-DOM	SHADE %	BEDROCK %	FINES IN RIFFLES %	GRAVEL IN RIFFLES %	LARGE BOULDERS #/100m
Rock Creek (8W-145)	6/24/1998	942	**6.2**	6	1	SV	CH	LT	MT	81	16	10	40	97.0
Coal Creek (8W-171)	8/20/1998	505	0	9	1	MV	CH	ST	LT	**93**	**0**	29	47	7.0
MAD CREEK	7/1/1996	4379	**4.8**	6.9	1.2	MV	CH	TH	LT	83	24	17	30	100.3
MAD CREEK	7/10/1996	1214	1.3	9.6	1	MV	CH	LT		83	47	6	38	90.1
MAD CREEK	7/11/1996	1727	2.7	15	1	MV	CH	ST		88	48	8	23	78.0
ROCK CREEK	7/5/1995	6486	**16.5**	3.2	8.3	MT	US	ST		84	**3**	14	22	122.4
ROCK CREEK	7/6/1995	2343	**5.7**	4.9	1.2	SV	CH	LT	MT	88	**12**	16	34	86.1
ROCK CREEK	7/11/1995	6729	**4.8**	9.6	1.3	MV	CH	LT	MT	87	**10**	18	36	97.2
SARDINE CREEK	7/16/1996	3200	**5.5**	9	1	MV	CH	ST	LT	75	28	16	32	68.6
SEVENMILE CREEK	6/17/1996	5251	**8.2**	13.1	1.1	MV	CH	LT		84	14	25	**50**	41.1

STREAM	REACH LENGTH (m)	ACTIVE CHANNEL WIDTH (m)	CHANNEL WIDTHS/ POOL	PERCENT POOLS	PERCENT SLACKWATER POOLS	POOLS >1m DEEP/km	RESIDUAL POOL DEPTH (m)	WOOD DEBRIS PIECES #/100m	WOOD DEBRIS VOLUME (m3)/100m	WOOD DEBRIS KEY PIECES #/100m	CONIFER TREES TOTAL/305m	RIPARIAN CONIFERS #>50cm dbh /305m	RIPARIAN CONIFERS #>90cm dbh /305m
Rock Creek (8W-145)	942	15	4	21	0	**17**	1	12	14	0	589	41	0
Coal Creek (8W-171)	505	2	26	9	0	0	0	15	30	1	81	41	0
MAD CREEK	4379	8.5	8.6	13.9	**13.4**	4.6	0.5	**22.3**	24	0.5	671	148	26
MAD CREEK	1214	9.2	10.2	7.7	**7.7**	**5.4**	1	**39.9**	**93.7**	**6.1**	1158	61	0
MAD CREEK	1727	5	26.6	20.4	**20.4**	2.7	0.7	15.7	25	0.3	2154	41	0
ROCK CREEK	6486	17.2	9.1	7.2	**6.7**	1.8	0.6	9.5	14.7	0.5	256	0	0
ROCK CREEK	2343	14.3	5.2	21.2	**21**	**7.7**	0.9	**22.4**	47.7	2.3	960	15	0
ROCK CREEK	6729	6.7	14.3	8.9	**8.7**	1.9	0.6	13.5	26.8	0.9	1690	183	0
SARDINE CREEK	3200	8.4	13.6	13.1	**13.1**	**7.3**	1.2	13.5	22.4	0.6	777	15	0
SEVENMILE CREEK	5251	10.4	11.5	8.2	**8.2**	3.1	0.6	**25.7**	38.1	0.6	1286	116	0

Table 6. Barriers and associated features (as identified by Streamnet) within the North Cascade project area.

Stream LLID	Stream name	Record Id	Barrier type	Passage*	Adult passage **	Comments
1225955450166	Coal Creek	3703	Unnamed culvert	99	fish use not mapped	Step falls on 18% cascade. Velocity appears Ok, slope of 3.8? (Clac Co slope)
1223511448411	unnamed stream	4217	Unnamed culvert	4	fish use not mapped	
1224422447536	Rock Creek	50569	Unnamed falls	99	ends at falls	Documented in 1959.
1224422447536	Rock Creek	50570	Unnamed falls	99	fish use not mapped	Documented in 1959. Ref. 598 reports the location as 4.8 miles above the mouth.
1223607448351	Evans Creek	50582	Unnamed falls	99	fish use not mapped	Documented in 1959.
1226091448084	Shelburg Creek	50586	Shellburg Falls	99	ends below falls	Documented in 1959.
1228325450363	Abiqua Creek	50781	Abiqua Falls	99	ends at falls	Documented in 1959 by Ref. 598. Also documented by Ref. 50122.
1227735451611	Butte Creek	50788	Butte Creek Falls	99	fish use not mapped	Ref. 50149 reported the location as river mile 28.65 and the height as 30 feet. Reported by the District Biologist to be a series of four consecutive falls.
1224563449610	Gawley Creek	50798	Unnamed falls	99	ends below falls	Documented in 1959. Ref. 598 reported the location as 2.3 miles above the mouth.
1223976447525	Mad Creek	51577	Unnamed falls	99	ends below falls	Notes state that there is an 18' falls and a 30' falls.
1223976447525	Mad Creek	55635	Unnamed falls	99	ends at or below falls	

*Passage 1=complete, 2=partial, 4=nonblocking, 99=unknown
**Migratory fish passage (coho, chinook, steelhead) as mapped by Streamnet

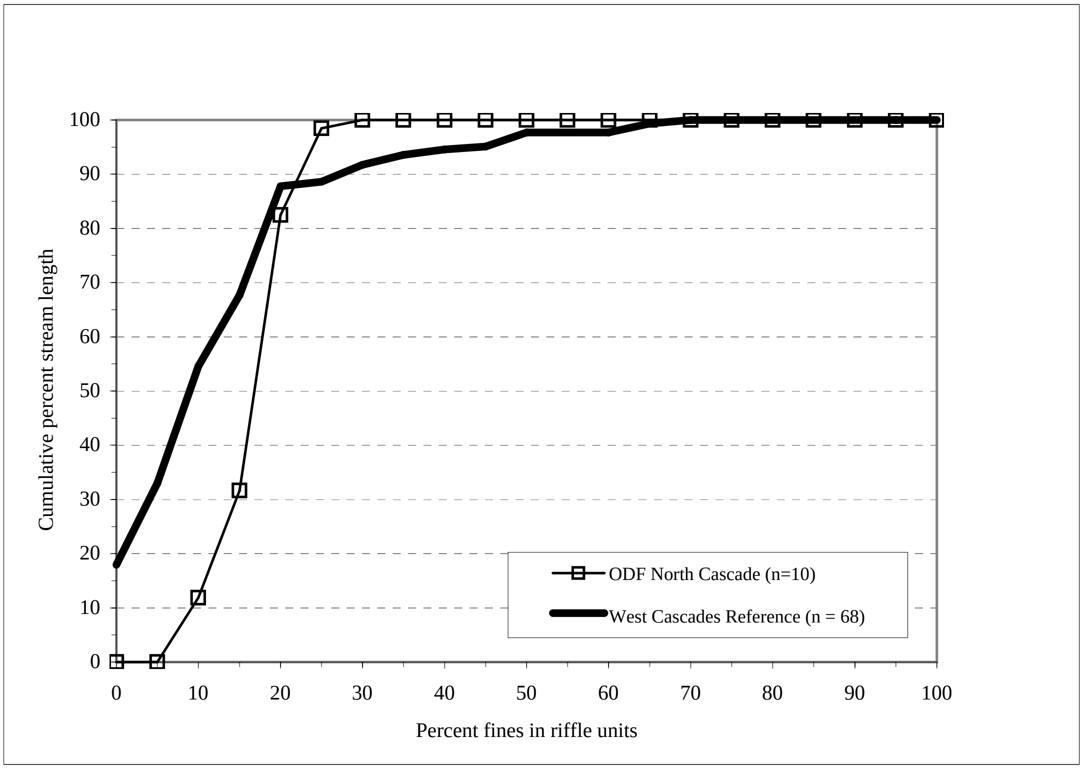
Table 7. Criteria for selecting restoration sites

Best stream reaches for restoration	**Poor stream reaches for restoration**	**Rational**	**Solution**
low gradient (<5%)	high gradient (>5%)	Structures placed in steep reaches will probably get washed down stream.	Although the overall gradient may be steep, it may be possible to locate flats or benches of low gradient. Instream work should be limited to such areas.
moderate channel size (<12m)	large channel size (>12m)	Structures placed in wide channels will probably get washed down stream.	Large channel restoration should use very large pieces of wood that partially extend into the channel.
moderate valley type	steep valley shape	Streams in steep valleys are constrained by the valley walls. During high flow events, there is limited over-wintering habitat potential.	Instream structures should be limited to sections of wider valley where stream energy can be dissipated.
water temperature cool enough for juvenile salmon summer survival	water too warm for juvenile salmon summer survival	Fish have water temperature tolerances.	Efforts to restore or improve streamside shading may result in water temperature suitable to salmonids.
water supply adequate to support young salmon summer survival	inadequate water supply to support young salmon summer survival	Fish need adequate water supply for survival	Although inadequate water supply during the summer, these reaches may provide over-wintering opportunities. However, if the stream is too steep, has inadequate water parameters, or not adjacent to summer rearing areas, there is little restoration potential. Restoration efforts in such streams should carefully assess winter rearing potential.
unobstructed access by juvenile and adult salmon during migration	restricted access to juvenile and adult migration	Salmon need access to the stream system	Streams blocked by culverts or other physical properties make them desirable for restoration.

Table 8. OWEB-funded instream restoration projects on ODF land in the North Cascade project area highlighting some actions, goals, and targeted species to benefit from the project.

Project Number	Basin	Year	Stream name	Project Description	Project Goals	coho	steelhead	Chinook	cutthroat	rainbow trout	other fish
980312	Willamette (Mid)	1998	Mad Creek	instream large wood placement	to improve structure and complexity to improve spawning habitat to increase the number of pools		X		X	X	X
980313	Willamette (Mid)	1998	East Fork Rock Creek	instream large wood placement	to improve spawning and rearing habitat to improve structure and complexity to increase the number of pools to help cool water and provide refuge		X		X	X	X
980315	Willamette (Mid)	1998	Stout Creek tributary	instream large wood placement	to improve structure and complexity						
980317	Willamette (Mid)	1998	Shelburg Creek	peak flow passage improvements surface drainage improvements 1 culvert replaced	to improve road drainage to decrease erosion and run off to improve fish passage						
980319	Pudding	1998	Butte Creek	instream large wood placement peak flow improvements surface drainage improvements	to improve structure and complexity to improve road drainage to decrease erosion and run off						
990363	Willamette (Mid)	1999	South Fork Mill Creek	instream large wood placement	to increase gravel recruitment to improve structure and complexity to increase the number of pools				X		
990369	Willamette (Mid)	1999	South Rock Creek	sidecast pulled back road vacated 2 culverts removed and not replaced	to decrease potential washouts at stream crossings to decrease road density to improve fish passage				X		
990588	South Santiam	1999	Cruiser Creek	instream large wood placement peak flow passage improvements surface drainage improvements	to improve spawning and rearing habitat to improve structure and complexity to increase the number of pools to decrease erosion and run off						
20010626	South Santiam	2001	Bald Barney Creek	instream large wood placement	to increase gravel recruitment to improve structure and complexity to increase the number of pools to improve spawning and rearing habitat				X		
20010627	South Santiam	2001	Cruiser, Bald Peter, and Green Mountain Creeks	peak flow passage improvements surface drainage improvements 1 culvert replaced with a bridge	to decrease erosion and run off to improve road drainage to improve fish passage to open 1.75mi of previously inaccessible stream				X		
20010631	North Santiam	2001	Little North Fork Santiam River tributaries	1 culvert replaced	to improve fish passage to improve 0.16mi of stream to open 0.13mi of previously inaccessible stream				X		
20010634	Pudding	2001	Butte Creek	instream large wood placement	to increase interaction with the floodplain to improve spawning and rearing habitat to improve structure and complexity		X		X		
20010637	Pudding	2001	Butte Creek	1 culvert replaced with bridge	to improve fish passage to improve 5.4 miles of stream				X		
20030579	Pudding	2002	Rhody Creek	3 culverts replaced with culverts	to open 1.8mi of previously inaccessible stream						
20030580	North Santiam	2002	Stout Creek tributary	4 culverts replaced with culverts	to open 2.7mi of previously inaccessible stream						

Oregon Department of Forestry: North Cascade Project Area



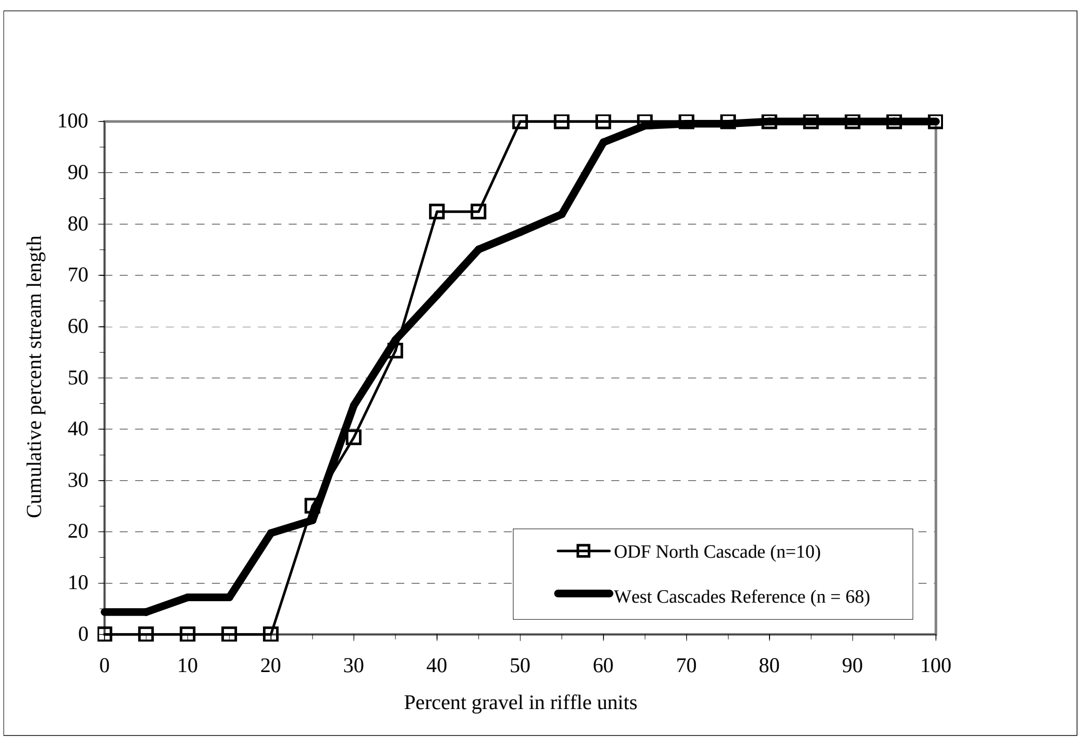
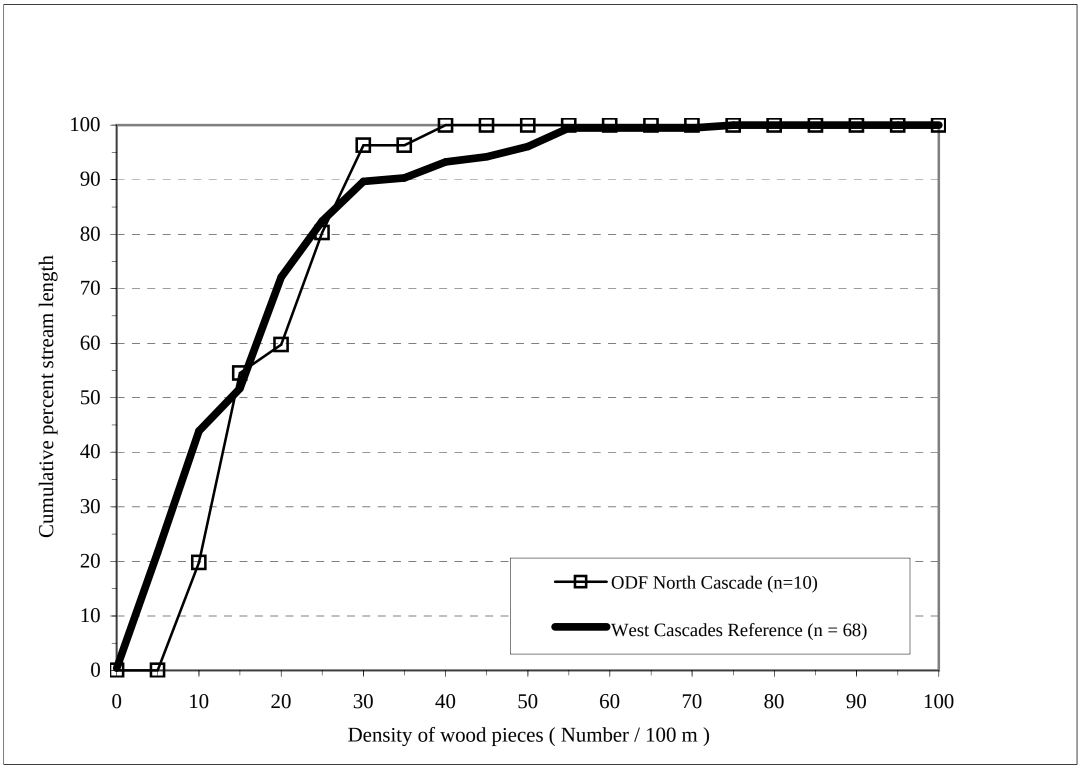


Figure 1. Cumulative frequency distribution comparing fines and gravel in riffle units in the ODF North Cascade project area to West Cascade reference conditions.

