THE OREGON PLAN for Salmon and Watersheds

2000 – 2002 Effectiveness Monitoring for the Western Oregon Stream Restoration Program

Report Number: OPSW-ODFW-2003-07

2000 – 2002 EFFECTIVENESS MONITORING FOR THE WESTERN OREGON STREAM RESTORATION PROGRAM

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Monitoring report No. OPSW-ODFW-2003-07

January 14, 2004

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Funds supplied by:

Oregon Watershed Enhancement Board

Citation: Jacobsen, P. S., K. K. Jones. 2003. 2000 – 2002 Effectiveness Monitoring for the Western Oregon Stream Restoration Program. Monitoring Program Report Number OPSW-ODFW-2003-07, Oregon Department of Fish and Wildlife, Salem, Oregon.

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INTRODUCTION

Human influences on streams and landscapes have made habitat restoration a necessary component of natural resource management. The lack of appropriate stream protections in the past resulted in the degradation of aquatic habitat, leading to the decline in many fish populations. In an attempt to bridge the gap between currently degraded systems and long-term recovery goals, habitat restoration programs have been undertaken to improve stream habitat in the near-term.

The protection of pristine or less affected streams is an important component in any restoration program. Areas that are minimally affected by anthropogenic disturbances and are still functioning in a natural state, with biological processes still intact are the highest priority for protection (IMST 2002). Next, areas that can benefit from restoration activities are identified and assessed on their current conditions and limiting factors. As appropriate, treatments are applied that may enhance habitat conditions in the short term and promote the recovery of natural processes. Restoration efforts will be most effective if land management practices prevent continued degradation and allow the return of natural stream function.

A critical aspect of habitat restoration is the monitoring of restoration activities in order to determine if the techniques applied were appropriate and effective. Currently, stream restoration monitoring is limited and very little literature describes long-term monitoring efforts. Achieving a noticeable response in stream habitat conditions requires at least one and usually several high flow events, and it may take two to five years before flows have noticeable effects, especially during dry winters. A biological response could take from 10-50 years (Roni et al. 2003). We monitored the effectiveness of projects over several years to determine if the techniques employed were working and to what degree habitat was affected.

This report characterizes change in habitat conditions of restoration projects competed by Western Oregon Stream Restoration Program biologists. Typical restoration activities included the placement of large wood and/or boulders in stream channels, removal of culvert passage barriers, riparian planting, road decommissioning, and streamside fencing. Implementation occurred coast-wide and in the Willamette Valley, with an overall goal of enhancing aquatic habitat for salmonid species. This program works in cooperation with the Oregon Heritage Foundation, Oregon Department of Forestry, US Fish and Wildlife Service, US Forest Service, industrial and private landowners, and watershed councils. Projects that were implemented in 2000 and 2001 were monitored to assess baseline pre-treatment and one-year post-treatment conditions. Additionally, projects that were treated in 1995 were monitored in 1996 to assess one-year post-treatment conditions and in 2001 to assess six-year post-treatment conditions. The objectives of the monitoring program were to describe changes in channel morphology, channel unit composition, and structural complexity in the restoration project areas.

HISTORICAL REVIEW

The role of large wood in streams and estuaries of North America and the Pacific Northwest, and its relevance to stream function and habitat for salmonids is of great interest. Large amounts of time and money are being spent on stream restoration projects annually. Questions remain as to the effectiveness of restoration efforts and whether or not they mimic nature and are helping return proper functioning conditions to the treated areas.

Historical accounts of stream conditions suggest that streams were complex and wood-loaded in the Pacific Northwest. When Lewis and Clark camped at Point Ellice on the Columbia River, across from Astoria, they were "…assaulted by the immense drift logs that slammed the riverbank at high tide." (Wells and Anzinger 2001, Moulton 1990). Reports from the U.S. Government and the diaries of settlers to the Pacific Northwest mention the great amounts of driftwood in estuaries and on beaches, and state that many of the drifted trees in the Lower Columbia were quite large, measuring 150 feet long and 13 to 18 feet in circumference (Maser and Sedell 1994). In the Puget Sound region, early observers commonly noted channel spanning wood jams, one extending three miles in the Skagit River, with wood imbedded in the banks and bottom of the stream (Collins et al. 2002).

In addition, early settlers observed a Willamette Valley very different from what we see today. Reports from early pioneers and government surveyors describe the Willamette River valley as swampy and wet, with standing water that remained for many months, a river that spread out practically between the hillslopes of the valley, and a gallery forest that in some places ran back from the river as much as a mile on either side (Wells and Anzinger 2001; Boag 1992). Travelers through Oregon generally stayed to the hillsides or traveled down alternate routes to avoid the wet valley bottom (Sedell and Luchessa 1982), while settlement in the Willamette Valley tended to be on upland areas for the practical reason that the rivers flooded lowland areas at frequent intervals (Wells and Anzinger 2001). The historical record illustrates that streams in the Pacific Northwest were typically choked with wood, had numerous backwater and main channel pools, plus other secondary channel area, and coincidentally, had an abundant and widespread salmonid population (Sedell and Luchessa 1982).

Beginning in the late 1800's and early 1900's, thousands of drifted trees were removed by the U.S. Army Corps of Engineers from the Tillamook, Coos and Coquille Rivers as well as rivers in the Puget Sound region in an effort to improve navigation on those streams (Sedell and Luchessa 1982; Maser and Sedell 1994; Collins et al. 2002). Land use practices such as logging, overgrazing, mining, the draining of wetlands, building of dikes and straightening of streams have all contributed to the degradation of stream habitat (Lichatowich 1999). Sedell and Luchessa's (1982) historical review provides many examples of activities to "improve" streams and to enhance them for such activities as log drives and steamship passage. Starting in the 1940's and continuing for at least 40 years, wood and debris jams were removed from streams in an ill-conceived effort to improve fish passage (Sedell and Luchessa 1982). These anthropogenic activities contributed to an overall reduction in channel and habitat complexity.

One of the effects of altering natural stream functions in the Northwest has been a decrease in the number and variety of salmonid species. As early as 1892, scientists were warning that changes in streams, combined with activities such as hatcheries and overfishing would cause a collapse of salmon populations (Stone 1892). By the 1980's, this prediction had become apparent. In the Pacific Northwest, salmon are now extinct in 40% of their historic range (Lichatowich 1999), 26 West Coast salmon and steelhead populations are listed as threatened or endangered, and four additional populations are under consideration for listing (NOAA 2003).

In an effort to correct previous mistakes and to make habitat improvements, stream restoration activities began as early as the 1930's. The intent and design of restoration projects evolved over time, as a combination of trial and error coupled with better awareness of stream processes led to new approaches. Many of the earlier projects were poorly designed weirs, gabions, v-log dams, and cabled notched logs that were unable to withstand the stresses of stream dynamics (Reeves et al. 1991). By the mid-1990's, natural placement of large wood without the use of cabling or rebar was being used (Thom 1997).

Government agencies became more concerned with habitat protection and restoration as salmonid species showed marked declines and species were listed for protection. In 1994 and continuing through 1997, the Oregon Department of Fish and Wildlife (ODFW) created guides to habitat restoration for all of the coastal basins of Oregon (Barber et al. 1994, 1995, Nicholas et al. 1995, 1996, Talabere et al. 1997, Thom et al. 1997). These guides were designed to aide in restoration site selection, using both stream habitat inventories and Geographic Information System (GIS) to select likely reaches based on stream gradient and stream size. The Oregon Plan for Salmon and Watersheds (OPSW), started in 1997, has been an impetus within the State of Oregon to enhance stream habitat, remove passage barriers and to increase public awareness of issues that affect fishes.

The Western Oregon Stream Restoration Program, as part of The Oregon Plan, conducts long-term monitoring of stream restoration projects that are completed by the program biologists. This program began in 1995 on the North Coast of Oregon and expanded in 1997 to include the entire Oregon coast and the Willamette Valley. The original focus of these restoration activities was to improve habitat for coho salmon (*Oncorhynchus kisutch*). However, with the expansion into the South Coast and Willamette Valley, steelhead (*O. mykiss*) and chinook salmon (*O. tshawytscha*) habitats are now part of the program. There are eight restoration biologists employed by ODFW to design and implement restoration projects. The objectives of the monitoring program are to detect change in stream habitat after restoration treatments are applied and to determine when these changes occur. This restoration program endeavors to build on previous studies (Jacobsen and Thom 2001) and makes some assumptions that if restoration activities are properly conducted in appropriate locations, stream habitat will improve and juvenile salmonid populations will increase.

METHODS

STUDY DESIGN

One hundred thirty eight instream and riparian projects were completed during 2000-01 (Table 1, Figure 1). Criteria for selecting restoration sites included sites with medium channel width, low gradient, moderate to high amount of pool habitat, and low structural complexity (wood or boulders). Stream restoration projects that were completed were summarized by project location, project type, and length of stream treated or opened for fish use. We selected up to ten sites each year from each program biologist for effectiveness monitoring (Lacy and Thom 2000). These projects were located in coastal Oregon basins and in the Willamette Valley. The sites selected must meet the criteria of having fish passage improvements or the placement of at least two instream structures within a 500-meter segment of stream. The length of treatment varies on a site-by-site basis. In the case of culvert or dam removals, the treated section may be very short, as little as 20 meters. With large wood projects, treated sections may extend over several miles.

Sites treated in 2000–2001 received both a pre-winter and a pre-summer evaluation to establish baseline conditions immediately preceding restoration treatment. Treatments occurred in the summer or fall, and follow-up post-winter and post-summer surveys were completed within the year immediately following treatment. For example, pre-treatment surveys were conducted winter 2000 and summer 2000. Sites were treated in late summer or fall of 2000, and resurveyed in winter 2001 and summer 2001.

In addition, monitoring was completed on selected sites that were treated six years prior in North Coast basins. Evaluation of these sites included post-treatment monitoring in 1996 and in 2001. We were not able to locate maps with start and end tags for all of the older surveys. Therefore, start and end locations were recreated from memory, and as a result, the lengths of the current surveys may vary from the older surveys.

SURVEY METHODS

The methods used to conduct physical habitat surveys were modified from the ODFW Aquatic Inventories protocols (Moore et al. 1997). Modifications to the survey methods included:

- Survey segments averaged 500 m (range: 300-800 m).
- All habitat unit lengths and widths were measured to avoid bias in estimations over short survey lengths.
- Riparian transects were conducted at three locations spaced at 125, 250, and 375 m through the surveyed reach, or at equal intervals for sites shorter or longer than 500 m.
- Winter surveys did not assess stream shading, quantity of large boulders, undercut banks, erosion, or riparian conditions.

In addition to comparisons between pre- and post- surveys of treated sites, treatment surveys were compared to surveys completed as part of the coast-wide Oregon Plan for Salmon and Watersheds (Flitcroft et al. 2002). The sites selected for the baseline surveys were randomly selected from the salmonid bearing tributaries of the study areas. Any segments used as comparison sites were of similar channel width, gradient, and reach morphology as the treated stream reaches. The streams used in the comparison did not contain habitat structures. These baseline surveys represented the range of natural stream conditions in coastal basins (Appendix A).

ANALYSIS

Aquatic habitat data was analyzed to determine whether habitat quality and quantity increased following the addition of large wood and/or boulders. Bar graphs were used to compare responses at individual sites. For the purpose of analysis, the bar graphs for the 2000–2002 data contain only those sites that had two pre-surveys and two post-surveys completed. Data were also analyzed using cumulative frequency distributions to compare the pre- and post- data sets with each other and with the random reaches from the OPSW (Flitcroft et al. 2002). The random reaches were used as baseline reference conditions for comparison with the treated sites. All pre- and post-treatment sites were used regardless of whether a matching pre- or post-treatment survey was conducted at the site (pre-treatment summer n=70, winter n=70; post-treatment summer n=41, winter n=42). This was done to increase the sample size, which was otherwise limited if only matching pairs were used. Paired t-tests were utilized to test the data for significant change from pre- to post-treatment. Box and whisker plots were also used to compare the range and median of data between pre- and post-treatment.

The 1996/2001 data set included ten post-treatment sites and ten reference sites. Bar graphs were used to compare the sites individually between years, while cumulative frequency distributions were used to make comparisons between treated and reference sites, and between years. Paired t-tests were used to detect significant change in the 1996/2001 data set and to see if comparable change occurred at both the treated and the reference sites.

When presenting the results we looked at changes in selected attributes including:

- Large wood pieces that were at least partially within the active channel and were at least 15 cm in diameter and 3 m in length.
- Large wood volume, key wood pieces (>60 cm in diameter x 10m in length), and wood jams.
- Fine substrates such as organics, clay, sand and gravel less than 64 mm in diameter.
- Pool habitat area.

OVERALL HABITAT QUALITY

We defined high quality habitat as those reaches that display a combination of habitat features beneficial to the ecological functions of a stream. 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 one key piece of woody debris per 100 m of stream length (Thom et al. 2000) (Appendix B.)

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 (flood prone width less than 2.5 times the active channel width and terrace height less than 125% of the flood prone height); and deeply incised reaches (terrace height more than 125% of the flood prone height).

RESULTS

We examined 34 restoration sites within one year of treatment. Twenty-three sites were treated in 2000 and resurveyed in 2001. Eleven sites were treated in 2001 and resurveyed in 2002 (Table 2, Figure 2). All sites were treated with large wood. In addition, boulders were placed in two of the restoration sites and culverts were replaced at two sites. The restoration sites were located in medium sized streams (median width of 7 m; range 2.5 m to 20 m active channel width). The gradient of the sites ranged from 0.4% to 8.4% with a median of 2.2%. Most sites (80%) were selected in sections of streams flowing though a wide valley. The rest were in narrow valley locations constrained by hillslopes.

Ten sites in North Coast basins were resurveyed one year and six years following restoration (Table 2, Figure 3). The ten sites received additions of large wood. Each site was paired with a reference site located either immediately upstream or downstream of the restoration site (Thom 1997). The reference sites had similar characteristics to the treatment segment, such as length, gradient, reach morphology, and channel size. Restoration was completed in 1995 and each of these sites was surveyed for post-treatment conditions in 1996. In the summer of 2001, these same sites were resurveyed to examine additional change after five years. This study compared the change in site conditions between surveys conducted one and five years following treatment.

Surveys were conducted during the winter and summer at each restoration site to assess habitat characteristics during different flow regimes. Habitat characteristics recorded by the surveyors were partially dependent on the flow characteristics at the time of survey. In particular, the depth, complexity, and pool types and number may be different during winter flows compared to summer low flow. Increased flows during the winter affect the dynamics of each project by moving wood into or out of the project area, creating jams, scouring pools, and redistributing substrate. A storm in February 1996 resulted in the highest recorded flow in many north coast streams. The precipitation during the winter and spring of 2000-01 was below average throughout the coast range. The winter of 2001-02 had average precipitation, although significant flow events occurred in the spring of 2002.

The results of the surveys are presented in five ways. Figures 4-8 display the changes observed in individual habitat attributes from pre- to post treatment conditions at each of the 34 sites treated in 2000-01 and 10 sites treated in 1995. Figures 9 and 10 display the overall results of the 2000-01 treatments as a series of cumulative distribution frequency graphs. The graphs allow a direct comparison of the treatment sites to each other and as a group, and in comparison to conditions from a random selection of non-treated sites in coastal drainages. Figures 11 and 12 are box and whisker plots of the 2000-01 data comparing overall pre- and post-treatment conditions. Tables 3 and 4 display the results of t-tests and show if changes were significant ($p<0.05$). Figure 13 displays the overall habitat trends in the sites restored in 1995 as a series of cumulative distribution frequency graphs. The graphs compare the effects of treatment from surveys conducted one and five years post-treatment, and comparisons to surveys of the reference sites conducted during the same period. Finally, Appendices C-G display pre- and post-treatment comparisons for each of the 34 sites treated in 2000-01 and the 10 sites treated in 1995.

YEAR 2000-01 RESTORATION PROJECTS

In the summer, the quantity of large woody debris increased following restoration (Figure 4). The number of pieces of large wood increased by an average of eight pieces per 100 m (range: -3 to 36), with 70% of the sites increasing by at least four pieces per 100 m. Similarly, the volume of large woody debris increased by an average of 26 m^3/100 m (range: -4 to 129), with 65% of the sites increasing by at least 13 m^3/100 m. The number of key pieces of wood increased by an average of two pieces per 100 m (range: -1 to 8), with 65% of the sites increasing by at least one piece per 100 m, and the number of large wood jams increased by an average of six jams per km (range: -8 to 21), with 65% increasing by at least three jams per km. In the winter, the quantity of large woody debris also increased following restoration (Figure 5). The number of pieces of large wood increased by an average of four pieces per 100 m (range: -11 to 15), with 79% of the sites increasing by at least two pieces per 100 m. Similarly, the volume of large woody debris increased by an average of 14 m^3/100 m (range: -18 to 36), with 88% of the sites increasing by at least seven m^3/100 m. The number of key pieces of wood increased by an average of one piece per 100 m (range: -3 to 5), with 50% of the sites increasing by at least 0.5 pieces per 100 m, and the number of large wood jams increased by an average of six jams per km (range: -11 to 27), with 65% increasing by at least three jams per km. Statistically significant increases ($p<0.05$) were noted for large wood volume, key pieces and wood jams for both summer and winter ($p<0.01$), (Table 3, Figure 11 and 12). In addition, significant change in large wood pieces ($p<0.001$) occurred in the summer.

The effect of the restoration activities on the number, type, and amount of pools was variable. The average change in percent pool area was a 5% decrease (range: -68 to 108) for summer, with three sites increasing in area by at least 50%, and a 31% increase (range: -63 to 260) for winter, with eight sites increasing in area by at least 50% (Figures 4 and 5). The number of sites with pools deeper than one meter decreased for those sites treated in 2000, but increased for most of the sites treated in 2001. In the summer, the average number of deep pools decreased following restoration by 0.5 deep pools/km, with six sites increasing by at least 0.25 deep pools/km. In the winter, the average number of deep pools decreased by one pool/km, with 11 sites increasing by at least 0.5 deep pools/km. There were no significant changes ($p<0.05$) for either pool area (summer $p=0.939$, winter $p=0.394$) or deep pools (summer $p=0.650$, winter $p=0.487$) (Table 3, Figures 11 and 12).

The distribution of sediments within the restoration projects was variable, although the amount of gravel showed a slight increase at several sites during the summer (Figure 4 and 5). There were no significant changes ($p<0.05$) for either riffle fines (summer $p=0.659$, winter $p=0.819$) or riffle gravel (summer $p=0.066$, winter $p=0.826$) (Table 3, Figures 11 and 12).

