THE OREGON PLAN for Salmon and Watersheds

Stream Habitat Conditions in Western Oregon, 1999

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STREAM HABITAT CONDITIONS IN WESTERN OREGON, 1999

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INTRODUCTION

The physical habitat of a stream forms the template from which the biological community can develop. The structure and complexity of the stream habitat influences the species composition, distribution, and production of the fish community. Assessing the status of stream habitat conditions in coastal Oregon streams is important for monitoring the effects of landscape and aquatic management practices on the character of riparian stream habitat. Comprehensive habitat assessments are also important for watershed assessments, restoration planning, and for studying the relationship between stream habitat, fish abundance, and fish distribution.

The goals of the Oregon Plan for Salmon and Watersheds (OPSW) Habitat Monitoring Program are to 1) provide an annual update on the status of stream habitat in Western Oregon, and 2) track trends in habitat over time. This report on stream habitat conditions covers sampling that occurred between June and October of 1999. The report is grouped into six different areas:

- Current habitat status by Gene Conservation Area (GCA)
- The status of habitat in relation to landscape variables
- An assessment of the high quality habitat existing on the landscape
- A comparison of 1998 and 1999 stream conditions
- An analysis of habitat variable precision
- An assessment of fish distribution outside of known coho salmon distribution

METHODS

STUDY AREA AND SITE SELECTION

The target population of streams were contained within watersheds of western Oregon draining into the Pacific Ocean south of the Columbia River. The area encompassed two Evolutionary Significant Units (ESU's) for coho salmon: the Oregon Coastal ESU and the Southern Oregon/Northern California ESU. The Oregon Department of Fish and Wildlife (ODFW) has further divided the Oregon Coastal ESU into three GCAs for coho salmon based on studies of genetic variation and life history traits (Kostow 1995). For fishery management the North Coast GCA was further split into a North Coast and a Mid Coast GCA (Bodenmiller et al. 1997). In total, there are currently five distinct analysis areas (GCAs) for monitoring habitat in Oregon coastal streams (Figure 1).

The target populations of streams for the study were based upon a hydrography data layer developed by the USGS at the 1:100,000 scale. Streams upstream of large dams that blocked anadromous fish passage were removed from the selection frame. A random tessellation stratified (RTS) design (Stevens 1997) was used to select potential sample site locations within the population of stream segments. Stevens and Olsen (1999) described the RTS survey design as applied to the integrated monitoring of habitat, adult spawners, and juvenile salmonids for the ODFW. The advantage of the RTS selection protocol was the selection of sites spread randomly across the landscape, better representing habitat conditions within a GCA, and reducing overall sample variance. In all GCAs surveyed, samples were weighted to provide an equal number of sample sites (50).

Some sample sites were not surveyed. The primary reason for not surveying a site was denial of access from landowners. Additional target sites were dropped due to inaccessibility and time constraints. Non-target sites were dropped because they were small (<0.6 km^2 catchment area), tidally influenced, or a result of errors in the selection coverage (Table 1).

The overall rate of access denial was low (6%), but encompassed 19 percent of private non-industrial sites. It is erroneous to assume that sites not surveyed due to access denial were a random sample of all sites. Historically, private non-industrial lands have had the lowest habitat quality (Thom et al. 1999). Given the lower quality habitat that was observed on private non-industrial lands in the past, and the high percentage of sites not surveyed in 1999 on private non-industrial lands, the findings of the 1999 surveys provide a biased estimate of conditions for private non-industrial ownership as well as the coast as a whole.

SURVEY METHODS

Habitat survey

Channel habitat and riparian surveys were conducted as described by Moore et al. (1997) with some modifications. Modifications to the survey methods included: survey of stream lengths of only 500-1000 m and measurement of all habitat unit lengths and widths (as opposed to estimation). Ten percent of the sites were resampled with a separate two-person crew. Repeat surveys were a randomly selected sub-sample from each geographic area and survey crew. The repeat surveys were intended to measure within-season habitat variation and differences in estimates between survey crews.

Fish survey

Fish presence/absence surveys were conducted at habitat sites outside of known coho salmon distribution in four GCAs. Fish presence/absence surveys were not conducted in the Umpqua GCA due to the threatened status of the Umpqua cutthroat trout (*Oncorhynchus clarkii*). Surveys were conducted using electrofishing. A complete description of the methods used is contained in ODFW (1998). A coordinated but separate project within ODFW conducted coho salmon summer density estimates using snorkeling (Rodgers 2000).

ANALYSIS

Overall Habitat Conditions

Habitat conditions were described using a series of cumulative distributions of frequency (CDF). The variables described were indicators of habitat structure, sediment supply and quality, riparian forest connectivity and health, and in-stream habitat complexity. The specific attributes were:

Density of woody debris pieces (> 3 m length, >0.15 m diameter)
Density of woody debris volume (> 3 m length, >0.15 m diameter)
Density of key woody debris pieces (>10 m length, $\geq$0.6 m diameter)
Density of wood jams (groupings of more than 4 wood pieces)
Density of deep pools (pools >1 m in depth)
Percent pool area
Density of riparian conifers (>0.5 m DBH) within 30 m of the stream channel
Percent of channel shading (percent of 180 degrees)
Percent of substrate area with fine sediments (<2 mm) in riffle units
Percent of substrate area with gravel (2-64 mm) in riffle units

While these attributes do not describe all of the conditions necessary for high quality salmonid habitat, they do describe important attributes of habitat structure within and adjacent to the stream channel. The attributes are also indicative of streamside and upland processes. Water quality and quantity, as well as food production, are not addressed in the discussion of physical habitat, although they are important to ecological integrity. The median and first and third quartiles were used to describe the range and central tendencies of the frequency distributions of the key habitat attributes used in the analysis of current habitat conditions (Zar 1984). Frequency distributions were tested to determine if significant differences ($p<0.05$) exist between GCAs in each habitat attribute. A set of reference conditions is also presented from which to gauge differences between the areas analyzed. A complete description of the reference database is included in the 1998 report of historic habitat conditions (Thom et al. 1998).

Status of Habitat by Land Use

The status of habitat for different land uses was described with the combined 1998/1999 data set using cumulative distributions of frequency and discriminant function analysis. Discriminant function analysis was used to determine which habitat attributes served as the best predictor of land use response in the studied streams. The combined data set was post stratified into three land use types: Non-forested, which included urban, rural residential, and agricultural land uses; Young Forest, which included timber harvest, young timber, second growth timber, and large timber up to 50 cm dbh; and Mature Forest/ Non-use, which included mature and old growth timber types, wilderness areas, forest fire areas, and areas listed as no use. Sites with two of the three land use types at a site were not used in the discriminant function analysis.

Overall habitat quality measures

The interactions between habitat metrics were examined through a series of data queries relating to habitat quality. Potential anadromous salmonid reaches with lower than 5% stream gradient were examined for habitat quality. The number of sites that had high quality habitat, or the potential for high quality stream habitat, were summarized by channel type. The major channel type divisions were: wide valley floor (greater than 2.5 times the active channel width) and narrow valley floor (less than or equal to 2.5 times the active channel width). The wide valley floor channels were subdivided into: unconstrained reaches (flood prone width greater than 2.5 times the active channel width and terrace height less than flood prone height); potentially unconstrained reaches (terrace height less than 25% greater than flood prone height); and deeply incised reaches (terrace height more than 25% greater than flood prone height).

The criteria used to define high quality in-channel habitat were: pool area > 35% of channel area, the presence of slackwater pools or secondary channels, wood volume greater than 20 m^3 per 100 m of stream channel and at least 1 key piece of woody debris per 100 m of stream length. These criteria differ slightly from the criteria used in the 1998 analysis. The criteria were changed to better represent the ODFW habitat benchmark conditions for high quality habitat (Appendix A).

Trends in habitat quality 1998-1999

Analysis of habitat attribute trends between 1998 and 1999 compared the overall frequency distributions of habitat variables between the two years. Changes between years were not expected because there were no major habitat forming events e.g. floods, fires, or windstorms, that occurred between the two survey seasons.

Habitat resurvey

The precision of an individual metric was calculated using the mean variance of the resurveyed streams "Noise" and the overall variance encountered in the habitat surveys "Signal". Three measures of precision were calculated, the standard deviation of the repeat surveys (SD_{rep}), the coefficient of variation of the repeat surveys (CV_{rep}), and the Signal to Noise ratio (S:N). S:N ratios of < 2 can lead to distorted estimates of distributions and limit regression and correlation analysis. S:N ratios between 2-10 are useful for analysis, but caution must be exercised due to the larger variances associated with each variable. S:N ratios > 10 are very good and indicate that variables have insignificant error caused by field measurements and short term habitat fluctuations (Kauffman et al. 1999).

RESULTS/DISCUSSION

HABITAT CONDITIONS FOR SUMMER 1999

The following descriptions of habitat variables are intended to highlight selected features of the aquatic habitat in western Oregon. Figure 2 - 12 and Table 3 - 13 provide an exhaustive summary. Mean channel gradients, mean active channel widths, and mean catchment areas of stream segments surveyed in each geographic area are listed in Table 2. The South Coast GCA had the highest mean channel gradient at 7.8 percent. The North Coast GCA had the greatest channel size at 9.4 m. Stream gradients were very similar between the survey years, with the exception of the Mid-south Coast GCA which had a higher average stream gradient in 1999. Bank full channel widths were different between the two survey years, with the 1999 sample showing wider bank full channel widths than the 1998 sample. The differences in channel size and gradient between the 1998 and 1999 sample years points to a need for a larger sample set from which to measure habitat attributes.

Pool quality

Percent of habitat area in pools was significantly different between the five GCAs analyzed. The three separate groupings from lowest to highest pool area were the South Coast GCA, the North Coast and Umpqua GCAs, and the Mid Coast and Mid-south Coast GCAs (Figure 2). There were no significant differences detected in the distributions of **deep pool density** between the five GCAs (Figure 3). Similar to the 1998 sample, at least 40% of the sites in each GCA did not contain pools greater than 1 m in depth (Figure 3).

Wood debris

The distributions of **wood piece densities** for all but the North Coast GCA were not significantly different than the distribution observed in the reference conditions (Figure 4). The North Coast GCA showed higher wood piece density in 1999. This shift in the distribution of wood for the North Coast is also evident in the distribution of **wood volume density** and **key piece density** (Figure 5,Figure 6). The North Coast GCA is the only GCA that was significantly different from the other GCAs in **wood volume density** and **key piece density**. Resurvey information for the North Coast did show differences between the original survey and second survey conducted at some of the sites. Based upon the resurvey information, this difference may be largely due to crew variability in the North Coast Area.

Similar to the 1998 surveys, **key piece density** was very low for the 4 southerly GCAs analyzed (Figure 6). More than 50% of the sites surveyed had less than 0.5 key pieces per 100 m of stream channel (Table 7). The median value for the reference reaches is 1.8 key pieces per 100 m of stream channel (Table 7).

