LARGE WOODY DEBRIS & PERCENT POOLS IN STREAMS DRAINING MANAGED AND UNMANAGED WATERSHEDS OF THE OLYMPIC AND WESTERN CASCADE MOUNTAINS OF WASHINGTON

Initial Results of the Analysis of 1991 Ambient Monitoring Field Data

By

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February 28, 1992

Large Woody Debris & Percent Pools in Streams Draining Managed and Unmanaged Watersheds of the Olympic and Western Cascade Mountains of Washington

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Introduction

The initial results of two years of stream monitoring efforts, reported on in the 1989-1991 Biennial Progress Report (Ralph et al., 1991), indicated a broad range in the values measured for key watershed and instream habitat variables. The range of values seen in survey data no doubt reflects some combination of inherent natural variability and the signature of basin level cumulative impacts associated with a history of forest land management. Differentiating between natural variation and that imposed by management would seem an important aspect of assessing cumulative impacts and designing a realistic strategy to develop management practices to protect instream fish habitat in managed watersheds.

Channel bankfull width, width to depth ratios by valley segment and stream size and gradient/confinement index, substrate particle size habitat unit type frequency, percent pools by total stream area, percent pools by pool type, percent pools formed by woody debris, and woody debris loading by stream width, segment type and gradient/confinement index - all showed broad ranges of values (see 1989-91 Biennial Progress Report). These ranges confound our ability to make meaningful interpretation of the current condition of streams in forested watersheds where timber harvesting is the primary land management activity.

Virtually all of the watersheds encompassing these surveyed stream segments have been harvested to varying degrees, although the specific role of management impacts on measurable channel and habitat features presently observed within these sites is not well understood. Specific information on basin conditions, timber management history, road density, stand age, location and age of erosional events originating on the hill slopes, and other information about disturbance history (fires) within these basins was not generally accessible for these sites.

Methods

Survey efforts in 1991 focused on stream segments in basins where no forest-management activities had occurred in an effort to understand the degree of natural variation that occurs in streams. Stream segments were delineated according to the guidelines of Cupp (1989). Twenty-seven stream segments in 11 undisturbed basins in western Washington State were included in the survey effort. A suite of 22 instream habitat and channel condition parameters were surveyed using the standardized field methods designed for the TFW Ambient Monitoring Project as described in Ralph (1990).

Because of time constraints, we chose to focus our analyses on two key measures: abundance of instream large woody debris and pool frequency. Data from unmanaged sites (collected in 1991) were compared to data from managed sites (collected 1990 and 1991) for these two measures. The following additional information was collected for each segment to make our comparisons more precise.

Cumulative basin area. Upper and lower end-points for each valley segment were located on USGS Quadrangle Maps (1:24,000 scale). Basin boundaries above the lower end-point of each segment were then traced on the maps and subsequently digitized using a *CalComp Drawing Board Digitizer* and an in-house program developed in *QuickBASIC*. Since none of the unmanaged basins in our sample exceeded 10 square miles in area, any managed basin exceeding that size were not used in the analyses. Thus the analysis was conditioned on this basis.

Surficial geology. Basins within which sampled segments are located were identified on the 1961 Geologic Map of the State of Washington compiled by the Washington Department of Conservation and the Division of Mines and Geology. Their predominant geology was noted.

Ecoregion. Only data from segment sites within the west slope of the Cascades and the Olympic coastal range were used in the analysis in an attempt to minimize variation due to vegetation and climate.

Stream map gradient. Elevations of each segment's upper and lower end-points were taken from contour lines on USGS Quadrangle maps (1:24,000 scale). These were then used in conjunction with the digitized stream lengths to calculate gradients for stream segments of interest.

Data Analysis

In our survey, large woody debris (LWD) was defined as any log greater than 10 cm in diameter and greater than 10 feet in length. Woody debris (LWD) is then divided into two size-classes -- 10 to 50 cm in diameter and greater than 50 cm in diameter. Pool frequency is calculated by dividing the stream area comprised of pools by the total stream area. Our analyses contained three response variables: 1) LWD frequency (pieces per 1000 ft of stream), 2) percent of LWD greater than 50 cm in diameter (pieces > 50 cm/total pieces), and 3) pool frequency.

