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Effects of Long-Term Cattle Grazing and Woody Plant Encroachment on Soil Microbial Communities at the Santa Rita Experimental Range, Arizona

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Effects of long-term cattle grazing and woody plant encroachment on soil microbial communities at the Santa Rita Experimental Range, Arizona



Cody Burton, Rebecca McCulley, & Steve Archer

- Intensification of cattle grazing coincided with rapid increases in woody plant abundance in rangelands worldwide over the past 100-150 years.



Early 1900s – initiation of grazing



Same site – 1941 - ~30 yrs of grazing

FIG. 10. Historical site in 1941 shows great increase in mesquite and reduction in grass.

Santa Rita Experimental Range, Arizona – Martin (1975)
<http://cnrit.tamu.edu/flem/faculty/archer/bibliography.html>



Grazing impacts ecological processes via:

- Preferential utilization of grasses
- Seed dispersal
- Dung deposition
- Trampling
- Alterations to nutrient cycling

Grazing also impacts the spatial distribution of vegetation and nutrients, especially in dryland systems.

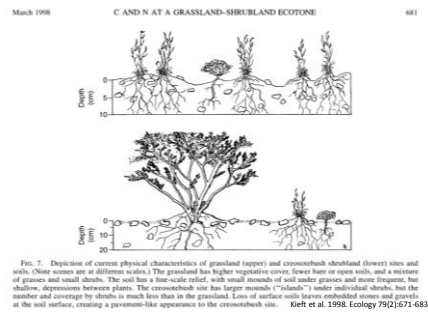


FIG. 7. Depiction of current physical characteristics of grassland (upper) and creosotebush shrubland (lower) sites and soils. (Note: scales are at different scales.) The grassland has higher vegetative cover, lower bare or open soils, and a mixture of grasses and small shrubs. The soil has a fine-scale relief, with small mounds of soil under grasses and more frequent, but shallow, depressions between plants. The creosotebush site has larger mounds ("islands") under individual shrubs, but the number and coverage by shrubs is much less than in the grassland. Loss of surface soils leaves eroded soil cores and gravel at the soil surface, creating a pavement-like appearance to the creosotebush site. Kiehl et al. 1998. Ecology 79(2):671-683.

- Microbial biomass is governed by the presence and type of vegetation in these systems; less is known regarding effects on microbial community composition.
- Very difficult to tease apart grazing and vegetation type effects.

Objective:

Quantify how long-term removal of livestock grazing affects soil microbial biomass and community structure, in a vegetation type specific manner.



H_{1,1}: grazed < un-grazed, biomass

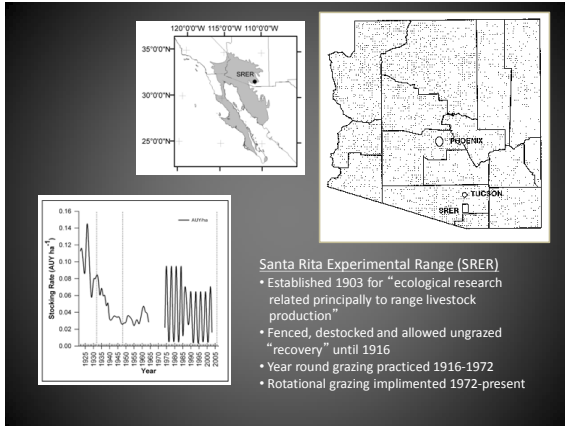
H_{1,2}: grazed ≠ un-grazed, community composition



