An Assessment of Washington State Riparian Management Zone Widths in Capitol State Forest, WA

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Abstract

Riparian zones are an important part of the ecosystem. They consist of complex gradients, which are difficult to delineate. The riparian zones of the Capitol State Forest are protected under the Department of Natural Resources' (DNR) riparian zone management regulations. This study examined the efficiency of the delineation methods of the DNR's riparian management zone widths. Our hypothesis was that plant community composition and soil moisture could be used as bioindicators of a riparian zone width. The plant communities and soil moisture content along a 340' transect from the stream through the upland forest were surveyed for 20 streams to determine if the DNR 170' riparian zone width sufficiently encompassed the riparian zone ecosystem. Ten plots (1 m x 2 m) were set up every 34' along transects for sampling soil moisture and plant species and abundance. There were a total of 55 plant species and 7,730 individual plants that were counted during the study. The data compiled supported the hypothesis that soil moisture and plant community composition are effective indicators for the riparian zone gradient. The findings also suggested that the plant communities show a distinction at 170', which is also the boundary set by the DNR. The results of this study support the DNR's riparian zone delineation of 170' and propose that soil moisture and plant species can serve as bioindicators for riparian zone delineation.

Introduction

Riparian ecosystems have received considerable attention from researchers over the past three decades (Naiman et al. 2000, Swanson and Franklin 1992). The importance of riparian ecological functions is now widely recognized and better understood among ecologists and land managers. Riparian vegetation regulates light and temperature for streams, provides nutrients for aquatic and terrestrial organisms, and maintains biodiversity through habitat and ecological functions (Naiman and Decamps 1990, Naiman et al. 1993). Riparian zones also regulate the flow of water, nutrients, and sediment from the upland forest and provide large woody debris, which has a significant impact on in-stream habitat (Naiman and Decamps 1990). The distinctive corridors formed by stretches of riparian areas provide a means for plant dispersal and animal movement (Gregory et al. 1991). Naiman et al. (1992) consider these corridors to be a key feature in regulating environmental vitality.

Riparian areas consist of complex mosaics of landforms, communities, and environments and consequently the boundaries are not easily delineated (Gregory et al. 1991, Naiman et al. 1993). The riparian forest covers wide gradients of environmental factors, ecological processes and plant communities (Gregory et al. 1991). Researchers' definitions of riparian zones have varied greatly since the 1970's. An ecosystem riparian zone model proposed by Gregory et al. (1991) includes examination of the physical geomorphic processes, succession of plant communities, and the level of habitat and nutrients provided for aquatic systems. Other methods of riparian zone definitions include hydrologic, topographic, edaphic, and near-stream vegetation characteristics (Karr and Schlosser 1978, Gregory et al. 1991). Naiman et al. (2000) also stated that riparian zones can be delineated by any other factor which reflects the aquatic-terrestrial interaction

In the latter portion of the twenty-first century, over half of Washington's water systems were found to be degraded in some way by heavy land use (Rauscher et al. 1995). Much of this decline in riparian habitat quality can be attributed to past timber harvest practices (Rauscher et al. 1995). As water quality became a concern in the 1960s and 1970s, the subsequent research led to federal and state policies regarding the retention of timber in buffer zones adjacent to streams (Swanson and Franklin 1992, Budd et al. 1987).

Concerns regarding land management techniques led to the formation of the Washington State Forest Practices Board (WSFPB) in 1974. The twelve-member board has been charged with setting standards for practices related to natural resource extraction on non-federal and non-tribal forested lands. Research throughout the 1980s led to an improvement in riparian habitat protection guidelines by 1988. These 1988 rules called for a Riparian Management Zone (RMZ) buffer width of 25' to 100' from either bank of a stream depending on stream class and stream width.

