A comparison of water table dynamics and soil texture under black cottonwood recent alluvial bar, beaked sedge, and Geyser's/Drummond's willow communities
by Darin Jay Law

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Range Science
Montana State University

Abstract:
Although riparian ecosystems comprise only two percent of the western United State's land area (Kovalchilc and Elmore, 1995), these areas are extensively used for wildlife (Thomas, 1979), fish habitat (Duff, 1979), and livestock forage (Reid and Pickford, 1946). They are also important in maintaining water quality and quantity (Horton and Campbell, 1974). Since cottonwood, willow, and sedge riparian areas are important, more needs to be known about the natural factors that control the occurrence of riparian community types. Managers need to know how water table fluctuations influence riparian vegetation (Fenner et al, 1985), and how soil texture relates to both riparian vegetation (Hansen et al, 1995) and the water table (Friedman et al., 1997).

Such knowledge will enable managers to develop restoration plans for degraded riparian community types.

I compared water table fluctuation and depth, soil texture, coarse fragment percentage and streamside and hillside slope degrees under beaked sedge, Geyer's willow, and black cottonwood recent alluvial bar communities. Six sites representing each community type were monitored. Two sites were west and four sites were east of the Continental Divide. Each community type was monitored for water table fluctuation and depth on a bimonthly basis. Soil texture, slope and species composition were analyzed at all monitoring sites.

There were no significant differences in water table fluctuation between the three community types (p = 0.6702). On the other hand, water table depths between community types were significantly different (p = 0.0035). Cottonwood communities had deeper water tables than willow communities, which had deeper water tables than sedge communities. Particle size percentages were significantly different between community types. Sand percentages ranged successively higher from willow (36%) to sedge (47%) to cottonwood (78%; p = 0.0004). Silt and clay percentages mirror the sand, willow (39%, 25%), sedge 35%, 18%) and cottonwood (15%, 7%; p=0.0002, 0.0031) and are significantly different. Coarse fragment percentages of 46% in cottonwood, 22% in willow and 15% in sedge soils are statistically different (p value = 0.0108). There were no significant differences in streamside and hillside slope degrees between cottonwood (0.6°, 0.6°; 0.6%), sedge (1,° 1°; 1.1%), and willow (1°, 1.6°; 1.1%, 1.7%) community types with p values of 0.7622 and 0.2850 respectively.

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APPROVAL

of a thesis submitted by

Darin Jay Law

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date April 19, 1999

This work is dedicated to the success of Range Management and all natural resource management. It is our responsibility to treat natural resources as a valuable gift. A gift such as grandpa's old hunting knife or bamboo flyrod from which satisfaction is received when properly used and cared for. This will ensure their legacy in our lives and in the lives of our children's children and beyond.

VITA

Darin J. Law was born February 11, 1972 in Brigham City, Utah to Verl and Evelyn Law. He graduated from Emmett High School in Emmett, Idaho in 1990. In 1996 he received a Bachelor of Science degree in Range Resources from the University of Idaho. Shortly after finishing his undergraduate studies, he married Tiffany G. Hanks on June 4, 1997. They are currently the parents of a beautiful baby girl, Caitlyn.

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ABSTRACT

Although riparian ecosystems comprise only two percent of the western United State's land area (Kovalchik and Elmore, 1995), these areas are extensively used for wildlife (Thomas, 1979), fish habitat (Duff, 1979), and livestock forage (Reid and Pickford, 1946). They are also important in maintaining water quality and quantity (Horton and Campbell, 1974). Since cottonwood, willow, and sedge riparian areas are important, more needs to be known about the natural factors that control the occurrence of riparian community types. Managers need to know how water table fluctuations influence riparian vegetation (Fenner *et al.*, 1985), and how soil texture relates to both riparian vegetation (Hansen *et al.*, 1995) and the water table (Friedman *et al.*, 1997). Such knowledge will enable managers to develop restoration plans for degraded riparian community types.