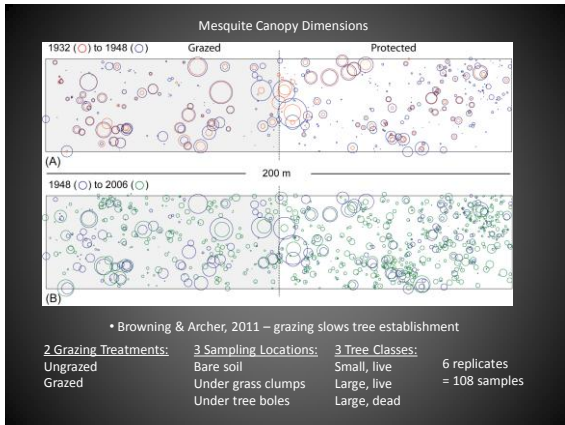
H_{2,1}: bare < grass < tree bole

H_{2,2}: small tree = skeleton < large tree





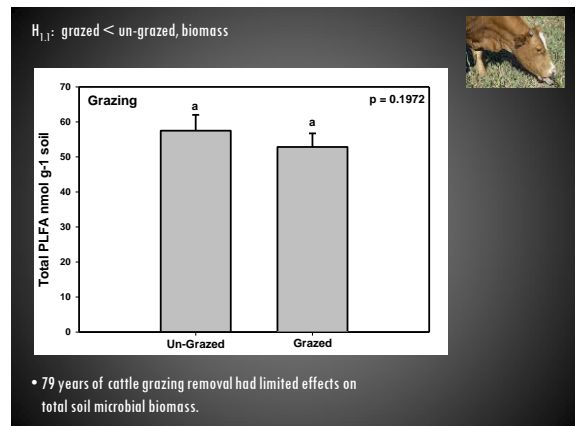
- W. McGinnies established two 1.8 ha plots, 1932
 - Herbivore effects on vegetation
 - Individual mesquite canopy dimensions mapped (1932, 1948, 2006)
- No recorded fires
- Aerial herbicide
 - 1964-1965
 - 2,4,5-Trichlorophenoxyacetic acid
 - To remove mesquite

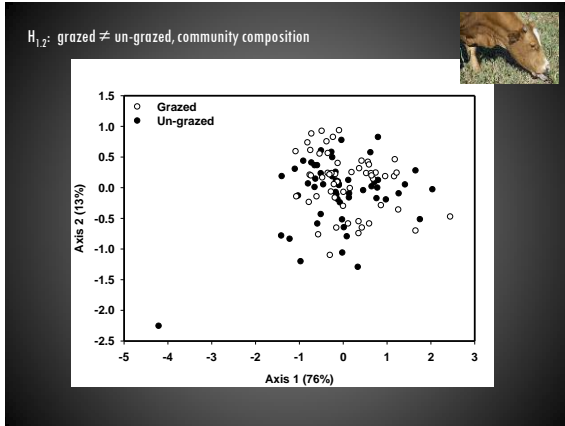


Bacillus subtilis

Phospholipid Fatty Acid Analysis (PLFA)

