MANAGING RIPARIAN BUFFERS TO IMPROVE SOIL STRUCTURAL PROPERTIES

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Abstract

Fifty-five percent of Kentucky's stream impairments have been attributed to agriculture. Riparian buffer management may improve buffer effectiveness and reduce agricultural contaminants impairing water quality. Three mowing regimes and one native grass establishment regime were imposed in the riparian buffer zone surrounding a tributary of Cane Run Creek in Fayette County KY. Treatment plots measured 10m x 15m, with 10 replications of each treatment. One year after treatment, root biomass, soil aggregate size distribution, and wet aggregate stability were evaluated. Preliminary analysis indicates no significant treatment effect on root biomass, soil aggregate size distribution, or wet aggregate stability after one year of treatment implementation. This result indicates a) reduced mowing and native grass establishment procedures had no adverse effects on the evaluated parameters, and b) one year of above-ground vegetation management is not sufficient time to see significant changes in root biomass and soil structure of riparian buffer soils.

Introduction

The Kentucky Division of Water points to agriculture as the leading source of stream impairments, with 3,842 of the 6,985 (55%) impaired stream miles in KY not supporting their designated uses due to agriculture (Kentucky Environmental and Public Protection Cabinet, 2010). Riparian zones play a key role in landscapes because of their prominent location in the transition between terrestrial and aquatic ecosystems. Soil water passes through riparian zones before entering streams and riparian vegetation may significantly modify the amount of dissolved nutrients entering streams by plant uptake (Gregory et al., 1991). Conservation buffers increase infiltration rates (Bharati et al., 2002), remove sediment and nutrients from surface runoff (Lowrance et al., 2002), and increase soil organic matter. Vegetated buffers improve soil quality in the riparian zone and may be effective in reducing NPS pollution in agroecosystems by increasing infiltration (Bharati et al., 2002). Vegetated streamside buffers provide foliage and stems that increase surface roughness, and a dense network of roots that bind riparian substrates to increase streambank resistance to erosion (Kiley and Schneider, 2005). Roots are important in riparian buffers because they reduce streambank erosion, with root exudates playing a role in soil cohesion (Wynn et al., 2004).

Assessing overall conservation buffer effectiveness can be complex; therefore, identifying specific soil and/or vegetative properties that measure or indicate desirable buffer behaviors is important. At present we do not fully understand the interaction between management of above-ground plants and soil structure development. Specifically, study is needed to determine above-ground treatment effects on the size and stability of soil aggregates, surface infiltration, persistence of macroporosity, and root biomass. These attributes may influence riparian buffer function and effectiveness in trapping nutrients from surface runoff. Specific information on establishing and maintaining riparian buffers will assist agricultural producers in maximizing the potential for water quality protection through using riparian buffers.

Methods

Research plots were established in July 2010 at the University of Kentucky Agriculture Experiment Station in the riparian buffer of an unnamed tributary of the Cane Run Creek (Figure 1). Prior to establishing the plots, the riparian buffer consisted of mixed grassland vegetation (e.g. fescue, bluegrass, broadleaf weeds) mowed every four to six weeks. The plots measure approximately 10m x 15m, with the 10m distance parallel to the stream. The experiment design consists of ten replications of four treatments in a repeating pattern to consider spatial variation along the length of the creek. Plot treatments were: 1) intensive mowing (mowed to 6” height once every four weeks during the growing season); 2) moderate mowing (mowed two times during the growing season); 3) no-mowing; and 4) native grass transition. Native grass transition plots received glyphosate herbicide treatment in Fall 2010 and Spring 2011 to eliminate existing vegetation, and then drill-seeded with a native grass-forb mixture in June 2011.

Figure 1. Study site detail.

A sampling transect located 2 m from top-of-bank was established along all plot locations. Soil samples were collected in May 2011 at 1, 3, 5, 7, and 9 m distances along the 2 m transect within each plot using a JMC Environmentalist’s Sub-Soil Probe Sampling System. Soil cores were collected to a depth of 30 cm, divided into 10 cm increments, and stored at 3°C until processed for root biomass, aggregate size distribution, and water stable aggregates. Roots were manually picked from each soil sample for 15 minutes, rinsed twice with deionized water, weighed, dried at 60°C for 24 hours, and weighed again to determine root biomass as described by Gift et al. (2010).

After roots were extracted, soil samples were air dried at room temperature (24°C) for approximately 5 days. Air dried soil was separated to determine aggregate size distribution by placing samples in a nest of sieves with openings of 4 mm, 2 mm, 1 mm, 0.25 mm, and 0.053 mm. Sieves were shaken at an amplitude of 2.5 cm for 1 minute. Mean weight diameter (MWD) was calculated by the methods described in Kemper and Rosenau (1986). Wet aggregate stability was determined from 1-2 mm-size aggregates using the wet sieving procedure (Kemper and Rosenau, 1986).