Each response variable was analyzed in the same fashion. First, mean, standard deviation, and range were calculated. Both measures of LWD were plotted against basin area and pool frequency was plotted against stream gradient. Linear regressions were run through these plots to determine trends in the data. T-tests were performed to test for significant differences between means for managed and unmanaged sites. Finally, unbalanced ANOVA's were run to account for the effects of basin area and stream gradient on LWD and pool frequency respectively, and to test for interaction of these variables with management when appropriate. Sample sizes of 31 unmanaged and 55 managed segments were used in the analyses.

Results

Figure 1 contains the scatter-plot and regressions of percent of LWD > 50 cm in diameter vs. basin area by management classification. The box plots to the right show the mean, standard deviation, and range of the data for both managed and unmanaged sites. The t-test showed the mean values were significantly different ($p = 0.0009$). Using an unbalanced ANOVA to predict percent of LWD > 50 cm from basin area and management class allowed us to test for significant differences between managed and unmanaged sites after removing any effect of basin area on frequency. This increased the significance of the effect of management ($p = 0.0002$). This plot suggests that management activities within basins shift the size-class distribution of LWD toward the smaller end of the distribution.

Figure 2 shows the same plots for frequency of LWD. The t-test showed mean values for managed sites were not significantly different from those in unmanaged sites ($p = 0.86$). However, the inverse slopes of the regressions for managed and unmanaged sites suggests a strong interaction between management and basin area. We tested the significance of this interaction by including both the main effects (management and basin area) and the interaction (management x basin area) in the ANOVA. The interaction was significant ($p = 0.0392$). This suggests that basin area and management when considered together, have a significant effect on the percent occurrence of large woody debris retained within basins. Management tends to reduce the size of woody debris within channels, and as basin area increases (up to 10 square miles) the number of large pieces of woody debris continues to decline.

Figure 3 contains data for pool frequency, or the percent of summer low flow total stream area (wetted area) attributable to pools. Again, t-tests showed significantly fewer pools in managed vs. unmanaged streams ($p = 0.0835$). Removing the effect of stream gradient using ANOVA again increased the significance ($p = 0.0060$).

Discussion

The issue of instream habitat integrity and complexity is directly tied to pool area and woody debris. The absolute number of pieces of woody debris may not be a particularly significant issue in an of itself. Field investigators generally agree that the distribution of woody debris within the channel may be more important than the absolute number of pieces. Woody debris piles in the form of log jams appear to be more common in managed vs. unmanaged watersheds, although our data has not yet been analyzed to corroborate this empirical observation. What may be of more significance is the relative size of the individual pieces (woody debris volume). Our data suggests that management activities tend to shift the size-class distribution of LWD in the channel downward (*Figure 1*). Given this, the significance of the interaction between management and basin area (*Figure 2*) can be explained by relating this shift in size class distribution to expected changes in stream discharge associated with timber harvesting and road construction.

Figure 2 seems to suggest that smaller, managed streams have a higher frequency of LWD than do smaller, unmanaged streams. However, the reverse is true for larger streams. The following hypothesis explains the two trends shown in figures 1 and 2. Assume that management activities tend to increase the number of pieces of LWD *available* to stream channels, but decrease the average size of these pieces. Since larger pieces tend to resist the higher hydraulic forces associated with larger streams, larger streams would be capable of washing-out these smaller pieces while the LWD would remain resident in smaller streams. This would result in exactly the pattern we see in the data -- management activities would increase the frequency of LWD in smaller streams, but decrease the frequency in larger streams. However, consider what might happen in the small streams given a 1000- or even 100-yr storm event. The larger LWD tends to provide a buffering capacity that protects the stream from the erosional forces associated with these events. Perhaps, in time, even the smaller managed streams will show a decrease in their LWD frequency.