16:0 Palmitic Acid

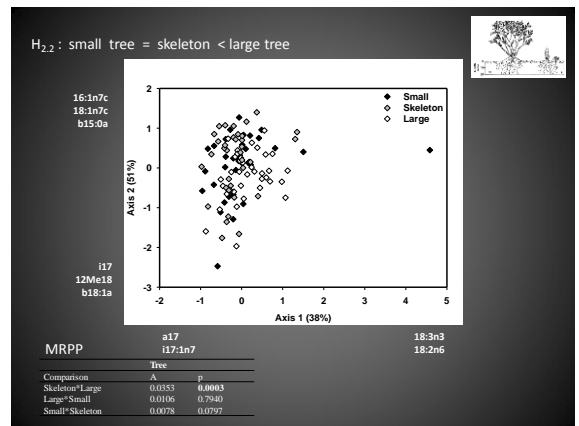
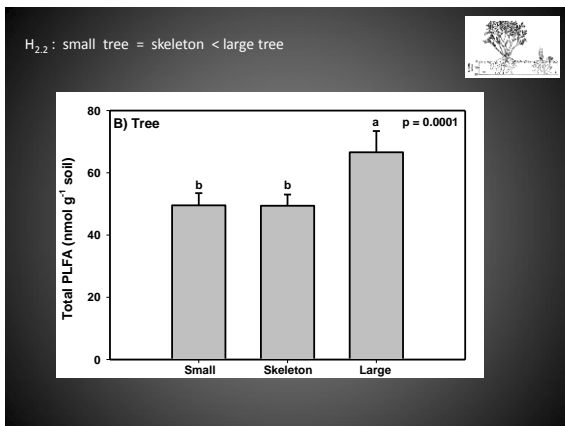
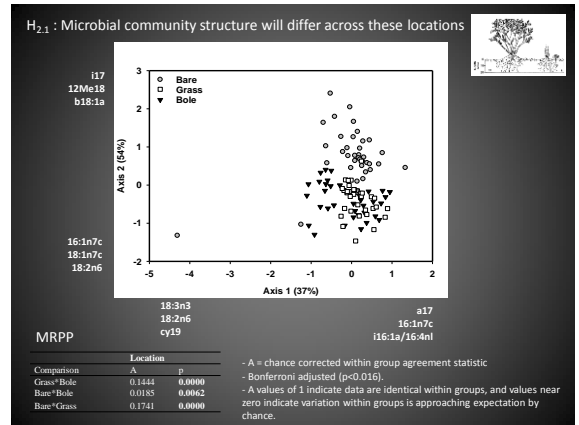
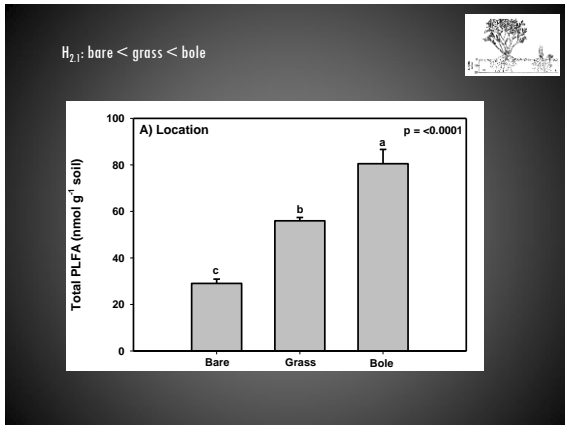




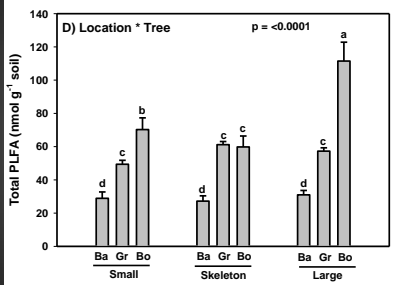
• The only PLFA with a significant main effect of grazing was 18:2n6 – a fungal biomarker.

Effect	16:1n5		18:1n9c		18:2n6		Group Total	
	DF	F	F	p	F	p	F	p
Grazing	1, 90	1.29	0.60	0.4415	4.27	0.0416	2.91	0.0912
Location	2, 90	52.29	<0.0001	49.95	<0.0001	38.90	<0.0001	58.01
Tree	2, 90	1.07	0.3485	9.81	0.0001	12.57	<0.0001	12.23
Grazing*Location	2, 90	0.04	0.9644	0.01	0.9879	2.06	0.1337	0.82
Grazing*Tree	2, 90	4.02	0.0213	2.96	0.0570	0.74	0.4777	2.10
Location*Tree	4, 90	2.56	0.0442	6.26	0.0002	11.18	<0.0001	9.56
Grazing*Location*Tree	4, 90	4.31	0.0031	0.58	0.6750	1.12	0.3528	1.32

grazing reduction = 73%

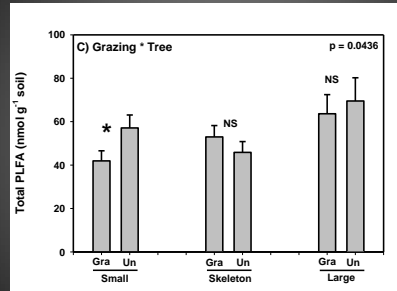


- Location effect magnified under large trees.



- Differences in microbial community composition magnified under large trees

- The only location where grazing effects were detected was under small trees.



Conclusions:

- Long term grazing reduces the abundance of soil fungal biomarker 18:2n6.
- However, otherwise, direct grazing effects were much less dramatic than vegetation presence and type on both microbial biomass and community composition.
- Grazing effects on soil microbes are primarily indirect via changes in the vegetation cover.

Acknowledgements

- Santa Rita Field Site
- Katie Predick and Jim Nelson