Results and Discussion

Dry root weight

Surface soil samples (0-10 cm) had overall greater dry root weight than sub-surface depths (10-20 cm and 20-30 cm), which was expected due to existing vegetation, because 75% of herbaceous vegetation roots have been shown to concentrate in the upper 30 cm of riparian buffer soils (Wynn et al., 2004). After one year of implementation, treatment had no significant effect on dry root weight at any sampled depth although the trend indicates an increase in dry root weight with decreased mowing frequency (Figure 2). It is important to note that the native grass transition treatment had no established above-ground vegetation at the time of sampling because of its transition from existing grassland vegetation to a native grass-forb mix. This absence of vegetation resulted in reduced dry root weight. Native grass transition plots had established above-ground vegetation by July 2011. This treatment will not be mowed, and with time to establish above-ground vegetation, this treatment is likely to have greater dry root weight than the data shown.

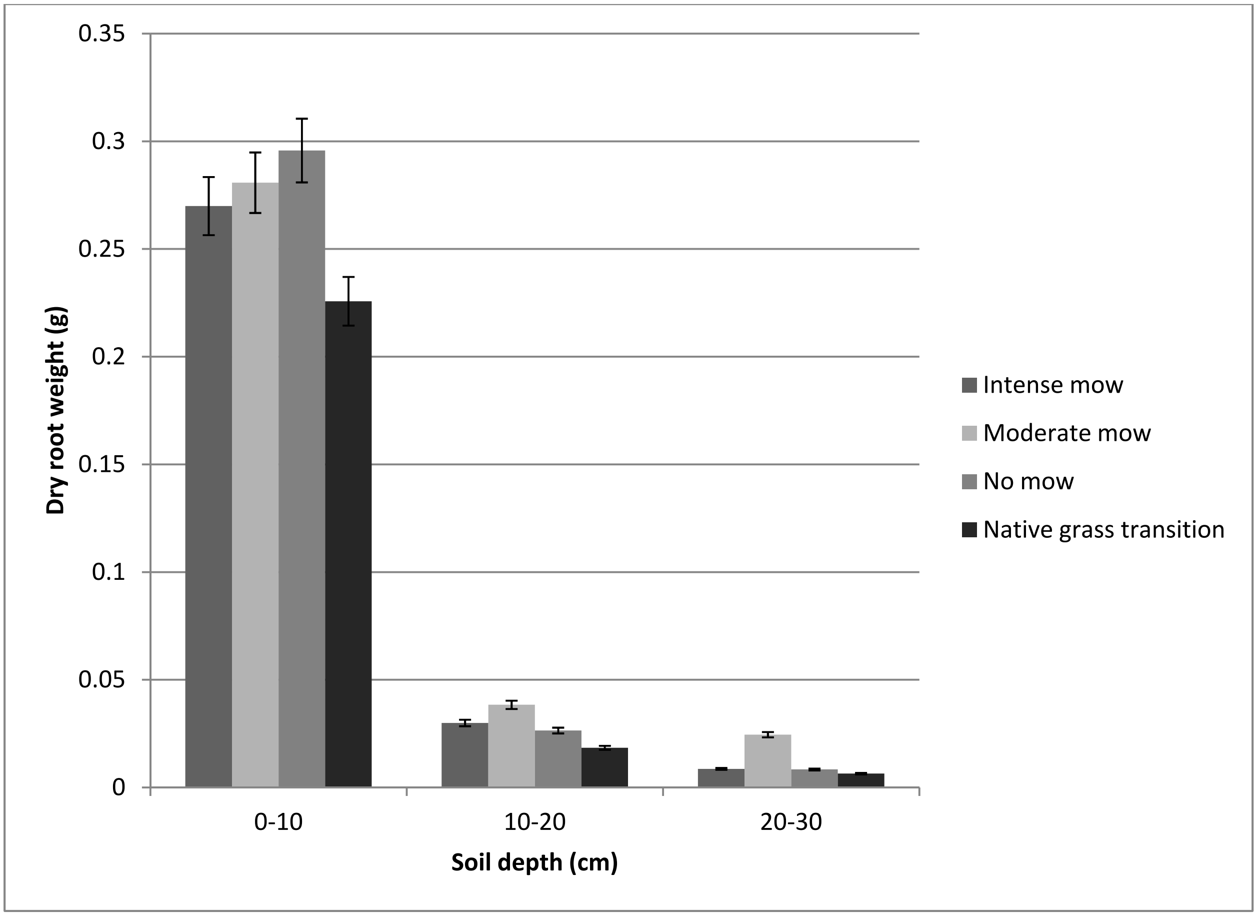

Figure 2: Dry root weight after one year of treatment. Values reported are means from soil sample volume of 32.4 cm^3, standard error bars at 95% confidence intervals. Dry root weight means by treatment were not compared among depths due to a failure of Levene's test of homogeneous variance.

