Stream Habitat Conditions on Industrial Forest Lands in Coastal Oregon

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Abstract

In the summer of 1998 and 1999, watersheds in western Oregon were randomly sampled for stream habitat conditions. Sites were selected using a random tessellation stratified design. Oregon Department of Fish and Wildlife Aquatic Inventories methods were used to quantify indicators of sediment supply and quality, riparian forest connectivity and health, habitat structure, in-stream complexity, and presence of salmonid species. As part of the overall sampling 47 sites in 1998 and 70 sites in 1999 were sampled on industrial forest lands. Of these sites 13 were sampled both in 1998 and 1999, and 37 sites were sampled for fish presence/absence. Approximately 44% of the sites sampled for habitat were within the range of anadromous salmonids.

Upstream catchment area and gradient were the two major factors driving the overall patterns of habitat variables. Secondarily, land ownership and geology were other factors correlated with the habitat variables analyzed. The private non-industrial land ownership type was characterized by slightly higher fine sediment levels, lower wood volumes and number of key wood pieces, lower densities of deep pools, and lower levels of stream shading. State and industrial forest lands show moderate wood levels in the stream channel, although they show low levels of conifers in riparian zones. The sedimentary geologic type was characterized by higher levels of fine sediments in riffle units. Twelve, high quality, unconstrained stream reaches occurred in the 1998 and 1999 habitat sample on Industrial forest lands.

Conditions on industrial forest lands in 1998-1999 were compared to conditions in 1993-1994 to detect any potential change over the five-year period. Three different datasets were analyzed. No significant changes in aquatic habitat or riparian conditions were detected.

Electrofishing surveys were conducted at 37 sites outside or the expected range of coho salmon to determine fish presence/absence. Salmonid species were present at 19 of the sites that were electrofished.

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INTRODUCTION

Current aquatic habitat conditions in Western Oregon were summarized in the 1999 annual monitoring report of the Oregon Plan for Salmon and Watersheds (Thom et al. 1999). The report summarized data from random stream surveys conducted in eight geographic areas in 1998 (Figure 1). As part of ongoing monitoring activities, sites were surveyed on private industrial forest lands in coastal drainages of Western Oregon both in 1998 and 1999.

The objectives of this report are to:

1) Describe the habitat conditions in Western Oregon Streams during the summer of 1998 and 1999 on industrial forest lands

2) Explore differences in habitat features due to stream type, geology, and land ownership.

3) Describe the distribution of fish on industrial forest lands

4) Present information on trends in stream habitat between 1993 and 1999 on industrial forest lands.

METHODS

STUDY AREA

The target populations were sites on industrial forest lands in coastal drainages in Western Oregon that contained historic populations of wild coho salmon (*Oncorhynchus kisutch*), chinook salmon (*O. tshawytscha*), cutthroat trout (*O. clarki*) or steelhead trout (*O. mykiss*) (Figure 1). Sites surveyed in 1998 in drainages of the Willamette and Lower Columbia rivers were dropped from this analysis due to differences in sample weighting between the areas surveyed, and because the drainages were not sampled in 1999.

A random tessellation stratified (RTS) design (Stevens 1997) was used to select potential sample site locations. Stevens and Olsen (1999) describe the RTS survey design as applied to streams. The RTS protocol selected sites randomly and spatially balanced across the landscape. In all areas surveyed, samples were weighted to provide an equal number of sample sites in each area (50).

SURVEY METHODS

Channel habitat and riparian surveys were conducted as described by Jones and Moore (1999) with some modifications. Modifications to the survey methods included: surveying stream lengths of only 500-1000 m, and measurement of all habitat unit lengths and widths (as opposed to estimation). A site length of 500-1000 m allowed data to be collected at more than 20 habitat units at each site which was sufficient to characterize stream features and attributes that tended to be patchy in nature.

Fish presence/absence surveys were conducted in the areas outside of historic coho salmon distribution using either electrofishing or snorkeling methods. A separate project within ODFW conducted density estimates of coho salmon during the summer.

ANALYSIS

Summarized data was entered in a database in MSAccess97. Habitat conditions were described using a series of cumulative distributions of frequency (CDF). The variables described were indicators of sediment supply and type, riparian forest connectivity and structure, habitat structure, and in-stream habitat complexity. The specific attributes were:

Density of deep pools (pools >1 m in depth).
Percent of substrate area with fine sediments (<2 mm) in riffle units
Percent of substrate area with gravel (2-64 mm) in riffle units
Density of woody debris pieces (> 3 m length, >0.15 m diameter).
Density of key woody debris pieces (>10 m length, ≥60 cm diameter).
Percent of channel shading (Percent of 180 degrees).
Density of large riparian conifers (>50cm DBH) within 30 m of the stream channel.
Density of riparian conifers within 30 m of the stream channel.

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. Water quality and quantity as well as food production are not addressed in the discussion of physical habitat, while 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). Thirteen sites were surveyed in both 1998 and 1999. There were no significant differences in habitat attributes between the 13 sites surveyed in both years (paired t-test, $p > 0.05$).

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).

Exploratory analysis was conducted using the CDFs of different variables. Sites were post stratified to look at differences resulting from land ownership, channel gradient, and catchment area. The design of the sample selection and the number of sites allowed for post-stratification (Cochran, 1977), given a minimum of 20 sites were included in each new strata and the weights of the sample were known. The purpose of the exploratory analysis was to describe patterns in habitat attributes across the landscape, and to develop hypothesis that can be tested in future years of sampling.

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 less than 5% in 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. Sites were classified as the wide valley width types of: unconstrained reaches, 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); and the narrow valley width type of hillslope constrained reaches. Within each reach type, the criteria used to define high quality in-channel habitat were: pool area greater than 30% of channel area, the presence of slackwater pools or secondary channels, wood volumes greater than 10 m^3 per 100 m of stream channel and the presence of key pieces of woody debris.

TRENDS IN HABITAT

We compared three sets of data to assess the potential change in aquatic and riparian habitat on industrial forest lands from 1993 to 1999. The objective of the comparisons was to assess the null hypothesis: there were no significant differences in aquatic and riparian conditions on private industrial forest land between 1993-94 and 1998-99. The three comparisons were as follows:

1. Compare 22 reaches sampled in 1993-94 with geographically identical sites sampled in 1998-99.

2. Compare overall status of 700 reaches in 1,300 kilometers of stream surveyed in 1993-94 to 113 randomly selected sites surveyed in 1998-99.

3. Determine the influence of the 1996 February flood by comparing 90 1-km reaches surveyed in 1993-95 with resurveys in 1996.

RESULTS AND DISCUSSION

CURRENT HABITAT CONDITIONS

POOL QUALITY

The distribution of deep pool numbers was different between the reference reaches and the sites on industrial forest lands (Figure 2). The difference occurs in the number of sites without any pools over 1 m in depth. Almost 50% of the sites on industrial forest land did not have any pools deeper than one meter. This difference is likely due to differences in mean channel size between the reference reaches and the random survey sites.

FINE SEDIMENTS

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. The industrial forest land sites do show higher fine sediment levels than the reference conditions (Figure 3). The difference in fine sediment levels between the industrial forest lands and the reference data set is most apparent in the upper ends of the distributions. The industrial forest lands have a higher proportion of stream length with very high levels of fine sediment.