In the 2000-01 restoration sites, wood levels observed in the pre-treatment streams for the summer and winter data sets were similar to the OPSW random sites (Figures 9 and 10). In almost all cases the post-treatment conditions were higher than the pre-treatment for number of pieces, volume, key pieces and wood jams (Figures 9, 10, 11, 12), with many sites meeting the desirable conditions for high quality habitat according to ODFW Benchmarks (Appendix B). Seventy-five percent of the pre-treatment surveys had less than one key piece per 100 m of channel length, while 40% of the post-treatment streams had at least two key pieces per 100 m of channel length. Half of the post-treatment sites had 11 or more wood jams compared to less than four jams in 50% of the pre-treatment sites in both summer and winter (Figures 9 and 10). The restoration treatment had a significant effect overall on the number, size, and position of large wood in the restoration sites (Table 3).

Pool area and the number of deep pools were similar at the pre- and post-treatment sites and the OPSW random sites for the 2000/2002 data sets (Figures 9 and 10). There was no overall change in the number of deep pools between the pre- and post-treatment surveys. Pool area observed during the summer was slightly higher in both the pre- and post-treatment sites than the random sites.

There were no differences observed in percent riffle fines between random, pre- and post-treatment sites (Figures 9 and 10) sampled during summer and winter. Post-treatment riffle gravel was higher in summer surveys than in the pre-treatment and random sites. Half of the sites had about 45% gravel post-treatment compared to about 30% gravel pre-treatment and about 35% gravel for the random sites. These differences were barely insignificant ($p=0.066$) (Table 3).

Secondary channel area increased significantly ($p>0.001$) during winter flow conditions but that was not the case for the summer surveys ($p=0.509$) (Table 3).

YEAR 1995 RESTORATION PROJECTS

Ten sites treated in 1995 were surveyed in the summers of 1996 and 2001. Additionally, ten reference sites paired with the treated sites were surveyed in the summers of 1996 and 2001. These results describe the post-treatment and reference site changes in habitat attributes from 1996 to 2001. For the post-treatment sites, the habitat response to treatment varied among sites. The number of large wood pieces increased by an average of four pieces per 100 m (range: -2 to 6) (Figure 6), with 70% of the sites increasing by at least two pieces per 100 m. Conversely, the volume of large wood decreased by an average of five m^3/100 m (range: -25 to 3), with 30% of the sites increasing by at least 2.5 m^3/100 m. Key pieces of wood decreased by an average of 0.5 pieces per 100 m (range: -2.0 to 0.5), with 10% of the sites increasing by at least 0.25 pieces per 100 m, while large wood jams increased by an average of three jams per km (range: -5 to 12), with 60% of the sites increasing by at least 1.5 jams per km. The reference sites had similar trends in levels of large wood. The number of large wood pieces increased by an average of two pieces per 100 m (range: -2 to 11) (Figure 6), with 50% of the sites increasing by at least one piece per 100 m. Conversely, the volume of large wood decreased by an average of eight m^3/100 m (range: -50 to 6), with 10% of the sites increasing by at least four m^3/100 m. Key pieces of wood decreased by an average of 0.5 pieces per 100 m (range: -3.0 to 0.5), with 10% of the sites increasing by at least 0.25 pieces per 100 m, while large wood jams increased by an average of two jams per km (range: -9 to 13), with 70% of the sites increasing by at least one jam per km.

For the treated sites, pool area showed little response at most sites but increased overall by an average of 79% (range: -28 to 477) (Figure 7). Three of the sites saw a substantial increase in pool area, one by over 450%. The number of deep pools decreased at all of the sites (average decrease = two deep pools per km, range: 0 to –5). The pool area for the reference sites increased by an average of 27% (range: -29 to 77), with four sites increasing by greater than 50%, while the number of deep pools decreased by an average of one deep pool per km (range: -9 to 3).

The percentage of fines and gravel in riffles also showed little change. Fines decreased an averaged of 6% (range: -29 to 8) at the treated sites while gravel decreased an average of 3% (range: -21 to 15) (Figure 7). Fines at the reference sites decreased by an average of 6% (range: -16 to 4) while riffle gravel increased an average of 2% (range: 19 to 38).

The percentage of dammed and off-channel pools decreased an average of 29% (range: -99 to 341) at the treated sites while secondary channel area decreased by an average of 5% (range: -88 to 131) (Figure 8). Dammed and off-channel pools increased an average of 531% (range: -67 to 4774) at the reference sites. Most sites showed little response although three increased by greater than 350%. The increase at one site was due primarily to a substantial increase in beaver ponds. Secondary channel area at the reference sites increased an average of 67% (range: -100 to 659) (Figure 8).

None of the trends were statistically significant ($p<0.05$) (Table 4). P-values of a two-tailed T-test ranged from 0.109 to 0.546 for the treated sites. P-values were less than 0.15 for wood jams (0.127), key wood pieces (0.131), percentage of off-channel area (0.109), and percentage of secondary channel (0.124), although the last three attributes showed a negative change. The same held true for the reference sites. P-values ranged from 0.124 to 0.926.

Cumulative frequency distributions showed similar changes in habitat occurred in both the treated and reference sites. Percent pool area did not change in either the treated or reference sites and both sets of sites had a decrease in the number of deep pools (Figure 13). Both also had increased wood pieces and wood jams, but similarly fewer key wood pieces and wood volume. Conversely, while both the treated and reference sites had lower secondary and off- channel area, the treated sites had a larger decrease.

HIGH QUALITY AQUATIC HABITAT

Three of the thirty-four 2000-01 restoration sites had high quality summer habitat prior to treatment while nine met the high quality standards after treatment. Similarly, two of thirty-four restoration sites had high quality winter habitat prior to treatment while seven met the high quality standards after treatment (Table 5). A similar percentage of high quality sites were observed in wide and narrow valley floor sites. Most of the sites did not meet both the large wood and pool requirements for designation as high quality habitat.

One reference site and six treatment sites had high quality habitat in 1996 following treatment. Five years later, no reference sites and only two treatment sites met the criteria for high quality habitat (Table 6). The movement of large wood out of the study areas prevented the sites from having the combination of attributes for high quality habitat.

DISCUSSION

The 2000-01 restoration activities were effective at increasing the complexity of the project reaches, and improving some of the habitat components important to over-winter survival of juvenile coho salmon. The net effect of the restoration activities was a result of the site selection criteria, the restoration treatment, and the river flows following treatment. Long-term trajectory for the restoration sites cannot be determined at this time.

Large wood pieces and volume increased as expected after treatment. The number of wood jams and key wood pieces also increased. The increases in number of pieces and volume were a direct result of the restoration treatment. However the reconfiguration of wood into jams was a combined effect of treatment and redistribution by high winter flows.

An increase in gravel was noted in the summer for the post-treatment group when compared to both the pre-treatment and random sites (Figure 9). This may indicate that the placed structures are already helping trap more substrate material.

Winter discharge did not have much effect on the 2000 restoration projects. The winter of 2001 (water year Oct 2000-Sept 2001) was one of the lowest on record (Table 7). As a result, there was not much hydrologic power to rearrange or recruit wood, redistribute or trap gravel, or scour deep pools. The winter of 2002 (water year Oct 2001-Sept 2002) was average, although the high flows occurred in spring of 2002. The timing of the high flows may explain some of the observed differences at the sites between the winter resurveys in 2002 and the summer resurveys in 2002.

Although there was no significant overall increase in the amount of pool area or number of deep pools, the sites had a substantial amount prior to treatment. One of the site selection criteria was that the reaches have a substantial (>35%) amount of pool area prior to treatment. Individual sites however did show increases in both amount of pool area and number of deep pools. The sites did not show a change in the amount of secondary channel or off-channel habitat.

Two of the treated sites had culverts replaced, opening up several kilometers in each stream to anadromous fish use. The sections of stream opened to anadromous fish had high quality habitat, with moderate amounts of pool area, large wood, low gradient, and off-channel habitat. The culvert removal projects were beneficial to coho salmon by improving access to spawning and juvenile rearing habitat. The boulder placement projects were in conjunction with large wood placement projects, and were utilized to increase channel roughness, enhance habitat structure stability, and in one site, improve substrate retention in a bedrock-heavy stream channel. It is unknown what effect the boulder placement will have on overall aquatic habitat.

The “long-term” response of projects implemented in 1995 and surveyed in 1996 and 2001, was mixed, both when comparing the treated to the reference sites, and when making comparisons between years. For example, there were slightly higher numbers of large wood pieces and more wood jams in the 2001 post-treatment sites, but lower wood volume and key pieces when compared to 1996. However, the reference sites followed trends similar to the treated sites for large wood. Overall, the 2001 post-treatment sites had more wood jams than any other data set, while the 1996 post-treatment set had the greatest wood volume. In general, the treated sites surveyed in 2001 had higher quality habitat (more pools, fewer riffle fines, more large wood pieces, and more wood jams), suggesting that the 1995 treatment was effective. However, since wood volume and key wood pieces declined, it may be that the largest wood was removed from the area and only smaller pieces were being recruited. Consequently, the number of sites with high quality habitat (Table 6) declined from 1996 to 2001 in both the reference and treatment locations. All but one of these sites had secondary or off-channel habitat, and nearly all had high pool area, but many sites were lacking either sufficient wood volume or key wood pieces, but not both. Half of the sites are located in the Nehalem River basin, with the rest elsewhere in other north coast basins. Peak flows for the Nehalem (as for other basins) appear to be somewhat average from June 1996 to August 2001, with no unusually high discharges (Table 7). However, the highest flows on record occurred in the Nehalem and Wilson river drainages, the location of many of the sites, in February 1996 (Thom 1997), the winter following treatment. Habitat conditions may have been set by this event, prior to the summer 1996 post-treatment surveys. Two stream gages, on the Wilson and Trask Rivers, show high peak flows in both 1999 and 2000. It appears as though the initial flood event in February 1996 modified the number and arrangement of large wood (Thom 1997). Subsequent high flow events continued to build jams, but also caused key pieces of wood to float out of the treatment reach, and to fill in side channels and off-channel pools with sediment. Some of the initial wood treatment may have been insufficient to stay anchored within the treated sites, coupled with no new large wood recruitment. However, even at six years post treatment, conditions were more favorable for salmonids and stream function that prior to treatment. A recent study by Roni and Quinn (2001) that included eight of these sites reported that juvenile coho salmon densities had increased as a result of restoration activities, compared to the paired reference reaches.

There were more deep pools (those at least 1.0 m deep) in the treated and reference sites in 1996 than in 2001, but this may simply be due to lower stream flows in 2001 than in 1996. Due to the small sample size, it is difficult to detect whether restoration efforts on these sites was effective as a whole. However, some individual sites responded very favorably, illustrating that the restoration techniques were successful in several situations. In all cases the projects continued to show considerable improvement over the 1995 pre-treatment conditions (Thom 1997). Comparisons of pre-treatment data to both the 1996 and 2001 post-treatment surveys showed not only more wood pieces but also more wood volume and channel-forming wood jams one and six years after treatment. Scour pools and complex pools are also higher six years after treatment when compared to pre-treatment conditions. The reference sites followed trends similar to the treated sites, which makes it difficult to determine whether the changes (and the magnitude) were a result of the restoration efforts.

The ability of our methodology to detect small change is limited by survey protocol and observer variability. For example, measurements of channel length are highly repeatable (signal to noise (S:N) is 55.2, and coefficient of variance (CV) is 4.8, 95% confidence interval (CI) ± 43 m) while estimations of gravel substrate were less repeatable (S:N=3.2, CV=30.0, CI ±

2.1%) (Appendix H). For the parameters that we examined and use to determine whether change has occurred, there is a measurable amount of variation that is due strictly to observer variability. Small changes in stream conditions are likely a result of observer variability rather than restoration treatment.

We defined high quality habitat as a set of indicator attributes important for the survival of juvenile coho salmon during summer and winter. High-quality stream habitat for salmonids is measured in part by the combination of percent of pool area, percent secondary channel and off-channel habitat, wood volume, and key large wood pieces in the surveyed sites. Overall habitat quality for the selected areas in the 2000/2002 data set increased by 14-17% from pre- to post-restoration (Table 5). This is a positive response, as most of these sites were selected based on having lower quality habitat but having potential for improvement. Nearly all of the sites had secondary channels and off-channel habitat, and more than half had at least 35% pool area. The sites that did not meet the high quality habitat standard had either insufficient wood volume or key wood pieces. This is not unexpected since these sites were selected on, among other things, low large wood volume. Restoration treatments were applied with the intent that additional wood will be naturally recruited.

Several studies demonstrate that stream restoration efforts like these are valuable. Modification of winter rearing habitat by the placement of large wood structures and the construction of alcoves to create more pool area can increase the survival of juvenile coho, as winter habitat may be a limiting factor in juvenile coho production (Nickelson et al. 1992; Roni and Quinn 2001). In a long-term paired study in Oregon, Solazzi et al. (2000) showed that by improving habitat in two streams as compared to nearby reference streams, sea-run cutthroat and coho salmon smolts increased by as much as 200%, while in the untreated reference streams numbers remained the same or decreased. Placement of large wood in streams that were lacking in complex habitat also helps to collect additional woody debris and trap stream sediments (Thom 1997). The wood can increase channel complexity, stabilize the stream channel, and improve spawning habitat for salmonids. Fish passage issues have also been an important component of habitat improvements. As of 2001 in Oregon, at least 1,841 miles of stream habitat had been made accessible to fish passage due to improving stream/road intersections (OWEB 2003).

Stream flow plays an important role in the restoration process. A review of United States Geological Service (USGS) stream flow data showed that for coastal basins and the Willamette Valley, 2001 (Oct 2000 – Sept 2001) peak flows (the latest data available) were at or near record lows for as long as the past 100 years (Table 7). These low flows help to illustrate why only small changes have been noticed in the treated segments beyond the addition of large wood. High flows and upstream conditions in combination with project design may dictate long-term success for these projects. Recent winters with lower than average flows may delay changes necessary for channel modification. Many sites have potential to improve further, but no major flow events have occurred since structure placement to recruit more wood, scour pools, or develop additional channel complexity. In addition, some sites may require a longer time frame to fully restore because they offer little upslope wood recruitment opportunities due to past land management activities.

Insufficient riparian buffers combined with the removal of large trees upstream of the treatment area will minimize future wood recruitment. The gradual loss of large (key) pieces of wood is indicative of the lack of recruitment from upstream or riparian areas. However, projects constructed with a sufficient size and number of logs relative to the active channel may retain large wood and be more successful in the long term.

Large wood in streams provides cover, refuge and future food sources for juvenile salmonids. The majority of the pools in low gradient streams are attributed to large wood in the system (Sedell and Luchessa 1982). Adding wood structure is intended to improve stream habitat in the short term until wood is contributed naturally from the adjacent or upstream riparian areas. Even though all structure has the potential to be relocated within the reach or completely out of the system by high flows, Roper et al. (1998) discovered that, depending on how and where the wood was placed, 80% of structures they surveyed remained in place after five-year interval flood events. They further found that structures in large streams were considerably more likely to be moved downstream when compared to those in small streams. Thom (1997) determined that significant movement of large wood pieces decreased as the number of naturally anchored ends of the wood increased. The use of whole trees with the rootwads and branches attached is believed to be more stable and more effective at trapping wood and gravel than log "cylinders". Recent projects in the Alsea basin placed entire trees in several miles of stream to test this theory.

It is important that restoration projects have pre-determined goals, and a monitoring plan that will help illustrate whether those goals were met and in what time frame. A good monitoring plan will reveal if restoration activities were properly designed and implemented, provide insight as to whether the goals were achieved and whether changes in restoration techniques need to be modified Kershner (1999). It is likely that a method of stream restoration that works in one system will not be effective in another system.

FUTURE CONSIDERATIONS

Modifications to the field survey techniques and data analysis procedures may allow us to detect a finer resolution of change in treated streams in the future. Although we are seeing positive responses to restoration activities, it may be that some sites, due to geology or other unknown constraints, may not stimulate changes that are easily detectable using our current methods. It may also be possible that we are looking for change to occur too rapidly, and that we need several high flow events to sort substrates and change stream structure (Roni and Quinn 2001).

We recommend that all future wood placed in a restoration project be measured and recorded by actual diameter and length at the time of implementation and in subsequent surveys. Measuring rather than estimating wood dimensions should improve our ability to detect wood movement and recruitment. One of the key attributes for detecting change in stream habitat quality is how well large wood additions are effective at modifying stream habitat and if they are collecting additional wood pieces. The behavior of different sizes of wood in a stream is influenced by the stream size, flow, and gradient. In order for us to understand the results of the restoration projects, we must know the baseline amounts and size of wood that has been added. We may also need to survey the full length of a treated reach to capture the response of a particular site to the treatment. The trade-off will be a reduction in the number of sites we can visit.

CONCLUSIONS

Restoration was effective in improving the complexity of sites treated in 1995 and in 2000-01. The amount of large wood increased as a direct result of the treatment. The response of the sites to the restoration activities was determined by the amount and type of large wood, the length of time after treatment, and the magnitude of high flow events. The trajectory of the response at the 1995 sites indicated that the first high flow, the 1996 flood event, induced the greatest changes in habitat characteristics, including an increase in wood jams and the creation of secondary channels and slow-water pool habitats. Subsequent changes over the next five years indicated a loss of key pieces of wood and slow-water habitats, but an increase in smaller pieces of wood and jams. However, the treated sites were more complex and were more suitable for juvenile coho salmon than the pre-treatment or reference sites. Changes at the 2000-01 sites were less obvious after restoration, although this is not unexpected given the low winter flows and short time for response. While the restoration did improve the site complexity over pretreatment conditions, the future trajectory of response is unclear for the 2000-01 sites.

Long-term monitoring of restoration activities is critical to our understanding of effective restoration methods. The time frame of response for many types of stream restoration projects extends far beyond the one or two post-treatment surveys often described. It is important that parties involved in stream restoration activities maintain effectiveness monitoring of projects, an often neglected but necessary component. Responses to restoration activities will vary based on geomorphic and aquatic characteristics. However, given sufficient study, restoration monitoring will provide answers that can be applied to a variety of stream and land management conditions.

ACKNOWLEDGMENTS

The monitoring of stream restoration projects would not be possible without the participation and cooperation of a wide group of private and industrial landowners. In addition, this program is greatly indebted to local ODFW district biologists for all of their assistance.