In 1999, the WSFPB updated the RMZ rules when they implemented the Forest Practices Habitat Conservation Plan, which is applicable on all lands within the state that are not under federal or tribal ownership. The new buffers were only half as large as those imposed on federal lands under the Northwest Forest Plan, but still afforded more protection for riparian systems than the 1988 law. Rather than requiring a standard buffer zone size on all streams of a particular order, the WSFPB chose to break up the RMZ into three zones of varying size with different harvest options available within the two outside zones. This allowed for silvicultural treatments to be applied within the RMZ to help speed the rehabilitation of stream systems that had been poorly managed in the past.

Under the Department of Natural Resources' current regulations, RMZs are organized into five site classes that express desired basal area per acre (or site productivity) for the stand at 140 years. The site class determines a width between 90' to 200' for the RMZ. The RMZ is then split into a Core Zone, an Inner Zone, and an Outer Zone. The width of the inner and outer zones is further defined by the average stream width, which is classified as either below or above 10' wide. Core Zones are a standard 50' from any stream regardless of size or site class. No harvest is permitted in the Core Zone and any trees incidentally damaged during harvest may not be removed. Inner Zones vary from 10' to 100' from the end of the core zone and a very limited harvest may be permitted. Growth modeling tools must be used to demonstrate that timber extraction within the Inner Zone will not prevent the RMZ reaching the desired basal area levels and that conifer to deciduous ratios will not be negatively affected. The Outer Zone width is 22' to 67' from the end of the Inner Zone. Harvest is allowed in the Outer Zone but landowners are required to leave 20 trees per acre.

This study examined the RMZ widths within Capitol State Forest, WA, in order to identify potential bioindicators for accurate delineation of riparian zones. Bioindicators such as soil moisture and vegetation community composition data were collected within the set 170' RMZ, as well as 170' past the RMZ boundary into the upland forest, to examine the delineation methods of the DNR. We hypothesized that plant communities and soil moisture content within the 170' riparian zone would be distinct from those of the upland forest. We hypothesized that these bioindicators would show marked differences along the riparian zone gradient from the stream through the upland forest. This research could lead to a better understanding of riparian zone components, and thus influence future land management protocols.

Methods

Study area

Twenty sites, located in Capitol State Forest, were used for this project. Capitol State Forest is a state-owned commercial forest that spans through Grays Harbor and Thurston Counties located on the southern reaches of the Puget Sound area and west of Olympia, Washington. Elevation within the forest ranges from 600 to 2659' (182 to 810 m). The 150 square mile (241 square kilometer) forest is known for its relatively dry, warm summers and wet winters. The overstory in the study area included red alder (*Alnus rubra* Bong.), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), bigleaf maple (*Acer macrophyllum* Pursh), and Douglas fir (*Pseudotsuga menziesii* (Mirbel) Franco). Dominant understory vegetation consisted of swordfern (*Polystichum munitum* (Kaulfuss) K. Presl), bracken fern (*Pteridium aquilinum* (L.) Kuhn), and salal (*Gaultheria shallon* Pursh).

Sampling Procedures

Twenty different streams within Capitol State Forest were randomly selected using GIS mapping. Once a selected stream was located, a study site was established one hundred paces either up or down stream to further randomize our sites. From this point GPS coordinates, stream gradient, stream width, and RMZ bank slope were recorded. Stream gradient and bank slope were measured in degrees using a clinometer. A 340' (103m) up-slope transect running perpendicular from the stream channel edge was then established. This 340’ transect represented twice the total length of the DNR’s RMZ width for a Class II forest. Plots measuring 2 x 1 m were created every 34’ (approximately 10 m) along this transect, totaling 10 plots per sample stream. Altogether, 200 plots were surveyed in this study. In each plot, plant species presence and abundance were recorded and soil samples collected. Soil samples were collected with a trowel and then deposited into plastic bags for preservation. Soil samples were then weighed before and after drying the samples for 24 hours at 110 degree (C) in order to determine soil moisture.

Statistical Analysis

All analyses were conducted using PC-Ord v.4.3 and SPSS v.13. Community analysis ordinations and non-metric multiple scaling (NMS) ordinations, indicator species analysis, and multi-response permutation procedure (MRPP) tests were run on PC-Ord. Linear regressions were run using SPSS.