In addition to reducing the proportion of large sizes of woody debris, figure 3 strongly suggests that management also has a substantial effect in reducing pool area in streams. The structural complexity of instream fish habitat is reduced in streams that occur within managed basins. This has important implications for the issue of whether or not these particular streams are stable over time and provide a mix of habitat components that are necessary for runs of native anadromous fish to sustain themselves into the future. Bilby & Ward (1992) noted that managed streams tend to have a significantly lower proportion of the stream area in pool type habitat. This issue warrants further analyses of the monitoring data.

Literature Cited

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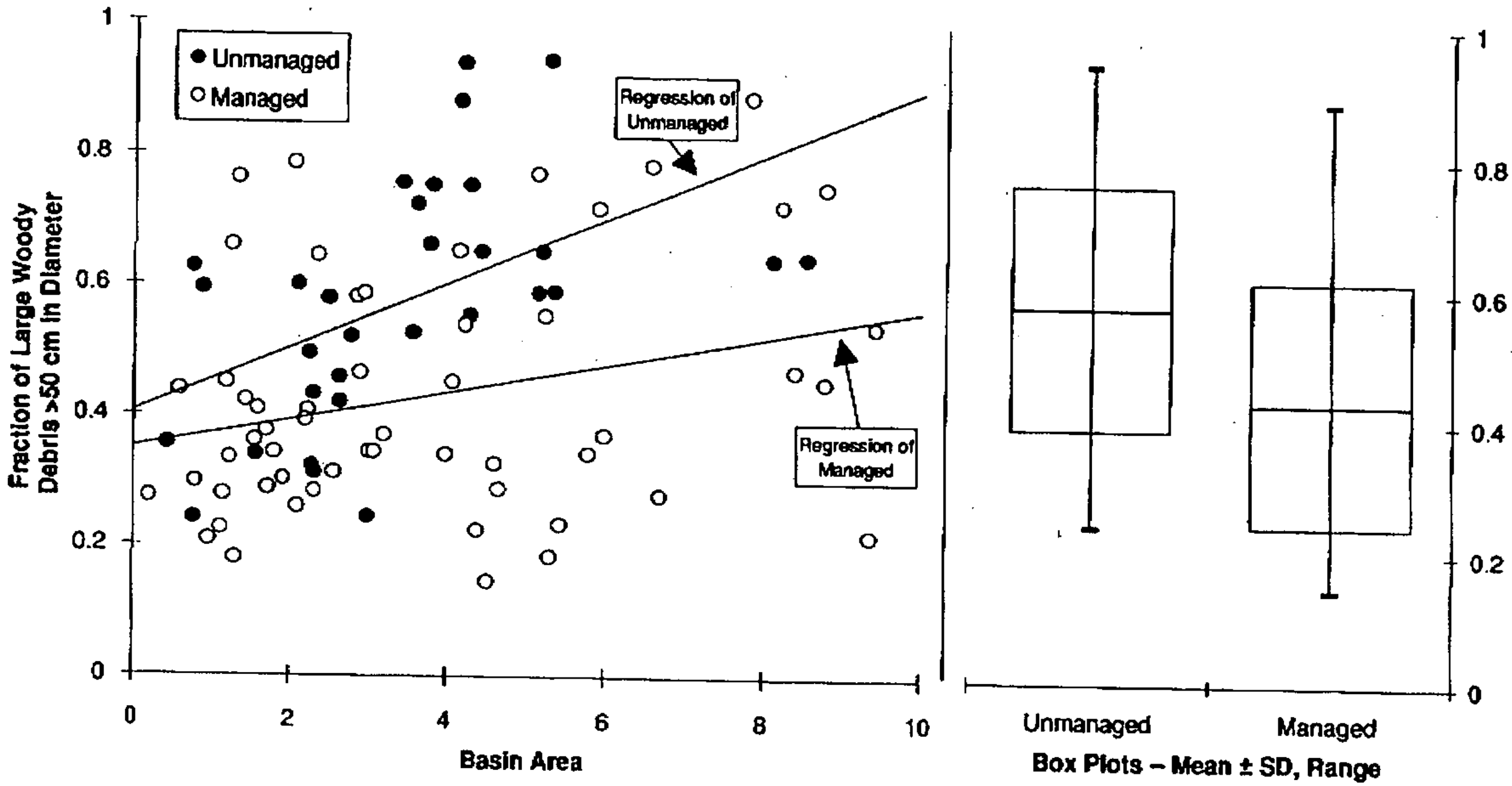


Figure 1. Fraction of instream large woody debris (>10 cm in diameter, >10 ft in length) greater than 50 cm in diameter. Scatter plot with least squares linear regression vs. stream gradient, and box plot showing mean ± SD, and range.