The authors wish to thank all of the habitat biologists, including Todd Alsbury, Jim Brick, Jane Hatfield, William Cannaday, Howard Crombie, Sam Dunnavant, Jason Kirchner, Steve Mazur, Sam Moyers, Dave Plawman, Alan Ritchey, Joseph Sheahan, Randy Smith, John Spangler, and Michael Weston. Kelly Moore, Jay Nicholas, and Mario Solazzi provided technical expertise, Andy Talabere, Kim Jones, Stephanie Gunckel, Paul Scheerer and Jeff Snyder offered huge amounts of editorial assistance, Bobbie Riggers contributed database information, and Charlie Stein, Peggy Kavanagh, Trevan Cornwell, Jennifer Bock, and Kelly Reis put in long hours coordinating crews and equipment in the field.

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Table 1. All Western Oregon Stream Program Restoration Projects by Area and Project Type, 2000-2001.

Project Types			Large wood		Boulders		Fish Passage		Stream Fencing		Riparian Planting		Misc.
			number of sites	treated miles	number of sites	treated miles	number of sites	miles opened	number of sites	treated miles	number of sites	treated miles	number of sites
North Coast													
	2000												
	2001		6	1.50							1	1.00	
Mid Coast													
	2000		11	4.85			1	1.00			2	0.75	1
	2001		7	4.35			1	1.50	1	1.31	2	1.02	6
Mid-South Coast													
	2000				2	2.50	13	15.69			1	0.50	1
	2001		3	0.40									
Umpqua													
	2000		6	12.60	2	1.60	2	3.50	7	4.80			
	2001		8	5.92	1	0.25	3	8.17	18	10.06	1	0.90	
South Coast													
	2000		11	2.54			1	1.50			2	0.50	
	2001												
Lower Willamette													
	2000		6	4.51			2	9.50					
	2001		4	1.66			1	12.75	2	0.53	2	0.50	
Upper Willamette													
	2000												
	2001												
Total ------------------	**Projects**	138	62		5		24		28		11		8
------------------	**Miles**	118.16		38.33		4.35		53.61		16.70		5.17	

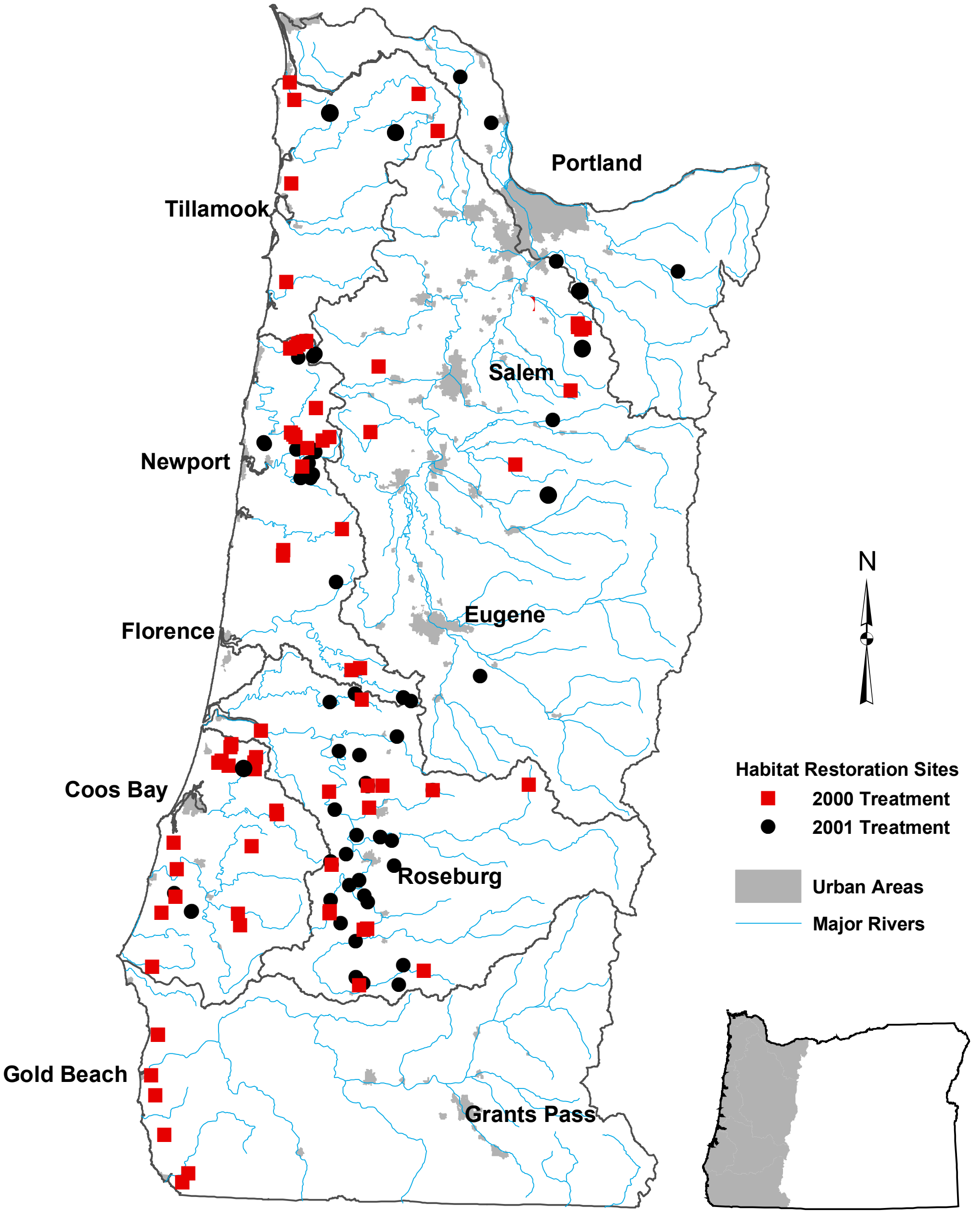


Figure 1. Western Oregon Stream Project Restoration Sites, 2000-2001.

Table 2. Monitored Projects, Kilometers Treated and Treatment Applied

Stream	Basin	Site No.	2001/2002		Active Channel Width (m)	Kilometers Treated	Key Pieces* Wood Placed	Boulders Placed	Culvert Stream km Opened
Anthony Creek	MF Willamette	1			8.6	0.8	11.0		
Buck Creek	Clatskanie	2			8.5	0.8	22.0		
Deadhorse Creek	Molalla	3			17.7	NA	NA		
Feagles Creek	Yaquina	4			8.8	1.3	23.0		4.8
Fish Creek	Millicoma	5			5.6	NA	NA		
LNF Nehalem River	Nehalem	6			10.8	NA	NA		
NF Wolf Creek	Nehalem	7			10.8	1.6	20.0		
Salmonberry Creek	Smith	8			4.4	1.1	43.0		
SF Crabtree Creek	S. Santiam	9			12.3	NA	NA		
Starvout Creek	S. Umpqua	10			5.7	1.6	62.0		
Wolf Creek	Yaquina	11			5.8	1.6	63.0		
			2000/2001						
Bales Creek	Yaquina	1			8.5	0.8	38.0		
Bear Creek	Coquille	2			6.0	0.5	43.0		
Beerman Creek	Necanicum	3			7.8	1.0	63.0		
Byron Creek	Umpqua	4			3.6	1.0	45.0	30.0	
Camp Creek	Siuslaw	5			4.9	0.5	43.0		
Canyon Creek	Mollala	6			8.0	0.2	23.0		
Cedar Creek	Wilson	7			19.7	0.8	35.0		
Charlotte Creek	Umpqua	8			8.8	1.6	47.0		
Cherry Creek	Alsea	9			5.9	0.8	32.0		
Coal Creek	Nehalem	10			6.7	1.3	36.0		
Farmer Creek	Nestucca	11			5.7	0.8	86.0		
Golf Creek	Clackamas	12			2.5	NA	NA		
Honeygrove Creek	Alsea	13			8.0	0.5	10.0		
Jack Creek	Chetco	14			9.9	1.1	97.0		
Johnson Creek	Necanicum	15			5.4	1.0	62.0		
Lane Creek	Umpqua	16			5.1	1.6	85.0	40.0	
Long Prairie Creek	Siletz	17			8.1	1.2	59.0		
Little Rock Creek	Siletz	18			5.1	0.8	19.0		
LSF Hunter Creek	Hunter	19			10.6	0.3	16.0		
Peterson Creek	Miami	20			9.6	0.5	60.0		
Rasler Creek	Coquille	21			4.4	0.4	48.0		
Roaring River Trib	S. Santiam	22			6.1	1.0	66.0		
Wood Creek	Umpqua	23			4.5	1.6	62.0		4.8
			1996/2001						
Bergsvick Creek	Necanicum	1			9.9	NA	NA		
Bewley Creek	Tillamook	2			8.8	NA	NA		
Deer Creek	Nehalem	3			4.4	NA	NA		
Hamilton Creek	Nehalem	4			11.7	NA	NA		
Kenusky Creek	Nehalem	5			7.1	NA	NA		
Klootchie Creek	Necanicum	6			9.6	NA	NA		
NF Rock Creek Lower	Nehalem	7			11.3	NA	NA		
NF Rock Creek Upper	Nehalem	8			9.7	NA	NA		
SF Little Nestucca River	Nestucca	9			12.4	NA	NA		
WF Ecola Creek	Ocean	10			14.7	NA	NA		

*Key Piece is equal to 1.5 times active channel width and minimum 25.4 cm diameter - applies to this table only.

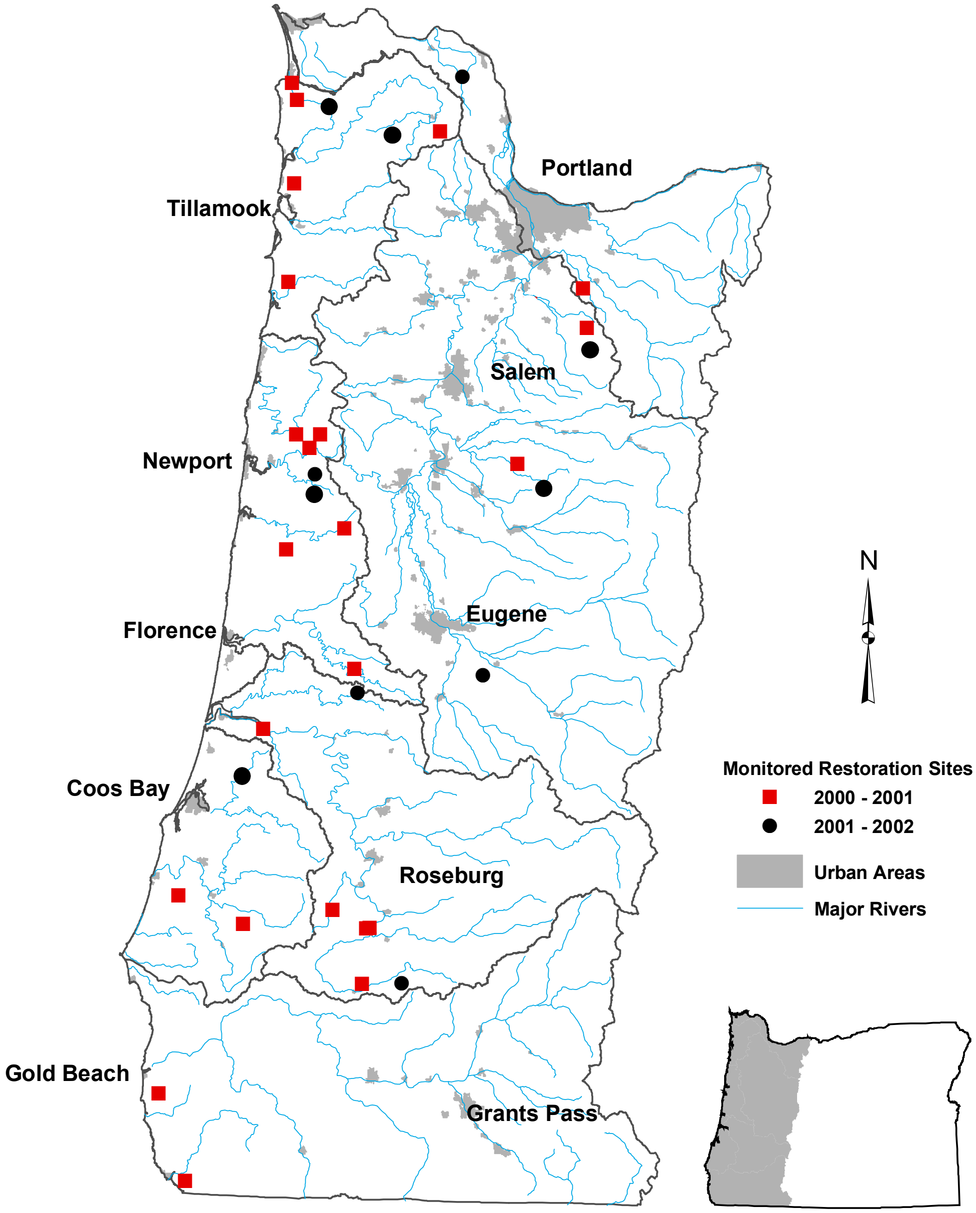


Figure 2. Western Oregon Stream Project Monitored Sites, 2000-2002.

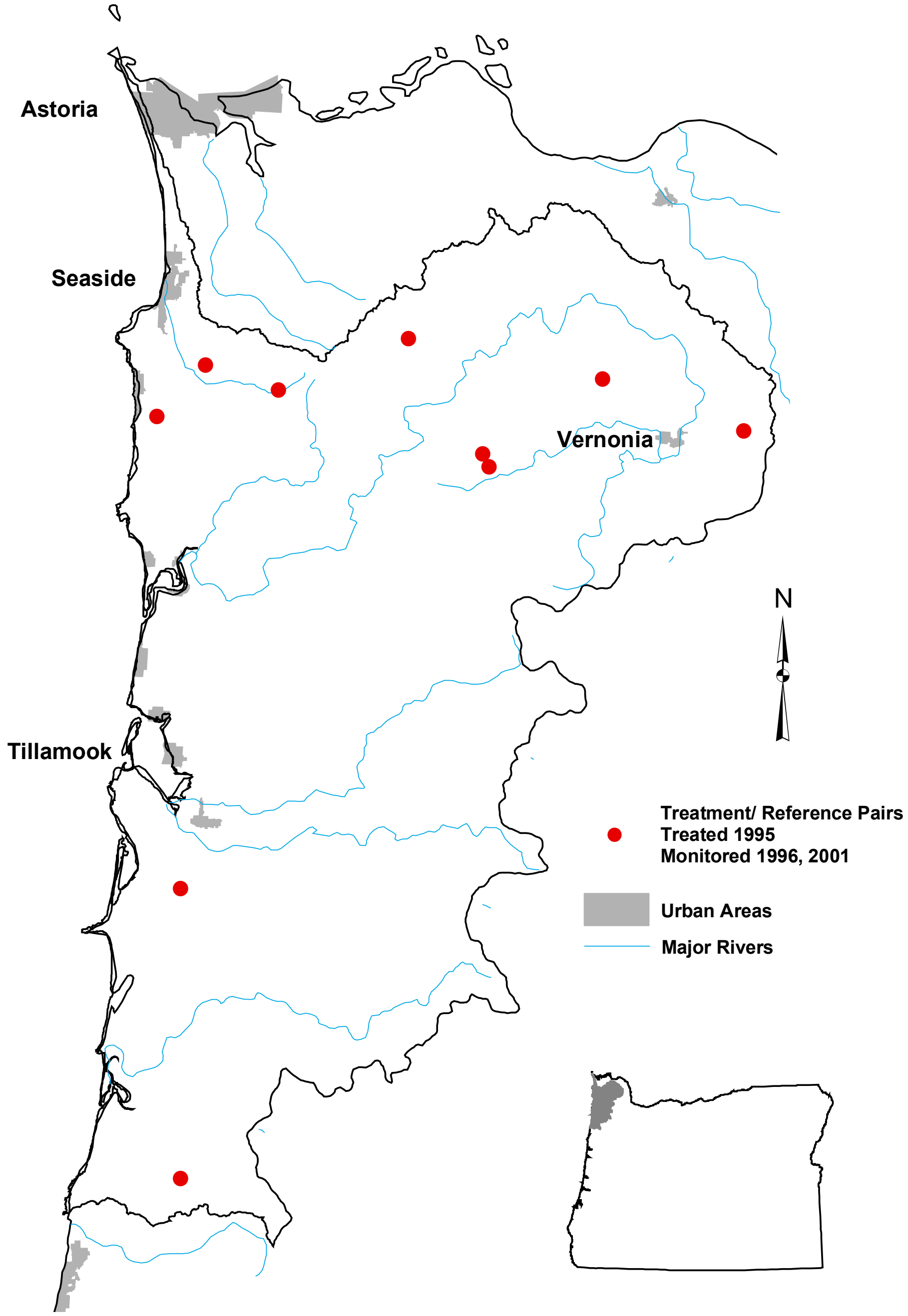


Figure 3. North Coast Treatment and Reference Pairs, Monitored in 1996 and 2001.