Oregon Department of Forestry: North Cascade Project Area



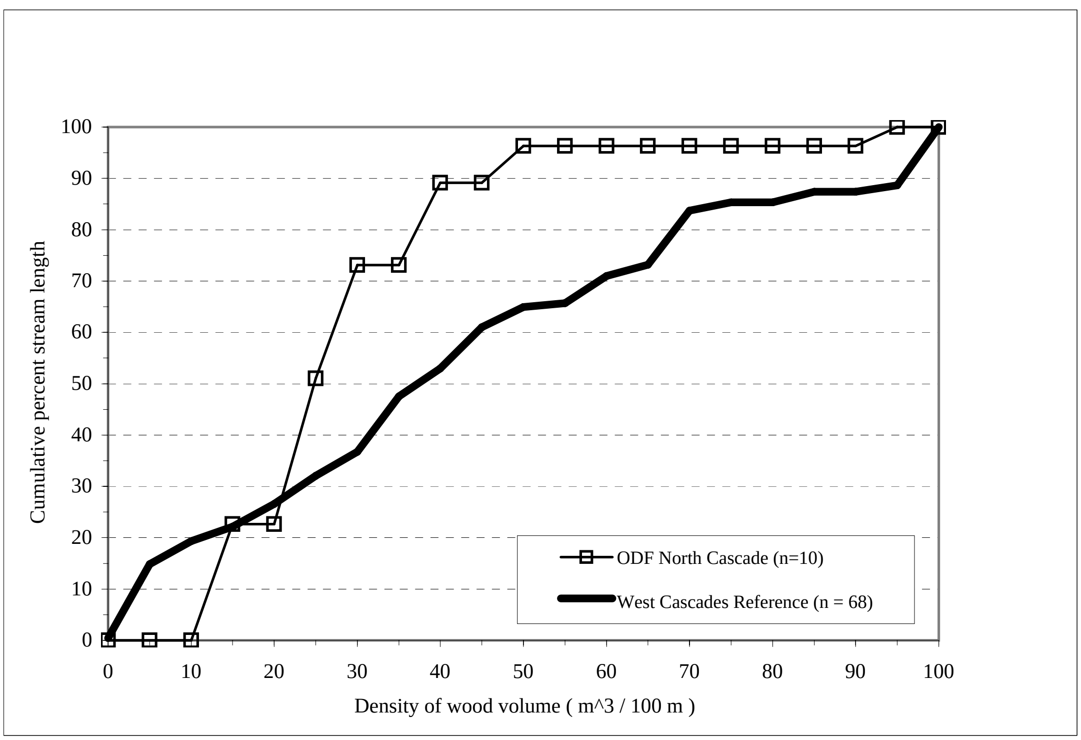
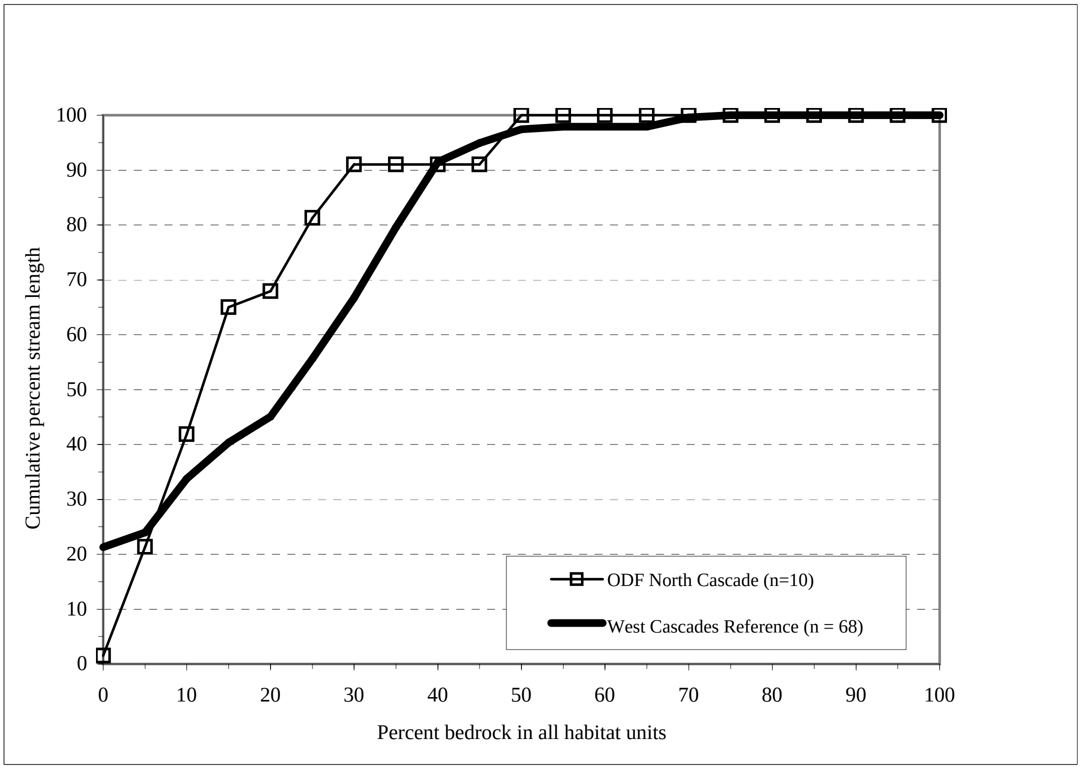


Figure 2. Cumulative frequency distribution comparing wood volume and pieces in the ODF North Cascade project area to West Cascade reference conditions.

Oregon Department of Forestry: North Cascade Project Area



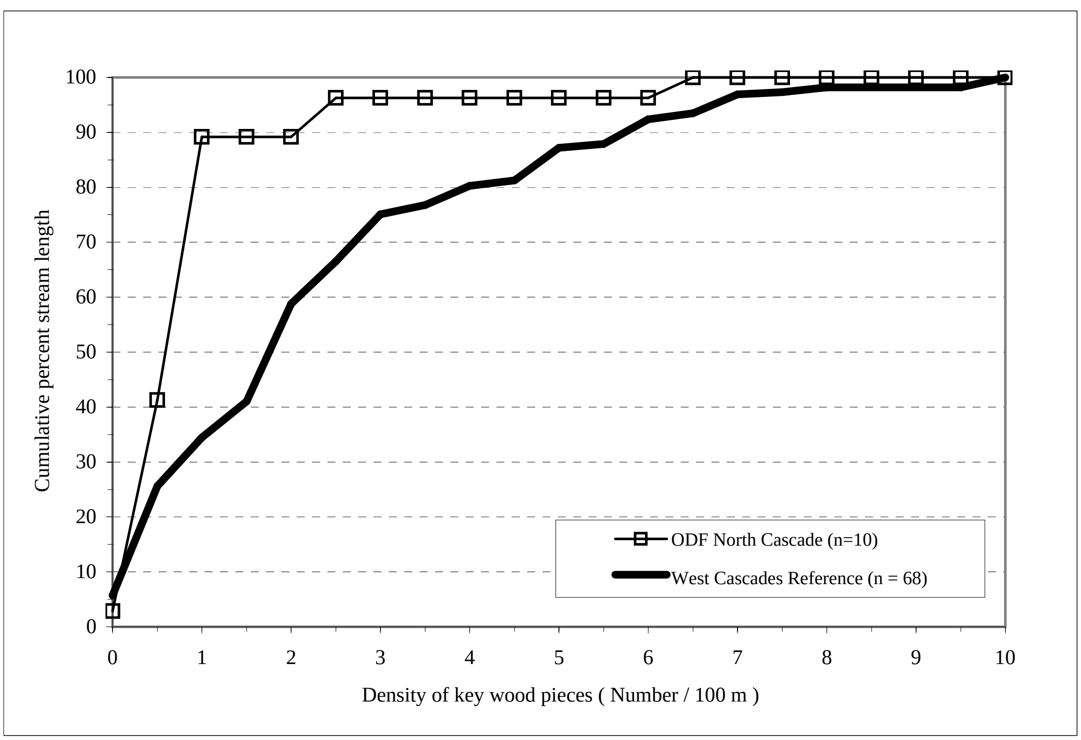
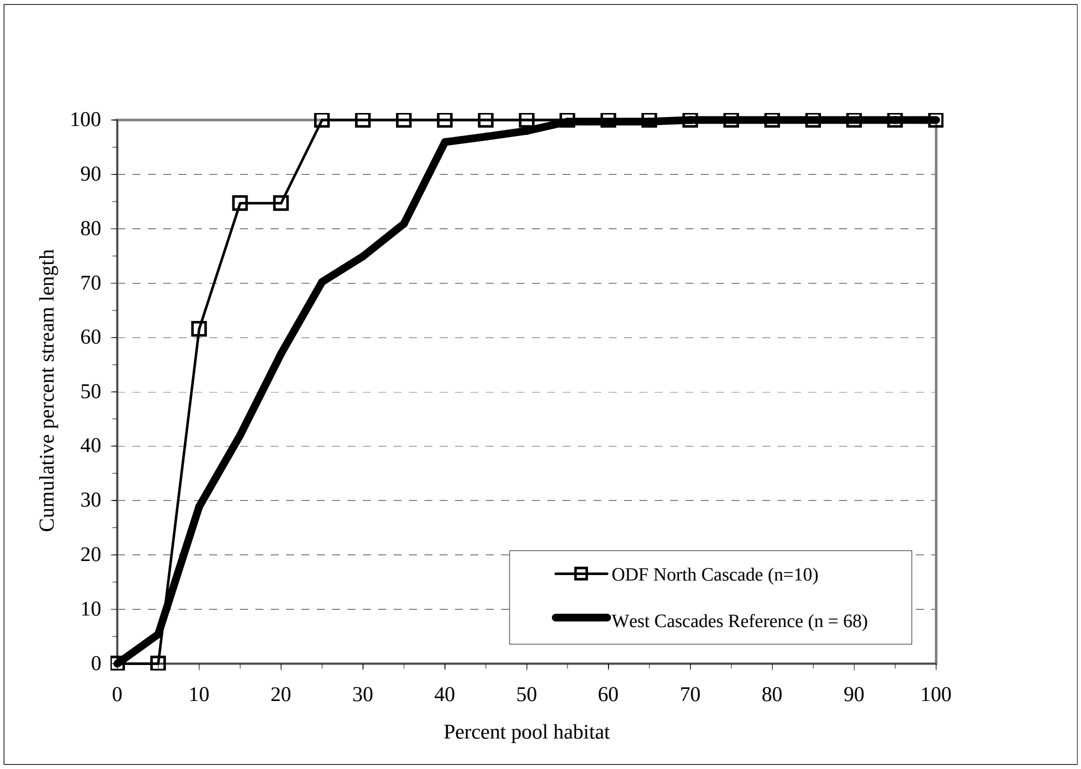


Figure 3. Cumulative frequency distribution comparing LWD keypieces and bedrock in the ODF North Cascade project area to West Cascade reference condit

Oregon Department of Forestry: North Cascade Project Area



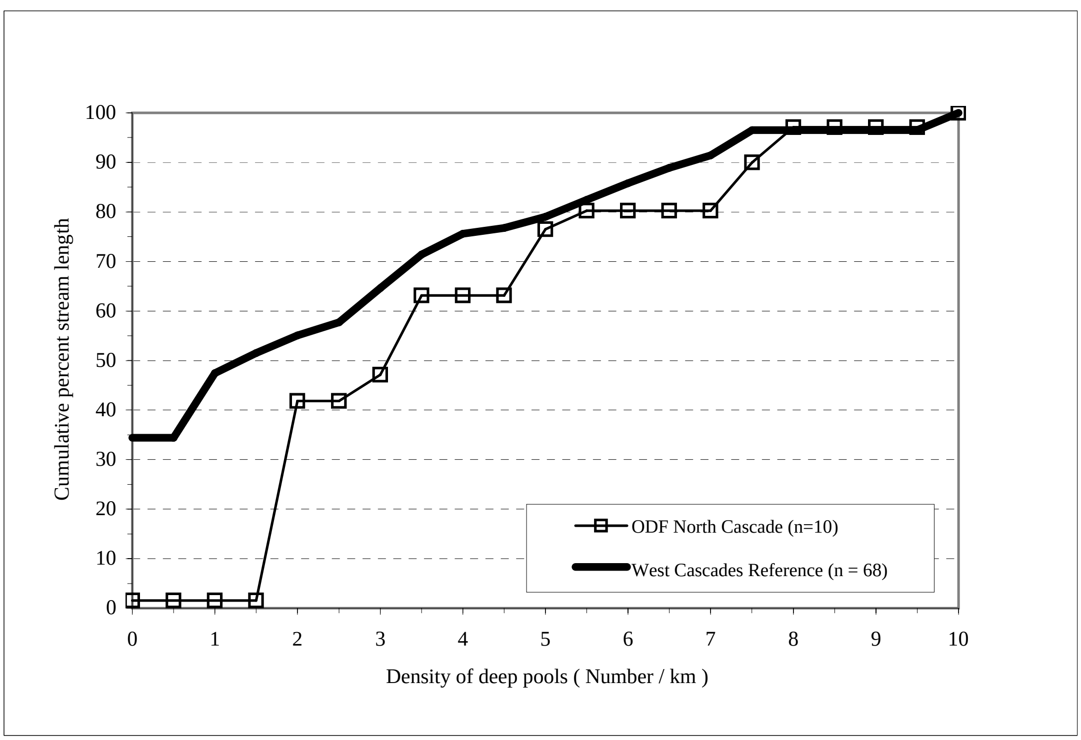


Figure 4. Cumulative frequency distribution comparing pools in the ODF North Cascade project area to West Cascade reference conditions.