The density of wood jams in the stream channel showed a slightly different pattern than the other wood indicators analyzed (Figure 7). Wood jams are very important to stream systems because they form a complex structure that traps sediment, slows water and scours pools. Two distinct groups of **wood jam density** were shown. These two groups were a lower **wood jam density** group, which included the Umpqua and South Coast Areas, and a higher density group, which included the North, Middle, and Mid-south GCAs. The median value for the lower group was approximately 2 jams per kilometer of stream length, while the median density for the higher group was over 6 jams per kilometer of stream length (Table 8).

Riparian Health

The distribution of channel shading appeared to be slightly higher for all of the GCAs than the reference reaches (Figure 8). For all GCAs, over 50% of the stream length sampled had more than 80 percent stream shading (Table 9).

Two distinct groups were observed in the pattern of riparian conifer density in the 5 GCAs (Figure 9). The Umpqua and South Coast GCAs had a high density of riparian conifers with over 50% of the stream length sampled having more than 900 conifers per 305 m of stream length (Figure 9, Table 10). The North Coast, Mid-coast, and Mid-south Coast GCAs had a median conifer density of less than 400 conifers per 305 m of stream length (Table 10).

The density of large riparian conifers (>0.5 m dbh) showed a different pattern than that of total conifer density. Only the Umpqua GCA had a significantly higher large conifer density than the other GCAs. The Umpqua GCA actually had a slightly higher, yet not significant, conifer density than the reference data set (Figure 10). The other four GCAs showed a low large conifer density with 50% of the stream length surveyed having less than 50 large conifers per 305 m of stream length (Table 11).

Substrate

The areal extent of silt and sand on the surface of low gradient (0.5-2.0%) riffles was selected to typify potential accumulation of fine sediments in a stream. Only the North Coast GCA had significantly higher ($p<0.05$) fine sediment levels than those observed in the reference reaches (Figure 11). All other GCAs showed higher, yet non-significant, fine sediment levels than the reference conditions (Table 12). Gravel substrate differed significantly between areas. The North Coast and Umpqua GCAs had significantly lower gravel levels than both the reference reaches or the other 3 GCAs. Gravel quantities were highest in the Mid-coast GCA.

EFFECTS OF LAND USE / LAND COVER ON HABITAT ATTRIBUTES

The combined data set for 1998 and 1999 included 432 sites. One hundred fifty four of these sites were determined to have mixed land use and were excluded from the analysis. Of the 278 sites remaining, 55 sites were excluded because they did not contain riffle habitat. A majority of the sites excluded due to lack of riffle habitat were in the Mature Forest/Non-use category. These sites were predominantly high gradient, small stream sites.

The forested land use sites had higher gradient channels than the Non-forested sites (Table 16). The larger upstream drainage areas of the Non-forested sites pointed to their position low in the watersheds, while the medium average upstream drainage area for the Mature Forest/Non-use sites was likely influenced by the large channels surveyed in the South Coast GCA.

Many of the differences observed in the habitat characteristics within the three land use categories (Non-forested, Young Forest and Mature Forest/Non-use) were attributed to position of the point within the watershed; these positions were highly correlated to stream size and gradient. To effectively quantify habitat differences between land use categories the relationships between channel size, gradient, and land use need to be investigated. The current sample size for 1998 and 1999 was not sufficient to address this issue.

A discriminant function analysis was carried out using all of the habitat indicator variables to determine which variables were the best predictors of land use. Two significant ($p<.0001$) discriminant functions were found that help predict land use. These two functions involved five of the habitat indicators. The habitat indicators that were useful predictors of land use were: stream shade, wood piece density, fine sediments in riffles, riffle gravel, and upstream drainage area. The two discriminant functions correctly classified 64% of the sites analyzed into the correct land use type. The Young Forest land use type was most often misclassified as the Mature Forest type and vice versa.

Each land use category was typified by differing levels of the five indicators. The Non-forested land use type was characterized by low stream shading, low wood piece density, high fines in riffles, high gravel in riffles and large watershed area. The Young Forest type was characterized by high stream shading, high wood piece density, high fines in riffles, moderate gravel in riffles, and small watershed area. The Mature Forest/Non-use type was characterized by moderate stream shade, moderate wood piece density, low riffle fines, low riffle gravel, and moderate watershed area.

The presence of beaver activity and dams as well as mass failures, debris jams and habitat structures all showed patterns related to land use. The Non-forested land uses had a higher incidence of beaver activity, a higher number of sites with beaver dams and a higher percentage of sites with culvert crossings than the Young and Mature Forest/Non-use types (Table 17). There appeared to be a slightly higher proportion of sites with mass failures in the Mature Forest/Non-use type; one third of the sites sampled had at least one mass failure.

Habitat enhancement structures were more prevalent in the Young Forest type and were present at 9% of those sites. Debris jams were more prevalent in the forested land use types; 47% of the sites had at least one debris jam present in the survey.

A confounding factor with the use of land use/land cover was that land use and ownership are highly correlated. Most of the Mature Forest/Non-use areas are located on federal lands in the upper portions of drainages, or in the large channels of the South Coast area. This locational bias could have easily caused the shift towards higher deep pool density, lower fine sediments, fewer riparian conifers, and a higher incidence of mass failures in the Mature Forest/Non-use category.

OVERALL HABITAT QUALITY

Of the 219 reaches surveyed and analyzed in 1999, 133 reaches had less than 5% stream gradient. Seventeen reaches were unconstrained, 23 were potentially unconstrained, 59 were terrace constrained, and 33 were hillslope constrained (Table 14). Unconstrained reaches usually retain the highest quality habitat in the form of complex pools, adequate spawning gravel, and high wood levels. Heavily incised (terrace constrained) channels are usually the lowest quality habitat with less complexity, lower wood levels, and limited spawning substrate.

Eight of the 133 reaches analyzed were high quality habitat in the 1999 sample. Two of the 17 unconstrained reaches had high habitat quality (Table 14). The potentially unconstrained reaches included 4 high quality reaches out of 23. The deeply incised channel type included one high quality reach. One of the 33 hillslope-constrained reaches was categorized as high quality. These hillslope-constrained reaches are acting as source areas to the lower gradient wide-valley floor segments for woody debris and sediment. In many cases, these reaches were fulfilling that function with high wood levels and high gravel quantities, and expectedly lack pool habitat. Pool area and wood volume were the two main factors limiting habitat quality in the analysis of high quality habitat. These two factors accounted for 83% of the sites that were deemed low quality.

In comparison, only four of the 137 reaches analyzed in the 1998 sample met the same criteria for high quality habitat. The lack of high quality reaches in both years (an average of 4 percent of the habitat) pointed to the rarity of this type of habitat on the landscape. It did not necessarily point to a significant increase in the quality of habitats over the one-year period between 1998 and 1999.

Of the eight high quality habitat reaches in 1999, seven were located in the Young Forest type and one site was located in the Mature Forest/Non-use type. There were no high quality, low gradient reaches identified on Non-forested lands. A majority (15 out of 19) of the sites on the Non-forested land use occurred in deeply incised, terrace constrained channels. These reaches are typically the least diverse, lowest quality habitat.

Currently, in coastal Oregon streams, a majority of the moderate and high quality anadromous habitat occurs in the Young Forest land use. A majority of the Mature Forest/Non-use lands occur in the upper portions of drainages, and in the high gradient large streams of the south coast. These streams did not typically contain the highest quality salmon habitat. Historically, the highest quality habitats were located in the lower gradient, valley bottom streams, where pool habitat, woody debris, and gravel occurred simultaneously to form complex habitat. Sample size limitations and the lack of high quality habitat limited the conclusions drawn between land management interactions and stream habitat.

In western Oregon a majority of streams were categorized as moderate quality habitat. These moderate quality areas may, and do, support salmonids. Without high quality refuge habitat, moderate quality areas cannot support a large abundance of salmonids through periods of frequent disturbance.

TRENDS IN HABITAT 1998 - 1999

Changes in the frequency distributions of habitat variables were analyzed between 1998 and 1999 for the coastal study area as a whole. It was not expected that habitat would change significantly between 1998 and 1999 because there were no large flow events during the winter of 1998-1999. There were no significant changes in the frequency distributions of all of the variables analyzed between 1998-1999. The only variable that appeared to be different between the two years was the density of large riparian conifers. It appeared that more conifers were present in the 1999 sample than in 1998. This may indicate the need for an increased sample size when it comes to documenting rare items such as large riparian conifers. As the sampling program continues, it may be beneficial to aggregate data for multiple years for individual GCAs to better describe the conditions within each GCA.

RESURVEY ANALYSIS

The precision of the habitat variables used for current conditions assessment were analyzed for the 1998, 1999 and 1998-1999 combined resurvey data sets. The combined data set included 51 repeat visits to the 522 total sample sites over the two year period (Table 15). The signal to noise ratios for pool attributes, wood attributes, and riparian conifers were highly variable between years, while the precision of substrate measurements appeared to be consistent between both data sets. It appeared that the precision of wood attributes, specifically wood pieces and volume were affected by two sites with very high wood volumes. The difficulty of counting the number of pieces and volume of wood, especially when the levels in the stream channel are high, is well known.

For the combined 1998/1999 data set, the Signal to Noise ratios for most variables fell within the range of 2-10, with the exception of key wood pieces and large riparian conifers. These variables are both rare items on the landscape and were easily biased when only a few were not counted in a survey. The most useful indicators from the combined resurvey data set were percent pool area, deep pool density, percent total sand/organics, percent bedrock, percent riffle sand/organics, and streamside shade. Other indicators that had high signal to noise ratios, and which may be useful indicators of aquatic habitat health were the percent area of slow water pool habitat and percent area in secondary channel habitat. Channel gradient, bank full channel width, and flood prone width had signal to noise ratios greater than 10 which made them useful independent variables in comparisons of stream channel habitat.

FISH SURVEYS

Seventy six sites were sampled for fish presence/absence by electrofishing in four coastal areas. The Umpqua GCA was not sampled in 1999. Juvenile coho salmon were present at five of the electrofished sites. All five sites were located outside of the known range of coho salmon, for a total of 4.2 km of previously undocumented distribution. In contrast, Rodgers (2000) found that 24-52 percent of sites sampled in a GCA within the range of coho salmon did not contain coho salmon in 1998 or 1999. Cutthroat trout were documented at 41 sites, and steelhead/rainbow trout were documented at six sites. One site in the South-Coast area had exotic species present (sunfish, *Lepomis sp*.). The use of the salmonid presence/absence surveys was valuable in two ways. The first was that the surveys helped to better define the range of coho salmon in the affected watersheds. This information can then be used to update the sample frame in the future. Secondly, the distribution helped to classify sites based on fish use of the surveyed reaches. Based on the fish presence/absence surveys 81% of the sites sampled for habitat contained fish. A majority of the non-fish bearing sites occurred in the South Coast GCA in dry streams.

