Opportunities to Increase Soil Carbon Sequestration in Pasture-Based Livestock Production

FUTURE OF FOOD FORUM
REDUCING THE CARBON FOOTPRINT OF FOOD SYSTEMS
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Soil Organic Carbon

- SOC is a complex and varied mixture of organic substances under different stages of decomposition (i.e., fresh litter to stable humus)

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Factors Controlling SOC

C INPUTS

- Above- and **below-ground biomass** residues
- Animal excreta
- Organic fertilizer

C OUTPUTS

- Decomposition
- Erosion/leaching

Balance between C inputs and outputs

Factors affecting SOC stocks

1. **Climate (temperature and precipitation)**
2. **Soil texture/soil type**
3. **Management practices**

Opportunities to increase SOC

- Management practices intended to promote SOC sequestration increase productivity and tend to make systems more resilient to climate variation

- These practices could result in the sequestration of 10.5 to 34.3 million metric tons C yr^{-1} (Follett et al., 2001)

- Each ton of C stored in soils removes ~ 3.67 tons of CO_2 from atmosphere; ~38 to 126 million tons CO_2 yr^{-1}

Management practices that promote SOC

1. **Fertilization**
   - Improve above- and below-ground production
   - Quantity and quality of C inputs
   - Unintended environmental consequences (N_2O emissions, nutrient losses)