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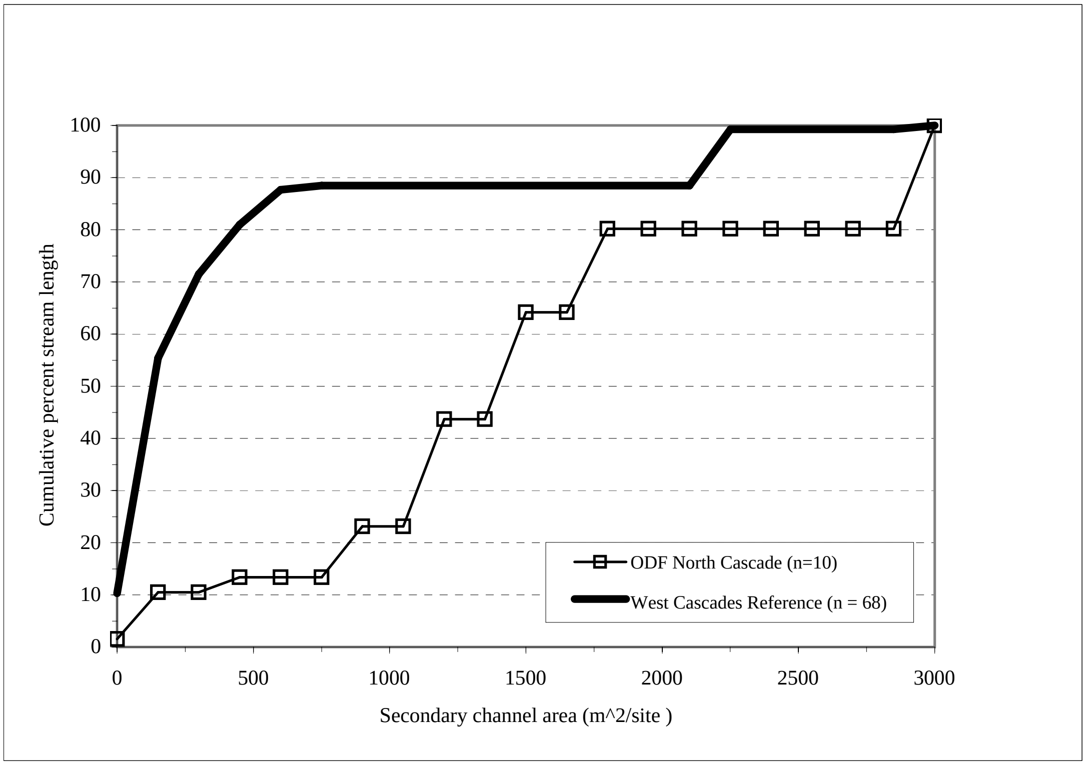


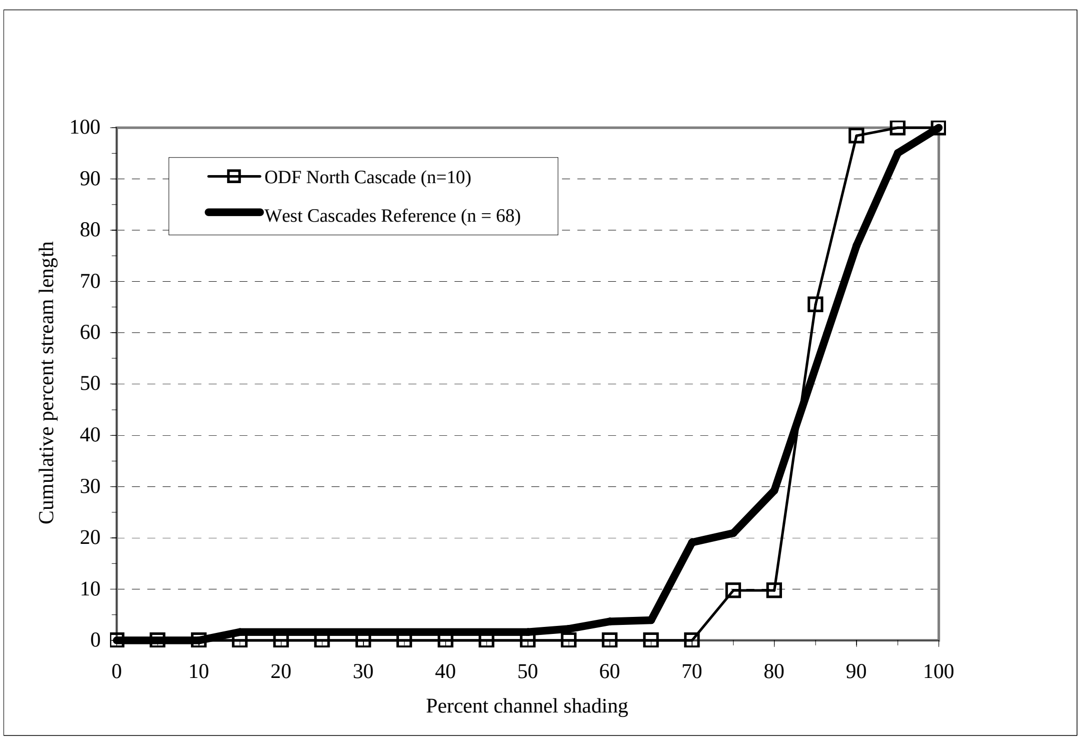
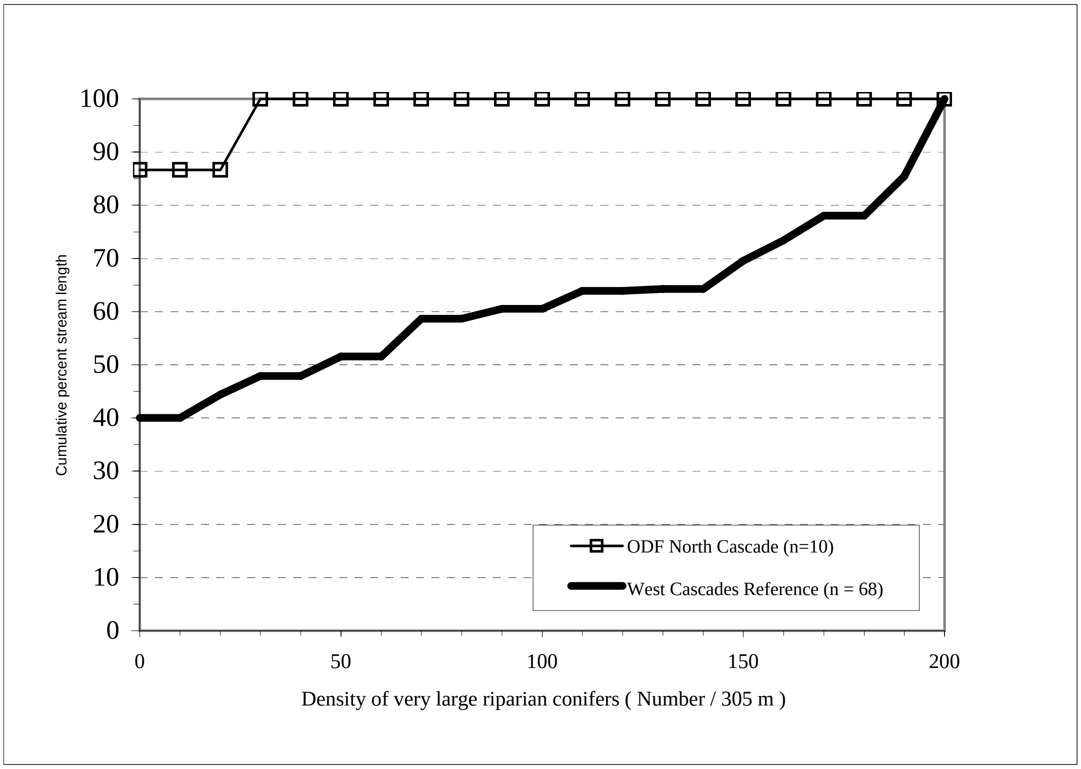


Figure 5. Cumulative frequency distribution comparing secondary channel area and shade in the ODF North Cascade project area to West Cascade reference conditions.

Oregon Department of Forestry: North Cascade Project Area



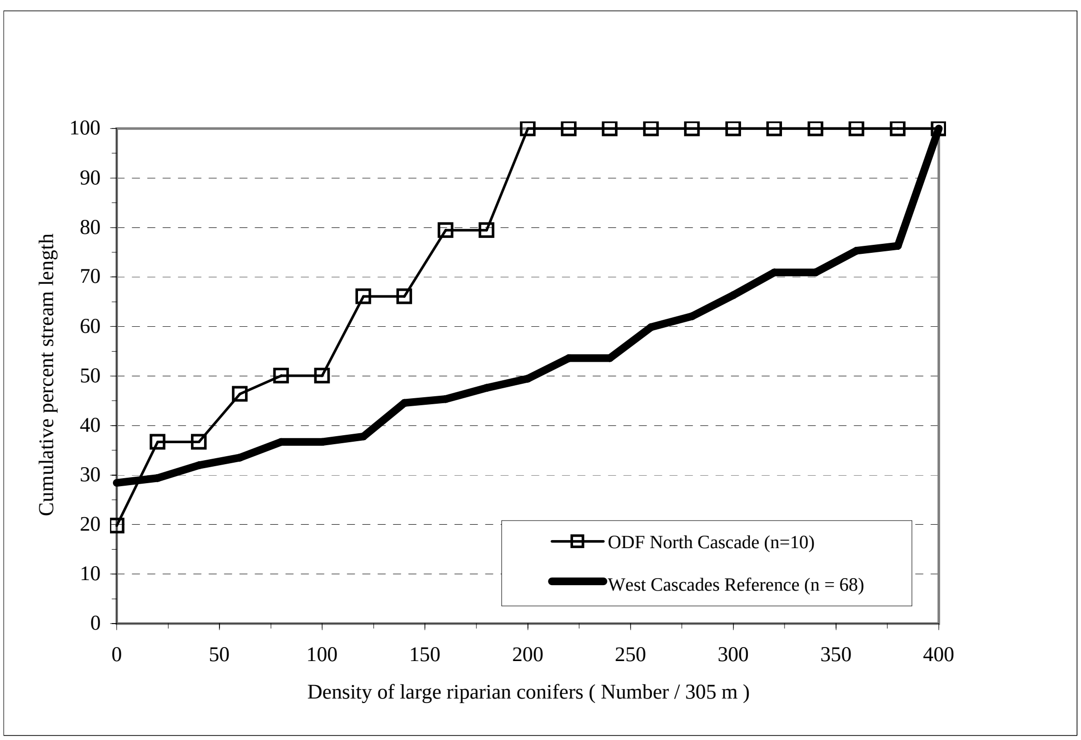
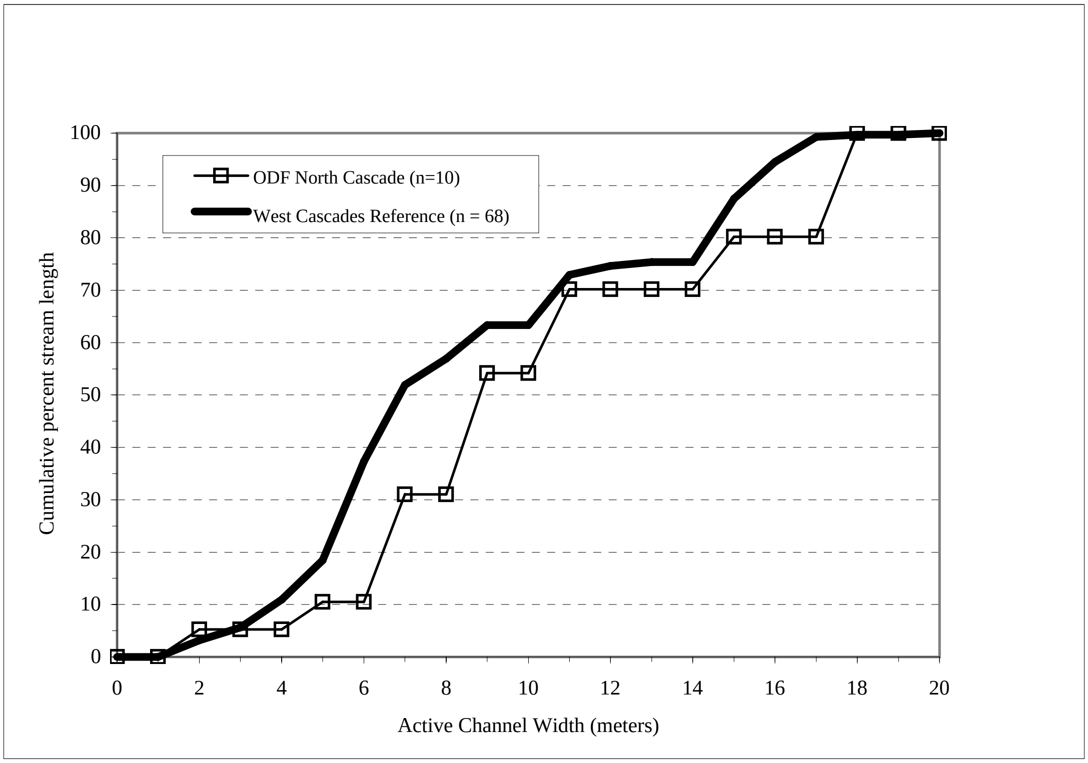


Figure 6. Cumulative frequency distribution comparing riparian conifers in the ODF North Cascade project area to West Cascade reference conditions.

Oregon Department of Forestry: North Cascade Project Area



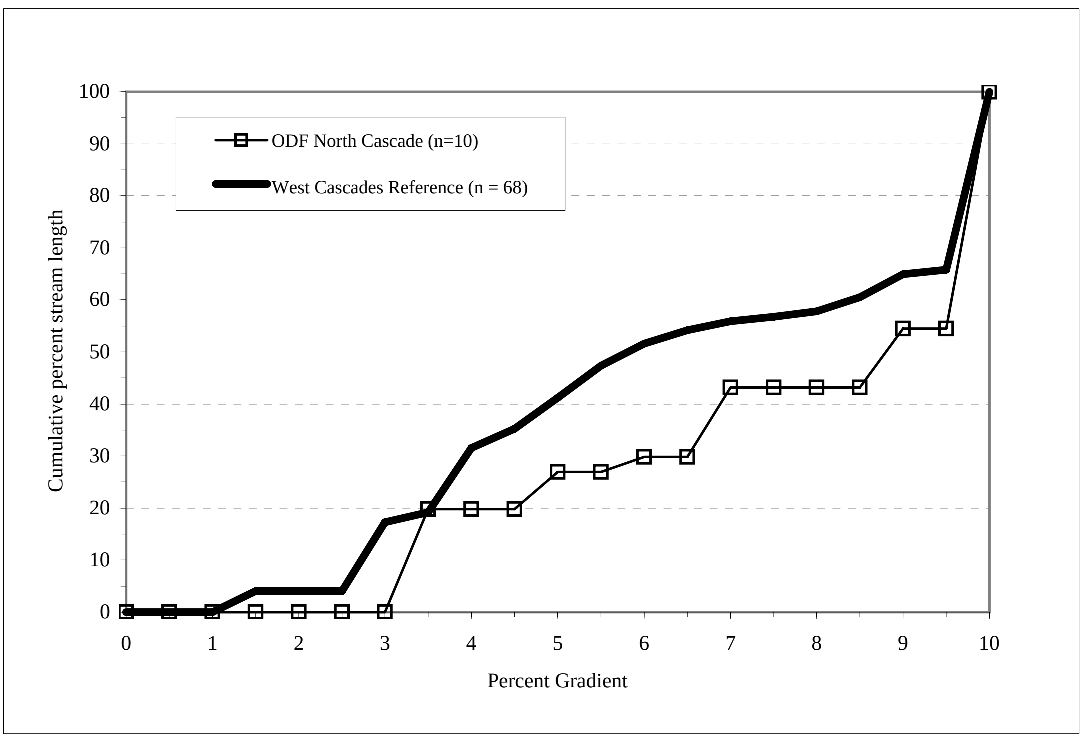


Figure 7. Cumulative frequency distribution comparing active channel width and gradient in the ODF North Cascade project area to West Cascade reference conditions.