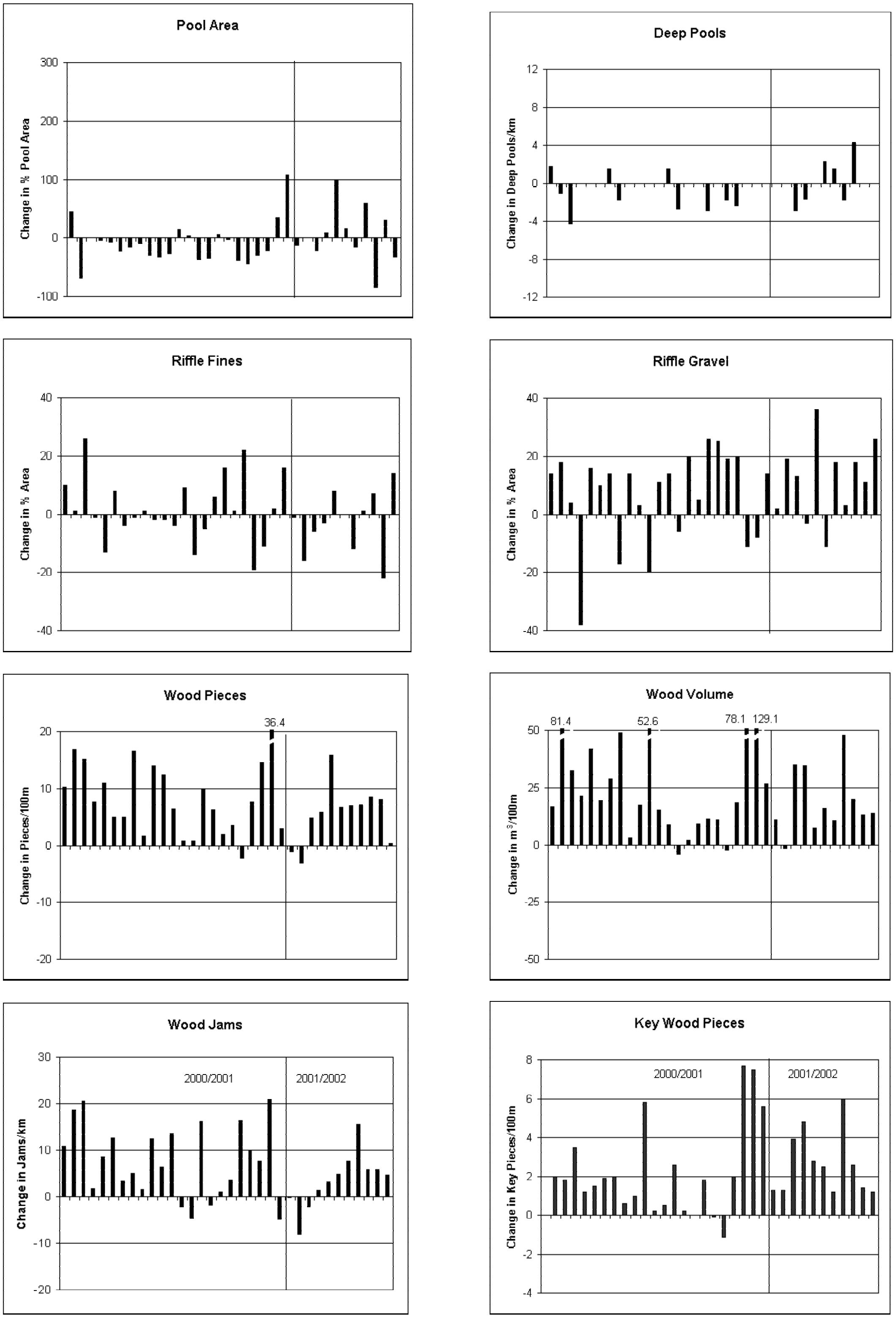


Figure 4. Summer Comparisons of Change at Individual Sites Pre- and Post-Treatment. 2000/2002 (n=34). Sites identified in Table 2.

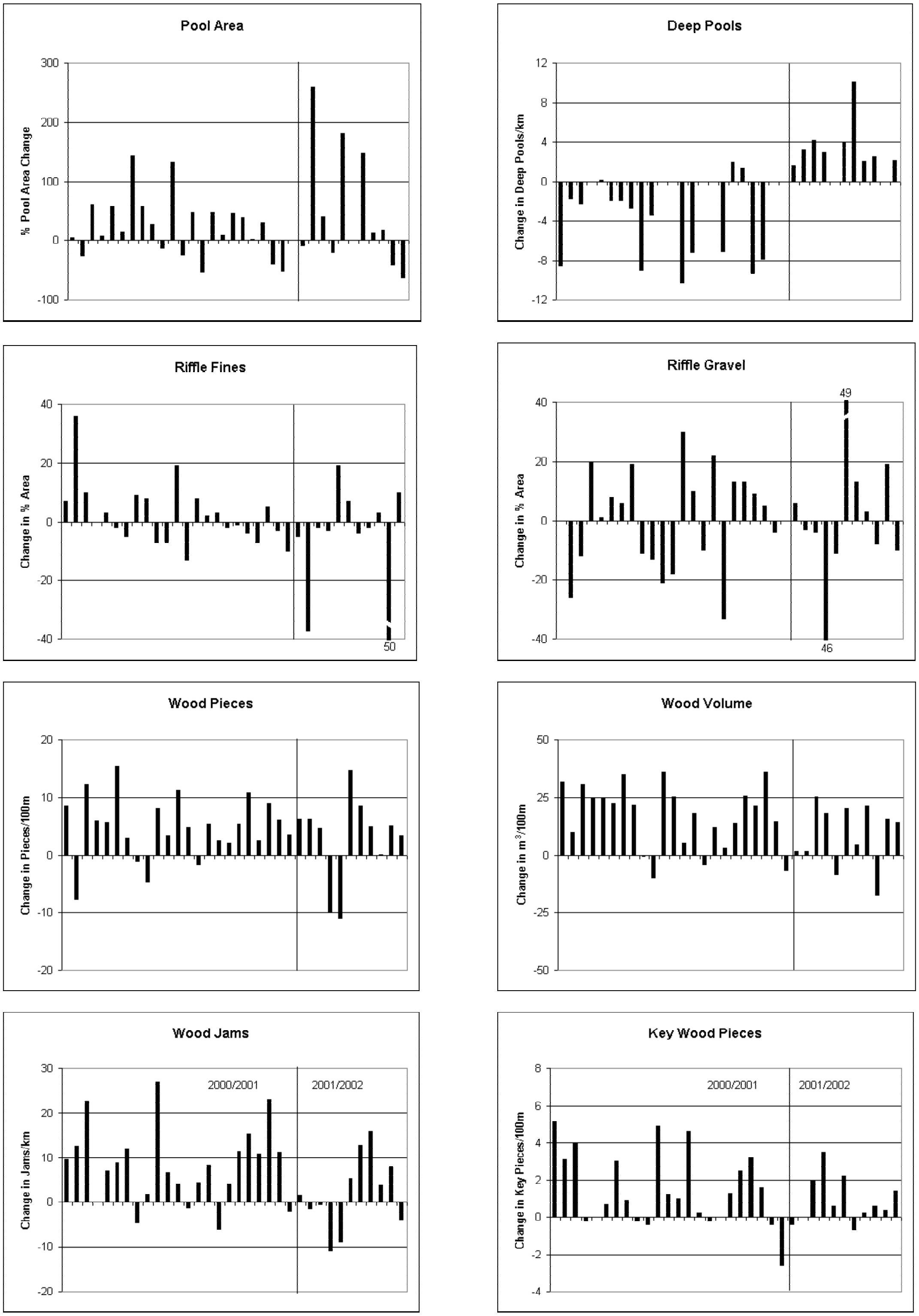


Figure 5. Winter Comparisons of Change at Individual Sites Pre- and Post-Treatment. 2000/2002 (n=34). Sites identified in Table 2.

Table 3. Results of Two-Tailed T-Tests Comparing Pre- and Post-Treatment Data. 2000-2002 (n=34).

	Summer					Winter			
	Pre-Tx	Post-Tx	Difference	P-Value		Pre-Tx	Post-Tx	Difference	P-Value
% Pool Area	40.921	40.488	-0.432	0.939		33.585	37.776	4.192	0.394
Deep Pools / km	1.965	1.656	-0.309	0.650		5.264	4.268	-0.996	0.487
% Riffle Fines	17.912	18.912	1.000	0.659		16.636	16.029	-0.607	0.819
% Riffle Gravel	39.735	47.941	8.206	0.066		51.030	50.000	-1.030	0.826
Wood Pieces / 100 m	11.691	19.453	7.762	**<0.000**		14.233	18.029	3.796	0.066
Wood Volume / 100 m	13.003	38.718	25.715	**<0.000**		15.964	29.815	13.851	**<0.000**
Wood Jams / km	5.798	12.185	6.386	**<0.000**		7.103	13.023	5.920	**0.001**
Key Wood Pieces / 100 m	0.421	2.691	2.271	**<0.000**		0.779	1.721	0.942	**0.006**
% Slackwater Pool Area	4.585	7.809	3.224	0.380		3.673	5.609	1.936	0.343
% Secondary Channel Area	6.324	4.649	-1.674	0.509		5.663	31.128	25.465	**<0.000**

*Significant ($p<0.05$) differences in value between pre- and post-treatment in bold font.

Table 4. Results of Two-Tailed T-Tests Comparing Reference and Post-Treatment Data. Summer 1996-2001 (n=10).

	Reference					**Post Treatment**			
	1996	2001	Difference	P-Value		1996	2001	Difference	P-Value
% Pool Area	48.150	49.790	1.640	0.858		51.200	56.590	5.390	0.383
Deep Pools / km	3.160	1.744	-1.416	0.345		4.110	2.156	-1.954	0.279
% Riffle Fines	18.500	13.111	-5.389	0.303		21.000	15.400	-5.600	0.335
% Riffle Gravel	36.700	39.444	2.744	0.702		50.300	46.900	-3.400	0.546
Wood Pieces / 100 m	14.240	18.000	3.760	0.402		17.660	21.400	3.740	0.233
Wood Volume / 100 m	22.700	15.300	-7.400	0.323		26.540	21.880	-4.660	0.280
Wood Jams / km	6.977	9.849	2.872	0.273		9.740	12.759	3.019	0.127
Key Wood Pieces / 100 m	0.720	0.233	-0.487	0.124		1.180	0.700	-0.480	0.131
% Slackwater Pool Area	3.010	11.156	8.146	0.345		13.390	5.500	-7.890	0.109
% Secondary Channel Area	8.222	7.910	-0.312	0.926		16.256	10.136	-6.120	0.124

*Significant ($p<0.05$) differences in value between pre- and post-treatment in bold font.

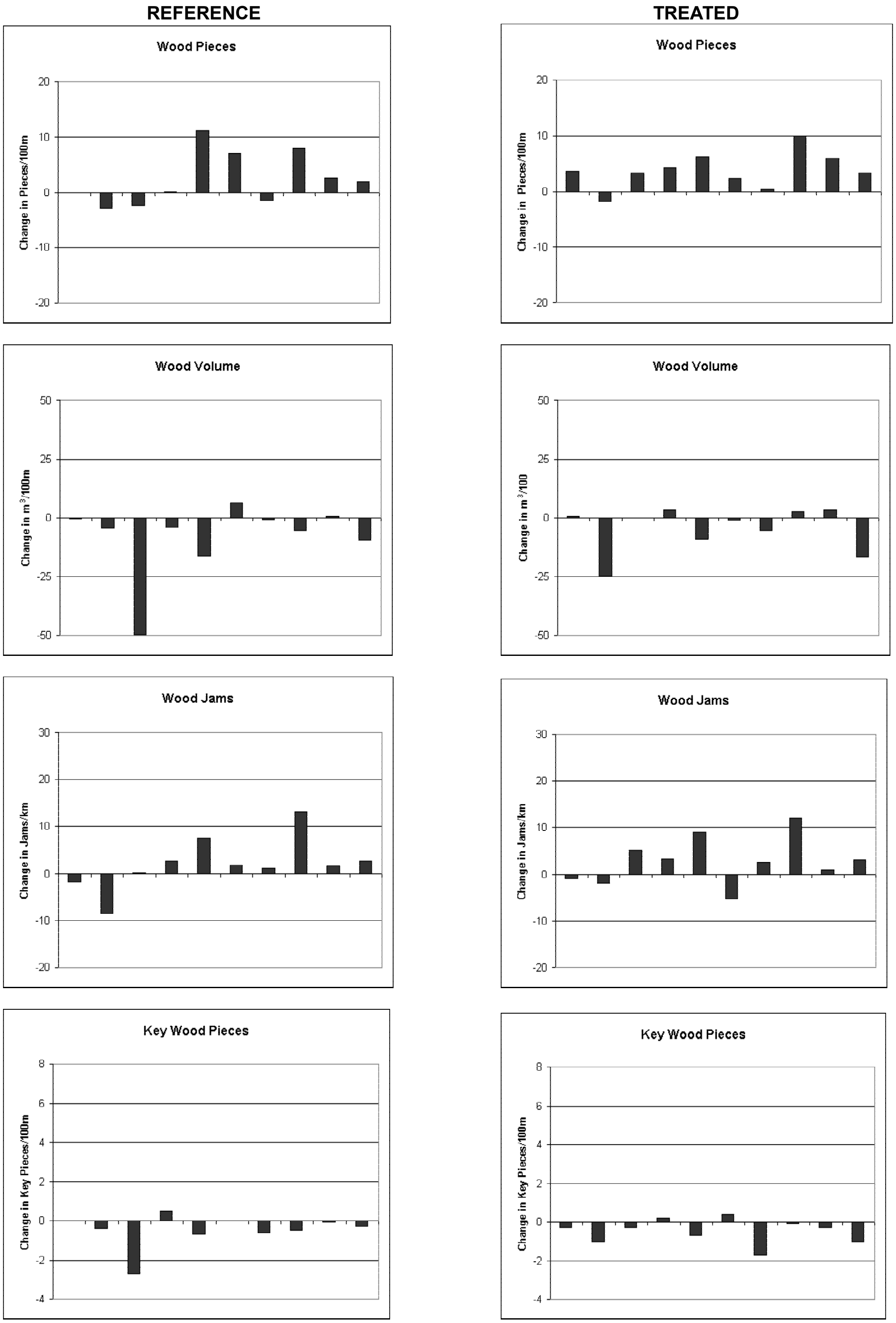


Figure 6. Summer Comparisons of Change in Wood Characteristics at Individual Reference and Treated Sites. 1996/2001 (n=10). Sites identified in Table 2.

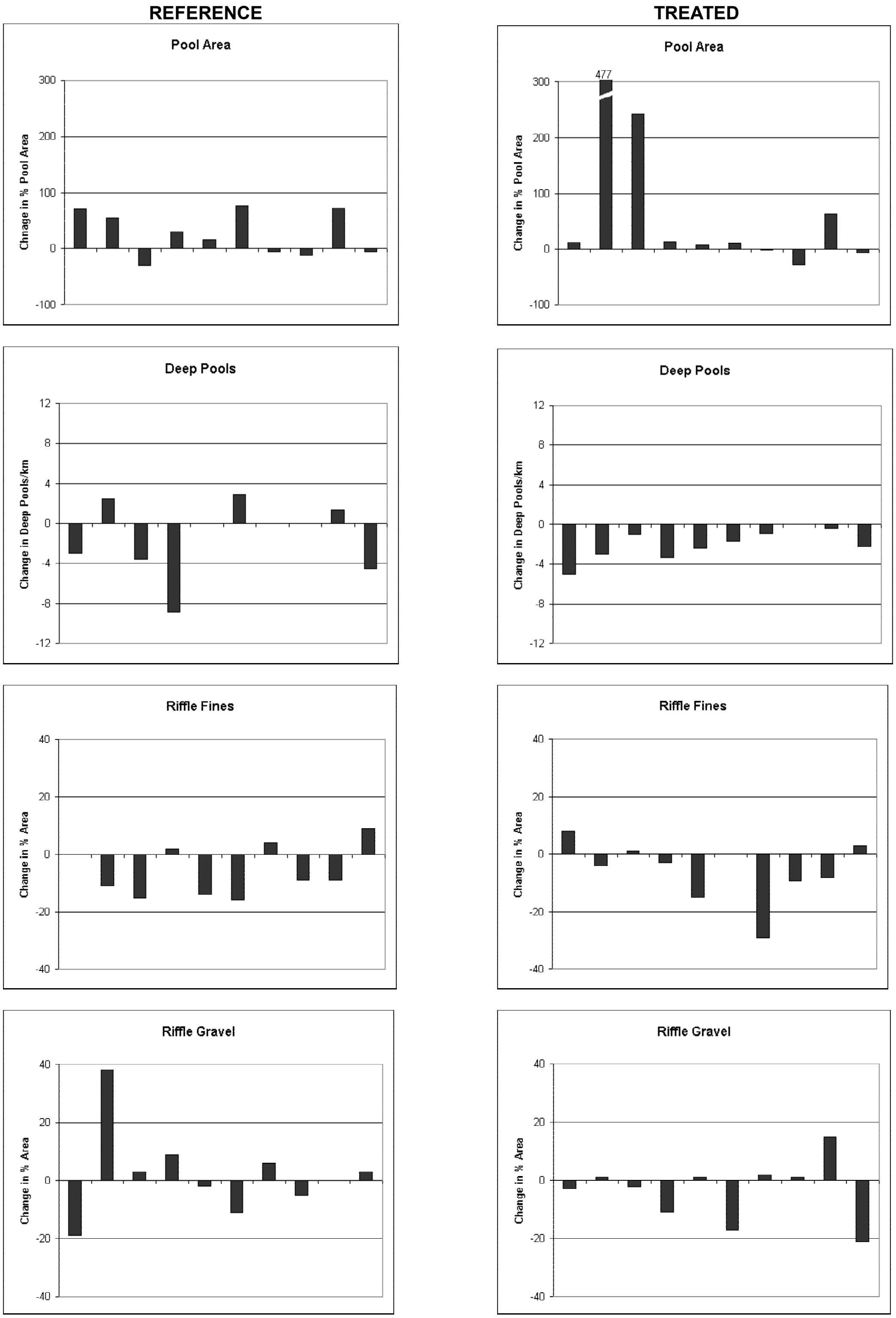


Figure 7. Summer Comparisons of Change in Pool and Substrate Characteristics at Individual Reference and Treated Sites. 1996/2001 (n=10). Sites identified in Table 2.

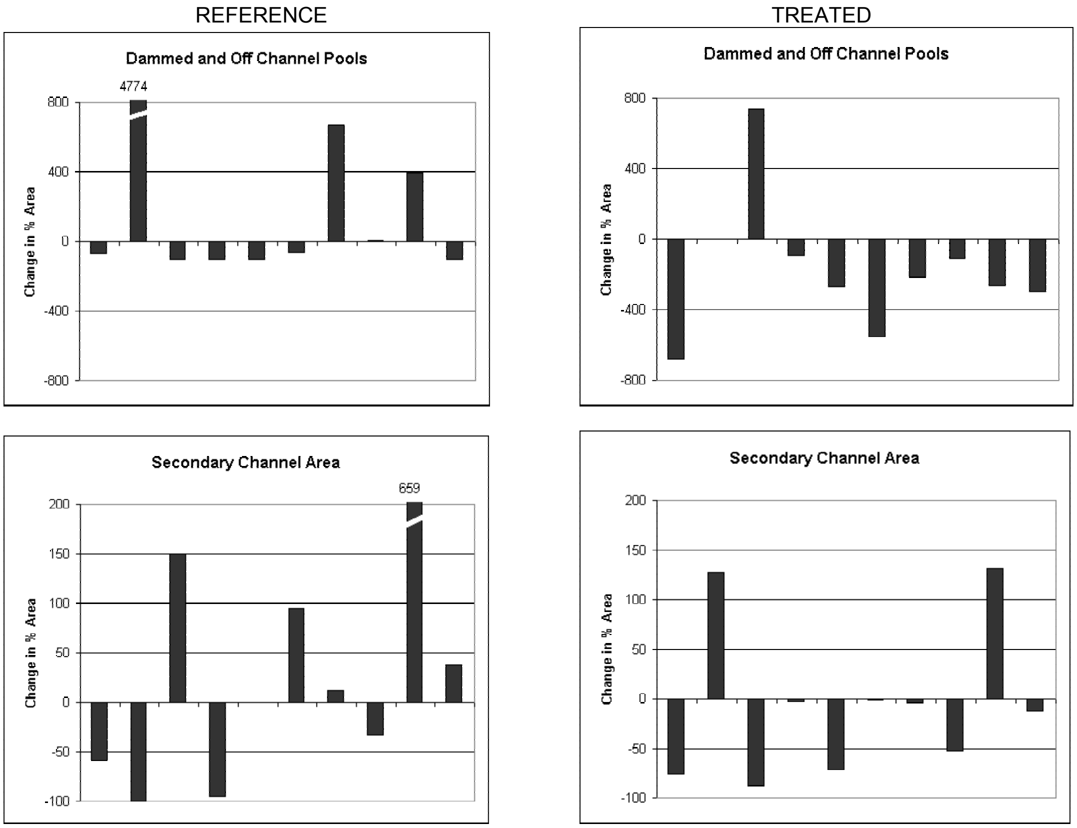


Figure 8. Summer Comparisons of Change in Off-Channel Habitat at Individual Reference and Treated Sites. 1996/2001 (n=10). Sites identified in Table 2.