GRAVEL SUBSTRATE

Gravel substrate did not differ greatly between the industrial forest lands and the reference reaches, in either range or distribution. The amount of gravel in riffle units shows a normally distributed frequency distribution. Based on the observed frequency distributions, gravel quantity does not appear to be limited for spawning salmon at the scale of the large geographic areas used in this analysis (Figure 4).

WOODY DEBRIS

The industrial forest lands show slightly higher levels of wood pieces in the stream channel than the reference data set (Figure 5). However, the density of key wood pieces appears much lower than the reference values (Figure 6). These large pieces were low in density with only 25% of the stream length surveyed having more than 1.0 key piece per 100 m of stream channel (Table 8). In the reference data set over 60% of the stream length has more than 1 key wood piece per 100 m of stream channel.

RIPARIAN STRUCTURE

Channel shading appears to mimic the distribution of shading observed in the reference reaches (Figure 7). The 1st quartile falls around 75% shading and the 3rd quartile falls slightly above the 90% shading observed in the reference reaches. The number of large riparian conifers observed differs markedly from the reference reaches (Figure 8). The industrial forest ownership shows low conifer numbers with over 50% of the stream length surveyed having no large conifers in the riparian zone (Figure 8). While the number of large conifers in the riparian zone is low, close to 50% of the stream length on industrial forest lands had over 300 conifers per 305 m of stream length (Figure 9).

STREAM SIZE EFFECTS ON HABITAT

Many habitat attributes are affected by stream size. Stream size confounds the comparisons between geology or ownership patterns. For purposes of this analysis, upstream drainage area was used as a surrogate for channel size. Streams were grouped into three major channel sizes. The three categories were 0.6 –1.9 km^2, 2-20 km^2 and greater than 20 km^2. The variables that varied with stream size include the density of deep pools, the amount of fine sediments in riffle units, and the quantity of wood in the stream channel (Figure 10).

GEOLOGIC EFFECTS ON HABITAT

The underlying geology of a site can have a large impact on the amount of fine sediments that may be present at a site, regardless of ownership patterns. In the Oregon Coast range, sedimentary parent geology leads to increased fine sediment levels in riffle units (Figure 11).

OWNERSHIP EFFECTS ON HABITAT

Land ownership was divided into three main classes based upon similarities in forest practices and riparian protection rules. The three main classes were: private non-industrial lands, which included urban, agriculture, residential, and small wood lot owners; private industrial and state owned forest lands; and federal lands. The intermediate sized streams (2-20 km^2) were compared to determine if differences were apparent in habitat features between the three ownership types. Riparian conifers, key wood pieces, and deep pool density show a gradation from private non-industrial lands to federal lands in habitat quality (Fig 12-14). Within the sedimentary geologic type, private non-industrial lands had elevated levels of fine sediments in riffle units. The distribution of fine sediments on industrial forest lands were similar to federal lands on half of the sites, although 50% of the industrial forest lands show a high percentage of stream length with elevated fine sediment levels.

FISH SURVEYS

Thirty-seven sites outside of the expected distribution of coho salmon were sampled in the five coastal areas for fish presence/absence. Of these sites 19 (51%) contained salmonids. Of the 107 industrial forest sites, 79 (74%) were located on fish bearing streams, 18 sites did not contain fish and 10 sites were not sampled in 1998 or 1999. The salmonid presence/absence surveys were valuable in two ways. The first is that the surveys helped to better define the range of salmonids in the affected watersheds. Secondly, the distribution helped to classify sites based on fish use of the surveyed reaches.

OVERALL HABITAT QUALITY IN WESTERN OREGON

While individual habitat attributes are important, it is the interaction between individual habitat features that creates and maintains salmonid habitat. Of the 107 reaches surveyed and analyzed on industrial forest lands, 70 reaches were less than 5% in stream gradient. Eleven reaches were unconstrained, 13 were potentially unconstrained, 21 were terrace constrained, and 25 were hillslope constrained. Unconstrained reaches are usually the highest quality habitat with complex pools, adequate spawning gravel and high woody debris levels. Heavily incised (terrace constrained) channels are usually the lowest quality habitat with less complexity, woody debris, and spawning substrate.

Five of the 11 unconstrained reaches had high habitat quality (Table 3). Overall, the reaches that were unconstrained had higher habitat quality than the other channel types. The potentially unconstrained reaches included 7 high quality reaches out of 13. The deeply incised channel type included 7 high quality reaches out of 21. Hillslope-constrained reaches contained 9 high quality sites out of the 25 surveyed. These hillslope-constrained reaches are source areas to the lower gradient wide-valley floor segments for woody debris and sediment. In many cases these reaches are fulfilling that function with high wood levels and high gravel quantities. A higher proportion of high quality habitat sites occurred on industrial forest lands than any other land ownership.

In western Oregon, very few stream reaches had high quality habitat. A majority of streams consisted of moderate quality habitat. These moderate quality areas may, and do, support salmonids. However, without high quality refuge habitat, moderate quality areas cannot support a large abundance of salmonids through periods of frequent disturbance.

TRENDS IN HABITAT FROM 1993-1999

We compared reaches surveyed in 1993-94 that directly overlapped sites surveyed in 1998-99. The 22 sites showed little change in percent fines in riffles or riparian conifers from 1993-94 to 1998-99 (Figure 15). There was a slight increase in the number of key pieces of wood in a few sites (Figure 15).

A more comprehensive comparison was made between the habitat features in 700 reaches covering 1,300 km of stream to the habitat features in 113 randomly selected sites across a similar geographic area. The CDFs of all habitat features were not significantly different (Figure 16). Rather, the CDFs were almost identical for percent fines in riffle units, density of key wood pieces, and density of large riparian conifers.

The final comparison was based on a study to quantify the influence of a large flood event on habitat features. The flood occurred in February 1996. We resurveyed 90 reaches of stream in the summer of 1996 that had been previously surveyed in 1993-94. We examined the responses of aquatic habitat in a separate report (Jones et al. 1998), although the overall responses were quite limited. Figure 15 depicts the CDFs for Percent fines in riffle units, the density of key wood, and the density of large riparian conifers. The only significant change was a slight increase in the amount of fine sediment.

However, the 1998-99 surveys, 2-3 years post flood, do not show a detectable difference in the levels of fine sediment.

CONCLUSIONS

Overall industrial forest lands were typified by high fines in riffle units, moderate to high gravel quantities, few key pieces of wood, low densities of large riparian conifers, and high amounts of stream shading.

In the analysis of the 1998 and 1999 monitoring data, some areas of potential concern in habitat quality arose. The greatest area of potential concern was in the quantity of fine sediments in half of the stream reaches surveyed. The presence of excessive fine sediment levels was even a concern in 21 of the 28 reaches denoted as high quality habitat. The lack of large riparian conifers and key wood pieces should be addressed through forest practices or active restoration.

Using three independent data sets, we concluded that there were no detectable changes in aquatic and riparian habitat conditions on private industrial forest land from 1993-94 to 1998-99.