Silveira et al, 2017

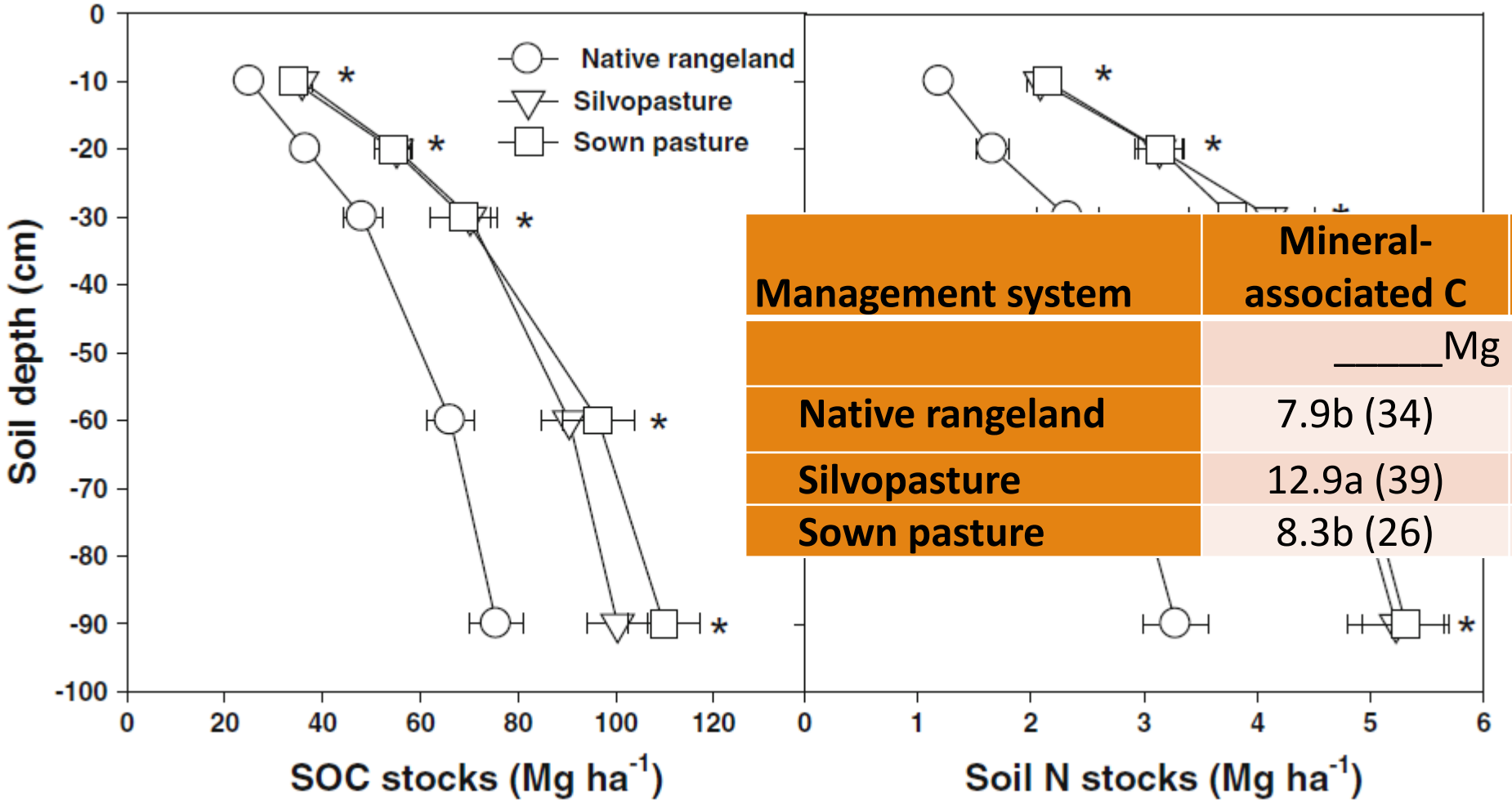
Management practices that promote SOC

1. Fertilization
2. Introduction or reintroduction of grass or legume species



1. Adewopo, J.B., Silveira. M.L., Xu, S., Gerber, S., Sollenberger, L.E., and Martin, T. 2015a. Long-term grassland management intensification impacts on particle-size soil carbon fractions: evidence from ^{13}C natural abundance. *Soil Science Society of America Journal*, 79:1198-1205.
2. Adewopo, J.B., Silveira, M.L., Xu, S., Gerber, S., Sollenberger, L.E., and Martin, T.A. 2015b. Management intensification effects on autotrophic and heterotrophic soil respiration in subtropical grasslands. *Ecological Indicators* 56:6-14
3. Adewopo, J.B., Silveira, M.L., Xu, S., Gerber, S., Sollenberger, L.E., and Martin, T. 2014. Management intensification impacts on soil and ecosystem carbon stocks in subtropical grasslands. *Soil Science Society of America Journal* 78:977-986.
4. Silveira, M.L., Xu. S., Adewopo, J.B., Franzluebbers, A.J., and Buonadio, G. 2014. Grazing land intensification effects on soil C dynamics in aggregate size fractions of a Spodosol. *Geoderma* 230-231:185-193.
5. Xu, S., Silveira, M.L., Ngatia, L.W., Normand, A.E. , Sollenberger, L.E. , Reddy, K.R. 2017a. Carbon and nitrogen pools in particle-size fractions as affected by sieving method and land use intensification. Geoderma 305:70-79.
6. Xu, S. , Silveira, M.L., Inglett, K.S., Sollenberger, L.E., Gerber, S. 2017b. Soil microbial community responses to long- term land use intensification in subtropical grazing lands. *Geoderma,* 293:73-81.
7. Xu, S., Silveira, M.L., Inglett, K.S., Sollenberger, L.E., and Gerber, S. 2016. Effect of land-use conversion on ecosystem C stock and distribution in subtropical grazing lands. *Plant and Soil,* 399:233-245.

Long-term (>25 yr) impacts of grazing land intensification on SOC stocks (0-100 cm)



