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Winter Habitat Condition of Oregon Coast Coho Salmon Populations, 2007-2014

Winter Habitat Condition of Oregon Coast Coho Salmon Populations, 2007-2014

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SUMMARY

In this report we summarize results of eight years (2007-2014) of habitat surveys for 18 independent Oregon coast coho salmon populations across four monitoring strata (North Coast, Mid Coast, Mid-South Coast, and Umpqua) in the Oregon Coast Coho Salmon Evolutionary Significant Unit (ESU). We also sampled dependent population blocks across three monitoring strata (North Coast, Mid Coast, and Mid-South Coast). Using a spatially balanced site selection process (Generalized Random Tessellation Stratification; GRTS) we surveyed 451 unique sites within the range of coho salmon spawning or rearing. With the exception of the 2014 survey year, habitat data were collected during winter conditions (February – March). Habitat sampled in 2014 occurred within the summer field season (June – September). We used a Habitat Limiting Factors Model (HLFM) to estimate habitat capacity for winter coho parr and the HabRate model to assess habitat quality for each surveyed stream reach. HLFM estimates were expanded based on the total coho distribution in each population. Based on the habitat data the HLFM predicted the Floras population could support the highest density of juvenile coho (1568 parr/km), while the streams in the Siltcoos watershed could support the least (290 parr/km). At the ESU-level, there was no detectable change of high quality rearing habitat (≥ 1850 parr/km) when compared to previous studies, but changes were observed among populations over the course of these survey years. We compared individual habitat metrics across populations, land use, geology, and between independent and dependent populations. While no significant differences were observed between independent and dependent populations, differences in habitat metrics were detected among individual populations, land use types, and geologies. In addition, we detected a difference in reproductive habitat quality (spawning and emergence) between both populations and land use types.

This report is organized into the following summaries for describing the freshwater habitat conditions of coho populations within the Oregon Coast Coho ESU:

1) Status of channel and valley attributes, stream morphology, substrate composition, and instream wood.

2) Presence of attributes that suggest active habitat forming processes such as beaver activity, instream restoration structures, debris jams, and mass wasting.

3) Summary of land use and geology across populations and association with instream habitat.

4) Describe winter habitat capacity and habitat quality for rearing juvenile coho salmon using a life stage model platform, Habitat Limiting Factors Model (HLFM) version 7.0 (version 5.0 in Nickelson et al. 1992a).

5) Describe overall habitat quality for coho salmon using HabRate (Burke et al. 2010).

INTRODUCTION

The Oregon Coast Coho Conservation Plan for the State of Oregon (Oregon Department of Fish and Wildlife 2007) indicated that a lack of stream complexity was a major factor limiting freshwater productivity for all coho populations within the Oregon Coast Coho ESU. Stream complexity is often indicative of higher quality habitat or essential winter rearing and refuge habitat for juvenile coho salmon, particularly during high flow conditions (Nickelson and Lawson 1998, ODFW 2005, Ebersole et al. 2006). An analysis in the conservation plan indicated that high quality winter habitat in Oregon coastal subbasins is capable of producing ≥ 1850 parr/km. This potential habitat capacity represents a large freshwater survival buffer that may help coho persist though extended periods of poor ocean survival.

In 2007, ODFW initiated a pilot study to assess the feasibility of sampling winter habitat at the coho population scale. Four Coast Coho ESU populations were selected (Nehalem, Siuslaw, Coquille, and South Umpqua) to identify logistical challenges associated with surveying during winter conditions, describe observed differences between winter and summer data, and estimate potential winter rearing capacity (Romer et al. 2008). The Nehalem, Siuslaw, and South Umpqua were all sampled to a spatial extent that adequately covered the known distribution of coho salmon spawning and rearing habitat, while the Coquille fell short of the targeted spatial sampling effort. Findings from the Romer et al. study suggested that data collected during summer conditions were applicable to winter conditions and could be used for capacity estimation within the Habitat Limiting Factors Model (Nickelson 1998). These data also suggested that surveys conducted during the winter were better at detecting secondary channels and slack water refuge habitat, which are critical to juvenile coho overwinter survival (Reeves et al. 1989, Nickelson et al. 1992b, and Beechie et al. 1994). The authors concluded these benefits outweighed the difficulty of conducting surveys during the winter. During subsequent field seasons (2008-2014) we sampled sites surveyed the previous fall by the Oregon Adult Salmonid Inventory & Sampling (OASIS) program along with a proportion of sites exclusively within the range of juvenile coho rearing. In addition, in 2013 we revisited the Coquille population to adequately sample habitat within the distribution of coho salmon spawning and rearing.

This report discusses the findings from stream habitat surveys conducted between February and April from 2007 to 2013, and between June and September in 2014. Surveys represented all wadeable streams within each population in the Oregon Coast Coho ESU. We (1) describe status of winter habitat in each population, (2) quantify and summarize the habitat capacity for juvenile coho salmon in each population, (3) compare stream conditions and habitat capacities between Independent and Dependent Coast Coho ESU populations, land use, and geology.

METHODS

Study Area and Site Selection

We used a generalized random tessellation stratified (GRTS) design to randomly select spatially balanced points within each of the Oregon Coast Coho ESU populations (Stevens 2002). Further details of the sample frame design and site selection are described in Anlauf-Dunn et al. (2012). This region is divided into four monitoring strata (North Coast, Mid Coast, Mid-South Coast, and Umpqua). Each stratum is composed of coho salmon population areas based on population dynamics, genetic information, geographic distribution, species life history, and morphological traits (Lawson et al. 2004, Wainwright et al. 2006). In addition, each population is designated as either independent or dependent. Dependent populations are those in small catchment areas and may require a periodic influx of adult coho salmon from adjacent independent basins to maintain long-term population persistence (Lawson et al. 2004). We sampled individual independent populations across the Oregon Coast Coho ESU and dependent population blocks within monitoring strata.

The underlying lithology of the Oregon Coast ESU is primarily marine sandstones, basaltic volcanic rock, and intrusive igneous rock (Spies et al. 2002). The regional climate is heavily influenced by marine processes and winter temperatures generally fluctuate between 5^{o} and 15^{o} C (Spies et al. 2002). Precipitation, primarily rain, generally ranges from 100 cm (inland areas) to 200 cm (coastal areas) per year. Land ownership in the Oregon Coast ESU is a mix of private and federal lands, and urban, agricultural, and forest land uses.

Stream Habitat Surveys

Sites surveyed by the Aquatic Inventories Project were approximately 1 kilometer in length and data collection adhered to protocols developed by Moore et al. (2007). Attributes collected and summarized at the reach level described physical habitat, channel morphology, substrate composition and instream wood (Table 1). These data were used to describe the status, capacity, and quality of habitat within coho populations from 2007 – 2014. During all years except 2014, habitat data were collected during winter conditions (February – March). Habitat sampled in 2014 occurred within the summer field season (June – September). To estimate winter habitat conditions at sites surveyed in the summer, a regression model was used to extrapolate conditions from summer to winter (Rogers et al. 2005).

Survey Statistics

Surveys were selected and summarized for each population; non-surveyed sites were inspected for reason dropped. We also summarized the proportion of surveys with beaver activity (chewed sticks, trails, dens, etc.) and beaver dams, debris jams, mass wasting, and habitat restoration structures (artificial wood and boulder structures) in each population. We described the distribution of surveys across land ownership and principle land use within populations using a United States Geological Survey (USGS) land use coverage layer in a Geographic Information System (GIS). Land use categories were: agriculture, federal forest, private forest, state forest, urban, and other (mix of parks, military, and Native American holdings). Lithology was assessed within and compared across populations using a USGS GIS geology layer (Walker et al. 2003) to identify the following petrology types: intrusive, metamorphic, sedimentary, and volcanic. A 1,000 meter buffer was created around individual sites to identify both dominant land use and rock type.

Habitat Condition

To provide comparative context for evaluating percent substrate, pool habitat, secondary channels, and large wood metrics within the range of coho salmon spawning and rearing habitat we used reference values derived from a multi-agency effort to standardize setting reference conditions (Miller et al. 2016). Reference sites were selected to represent areas of least human disturbance or the most natural state. Once those sites were chosen, we extracted the 25th and 75th percentile values of a given habitat metric to compare with current data. It should be noted, reference sites described in Miller et al. 2016 only fell within our categories of sedimentary or volcanic rock so we did not compare reference thresholds with habitat data associated with rock type.