CONCLUSIONS

The random selection and survey of habitat in western Oregon helped to better define the conditions that salmonids face when spawning and rearing in the freshwater environment. The surveys have allowed the Oregon Department of Fish and Wildlife to assess habitat conditions, determine the impact of land use on these conditions, describe the patterns of fish use on the landscape, and to begin to monitor trends in habitat over time.

Habitat quality and quantity in western Oregon in 1999 appeared very similar to the 1998 data set. A majority of sampled areas had low wood levels, moderate pools, moderate gravel and fine sediment levels in riffles, and a low number of large riparian conifers. High quality habitat for salmonids occurred in the western Oregon landscape in 1999, but it was very rare. These high quality areas may be the key to the conservation of salmonids

When land use was factored in, it appeared that the forested streams had higher habitat quality than the non-forested streams. This was largely due to the lack of large riparian conifers, and the subsequent lack of input of wood into the non-forested streams. With the exception of fine sediments, the Young Forest type appeared to be providing better salmonid habitat than the Mature Forest/Non-use streams. The Mature Forest/Non-use streams had high levels of wood and riparian conifers and low levels of fine sediments, but their position high in the watershed precluded the formation of pool habitat. There are very few Mature Forested streams within the range of coho salmon in coastal Oregon.

The poorest habitat on the landscape occurred in the Non-forested, Urban and Agricultural land uses. These streams not only lacked riparian conifers, but they also had high fine sediments and low streamside shading. Historically these low gradient areas were the most productive for salmonids.

Fish were found in many of the sites sampled in western Oregon. The biggest reason for not seeing fish at a site was that the stream was dry. Coho salmon were found outside of their known range, and it will be important to update the distribution maps for this species, both for protection as well as improved sampling in future years.

The survey data gathered in 1998 and 1999 has been very useful in defining current habitat conditions. In the future, sampling should begin to focus on the detection of trends in habitat quality. The ability to detect trends will be of paramount importance to document the decline or improvement of habitat conditions with increased watershed restoration activities.

The repeatability of the surveys was evident in both the resurvey effort as well as the comparisons between survey years. Sample size may have limited the analysis of some of the more infrequent items found on the landscape such as large riparian conifers and key wood pieces. Future years samples may have to be combined to help understand the patterns that exist.

The 2000 and 2001 sampling years should provide a more detailed description of habitat in western Oregon. Analysis should focus on how habitat is changing from the baseline conditions observed in the first two years of the study. The larger data set should also allow researchers to better define the interaction of fish and habitat at sites that are shared between different monitoring projects.

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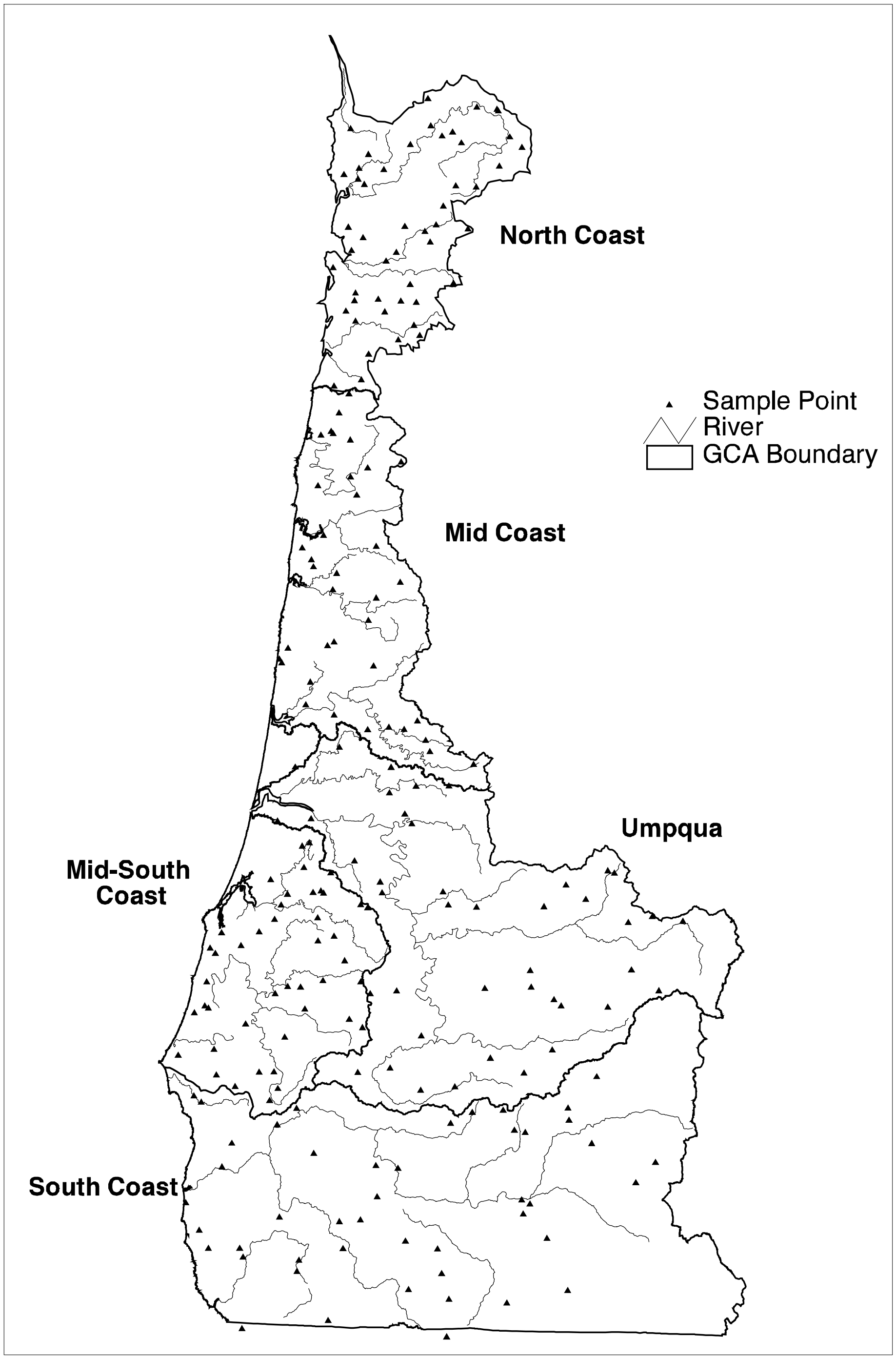

Figure 1: Sites sampled in the summer of 1999 with associated Gene Conservation Areas (GCAs).

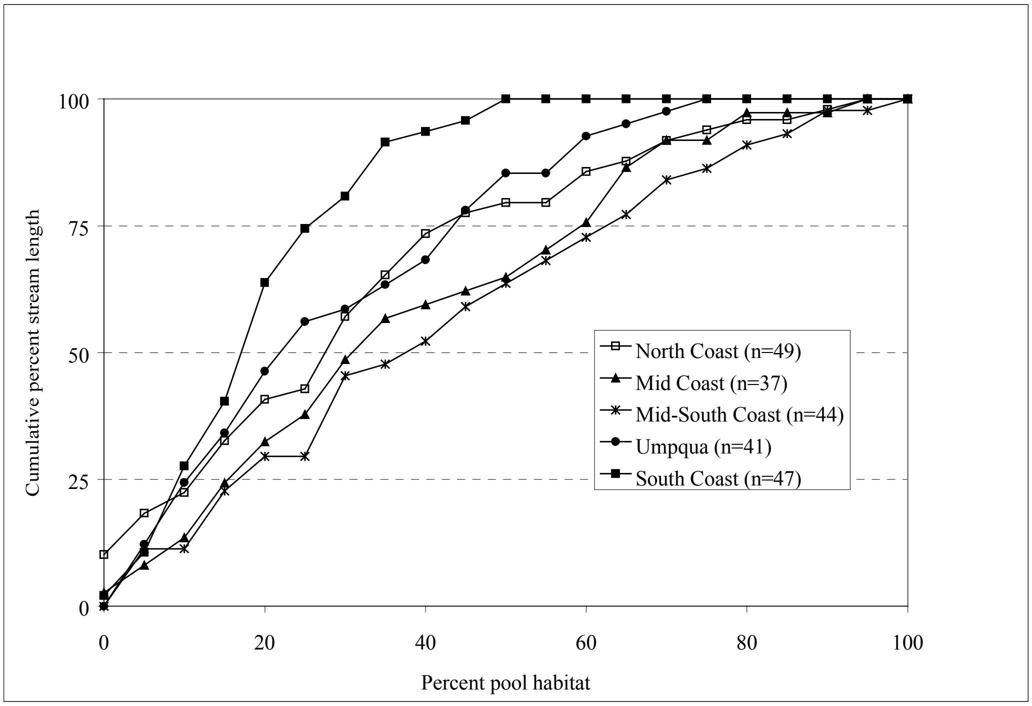

Figure 2: Cumulative distribution of frequency for the percent pool area for five geographic areas in western Oregon.

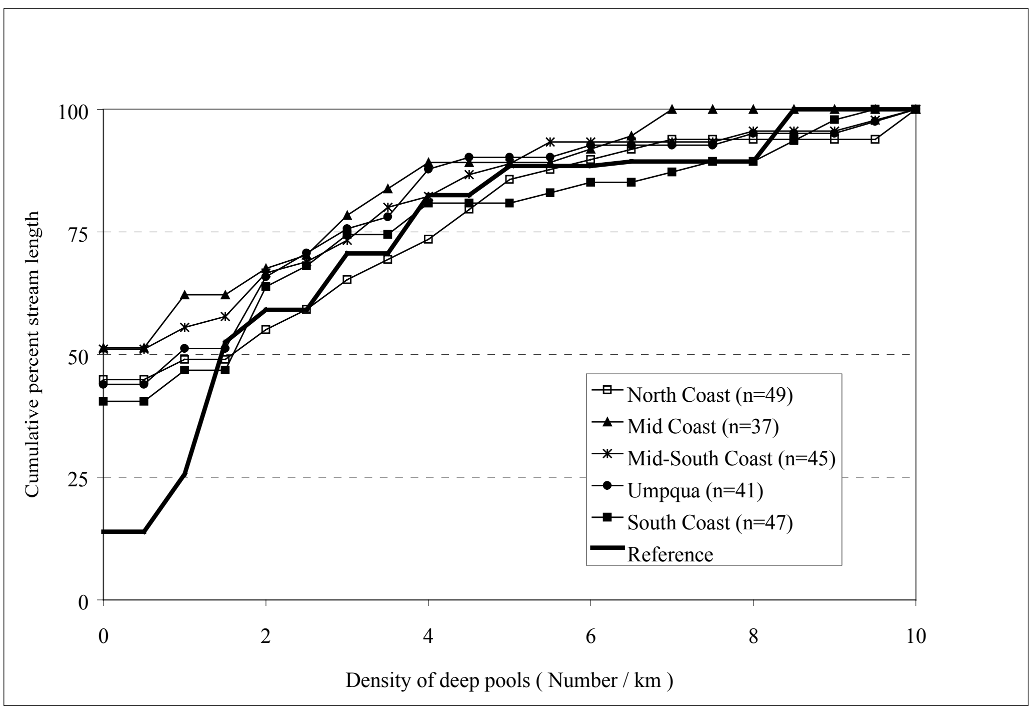

Figure 3: Cumulative distribution of frequency for the density of deep pools for five geographic areas in western Oregon.