I compared water table fluctuation and depth, soil texture, coarse fragment percentage and streamside and hillside slope degrees under beaked sedge, Geyer's willow, and black cottonwood recent alluvial bar communities. Six sites representing each community type were monitored. Two sites were west and four sites were east of the Continental Divide. Each community type was monitored for water table fluctuation and depth on a bimonthly basis. Soil texture, slope and species composition were analyzed at all monitoring sites.

There were no significant differences in water table fluctuation between the three community types ($p = 0.6702$). On the other hand, water table depths between community types were significantly different ($p = 0.0035$). Cottonwood communities had deeper water tables than willow communities, which had deeper water tables than sedge communities. Particle size percentages were significantly different between community types. Sand percentages ranged successively higher from willow (36%) to sedge (47%) to cottonwood (78%; $p = 0.0004$). Silt and clay percentages mirror the sand, willow (39%, 25%), sedge 35%, 18%) and cottonwood (15%, 7%; p=0.0002, 0.0031) and are significantly different. Coarse fragment percentages of 46% in cottonwood, 22% in willow and 15% in sedge soils are statistically different (p value = 0.0108). There were no significant differences in streamside and hillside slope degrees between cottonwood (0.6°, 0.6°; 0.6%), sedge (1°, 1°; 1.1%), and willow (1°, 1.6°; 1.1%, 1.7%) community types with p values of 0.7622 and 0.2850 respectively.

Chapter 1

INTRODUCTION

Riparian Areas

Riparian ecosystems are those lands adjacent to water where plants dependent on a continuous water source exist (Kovalchik, 1987). These ecosystems comprise only about 2 percent of the total western United States land area (Kovalchik and Elmore, 1991), but contribute many important functions and values. Riparian ecosystems: are important wildlife habitat (Ames, 1977; Patton, 1977; Thomas, 1979; Johnson *et al.*, 1977), modify aquatic environments and fish habitat (Duff, 1979; Meehan *et al.*, 1977), help maintain water quality and quantity (Horton and Campbell, 1974; Brinson *et al.*1981), and are valuable for livestock forage (Reid and Pickford, 1946). For managers to better understand riparian community types, information is needed regarding which factors naturally control their extent. Such information will help reclamation activities in the riparian area and would provide much needed perspective regarding factors that control the presence or absence of riparian community types.

Many authors have studied the relationship between vegetation and various influencing factors. Dyksterhuis (1949) reported that climax vegetation is a product of soil and climate and present rangeland vegetation is a product of soil, climate and grazing disturbance. Nearly 20 years later, Daubenmire (1970) reported that individual ecosystems are distinguished by abiotic and biotic characteristics. Riparian areas are very dynamic (Padgett *et.* a*l*., 1989) due to: constant reworking of substrates, the presence of side channels, topographic variability as well as flooding. Nevertheless, biotic characteristics such as climate, water availability, topography, and chemical and physical properties of the soil determine riparian communities (USDA, 1998). Therefore, more research is needed on the relationship between biotic and abiotic factors that might control the distribution of riparian communities.

As a first attempt, several riparian vegetation classification systems have been created to aid managers in the western states: eastern Idaho and western Wyoming (Youngblood *et. al.*, 1985), southern Oregon forests (Kovalchik, 1987), Utah and southeastern Idaho (Padgett *et. al.*, 1989), Nevada and eastern California (Manning and Padgett, 1995) and Montana (Hansen *et. al.*, 1995). These classification systems contain valuable information about succession, soil pedon descriptions and management. However, they provide little quantitative information regarding soil texture and water tables, which largely determine community type (Brady, 1990). According to Hansen *et al.* (1995), soils are generally thought to influence riparian species composition, species coverage, and growth form. Groundwater may affect riparian vegetation more than soil characteristics (Hansen *et al.*, 1995) and effects of water table declines are related to soil textures (Friedman *et al.*, 1997). However, most of the classification field methods only classified soil pedons to the family level (USDA-SCS, 1975). Equally common was that depth to water table was only recorded when it appeared in the soil pit, and was considered to be at the soil surface in moist organic soils. Water table fluctuations were not recorded. As a result, the above classifications do not adequately address those factors that determine riparian communities.