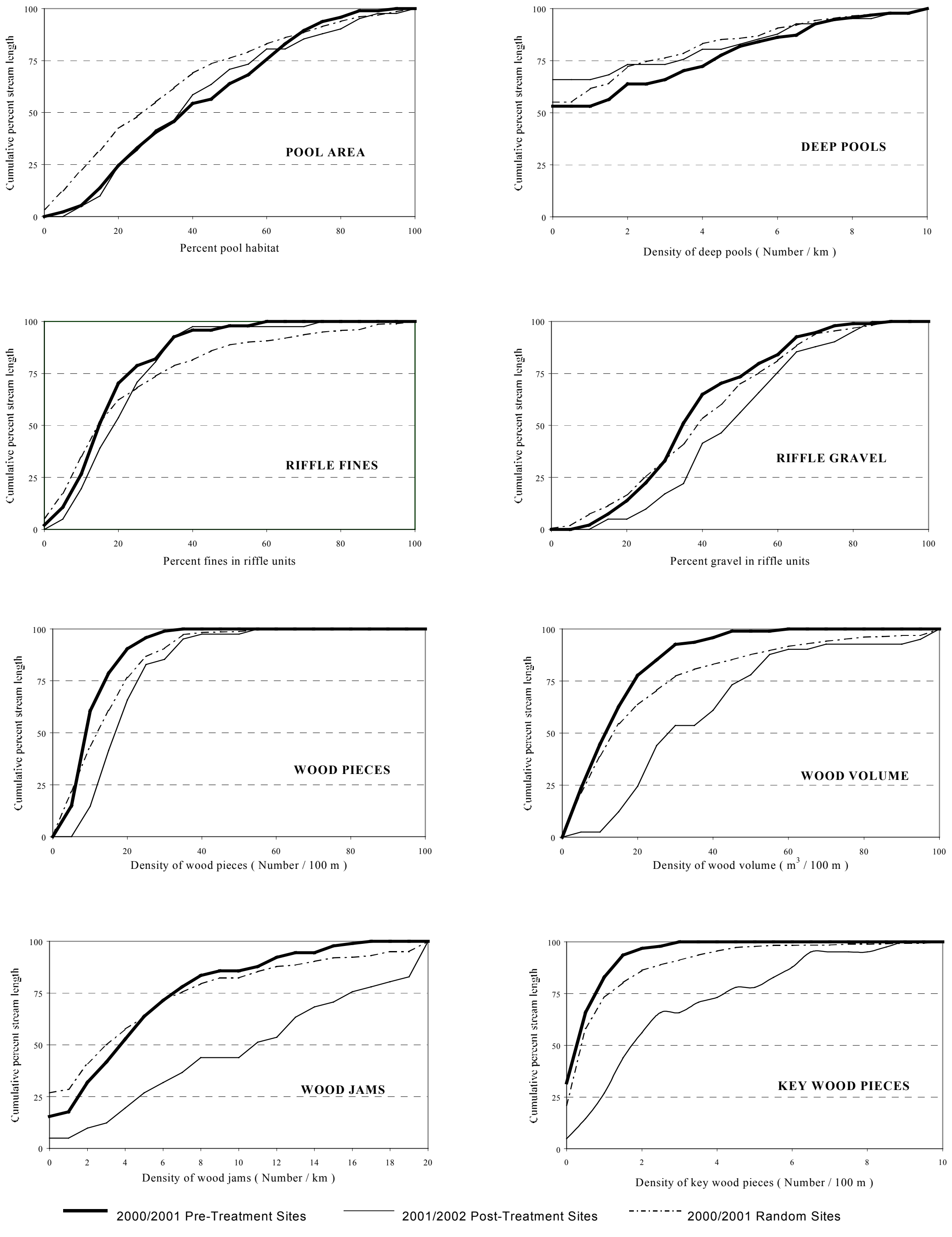


Figure 9. Summer Characterization of Pre-Treatment, Post-Treatment, and Random Sites in 2000-2002.

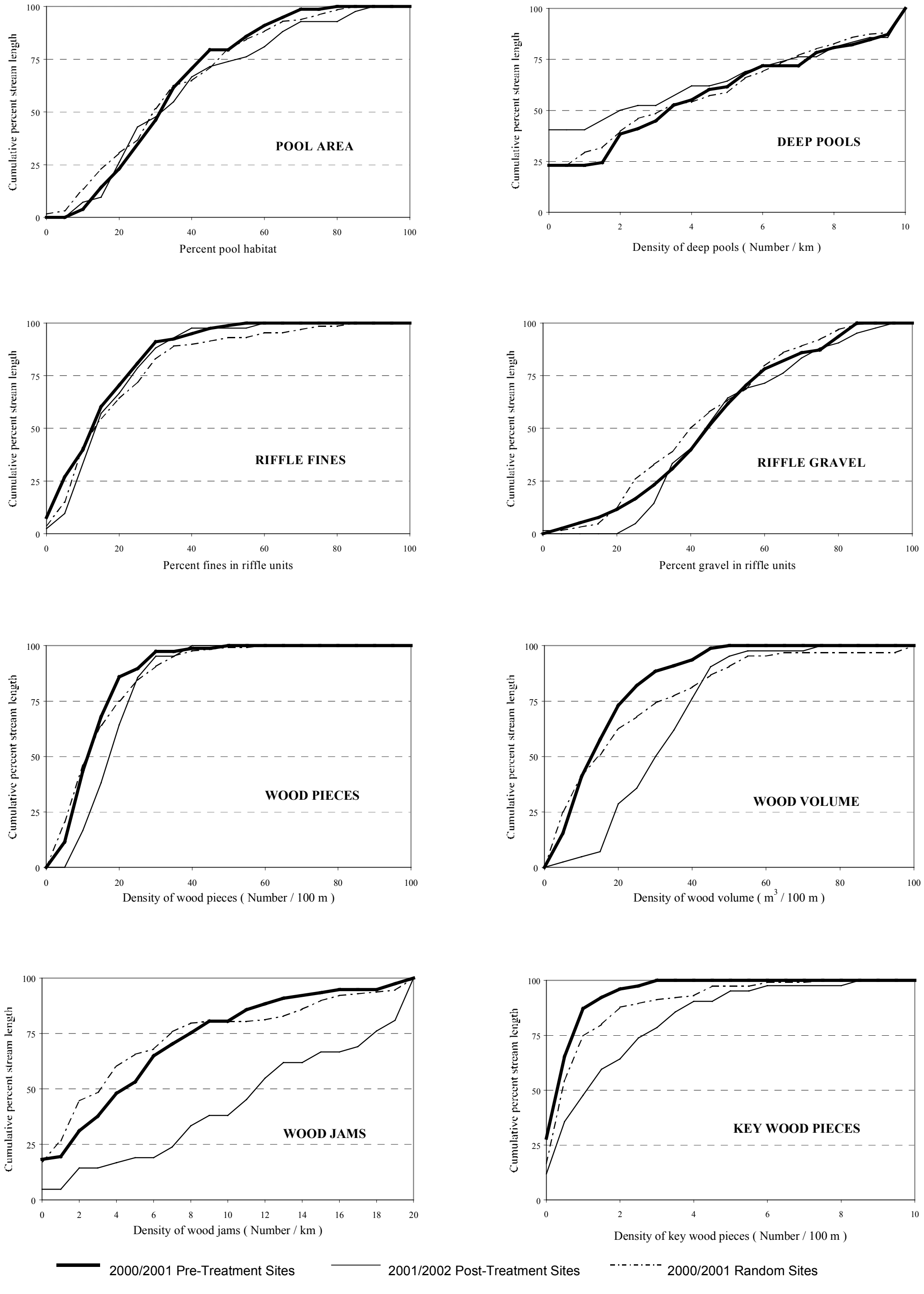


Figure 10: Winter Characterization of Pre-Treatment, Post-Treatment and Random Sites in 2000-2002

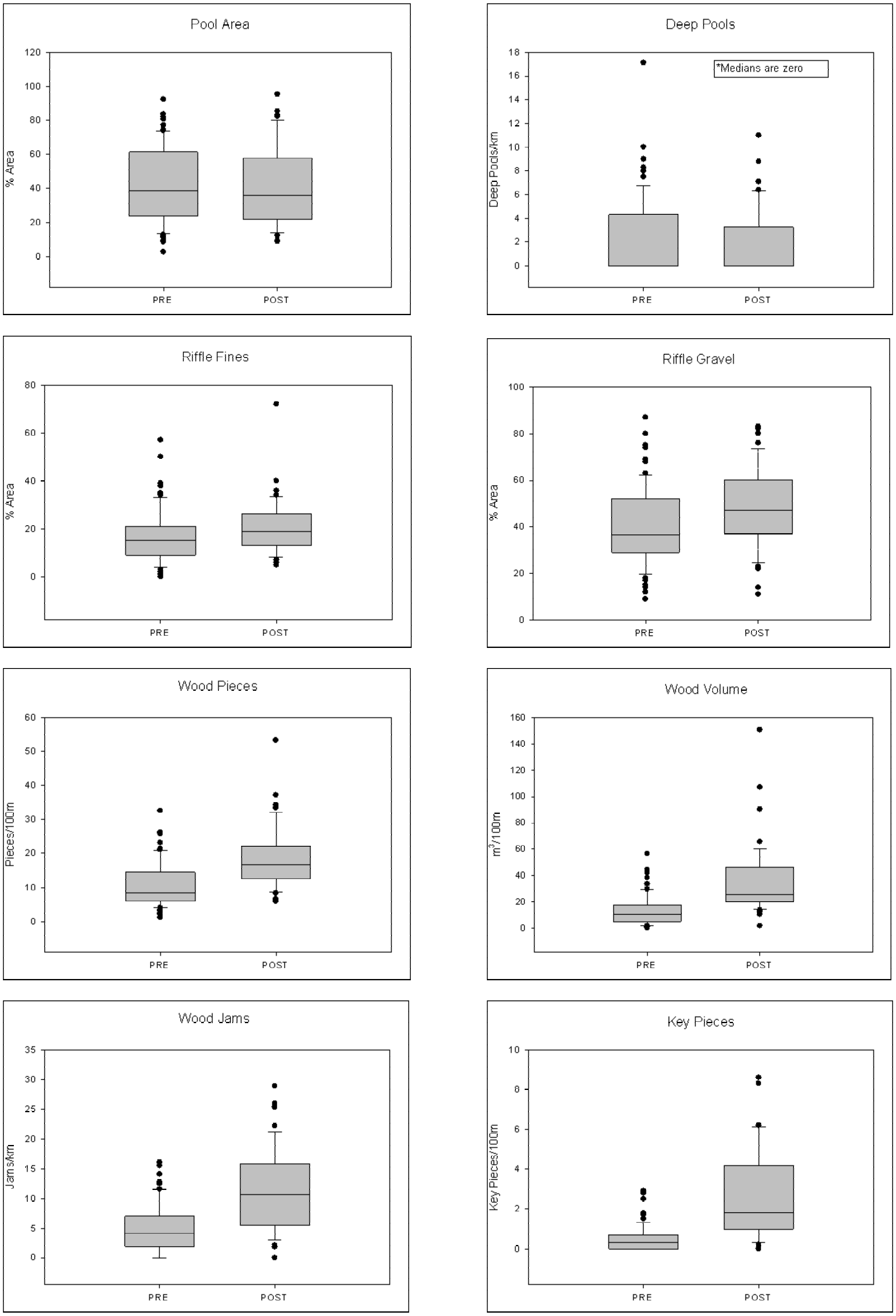


Figure 11. Summer Characterization of Pre-Treatment vs. Post-Treatment. 2000/2002.

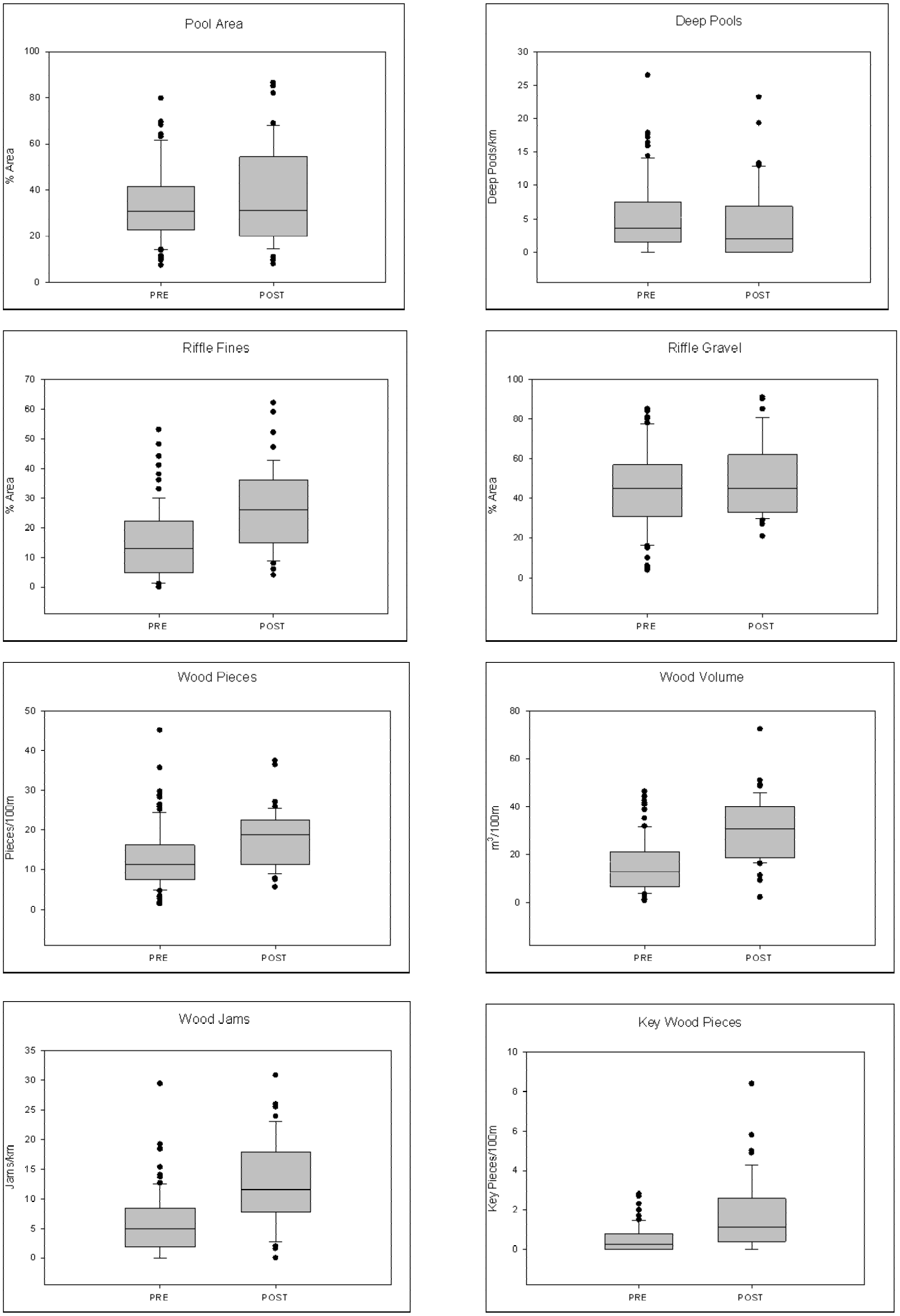


Figure 12. Winter Characterization of Pre-Treatment vs. Post-Treatment. 2000/2002.

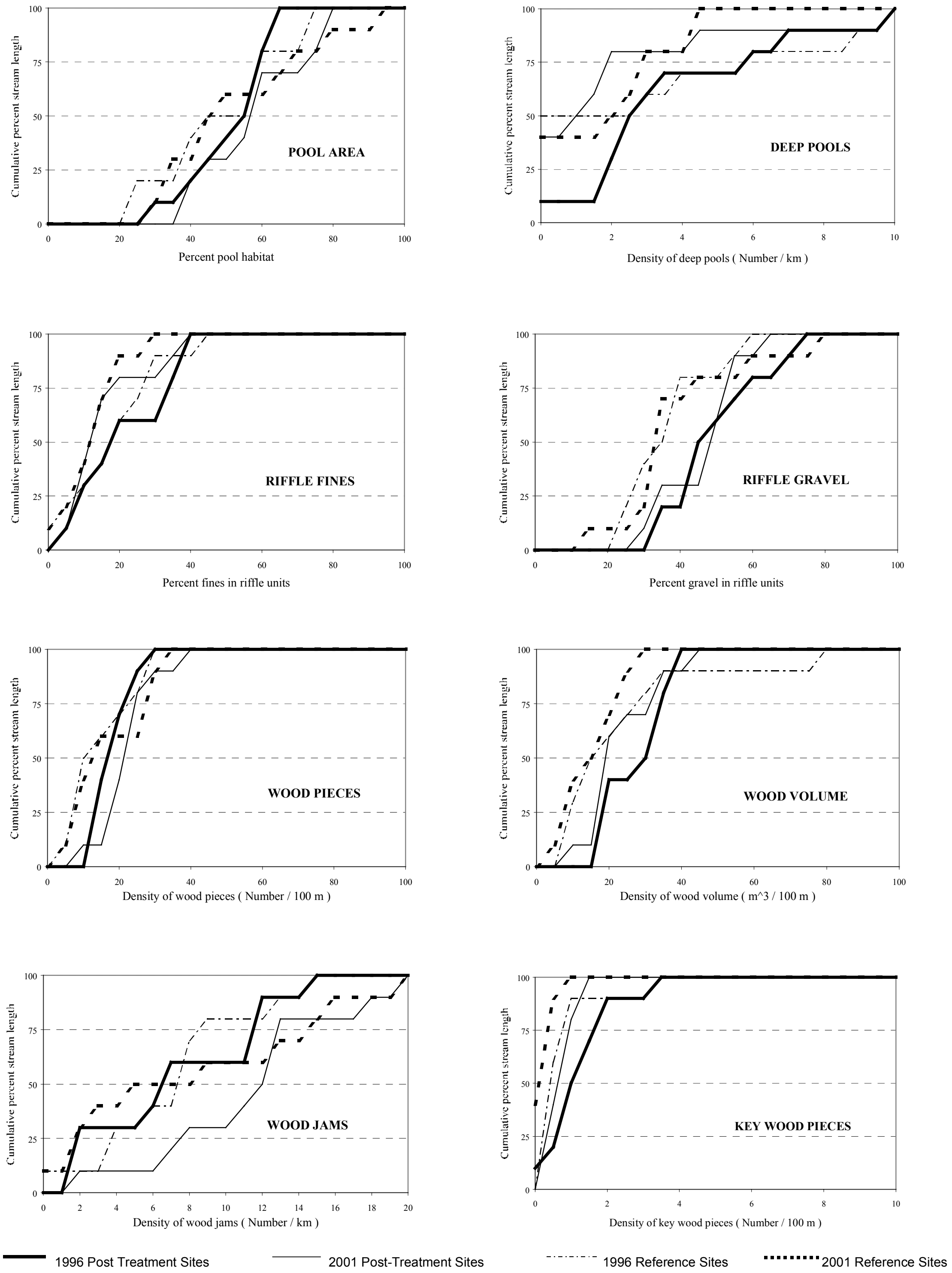


Figure 13. Summer Characterization of Reference vs. Post-Treatment Sites After Six Years. 1996-2001.