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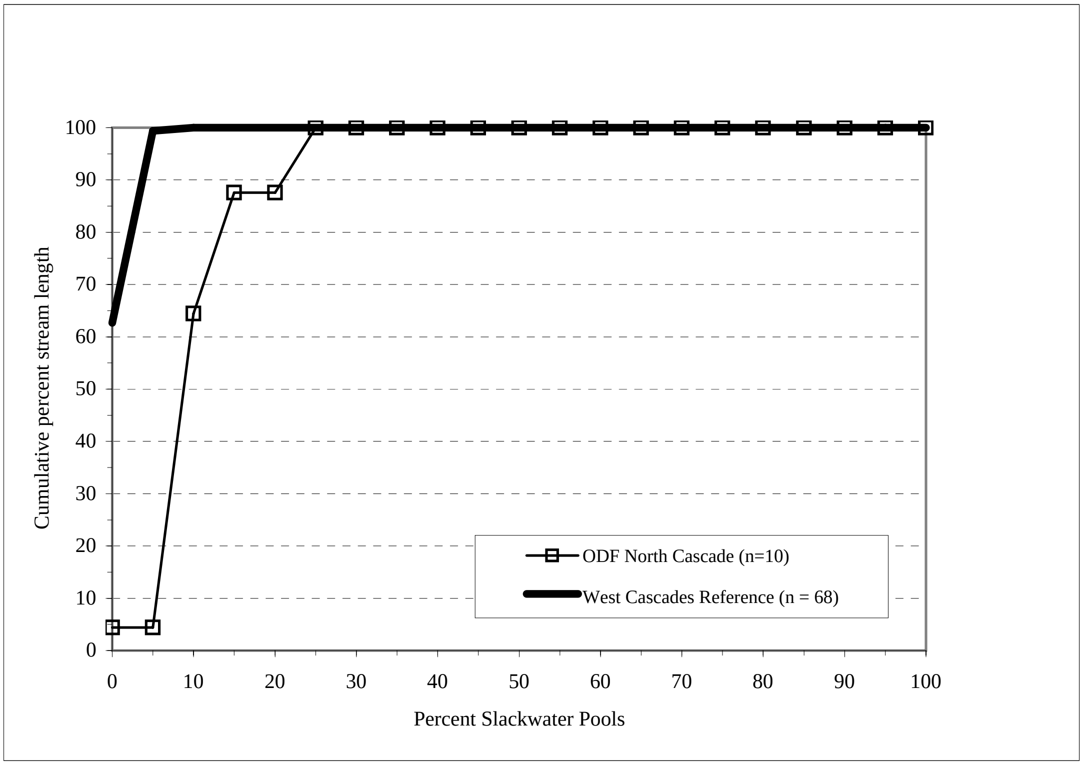


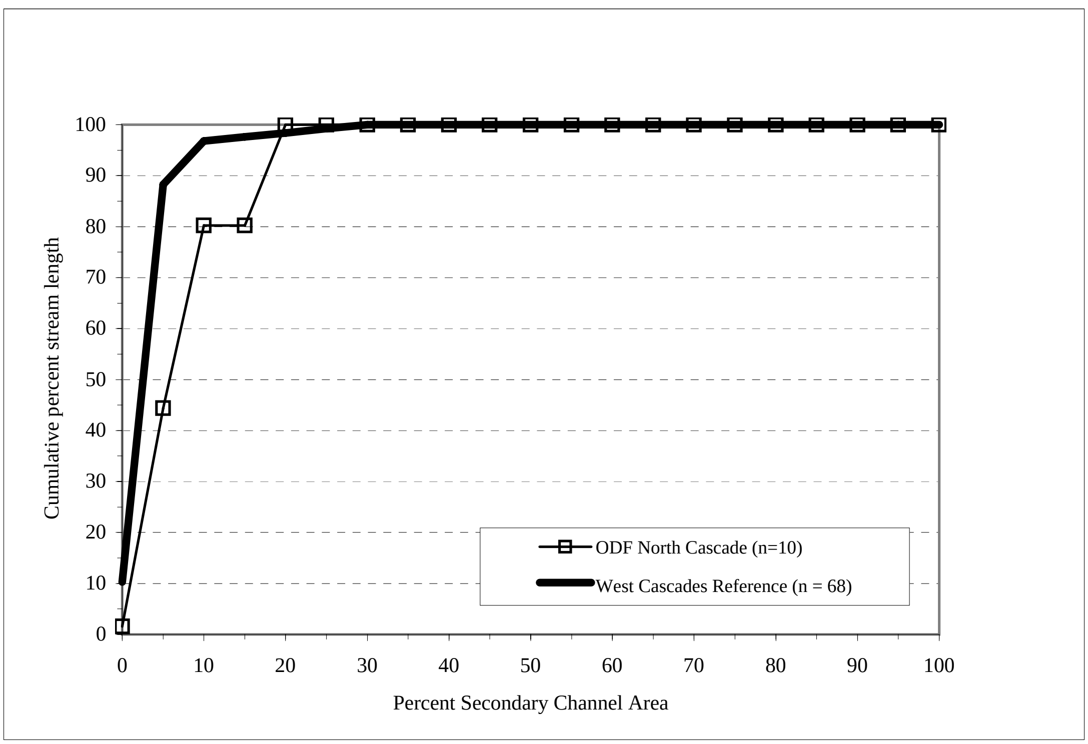
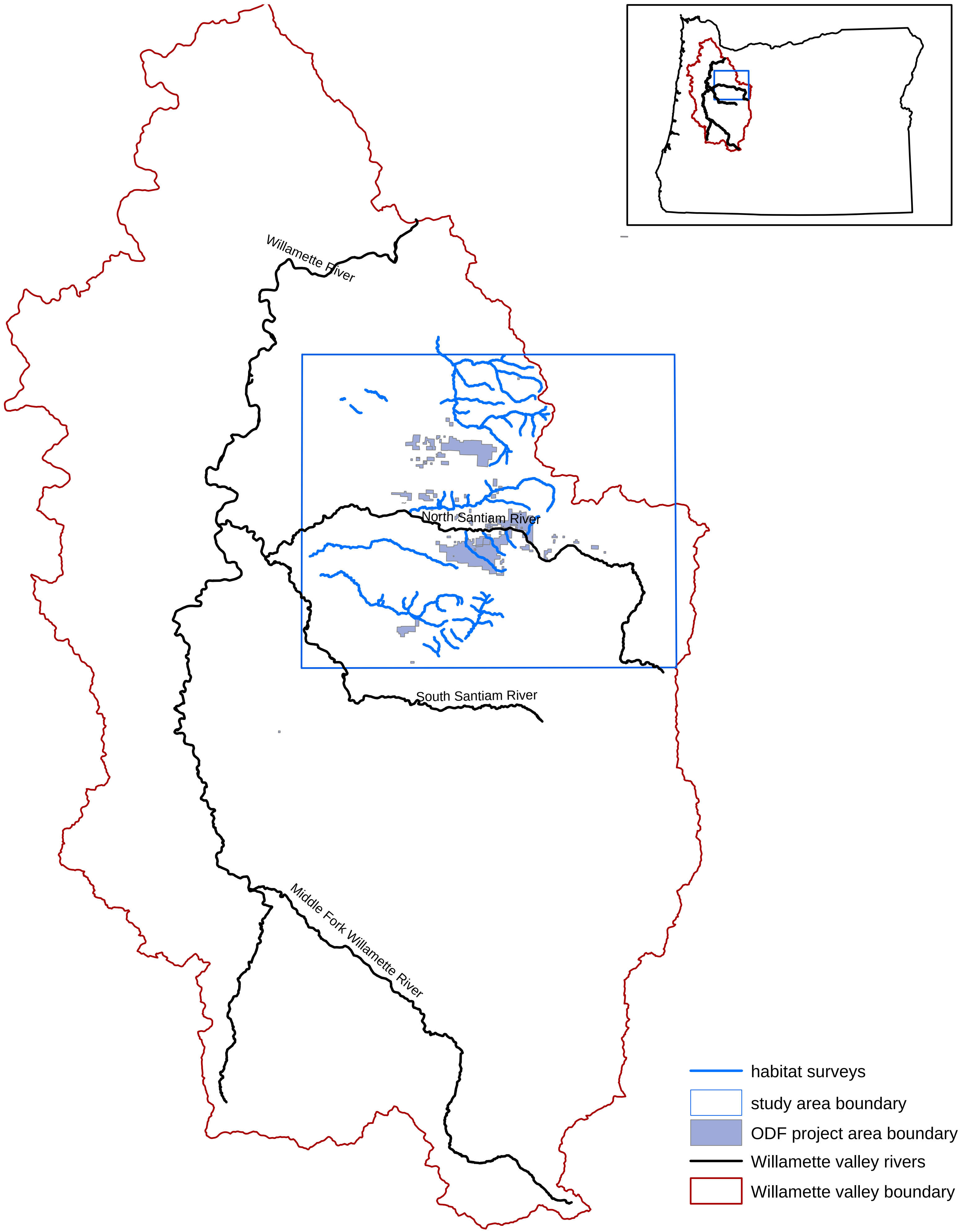
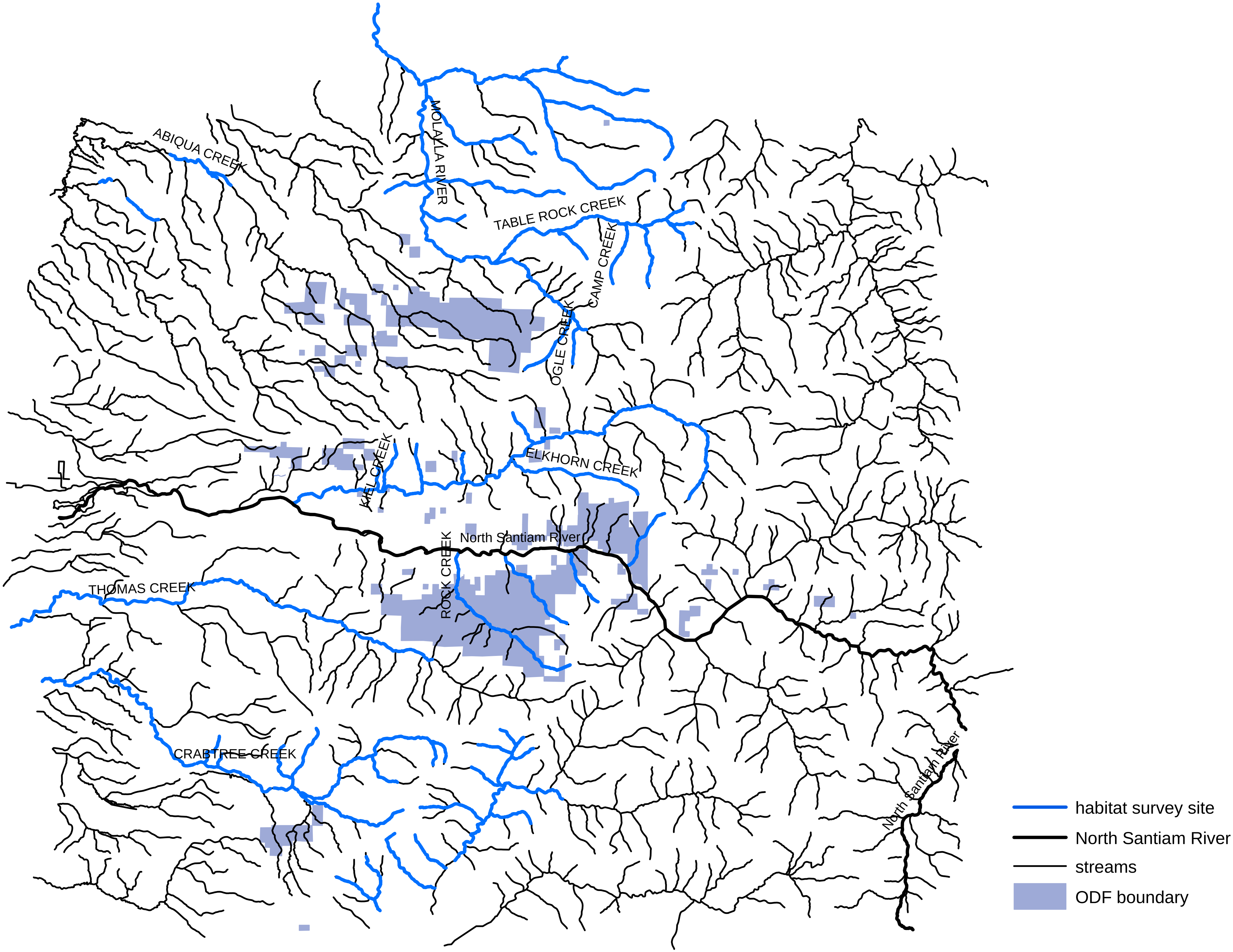


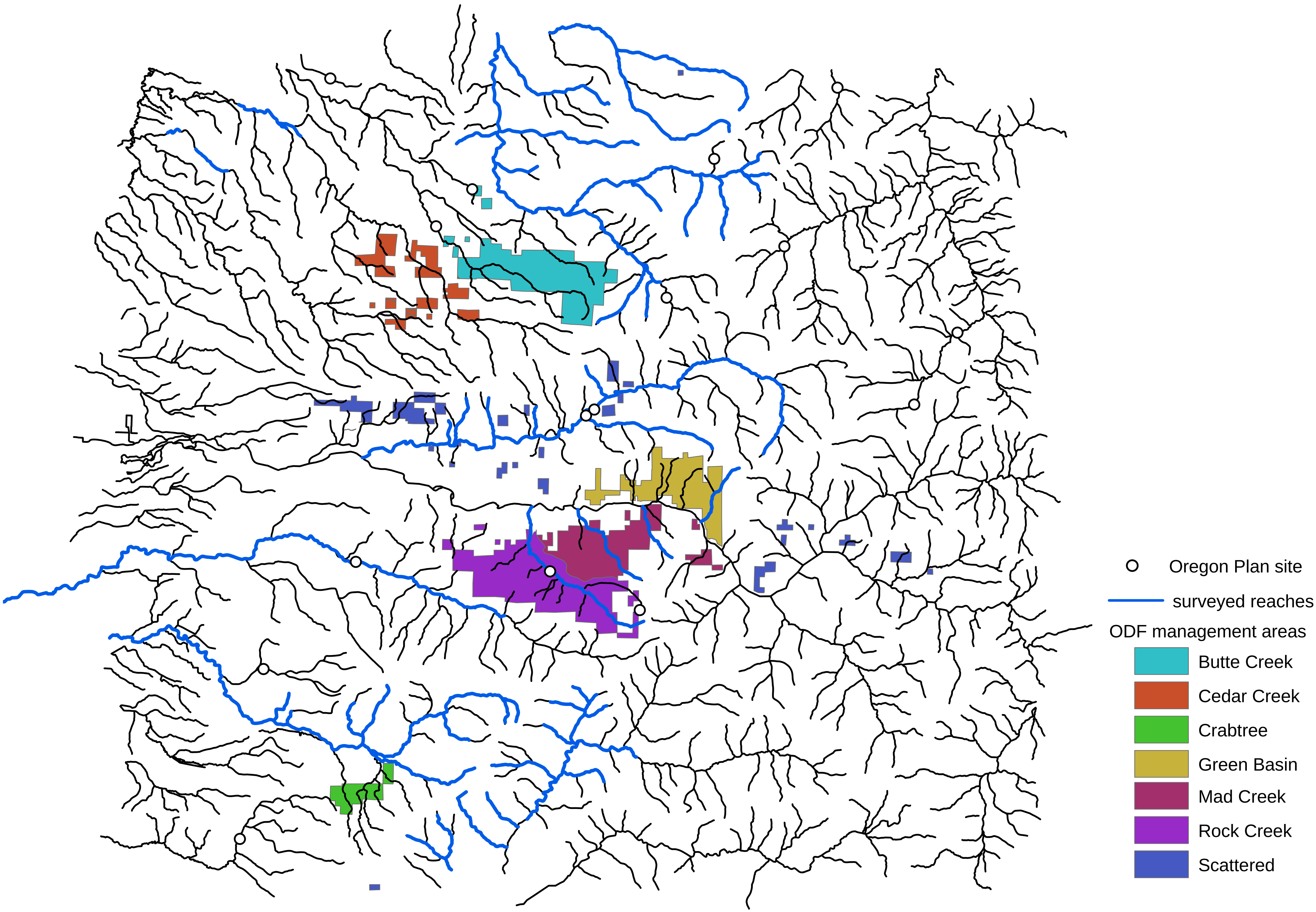
Figure 8. Cumulative frequency distribution comparing percent slackwater and secondary channel in the ODF North Cascade project area to West Cascade reference conditions.