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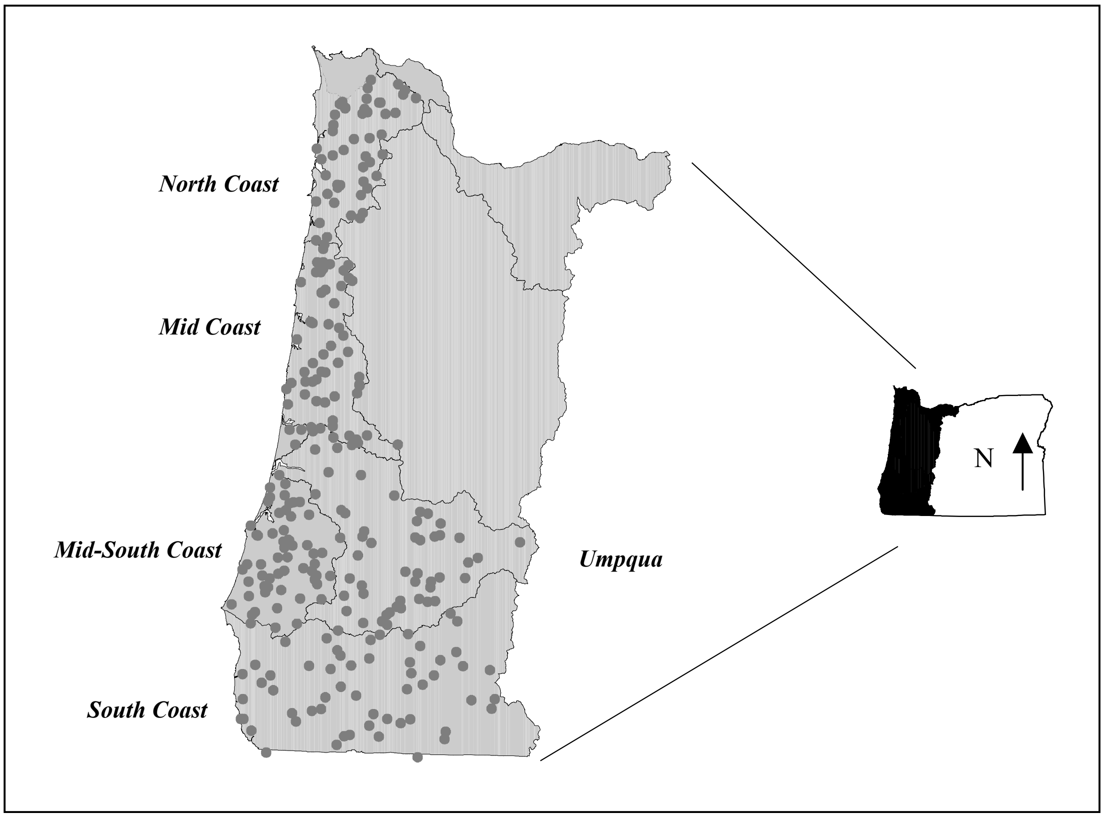


Figure 1: Randomly selected sample site locations in Western Oregon

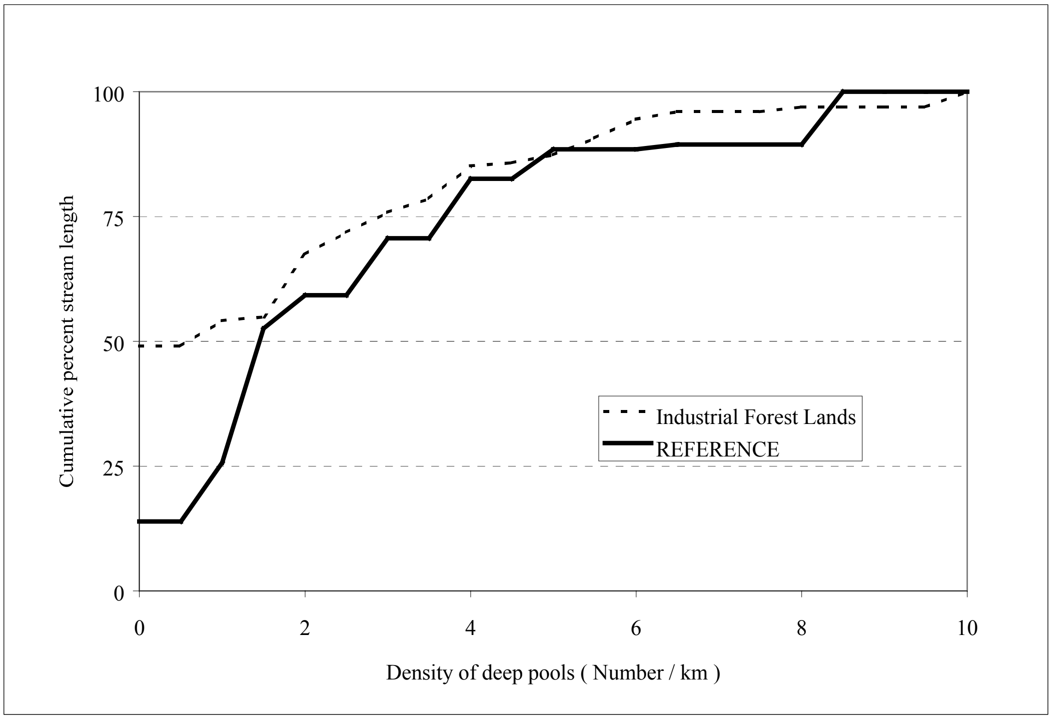


Figure 2: Cumulative distribution of frequency for the density of deep pools on industrial forest lands in coastal watersheds of western Oregon

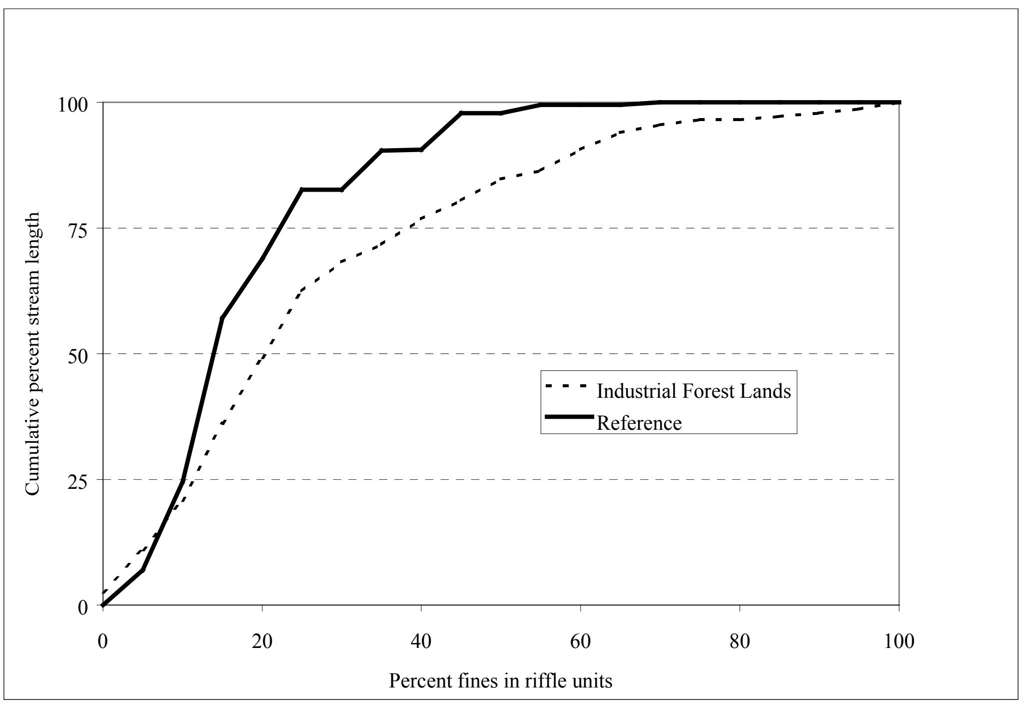


Figure 3: Cumulative distribution of frequency for percent fine sediments in riffle units on industrial forest lands in coastal watersheds of western Oregon.