To begin to fill in the gaps in data about possible abiotic/biotic riparian community classification, this study tests reported riparian vegetation, soil texture, slope and water table relationships against those actually measured in three riparian communities. These communities are dominated by either black cottonwood (*Populus trichocarpa* T. & G. ex Hook), beaked sedge (*Carex rostrata* Stokes), or Geyer's (*Salix geyeriana* Anderss.) and Drummond's willow (*Salix drummondiana* Barratt).

These three species were chosen because of their abundance and common occurrence throughout the northern Rocky Mountains (Hansen *et. al.*, 1988). By comparing the descriptions of these riparian communities with actual field conditions managers will be more capable of interpreting the ability of a specific riparian area to support a certain community type.

Chapter 2

LITERATURE REVIEW

Black Cottonwood (*Populus trichocarpa* Torr. & Gray ex Hook)

Black cottonwood communities: provide food and cover for livestock and big game, help stabilize stream banks for erosion control and fish habitat (Hansen *et al.*, 1995) and provide nesting sites for birds (Dittberner and Olson, 1983). Native plains cottonwood (*Populus deltoides* Marsh.) stands provide habitat for 82% of all bird species breeding in northeastern Colorado (Knopf, 1985). Beidleman (1978) recorded 245 vertebrate species and subspecies in cottonwood stands in Colorado. Eastern Colorado cottonwoods also provide nearly all the native tree cover (Crouch, 1979)

Cottonwoods are fast growing pioneer species that do not have a long lifespan (150 – 200 years), in comparison with other tree species. During their first year, cottonwoods invest a lot of their energy seeking water. Below ground growth far exceeds above ground growth during their first year. The greater the contact with the ground water table, the more successful the tree becomes. After contact is made with ground water, growth shifts from roots to above ground biomass, leaves, branches, and stems. Once established, the trees respond poorly to permanent changes or fluctuations in ground water depths. In many agricultural settings permanent changes in ground-water level result in death of mature cottonwoods. Thus, human storage and use of water can change cottonwood communities (Scott, 1991).

Boggs and Weaver (1992) found cottonwood communities eventually became grassland communities with declining water availability. Along those lines, flood suppression and water development since the 1800s caused cottonwood communities to become dominated by exotic trees like Russian-olive (*Elaeagnus anugstifolia* L.) and trees from the eastern Plains (Olson and Knopf, 1986; Johnson, 1992; Shafroth *et. al.*, 1995). Without measurements of ground-water fluctuations, it is difficult to understand how much change causes mortality. Rood *et al.* (1994) in southwestern Alberta found that there exists a close relationship between river stage and depth to water table in a permeable substrate. Rood *et al.* (1994), also noted that riparian substrates consist of a mixture of sand, gravel, and cobble, which allows free water movement (Mahoney and Rood, 1992). Catherine Creek in northeastern Oregon displays soil characteristics similar to those reported in Canada; well-drained loamy soils with sand, gravel, and cobbles 1 m below the soil surface (Kauffman *et al.* 1985). Hansen *et al.* (1995) described the soils that cottonwoods inhabit as silt loams with sand and cobble layers and a water table existing within 1 m of the soil surface during the growing season. These types of soil are very significant to black cottonwood community development. The coarse sands and cobbles provide aerated, well-drained horizons favored by black cottonwood (Anderson as cited by Kauffman *et al.*, 1985).

Beaked Sedge (*Carex rostrata* Stokes)

Beaked sedge is an important dominant type in Montana and other temperate climates (Hansen *et al.* 1988; Kovalchik 1987). This species is used to restore degraded riparian areas because it provides high value for erosion control (USDA, 1986). Dominating the understory of many willow communities throughout the northern Rocky Mountains, beaked sedge is very productive. Clippings in northwestern Montana produced 5376 kilograms per hectare (Winward, 1998). Although its value rating for cattle and wildlife forage is low to moderate (Manning and Padgett, 1995) beaked sedge is moderately palatable and tolerant to cattle grazing (Hermann, 1970; Ratliff, 1983). Its thick dense sod also forms streambank undercuts providing excellent fish habitat (Hansen *et al.* 1988).