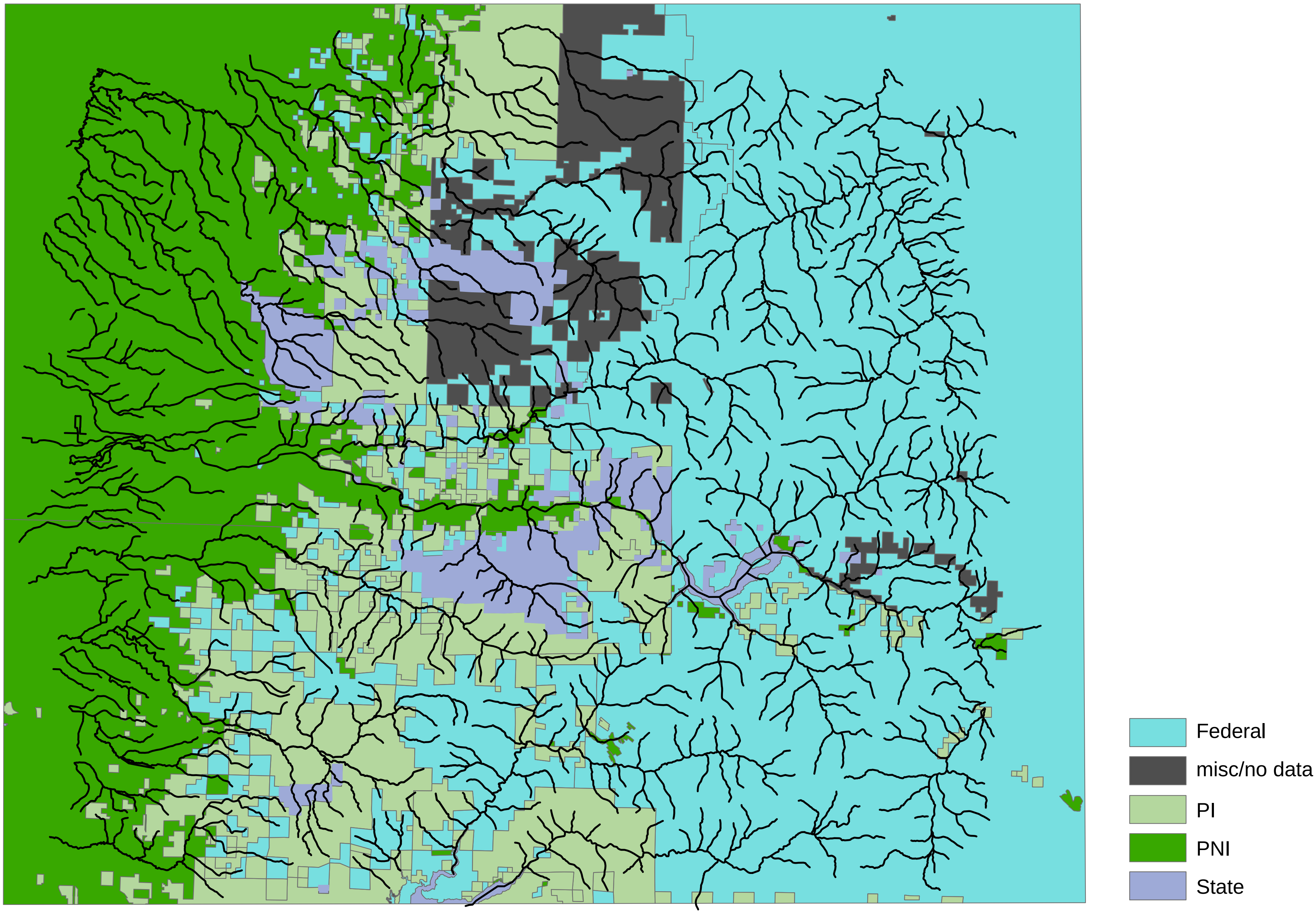
Map 1. Proximity of the ODF North Cascade study area to major rivers within the Willamette valley of Oregon.



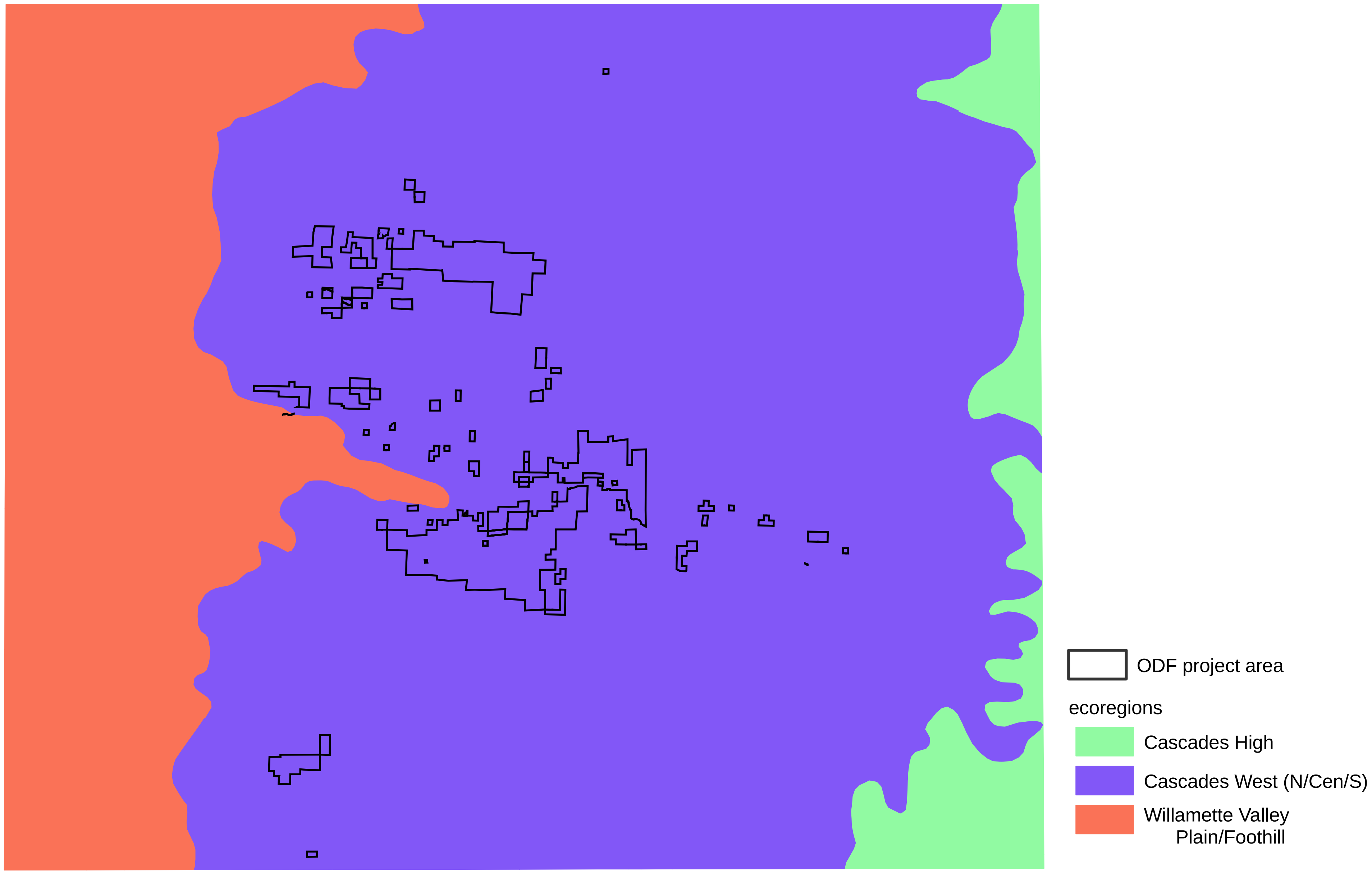
Map 2. Stream habitat reaches in the North Cascades study area.



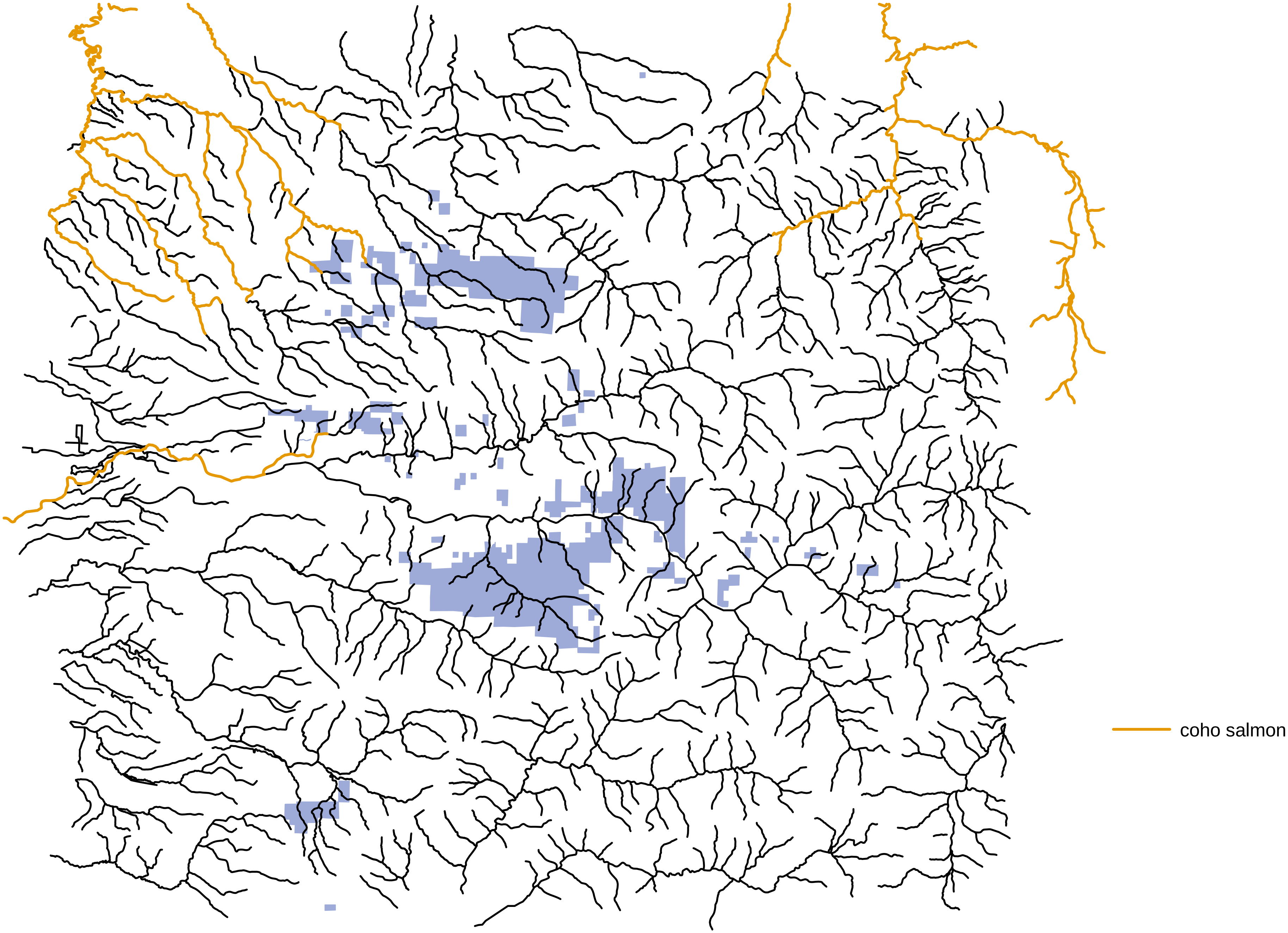
Map 3. Surveyed reaches and Oregon Plan survey sites in proximity to ODF management areas in the North Cascades study area.



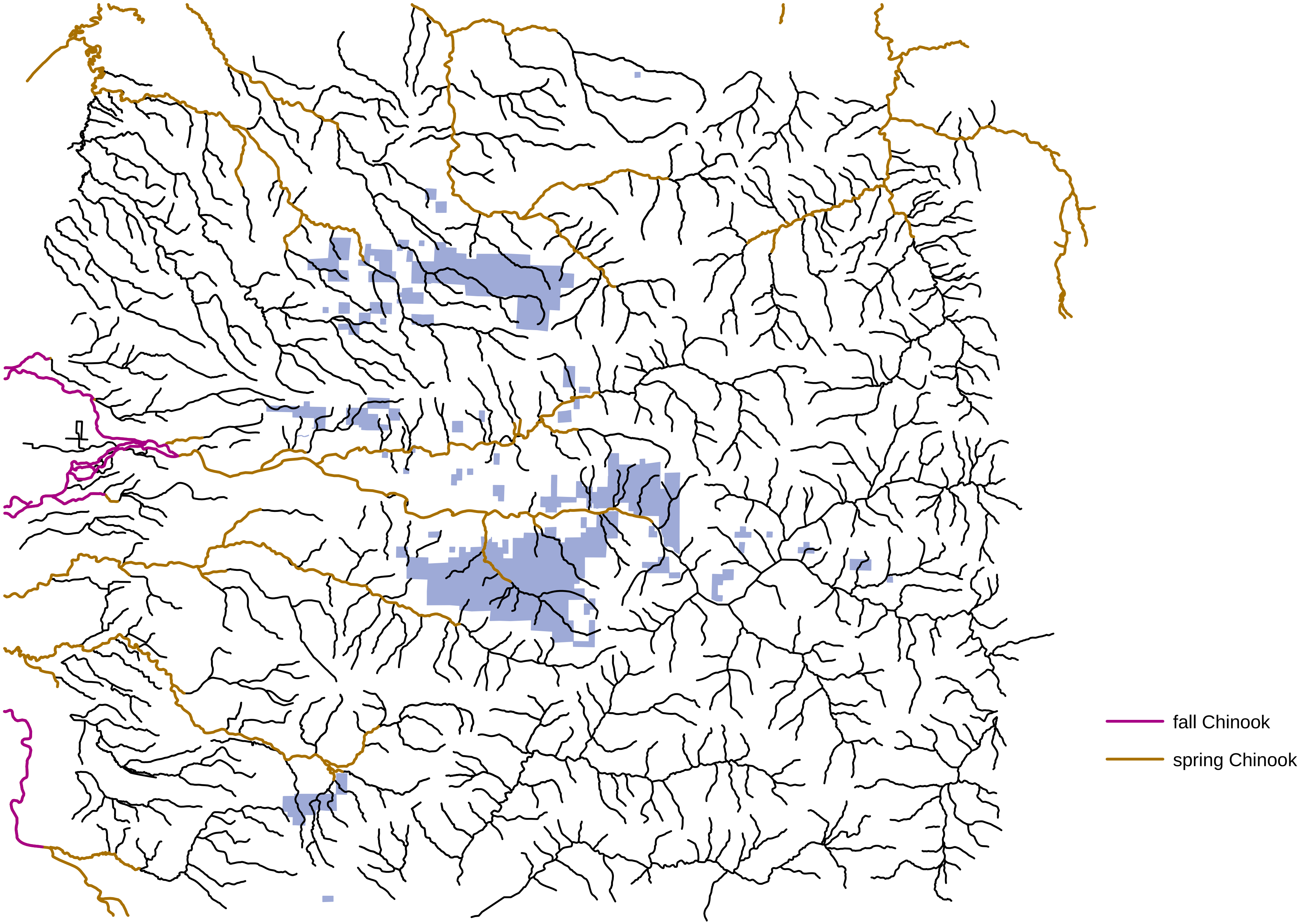
Map 4. Landownership within the North Cascades study area.



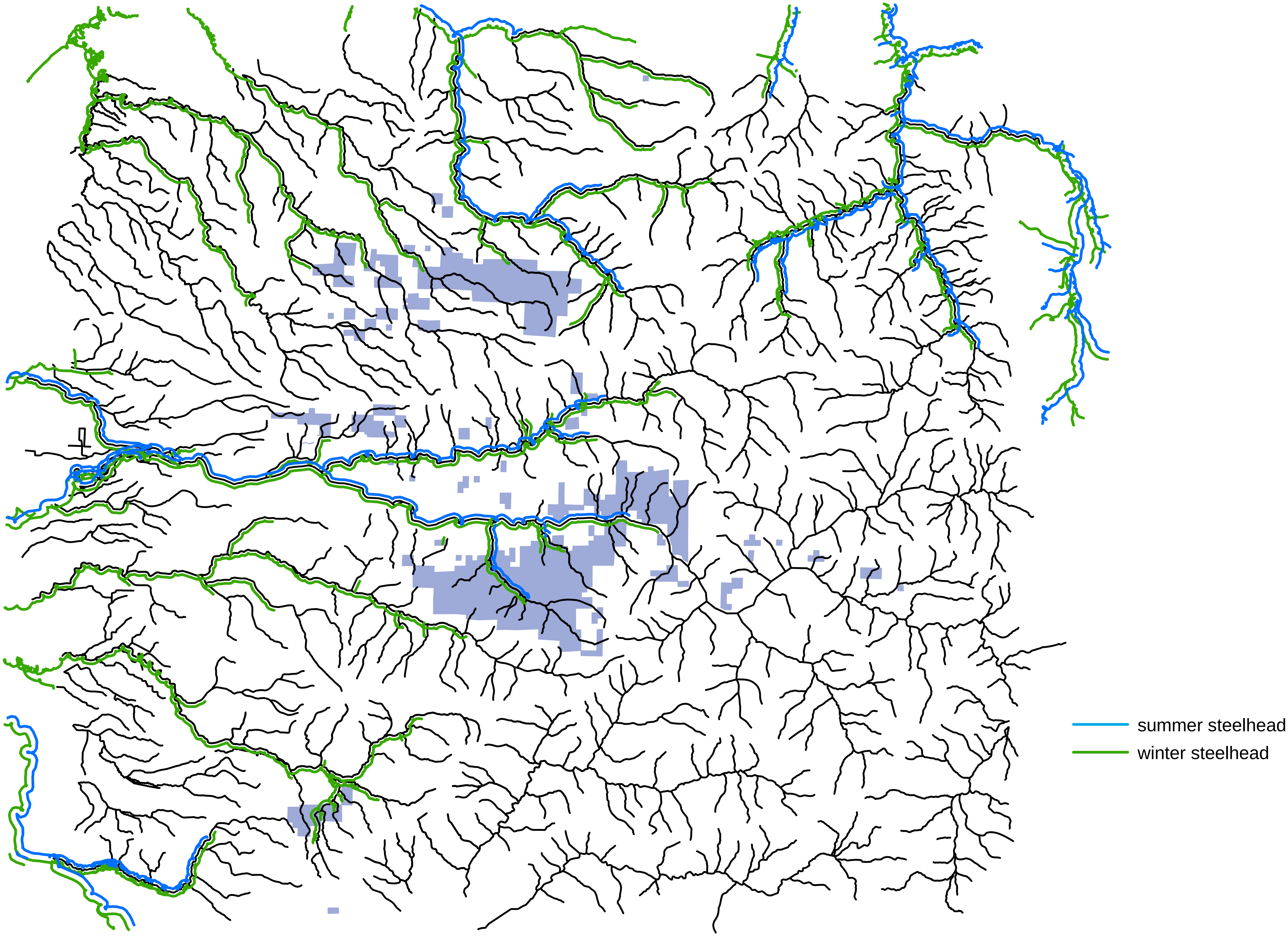
Map 5. Level IV ecoregions within the North Cascades study area (Thorson et al. 2003).



