Land use intensification effects on soil C dynamics in subtropical grazing land ecosystems

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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. Because intensive management affects above- and below-ground C inputs (Schuman *et al.* 1999; Liu *et al.* 2011a,b), it can therefore have important implications on 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 of converting native rangeland ecosystems into intensively managed systems on SOC dynamics in subtropical ecosystems.

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 ~ 1650 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 three grazing land biomes with increasing management intensity: native rangelands, silvopasture, and improved pastures. Each grazing land biomes was replicated twice and was under similar soil type and climate conditions. Twenty-five soil core samples (0-10 and 10-20 cm depth) 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 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.

Table 1. Effect of grazing land intensification on soil organic C and N stocks and $\delta^{13}C$ values. Means within soil depth 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	Mg/ha	g/kg	Mg/ha		‰
0 – 10 cm depth						
Native rangeland	12.9 b	13.9 b	0.8 b	0.8 b	17 b	-22.4 a
Silvo-pasture	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
SE	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
Silvo-pasture	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
SE	1.7	1.7	0.08	0.2		0.2

Results

Grazing land intensification showed a significant effect 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 the relatively high N inputs and greater biomass production of the warm-season grass as compared to the native vegetation. The $\delta^{13}C$ values at the 0 to 10 cm depth varied from -22.4 (native rangeland) to -14.7 (improved pasture) (Table 1) indicating the proportion of recently incorporated C_4-derivated C was more pronounced in improved pasture as compared to other ecosystems. Similar trend was observed in the 10 to 20 cm depth.

Despite the relatively greater SOC and N stocks,

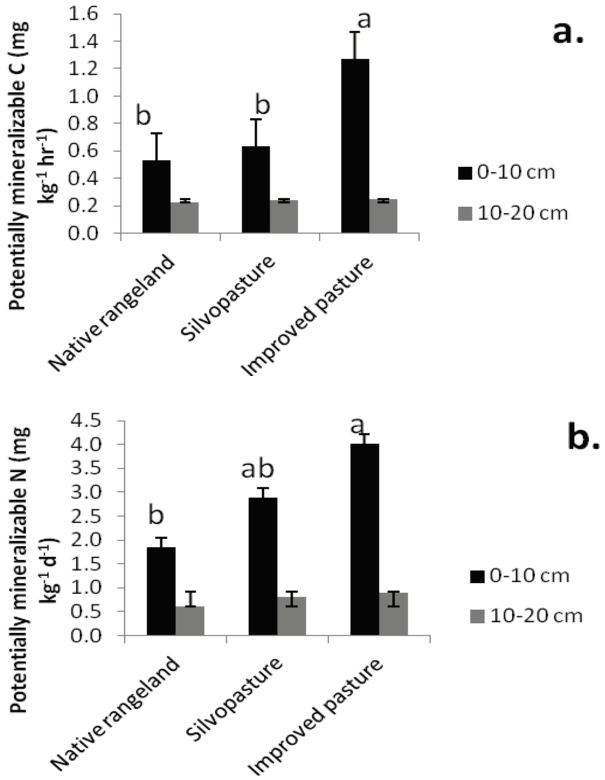

Figure 1.Potentially mineralization C (a) and N (b) as affected by grazing land ecosystem.

grazing land intensification (native vs. improved pastures) increased C and N mineralization rates at the 0-10 cm soil depth (Fig. 1). Data indicated that C and N associated with the improved pasture are present in forms that are more readily bioavailable than that 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 introduction of 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 C_4 grass species. Although current grazing land intensification had a positive effect of SOC stocks, much of the C is stored in relatively more labile forms of SOC than that in the native ecosystems.

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