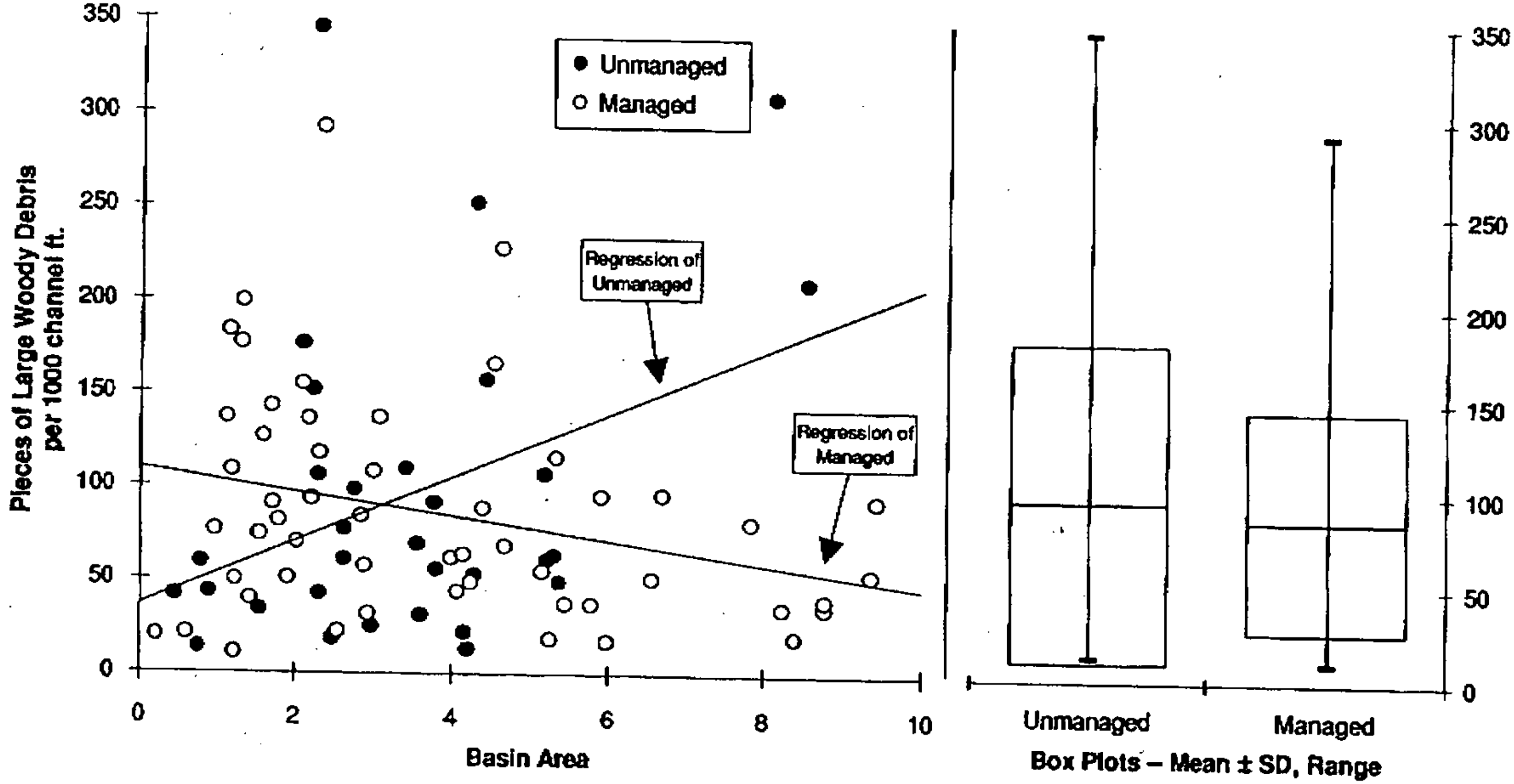