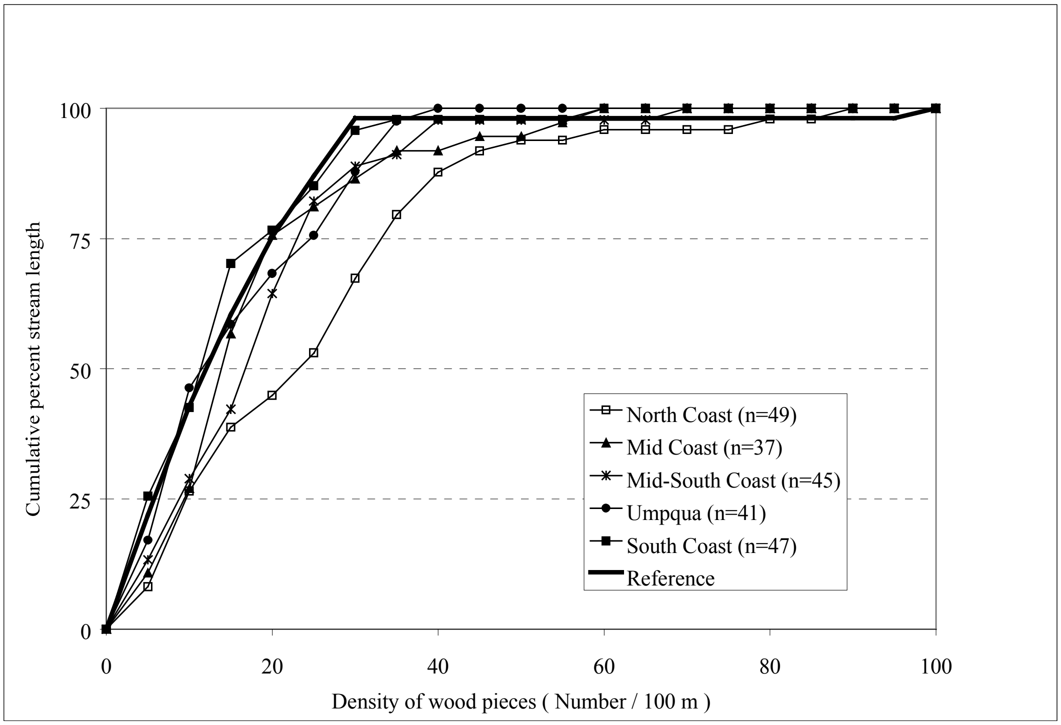

Figure 4: Cumulative distribution of frequency for the density of wood pieces for five geographic areas in western Oregon.

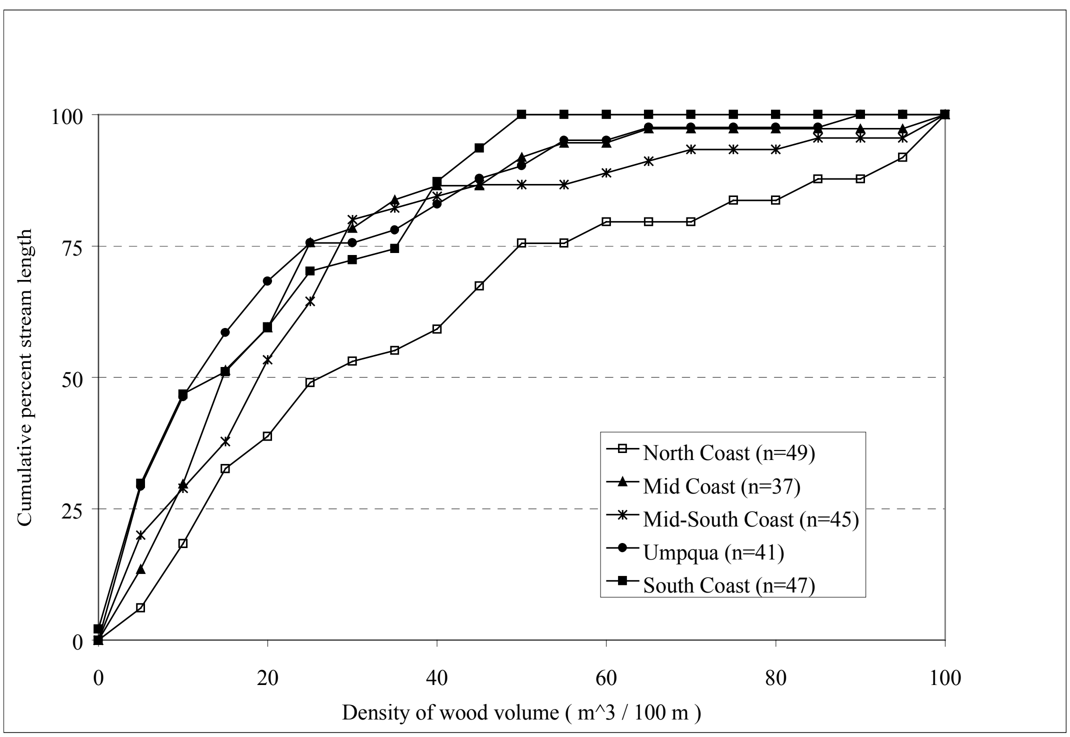

Figure 5: Cumulative distribution of frequency for wood volume density for five geographic areas in western Oregon.

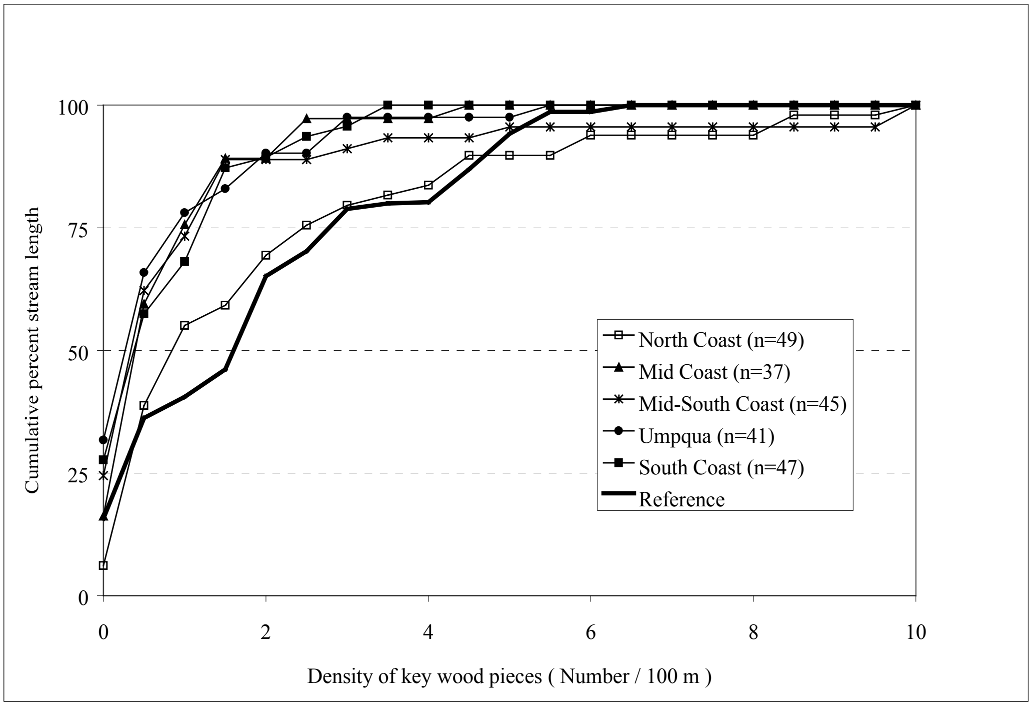

Figure 6: Cumulative distribution of frequency for the density of key wood pieces for five geographic areas in western Oregon.

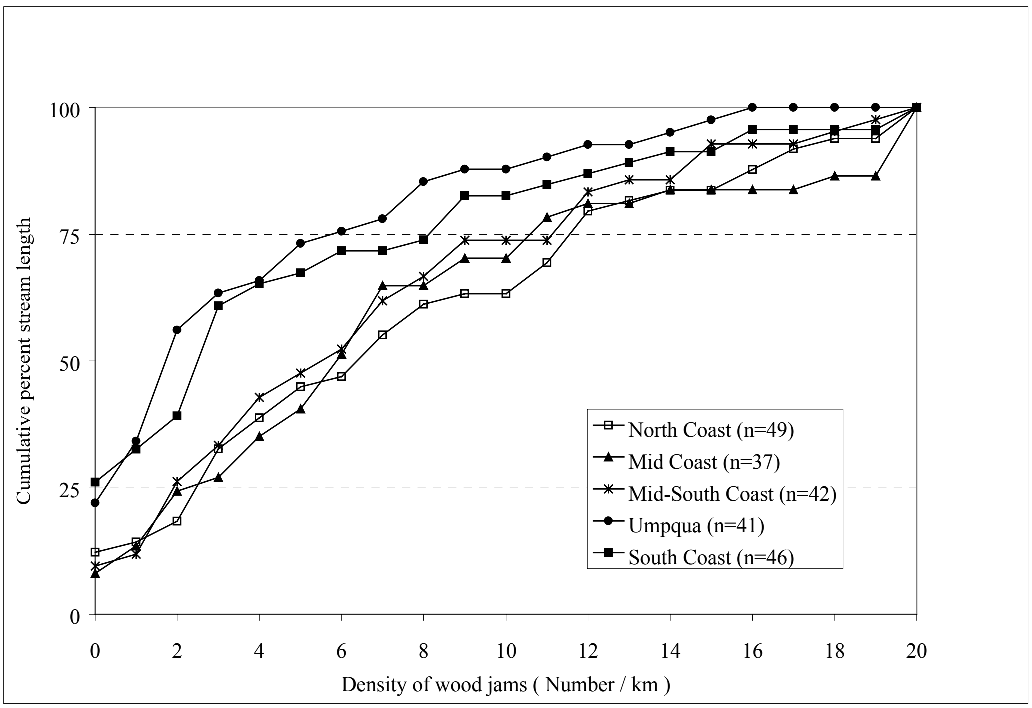

Figure 7: Cumulative distribution of frequency for the density of wood jams for five geographic areas in western Oregon.