Results

A total of 55 species were encountered, as well as a total abundance of 7,730 plants. The species richness in each plot ranged from 1 to 14 with an average of 4, and overall plant abundance in each plot ranged from 1 to 363 with an average of 39 plants per plot. The average species richness for all plots was explained by distance from the stream (Fig. 1; $R^2 = 0.820$, $P < 0.001$). The species diversity averages, which follows Shannon’s Diversity Index, were also explained by distance from the stream (Fig. 2; $R^2 = 0.440$, $P =$

0.037). The distance from the stream was also correlated with soil moisture (Fig. 3; R^2 =0.591, *P* = 0.009). The stream widths ranged from 5' to 38' with an average of 10.74'. Stream gradients varied from 1 to 7.5 degrees with an average of 3.2 degrees. The bank slopes ranged from 2 to 30 degrees with an average of 15.3 degrees.

MRPP tests were run with plot locations grouped together according to distance from stream (Table 1). These categories grouped a certain number of continuous plots together; for instance, the category 1-4 vs. 5-10 contained first four plots (distances 34' to 136' from stream) and compared that group to the last six plots (distances 170' through 340'). In the grouped MRPP tests, the categories 1-4 vs. 5-10 and 1-5 vs. 6-10 had the strongest results (A = 0.010, *P* = 0.001; A = 0.012, *P* = 0.012, respectively). A community analysis ordination and MRPP with all plot locations independently grouped showed no strong distinctions (A = 0.005, *P* = 0.073).

An indicator species analysis, when run with individual plot locations, showed that the plots located at 34' held indicator species. The four indicator species were *Tolmiea menziesii* (*P* = 0.010, IV = 12.9), *Asarum caudatum* (*P* = 0.012, IV = 11.1), *Rubus spectabilis* (*P* = 0.015, IV = 13.2), and *Maianthemum dilatatum* (*P* = 0.027, IV = 15.8). Indicator species analyses run with plot locations grouped together resulted in more indicator species (Table 2). The grouped categories closest to the stream contained a higher number of indicator species than those further from the stream.

Discussion

We found significant differences in species richness, soil moisture, and species diversity across the transects. These results supported our hypothesis that these bioindicators would change as distance from the stream increased. Species richness, soil moisture, and species diversity all decreased as distance from stream increased. These findings suggest that riparian zones consist of distinct gradients. These gradients in species and soil moisture could be used to determine the width of a riparian zone.

The plant species community composition between grouped plots served as an indication for delineation of riparian zones. The grouped category that was the most indicative of a change in community was 1-5 vs. 6-10 ($A = 0.012$, $P < 0.001$). This reveals that the riparian zone and upland forest could be considered distinct communities at 170' from the stream, which is consistent with the DNR riparian zone management width.

The indicator species analysis run with the first 5 plot locations grouped together (group 1-5 vs. 6-10) resulted in 13 indicator species within 170' of the stream and 2 indicator species in the 170' – 340' range. Eight of these 13 are listed by the USDA as wetland indicator status plants (USDA). The two indicator species for the upland area, salal (*Gaultheria shallon* Pursh) and Oregon grape (*Mahonia nervosa* (Pursh) Nutt.), are common understory species in interior forests.

The results of this study show that species richness and soil moisture, along with indicator species, change markedly over a riparian zone gradient. These findings could support future land management decisions in riparian zone delineations. Factors such as soil moisture and species richness could be used to find the true scope of a riparian area's size. The indicator species listed on table 2 could indicate for the riparian zone/upland forest communities.

Conclusion

Over the course of this study we have come to find that all three of our tested variables, soil moisture, species richness, and species diversity, show distinct gradients throughout a 340’ distance from any given Site Class II stream in the Capitol State Forest. Though all three of these elements showed change, species richness proved to be the largest determining factor for delineating a 170’ riparian zone. Aiding in the 170’ delineation are certain indicator species; the two species found in upland forests (170’ to 340’), salal and Oregon grape, are vastly outnumbered by the 13 riparian species. All of these variables can be used while evaluating the riparian zone management widths.

