The Ecology of Riparian Ecosystems of Northeast Oregon: Shrub Recovery at Meadow Creek and the Structure and Biomass of Headwater Upper Grande Ronde Ecosystems

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Riparian ecosystems play numerous and essential roles related to the quality and flow of water, and food/habitat for fish, and varieties of wildlife. Due to lateral and linear linkages throughout the landscape, these zones influence the integrity of the terrestrial as well as the entire aquatic-riverine ecosystem. Since Euro-American settlement in the West, the structure and condition of many riparian ecosystems has been significantly altered. To provide tools and an ecological perspective related to riparian restoration and management, and to document late 20th century headwater riparian structure and biomass in the Upper Grande Ronde Basin, this research project was undertaken.

At Meadow Creek, the response of riparian hardwood species to the termination of livestock grazing was quantified. Regression equations were developed to predict shrub biomass. Permanently marked hardwood plants were measured annually to quantify parameters of growth (height, crown area, mainstem diameter, number of stems, biomass). Permanent belt transects on gravel bars were utilized to quantify rates of shrub establishment. Elk/deer-proof exclosures allowed the quantification of the browsing influence of wild ungulates. In 1991, initial shrub heights and densities reflected decades of grazing pressure. Mean heights of 515 woody plants (14 species) was 47 cm and densities on gravel bars averaged 10.7 plants/100m^2. After two seasons without livestock grazing, mean crown volumes of willows *(Salix spp.)* increased 550% inside of wild

ungulate exclosures and 195% outside, black cottonwood *(Populus trichocarpa)* 773% inside and 808% outside, and thin-leaf alder *(Alnus incana)* 1046% inside and 198% outside, respectively. Willows were significantly impeded by mule deer and Rocky Mountain elk ($p<0.01$), alder sample size was too small to statistically test, and cottonwood was not significantly impeded. Impacts by deer and elk may be exaggerated due to restricted migrations and the unique wild/domestic ungulate density-dynamics within the 77 km^2 Starkey Experimental Forest big-game enclosure surrounding the study site. Establishment rates are low at this time, i.e., only 10% of previously suppressed willows produced catkins. Hardwood densities in transects increased by 5 new woody plants/100m^2 (50m of streambank). Other non-anthropogenic factors influencing the recovery of shrubs, included beaver which removed mainstems from 20% of willows, 11% of thin-leaf alder, and 4% of black cottonwood, and active insect defoliation which was noted on 16% of willows, 7% of thin-leaf alder, and 0% of black cottonwood. Crude protein levels measured in willow and alder leaves was relatively high (16.1 to 16.3%) helping to explain their palatability and use by wild and domestic herbivores.

Few studies have quantified biomass, structure, and composition of headwater riparian ecosystems. Data such as this are important given their dominant roles in ecosystem biodiversity and aquatic function. To document relatively intact forested headwater riparian conditions in the Upper Grande Ronde Basin, the biomass, structure and composition along six headwater reaches was quantified. Sampling was done using a nested belt transect/plot arrangement along 500 meter reaches. Total aboveground biomass (TAGB) ranged from 203 to 261 Mg/ha, with overstory conifers contributing 101 to 177 Mg/ha. Living understory components (saplings, seedlings, shrubs, and herbs) comprised 5 to 18 Mg/ha (2 to 9% of TAGB), while forest floor detrital accumulations comprised 65 to 101 Mg/ha (29 to 42% of TAGB). Average shade per day for July, 1993 ranged between 53% and 75%, reducing the unshaded solar energy potential of 2390 Mj/day to between 680 and 1280 Mj/day striking each m^2 of stream surface. This base-line reference information can serve in multi-disciplined research, as well as, be a basis for long term studies of natural systems responding to changing climate and/or different resource management scenarios.

THE ECOLOGY OF RIPARIAN ECOSYSTEMS OF NORTHEAST OREGON: SHRUB RECOVERY AT MEADOW CREEK AND THE STRUCTURE AND BIOMASS OF HEADWATER UPPER GRANDE RONDE ECOSYSTEMS

CHAPTER I

INTRODUCTION

Headwater riparian zones are among the most numerous and important of riparian ecosystems. They provide multiple functions related to ecosystem integrity and the support of terrestrial and aquatic communities. Among their complex roles are included channel structure and the flow and quality of water, as well as, food, habitat, and energy in support of the riverine ecosystem (Cummins 1974, Vannote et al. 1980, Minshall et al. 1985, Dahm et al. 1987, Maser et al. 1988). Riparian zone structure and composition are reflections of many kinds of disturbance including fluvial, fire, wind, insects, disease, and human activity (Resh et al. 1988, Gregory et al. 1991). Soil properties, water table depth, and the microtopography of valley floors can be extremely varied over short distances, contributing to the high degrees of structural and compositional diversity. This diversity is manifested in high levels of productivity and unique plant communities with multiple edges associated with various levels of vegetative strata. Riparian zone productivity, diversity, elongated nature, and proximity to water also makes them ideal zones for nesting, foraging, refuge, and migration for varieties of wildlife from the headwaters to the sea (Hubbard 1977, Johnson 1978, Thomas et al. 1979, Kauffman 1988).