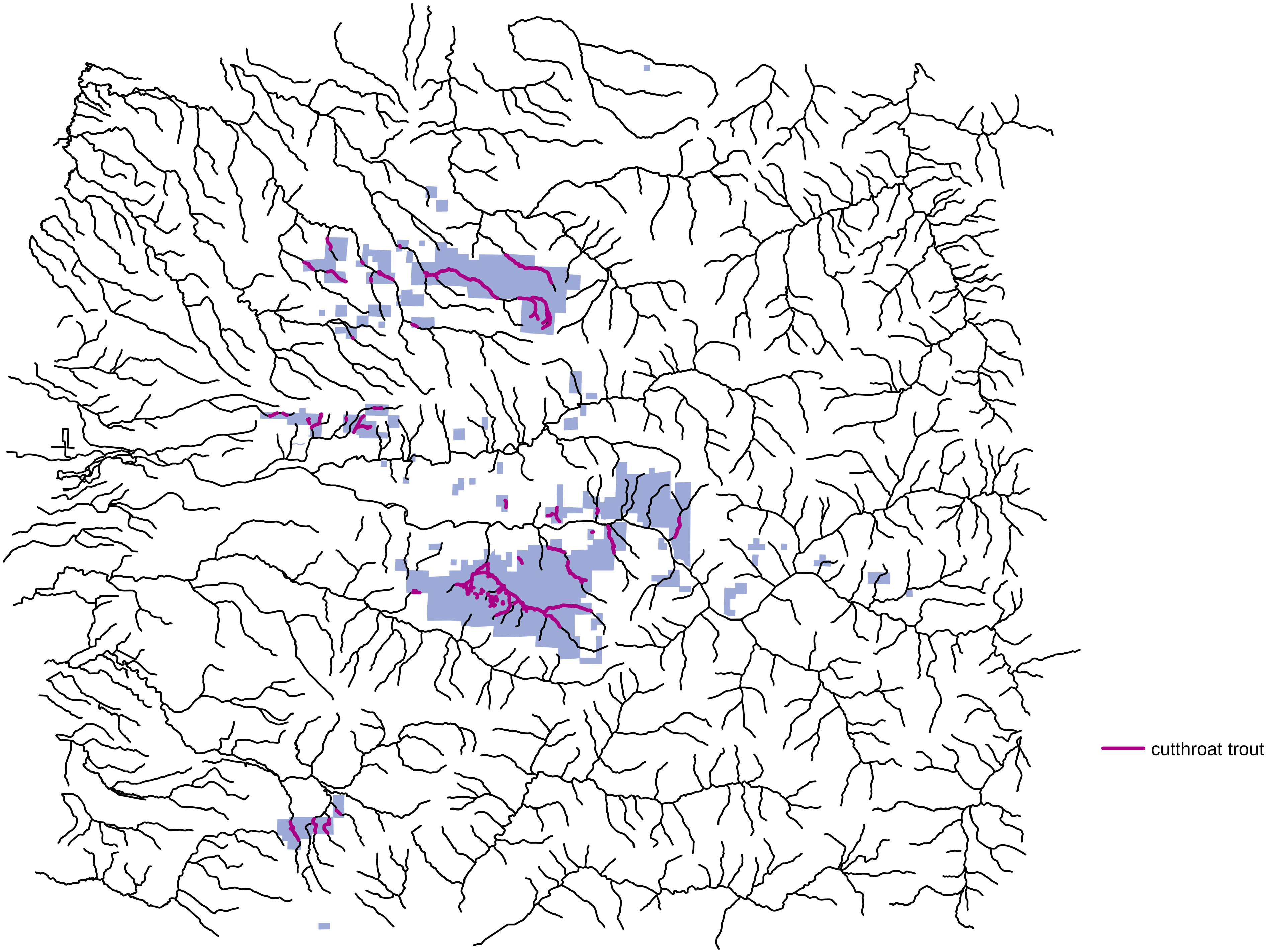
Map 6. Coho salmon distribution in the North Cascade study area.



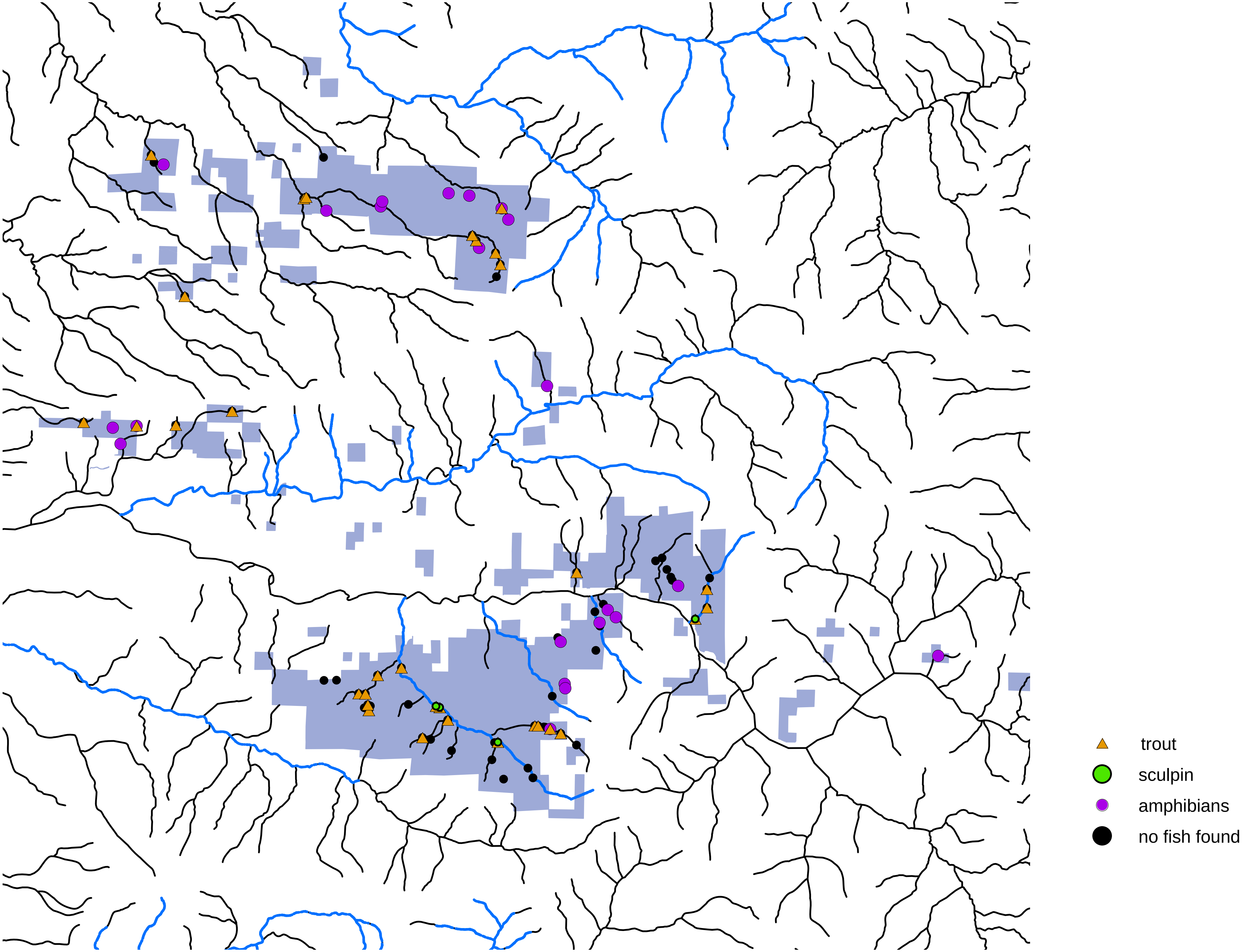
Map 7. Fall and spring Chinook distribution in the North Cascade study area.



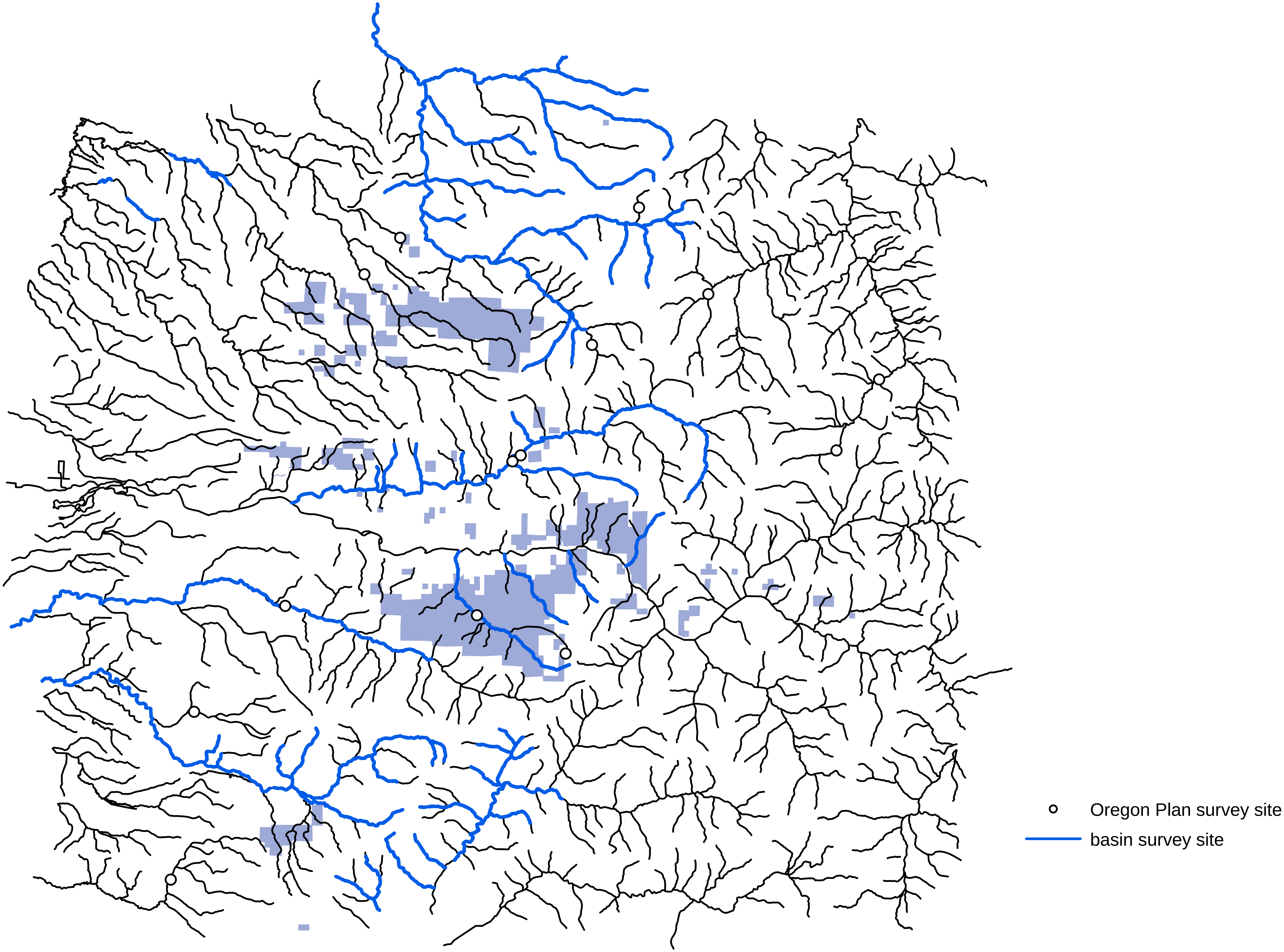
Map 8. Summer and winter steelhead distribution in the North Cascade study area.



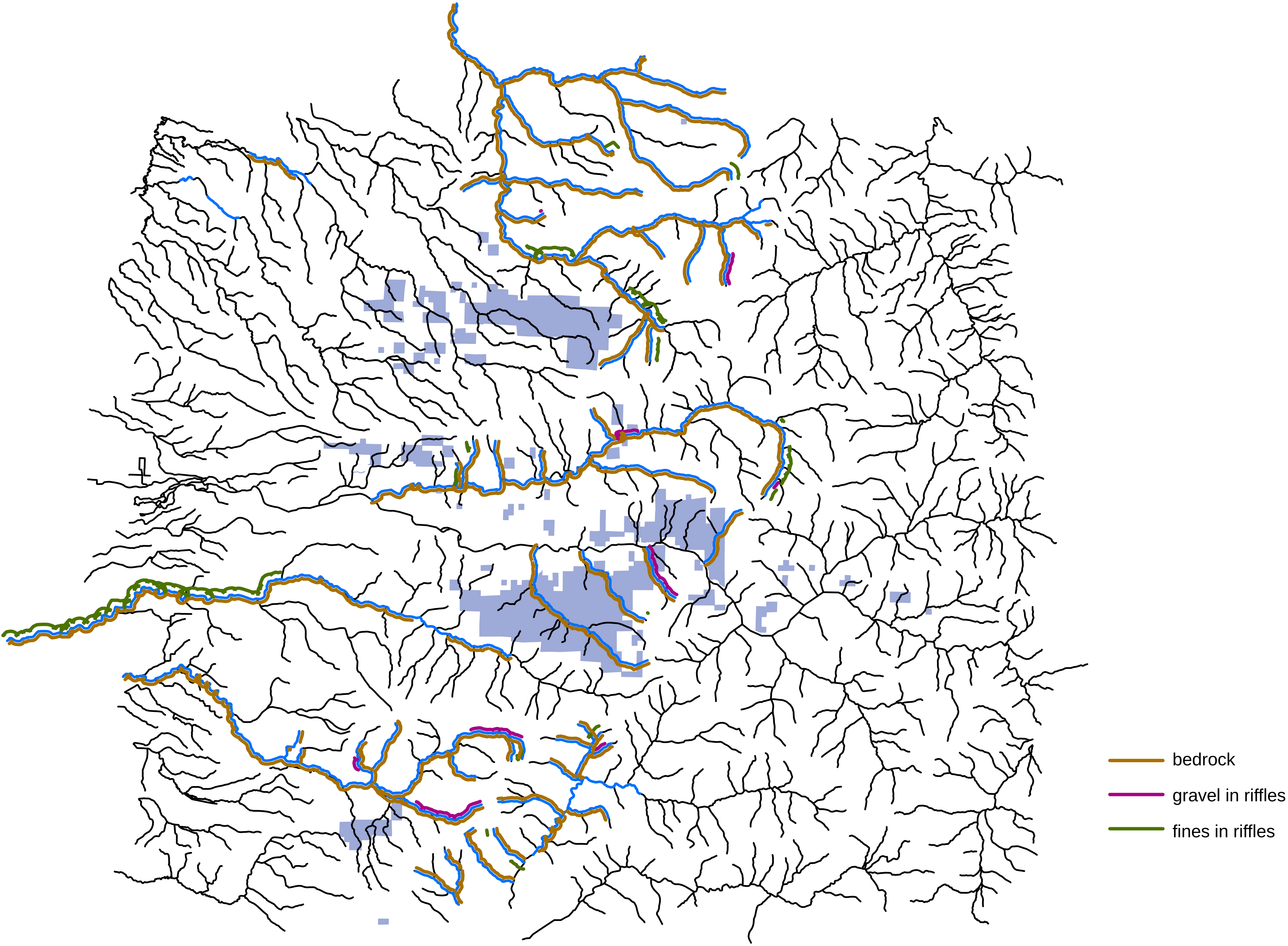
Map 9. Cutthroat trout distribution within the North Cascades project area.