We found the DNR’s management zone of 170’ for a Site Class II stream to be a sufficient distance from the stream in order to protect a riparian zone habitat. Further research in riparian zone delineation methods could help to support future land management decisions not only in Capitol State Forest or Site Class II streams but in other managed areas and smaller or larger streams.

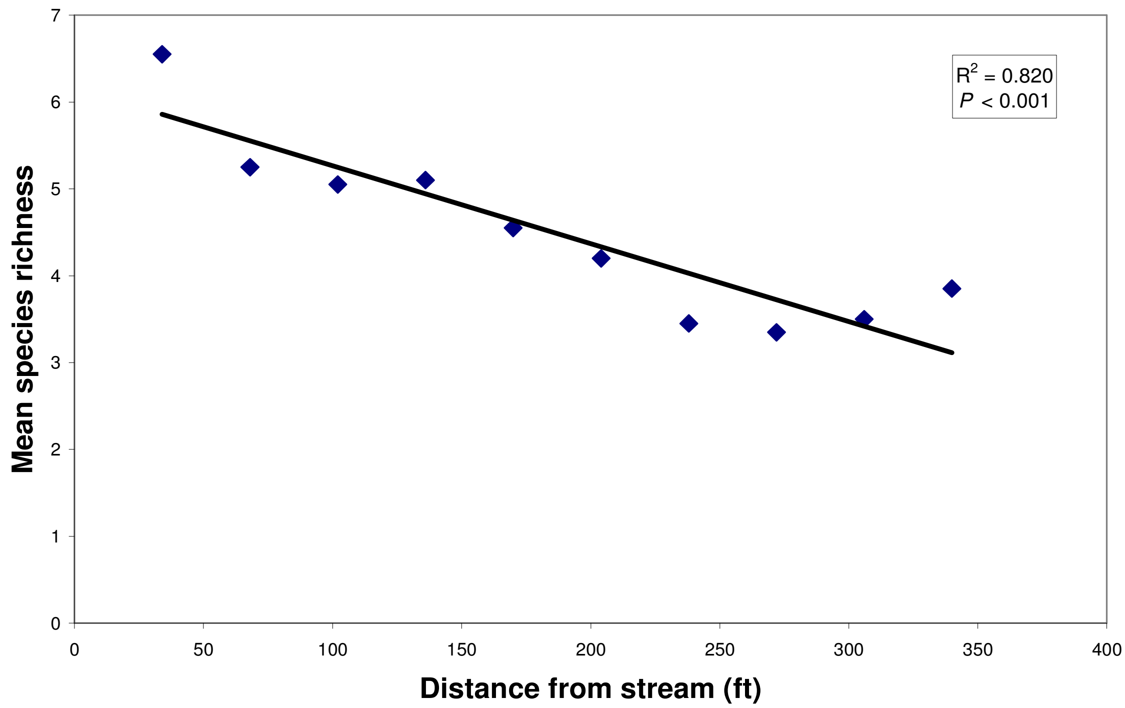

Fig. 1. Mean species richness taken from 10 plots from each of the 20 streams. Distance from stream (ft) indicates plot location along transect. Plot distance from the stream explained 82% of the variation in mean species richness (F-value = 36.515, $P < 0.001$).

