Effects of land use intensification on soil C dynamics in subtropical grazing land ecosystems

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Keywords: Rangeland, silvopasture, stable isotope ratios ($\delta^{13}C$), warm-season grass, coastal plain soils, bahiagrass.

Introduction

The impacts of land intensification on carbon (C) responses are important components of soil organic carbon (SOC) management. Grazing land intensification typically involves the use of highly productive plant species that can support greater grazing pressure, removal of higher proportions of site biomass and nutrients during mechanical harvest or grazing, and increased use of fertilizers, particularly N. Current improved grazing land management strategies are aimed at increasing above-ground biomass yield, with less regard for below-ground C dynamics. Since intensive management affects above- and below-ground C inputs (Schuman et al. 1999; Liu et al. 2011a, 2011b), it can have important implications for the amount and characteristics of SOC stored in grazing lands (Franzluebbers and Stuedemann 2003; Dubeux et al. 2006; Silveira et al. 2013). The objective of this study was to investigate the long-term impacts on SOC dynamics in subtropical ecosystems of converting native rangeland ecosystems into intensively managed systems.

Methods

The study was conducted at the University of Florida, Range Cattle Research and Education Center in South Central Florida (27°35' N, 81°55' W). Mean annual precipitation is ~1,650 mm. Average maximum/minimum temperatures are 28/17 °C. Soil was classified as a Spodosol [Ona and Smyrna fine sands (sandy, siliceous, hyperthermic Typic and Arenic Haplaquods)]. The experimental sites (~6 ha) consisted of 3 grazing land biomes with increasing management intensity: native rangeland; silvopasture; and improved pasture. The vegetation in the native rangeland was predominantly saw palmetto (*Serenoa repens*) and a wide variety of grass genera including *Andropogon*, *Panicum*, *Aristida* and *Schizachyrium* spp. The improved pasture consisted of an established bahiagrass (*Paspalum notatum*) stand and the silvopasture was slash pine (*Pinus elliottii*) trees and bahiagrass. Each grazing land biome was replicated twice and was under similar soil type and climatic conditions. Twenty-five soil core samples (0−10 and 10−20 cm depths) were collected from each biome for C and N determinations. Soil samples were dried at 65 °C and analyzed for C and N on a Flash EA 1112 CN analyzer. Natural abundance stable isotope ratios ($\delta^{13}C$) were measured on a *Thermo-Finnigan MAT Delta^{Plus} XL Isotope Ratio Mass Spectrometer (IRMS) interfaced via a Conflo-III device to a Costech ECS 4010 elemental analyzer* (Costech, Valencia, CA). Potentially mineralizable C and N were determined following laboratory incubation. Statistical analyses were performed using SAS Mixed procedure (SAS 2001). Grazing land biome was considered a fixed effect with replicates considered random effects. The PDIFF test of the LSMEANS procedure and single degree of freedom orthogonal contrasts were used to compare means. Treatments and their interactions were considered significant when F-test P values were <0.05.

Results and Discussion

Grazing land intensification showed significant effects on SOC and N stocks and $\delta^{13}C$ signature at both depths (Table 1). Accumulation of C and N in the improved pasture was due to the relatively high N inputs and greater biomass production of the warm-season grass as compared with the native vegetation. The $\delta^{13}C$ values at the 0–10 cm depth varied from -22.4 (native rangeland) to -14.7 (improved pasture), indicating the proportion of recently incorporated C4-derived C was more pronounced in improved pasture as compared with other ecosystems. A similar trend was observed in the 10–20 cm depth.

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Table 1. Effects of grazing land intensification on soil organic C and N stocks and $\delta^{13}C$ values. Means within soil depth and parameter followed by the same letter are not different using the LSMEANS procedure (P>0.05).

Site	Total C		Total N		C:N ratio	$\delta^{13}C$
	g/kg	t/ha	g/kg	t/ha		‰
0–10 cm depth						
Native rangeland	12.9 b	13.9 b	0.8 b	0.8 b	17 b	-22.4 a
Silvopasture	19.4 a	22.9 a	1.4 a	1.6 a	14 a	-20.3 a
Improved pasture	21.4 a	21.2 a	1.6 a	1.6 a	13 a	-14.7 b
s.e.	1.8	1.9	0.08	0.1		0.8
10–20 cm depth						
Native rangeland	7.9 b	10.2 b	0.8 b	1.0 b	10 a	-22.7 a
Silvopasture	15.5 ab	21.1 a	1.1 a	1.4 a	14 a	-20.9 b
Improved pasture	17.1 a	22.7 a	1.1 a	1.5 a	15 a	-18.8 c
s.e.	1.7	1.7	0.08	0.2		0.2