Aggregate size distribution

Changes in soil aggregate size class distribution may occur rapidly in restored stream corridors, and quantifying these changes will be important in assessing stream restoration success (Handayani et al., 2008). One year after establishment, vegetation treatment had no significant effect on mean weight diameter (MWD) of soil aggregates at any sampled depth (Figure 3). Any differences in MWD by sampling depth are likely a result of inherent mineralogical characteristics of the soil, although the trend indicates an increase in MWD with decreasing mowing intensity.

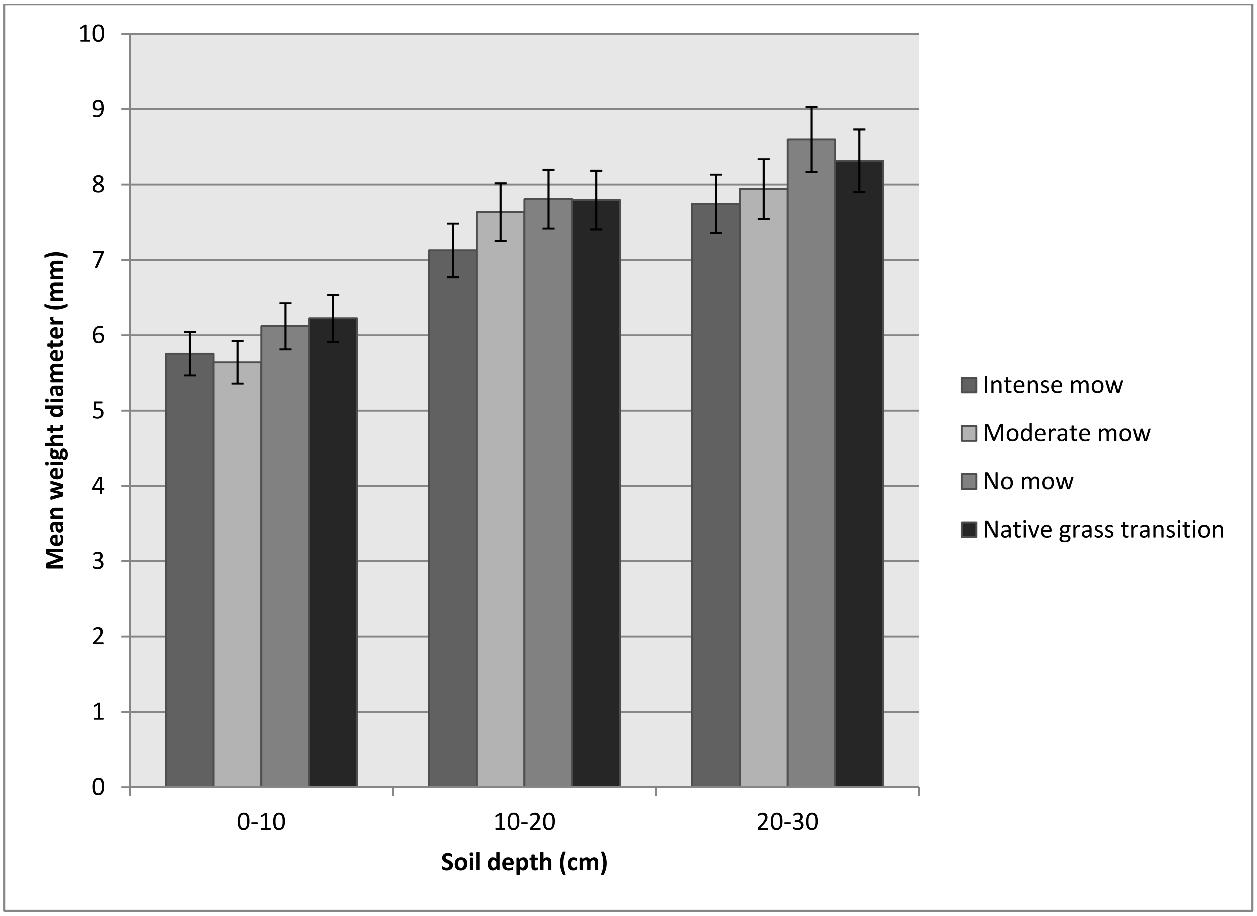

Figure 3: Mean weight diameter (MWD) of soil aggregates after one year of treatment. Values reported are means with standard error bars at 95% confidence intervals.