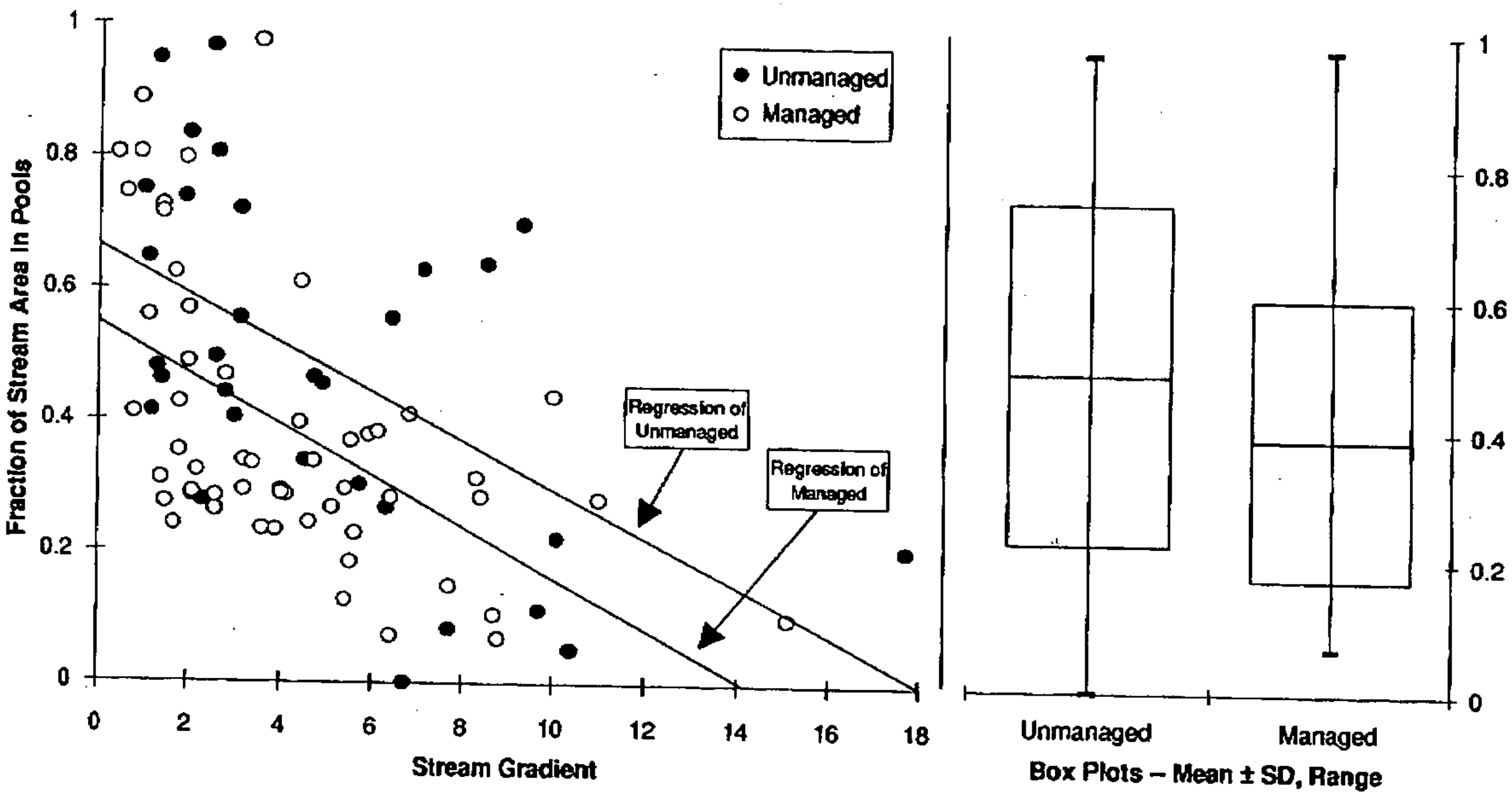