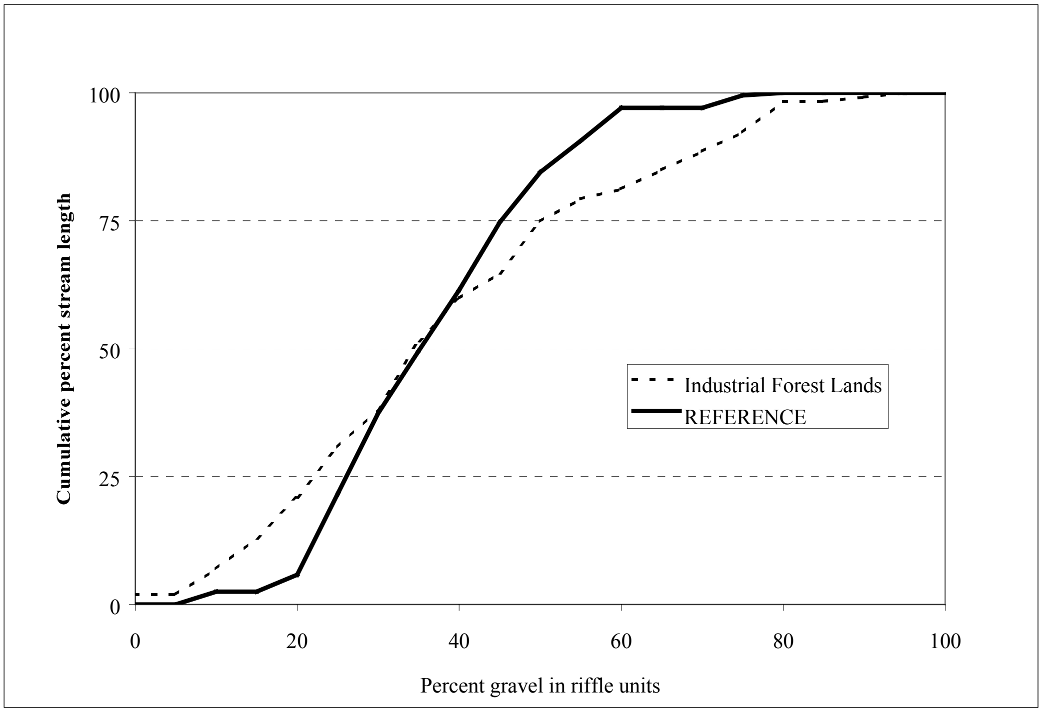


Figure 4: Cumulative distribution of frequency for the percent gravel in riffle units on industrial forest lands in coastal watersheds of western Oregon.

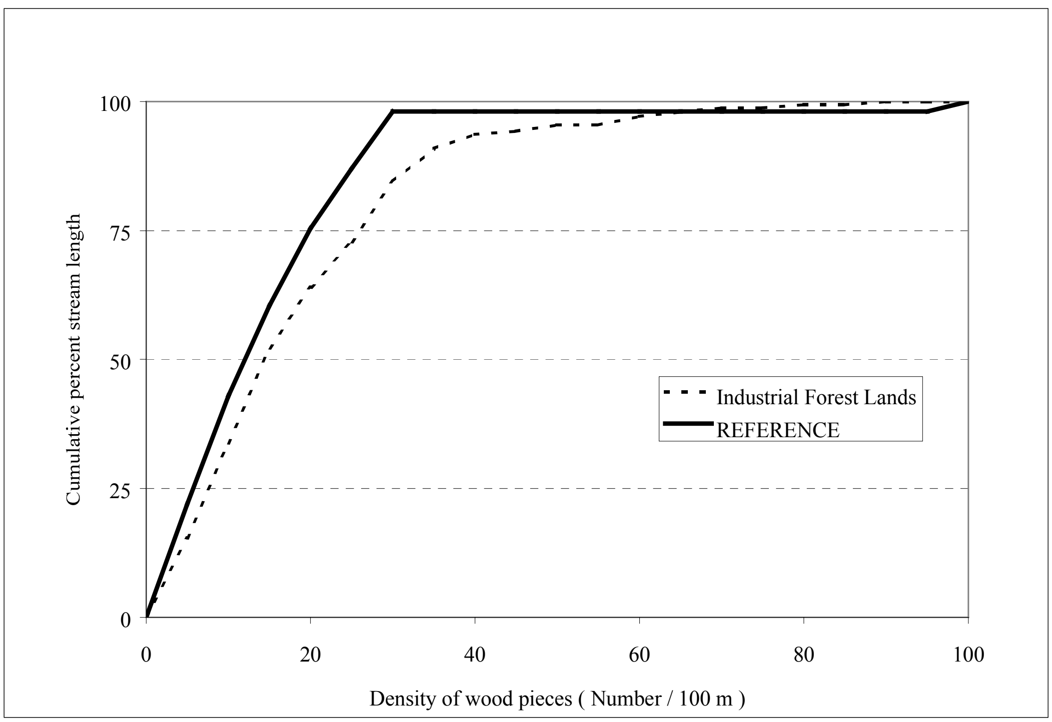


Figure 5: Cumulative distribution of frequency for the density of wood pieces on industrial forest lands in coastal watersheds of western Oregon.

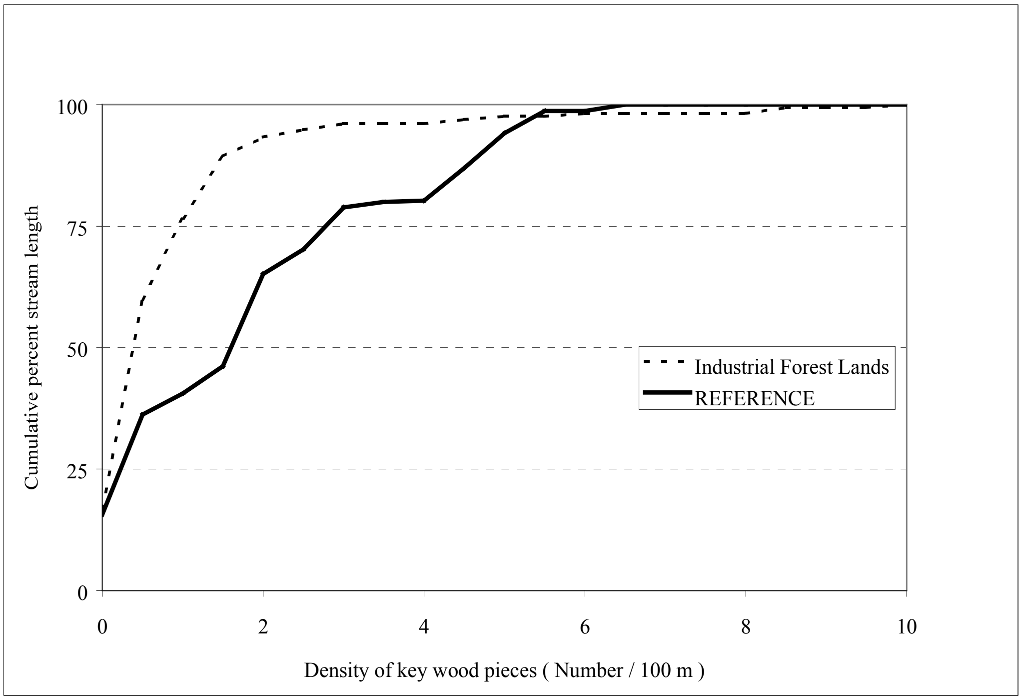


Figure 6: Cumulative distribution of frequency for the density of key wood pieces on industrial forest lands in coastal watersheds of western Oregon.

