# STRATEGIC ROTATIONAL GRAZING REDUCES TOTAL SUSPENDED SEDIMENTS AND CARBON IN SEDIMENTS IN RUNOFF

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**Abstract.** Pastures can sequester soil organic carbon or be a source of contamination to local streams depending on management. Rotational grazing, exclusion with over-seeding of areas vulnerable to erosion and runoff, and use of cattle lures may improve soil carbon abundance and retention in pastures. Strategic rotational grazing system (SRG) was compared to conventional grazing with rolling out of hay (C) on 8 pastures: four near Watkinsville and four near Eatonton. This portion of the study compares loss-on-ignition (LOI) carbon, bulk density (BD) in soil samples, total suspended sediments (TSS), carbon in sediments (CS), and dissolved organic carbon (DOC) in runoff water samples from baseline (2015) to post-treatment year (2017) between C and SRG. Reduction in LOI carbon in both C and SRG treatments in spring-2017 might be attributed to the 'Birch Effect' when, organic carbon in soil was rapidly mineralized to release $CO_2$ after rewetting the drought exposed soil. Significantly greater LOI carbon in SRG pastures as compared to C pastures in top 5 cm soil in summer-2017 was observed probably due to downward movement of carbon in soil profile by plant roots. Significantly lower bulk density in SRG pastures in summer-2017 could be due to increased porosity of soil by plant roots and active biology. Comparison of treatments (SRG and C) showed statistically similar TSS and CS during baseline, whereas SRG had significantly lower TSS and CS in 2017. Exclusion of areas vulnerable to erosion, over-seeding with productive forage mixes to maintain ground cover, and reduced trampling via lure management are possible explanations for reduction in TSS and CS in SRG. As in multiple previous studies, organic carbon was prone to loss in particulate form more than in dissolved form as revealed by similar DOC losses from both treatments during baseline and post-treatment year.

## INTRODUCTION

Pastures can improve soil quality and reduce $CO_2$ emissions through soil organic carbon sequestration in the Southern Piedmont region of USA (Franzluebbers et al., 2000; Causarano et al., 2008). As beef cattle are grown in all 159 counties of the state of Georgia, there is an immense opportunity for carbon sequestration in pasture soils in the state. Soil organic matter is subject to decline under excessive grazing pressure, which in turn reduces plant productivity of pastures (Conant and Paustian, 2002). Grazing management with high stocking rates can result in high level of runoff, and sediment and nutrient losses to surface waters (Park et al., 2017). Agriculture nonpoint source pollution from livestock grazing must be addressed to maintain quality of streams and may be reduced by implementing combination of best management practices in relation with stream hydraulic and geomorphic characteristics (Agouridis et al., 2005).

Loss of organic carbon via runoff may occur in two main forms; particulate organic matter in sediments or dissolved organic carbon in water. Loss of soil as sediment can be accelerated by grazing (Haan et al., 2006). McGinty et al. (1979) reported lower infiltration rates and higher sediment losses from continuously grazed pastures in comparison to rotational grazing, and also found that the differences were related to plant biomass, bulk density, depression storage, and soil depth. Carbon bound with sediments and dissolved organic carbon can be a significant source of organic carbon inputs to nearby streams. Reducing losses of carbon in runoff is needed to reduce all sediment loss from pastures (Owens and Shipitalo, 2011).

Cattle congregate around the farm equipages (e.g., shades, hay-feeding areas, waterers) causes uneven spatial distribution of nitrogen, carbon and bulk density (Dahal et al., 2018; Hendricks et al., in press), which may be ameliorated by strategic placement of farm equipages.

## METHODOLOGY

This study was conducted in two sites in the Georgia Piedmont; J Phil Campbell (JPC) Sr. Research and Education Center near Watkinsville in Oconee county, and Eatonton Beef Research Unit near Eatonton in Putnam county. Both sites are characterized by moderate wet winter and long dry summer. The two sites had 4 pastures each, of which two were continuously grazed with rolling out of hay (C) and two were managed as Strategic Rotational Grazing (SRG) pastures. The SRG-grazing included the following practices: rotational grazing, exclusion of areas vulnerable to erosion, over-seeding of exclusions, and lure management of cattle by strategic placement of farm equipages like hay-feeding rings, waterers, and portable shades. Grazing systems SRG against C were compared for their potential to conserve or sequester soil organic carbon, reduce soil compaction and reduce losses of sediment and nutrients associated with it in surface runoff. In this work we are presenting baseline (2015) and early results after treatment implementation.

Approximately 80 points in each pasture were sampled during summer 2015, which is hereafter referred to as 'baseline' and analyzed for Loss-on-Ignition (LOI) carbon and Bulk Density (BD). Post-Treatment soil sampling was done in spring- and summer-2017. Pour-point runoff collectors were set up at the outlet of each watershed at the edge-of-field. Surface runoff collected at these collectors was filtered through 0.45-µm filter-paper and analyzed for amount of total suspended sediments (TSS), Carbon in Sediment (CS) and Dissolved Organic Carbon (DOC) during baseline and post treatment sampling dates.