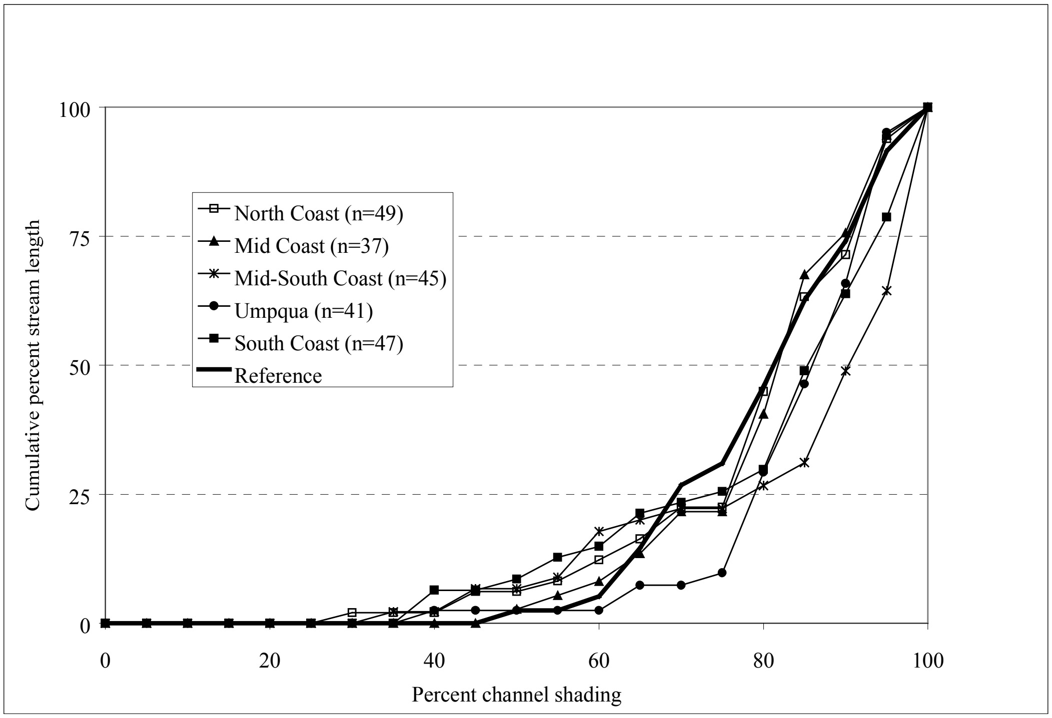

Figure 8: Cumulative distribution of frequency for the percent channel shading for five geographic areas in western Oregon.

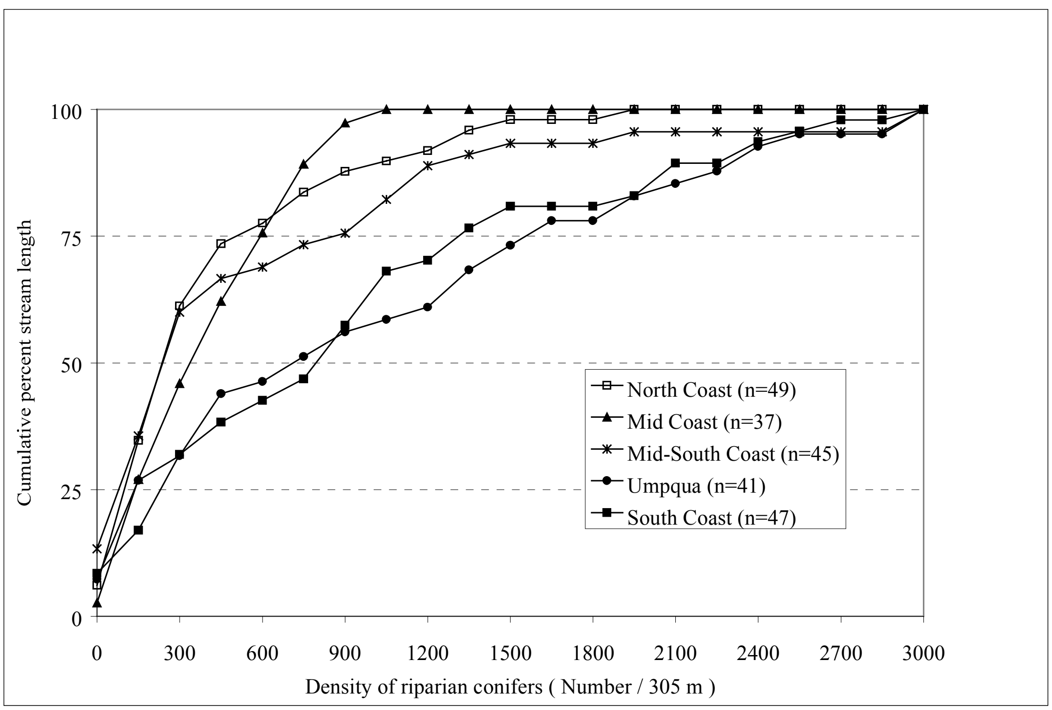

Figure 9: Cumulative distribution of frequency for the density of riparian conifers for five geographic areas in western Oregon.

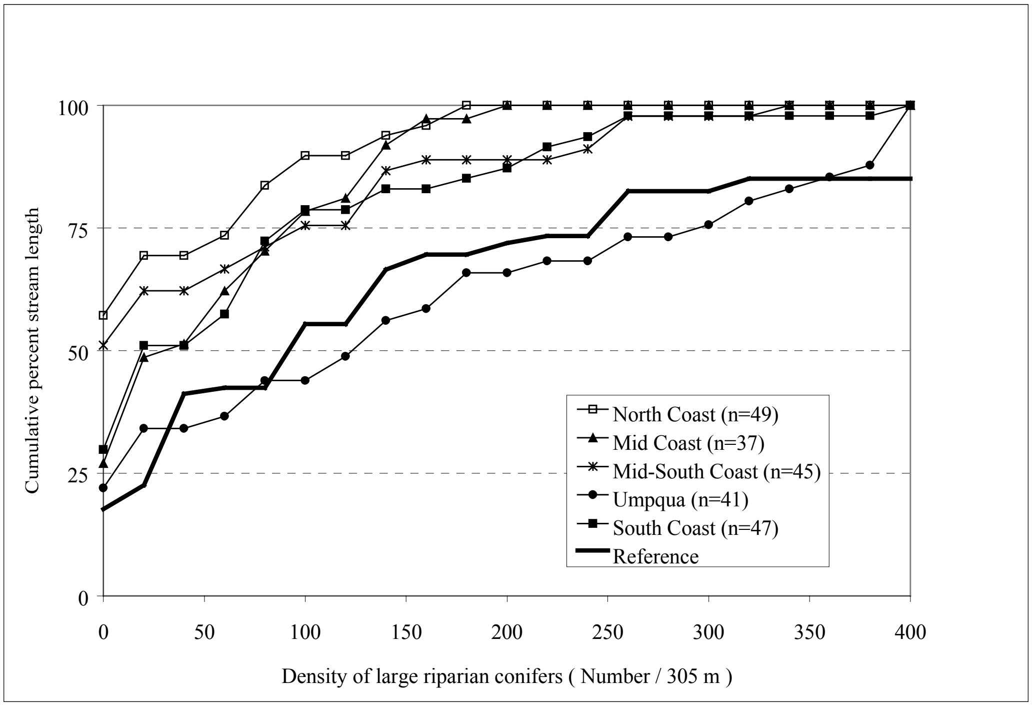

Figure 10: Cumulative distribution of frequency for the density of large riparian conifers for five geographic areas in western Oregon.

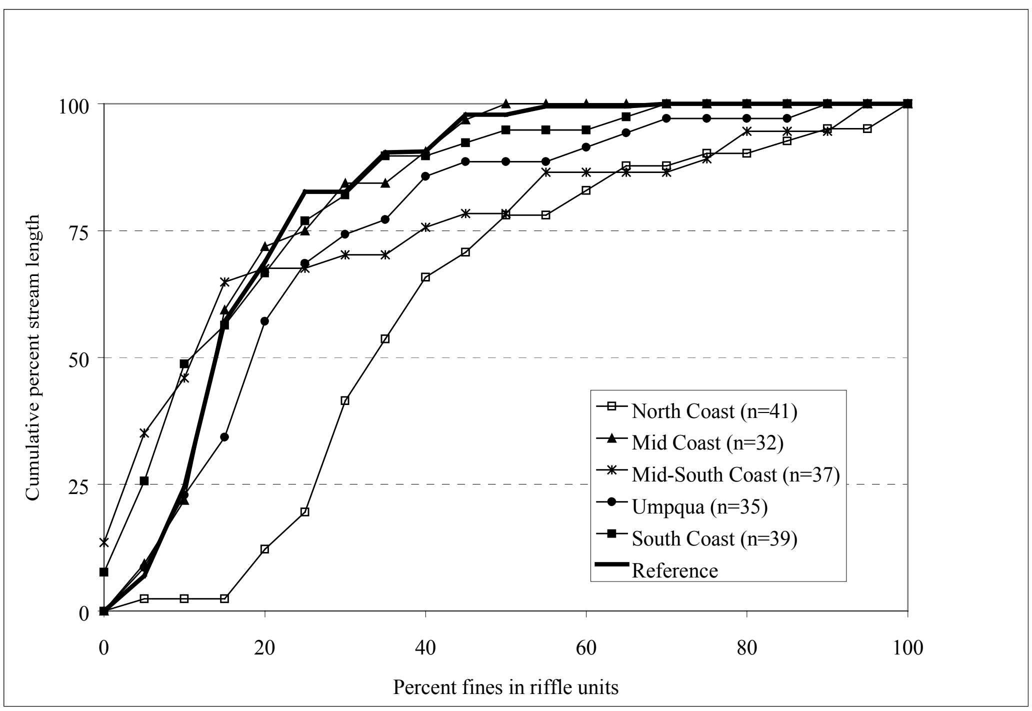

Figure 11: Cumulative distribution of frequency for the percent fines in riffle units for five geographic areas in western Oregon.