Metric data were summarized for each site as a percent composition or scaled to a standardized stream length. Sites within a population unit were weighted equally and combined to provide a population scale profile of instream physical habitat. Analysis of Variance (ANOVA) procedures were used to test differences among instream habitat attributes across individual populations, land use types and lithology. In instances where significant differences were observed, Kruskal-Wallis rank sum and chi-squared tests were performed to assess differences between independent variables. All statistical analyses were performed with R software (R Development Core Team 2006).

Habitat Capacity and Quality

Habitat Capacity: We used the Habitat Limiting Factors Model (HLFM) to estimate rearing capacity by assigning a density (juvenile coho salmon/m^2) value based on the size, type and complexity of habitat units. The HLFM model assigns the highest value to beaver ponds, alcoves, and pools with large wood (Nickelson 1998). Capacity to support juvenile coho salmon during winter conditions was considered high if the HLFM value exceeded 1,850 parr/kilometer, and low if capacity estimates were below 900 parr/kilometer (Anlauf-Dunn et al. 2012). A detailed overview of how the HLFM is used to describe habitat capacity at the reach scale is in Anlauf and Jones (2007) and Anlauf-Dunn et al. (2012). ANOVA was used to test the null hypothesis of no difference in juvenile coho parr/kilometer across populations, land use, and geology. Where a significant difference was observed, Kruskal-Wallis rank sum and chi-squared tests were performed to assess where these differences occurred.

Habitat Quality (HLFM): The HLFM was used to estimate the amount of high quality (HQ) habitat available in both stream kilometers and as a percentage of the known distribution of coho salmon spawning and rearing habitat. These estimates were based on the number of sites within each population that exceeded a capacity of 1,850 juvenile coho parr/km. We calculated a site weight based on the number of sites surveyed within the distribution of coho salmon. We then multiplied the site weight by the number of sites exceeding 1,850 juvenile coho parr/km to estimate the kilometers of high quality habitat in each population. The error estimate was derived from the upper and lower 95% confidence interval based on the nearest estimate to 1,850 parr/km on the cumulative distribution function. A more comprehensive overview of the calculation of high quality habitat at the population scale can be found in Anlauf-Dunn et al. (2012).

In addition, we used simple linear regression to assess whether methods used to describe high quality habitat estimates in populations sampled from 2007-2014 were similar to those described in the Oregon Coast Coho Habitat Assessment (Rodgers et al. 2005). We used a non-parametric t-test to assess whether methods were similar when describing high quality habitat estimates across population means at the Coast ESU scale.

Habitat Quality (HabRate): A second model was used to evaluate spawning and emergence habitat quality, and summer and winter rearing habitat quality (HabRate: Burke et al. 2010). HabRate was designed to evaluate juvenile coho salmon habitat quality based on critical habitat values defined in the literature. The model output creates habitat rankings of high (3), medium (2), and low (1) for each habitat variable and for each life stage of coho salmon (Anlauf and Jones 2007 and Anlauf-Dunn and Jones 2012). We used a Kruskal-Wallis rank sum test to assess differences among HabRate life history ratings across populations and land use types. Results of the model ratings were based on data collected to evaluate general habitat condition therefore the spawning and emergence ratings were mostly influenced by observed percentages of gravel as well as the amount of pool habitat. Overwinter habitat ratings can be attributed to available pool habitat, large wood, and channel complexity (i.e. percent secondary channels).

RESULTS

Survey Statistics

From 2007 – 2014 we sampled 451 unique sites across 18 of 21 independent populations. We were unable to sample three independent coho populations due to time and budget constraints; Necanicum River in the North Coast, Beaver Creek in the Mid Coast, and the North Umpqua River in the Umpqua. We also sampled dependent population blocks within three strata; North Coast, Mid Coast, and Mid-South Coast (Figure 1). This study was designed to target population scale sampling within wadeable streams and due to this strategy, populations were all sampled with adequate coverage across the range of coho salmon spawning and rearing habitat. We did not intentionally stratify by land use or geology and we did not sample non-wadeable habitat. Across all populations we surveyed 4.3% of the stream km of total coho rearing and spawning km in the ESU. Within populations, sampling ranged from a low of 1.54% in the South Umpqua in 2007 to a high of 32.41% of the accessible stream km in the Sixes River in 2014. The total number of not surveyed sites across populations was 133 and the primary reason for sites not surveyed was private landowner denial to access (Table 2).

The vast majority of surveyed sites occurred largely within sedimentary rock which is the dominant petrology type in the coast range (Table 3). Volcanic rock made up a significant proportion in most populations and about half of the basins also had varying proportions of intrusive rock. Metamorphic rock was not present in the Oregon Coast Coho ESU. Most sites were in federal forest or industrial timber lands (Figure 2, Table 4), but several populations were found to be almost entirely within other land use types; the Tillamook Bay population was largely within the Tillamook State Forest and Tenmile Lakes were almost entirely within the Elliott State Forest, while the Middle Umpqua River was largely found to be within agricultural land use.

While beaver activity was observed in all populations, there were no beaver dams observed in the Sixes River or Tahkenitch Lake populations. Overall, the proportion of beaver activity observed within populations was significantly greater than constructed dams (Table 5). This is likely attributed to most Oregon Coast Range beaver dams being small, ephemeral, and generally unable to withstand peak winter flow events (Leidholt-Bruner et al. 1992). Large wood stream restoration structures (artificially placed wood) were observed most prominently in the Tillamook Bay and Tahkenitch populations, while the highest proportion of sites with boulder restoration structures (clusters, weirs, wing dams, etc.) occurred in the Lower Umpqua. Debris jams were found in all populations and occurrence across sites ranged from a low of 4% in the Sixes to a high of 82% in Coos Bay. Evidence of mass wasting (avalanches, earthflows, and landslides) was not observed in the Coos Bay or Mid-South Coast Dependent populations. The highest proportion of sites with evidence of these events occurred in the Salmon River and Middle Umpqua.

Habitat Condition

Data were evaluated across populations, land use, and petrology type. Differences were observed among all instream habitat attributes across populations (Table 6), therefore we rejected our null hypothesis that instream habitat attributes would not differ significantly across individual populations. Across land use and petrology types, differences were observed across several habitat attributes and all wood attributes (Tables 7 and 8). When habitat data were compared to the reference thresholds (25th and 75th percentiles), median values summarized in several populations fell below the lower thresholds for a number of habitat attributes. In both populations and land use types several of the independent variables fell below the 25th percentiles in all attributes associated with instream wood (Figures 3 and 4). The following populations fell below the 25th percentile in wood volume: Coquille, Floras, Middle Umpqua, Mid-South Dependent, North Coast Dependent, Siltcoos, Sixes, South Umpqua, Tahkenitch, Tenmile Lakes, and Yaquina. It should also be noted the following populations exceeded the 75th percentile in percent bedrock: Alsea, Coos, Coquille, Lower Umpqua, Middle Umpqua, South Umpqua, and Yaquina. Agriculture, private forest, and urban land uses all fell below the 25th percentiles in all attributes associated with instream wood.

Habitat Capacity and Quality

The ANOVA results indicated a significant difference in juvenile coho salmon capacities among populations (alpha level of 0.05), but not among land use, geology types, or between independent and dependent populations (Table 9). While the majority of population median estimates fell below low quality habitat thresholds (< 900 parr/km), several of the populations (Mid-South Dependent, North Coast Dependent, Salmon, Siltcoos, South Umpqua, Tenmile Lakes, and Tillamook Bay) had upper quartile bounds that fell entirely below that threshold (Figure 5). No significant differences were observed among land use types, geology or among independent and dependent populations. All land use and geology types median values fell below the low quality habitat threshold.

We calculated summary statistics within populations for winter habitat capacity estimates of juvenile coho salmon and found a high of 1,567.68 parr/km in Floras Creek and a low of 289.50 parr/km in the streams that flow into Siltcoos Lake (Table 10). We also found Floras Creek to have the highest percentage of high quality habitat within the coho salmon frame (43.64%) while several populations (Mid-South Coast Dependent, Siltcoos Lake, and Tahkenitch Lake) were found to have no high quality habitat (Table 11). All of the lake population’s mean winter coho parr/km were below the low quality habitat threshold and only Tenmile Lakes contained any high quality habitat (11.15%).