One-way ANOVA was used to detect differences in mean LOI carbon and BD between different sampling dates. Tukey HSD test was used to test for differences in means at 0.05 level of significance using JMP software package.

## RESULTS AND DISCUSSION

### Loss-on-ignition (LOI) Carbon

There was no significant change in LOI carbon at 0-5 cm depth in continuously grazed pastures with rolling out of hay (C) and Strategic Rotational Grazing (SRG) pastures from baseline to summer 2017 (Figure 1a.). But similar LOI carbon between treatments (SRG = 8.54 g 100 $g^{-1}$ soil and C = 7.84 g 100 $g^{-1}$ soil) during baseline changed in summer 2017 where, SRG pastures (8.80 g 100$g^{-1}$ soil) had significantly greater ($p<0.05$; Tukey HSD test) LOI carbon compared to C pastures (7.26 g 100$g^{-1}$ soil).

There was no significant change in LOI carbon at 5-10 in C pastures from baseline to summer 2017. In SRG pastures however, LOI carbon at 5-10 cm depth was significantly lower in spring 2017 as compared to other sampling dates and similar results were seen in LOI carbon at 10-20 cm depth in both C and SRG pastures. 2016 was a drought year where drought extended from April to early December followed by a few heavy rainfall events in early spring 2017. The observed reduction in LOI carbon in spring 2017 (significant in some cases) in both C and SRG pastures from baseline was likely a result of the rewetting post severe drought (Birch Effect, Jarvis et al., 2007). The Birch Effect causes rapid mineralization of labile organic matter and microbial biomass in the soil which easily decompose to release $CO_2$. Significantly greater LOI carbon in summer 2017 in SRG pastures as compared to C pastures could be due to observed new plant roots to depths below 20 cm improving porosity and allowing surface soil carbon to move into and deeper into the soil profile.

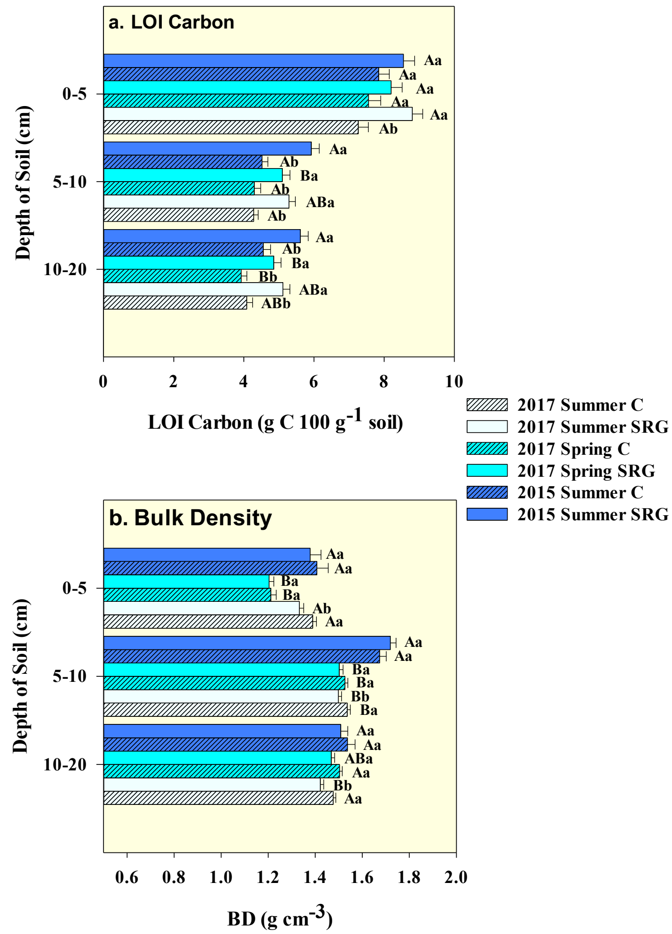


**Figure 1.** a. Loss on Ignition (LOI) carbon and b. Bulk Density (BD) of soils in Continuous Grazing with rolling out of hay (C) and Strategic Rotational Grazing (SRG) pastures in different sampling years. Means separated by different upper-case letters denote significant difference at 0.05 level of significance between different sampling dates within a treatment. Means separated by different lower-case letters denote significant difference at 0.05 level of significance between the two treatments (C and SRG) within a sampling date.

### Bulk Density (BD)

There was no significant difference in bulk density (BD) in 0-5 cm soil in both C and SRG pastures from baseline to summer 2017. In spring 2017 however, BD was significantly ($p<0.05$; Tukey HSD test) lower in both treatments compared to baseline. In 5-10 cm depth, both C and SRG treatments had greatest bulk density during baseline, which in spring and summer of 2017 were significantly lower as compared to baseline. In the 10-20 cm soil depth, C pastures had no significant difference in BD from baseline to any other sampling dates whereas SRG pastures had significantly lower BD during the same sampling period. Baseline values of BD at all three depths under study were similar for both treatments, which became significantly lower in SRG pastures as compared to C pastures in summer 2017 (Figure 1b.).