High water tables determine and influence beaked sedge distribution more than the substrate properties (Youngblood *et al.* 1985), water tables generally rest at about 23 cm below the soil surface and are seasonal (Manning and Padgett, 1995). Sjoberb and Danell (1983) found that shoot densities of beaked sedge were higher on seasonally flooded soils, and that with continual flooding, shoot densities decreased although beaked sedge does colonize permanently flooded sites (Manning and Padgett, 1995). Soils are usually anaerobic (Hansen *et al.* 1988) and consist of clay and clay loam to sandy loam (Hansen *et al.* 1995; Manning and Padgett, 1995). Kauffman (1985) described soils of sedge communities as having fine-textured A-horizons above a coarse-textured horizon, which forms a water restrictive horizon. When beaked sedge communities experience a drop in the water table, willow species begin to increase (Hansen *et al.* 1988), with

Nebraska sedge (*Carex nebrascensis* Dewey) and tufted hairgrass (*Deschampsia cespitosa* (L.) Beauv.) increasing in the understory (Manning and Padgett, 1995) and becoming codominants with high grazing use (Kovalchik 1987). Thus, high relatively stable water tables are necessary to maintain stable beaked sedge communities (Hansen *et al.* 1988).

Willow (*Salix* sp.)

Being very common in many riparian communities (Kovalchik, 1987) willows are important in maintaining stream bank characteristics and biological diversity in riparian areas (Smith, 1980). Willows also hinder erosion in riparian areas. Stems and leaves help slow water velocity dissipating energy while roots provide bank stability (Crouch and Honeyman 1986; Elmore and Beschta, 1987; Platts *et al.*, 1987; Skinner *et al.*, 1986). Willows trap sediment in overland flow, (Platts *et al.*, 1987) that can pollute streams. Because of these beneficial effects, willows are considered valuable to "proper riparian function" (Kovalchik and Elmore, 1991).

Willow species, as a whole, are generally adapted to various soil textures (Winward, 1998). Soils under a Wolf willow (*Salix wolfii*) stand near Stanley, Idaho were moderate to rapidly permeable with a gravelly loam of 25% cobbles in the upper 38 cm. Immediately below this layer is a gravelly sandy clay loam with 30% cobbles (Clary, 1995). Hansen *et al.* (1995) found coarse-textured soils under Geyer's willow stands in Montana while Winward (1998) stated that Geyer's willow does well on fine textures and Drummond's willow will flourish on coarse textures. Youngblood *et. al.* (1985) discovered that most Geyer's willow communities occupied fine-textured soils. The only community with abundant coarse fragments was the Geyer's willow /Mesic forb community type. Manning and Padgett (1995) found soils to be fine, loamy-textured under Geyer's and booth (*Salix boothii*) willow stands in Nevada. Kauffman *et al.* (1985) also noted soils along Catherine Creek in northeastern Oregon to be well drained and shallow beneath shrub-dominated communities. Water tables remained within 1 m (39 cm) during the spring and available water is texture dependent in Montana sites described by Hansen *et al.* (1995). Water tables commonly remain within 1 m of the soil surface throughout the growing season. These characteristics (e.g. well drained soils) provide aerated water in the rooting zone (Hansen *et al.* 1995).

Summary

Rood *et al.* (1994) described Alberta riparian soils textures as mixtures of sand, gravel, and cobbles. Kauffman *et. al.* (1985) in northeastern Oregon described cottonwood soil textures as loamy with sand gravel, and cobbles 1 m below the soil surface. Hansen *et. al.* (1995) in Montana described cottonwood soil textures to be silt loams with sand and cobble layers. Hansen *et. al.* (1995) also stated that water tables were within 1 m of the soil surface during the growing season.