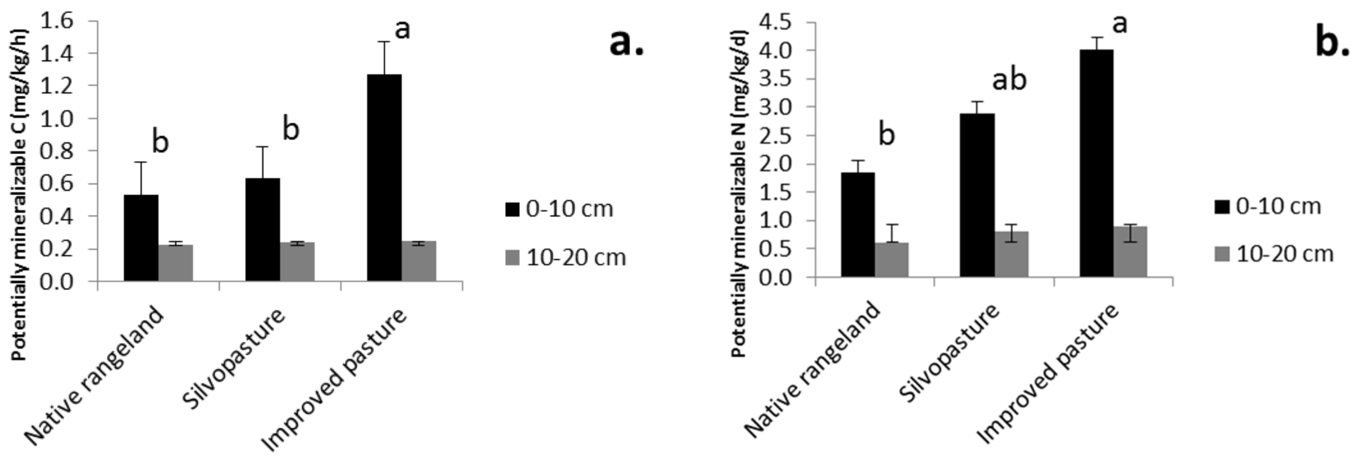

Figure 1. Potentially mineralizable C (a) and N (b) as affected by grazing land ecosystem.

Despite the relatively greater SOC and N stocks, grazing land intensification (native vs. silvopasture and improved pasture) increased C and N mineralization rates at the 0−10 cm soil depth (Figure 1). Data indicated that C and N associated with the improved pasture were present in forms that were more readily bioavailable than those in the less intensively managed ecosystems. These increases in more labile C and N forms were augmented by N fertilization.

Conclusion

Grazing land intensification using proper management techniques promoted SOC and N accumulation. This response occurred because of greater primary productivity in response to the introduction of a highly productive warm-season grass species and the use of N fertilizer. Intensively managed pastures and silvopasture systems have the potential to retain more C and N than native rangeland ecosystems. Nevertheless, C and N stored under improved pastures can be more easily susceptible to decomposition. As indicated by the $\delta^{13}C$ data, a large proportion of the native C stored in intensively managed pastures is being replaced by newly added C derived from the C4 grass species. Although current grazing land intensification has a positive effect on SOC stocks, much of the C is stored in relatively more labile forms of SOC than that in the native ecosystems.

References

Dubeux JCB; Sollenberger LE; Comerford NB; Scholberg JM; Ruggieri AC; Vendramini JMB; Interrante SM; Portier KM. 2006. Management intensity affects density fractions of soil organic matter from grazed bahiagrass swards. Soil Biology and Biochemistry 38:2705−2711.

Franzluebbers AJ; Stuedmann JA. 2003. Bermudagrass management in the southern piedmont USA: III Particulate and biologically active soil carbon. Soil Science Society of America Journal 67:132−138.

Liu K; Sollenberger LE; Silveira ML; Vendramini JMB; Newman YC. 2011a. Distribution of nutrients among soil-plant pools in 'Tifton 85' bermudagrass pastures grazed at different intensities. Crop Science 51:1800−1807.

Liu K; Sollenberger LE; Silveira ML; Vendramini JMB; Newman YC. 2011b. Grazing intensity and nitrogen fertilization affect litter responses in 'Tifton 85' bermudagrass pastures: I. Mass deposition rate and chemical composition. Agronomy Journal 103:156−162.

SAS. 2001. SAS Release 82. SAS Institute Inc., Cary, NC, USA.

Schuman GE; Reeder JD; Manley JT; Hart RH; Manley WA. 1999. Impact of grazing management on the carbon and nitrogen balance of a mixed-grass rangeland. Ecological Applications 9:65−71.

Silveira ML; Liu K; Sollenberger LE; Follett RF; Vendramini JMB. 2013. Short-term effects of grazing intensity and nitrogen fertilization on soil organic carbon pools under perennial grass pastures in the Southeastern USA. Soil Biology and Biochemistry 58:42−49.

Silveira ML; Xu S; Adewopo J; Inglett KS. 2014. Land use intensification effects on soil C dynamics in subtropical grazing land ecosystems. Tropical Grasslands – Forrajes Tropicales 2:142–144.
DOI: 10.17138/TGFT(2)142-144

This paper was presented at the 22nd International Grassland Congress, Sydney, Australia, 15−19 September 2013. Its publication in *Tropical Grasslands – Forrajes Tropicales* is the result of a co-publication agreement with the IGC Continuing Committee. Except for adjustments to the journal's style and format, the text is essentially the same as that published in: **Michalk LD; Millar GD; Badgery WB; Broadfoot KM, eds. 2013. Revitalising Grasslands to Sustain our Communities. Proceedings of the 22nd International Grassland Congress, Sydney, Australia, 2013. New South Wales Department of Primary Industries, Orange, NSW, Australia. p. 1229–1230.**