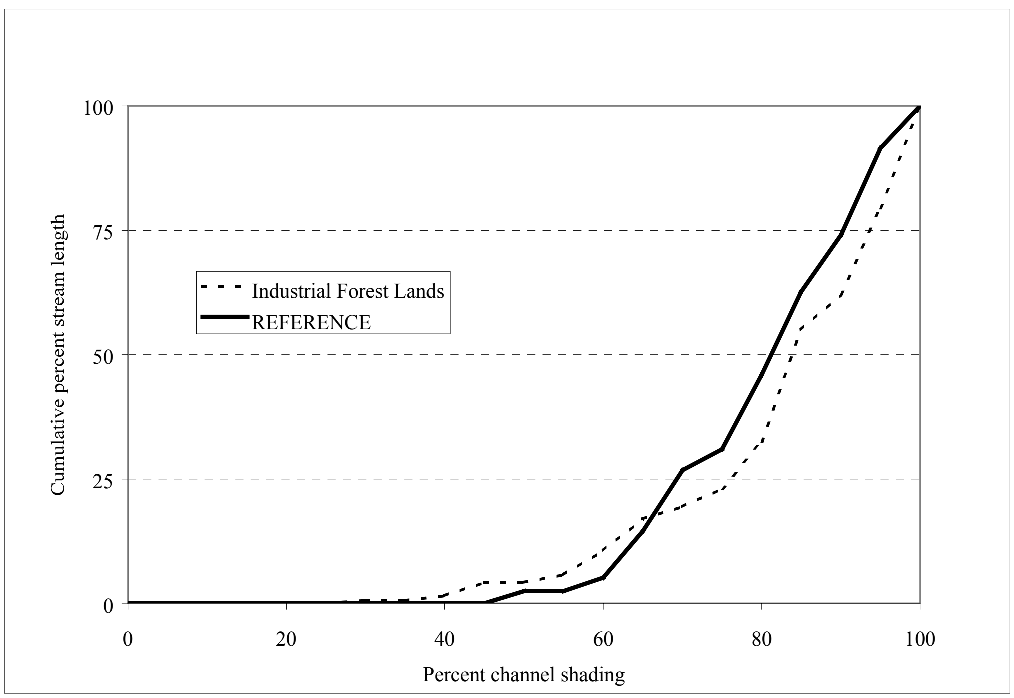


Figure 7: Cumulative distribution of frequency for the percent channel shading on industrial forest lands in coastal watersheds of western Oregon.

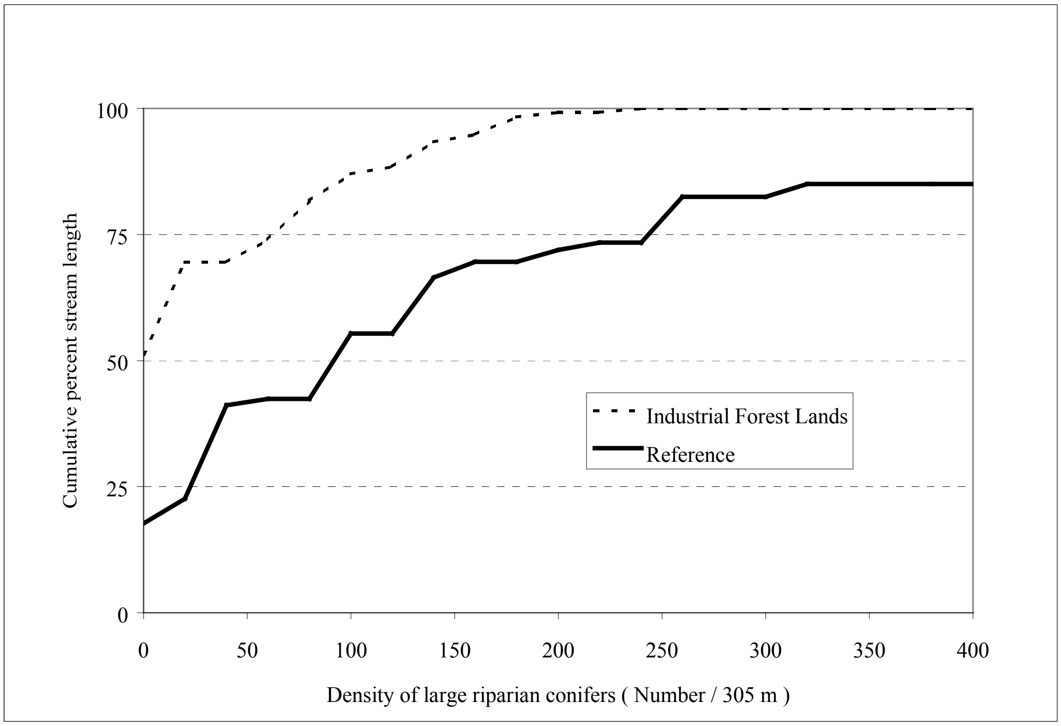


Figure 8: Cumulative distribution of frequency for the density of large riparian conifers on industrial forest lands in coastal watersheds of western Oregon.

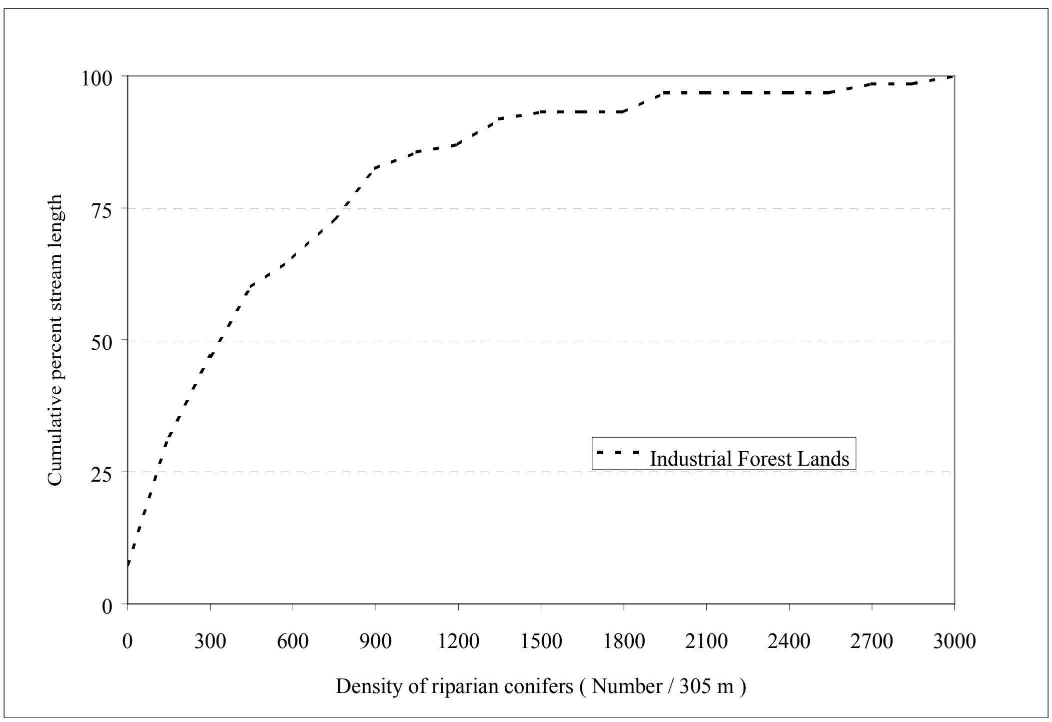


Figure 9: Cumulative distribution of frequency for the density of riparian conifers on industrial forest lands in coastal watersheds of western Oregon.