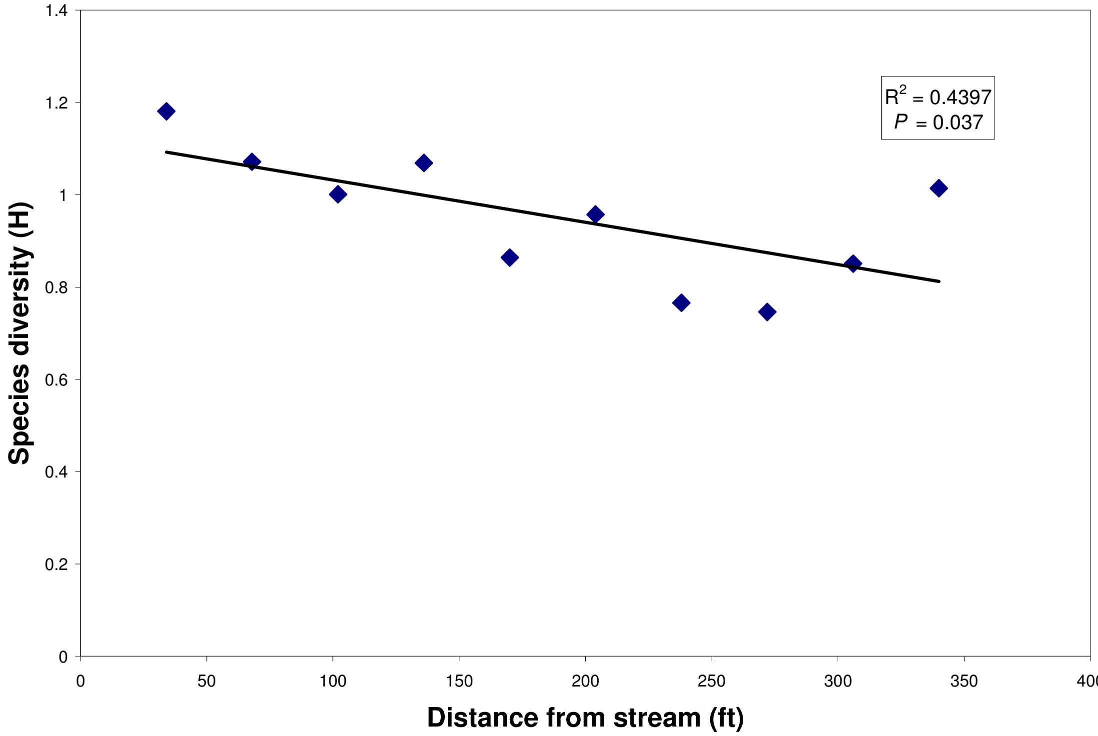

Fig. 2. Linear regression of species diversity and distance from stream. Diversity follows Shannons Diversity Index values for the mean of 10 plots along 20 transects. Plot distance from the stream explained 43% of the variation in the mean Shannon's diversity index values (F-value = 6.278, $P = 0.037$).