Figure 2. Number of pieces of LWD per 1000 ft of stream. Scatter plot with least squares linear regression vs. basin area, and box plot showing mean ± SD, and range.



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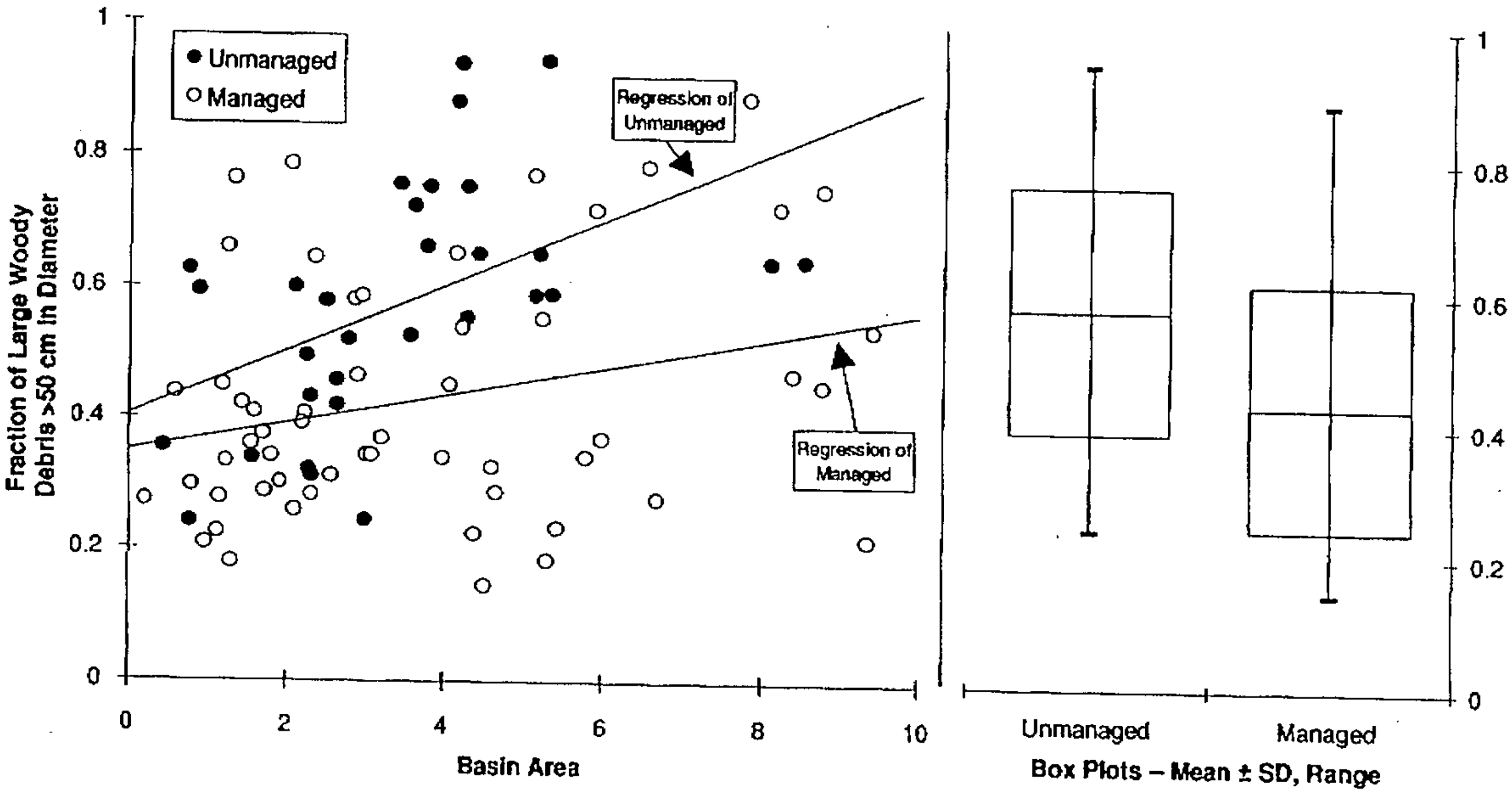