Table 5. Number of Restored Reaches With High Quality Habitat Based On Channel Type and Instream Habitat. 2000-2002.

Summer Pre Treatment	Wide Valley Floor Unconstrained	 Potentially Unconstrained	 Deeply Incised	Narrow Valley Constrained By Hillslopes
High Quality	2	0	0	1
Moderate-Low Quality	7	11	10	3
Total Number	9	11	10	4

Summer Post Treatment	Wide Valley Floor Unconstrained	 Potentially Unconstrained	 Deeply Incised	Narrow Valley Constrained By Hillslopes
High Quality	0	4	3	2
Moderate-Low Quality	6	4	10	5
Total Number	6	8	13	7

Winter Pre Treatment	Wide Valley Floor Unconstrained	 Potentially Unconstrained	 Deeply Incised	Narrow Valley Constrained By Hillslopes
High Quality	0	1	1	0
Moderate-Low Quality	7	3	15	7
Total Number	7	4	16	7

Winter Post Treatment	Wide Valley Floor Unconstrained	 Potentially Unconstrained	 Deeply Incised	Narrow Valley Constrained By Hillslopes
High Quality	2	3	1	1
Moderate-Low Quality	6	4	11	6
Total Number	8	7	12	7

Table 6. Number of Restored Reaches With High Quality Habitat Based On Channel Type and Instream Habitat. 1996-2001.

	Wide Valley Floor			Narrow Valley
Six year Reference - 1996	Unconstrained	Potentially Unconstrained	Deeply Incised	Constrained By Hillslopes
High Quality	0	1	0	0
Moderate-Low Quality	1	6	1	1
Total Number	1	7	1	1

	Wide Valley Floor			Narrow Valley
Six year Reference - 2001	Unconstrained	Potentially Unconstrained	Deeply Incised	Constrained By Hillslopes
High Quality	0	0	0	0
Moderate-Low Quality	3	4	2	1
Total Number	3	4	2	1

	Wide Valley Floor			Narrow Valley
Six Year Post Treatment - 1996	Unconstrained	Potentially Unconstrained	Deeply Incised	Constrained By Hillslopes
High Quality	1	5	0	0
Moderate-Low Quality	0	4	0	0
Total Number	1	9	0	0

	Wide Valley Floor			Narrow Valley
Six Year Post Treatment - 2001	Unconstrained	Potentially Unconstrained	Deeply Incised	Constrained By Hillslopes
High Quality	1	1	0	0
Moderate-Low Quality	5	3	0	0
Total Number	6	4	0	0

Table 7. Peak and Average Annual Flows, 1996-2001.

USGS (2003)

*water year is October 1 - September 30.

NEHALEM RIVER NEAR FOSS, OR

	Year	ft^3/s	
ANNUAL MEAN STREAMFLOW	1996	4,128	
	1997	3,256	
	1998	3,246	
	1999	4,047	
	2000	1,739	
	2001	2,104	
PEAK STREAMFLOW	1996	70,300	**
	1997	34,300	
	1998	22,800	
	1999	34,400	
	2000	33,300	
	2001	6,980	***

ALSEA RIVER NEAR TIDEWATER, OR

	Year	ft^3/s	
ANNUAL MEAN STREAMFLOW	1996	2,226	
	1997	1,482	
	1998	1,790	
	1999	1,958	
	2000	1,028	
	2001	923	
PEAK STREAMFLOW	1996	32,100	
	1997	28,200	
	1998	10,200	
	1999	32,500	**
	2000	23,200	
	2001	7,520	***

UMPQUA RIVER NEAR ELKTON, OR

	Year	ft^3/s	
ANNUAL MEAN STREAMFLOW	1996	13,510	
	1997	7,235	
	1998	10,010	
	1999	8,604	
	2000	6,178	
	2001	3,832	
PEAK STREAMFLOW	1996	106,000	
	1997	169,000	**
	1998	61,900	
	1999	117,000	
	2000	98,000	
	2001	14,200	

**25 year record high flow
***record low flow

Appendix A. List of Monitored Sites and Oregon Plan (OPSW) Streams. 2000-2002.

		2000 - 2002	
		RESTORATION SITES	
BASIN	**STREAM NAME**	**SUMMER**	**WINTER**
		n = 70	n = 70
WILLAMETTE	ANTHONY CR	X	X
YAQUINA	BALES CR	X	X
NESTUCCA	BAYS CR	X	X
COQUILLE	BEAR CR	X	X
NECANICUM	BEERMAN CR	X	X
WILSON	BEN SMITH CR	X	X
EUCHRE	BOULDER CR	X	X
UMPQUA	BRADS CR	X	X
CLATSKANIE	BUCK CR	X	X
ALSEA	BUCK CR	X	X
ALSEA	BUMMER CR	X	X
UMPQUA	BYRON CR	X	X
SIUSLAW	CAMP CR	X	X
MOLALLA	CANYON CR	X	X
WILSON	CEDAR CR	X	X
UMPQUA	CHARLOTTE CR	X	X
ALSEA	CHERRY CR	X	X
UMPQUA	CLABBER CR	X	X
NEHALEM	COAL CR	X	
UMPQUA	COON CR	X	X
MILLICOMA	COUGAR CR	X	X
ALSEA	CRAB CR	X	X
SANTIAM	CRABTREE CR, S FK	X	X
SIXES	CRYSTAL CR	X	X
MOLALLA	DEADHORSE CR	X	X
PISTOL	DEEP CR	X	X
MILLICOMA	DEER CR	X	X
YAQUINA	DEER CR	X	X
UMPQUA	DEETS CR	X	X
CLACKAMAS	DELPH CR	X	X
TRASK	EF SF TRASK R TRIB		X
MILLICOMA	ELK CR	X	X
COOS	FALL CR	X	X
NESTUCCA	FARMER CR	X	X
YAQUINA	FEAGLES CR	X	X
MILLICOMA	FISH CR	X	X
CLACKAMAS	FOSTER CR	X	X
CLACKAMAS	GOLF CR	X	X
NECANICUM	GRINDY CR	X	X
UMPQUA	HANEY CR	X	X
ALSEA	HONEY GROVE CR	X	X
CHETCO	JACK CR	X	X
NECANICUM	JOHNSON CR	X	X
WILLAMETTE	KING CR	X	X
NECANICUM	KLOOTCHIE CR		X
NEHALEM	L NF NEHALEM R	X	X
UMPQUA	LANE CR	X	X
SILETZ	LITTLE ROCK CR	X	X
HUNTER	LITTLE SF HUNTER CR	X	X
SANTIAM	LITTLE WILEY CR	X	X
SILETZ	LONG PRAIRIE CR	X	X
MILLICOMA	MILLICOMA R, W FK	X	X
CLACKAMAS	MOSIER CR	X	X
COOS	NF BOTTOM CR	X	X
ROGUE	NF SAUNDERS CR	X	X
NEHALEM	NF WOLF CR	X	X
SIUSLAW	OXBOW CR	X	X
UMPQUA	PANTHER CR	X	X
MIAMI	PETERSON CR	X	X
SIUSLAW	PHEASANT CR	X	
ROGUE	RANCH CR	X	X
COQUILLE	RASLER CREEK	X	X
SANTIAM	ROARING R TRIB	X	X
ELK	ROCK CR	X	X
UMPQUA	SALMONBERRY CR	X	X
ALSEA	SEELEY CR	X	X
UMPQUA	SMITH R		X
UMPQUA	STARVOUT CR	X	X
OCEAN	TURNER CR	X	X
YAQUINA	WOLF CR	X	X
UMPQUA	WOOD CR	X	X

		1996 - 2001	
		RESTORATION SITES	
BASIN	**STREAM NAME**	**SUMMER**	**WINTER**
		n = 10	
NECANICUM	BERGSVICK CR	X	
TILLAMOOK	BEWLEY CR	X	
NEHALEM	DEER CR	X	
ECOLA	ECOLA CR, W FK	X	
NEHALEM	HAMILTON CR	X	
NEHALEM	KENUSKY CR	X	
NECANICUM	KLOOTCHIE CR	X	
NESTUCCA	L NESTUCCA R, S FK	X	
NEHALEM	NF ROCK CR LOWER	X	
NEHALEM	NF ROCK CR UPPER	X	

		2000 - 2002	
		OREGON PLAN STREAMS	
BASIN	**STREAM NAME**	**SUMMER**	**WINTER**
		n = 344	n = 108
ROGUE	1918 GULCH	X	
NEHALEM	ADAMS CR	X	
SALMON	ALDER BROOK	X	
NESTUCCA	ALDER CR	X	X
ROGUE	ALLEN CR	X	
ALSEA	ALSEA R, N FK	X	
ALSEA	ALSEA R, S FK	X	
ALSEA	ALSEA R, S FK		X
NEHALEM	ANDERSON CR	X	
ROGUE	ANTELOPE CR TRIB	X	
ROGUE	APPLEGATE R TRIB	X	
UMPQUA	ASH CR	X	
ROGUE	ASHLAND CR, E FK	X	
ROGUE	ASHLAND CR, W FK	X	
SILETZ	BAKER CR #2	X	
NESTUCCA	BARNEY RIVER TRIB	X	
COQUILLE	BEAR CR	X	
NESTUCCA	BEAR CR	X	
SALMON	BEAR CR		X
UMPQUA	BEAR CR	X	
SIUSLAW	BEAR CR, S FK	X	
NEHALEM	BEAVER CR	X	
SIUSLAW	BEAVER CR	X	
OCEAN	BELL CR	X	X
WILSON	BEN SMITH CR	X	X
OCEAN	BENSON CR	X	
NECANICUM	BERGSVICK CR	X	
SIUSLAW	BERKSHIRE CR	X	X
COOS	BESSEY CR	X	
NESTUCCA	BIBLE CR	X	
OCEAN	BIG CR	X	X
OCEAN	BIG CR, S FK	X	
SILETZ	BIG ROCK CR	X	
UMPQUA	BIG TOM FOLLEY CR		X
ROGUE	BILLINGS CR	X	
ELK	BLACKBERRY CR TRIB	X	
UMPQUA	BOB CR	X	
UMPQUA	BONNIE CR TRIB	X	
COOS	BOTTOM CR		X
OCEAN	BOULDER CR	X	
SILETZ	BOULDER CR	X	
UMPQUA	BOULDER CR	X	X

		2000 - 2002	
		OREGON PLAN STREAMS	
BASIN	STREAM NAME	SUMMER	WINTER
CHETCO	BOULDER CR TRIB	X	
TRASK	BOUNDARY CR	X	X
CHETCO	BOX CANYON	X	
NECANICUM	BRANDIS CR	X	
COQUILLE	BRIDGE CR	X	
UMPQUA	BRUSH CR		X
ROGUE	BRUSH CR TRIB	X	
NEHALEM	BUCHANAN CR	X	
COQUILLE	BUCK CR	X	
ROGUE	BULL CR	X	
UMPQUA	BURNT CR	X	X
NEHALEM	BUSTER CR		X
NEHALEM	BUSTER CR TRIB	X	
OCEAN	BUTTE CR	X	X
UMPQUA	CALAPOOYA CR	X	X
UMPQUA	CAMAS CR	X	
COQUILLE	CAMAS CR, E FK	X	
UMPQUA	CAMP CR	X	
OCEAN	CANYON CR	X	
UMPQUA	CANYON CR	X	X
ALSEA	CARNS CANYON	X	
COQUILLE	CATCHING CR	X	X
UMPQUA	CAVITT CR	X	X
NEHALEM	CEDAR CR	X	
WILSON	CEDAR CR TRIB	X	
WILSON	CEDAR CR, N FK		X
ROGUE	CEDAR SWAMP CR	X	
SILETZ	CERINE CR	X	X
ROGUE	CHAPMAN CR TRIB	X	
SIUSLAW	CHAPPEL CR	X	X
CHETCO	CHETCO R	X	
ROGUE	CLARK CR	X	
SIUSLAW	CLAY CR	X	X
ROGUE	CLAYTON CR	X	
UMPQUA	CLEAR CR	X	X
NESTUCCA	CLEAR CR	X	X
TRASK	CLEAR CR	X	
SIUSLAW	CLEVELAND CR	X	X
COQUILLE	COLE CR	X	
SIUSLAW	CONDON CR	X	X
ROGUE	COON CR	X	
UMPQUA	COON CR	X	X
UMPQUA	COPELAND CR	X	
UMPQUA	COPELAND CR TRIB	X	
COQUILLE	COQUILLE R, N FK	X	
COQUILLE	COQUILLE R, N FK		X
COQUILLE	COQUILLE R, S FK	X	
NEHALEM	COW CR	X	X
UMPQUA	COW CR TRIB	X	
UMPQUA	COW CR, FORTUNE BR	X	
COOS	COX CANYON		X
ROGUE	COYOTE CR	X	
ALSEA	CRAB CR	X	X
NEHALEM	CRAWFORD CR	X	
NEHALEM	CRONIN CR, N FK	X	
NEHALEM	CRONIN CR, N FK		X
NEHALEM	CROOKED CR	X	
UMPQUA	CROOKED CR	X	
SIXES	CRYSTAL CR	X	
COOS	DANIELS CR	X	X
ROGUE	DANS CR	X	
UMPQUA	DAYS CR	X	X
SIUSLAW	DEADWOOD CR	X	X
YAQUINA	DEER CR	X	
UMPQUA	DEER CR TRIB	X	
YAQUINA	DEER CR TRIB	X	
NEHALEM	DELL CR		X
WILSON	DEO CR	X	
COOS	DEVILS ELBOW CR	X	
SILETZ	DEWEY CR	X	
ROGUE	DITCH CR	X	
UMPQUA	DIXON CR	X	
SIUSLAW	DOGWOOD CR		X
SILETZ	DRIFT CR	X	X
ROGUE	DRY CR	X	
SIXES	DRY CR	X	
ROGUE	DUTCH CR TRIB	X	
NESTUCCA	E BEAVER CR	X	X
UMPQUA	E FK COPELAND CR	X	
YAQUINA	E FK MILL TRIB	X	
MILLICOMA	E FK MILLICOMA R	X	X
MILLICOMA	E FK MILLICOMA R TRIB	X	
ROGUE	ELDER CR TRIB	X	
COQUILLE	ELK CR	X	X
NESTUCCA	ELK CR	X	X
SIUSLAW	ELK CR	X	
WILSON	ELK CR TRIB	X	
COQUILLE	ELK CR, S FK		X
OCEAN	ELKHORN CR		X
OCEAN	ELKHORN CR TRIB	X	
SIUSLAW	ESMOND CR	X	X
EUCHRE	EUCHRE CR	X	
UMPQUA	FAIRVIEW CR	X	
ROGUE	FALL CR	X	
TILLAMOOK	FAWCETT CR	X	
COQUILLE	FERRY CR	X	
SIUSLAW	FISH CR	X	
UMPQUA	FISH LAKE CR TRIB	X	
ALSEA	FIVE RIVERS	X	
ROGUE	FOOTS CR, M FK	X	
ROGUE	FOX CR	X	
UMPQUA	FRENCH CR	X	
OCEAN	FRYINGPAN CR	X	
ROGUE	GILBERT CR	X	
NEHALEM	GILMORE CR	X	X
NEHALEM	GINGER CR	X	
PISTOL	GLADE CR	X	
COOS	GODS THUMB CR	X	
ALSEA	GOLD CR		X
TRASK	GOLD CR, N FK	X	
NEHALEM	GRAVEL CR	X	
ALSEA	GREEN R	X	
SIUSLAW	HADSALL CR, TRIB D		X
SIUSLAW	HAIGHT CR	X	
ROGUE	HANLEY CR	X	
UMPQUA	HARE CR	X	
UMPQUA	HARLAN CR	X	
ALSEA	HATCHERY CR		X
UMPQUA	HEDDIN CR	X	
COOS	HOG RANCH CR	X	
ALSEA	HONEY GROVE CR		X
ALSEA	HONEY GROVE CR TRIB A	X	
TRASK	HOQUARTEN SLOUGH	X	
OCEAN	HORSE CR	X	
UMPQUA	HORSE CR	X	
UMPQUA	HUBBARD CR TRIB	X	
ROGUE	HUKILL CR	X	
NEHALEM	HUMBUG CR		X
UMPQUA	INDIAN CR	X	
COQUILLE	INDIAN CR TRIB	X	
SIUSLAW	INDIAN CR, N FK	X	
ROGUE	JACK CR	X	
OCEAN	JEFFRIES CR	X	
ROGUE	JENNY CR	X	
UMPQUA	JERRY CR	X	
COQUILLE	JERUSALEM CR	X	X
ROGUE	JIM HUNT CR	X	
ROGUE	JOE CR	X	
COQUILLE	JOHNS CR	X	X
OCEAN	JOHNSON CR	X	X
WILSON	JORDAN CR		X
UMPQUA	JOYCE CR, W FK	X	