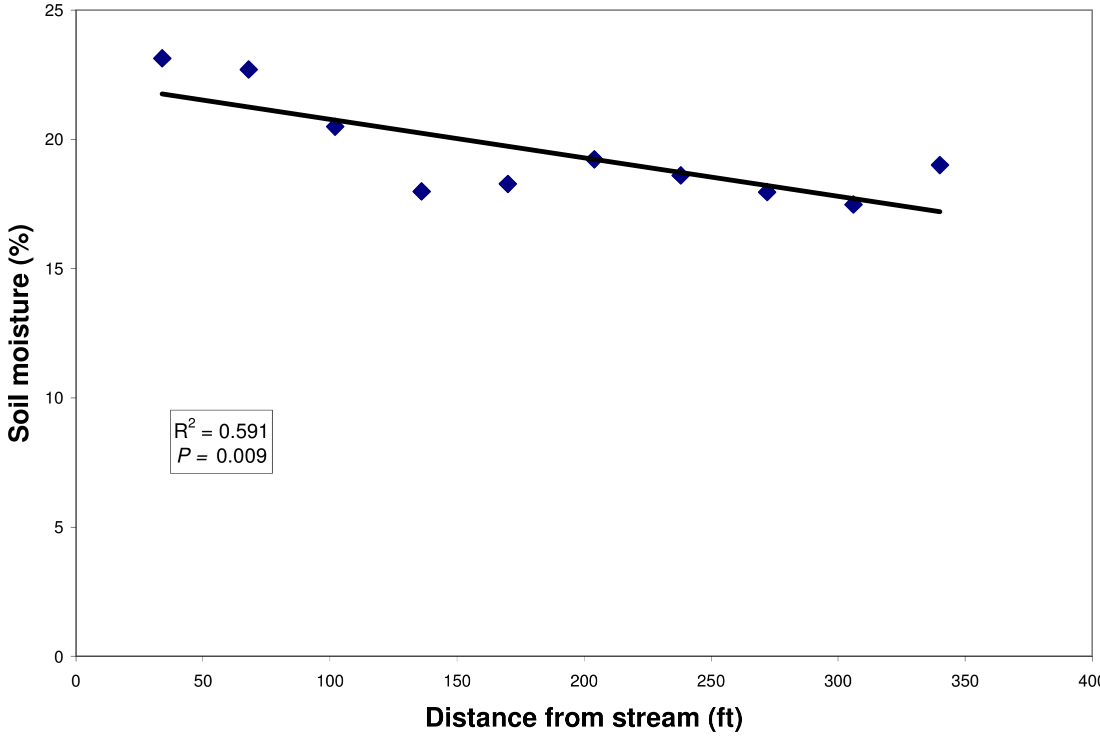

Fig. 3. Mean soil moisture percentages taken from 10 plots located along transects from each of the 20 streams. The distance from stream (ft) indicates plot location. Plot distance from the stream explained 59% of the variation in soil moisture (F-value = 11.567, $P = 0.009$).

Table 1. A- and P- values from MRPP analyses. Categories were defined as grouped plot distances from stream (1 = 34'; 2 = 68'; 3 = 102'; 4 = 136'; 5 = 170'; 6 = 204'; 7 = 238'; 8 = 272'; 9 = 306'; 10 = 340'). NS indicates a non-significant P-value.

Grouping Category	**1 vs 2-10**	**1-2 vs 3-10**	**1-3 vs 4-10**	**1-4 vs 5-10**	**1-5 vs 6-10**	**1-6 vs 7-10**	**1-7 vs 8-10**	**1-8 vs 9-10**	**1-9 vs 10**
A =	0.003	0.005	0.008	0.010	0.012	0.009	0.005	NS	NS
P =	0.039	0.005	< 0.001	< 0.001	< 0.001	< 0.001	0.004	NS	NS

Table 2. Indicator species for plots grouped together by distance from stream. Categories were defined as grouped plot distances from stream (1 = 34'; 2 = 68'; 3 = 102'; 4 = 136'; 5 = 170'; 6 = 204'; 7 = 238'; 8 = 272'; 9 = 306'; 10 = 340').

Grouping Categoryy	**1-4 vs 5-10**	**1-5 vs 6-10**	**1-6 vs 7-10**
# of Indicator Species for Group 1	13	13	8
# of Indicator Species for Group 2	2	2	2
Indicator Species for Group 1 (Riparian)	Mainthemum dilatatum, Rubus spectabilis, Pteridium aquilinum, Dicentra formosa, Smilacina racemosa, Sambucus nigra, Vancouveria hexandra, Tolmiea menziesii, Asarum caudatum, Viola glabella, Oplopanax horridus, Corydalis scouleri, Poaceae sp.,	Mainthemum dilatatum, Rubus spectabilis, Pteridium aquilinum, Dicentra formosa, Vaccinium parvifolium, Smilacina racemosa, Sambucus nigra, Vancouveria hexandra, Tolmeia menziesii, Asarum caudatum, Viola glabella, Oplopanax horridus, Corydalis scouleri,	Mainthemum dilatatum, Rubus spectabilis, Pteridium aqulilinum, Dicentra formosa, Vancouveria hexandra, Tolmeia menziesii, Asarum caudatum, Viola glabella,
Indicator Species for Group 2 (Upland)	Gaultheria shallon, Mahonia nervosa	Gaultheria shallon, Mahonia nervosa	Gaultheria shallon, Mahonia nervosa

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