Results of the Kruskal-Wallis chi-squared test assessing differences among HabRate ratings found significant differences in spawning and emergence habitat among populations and among land use types (Table 12). A multiple comparison test did not detect any differences in spawning and emergence habitat between populations, but differences were detected between land uses; agriculture and state forest, federal forest and private forest, and private forest and state forest. In addition, overwinter habitat was found to be significantly different between populations. The multiple comparison test did not detect any differences in overwinter habitat between populations. No significant difference was observed among geology types or between independent and dependent populations.

We evaluated site selection methods used to describe measurable criteria and desired status across populations defined in the 2005 Oregon Coast Coho Assessment viability analysis (ODFW 2007). When we compared results of high quality habitat across surveyed populations from 2007-2014 with those described in the 2007 Conservation Plan and Rodgers et al. (2005), our results suggest high quality habitat differed within particular populations (p-value = 0.02) (Table 13). But, across the entire Coast ESU, results indicate high quality habitat did not change significantly across population means (p-value = 0.13). High quality habitat was estimated to be higher by approximately 125 km across all populations sampled from 2007-2014.

Across all populations the current high quality habitat was found to be 31% of the desired high quality kilometers outlined in the Conservation Plan (ODFW 2007) and only three populations exceeded 50% of desired (Floras, Nestucca, and Siletz) (Table 14). When extrapolated to the ESU, the kilometers of high quality stream habitat would need to increase by over 3,600 for the ESU, with the lowest increase needed in the Floras population at 13 km. The Siuslaw, South Umpqua and Middle Umpqua would all require increases near or greater than 500 km.

DISCUSSION

While many of the observed differences among habitat attributes across individual populations, such as percent substrate (i.e. % Fine sediments), were not surprising, some surprises did emerge. The dearth of high quality rearing habitat in the streams that flow into Tenmile, Siltcoos, and Tahkenitch Lakes was particularly unexpected as these consistently produce the highest spawning density of adult coho within the Oregon Coast ESU (ODFW 2015). While over-winter abundance and survival in slack water habitat (i.e. beaver ponds and alcoves) has been examined (Nickelson et al. 1992a and 1992b) and speculation the lakes themselves offer increased rearing capacity has been suggested (Nickelson 1998 and Rodgers et al. 2005), little is known regarding specific habitat interactions and utilization within these particular populations. Exploring habitat utilization and interaction within the lake populations will require integrating empirical fish data, both juvenile and adult, with the existing habitat data where the three datasets directly overlap. These data along with sampling fish within the lakes themselves may offer clues as to whether life history strategies or habitat availability has the greater effect on coho abundance.

The lack of beaver dams in relation to beaver activity in the Tahkenitch Lake population was viewed as a surprise, as was the lack of artificial wood structures in the Nehalem population. These data, collected largely as ancillary notes and comments, were viewed as a general description of presence or absence within individual sites. In populations where presence of particular activities was not observed, i.e. beaver dams, mass wasting, or restoration, activities should be viewed more as a ‘not detected’ rather than complete absence. It should also be noted these data are not a required field entry. The higher number of recorded activities is likely biased towards newer or larger concentrations as these are more readily observed by field crews.

Sites within populations surveyed from 2008-2014 directly overlapped with sites surveyed for adult coho spawning the previous fall. The differences observed in HabRate spawning and juvenile emergence across populations and land use types may warrant further investigation utilizing methods described in Anlauf-Dunn et al. (2014). These methods may allow for investigation of both spawning habitat quality and proximity to juvenile rearing habitat as well as exploring correlations between juvenile habitat condition and presence or abundance of adult spawners. Within dependent populations both the amount of high quality habitat in relation to catchment area and similarity of habitat compared to independent populations was unexpected. Associations between abundance of adult spawners and juvenile rearing habitat may be difficult to define within dependent populations considering the potential need for a periodic influx of adult coho salmon from adjacent independent basins. Determining whether abundance is a result of habitat condition, genetic variation, or ocean productivity within these small catchment areas may only be possible by utilizing ODFW Life Cycle Monitoring data (Suring et al. 2015).

Evaluating habitat data to assess differences in spawning habitats across populations may be difficult as our habitat methods are tailored to evaluate general stream habitat condition. While tools exist to evaluate individual habitat attributes for condition and capacity at the juvenile stages, our modeled efforts of adult spawning habitat are limited to qualitative measures due to a lack of life stage specific data collected. Future sampling and analyses investigating the quantity of adult spawning habitat should include measures of flow, substrate depth profile, and exact size of substrate within particular habitats (Montgomery et al. 1999 and Beechie et al. 2008).

The Oregon Coast Coho Conservation Plan identified goals for HQ habitat intended to help populations persist during periods of poor marine survival (Lawson 1993, Nickelson and Lawson 1998, and ODFW 2007). These goals align to the hypothesis proposed by Nickelson and Lawson (1998) that a threshold proportion of habitat must remain of sufficient quality for a population to maintain acceptable probabilities of persistence. Our results indicate low levels of high quality habitat at the population and ESU scale when compared to desired goals outlined in the Conservation Plan. The comparison of site selection methods from those in this report and Rodgers et al. (2005) suggests sampling at the ESU scale is comparable, but stratified sampling within populations is the most appropriate method to describe HQ habitat for each individual population. We suggest results of this report be used when comparing current HQ habitat with desired status goals identified in the Conservation Plan. Population scale habitat surveys from this report may also indicate slightly more HQ habitat across the entire Oregon Coast Coho ESU than previously estimated by Rodgers et al. 2005. This suggests that although habitat improvement has not increased to the extent desired for coho recovery, ongoing management actions (i.e. stream restoration and regulatory efforts) may have contributed to more, high quality freshwater rearing habitat for coho salmon within the Oregon Coast Coho ESU, potentially improving their future persistence.

Results from report should be viewed as a tool to help prioritized habitat enhancement actions for coast coho populations. Stream reaches and sections with higher proportions of agriculture, private forest, or urban land use types, should be evaluated for restorative feasibility given these are areas with median values for large wood attributes (i.e. number of pieces, volume, and key pieces) that fell below the 25th percentile when compared to reference streams. These attributes have often been described as a critical component of fluvial process and juvenile salmonid refuge habitat (Fausch and Northcote 1992, Ralph et al. 1994, Gurnell et al. 2002, and Johnson et al. 2005). Some of these populations (Middle Umpqua and Yaquina) also had the lowest percentage of high quality habitat when compared to desired status described in the Conservation Plan. Providing a roadmap for restoration practitioners to focus effort where quality of winter rearing habitat for coho salmon can be increased to the extent that desired status is satisfied may be the only way to achieve species recovery.

REFERENCES

Anlauf, K.J. and K.K. Jones. 2007. Stream Habitat Conditions in Western Oregon, 2005. OPSW-ODFW-2007-5, Oregon Department of Fish and Wildlife, Salem, Oregon.

Anlauf-Dunn, K.J. and K.K. Jones. 2012. Stream Habitat Conditions in Western Oregon, 2006-2010. OPSW-ODFW-2012-5, Oregon Department of Fish and Wildlife, Salem.

Anlauf-Dunn, K.J., E.J. Ward, M. Strickland, K. Jones. 2014. Habitat connectivity, complexity, and quality: predicting adult coho salmon occupancy and abundance. Canadian Journal of Fisheries and Aquatic Sciences, 71(12), 1864-1876.

Beechie, T.J., E. Beemer, and L. Wasserman. 1994. Estimating coho salmon rearing habitat and smolt production losses in a large river basin, and implications for habitat restoration. North American Journal of Fisheries Management, 14:797-811.

Beechie, T.J., H. Moir, and G. Pess. 2008. Hierarchical physical controls on salmonid spawning location and timing. *In* Salmonid spawning habitat in rivers: physical controls, biological responses, and approaches to remediation. *Edited by* D.A. Sear and P. DeVries. American Fisheries Society, Symposium 65, Bethesda, Md. Pp. 83-101.

Burke, J.L, K.K. Jones, and J.M. Dambacher. 2010. Habrate: A limiting factors model for assessing stream habitat quality for salmon and steelhead in the Deschutes river basin. Information Report 2010-03, Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Ebersole, J. L., P.J. Wigington, Jr., J.P. Baker, M.A. Cairns, M. Robbins Church, B.P. Hansen, B.A. Miller, H.R. LaVigne, J.E. Compton, and S.G. Leibowitz. 2006. Juvenile Coho Salmon Growth and Survival across Stream Network Seasonal Habitats. Transactions of the American Fisheries Society 135:1681 – 1697.