Beaked sedge soils are very different than cottonwood soils in that they are fine textured (Kauffman, 1985) and consist of clay and clay loam to sandy loam (Hansen *et. al.*, 1995). Water tables are similar to cottonwood water tables in that they are high

(Youngblood *et. al.*, 1985) usually resting 23 cm below the soil surface (Manning and Padgett, 1995).

Willow soils are more variable and intermediate between cottonwood and sedge soils. They are permeable with gravelly loams of 25% cobbles above gravelly sandy clay loams with 30% cobbles near Stanley, Idaho (Clary, 1995) they are also coarse textured (Hansen *et. al.*, 1995) and fine textured (Winward, 1998; Youngblood *et. al.*, 1985). Manning and Padgett (1995) noted willow soils to be fine loamy textured. Water tables beneath willow communities were within 1 m (39 cm) of the soil surface in Montana (Hansen *et. al.*, 1995).

It can be seen that there is overlap and inconsistencies between the soils and water tables described in cottonwood, sedge and willow communities. There is reference to sand and loam in every one of the community types with gravels and cobbles noted in cottonwood and willow communities. Water tables are only generally described in cottonwood communities (within 1 m) to quite narrow in sedge (23 cm) and willow (39 cm) communities. But, there is reference to "within 1 m" of the soil surface in all of the community types. Therefore, given the above information, cottonwood soils are probably coarse textured made up of sand, gravels and cobbles with deeper water tables than sedge and willow water tables. Sedge soils are probably fine textured with the highest water tables. Willow soils are probably fine textured containing some gravels and cobbles with water tables intermediate in depth between cottonwood and sedge water tables.

Chapter 3

WEST VERSUS EAST OF THE CONTINENTAL DIVIDE

Introduction

Due to the overlap and inconsistency in soils and water tables between cottonwood, sedge and willow communities the primary objectives of the study were to describe and compare: water table depth and fluctuation, soil texture, coarse fragment percentages and streamside and hillside slope across the three community types. Streamside slopes are those slopes parallel to the contour, adjacent to the stream while hillside slopes are perpendicular to the stream. The community types were located in two groups, the west group and the east group. One group of the three community types was located west of the continental divide while a second group of the three community types was located east of the continental divide (Fig. 3.1). The continental divide forms a natural boundary between two primary climates in Montana. A maritime climate with relatively uniform temperatures and higher precipitation dominates west of the divide. East of the divide a true continental climate causes more extreme temperatures and lower precipitation (Southard, 1967). Thus, climate may have an overriding effect on the community type: water table depth and fluctuation, soil texture, coarse fragment percentage and streamside and hillside slope degrees attributed to their location east or west of the Continental Divide. As a result, I compared water table fluctuation and depth, soil texture, coarse fragments and slope between the two groups of community types to test whether or not there were differences between the two groups that would bias the individual community type comparisons.

Objectives

A. To compare/contrast water table fluctuation and depth, soil texture, coarse fragments and slopes between the west group of communities and the east group of communities.

Hypotheses

1. Ho: There is no difference in mean water table fluctuation between west and east groups.

   Ha: There is a difference in mean water table fluctuation between west and east groups.

2. Ho: There is no difference in mean water table depth between west and east groups.

   Ha: There is a difference in mean water table depth between west and east groups.

3. Ho: There is no difference in soil texture between west and east groups.

   Ha: There is a difference in soil texture between west and east groups.

4. Ho: There is no difference in mean coarse fragment percentages between west and east groups.

Ha: There is a difference in mean coarse fragment percentages between west and east groups.

5. Ho: There is no difference in mean slope degrees between west and east groups.

   Ha: There is a difference in mean slope degrees between west and east groups.

Study Area

Study sites (Fig. 3.1) covered a broad range of Montana, mountain valleys at elevations between 1000 m and 1462 m. Cattle and wildlife have grazed all study sites.

Figure 3.1. Map of Montana. Stars represent study locations, not individual sampling units.