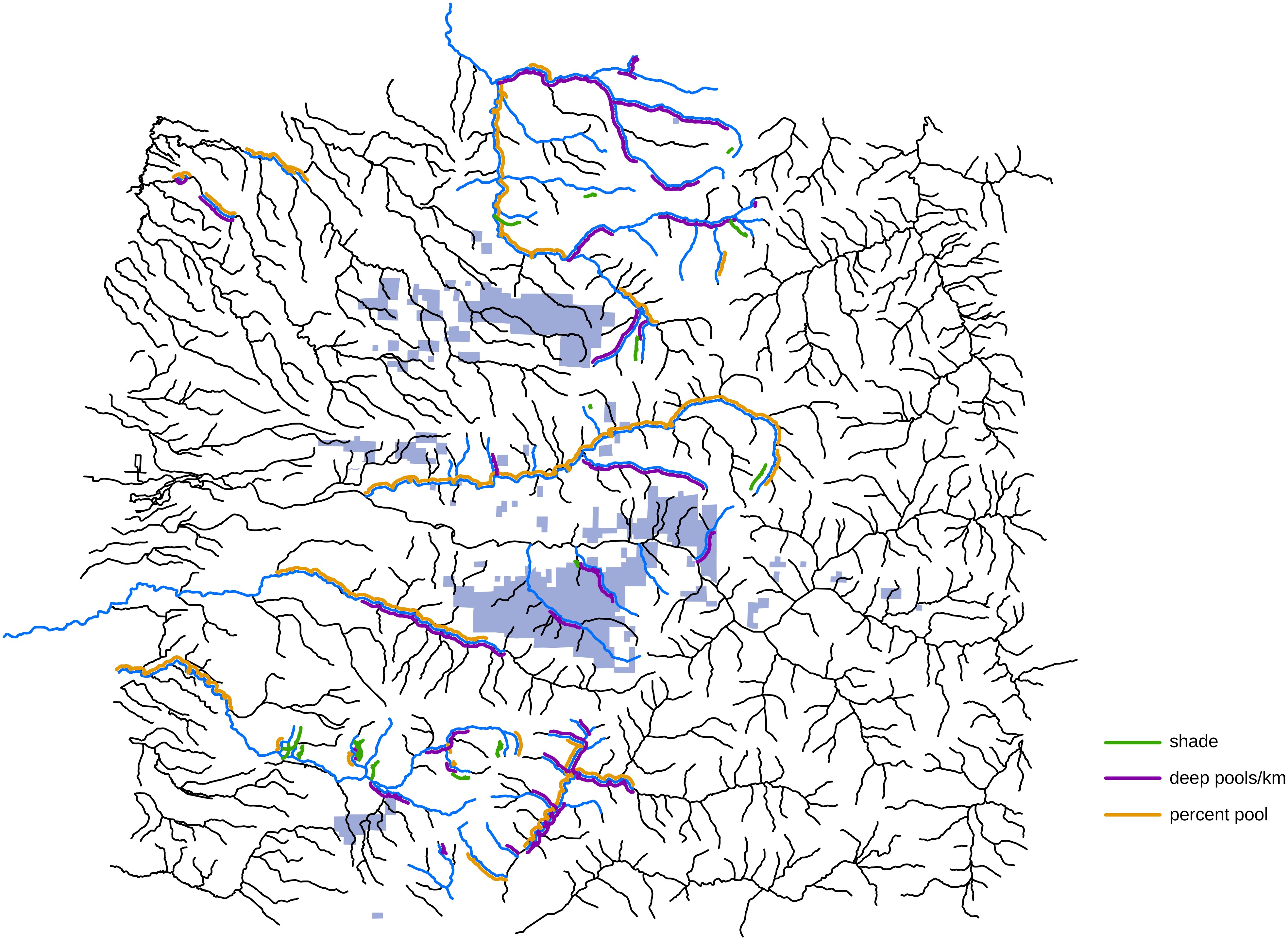
Map 10. ODFW Aquatic Inventories fish presence / absence surveys - cutthroat and/or rainbow trout, sculpin, and amphibians - in the North Cascade project area.



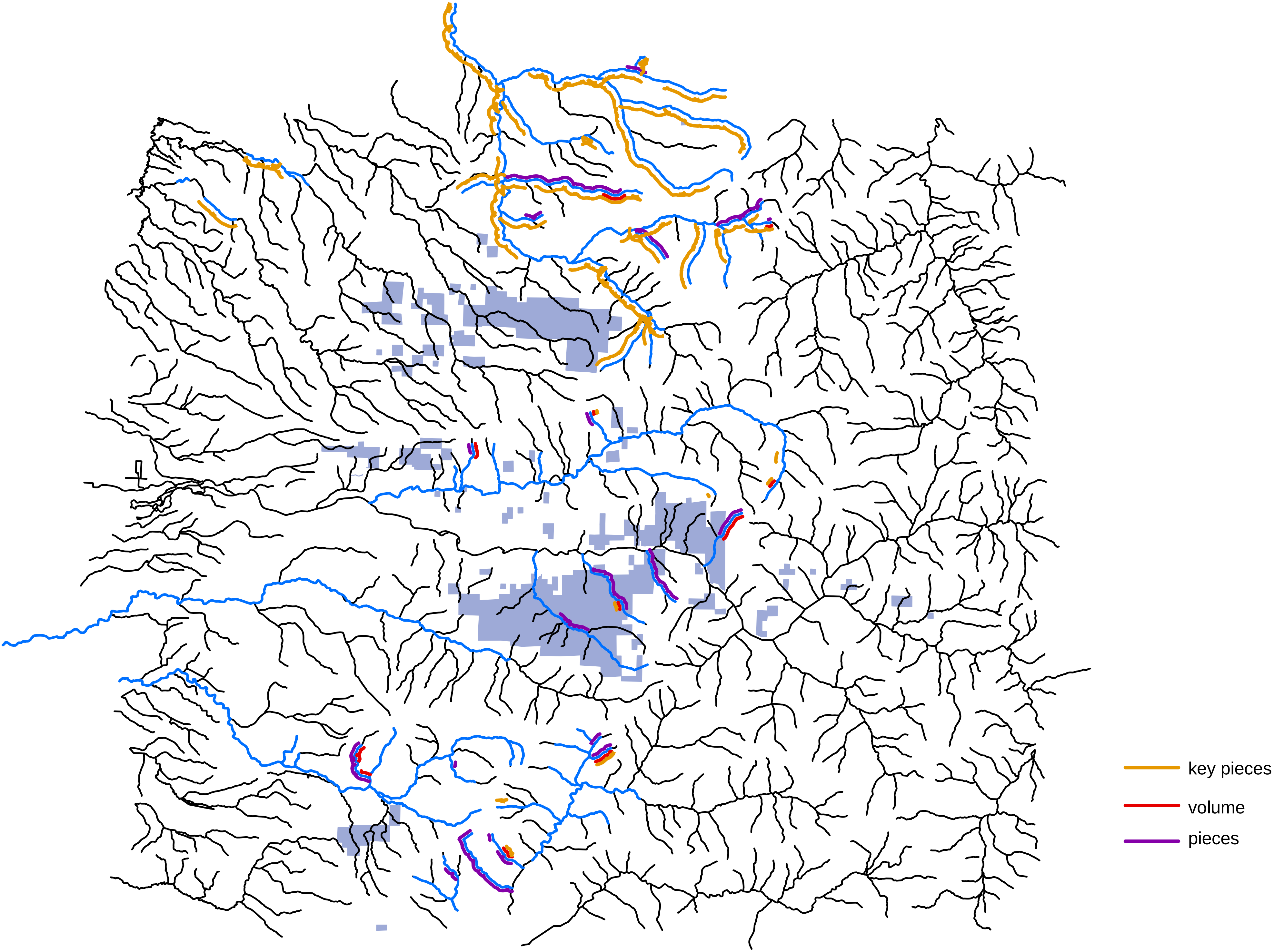
Map 11. Summer survey sites - Oregon Plan and basin - in the North Cascade study area.



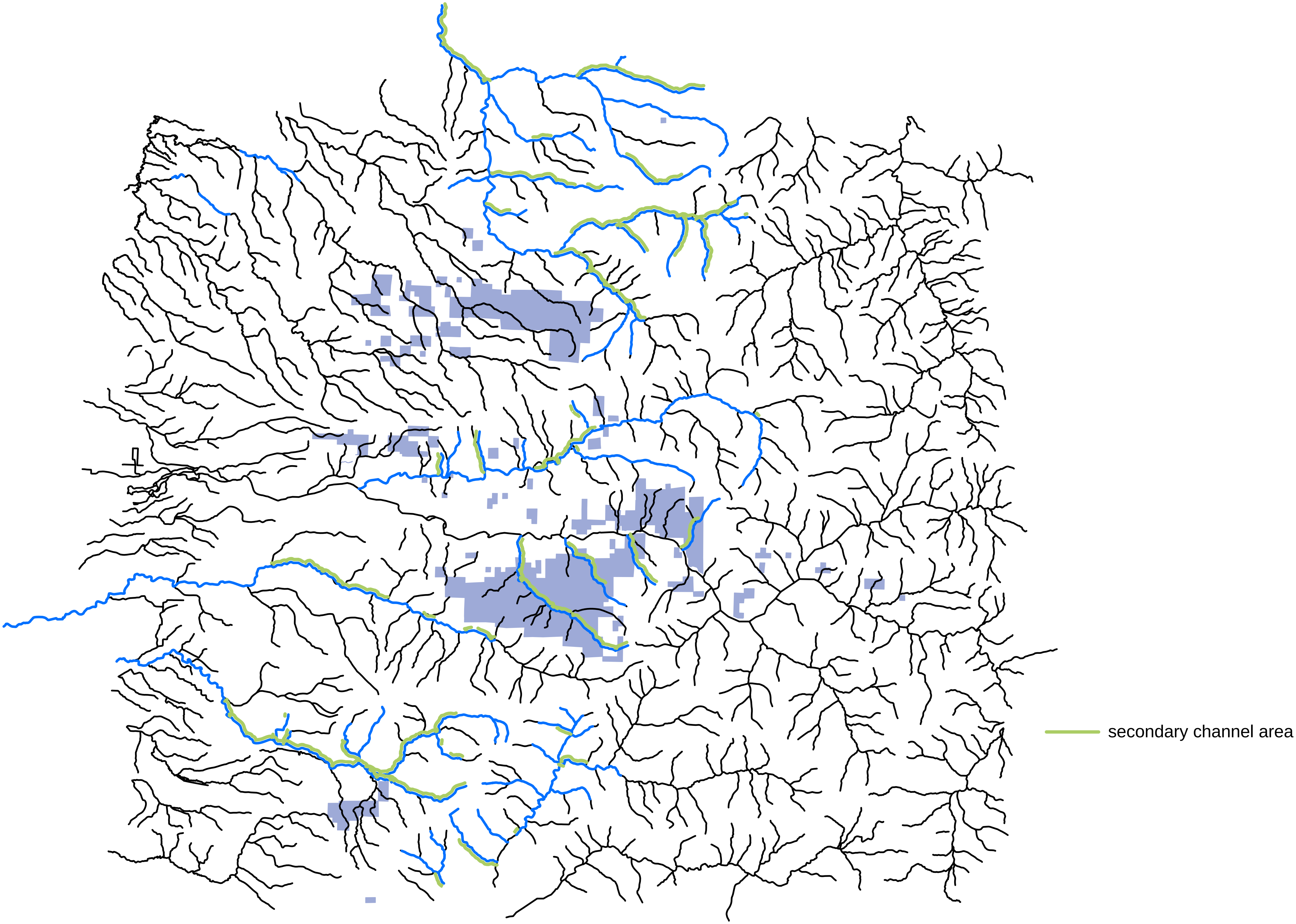
Map 12. Reaches which met or exceeded the benchmark for key habitat characteristics - percent bedrock and fine and gravel substrates in riffle units - in the North Cascade study area.



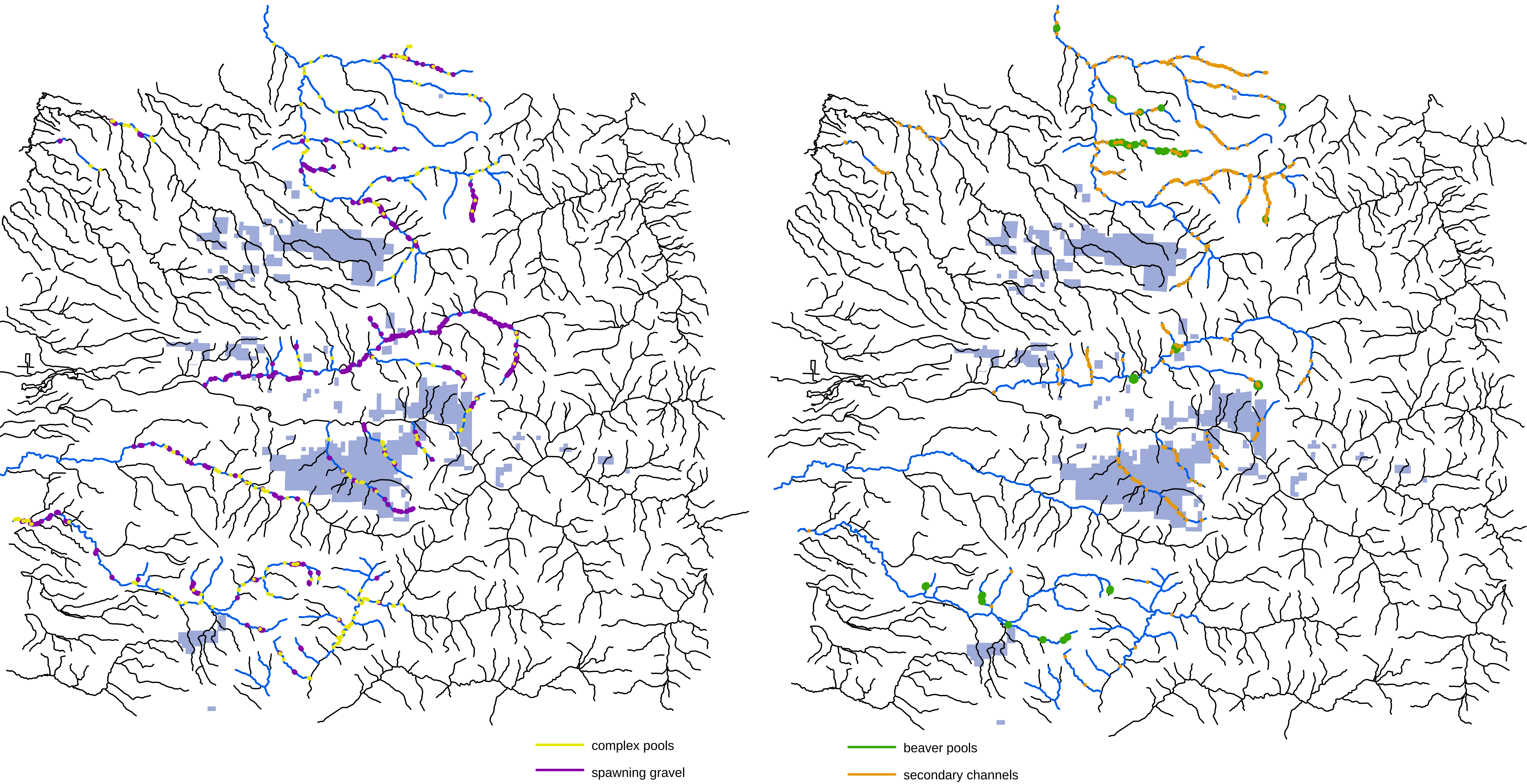
Map 13. Reaches which met or exceeded the benchmark for key habitat characteristics - shade, percent pools, number of deep pools (>1m deep)/km of stream length - in the North Cascade study area.