Fausch, K. D. and T. G. Northcote. 1992. Large woody debris and salmonid habitat in a small coastal British Columbia stream. Can. J. Fish. Aquat. Sci. 49:682-693.

Gurnell, A. M., H. Piégay, F.J. Swanson, and S.V. Gregory. 2002. Large wood and fluvial processes. Freshwater Biology, 47:601-619.

Johnson, S. L., J. D. Rodgers, M. F. Solazzi, and T.E. Nickelson. 2005. Effects of an increase in large wood on abundance and survival of juvenile salmonids (Oncorhynchus spp.) in an Oregon coastal stream. Can. J. Fish. Aquat. Sci. 62(2): 412-424.

Lawson, P.W. 1993. Cycles in Ocean Productivity, Trends in Habitat Quality, and the Restoration of Salmon Runs in Oregon. Transactions of the American Fisheries 18:8, 6-10.

Lawson, P.W., E. Bjorkstedt, M. Chilcote, C. Huntington, J. Mills, K. Moore, T.E. Nickelson, G.H. Reeves, H.A. Stout, and T.C. Wainwright. 2004. Identification of Historical Populations of Coho Salmon (*Onchorhynchus kisutch*) in the Oregon Coast Evolutionarily Significant Unit. Review Draft. Oregon Northern California Coast Technical Recovery Team. NOAA/NMFS/NWFSC. 129 p.

Leidholt-Bruner, K., D.E. Hibbs, and W.C. McComb. 1992. Beaver dam locations and their effects on distribution and abundance of coho fry in two coastal Oregon streams. Northwest Sci. 66, 218-223.

Miller, S., P. Eldred, A. Muldoon, K. Anlauf-Dunn, C. Stein, S. Hubler, L. Merrick, N. Haxton, C. Larson, A. Rehn, P. Ode, and J. Vander Laan. 2016. A large-scale, multiagency approach to defining a reference network for Pacific Northwest Streams. Environmental Management, 58, 6: 1091-1104.

Moore, K.M.S., K.K. Jones, and J.M. Dambacher. 2007. Methods for stream habitat surveys. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Montgomery, D.R., E.M. Beamer, G.R. Pess, and T.P. Quinn. 1999. Channel type and salmonid spawning distribution and abundance. Can. J. Fish. Aquat. Sci. 56(3): 377-387. Doi:10.1139/f98-181.

Nickelson, T.E., M.F. Solazzi, S.L. Johnson, and J.D. Rodgers. 1992a. Effectiveness of selected stream improvement techniques to create suitable summer and winter rearing habitat for juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49:790-794.

Nickelson, T.E., M.F. Solazzi, S.L. Johnson, and J.D. Rodgers. 1992b. Seasonal changes in habitat use by juvenile coho salmon (Oncorhynchus kisutch) in Oregon coastal streams. Can. J. Fish. Aquat. Sci. 49:783-789.

Nickelson, T.E., and P.W. Lawson. 1998. Population viability of coho salmon, *Oncorhynchus kisutch*, in Oregon coastal basins: application of a habitat-based life cycle model. Can. J. Fish. Aquat. Sci. 55(11): 2383-2392. Doi:10.1139/f98-123.

Nickelson, T.E. 1998. A habitat-based assessment of coho salmon production potential and spawner escapement needs for Oregon coastal streams. Oregon Department. Fish and Wildlife, Information Report, 98-4, Salem, Oregon.

Oregon Department of Fish and Wildlife (ODFW). 2005. Viability Criteria and Status Assessment of Oregon Coastal Coho. Part 2 in The Oregon Coastal Coho Assessment. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Fish and Wildlife. 2007. Oregon coast coho salmon conservation plan for the state of Oregon. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Fish and Wildlife. 2015. Personal communication with the OASIS Program. Oregon Department of Fish and Wildlife, Corvallis Fish Research Lab, Corvallis, Oregon.

Reeves, G.H., F.H. Everest, and T.E. Nickelson. 1989. Identification of physical habitats limiting the production of coho salmon in western Oregon and Washington. U.S. Forest Service General Technical Report PNW-245.

R Development Core Team. 2006. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org.

Ralph, S.C., G.C. Poole, L.L. Conquest, and R.J. Naiman. 1994. Stream Channel Morphology and Woody Debris in Logged and Unlogged Basins of Western Washington. Can. J. Fish. Aquat. Sci. 51(1): 37-51.

Rodgers, J.D., K.K. Jones, A.G. Talabere, C.H. Stein, and E.H. Gilbert. 2005. Oregon coast coho salmon assessment: habitat. Oregon Plan for Salmon and Watersheds, Oregon Department of Fish and Wildlife, Salem, Oregon.

Romer, J.D., K.J. Anlauf, and K.K. Jones. 2008. Status of Winter Rearing Habitat in Four Coho Population Units, 2007. Monitoring Program Report Number OPSW-ODFW-2008-7, Oregon Department of Fish and Wildlife, Salem, OR.

Spies, T.A., D.E. Hibbs, J.L. Ohmann, G.H. Reeves, R.J. Pabst, F.J. Swanson, C. Whitlock, J.A. Jones, B.C. Wemple, L.A. Parendes, and B.A. Schrader. 2002. The ecology basis of forest ecosystem management in the Oregon Coast Range. *In* Forest and stream management in the Oregon Coast Range. Edited by S.D. Hobbs, J.P. Hayes, R.L. Johnson, G.H. Reeves, T.A. Spies, J.C. Tappeiner, II, and G.E. Wells. Oregon State University Press, Corvallis, Ore. Pp.31-67.

Stevens, D.L., Jr. 2002. Sampling design and statistical analysis methods for the integrated biological and physical monitoring of Oregon streams. Monitoring Program Report Number OPSW-ODFW-2002-7, Oregon Department of Fish and Wildlife, Salem, Oregon.

Suring, E., P. Burns, R.J. Constable, C.M. Lorion, and D.J. Wiley. 2015. Salmonid Life Cycle Monitoring in Western Oregon streams, 2012-2014. Monitoring Program Report Number OPSW-ODFW-2015-2, Oregon Department of Fish and Wildlife, Salem.

Wainwright, T.C., M.W. Chilcote, P.W. Lawson, T.E. Nickelson, C.W. Huntington, J.S. Mills, K.M.S. Moore, G.H. Reeves, H.A. Stout, and L.A. Weitkamp. 2006. Biological recovery criteria for the Oregon coast coho salmon evolutionarily significant unit. Draft Report, January 2006. (Available from T.C. Wainwright, NWFSC, Fish Ecology Division, Newport Research Station, Newport, OR.)

Walker, G.W., N.S. MacLeod, R.J. Miller, G.L. Raines, and K.A. Connors. 2003. Spatial digital database for the geologic map of Oregon: U.S. Geological Survey Open-File Report 03-67, ver. 2.0, 22 p. Received Director's approval Feb. 2003. URL = http://geopubs.wr.usgs.gov/open-file/of03-67/.

Table 1. Habitat attributes used in report analyses, categorized by general stream template grouping.

Habitat Category	Habitat Attribute
Channel and Valley Form	Valley width Index Active channel height (m) Active channel width (m) * Channel gradient (%) * Width: Depth Ratio
Stream Morphology	Primary channel length Primary channel area Secondary channel length Secondary channel area (%) * Pool habitat (%) * Slackwater pool habitat (%) * Residual pool depth (m) * Riffle depth (m) Units per 100 m Number of pools
Substrate Composition	% Fines (weighted by habitat unit area) * Sand and organics in riffle habitat units (%) % Gravel (weighted by habitat unit area) * Gravel in riffle habitat units (%) % Bedrock (weighted by habitat unit area) *
Instream Wood	Number of wood pieces * Wood volume (m^3) * Number of large wood key pieces *

* Habitat attributes with ANOVA results.

Table 2. Proportion of sites surveyed 2007-2014 in each population relative to total number of sites drawn in random pull and primary reason for sites not surveyed.