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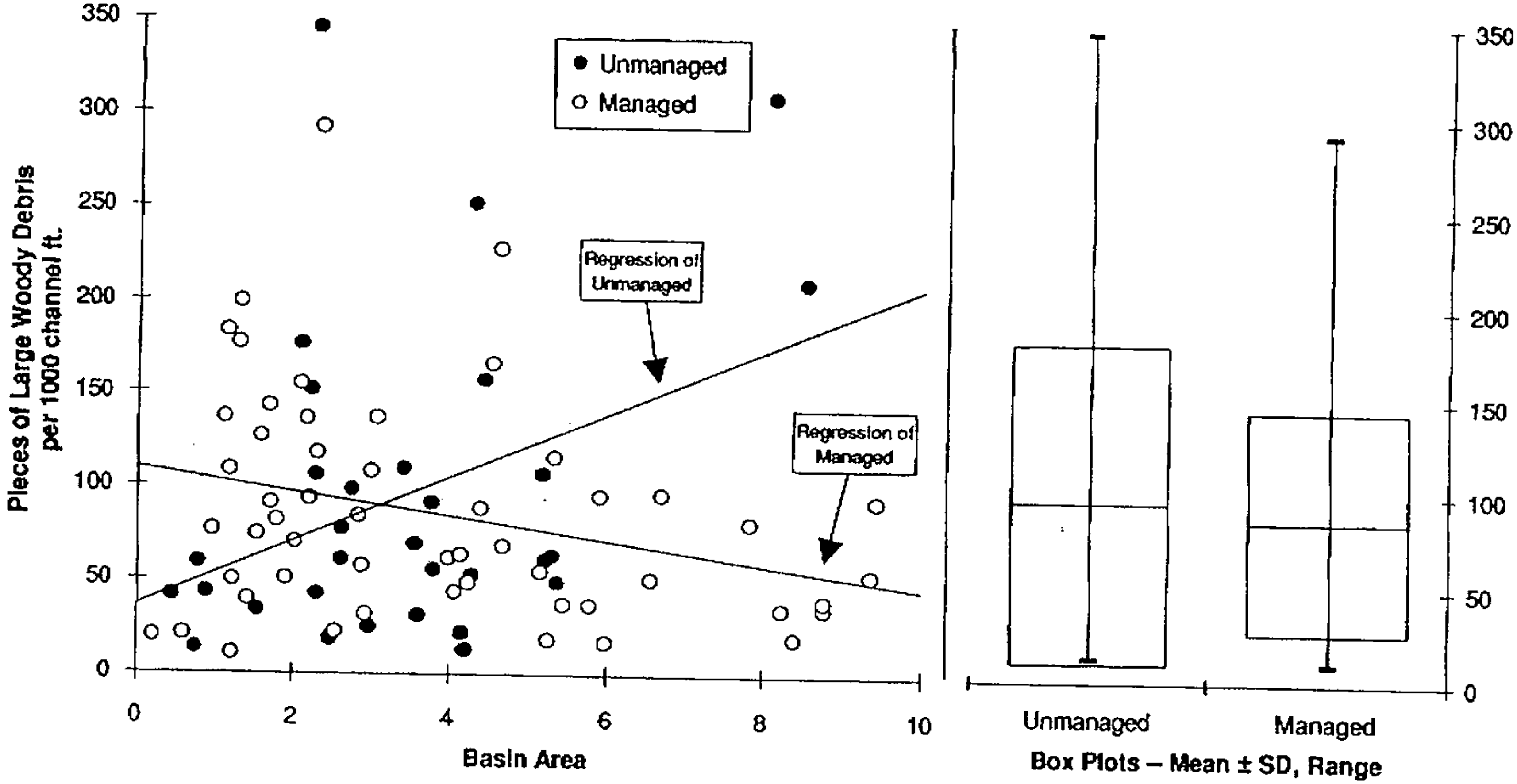