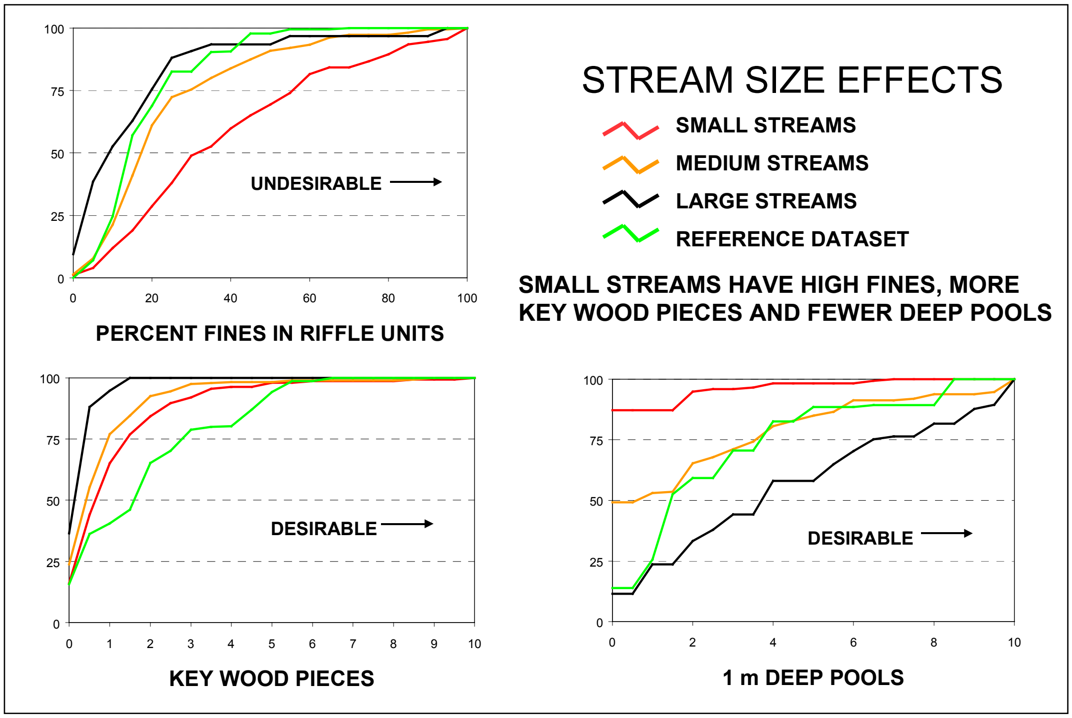


Figure 10: The effect of stream size on riffle fines, key wood pieces and the density of deep pools.

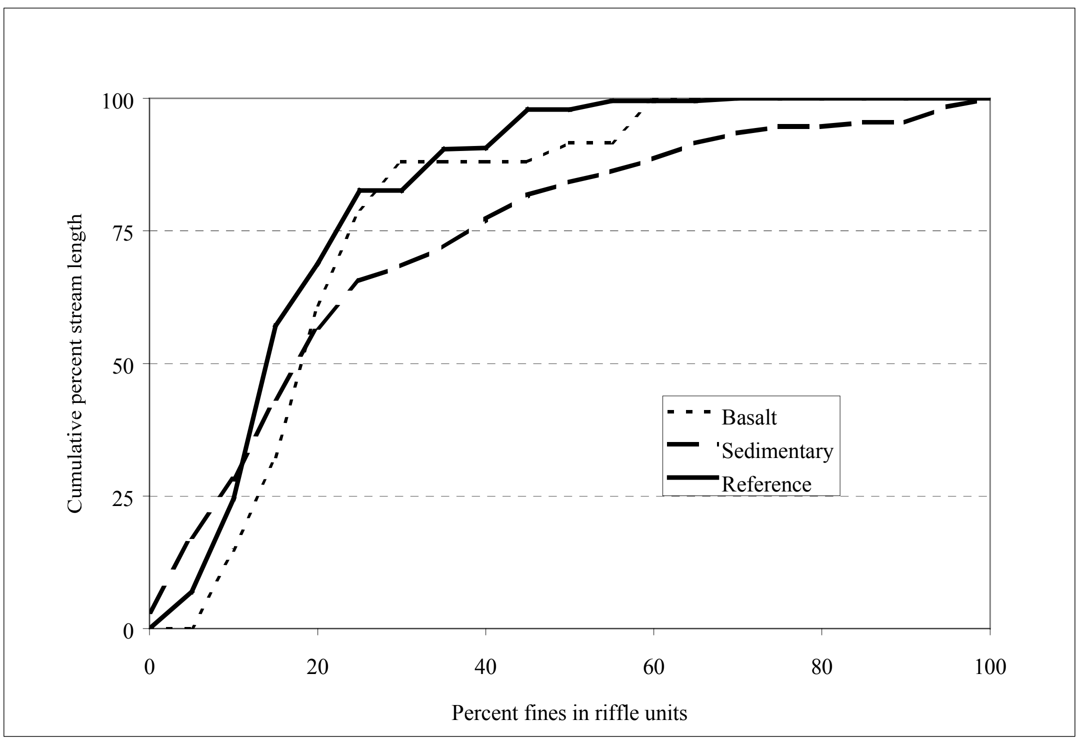


Figure 11: Differences in fine sediments in riffle units between basalt and sedimentary geology.