Population	Year	Proportion Surveyed (%)	Primary Reason for Not Surveying
Nehalem	2007	73.33	Lack of Time
Siuslaw	2007	72.72	High Flows / Non Responsive Landowner
South Umpqua	2007	84.62	High Flows / Lack of Time
Alsea	2008	86.67	Non Wadeable
Nestucca	2008	70.97	Non Wadeable
Tillamook Bay	2009	79.31	Access Denied by Landowner
Yaquina	2009	86.20	Access Denied by Landowner
Salmon	2010	84.00	Access Denied / Non Responsive Landowner
Siletz	2010	74.19	Non Responsive Landowner
Coos Bay	2011	64.70	Lack of Time
Lower Umpqua	2011	75.75	Lack of Time
Middle Umpqua	2012	72.22	Lack of Time
Coquille	2013	57.44	Access Denied by Landowner / Lack of Time
Mid Coast Dependent	2013	83.78	Lack of Time / Inaccessible / Active Logging
*Floras	2014	72.72	Access Denied by Landowner
*Mid-South Dependent	2014	71.42	Access Denied by Landowner
*North Coast Dependent	2014	80.76	Access Denied / Non Responsive Landowner
*Siltcoos	2014	91.66	Lack of Time
*Sixes	2014	100	N/A
*Tahkenitch	2014	71.42	Access Denied by Landowner
*Tenmile	2014	80.33	Access Denied by Landowner
	Total Sites Pulled	Total Sites Surveyed	Total Sites Not Surveyed
	584	451	133

*Indicates surveys conducted during summer field season.

Table 3. Lithology within populations based on individual sampled sites. Data depicts total number of sites surveyed and percent of petrology type encountered within a 1000 meter buffer around the GRTS point.

Population	Number of Sites	% Intrusive	% Sedimentary	% Volcanic
Nehalem	22	11.68	56.63	31.69
Siuslaw	24	10.73	89.27	0
South Umpqua	22	15.96	51.57	30.96
Alsea	26	0	100	0
Nestucca	22	17.20	43.86	38.94
Tillamook Bay	23	2.55	39.22	58.23
Yaquina	25	0	84.60	15.40
Salmon	21	0.56	65.70	33.74
Siletz	23	17.47	82.43	33.74
Coos Bay	22	0	94.27	5.73
Lower Umpqua	25	0	89.08	10.92
Middle Umpqua	26	0	86.81	13.19
Coquille	27	0	100	0
MC Dependent	31	0	82.28	17.72
Floras	16	5.97	88.21	5.83
MS Dependent	5	0	100	0
NC Dependent	21	21.69	38.52	39.78
Siltcoos	22	0	100	0
Sixes	23	8.30	85.06	6.64
Tahkenitch	5	0	100	0
Tenmile	20	0	100	0

Table 4. Percent land use within populations based on individual sampled sites. Data depicts total number of sites surveyed and percent of land use type encountered within a 1000 meter buffer around the GRTS point.

Population	Number of Sites	% Agriculture	% Federal Forest	% Private Forest	% State Forest	% Urban	% *Other
Nehalem	22	0.01	0	54.95	45.04	0	0
Siuslaw	24	21.46	75.74	2.77	0.03	0.003	0.003
South Umpqua	22	6.13	92.17	1.42	0	0.28	0
Alsea	26	6.36	86.94	7.71	0	0	0
Nestucca	22	15.76	77.07	7.09	0.06	0.02	0.01
Tillamook Bay	23	1.36	2.64	2.38	93.55	0.007	0.06
Yaquina	25	25.52	2.35	71.93	0.20	0.004	0.002
Salmon	21	14.95	11.58	54.84	3.70	14.94	0.001
Siletz	23	0.63	1.88	97.25	0.22	0	0.02
Coos Bay	22	0.03	6.78	76.89	16.30	0.002	0.16
Lower Umpqua	25	19.98	58.72	21.29	0	0	0
Middle Umpqua	26	80.17	7.03	12.80	0	0.001	0
Coquille	27	0.09	8.77	91.10	0	0.008	0.04
Mid Coast Dependent	31	0.03	87.94	11.87	0.15	0.01	0.001
Floras	16	5.89	0	93.94	0	0.17	0
Mid-South Dependent	5	0.31	0	99.49	0	0.20	0
North Coast Dependent	21	0.06	23.62	65.71	0.75	9.86	0
Siltcoos	22	0.05	95.06	4.88	0	0.002	0.01
Sixes	23	0.02	10.27	89.71	0	0	0.001
Tahkenitch	5	0.04	78.28	21.67	0	0	0.002
Tenmile	20	0.02	0.05	1.27	98.07	0.08	0.51

* Includes, state park, tribal, and military lands.

Table 5. Summary of presence of comment codes at each site within individual populations. Values based on the ratio of the number of sites presence of observation was identified within individual populations and the total number of sites surveyed.

Population	Beaver Dams	Beaver Activity	Debris Jams	Mass Wasting	Artificial Wood Structures	Artificial Boulder Structures
Nehalem	0.20	0.56	0.28	0.08	0	0
Siuslaw	0.18	0.43	0.25	0.18	0.21	0.07
South Umpqua	0.04	0.30	0.22	0.26	0.13	0
Alsea	0.14	0.43	0.43	0.11	0.25	0.04
Nestucca	0.13	0.35	0.57	0.43	0.13	0.04
Tillamook Bay	0.13	0.21	0.13	0.29	0.58	0
Yaquina	0.24	0.56	0.16	0.04	0.12	0.04
Salmon	0.10	0.33	0.67	0.67	0.05	0
Siletz	0.22	0.39	0.13	0.39	0.35	0
Coos Bay	0.18	0.50	0.82	0	0.27	0.18
Lower Umpqua	0.04	0.68	0.68	0.40	0.40	0.20
Middle Umpqua	0.23	0.69	0.81	0.65	0.38	0.15
Coquille	0.15	0.44	0.67	0.59	0.15	0.04
Mid Coast Dependent	0.03	0.65	0.77	0.26	0.32	0.03
*Floras	0.25	0.69	0.19	0.25	0.44	0.13
*Mid-South Dependent	0.40	0.80	0.40	0	0.20	0
*North Coast Dependent	0.33	0.67	0.62	0.38	0.10	0.05
*Siltcoos	0.14	0.23	0.73	0.27	0.09	0.05
*Sixes	0	0.22	0.04	0.35	0.13	0.13
*Tahkenitch	0	0.60	0.60	0.20	0.60	0.20
*Tenmile	0.20	0.45	0.80	0.40	0.10	0

*Indicates surveys conducted during summer field season.

Table 6. Results of ANOVA assessing differences among instream habitat attributes across individual populations. Dependent variable = Habitat attribute; Independent variable = Population. Alpha = 0.05

Habitat Attribute	Residual DF	DF	MSE	F value	P-value
% Fine sediments	430	20	2019.2	4.037	< 0.001
% Gravel	430	20	527.0	2.246	0.001
% Bedrock*	430	20	33.0	5.352	< 0.001
% Secondary channel area*	430	20	12.151	4.182	< 0.001
Gradient*	430	20	2.5393	3.295	< 0.001
% Pool habitat	430	20	3115.7	5.945	< 0.001
% Slackwater pool*	430	20	26.27	2.707	< 0.001
**Residual pool depth*	429	20	0.3920	2.987	< 0.001
Active channel width*	430	20	1.5165	4.62	< 0.001
Wood volume*	430	20	5.455	5.325	< 0.001
Key pieces of wood*	430	20	22.591	3.724	< 0.001
Wood pieces/100m*	430	20	2.7635	4.781	< 0.001

* Habitat attributes were log transformed. **1 site contained zero pools.

Table 7. Results of ANOVA assessing differences among instream habitat attributes across populations by land use. Dependent variable = Habitat attribute, Independent variable = Land use. Alpha = 0.05.

Habitat Attribute	Residual DF	DF	MSE	F value	P-value
% Fine sediments	445	5	4564	8.731	< 0.001
% Gravel	445	5	594.4	2.438	0.033
% Bedrock*	445	5	12.701	1.74	0.124
% Secondary Channel area*	445	5	31.63	10.55	< 0.001
Gradient*	445	5	3.0209	3.662	0.003
% Pool habitat	445	5	1627.3	2.591	0.025
% Slackwater pool*	445	5	5.08	0.483	0.789
**Residual pool depth*	444	5	0.1171	0.818	0.537
Active channel width*	445	5	0.1463	0.381	0.862
Wood volume*	445	5	13.79	12.77	< 0.001
Key pieces of wood*	445	5	45.17	7.092	< 0.001
Wood pieces/100m*	445	5	3.304	5.118	< 0.001

* Habitat attributes were log transformed. **1 site contained zero pools.