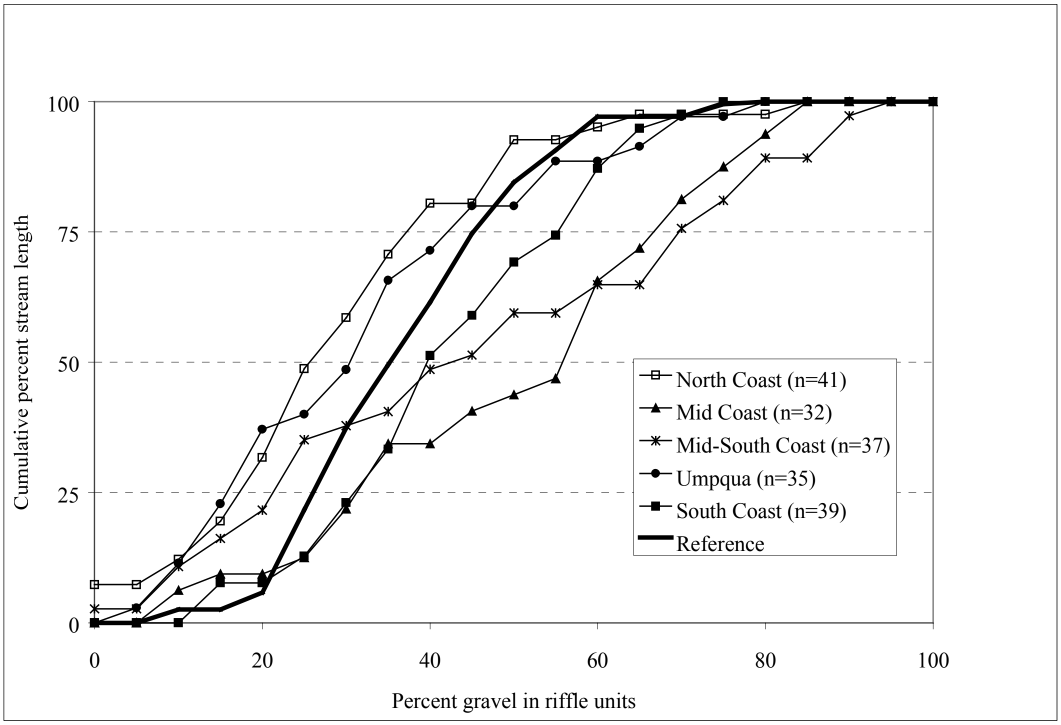

Figure 12: Cumulative distribution of frequency for the percent gravel in riffle units for five geographic areas in western Oregon.

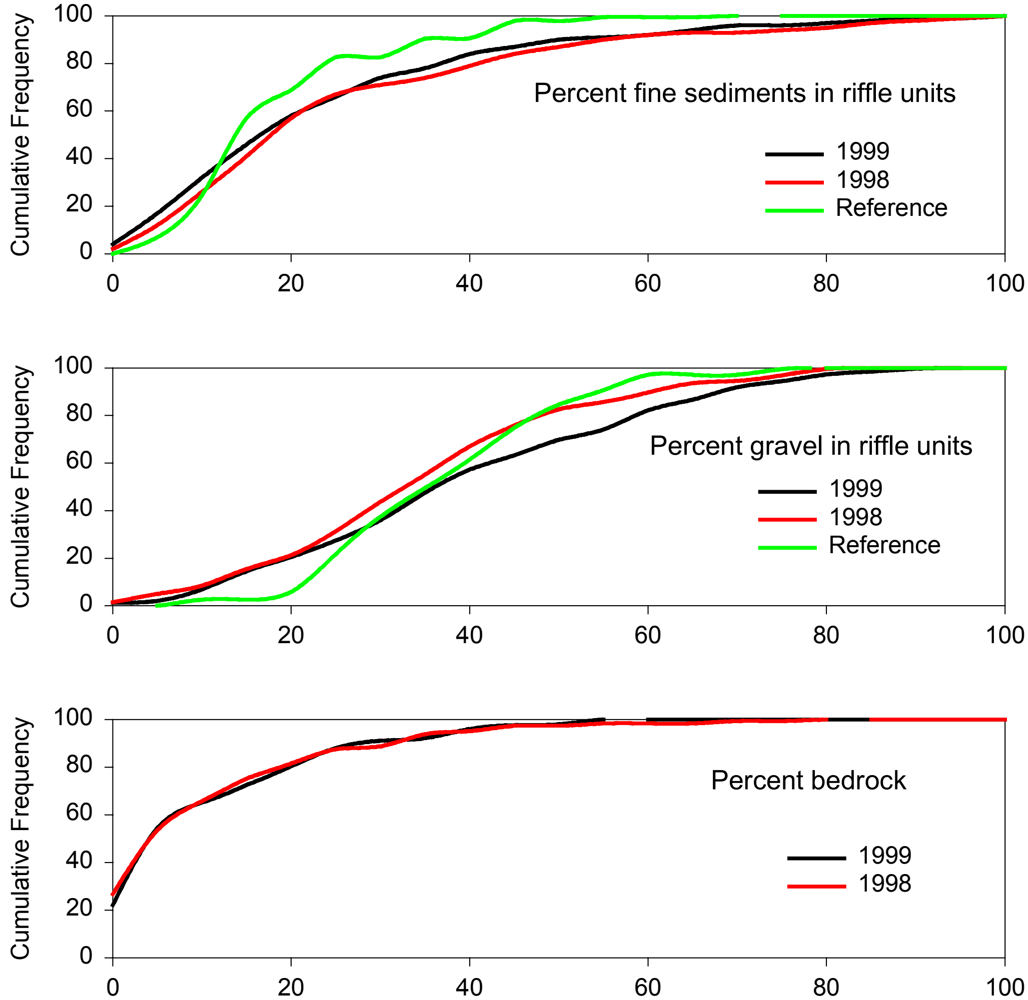

Figure 13: Cumulative distribution of frequency of substrate attributes for all sites surveyed in 1998 and 1999 and the reference data set.

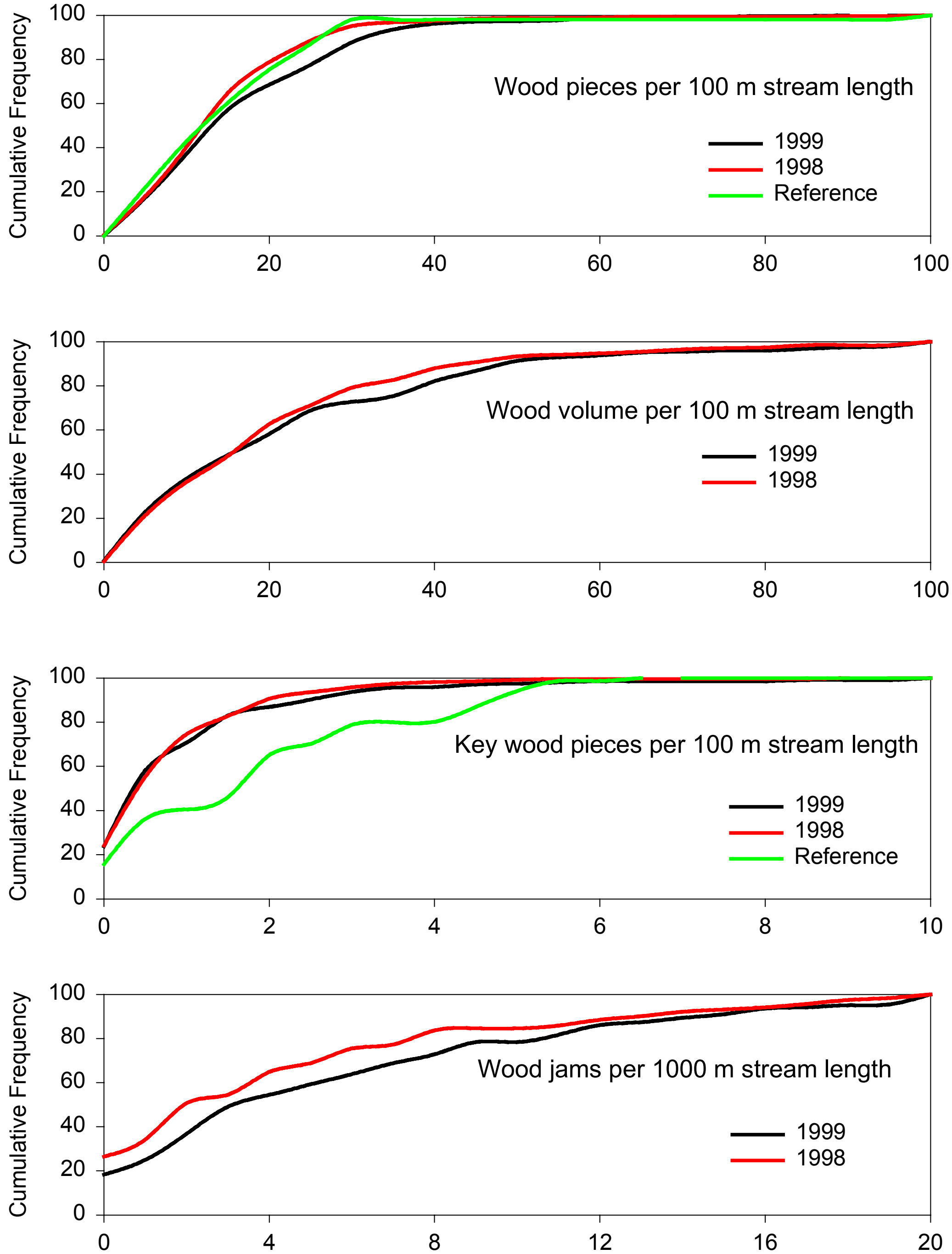

Figure 14: Cumulative distribution of frequency wood attributes for all sites surveyed in 1998 and 1999 and the reference data set.

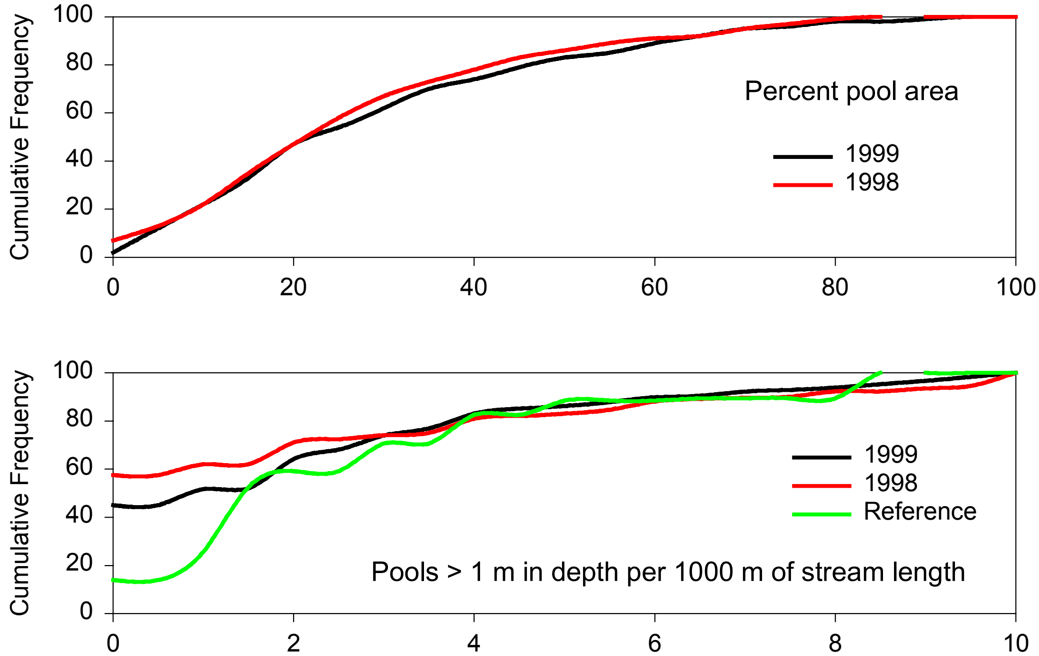

Figure 15: Cumulative distribution of frequency for pool attributes for all sites surveyed in 1998 and 1999 and the reference data set.