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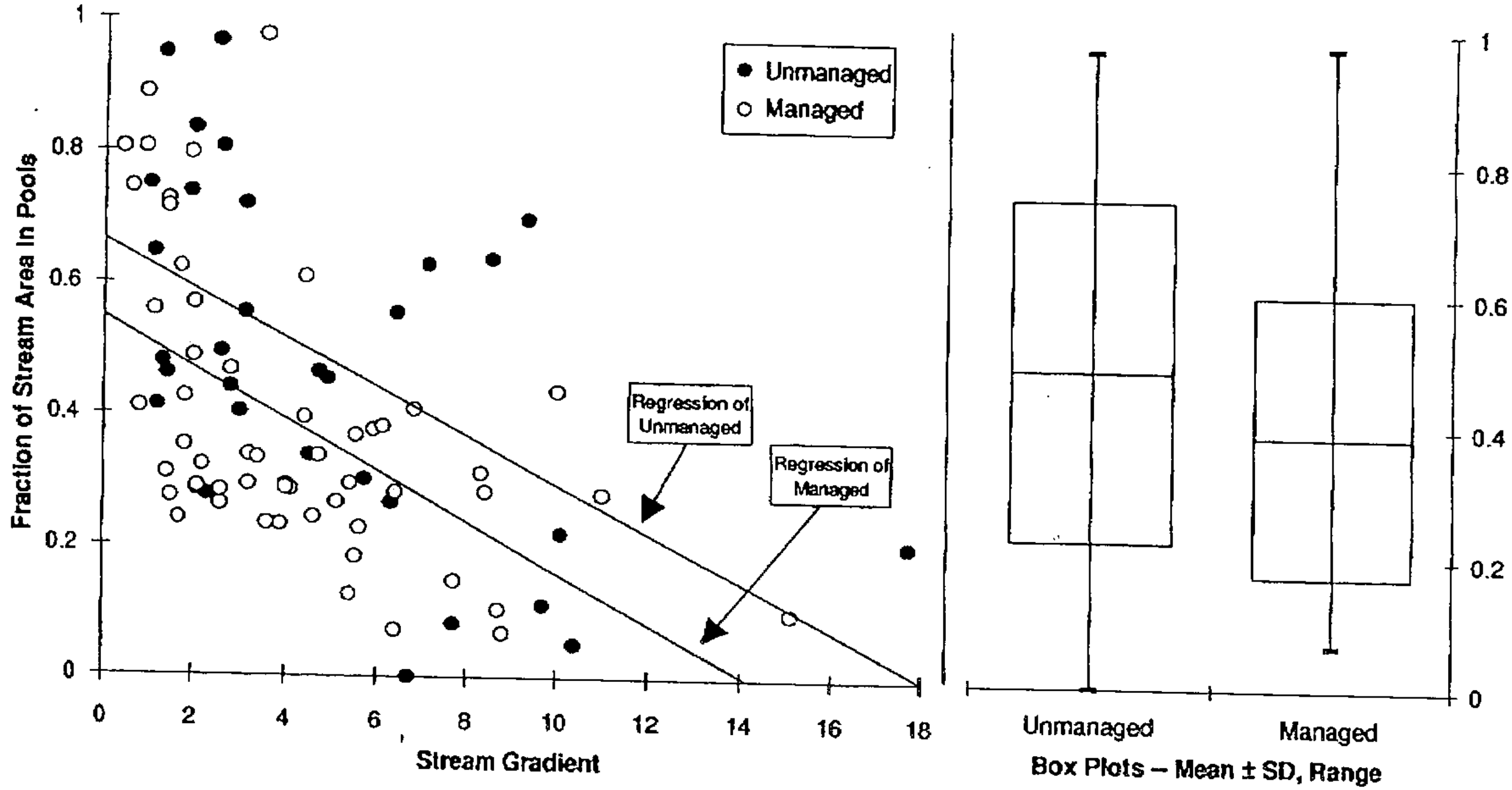

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