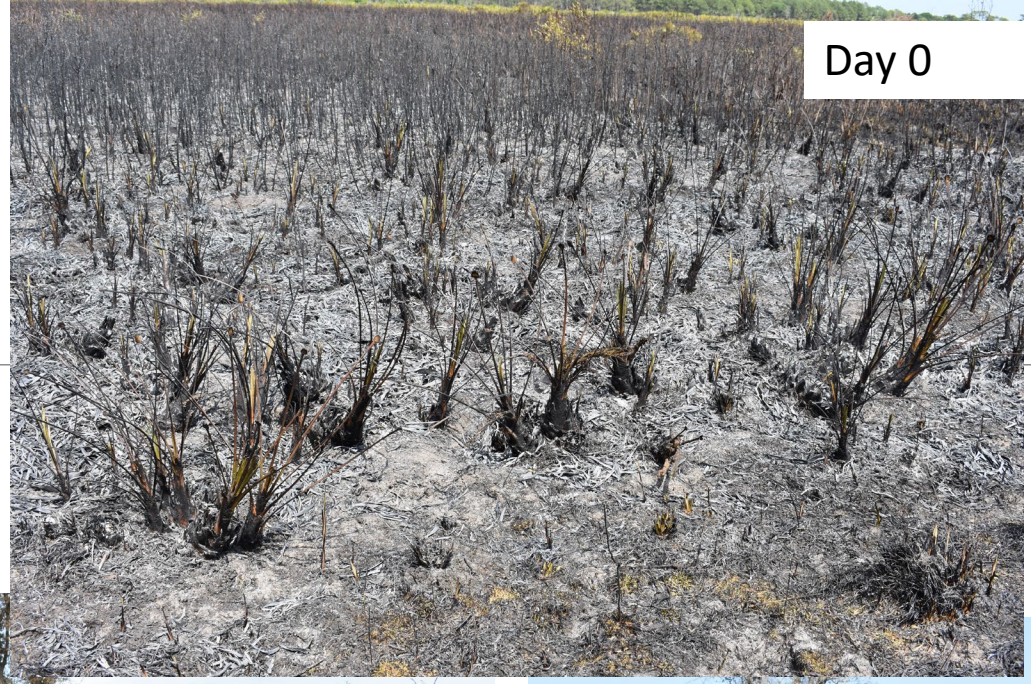
Management system	Mineral-associated C	Particulate organic C
	_____Mg ha $^{-1}$ ____	
Native rangeland	7.9b (34)	15.9b (66)
Silvopasture	12.9a (39)	20.0ab (61)
Sown pasture	8.3b (26)	23.2a (74)