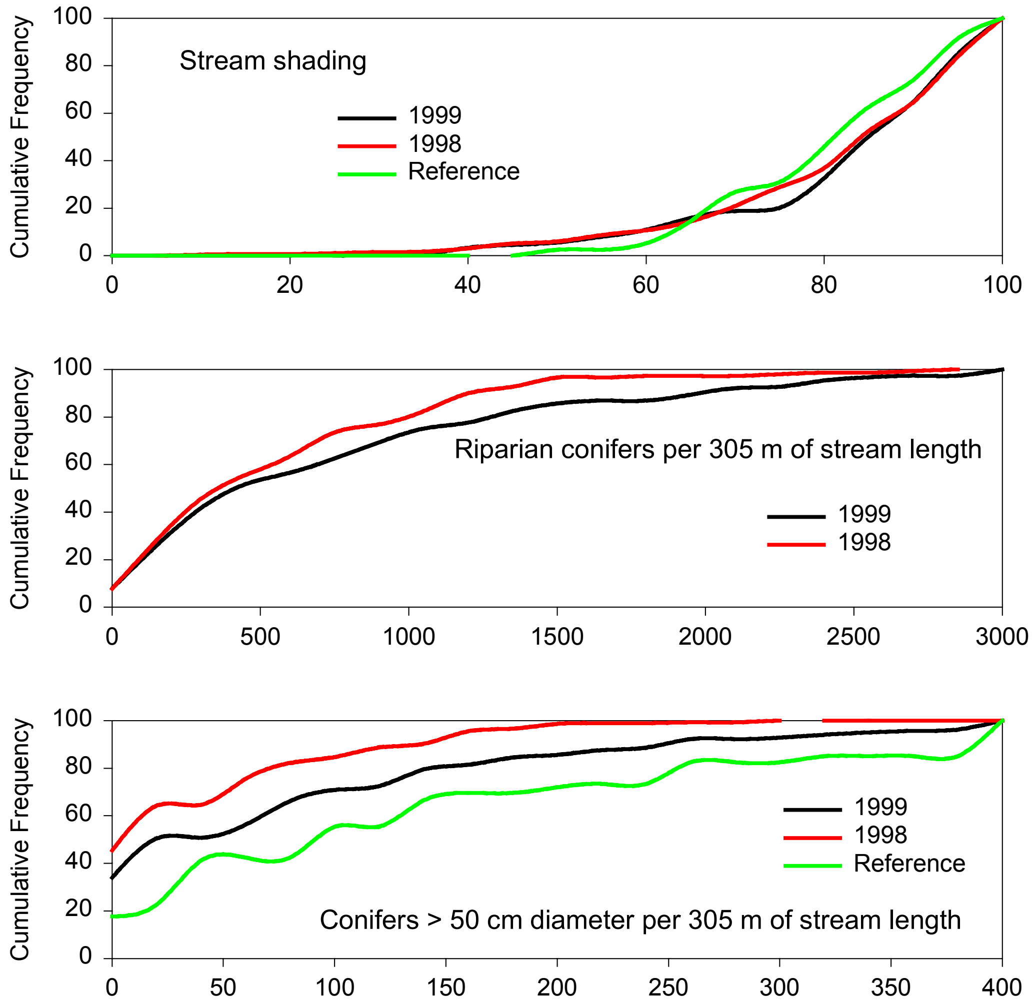

Figure 16: Cumulative distribution of frequency for riparian attributes for all sites surveyed in 1998 and 1999 and the reference data set.

Table 1. Number of sites with habitat and fish surveys were completed during the summer of 1999 in western Oregon.

Analysis Area	Target					Non-Target	Total selected
	Completed		Not Completed		Total		
	Habitat	Salmonid Presence /Absence	Denied Access (%)	Lack of Time/ Other			
North Coast	49	15	11(2)	2	52	4	56
Mid-coast	37	13	8(18)	0	45	7	52
Mid-south Coast	45	23	4(8)	3	52	6	58
Umpqua	41	0	1(2)	3	45	3	48
South Coast	47	25	2(4)	5	54	5	59
Total	219	76	16(6)	13	248	25	273

Table 2. Mean gradient, mean active channel width, and mean catchment area for sites surveyed in western Oregon during the summer of 1999.

Analysis Area	Mean gradient (%)+/-SD	Mean active channel width (m)+/-SD	Mean catchment area (km^2)+/-SD
North Coast	4.3+/-4.5	9.4+/-7.6	18.2+/-34.8
Mid-coast	4.4+/-6.3	8.1+/-7.4	14.1+/-29.4
Mid-south Coast	6.1+/-7.1	9.2+/-15.0	11.4+/-26.9
Umpqua	5.2+/-4.9	6.7+/-4.5	20.0+/-32.6
South Coast	7.8+/-6.8	8.7+/-6.9	27.8+/-48.3

Table 3. Cumulative frequency distribution quartiles for the percent pool habitat.

			Quartile		
Analysis Area	Mean	S.D.	25th	50th	75th
North Coast	30	(25)	10	27	41
Mid-coast	37	(25)	15	30	60
Mid-south Coast	51	(76)	15	37	62
Umpqua	27	(20)	10	22	43
South Coast	19	(12)	9	17	25
Reference	---	---	---	---	---

Table 4. Cumulative frequency distribution quartiles for the number of deep pools. Habitat quality increases with increased number of deep pools.

			Quartile		
Analysis Area	Mean	S.D.	25th	50th	75th
North Coast	2.4	(2.9)	0	1.5	4.0
Mid-coast	1.6	(2.1)	0	0	2.7
Mid-south Coast	1.9	(2.6)	0	0	3.0
Umpqua	2.0	(2.6)	0	1.0	3.0
South Coast	2.4	(2.9)	0	1.5	3.5
Reference	---	---	1.0	1.8	3.8

Table 5. Cumulative frequency distribution quartiles for the number of pieces of wood. Habitat quality increases with increased number of wood pieces.

			Quartile		
Analysis Area	Mean	S.D.	25th	50th	75th
North Coast	25	(18)	10	23	33
Mid-coast	17	(13)	9	14	20
Mid-south Coast	18	(12)	9	16	23
Umpqua	15	(11)	6	11	25
South Coast	13	(10)	5	11	20
Reference	---	---	6	12	20

Table 6. Cumulative frequency distribution quartiles for the volume of wood. Habitat quality increases with increased wood volume.

			Quartile		
Analysis Area	Mean	S.D.	25th	50th	75th
North Coast	41	41	12	25	50
Mid-coast	21	20	9	15	25
Mid-south Coast	30	45	8	19	28
Umpqua	19	21	4	11	25
South Coast	18	16	4	15	35
Reference	---	---	14	33	46

Table 7. Cumulative frequency distribution quartiles for the number of key pieces of wood. Habitat quality increases with increased number of key wood pieces.

			Quartile		
Analysis Area	Mean	S.D.	25th	50th	75th
North Coast	2.0	(2.7)	<0.5	0.8	2.5
Mid-coast	0.7	(0.9)	<0.5	<0.5	1.0
Mid-south Coast	1.1	(2.5)	<0.5	<0.5	1.0
Umpqua	0.7	(1.1)	<0.5	<0.5	0.9
South Coast	0.7	(0.9)	<0.5	<0.5	1.2
Reference	---	---	0.5	1.8	2.7

Table 8. Cumulative frequency distribution quartiles for the number of wood jams. Habitat quality increases with increased number of wood jams.

			Quartile		
Analysis Area	Mean	S.D.	25th	50th	75th
North Coast	7.5	6.2	2.5	6.5	11.5
Mid-coast	8.9	8.6	2.0	6.0	10.5
Mid-south Coast	8.4	7.4	2.0	6.0	11.0
Umpqua	4.9	4.7	<1.0	1.8	6.0
South Coast	4.9	6.4	<1.0	2.5	8.0
Reference	---	---	---	---	---

Table 9. Cumulative frequency distribution quartiles for stream shade.

Analysis Area	Mean	S.D.	Quartile 25th	50th	75th
North Coast	79	(15)	76	82	90
Mid-coast	81	(12)	76	82	90
Mid-south Coast	84	(18)	78	90	97
Umpqua	84	(11)	76	85	92
South Coast	81	(18)	75	85	94
Reference	---	---	70	81	90

Table 10. Cumulative frequency distribution quartiles for the number of total riparian conifers per 305 m of stream length

Analysis Area	Mean	S.D.	Quartile 25th	50th	75th
North Coast	389	(427)	<150	225	450
Mid-coast	370	(257)	<150	300	600
Mid-south Coast	557	(820)	<150	225	900
Umpqua	995	(968)	<150	750	1500
South Coast	903	(813)	225	750	1350
Reference	---	---	---	---	---

Table 11. Cumulative frequency distribution quartiles for the number of riparian conifers > 50 cm per 305 m of stream length. Habitat quality increases with increased number of large riparian conifers.

Analysis Area	Mean	S.D.	Quartile 25th	50th	75th
North Coast	30	(46)	0	40	60
Mid-coast	50	(51)	0	<20	90
Mid-south Coast	55	(85)	0	<20	90
Umpqua	155	(156)	<20	120	300
South Coast	70	(106)	0	40	90
Reference	---	---	25	90	240

Table 12. Cumulative frequency distribution quartiles for the percent areal extent of fine sediments in riffle units. Habitat quality decreases with increased fine sediment levels.

Analysis Area	Mean	S.D.	Quartile 25th	50th	75th
North Coast	41	(22)	26	34	47
Mid-coast	19	(13)	10	14	25
Mid-south Coast	24	(29)	2	11	40
Umpqua	25	(20)	10	18	30
South Coast	18	(17)	5	10	24
Reference	---	---	10	14	22

Table 13. Cumulative frequency distribution quartiles for the percent areal extent of gravel sediments in riffle units. Habitat quality decreases with very high and very low gravel quantity.