Table 8. Results of ANOVA assessing differences among instream habitat attributes across populations by petrology type. Dependent variable = Habitat attribute. Dependent variable = Petrology type. Alpha = 0.05.

Habitat Attribute	Residual DF	DF	MSE	F value	P-value
% Fine sediments	447	3	3302	6.011	< 0.001
% Gravel	447	3	7.03	0.028	0.994
% Bedrock*	447	3	1.074	0.145	0.933
% Secondary Channel area	447	3	7.502	2.282	0.078
Gradient*	447	3	6.333	7.794	< 0.001
% Pool habitat	447	3	5445	8.971	< 0.001
% Slackwater pool*	447	3	21.25	2.048	0.106
**Residual pool depth*	447	3	0.036	0.253	0.860
Active channel width*	447	3	0.519	1.365	0.253
Wood volume*	447	3	7.921	6.734	< 0.001
Key pieces of wood*	447	3	27.14	4.073	0.007
Wood pieces/100m*	447	3	3.086	4.682	0.003

* Habitat attributes were log transformed. **1 site contained zero pools.

Table 9. Results of ANOVA assessing winter parr/km by population, land use, petrology type, and population type (Independent and Dependent). Alpha = 0.05.

Independent variable	Dependent variable	Residual DF	DF	MSE	F value	P-value
Population	Winter Parr/km*	430	20	4.232	4.001	< 0.001
Land Use	Winter Parr/km*	445	5	0.7637	0.635	0.673
Petrology Type	Winter Parr/km*	447	3	2.297	1.928	0.124
Population Type	Winter Parr/km*	449	1	0.1106	0.092	0.762

* Habitat attributes were log transformed.

Table 10. Summary statistics within populations for winter parr/km for Oregon Coast coho ESU.

ESU	Population	N	Mean	StdDev	Lower95%	Upper95%
Oregon Coast	Alsea	26	793.32	801.48	538.92	1047.72
	Coos Bay	22	859.87	707.12	683.78	1035.96
	Coquille	27	1176.62	820.87	892.49	1460.75
	Floras	16	1567.68	1121.76	1113.13	2022.23
	Lower Umpqua	25	1129.72	764.82	857.26	1402.18
	MC Dependent	31	1429.59	1048.00	1148.25	1710.93
	Middle Umpqua	26	974.49	641.24	784.69	1164.28
	MS Dependent	5	378.26	403.60	52.08	704.44
	NC Dependent	21	597.03	743.32	302.64	891.41
	Nehalem	22	1213.11	997.63	942.87	1483.35
	Nestucca	22	1196.15	1098.39	837.42	1554.88
	Salmon	21	637.92	847.02	308.56	967.28
	Siletz	23	1010.37	886.87	745.42	1275.31
	Siltcoos	22	289.50	318.59	171.12	407.88
	Siuslaw	24	1151.37	1130.54	825.83	1476.91
	Sixes	23	1014.04	867.45	740.83	1287.24
	South Umpqua	22	489.81	638.48	263.97	715.65
	Tahkenitch	5	838.32	340.40	566.07	1170.57
	Tenmile	20	704.10	720.77	407.05	1001.15
	Tillamook Bay	23	817.35	944.22	515.92	1118.77
	Yaquina	25	1058.70	1021.66	751.07	1366.34

Table 11. HLFM results by population. High quality (HQ) is considered >1850 winter parr per km.

Population	# Sites	Surveyed km	Coho km	# Sites w/ HQ Habitat	HQ Habitat (km)	% HQ	%Error	Error (km)
Alsea	26	26.40	591.39	4	89.62	15.15	11.85	70.09
Coos Bay	22	21.73	562.37	3	77.64	13.81	9.57	53.85
Coquille	27	26.58	833.96	6	188.28	22.58	13.02	108.61
Floras	16	16.04	194.29	7	84.79	43.64	20.99	40.78
Lower Umpqua	25	25.32	861.74	3	102.08	11.85	11.51	99.23
MC Dependent	31	31.37	288.45	7	64.37	22.32	11.07	31.93
Middle Umpqua	26	26.57	925.01	3	104.42	11.29	10.15	93.92
MS Dependent	5	4.91	67.59	0	0.00	0.00	0.00	0.00
NC Dependent	21	20.48	118.06	2	11.53	9.77	11.73	13.85
Nehalem	22	22.30	1137.40	5	255.07	22.43	12.47	141.78
Nestucca	22	22.98	397.27	5	86.45	21.76	13.93	55.34
Salmon	21	21.73	86.05	2	7.92	9.20	11.41	9.82
Siletz	23	22.20	514.21	4	92.66	18.02	11.47	58.98
Siltcoos	22	20.13	115.13	0	0.00	0.00	0.00	0.00
Siuslaw	24	24.19	1339.42	5	276.82	20.67	11.35	152.02
Sixes	23	22.35	68.95	2	6.17	8.95	10.15	7.00
South Umpqua	22	20.82	1350.65	2	129.73	9.60	10.60	143.20
Tahkenitch	5	5.15	42.19	0	0.00	0.00	0.00	0.00
Tenmile	20	21.17	117.97	2	11.15	9.45	12.43	14.67
Tillamook Bay	23	24.48	557.11	3	68.28	12.26	10.09	56.22
Yaquina	25	25.26	356.96	5	70.66	19.80	12.28	43.83

Table 12. Results of Kruskal-Wallis chi-squared test assessing differences among HabRate life history ratings across populations, land use, geology and population types. Dependent variable = Life history stage, Independent variables = Population, land use type, geology type, and population type (Independent and Dependent).

Life history stage	DF	chi-square test	P-value
	Across Populations		
Spawning and emergence	20	56.501	< 0.001
Overwinter habitat	20	39.848	0.005
	Across Land Use Types		
Spawning and emergence	5	31.086	< 0.001
Overwinter habitat	5	3.410	0.637
	Across Geologies		
Spawning and emergence	3	6.5594	0.087
Overwinter habitat	3	3.2512	0.355
	Across Population Types		
Spawning and emergence	1	2.5909	0.1075
Overwinter habitat	1	0.0404	0.8407

Table 13. Comparison of total kilometers (km) of high quality habitat (HQ) within populations surveyed 2007-2014 and total km HQ within populations described in the Oregon Coast Coho Habitat Assessment (OCCHA) (Rodgers et al. 2005).

Population	2007 - 2014 HQ Habitat (km)	2007 – 2014 HQ %	OCCHA HQ Habitat (km)	OCCHA HQ %
Alsea	89.62	15.15	69.20	11.70
Coos Bay	77.64	13.81	281.63	50.08
Coquille	188.28	22.58	173.81	20.84
Floras	84.79	43.64	30.58	15.74
Lower Umpqua	102.08	11.85	177.03	20.54
Middle Umpqua	104.42	11.29	93.34	10.09
Nehalem	255.07	22.43	131.97	11.60
Nestucca	86.45	21.76	51.50	12.96
Salmon	7.92	9.20	4.83	5.61
Siletz	92.66	18.02	51.50	10.02
Siuslaw	276.82	20.67	204.39	15.26
Sixes	6.17	8.95	4.83	7.00
South Umpqua	129.73	9.61	109.44	8.10
Tillamook Bay	68.28	12.26	43.45	7.80
Yaquina	70.66	19.80	88.51	24.80
Sum	1640.60		1515.99	

Simple Linear Regression: P-value = 0.02

Wilcoxon Signed Rank Test: P-value = 0.13

Table 14. High quality (HQ) habitat based on sites surveyed from 2007-2014 within each population compared to desired status as outlined by the Measurable Criteria in Appendix 2 of the Oregon Coast Coho Conservation Plan. Data only includes independent, non-lake populations highlighted in Conservation Plan.