[1]Source: Adewopo et al., 2014; Xu, et al., 2016

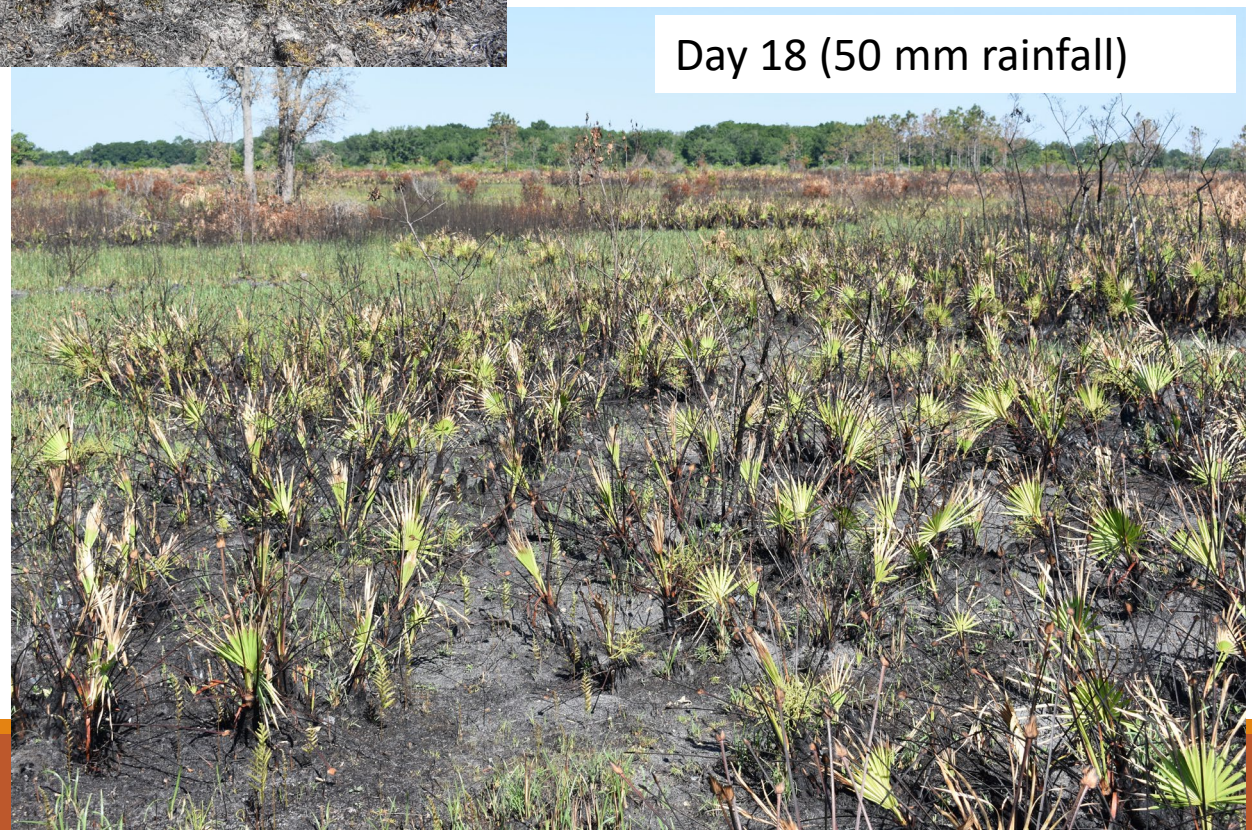
Management practices that promote SOC

1. Fertilization
2. Introduction or reintroduction of grass or legume species
3. Fire

Impacts of grazing land intensification on ecosystem C stocks


Day 0


Day 5


Day 18 (50 mm rainfall)

Day 5 –native grasses

Day 18

Impacts of grazing land intensification on ecosystem C stocks

Long-Term Agroecosystem Research

ELSEVIER

Agricultural and Forest Meteorology

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Carbon dynamics and soil greenhouse fluxes in a Florida's native rangeland before and after fire

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CONCLUSIONS

- Pine flatwoods are C sinks even in year when prescribed burning occurred
- During a 4-yr burning cycle, net ecosystem production can reach -1287 g C m^{-2} yr^{-1} with an average of -322 g C m^{-2} yr^{-1}
- Pine flatwoods vegetation is well-adapted to burning and can recover its photosynthetic capacity in 60 days following a prescribed burning event

Response variable	Year			
	2016	2017	2018	2019
	g C m^{-2} yr^{-1}			
Gross primary production	-1854	-1749	-1861	-2033
Ecosystem respiration	1445	1422	1492	1851
Net ecosystem production	-409	-327	-369	-182

Management practices that promote SOC

1. Fertilization
2. Introduction or reintroduction of grass or legume species
3. Fire
4. Grazing management
   - **Positive** : Derner et al., (1997); Schuman et al., (2001); Franzluebbers and Stuedemann (2003); Franzluebbers et al., (2012)
   - **Negative** : Bauer et al. (1987); Derner et al. (1997); April and Bucher (1999); Conant and Paustian (2002)
   - **Neutra**l: Milchunas and Laurenroth (1993); Manley et al., (2005)

Total C and N content in bulk soil samples from pastures under different stocking densities (Liu et al., 2011; Silveira et al., 2013)

Stubble Height†	Total C	Total N	Particulate C	
cm	----------	Mg ha^{-1}	----------	% total
24	26	1.7	10.4	34
16	23	1.5	8.6	29
8	24	1.5	8.3	27
SE	3	0.2	1.1	2.6
Polynomial Contrast	NS‡	NS	L*	L*

†Stocking density treatments were based on target stubble height. ‡NS = not significant ($P > 0.1$). L = linear; * = $P \leq 0.05$

Limitations

- Lack of financial benefits and policies that encourage SOC sequestration. Increases in soil C should be positively correlated with productivity
- The direction and magnitude of SOC responses to management depend on the duration and intensity of these practices, region, and current SOC levels
- Unintended consequences
- Time and space scale

- Projected increases in temperature and changes in precipitation patterns

THANKS

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