Analysis Area	Mean	S.D.	Quartile 25th	50th	75th
North Coast	29	(17)	17	25	37
Mid-coast	50	(22)	31	56	66
Mid-south Coast	46	(28)	22	41	70
Umpqua	32	(19)	16	30	42
South Coast	42	(15)	31	40	55
Reference	---	---	26	35	45

Table 14. Number of reaches with high quality habitat in 1999 based on channel type and instream habitat. All reaches < 5% gradient.

	Wide Valley Floor			Narrow Valley
	Unconstrained	Potentially Unconstrained[a]	Deeply Incised[b]	Constrained by hillslopes
High Quality	7	13	13	8
Moderate-Low quality	10	10	46	24

[a] Terrace height < 1.25*Floodprone height, [b] Terrace height > 1.25* Floodprone height

Table 15. Precision of habitat metrics for streams in western Oregon. 1998 n = 303 with 25 repeat visits, 1999 n = 219 with 26 repeat visits, 1998-1999 n = 522 with 51 repeat visits

Variables		**Year**	SD_{rep}	**CV**	**S:N**
Independent	Channel Length	1998	47.8	6.6	29.8
		1999	26.7	3.5	93.8
		1998-99	**38.5**	**5.2**	**45.6**
	Channel Width	1998	1.3	18.1	13.7
		1999	1.7	19.5	29.8
		1998-99	**1.5**	**17.6**	**32.1**
	Floodprone Width	1998	3.7	25.9	10.0
		1999	3.4	27.6	11.2
		1998-99	**3.6**	**26.4**	**10.7**
	Gradient	1998	0.5	8.9	172.9
		1999	1.8	31.6	11.8
		1998-99	**1.3**	**23.0**	**24.6**
Dependent	% Pools	1998	8.1	30.2	6.8
		1999	7.7	23.7	27.3
		1998-99	**7.9**	**27.1**	**15.2**
	Deep Pools / km	1998	0.7	28.9	33.4
		1999	1.1	54.1	5.8
		1998-99	**1.0**	**40.4**	**15.2**
	% Riffle Sand/Org	1998	7.6	30.2	7.6
		1999	7.6	29.7	8.7
		1998-99	**7.6**	**30.0**	**8.0**
	% Riffle Gravel	1998	9.5	28.3	3.3
		1999	10.3	26.2	4.5
		1998-99	**9.9**	**27.6**	**3.9**
	Wood Pieces / 100 m	1998	3.6	24.9	13.4
		1999	4.2	23.8	2.1
		1998-99	**7.3**	**46.3**	**3.4**
	Wood Volume / 100 m	1998	7.4	34.2	11.0
		1999	9.4	35.7	2.5
		1998-99	**15.5**	**65.6**	**3.3**
	Key Wood Pieces / 100 m	1998	0.6	70.9	3.8
		1999	1.5	136.5	1.7
		1998-99	**1.1**	**123.5**	**1.8**
	Wood Jams / km	1998	2.6	52.4	5.3
		1999	1.7	36.6	6.4
		1998-99	**3.2**	**54.5**	**4.2**
	Shade	1998	5.2	6.7	11.5
		1999	6.2	7.5	6.2
		1998-99	**5.7**	**7.2**	**8.7**
	20 in. Conifers / 1000 ft	1998	20.0	49.5	10.0
		1999	69.4	98.3	2.3
		1998-99	**52.4**	**98.8**	**2.6**

SD_{rep}: Standard Deviation of the repeat surveys, CV:coefficient of variation of the repeated surveys, S:N: ratio of variance among all streams to variance of repeat visits.

Table 16. Stream gradient, channel width and upstream drainage area for sites in different land uses/covers for the combined 1998 and 1999 habitat data sets.

Land Use/Cover	Gradient (%)	Channel Width (m)	Basin Area (km^2)
Non-Forested	1.3	9.4	38.9
Young Forest	5.9	8.0	14.4
Mature Forest	9.2	8.5	20.6

Table 17. Counts of beaver dams, beaver activity, culvert crossings, mass failures, debris jams and habitat structures for sites within different land use categories for the combined 1998 and 1999 habitat data sets.

Land Use/ Cover	Total Number of sites	Beaver Dams	Beaver Activity	Culvert Crossings	Mass Failures	Debris Jams	Habitat Structures
Non-Forested	29	6(21%)	13(45%)	4(14%)	6(21%)	4(14%)	2(7%)
Young Forest	262	37(14%)	69(26%)	27(10%)	76(29%)	120(46%)	21(8%)
Mature Forest	40	3(8%)	5(13%)	2(5%)	11(28%)	12(30%)	3(8%)
Total	331	46(14%)	87(26%)	33(10%)	93(28%)	136(41%)	26(8%)

APPENDIX A: HABITAT BENCHMARKS

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Oregon Department of Fish and Wildlife

1 April 1997

The development of quantitative criteria for habitat quality provides an important tool for evaluation of current habitat condition and for setting goals for improved habitat values. Benchmark values, derived from reference conditions, analysis of variable distribution, and compiled from published values, provide the initial context for evaluating measures of habitat quality. Comparison of habitat measures to benchmark values, however, must be made with caution, taking into consideration both the geomorphic template that defines the potential of the system and the combination of natural disturbance and management history that influence the expression of that potential.

The ecological potential of each stream should be considered when comparing values to the benchmarks. The ecological potential for performance will vary depending on the ecoregion, geology, natural disturbance history, local geomorphic constraints on habitat, and the size and location of the stream within its watershed.

When interpreting stream habitat data in the context of these benchmarks, it is important to recognize that the capacity of a stream reach to meet benchmark values is a function of both its ecological setting and the patterns of land use and management that modify “performance” of the stream relative to benchmark values.

Conceptually, it would appear valuable to further develop benchmark values specifically targeted to streams within individual strata of ecoregion, geologic, disturbance, etc. However, our experience with analysis of stream data from over 5,000 miles of surveys located in all regions of Oregon has led away from this approach. We have found that as the strata for interpretation becomes more limiting, each stream or small group of streams needs to be interpreted in terms of their individual characteristics and land use history as compared to general performance values. It also becomes more useful to look at combinations and interactions of features rather than single out individual values. At this level, each stream is essentially unique. In addition, as attempts to "fine tune" benchmark values focus on smaller geographic areas and sample sizes, the limited availability of reference sites and insufficient information on the range of natural conditions within the sample make such an attempt at precise development of benchmarks impractical and a misapplication of the approach.

Benchmark values are best applied to the evaluation of conditions in individual streams or stream reaches. The benchmarks provide a context for interpretation and a starting point for more detailed and meaningful analysis. For each habitat variable that meets or fails to meet desirable habitat benchmarks, the investigation and analysis should focus on both proximal and historic causes. An important part of this work is to interpret channel and riparian conditions in a broader landscape context.

Benchmark values are also very useful at looking at overall conditions within a watershed, basin, or region. Whenever aggregating reach information to this level, however, it must be remembered that under natural condition some percentage of a watershed, basin, or region may always be classified as below desirable condition. Land use and management activities will modify this percentage, commonly increasing the amount of habitat demonstrating undesirable conditions. The impact of current land use and management designed to improve these conditions is difficult to assess against the background of natural disturbance and past management and use. At the basin and region level in particular, the analysis required to evaluate these relationships has not been done.

Given these qualifications, the use of the ODFW Habitat Benchmarks requires the application of common sense and openness to further analysis. Proper use can reveal important trends in habitat condition and suggest appropriate management action.

Development of Benchmark Values:

The Habitat Benchmark values for desirable (good) and undesirable (poor) conditions are derived from a variety of sources. Habitat characteristics representative of conditions in stream reaches with high productive capacity for salmonid species are used as a starting point. Values from “reference” reaches were used to develop standards for large woody debris and riparian conditions. These reference values were then compared to the overall distribution of values for each habitat characteristic expressed as a frequency distribution within a basin or region. From this analysis, it was generally apparent that values from the 66th or higher percentile could represent desirable or good conditions and values from the 33rd or lower percentile represent undesirable or poor conditions. This development of benchmarks from the frequency distributions was made specific to appropriate stream gradient, regional, and geologic groupings of the reach data. Finally, values for habitat characteristics such as pool frequency, silt-sand-organics, and shade were developed from a comparison between the distributions and generally accepted or published values.

Benchmark Values and Example Distributions:

The Habitat Benchmark values developed for use for evaluating Oregon streams and watersheds are summarized in Table 1. Where appropriate, the values have been adapted for application to large or small stream reaches with high or low gradient. Values for fine sediments in riffles reflect differences in parent material and channel gradient. Stream shading refers to the percent of the total horizon shaded by topography and vegetation and are adjusted for stream width and geographic region. Large woody debris and riparian conifer values apply only to reaches within forested basins.

Table 1: ODFW Aquatic Inventory and Analysis Projects: Stream Channel and Riparian Habitat Benchmarks

POOLS	UNDESIRABLE	DESIRABLE
POOL AREA (% Total Stream Area)	<10	>35
POOL FREQUENCY (Channel Widths Between Pools)	>20	5-8
RESIDUAL POOL DEPTH		
SMALL STREAMS(<7m width)	<0.2	>0.5
MEDIUM STREAMS(≥ 7m and < 15m width)		
LOW GRADIENT (slope <3%)	<0.3	>0.6
HIGH GRADIENT (slope >3%)	<0.5	>1.0
LARGE STREAMS (≥15m width)	<0.8	>1.5
COMPLEX POOLS (Pools w/ wood complexity >3)km	<1.0	>2.5
RIFFLES		
WIDTH / DEPTH RATIO (Active Channel Based)		
EAST SIDE	>30	<10
WEST SIDE	>30	<15
GRAVEL (% AREA)	<15	≥35
SILT-SAND-ORGANICS (% AREA)		
VOLCANIC PARENT MATERIAL	>15	<8
SEDIMENTARY PARENT MATERIAL	>20	<10
CHANNEL GRADIENT <1.5%	>25	<12
SHADE (Reach Average, Percent)		
STREAM WIDTH <12 meters		
WEST SIDE	<60	>70
NORTHEAST	<50	>60
CENTRAL - SOUTHEAST	<40	>50
STREAM WIDTH >12 meters		
WEST SIDE	<50	>60
NORTHEAST	<40	>50
CENTRAL - SOUTHEAST	<30	>40
LARGE WOODY DEBRIS* (15cm x 3m minimum piece size)		
PIECES / 100 m STREAM LENGTH	<10	>20
VOLUME / 100 m STREAM LENGTH	<20	>30
"KEY" PIECES (>60cm dia. & ≥10m long)/100m	<1	>3
RIPARIAN CONIFERS (30m FROM BOTH SIDES CHANNEL)		
NUMBER >20in dbh/ 1000ft STREAM LENGTH	<150	>300
NUMBER >35in dbh/ 1000ft STREAM LENGTH	<75	>200

* Values for Streams in Forested Basins