Population	Coho km	HQ Habitat km	Desired HQ km	% of Desired HQ
Alsea	591.39	89.62	276.81	32.38
Coos Bay	562.37	77.64	374.98	20.71
Coquille	833.96	188.28	516.60	36.45
Floras	194.29	84.79	98.17	86.37
Lower Umpqua	861.74	102.08	492.46	20.73
Middle Umpqua	925.01	104.42	577.75	18.07
Nehalem	1,137.40	255.07	568.10	44.90
Nestucca	397.27	86.45	122.31	70.68
Salmon	86.05	7.92	30.58	25.89
Siletz	514.21	92.66	178.64	51.87
Siuslaw	1,339.42	276.82	817.54	33.86
Sixes	68.95	6.17	30.58	20.18
South Umpqua	1,350.65	129.73	669.49	19.38
Tillamook Bay	557.11	68.28	246.23	27.73
Yaquina	356.96	70.66	307.38	22.99
Sum of Populations	9,776.78	1,640.60	5,307.60	30.91

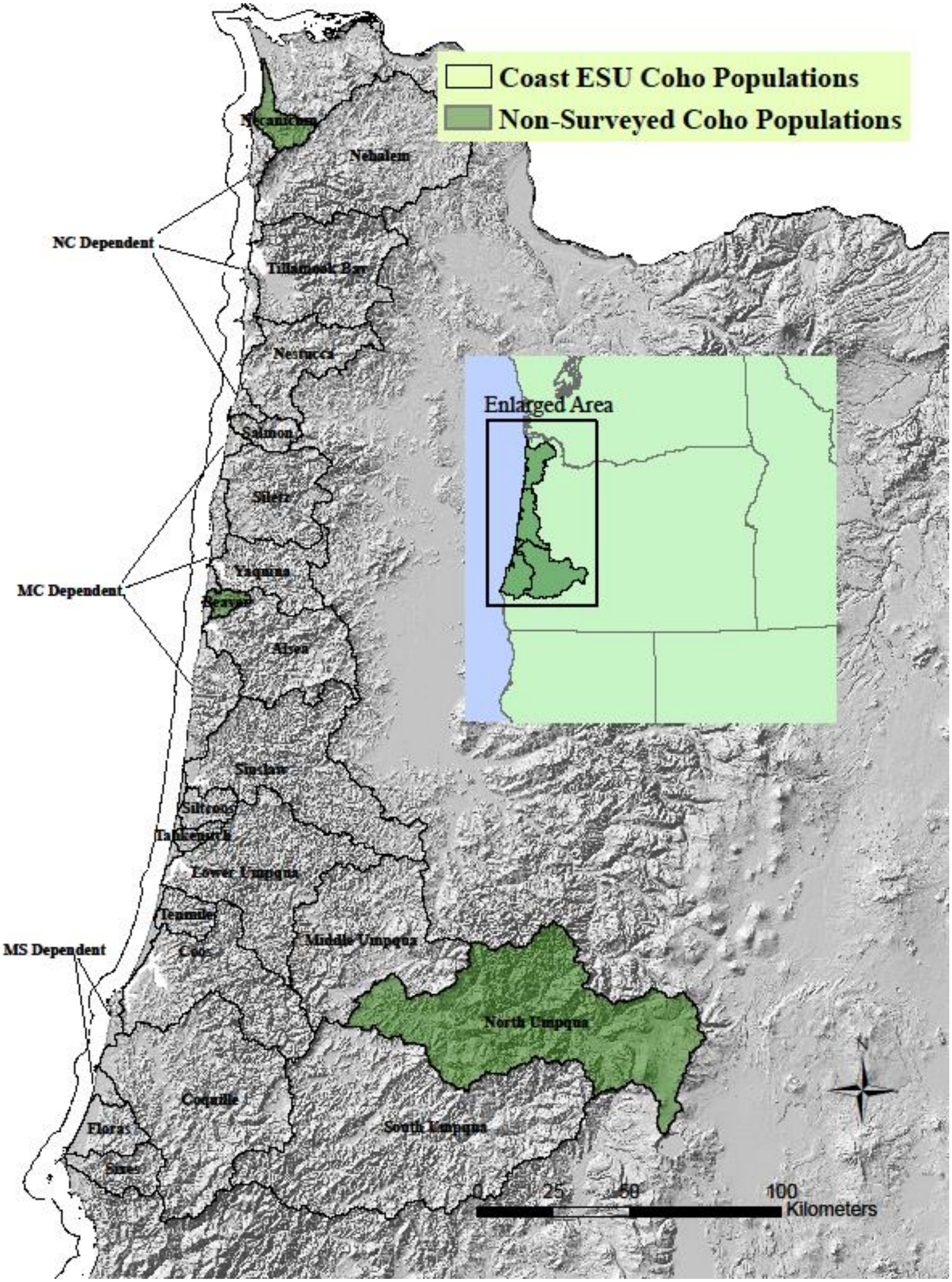

Figure 1. Oregon Coast Coho ESU populations surveyed 2007 – 2014.

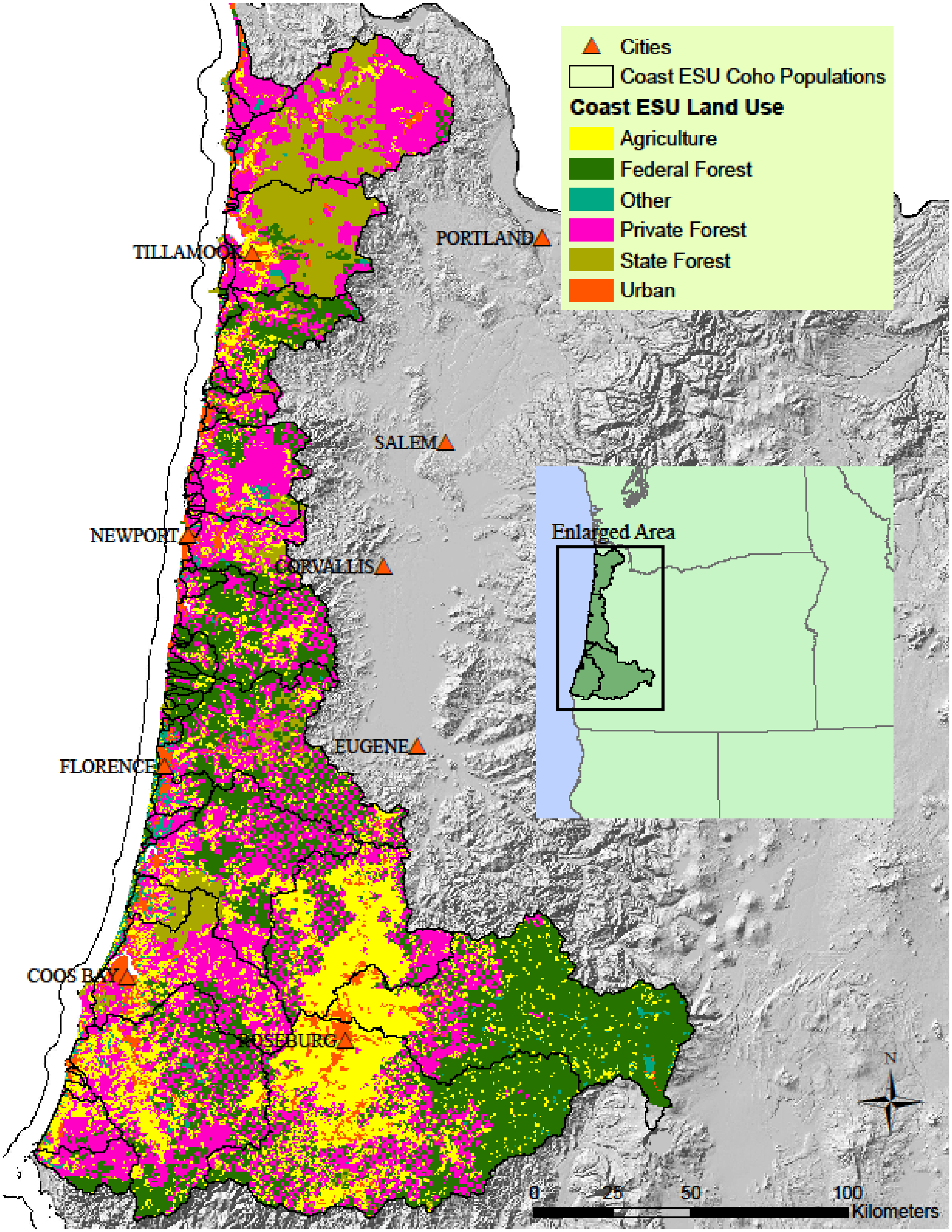

Figure 2. Land use within Oregon Coast Coho ESU.

Figure 3. Boxplots of habitat attributes (y-axis) within coast coho populations (x-axis). Plots depict minimum values, lower quartile bounds, medians, upper quartile bounds, and maximum values. Horizontal red lines indicate upper and lower breakpoints for the respective habitat attributes (Miller et al. 2016).