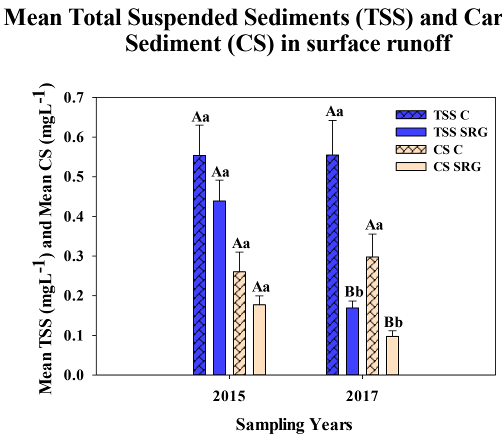


**Figure 2.** Mean Total Suspended Sediments (TSS) and Carbon in Sediment (CS) in surface runoff in Continuous Grazing with rolling out of hay (C) and Strategic Rotational Grazing (SRG) pastures in different sampling years. Means separated by different upper-case letters denote significant difference at 0.05 level of significance between different sampling years within a treatment. Means separated by different lower-case letters denote significant difference at 0.05 level of significance between the two treatments (C and SRG) within a sampling year.

The lower bulk density in spring 2017 at 0-5 cm depth could be due to greater moisture in spring as compared to late summer. We speculate that frost heaving influenced lower bulk densities in Spring-2017 when soil water freezes and expands soil porosity thereby reducing BD. Reduced compaction of soil in SRG pastures compared to C pastures in summer 2017 might have been due to increased porosity of soil by root and other active biology.

### Total Suspended Sediments, Carbon in Sediments, and Dissolved Organic Carbon

There was a significant ($p<0.05$; Tukey HSD test) reduction in amount of total suspended sediments (TSS) and carbon in sediments (CS) from baseline to 2017 in SRG treatments whereas C treatment had similar TSS and CS loss as compared to baseline (Figure 2). Comparison between the treatments revealed similar TSS and CS in C and SRG during baseline, which in 2017 was significantly lower in SRG pastures as compared to C pastures. Exclusion of vulnerable areas in the pasture to limit cattle movement, over-seeding with productive forage mixes to maintain ground cover, and reduced trampling via lure management could be explanations for the reduced amounts of TSS and CS in SRG.

Sheffield et al. (1997) reported 90% reduction in TSS with an alternative water source like water trough. Pilon et al., (2017) reported lower sediment concentration and load from pastures with riparian buffer strips as compared to continuous grazed pastures. BD was also greatest in continuously grazed pasture as compared to pastures with riparian buffer strips (Pilon et al., 2017). Dissolved Organic Carbon (DOC) in surface runoff showed no change from baseline to summer 2017 in both C and SRG treatments (Figure 3).

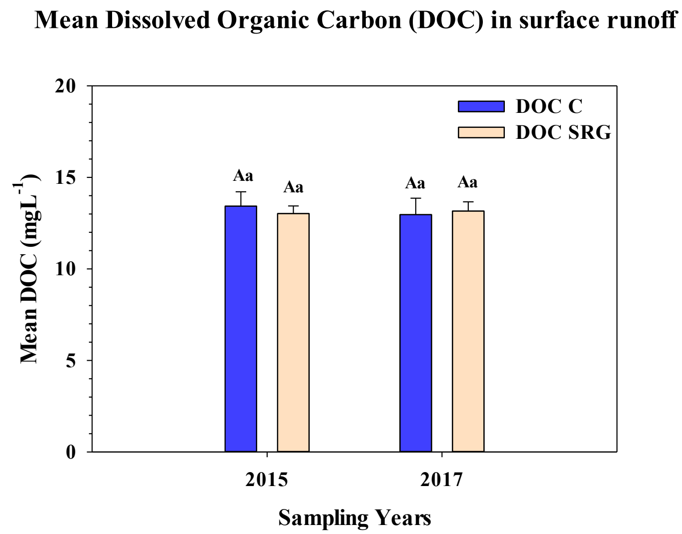


**Figure 3.** Mean Dissolved Organic Carbon (DOC) in surface runoff from Continuous Grazing with rolling out of hay (C) and Strategic Rotational Grazing (SRG) pastures in different sampling years. Means separated by different upper-case letters denote significant difference at 0.05 level of significance between different sampling years within a treatment. Means separated by different lower-case letters denote significant difference at 0.05 level of significance between the two treatments (C and SRG) within a sampling year.

## MANAGEMENT IMPLICATIONS

Grazing pastures can be a sink of carbon under good management practices while conventional practices like continuous grazing can result in greater losses due to erosion by runoff water. Grazing by cattle can have detrimental impact on water quality of nearby streams, so monitoring TSS, CS and DOC can prove useful in regulating the erosion below permissible limits.

Exclusion of vulnerable areas like riparian areas, concentrated flow paths and edges of streams can be useful in reducing the concentration of TSS and CS in surface runoff. Use of non-riparian shades (portable shades in our case) and alternative source of water for cattle can have significant impact on the TSS concentration in surface runoff (Sheffield et al., 1997). SRG is a better management practice than C with increased organic carbon in top 5 cm of soil, reduced compaction in top 20 cm of soil and reduced losses of sediment and associated carbon in surface runoff.

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