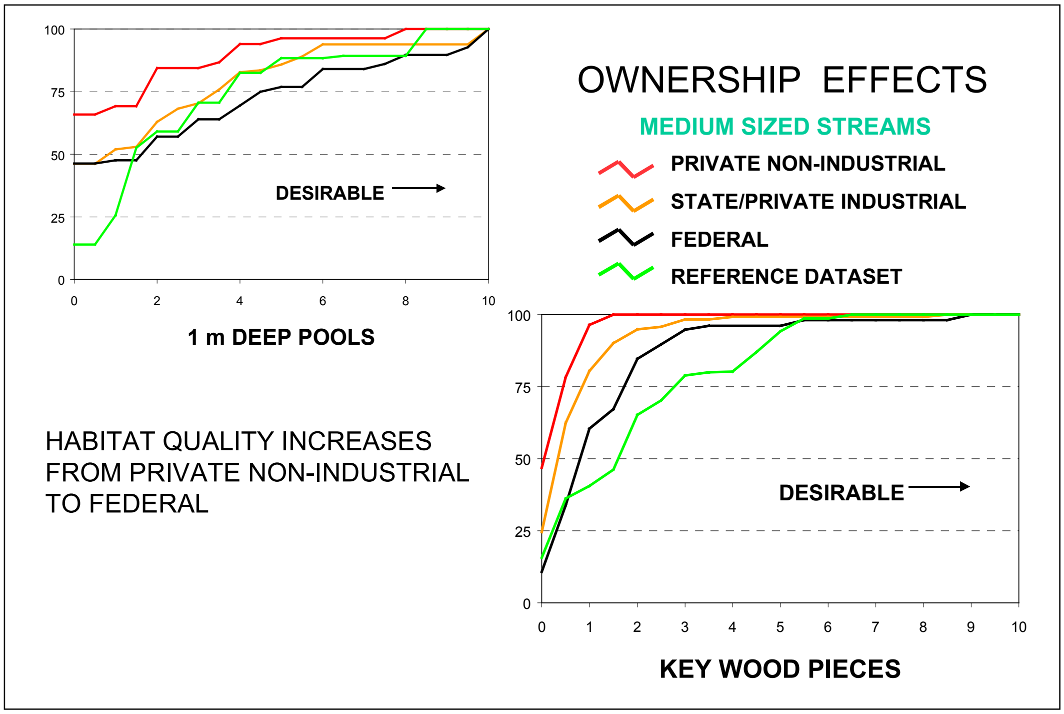


Figure 12: The relationship of land ownership on deep pool density and key wood piece density in medium sized streams.

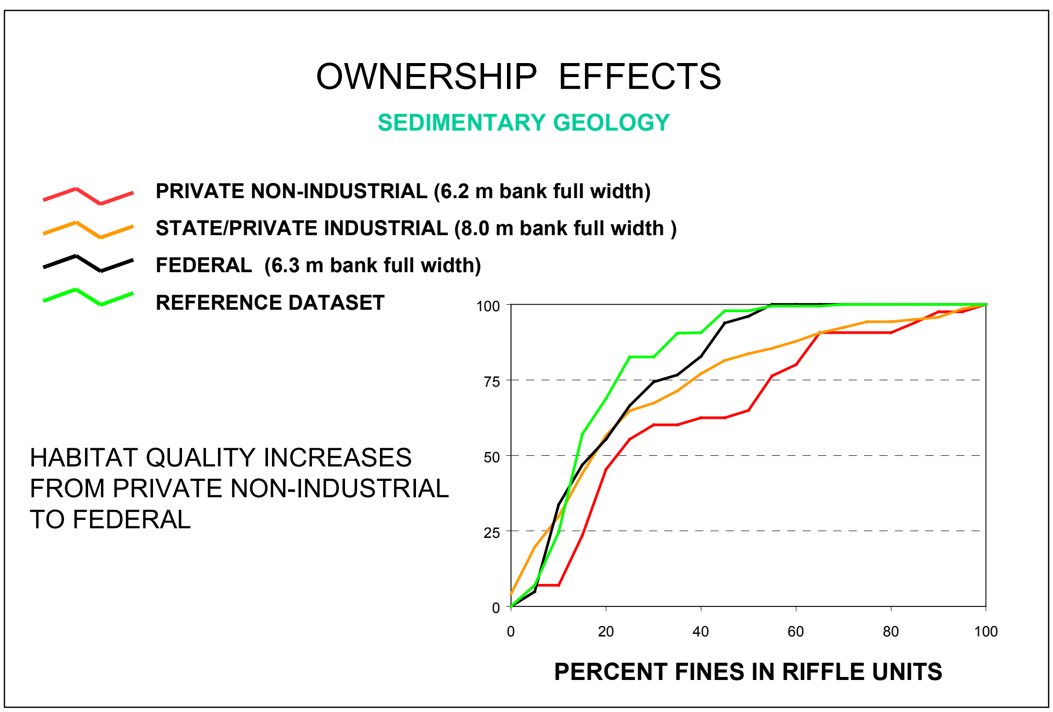


Figure 13: The relationship of land ownership on fines in riffle units within the sedimentary geologic type.

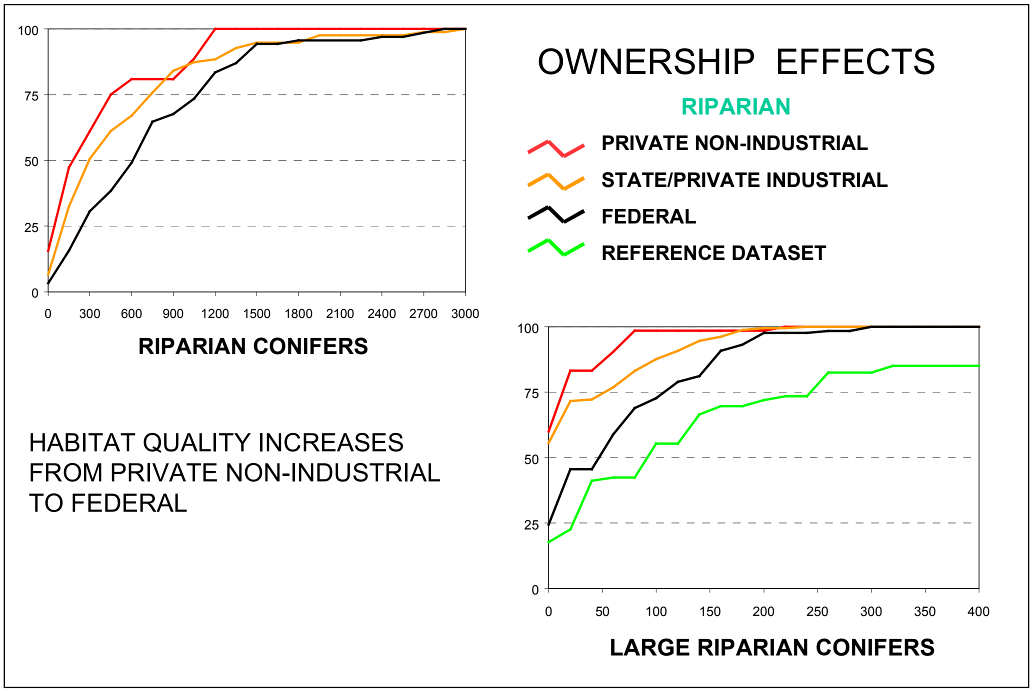
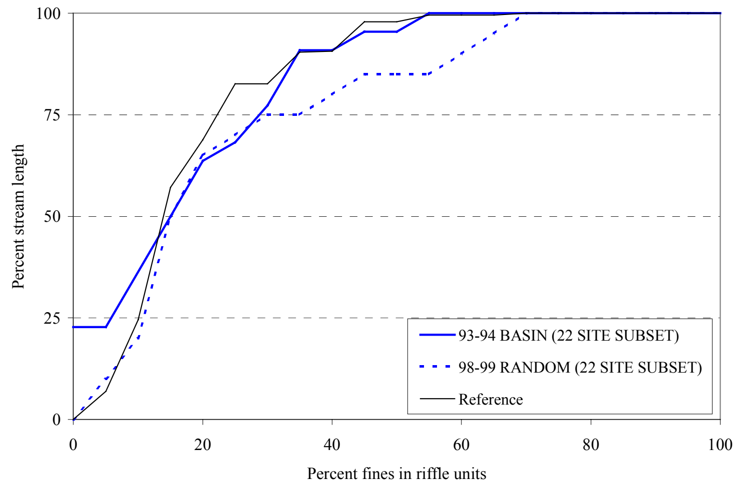
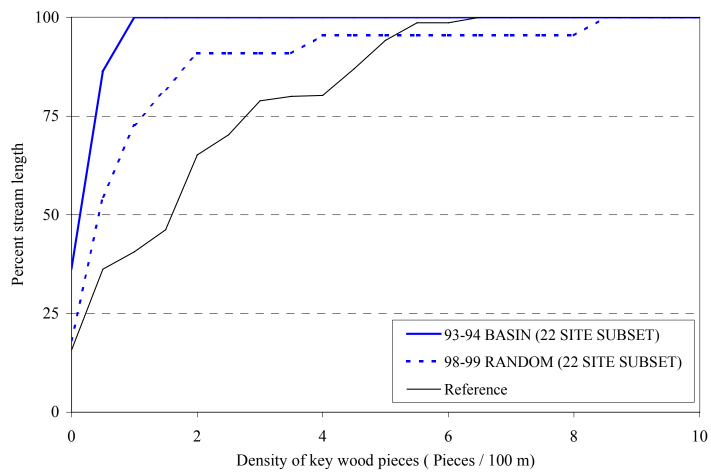