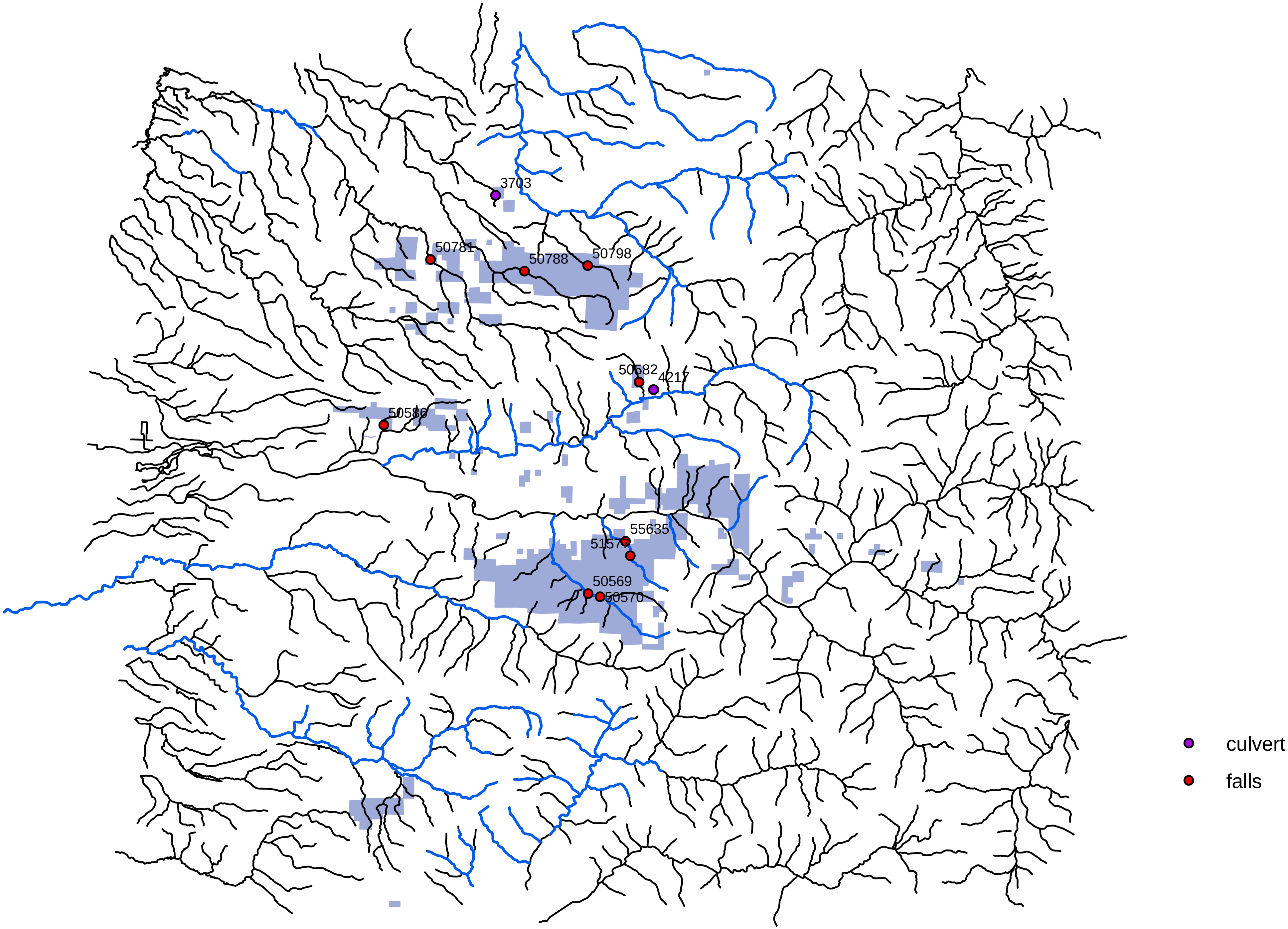
Map 14. Reaches which met or exceeded the benchmark for key habitat characteristics - number of pieces, volume, and key pieces of large wood per 100m of stream length - in the North Cascade study area.



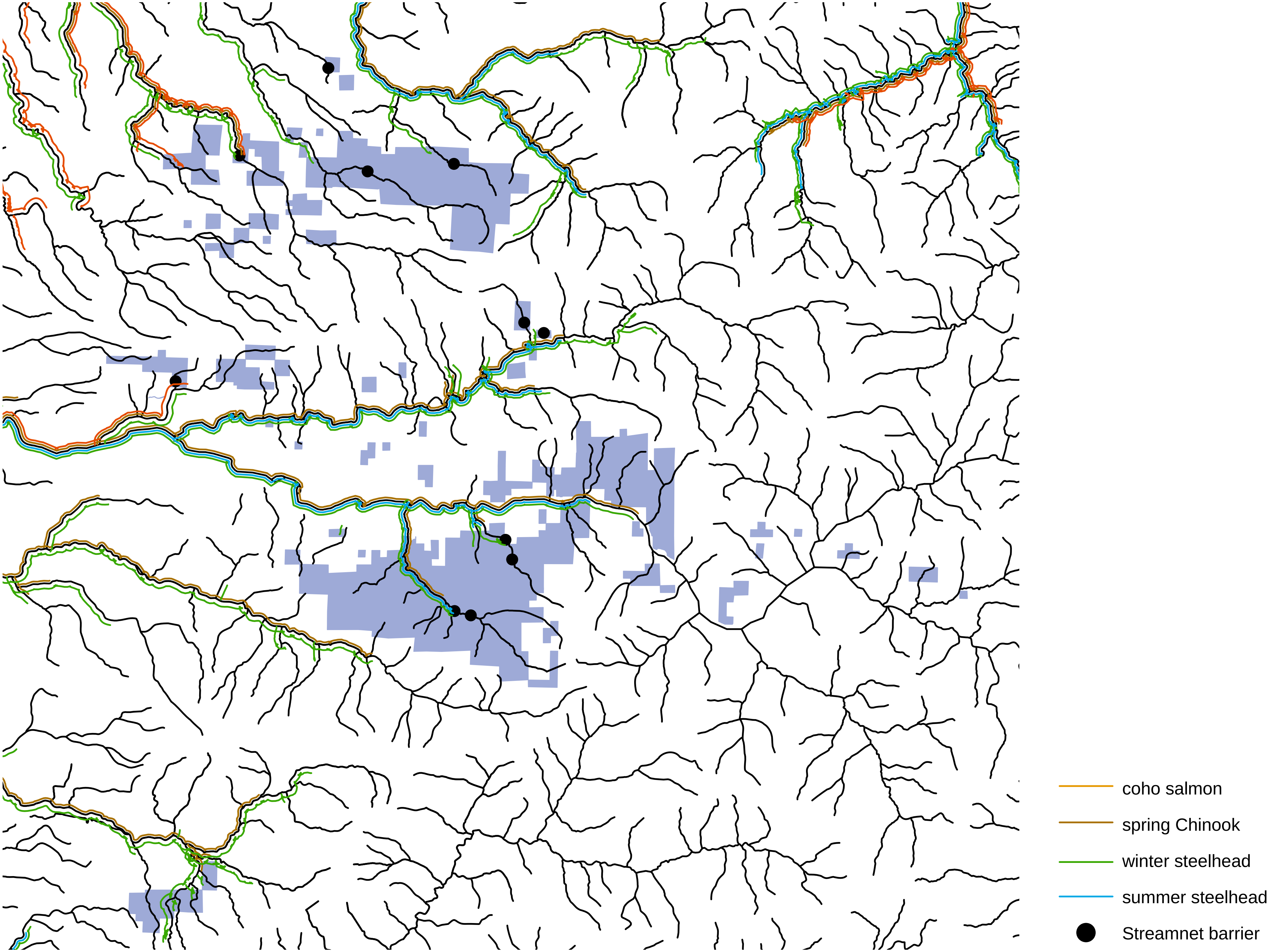
Map 15. Reaches which met or exceeded the benchmark for key habitat characteristics - secondary channel area - in the North Cascade study area.



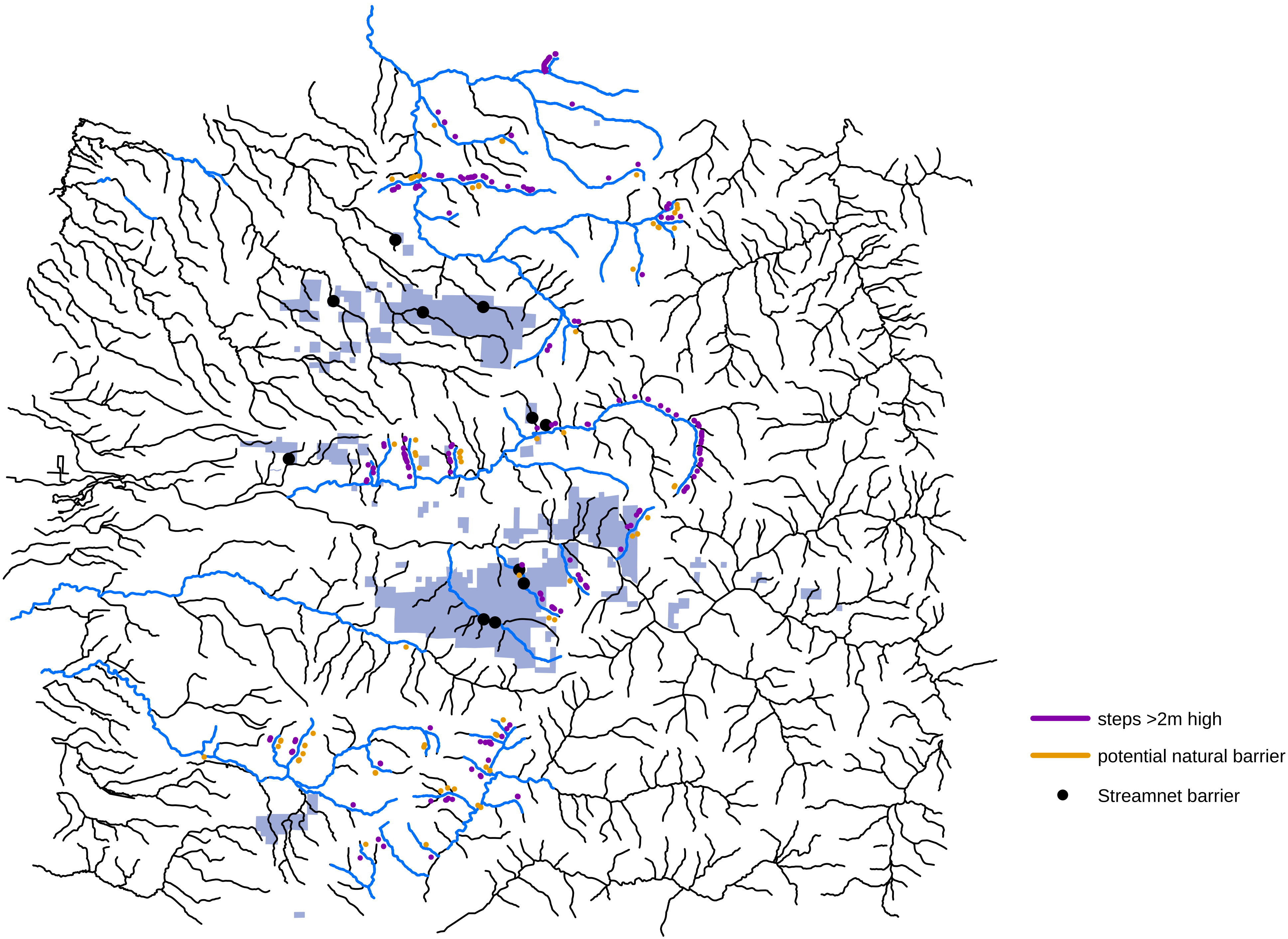
Map 16. Habitat units displaying important habitat characteristics - beaver pools, deep pools with wood, secondary channels, and spawning area - in the North Cascade study area.



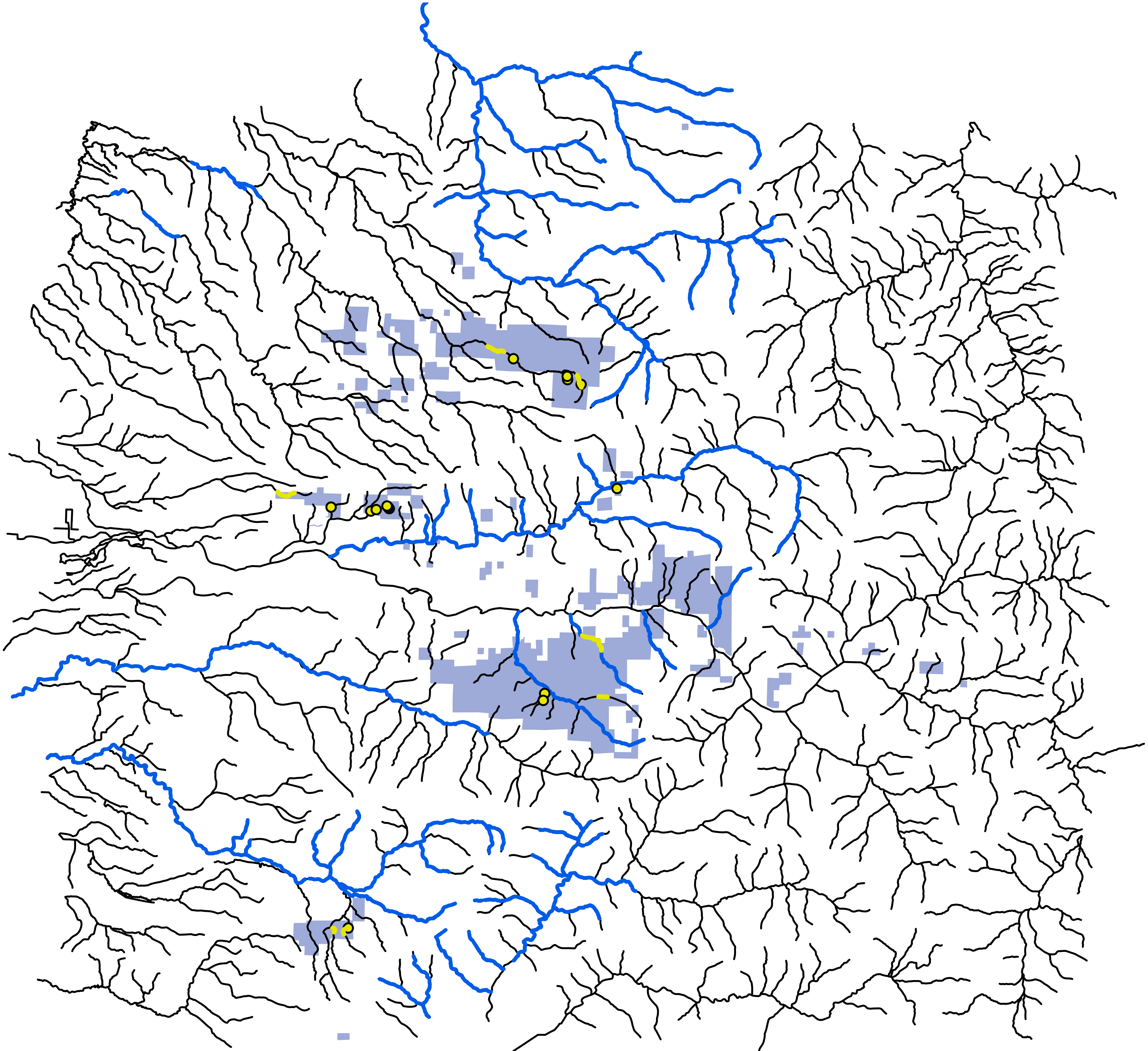
Map 17. Potential barriers to fish distribution (labeled by Record Id) as identified by Streamnet in the North Cascade project area.



Map 18. Distribution of fish species in relation to potential barriers identified by Streamnet in the North Cascade study area.



Map 19. Potential barriers to fish distribution as documented by habitat stream crews at the unit level scale and those identified by Streamnet in the North Cascade study area.



Map 20. OWEB-funded instream restoration sites (yellow) in the North Cascade project area.