		2000 - 2002	
		OREGON PLAN STREAMS	
BASIN	STREAM NAME	SUMMER	WINTER
ROGUE	JUMPOFF JOE CR	X	
ROGUE	KANE CR	X	
SIUSLAW	KELLY CR	X	
COOS	KENTUCK CR	X	X
NEHALEM	KENUSKY CR		X
KILCHIS	KILCHIS R, LITTLE S FK	X	
KILCHIS	KILCHIS R, N FK	X	
COQUILLE	KING CR	X	
COQUILLE	KIRKENDALL BR	X	
NECANICUM	KLOOTCHIE CR	X	
NECANICUM	KLOOTCHIE CR TRIB	X	
SIUSLAW	KNOWLES CR	X	
ROGUE	LAKE CR	X	
SIUSLAW	LAKE CR	X	
UMPQUA	LAST CR	X	
UMPQUA	LAUGHLIN CR	X	
ROGUE	LAWSON CR	X	
UMPQUA	LAWSON CR	X	
ROGUE	LICK CR	X	
COOS	LILLIAN CR	X	X
CHETCO	LITTLE DRY CR	X	
ALSEA	LITTLE LOBSTER CR		X
COOS	LITTLE MATSON CR	X	
NEHALEM	LITTLE RACKHEAP CR	X	
COQUILLE	LITTLE ROCK CR	X	
SILETZ	LITTLE ROCK CR	X	
ROGUE	LITTLE WINDY CR	X	
UMPQUA	LITTLE WOLF CR	X	
ALSEA	LOBSTER CR	X	
NEHALEM	LOUISGNONT CR	X	X
UMPQUA	LUTSINGER CR	X	
UMPQUA	MAPLE CR	X	
SIUSLAW	MARIA CR	X	
PISTOL	MEADOW CR	X	
MIAMI	MIAMI R	X	X
COQUILLE	MIDDLE CR	X	
UMPQUA	MIDDLE CR TRIB	X	
ROGUE	MIKES GULCH	X	
COQUILLE	MILL CR	X	
OCEAN	MILL CR	X	X
TRASK	MILL CR	X	
YAQUINA	MILL CR	X	X
OCEAN	MILLER CR	X	
UMPQUA	MILLER CR	X	X
MIAMI	MINICH CR		X
YAQUINA	MONTGOMERY CR	X	
NEHALEM	MUD FORK BATTLE CR	X	
ROGUE	MULE CR TRIB	X	
OCEAN	MUSSEL CR	X	
KILCHIS	MYRTLE CR	X	
OCEAN	MYRTLE CR	X	
COQUILLE	MYRTLE CR TRIB	X	
OCEAN	N FK BEAVER CR TRIB	X	
COQUILLE	N FK COQUILLE R TRIB	X	
NEHALEM	N FK REESE TRIB	X	
TRASK	N FK TRASK R TRIB	X	
UMPQUA	N MYRTLE CR		X
SIUSLAW	N.FK INDIAN CR		X
SIUSLAW	N.FK. INDIAN CR TRIB	X	
NEHALEM	NEAHKAHNIE CR	X	X
NECANICUM	NECANICUM R	X	X
NECANICUM	NECANICUM R, S FK	X	
NECANICUM	NECANICUM R, S FK		X
NEHALEM	NEHALEM R, N FK	X	X
NEHALEM	NEHALEM R, N FK, TRIB R	X	
NESTUCCA	NESTUCCA R	X	
NESTUCCA	NIAGARA CR	X	
CHETCO	NOOK CR	X	
SILETZ	NORTH CR		X
ROGUE	NORTH PRONG CR	X	
NEHALEM	NORTHRUP CR	X	

		2000 - 2002	
		OREGON PLAN STREAMS	
BASIN	STREAM NAME	SUMMER	WINTER
NEHALEM	OAK RANCH CR	X	X
ROGUE	OBRIEN CR	X	
YAQUINA	OLALLA CR, TRIB A	X	
ROGUE	OSIER CR	X	
COOS	PACKARD CR	X	X
ROGUE	PANTHER GULCH	X	
COQUILLE	PARK CR, TRIB B		X
UMPQUA	PART CR	X	
NEHALEM	PEBBLE CR	X	X
PISTOL	PISTOL R	X	
ROGUE	PLEASANT CR, QUEENS BR	X	
SIUSLAW	PORTER CR	X	
UMPQUA	QUINES CR	X	
ROGUE	RAMSEY CANYON	X	
TRASK	RAWE CR	X	X
ROGUE	REEVES CR	X	
ROGUE	REUBEN CR	X	
NETARTS BAY	RICE CR	X	
OCEAN	ROBERTS CR	X	
UMPQUA	ROBERTS CR TRIB	X	
COQUILLE	ROCK CR	X	
NEHALEM	ROCK CR	X	X
ROGUE	ROCK CR TRIB	X	
COOS	ROGERS CR		X
SILETZ	ROGERS CR	X	X
ROGUE	ROGUE R TRIB	X	
ROGUE	ROUGH AND READY CR, S FK	X	
COQUILLE	ROWLAND CR	X	
ROGUE	S FK COLLIER CR TRIB	X	
UMPQUA	S SISTER CR	X	X
NEHALEM	SAGER CR	X	
SALMON	SALMON R	X	X
SALMON	SALMON R TRIB	X	
NEHALEM	SALMONBERRY R, N FK	X	
UMPQUA	SALT CR #2	X	
SILETZ	SAM CR		X
SILETZ	SAMPSON CR, UNNAMED TRIB	X	
SAND LAKE	SAND CR	X	
NESTUCCA	SANDERS CR (SMITH CR)	X	
COOS	SCHUMACHER CR	X	
UMPQUA	SECTION CR	X	
UMPQUA	SERVICEBERRY CR	X	
UMPQUA	SHEILDS CR	X	X
UMPQUA	SHIVELY CR, E FK	X	
UMPQUA	SHOUP CR	X	
SILETZ	SILETZ RIVER TRIB	X	
ROGUE	SILVER CR	X	
COOS	SILVER CR, W FK	X	
TILLAMOOK	SIMMONS CR	X	
SIUSLAW	SIUSLAW R	X	X
SIXES	SIXES R	X	X
UMPQUA	SKIMMERHORN CR	X	
ALSEA	SLICK CR	X	
ALSEA	SLIDE CR	X	
COOS	SLIDE OUT CR	X	
UMPQUA	SLIPPER CR	X	
NESKOWIN	SLOAN CR	X	X
UMPQUA	SLOTTED PEN CR	X	
UMPQUA	SMITH CR	X	X
UMPQUA	SMITH R, N FK	X	
UMPQUA	SMITH R, N FK, M FK	X	
UMPQUA	SMITH R, S FK		X
ROGUE	SODA CR	X	
YAQUINA	SPOUT CR	X	X
UMPQUA	STARVOUT CR	X	X
COQUILLE	STEELE CR	X	X
SILETZ	STEERE CR	X	
NESTUCCA	STILLWELL CR	X	
YACHATS	STUMP CR	X	
ROGUE	SUGARPINE CR	X	
TRASK	SUMMIT CR, S FK		X

		2000 - 2002	
		OREGON PLAN STREAMS	
BASIN	**STREAM NAME**	**SUMMER**	**WINTER**
SILETZ	SUNSHINE CR		X
TILLAMOOK	SUTTON CR	X	X
COOS	TALBOTT CR	X	
ROGUE	TALLOWBOX CR TRIB	X	
ROGUE	TAYLOR CR, S FK	X	
OCEAN	TENMILE CR	X	
NESTUCCA	TESTAMENT CR	X	
UMPQUA	THIELSEN CR	X	
OCEAN	THOMAS CR TRIB	X	
ROGUE	THOMPSON CR	X	
NESTUCCA	THREE RIVERS	X	
TILLAMOOK	TILLAMOOK R	X	X
COOS	TIOGA CR		X
UMPQUA	TOLO CR TRIB	X	
SILETZ	TONY CR	X	
ROGUE	TRAIL CR, W FK	X	
MIAMI	TRIANGULATION CR	X	
COQUILLE	TWELVEMILE CR TRIB	X	
ROGUE	TWO BIT CR	X	
OCEAN	TWOMILE CR		X
UMPQUA	UMPQUA R TRIB	X	
SIUSLAW	UNCLE CR	X	X
NEHALEM	UNNAMED TRIB E FK NEHALEM	X	
COQUILLE	UPPER LAND CR		X
ROGUE	UPTON SLOUGH	X	
TILLAMOOK BAY	VAUGHN CR		X
SIUSLAW	WAITE CR TRIB	X	

		2000 - 2002	
		OREGON PLAN STREAMS	
BASIN	**STREAM NAME**	**SUMMER**	**WINTER**
MIAMI	WALDRON CR	X	X
NEHALEM	WALKER CR	X	
NESTUCCA	WALKER CR	X	
COQUILLE	WARD CR	X	
SILETZ	WARNICKE CR	X	
SILETZ	WARNICKE CR TRIB	X	
ROGUE	WATER BRANCH	X	
UMPQUA	WEATHERLY CR	X	
NESTUCCA	WEST CR	X	
NEHALEM	WEST HUMBUG CR TRIB	X	
OCEAN	WHALEHEAD CR, S FK	X	
ROGUE	WHETSTONE CR	X	
UMPQUA	WHITE MULE CR	X	
UMPQUA	WHITEHORSE CR	X	
SIUSLAW	WHITTAKER CR		X
OCEAN	WILDCAT CR	X	X
WILSON	WILSON CR	X	
COOS	WINCHESTER CR	X	
OCEAN	WINCHUCK R, E FK	X	
OCEAN	WINCHUCK R, S FK	X	
UMPQUA	WOLF CR	X	X
UMPQUA	WOOD CR	X	X
COOS	WREN SMITH CR	X	X
YACHATS	YACHATS R, N FK		X
YACHATS	YACHATS R, N FK	X	
ROGUE	YALE CR	X	
YAQUINA	YOUNG CR	X	

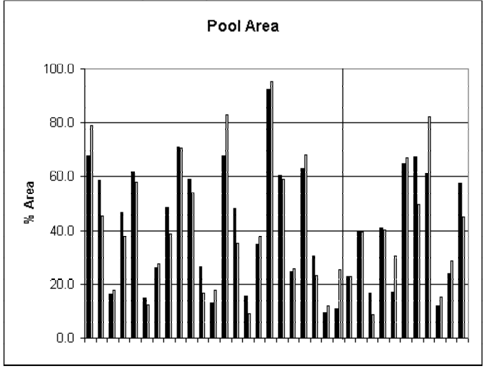
Appendix B. Stream Channel and Riparian Habitat Benchmark.

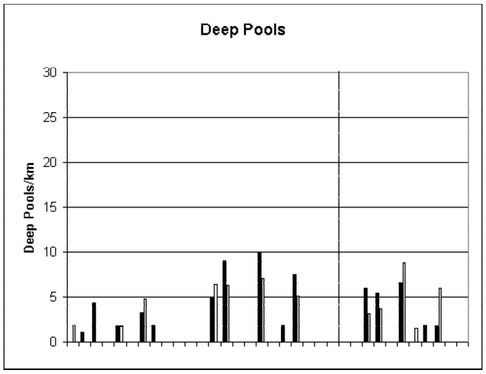
(From Flitcroft et al. 2002)

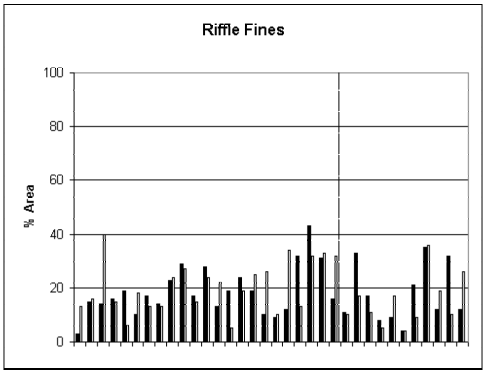
POOLS	UNDESIRABLE	DESIRABLE
POOL AREA (% Total Stream Area)	<10	>35
POOL FREQUENCY (Channel Widths Between Pools)	>20	5-8
RESIDUAL POOL DEPTH		
SMALL STREAMS(<7m width)	<0.2	>0.5
MEDIUM STREAMS(≥ 7m and < 15m width)		
LOW GRADIENT (slope <3%)	<0.3	>0.6
HIGH GRADIENT (slope >3%)	<0.5	>1.0
LARGE STREAMS (≥15m width)	<0.8	>1.5
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

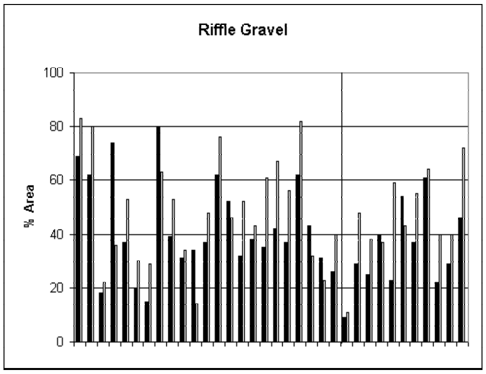
* Values for Streams in Forested Basins

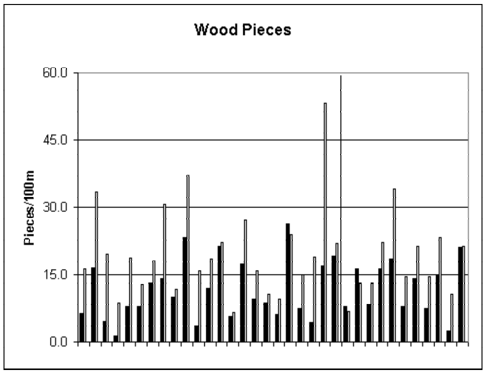
Appendix C. Summer Comparisons of Individual Sites Pre- and Post-Treatment. 2000/2002 (n=34). Sites identified in Table 2.

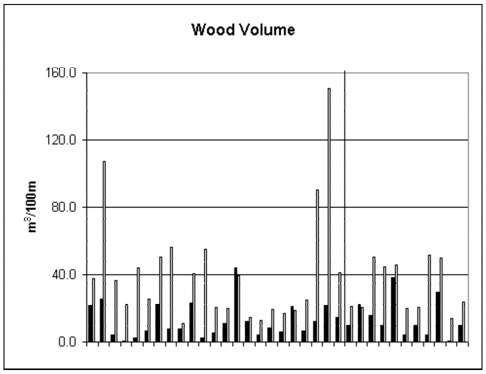


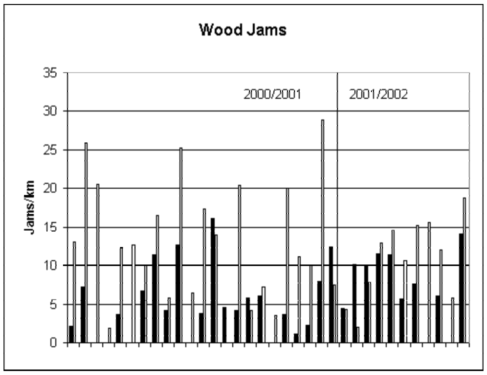


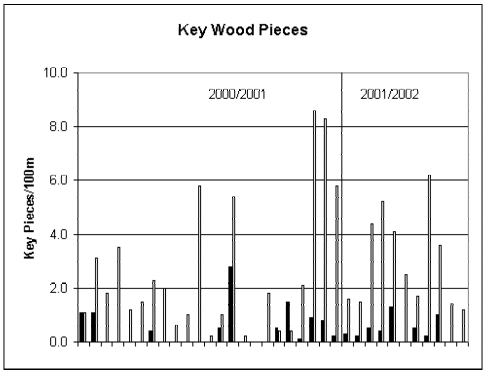




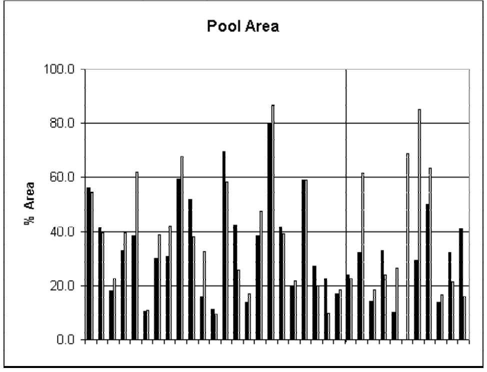








Appendix D. Winter Comparisons of Individual Sites Pre- and Post-Treatment. 2000/2002 (n=34). Sites identified in Table 2.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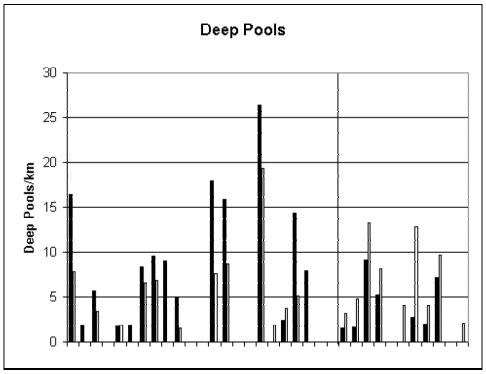
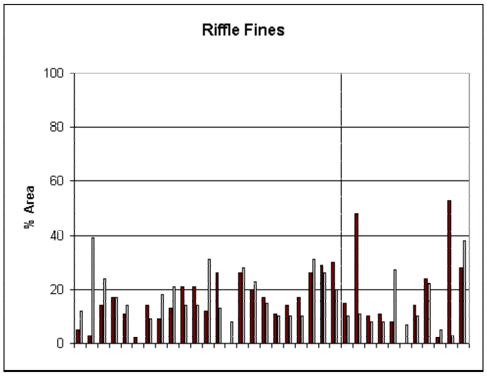
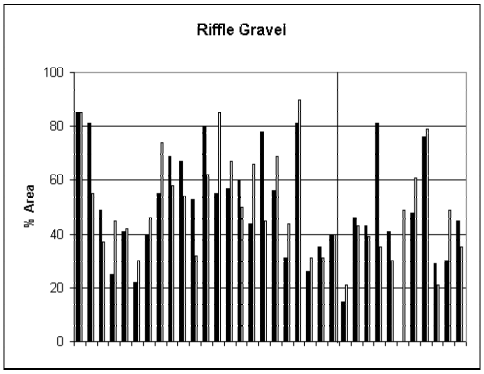
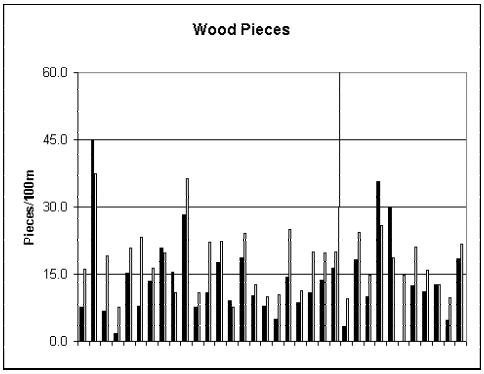
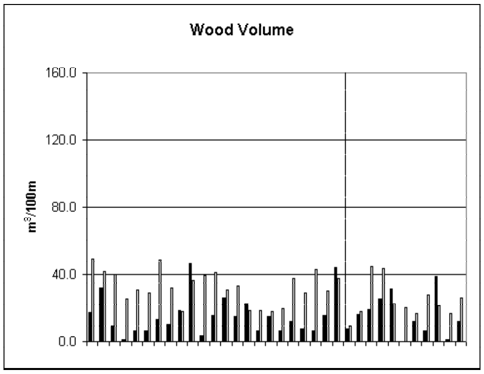
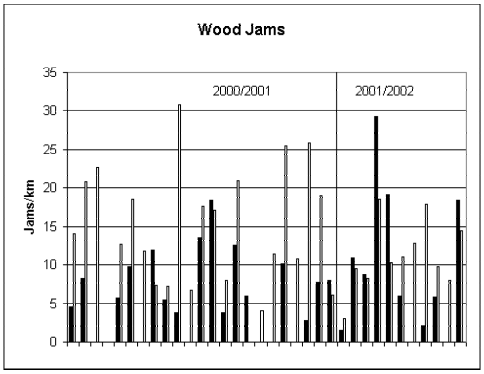

Deep Pools

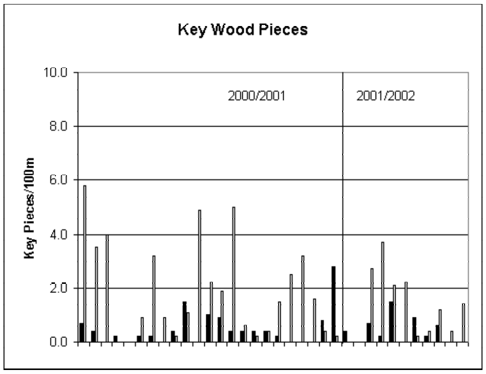

Riffle Fines


Riffle Gravel


Wood Pieces


Wood Volume


Wood Jams


Key Wood Pieces

Appendix E. Summer Comparisons of Individual Sites Pre- and Post-Treatment. 1996/2001 (n=10). Sites identified in Table 2.