Figure 14: The relationship of land ownership on the density of riparian conifers and large riparian conifers





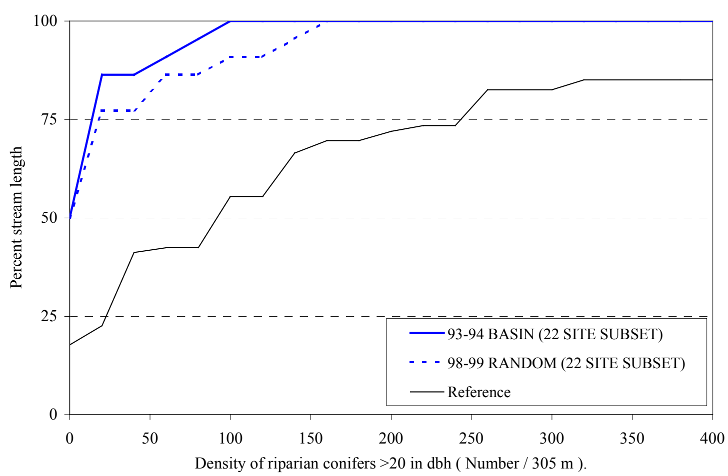
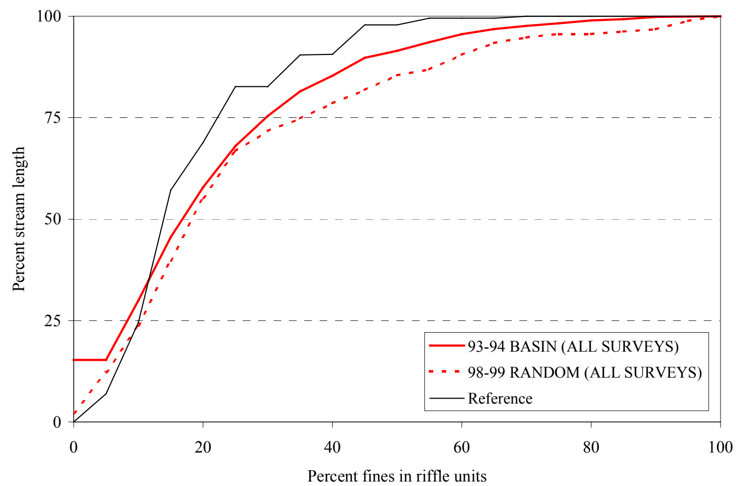
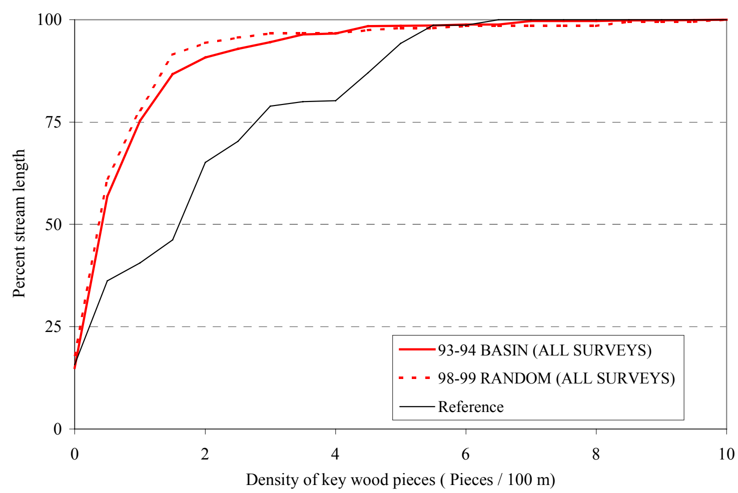


Figure 15. Riffle fines, density of key wood pieces and density of riparian conifers for 22 stream reaches sampled between 1993-1994 and again between 1998 and 1999.





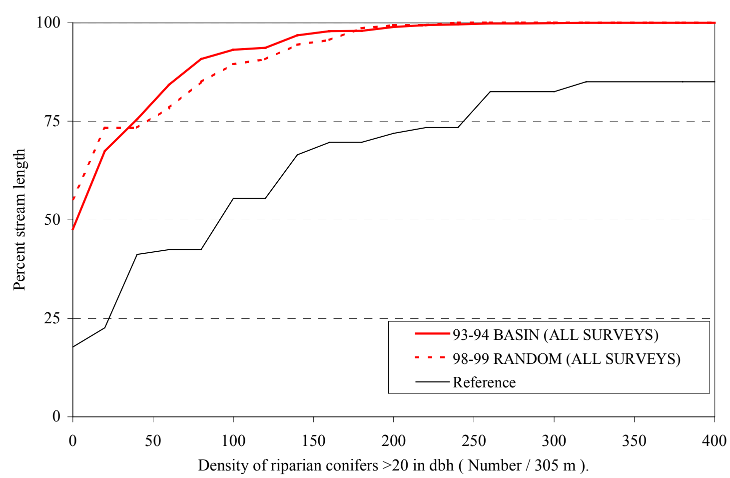


Figure 16: Riffle fines, density of key wood pieces and density of riparian conifers for surveys conducted on OFIC forest lands between 1993 and 1994 and again between 1998 and 1999.

Table 1. Mean gradient, mean active channel width, and mean catchment area for sites surveyed in western Oregon.

Analysis Area	Mean gradient (%)	Mean active channel width (m)	Mean catchment area (km^2)
Industrial Forest lands	5.0	7.6	16.6
Private non-industrial lands	3.7	8.2	13.6
State/Industrial Forest lands	5.2	7.7	17.3
Federal Lands	9.0	6.3	11.7

Table 2. Cumulative frequency distribution quartiles for all habitat attributes for industrial forest lands.

	Quartile		
Metric	25th	50th	75th
Riffle fines	12	20	37
Riffle gravel	22	34	50
Bedrock	1	6	17
Wood Pieces	7	14	26
Wood Volume	7	17	35
Key Wood Pieces.	0.1	0.4	0.9
Wood Jams	1	4	9
Pool Area	13	27	43
Deep Pools	0	0.5	3
Shade	76	84	93
Total Conifers	100	310	750
Large Conifers	0	0	60

Table 3. Number of reaches with high quality habitat 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	5	7	7	9
Moderate-Low quality	6	6	14	16
Total number	11	13	21	25

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