Riparian vegetation plays many physical, biological, and hydrological, roles in the functioning of ecosystems. They protect and strengthen streambanks, deflect and slow the erosional high flows, assist in the settling out and trapping of transported materials, and play major roles in the aggradation of soils and nutrients in channel and floodplain recovery processes (Meehan et al. 1977, Elmore and Beschta 1987, Gregory et al. 1991, Elmore 1992). Riparian vegetation is also important in moderating stream temperature extremes and in influencing the hydroperiod (i.e., higher and cooler base flows during warm summer drought periods and warmer winter flows with less anchor ice development) (Winegar 1977, Elmore 1992). With regard to stream ecosystem restoration, riparian plant community regrowth and the accompanying successional processes are central to the rebuilding of streambanks, reconnection of water to the floodplain, and the recovery of food/habitat for fish, plant, and wildlife populations (Elmore and Beschta 1978, Sedell and Beschta 1991, Platts 1991, Elmore 1992).

Early explorers and fur trappers in the Columbia Basin repeatedly described streams as abounding with beaver and salmon and riparian areas as dominated by dense stands of willow *(Salix spp.)*, aspen *(Populus tremuloides)*, and cottonwood *(Populus trichocarpa)* (Thwaites 1905, Rollins 1935, Ogden 1950). By the early 1900's, many of these stands had been severely degraded or eliminated due to the removal of beaver (Parker et al. 1985) and overgrazing by livestock (Kauffman 1988, Elmore and Kauffman 1994). Because cattle tend to congregate and have strong affinities for riparian areas (Bryant 1982, Roath and Krueger 1982) many have been overgrazed (Fleischner 1994). Unfortunately, the biological consequences of overgrazing riparian systems are disproportionately high because of the diversity and large number of aquatic and terrestrial organisms that depend on these systems (Mackie 1978). With increased awareness of this problem more efforts may likely be directed toward riparian ecosystem restoration (Jenson and Bourgeron 1994). To assess riparian condition and trends, to plan for restoration in the near and long term, to define desired future conditions, and to provide tools and a reference base for monitoring purposes, ecologists and managers need documented baseline riparian information.

At Meadow Creek, in northeast Oregon, during the early stages of recovery of a degraded system I quantified shrub re-growth and rates of establishment following release from livestock grazing pressures (Chapter II). Riparian logging and decades of heavy grazing had resulted in a depauperate and suppressed riparian condition where stream temperatures, winter ice floes, and declines in fish habitat are known problems (Beschta et al. 1991, McIntosh 1992, Bouhle 1994). It was hypothesized that the release from domestic grazing would facilitate a riparian recovery. To separate the browsing influences of wild ungulates, elk-proof exclosures were utilized to protect one-third of the shrubs.

Land use history and initial riparian conditions, general riparian ecological functions, the ecology of the Salicaceae family, grazing impacts on riparian shrubs, native herbivory inherent to ecosystems, shrub reproduction dynamics, and the social relationships between elk, deer, and livestock are all also discussed. A total of 244 tagged plants representing eight common riparian species were used to quantify the first stages of shrub regrowth. And fifty-two 2x25m belt transects were used to quantify densities and rates of establishment of woody riparian species.

Biomass prediction equations for riparian shrubs are scarce to non-existent in the Pacific Northwest and valuable to ecologists studying natural systems. To calculate shrub biomass it was necessary to develop biomass prediction models. In Chapter II, 75 regression equations were developed for predicting component and total shrub biomass of four common riparian shrubs, thin-leaf alder *(Alnus incana)*, black cottonwood *(Populus trichocarpa)*, Mackenzie willow *(Salix rigida* var. *mackensieana)*, and coyote willow *(Salix exigua* var. *exigua)*. Models were generated by regressing combinations of the four independent variables height, crown area, mainstem diameter, and number of stems against the oven dry weights of leaves, twigs, and stems. Shrub form based equations and equations using different variables were also developed. Nutrient concentrations for these species and plant parts were also determined. Combined with nutrient concentrations these equations are of value as predictors in a variety of ecological studies where biomass, rates of biomass accumulation, and nutrient dynamics are important.

To facilitate riparian restoration and management, to help define desired future conditions, and to provide a background and basis for further and long term riparian research, the composition, structure, and biomass of relatively intact forested headwater riparian ecosystems of the Upper Grande Ronde Basin was quantified (Chapter IV). The structure and biomass contributions by all aboveground living and dead components was measured. Riparian forest community components included trees, snags, saplings, seedlings, shrubs, and coarse woody debris, in the stream and on the floodplain. Terrestrial portions of small woody debris, fine woody debris, herbaceous materials, and litter were also measured. In addition, a solar pathfinder was used to quantify the percent shade and solar energy inputs averaged for the day and month striking the stream surface.

The overall objectives of this project were to: quantify shrub recovery rates along a degraded riparian system following the removal of livestock and to document intact forested headwater conditions including the quantification of all aboveground living and dead structures and biomass. Both studies should be useful to ecologists and managers in the planning and monitoring of restoration projects and the riparian structure and biomass data should be useful in multi-disciplined ecological studies where riparian ecosystems provide an important function. Both studies will be valuable in the next century and beyond as researchers adapt to and study natural systems and their responses to changing climate and/or alternative management scenarios.