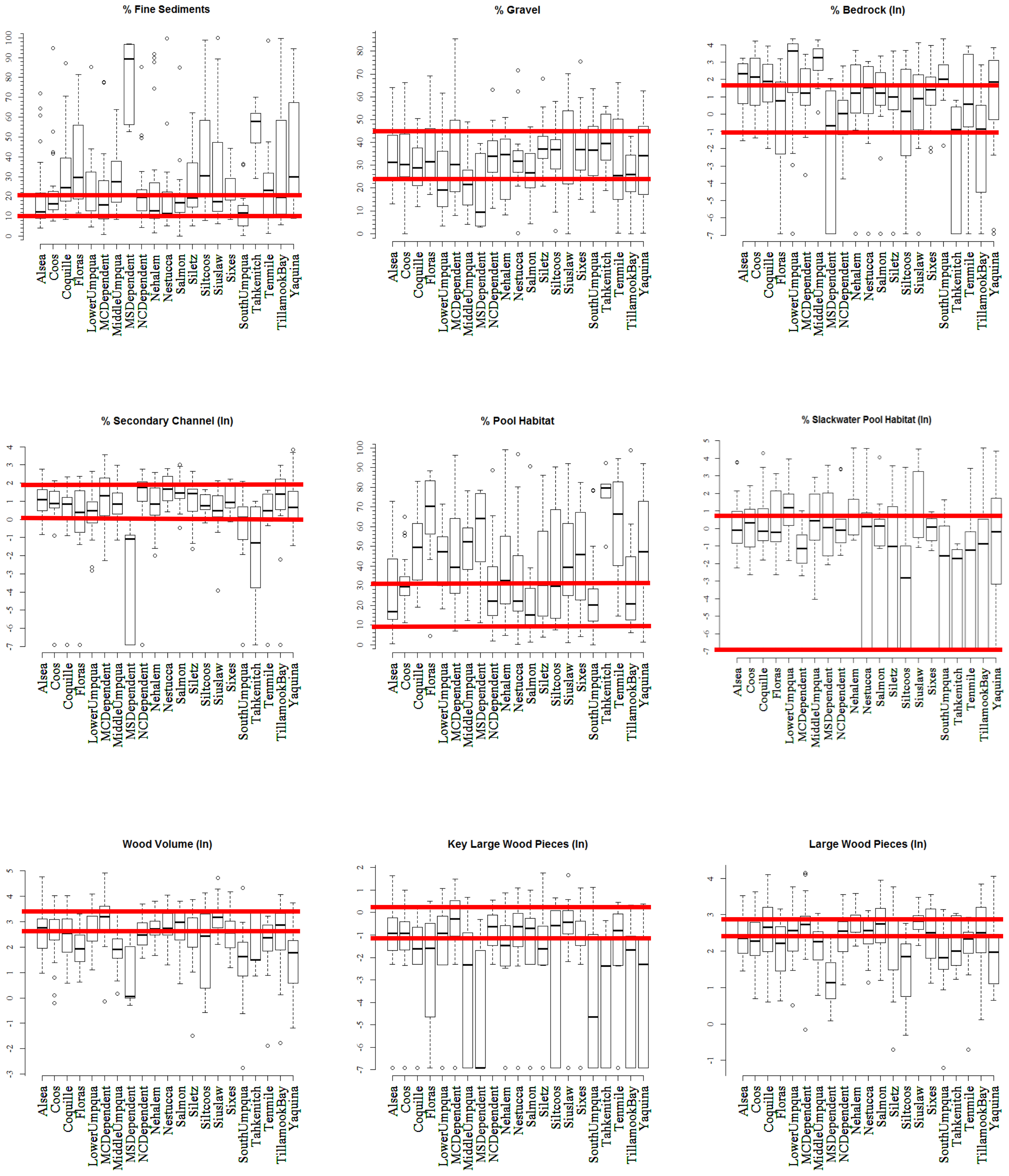

Figure 4 Boxplots of habitat attributes (y-axis) within dominant land use types (x-axis) at individual sites. Plots depict minimum values, lower quartile bounds, medians, upper quartile bounds, and maximum values. Horizontal red lines indicate upper and lower breakpoints for the respective habitat attributes (Miller et al. 2016).

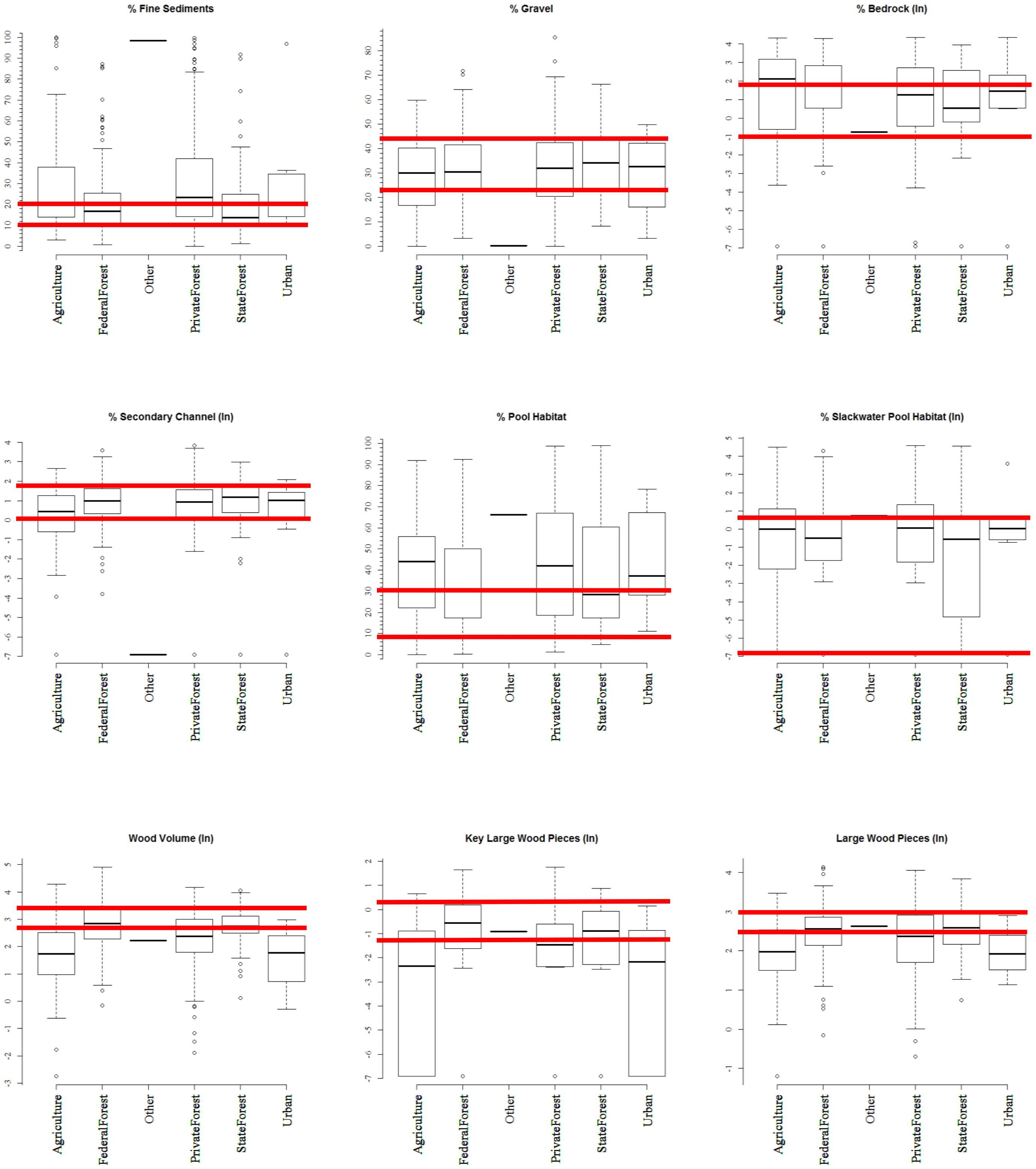

Figure 5. HLFM estimates of winter parr/km (ln) (y-axis) within (a) coastal coho populations, (b) land use types, (c) petrology type, and (d) population type (Independent and Dependent) (x-axis). The horizontal red lines indicate thresholds for high quality habitat (>1850 parr/km) and low quality habitat (<900 parr/km).