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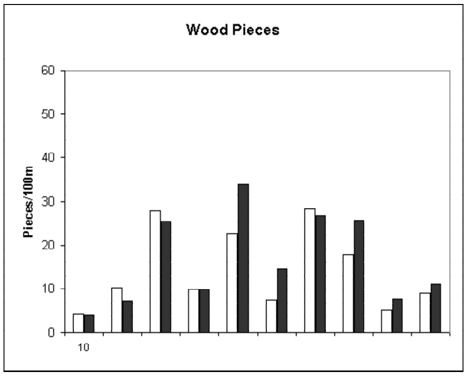

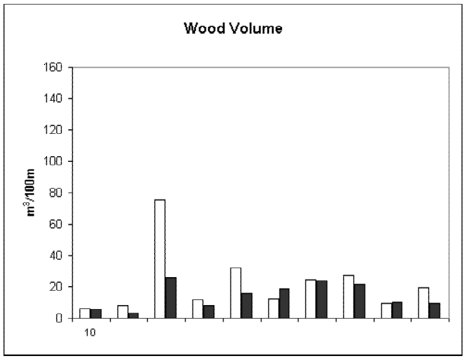

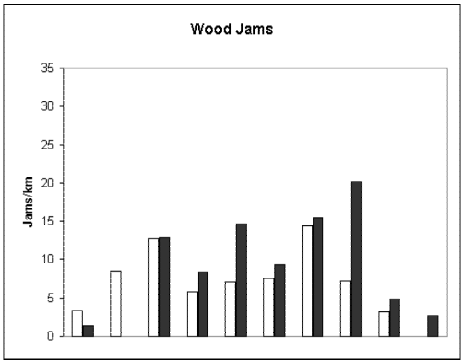

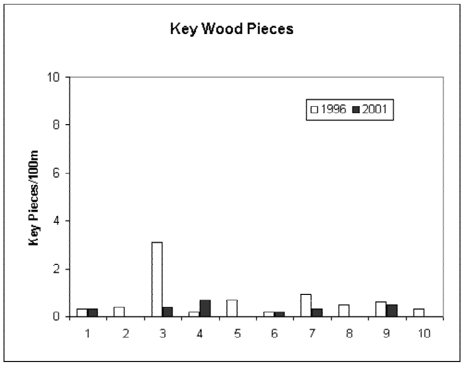

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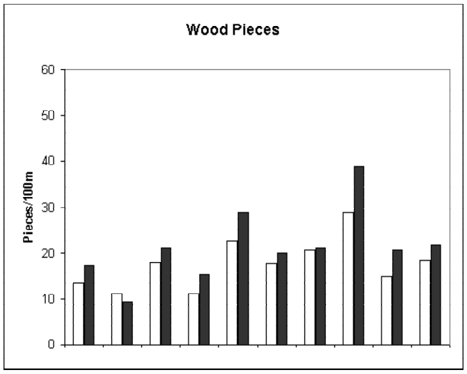

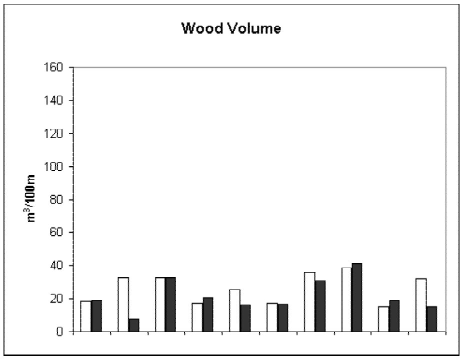

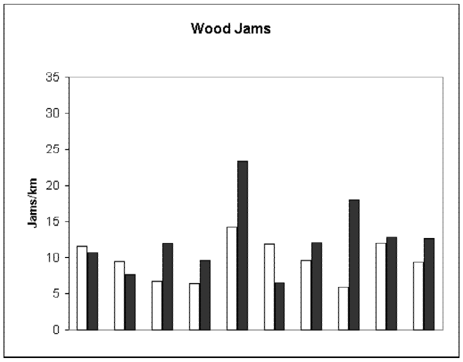

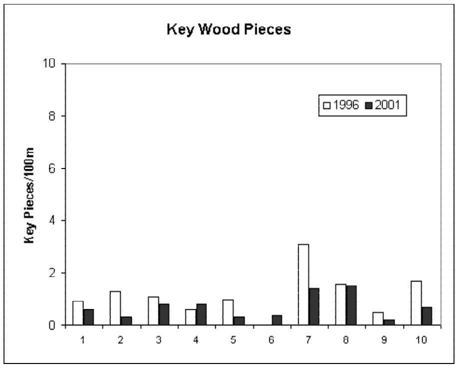

Appendix F. Summer Comparisons of Individual Sites Pre- and Post-Treatment. 1996/2001 (n=10). Sites identified in Table 2.

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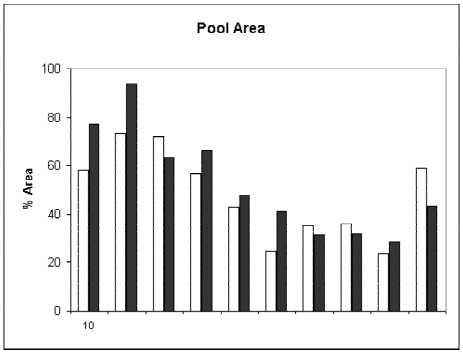

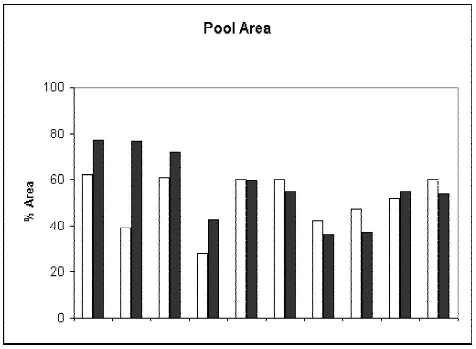

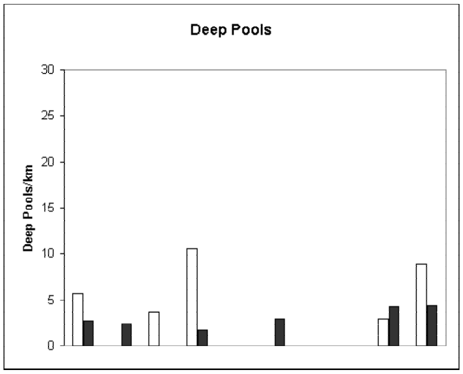

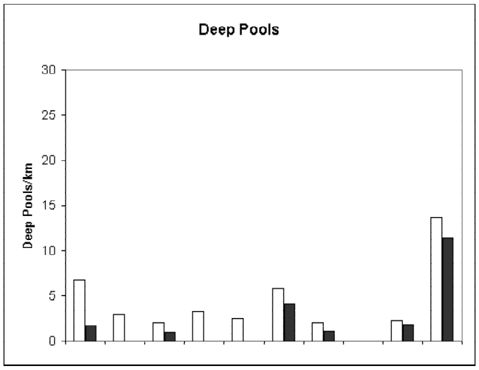

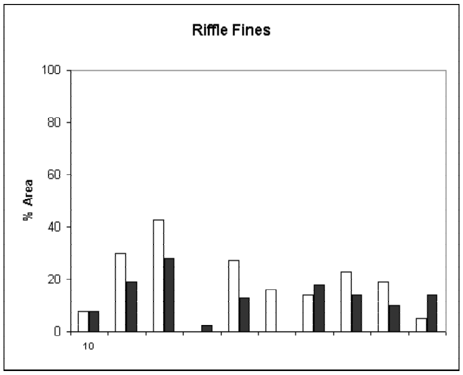

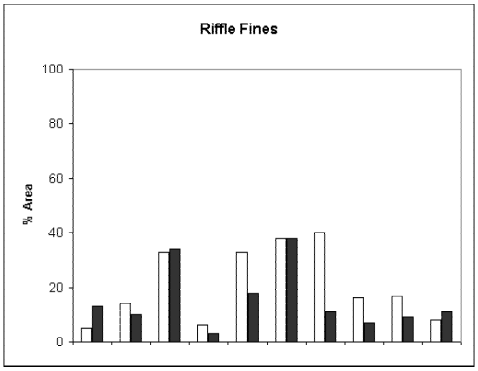

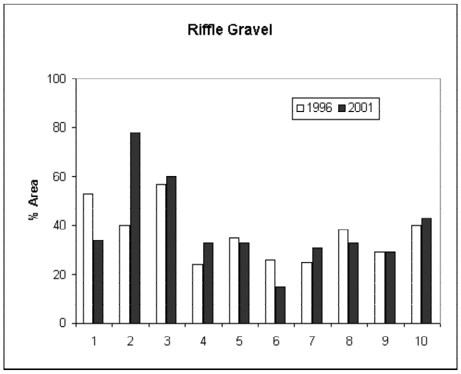

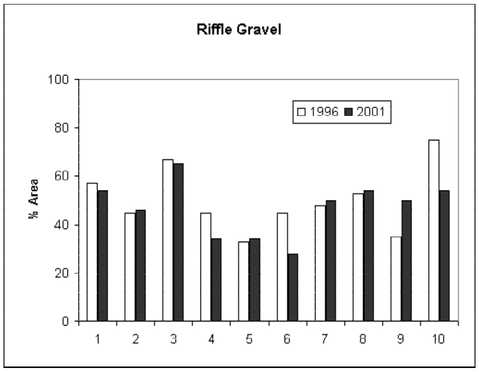

Appendix G. Summer Comparisons of Individual Sites Pre- and Post-Treatment. 1996/2001 (n=10). Sites identified in Table 2.

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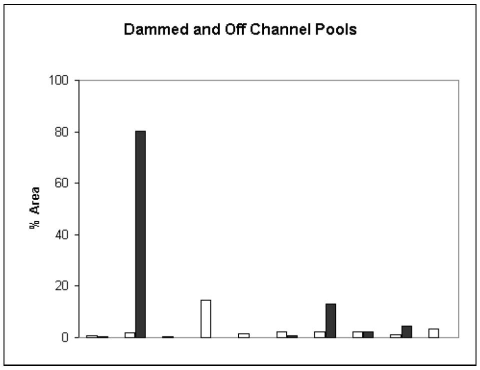

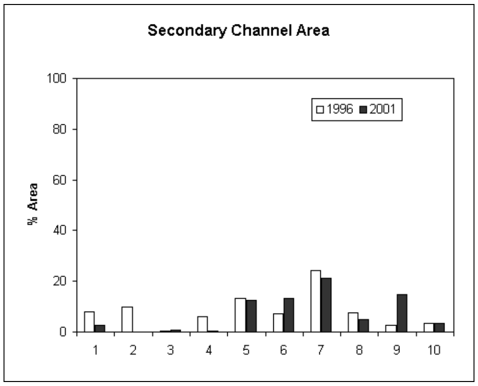

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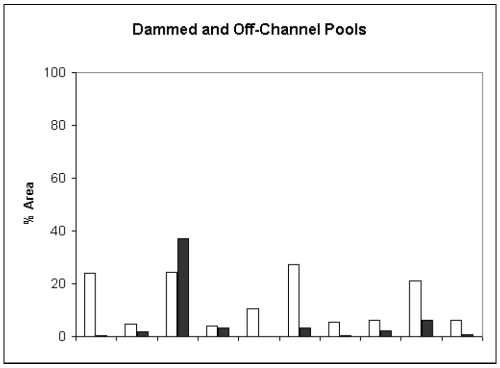

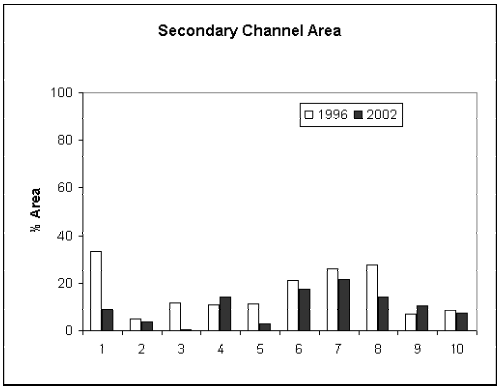

Appendix H. Signal to Noise Ratios for 2000 and combined 1998-2000.

Variables		Year	S.D. (repeats)	CV	S:N
Independent	Channel Length	1998	47.8	6.6	29.8
		1999	26.7	3.5	93.8
		2000	23.8	3.4	114.7
		1998-2000	**34.8**	**4.8**	**55.2**
	Channel Width	1998	1.3	18.1	13.7
		1999	1.7	19.5	29.8
		2000	0.6	14.9	39.5
		1998-2000	**1.6**	**18.4**	**27.8**
	Floodprone Width	1998	3.7	25.9	10.0
		1999	3.4	27.6	11.2
		2000	3.1	20.9	39.8
		1998-2000	**4.4**	**32.0**	**10.4**
	Gradient	1998	0.5	8.9	172.9
		1999	1.8	31.6	11.8
		2000	0.8	16.9	47.6
		1998-2000	**1.1**	**20.7**	**30.9**
Dependent	% Secondary Channels	1998	3.0	70.0	4.3
		1999	3.1	66.2	7.9
		2000	3.0	74.8	4.4
		1998-2000	**2.9**	**68.9**	**5.6**
	% Pools	1998	8.1	30.2	6.8
		1999	7.7	23.7	27.3
		2000	5.8	16.9	18.4
		1998-2000	**7.1**	**23.2**	**17.0**
	% Dammed Pools	1998	0.9	18.5	235.7
		1999	5.6	112.2	6.8
		2000	2.6	45.7	34.0
		1998-2000	**3.9**	**76.6**	**13.6**
	Deep Pools / km	1998	0.7	28.9	33.4
		1999	1.1	54.1	5.8
		2000	1.0	43.7	12.7
		1998-2000	**1.2**	**51.5**	**9.3**
	Residual pool depth	1998	0.3	55.7	1.7
		1999	0.1	13.5	14.4
		2000	0.1	12.6	13.2
		1998-2000	**0.2**	**31.9**	**3.5**
	% Fines	1998	6.8	23.6	11.5
		1999	7.8	26.2	9.1
		2000	5.6	18.8	19.3
		1998-2000	**6.7**	**22.9**	**12.4**
	% Gravel	1998	9.1	36.3	2.0
		1999	7.6	27.6	4.1
		2000	8.1	27.1	3.8
		1998-2000	**8.1**	**30.0**	**3.2**
Dependent (continued)	% Bedrock	1998	2.9	27.1	21.6
		1999	2.8	27.9	20.3
		2000	4.6	47.8	8.2
		1998-2000	**3.5**	**34.4**	**13.9**
	% Riffle Fines	1998	7.6	30.2	7.6
		1999	7.6	29.7	8.7
		2000	10.2	41.5	5.4
		1998-2000	**8.6**	**34.1**	**6.7**
	% Riffle Gravel	1998	9.5	28.3	3.3
		1999	10.3	26.2	4.5
		2000	16.1	38.9	1.6
		1998-2000	**11.9**	**31.6**	**2.8**
	Wood Pieces per 100 m	1998	3.6	24.9	13.4
		1999	4.2	23.8	2.1
		2000	10.2	70.1	2.2
		1998-2000	**9.4**	**60.8**	**2.2**
	Wood Volume per 100 m	1998	7.4	34.2	11.0
		1999	9.4	35.7	2.5
		2000	17.3	63.9	4.0
		1998-2000	**15.8**	**64.3**	**3.6**
	Key Wood Pieces/100m	1998	0.6	70.9	3.8
		1999	1.5	136.5	1.7
		2000	1.0	88.4	3.7
		1998-2000	**1.1**	**108.4**	**2.4**
	Wood Jams per km	1998	2.6	52.4	5.3
		1999	1.7	36.6	6.4
		2000	3.0	51.1	5.5
		1998-2000	**1.9**	**49.7**	**4.5**
	Shade	1998	5.2	6.7	11.5
		1999	6.2	7.5	6.2
		2000	9.8	12.8	4.1
		1998-2000	**7.6**	**9.6**	**5.5**
	20 in. Conifers per 1000 ft	1998	20.0	49.5	10.0
		1999	69.4	98.3	2.3
		2000	22.0	61.5	5.6
		1998-2000	**42.4**	**88.3**	**3.3**
	36 in. Conifers per 1000 ft	1998	6.0	58.0	24.6
		1999	32.8	161.7	1.6
		2000	14.7	125.7	4.0
		1998-2000	**23.1**	**168.3**	**2.1**

Reprinted from Flitcroft, et al (2001).