Water stable aggregates

The ability of soil aggregates to resist destruction by the disruptive force of water in the soil matrix may be an indication of the soil's ability to resist erosion. By measuring water stable aggregates, we can begin to understand the resistance of the soil to destruction by water and mechanical stress (Paudel et al., 2011). One year after establishment, vegetation treatment had no significant effect on water stable aggregates at any sampled depth (Figure 4).

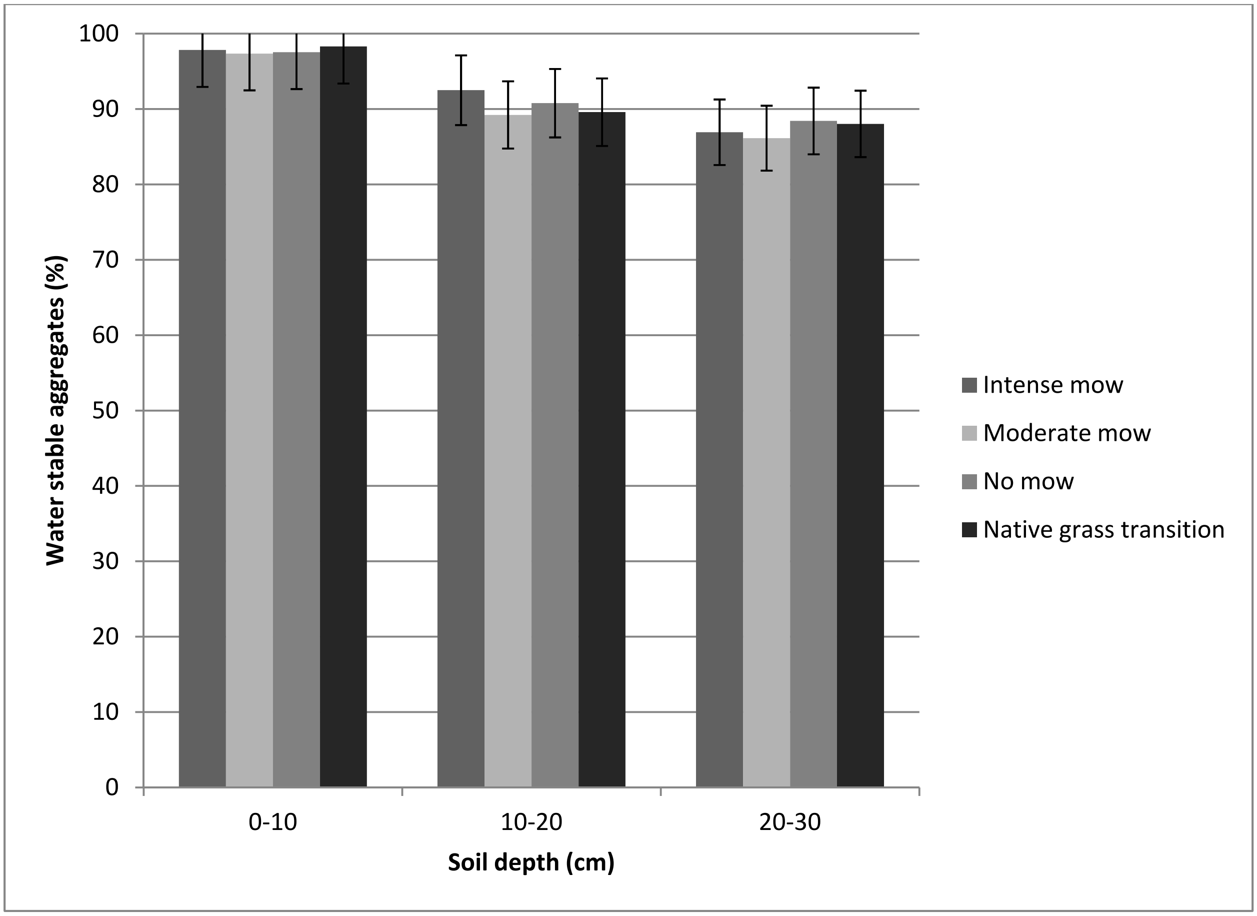

Figure 4: Percent water stable aggregates after one year of treatment. Values reported are means with standard error bars at 95% confidence intervals.

Summary

While treatment effects are not evident after one year of implementation, no negative effects are shown in the data as a result of reduced mowing frequency or native grass establishment with conventional herbicide methods. Root biomass, soil aggregate size distribution, and wet aggregate stability will be analyzed after a second year of treatment, as we look for long-term benefits while avoiding adverse effects in the short term.

From this research we hope to assemble information that will lead to better riparian area management recommendations for water quality protection. The information will not only be important in the Cane Run watershed, but also to other mixed-use watersheds as a method for reducing nonpoint source pollution from agricultural operations.

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