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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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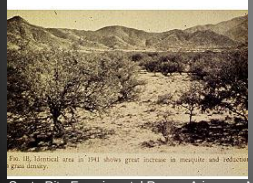
Cody Burton, Rebecca McCulley, & Steve Archer

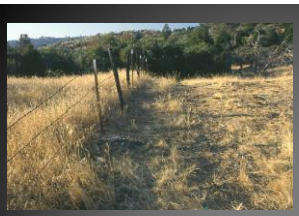
- Intensification of cattle grazing coincided with rapid increases in woody plant abundance in rangelands worldwide over the past 100-150 years.

Early 1900s – initiation of grazing



Same site – 1941 - ~30 yrs of grazing

Santa Rita Experimental Range, Arizona – Martin (1975)
http://cnrit.tamu.edu/rlem/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.

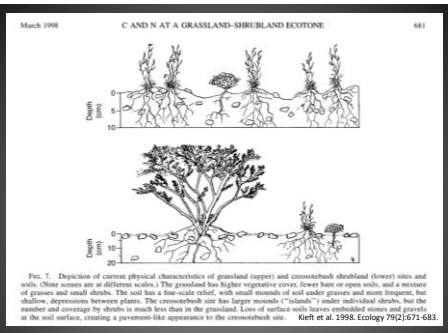


FIG. 7. Depiction of current physical characteristics of grassland (upper) and creosotebush shrubland (lower) sites and soils. (Note scenes are at different scales.) The grassland has higher vegetative cover, fewer bare or open soils, and a mixture of grasses and small shrubs. The soil has a fine-scale 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 embedded stones and gravels at the soil surface, creating a pavement-like appearance to the creosotebush site. Kieft 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:

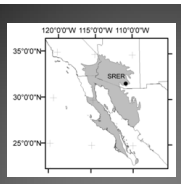
Quantify how long-term removal of livestock grazing affects soil microbial biomass and community structure, in a vegetation type specific manner.

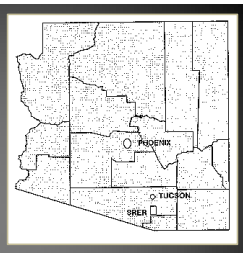
$H_{1.1}$: grazed < un-grazed, biomass

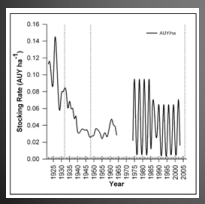
$H_{1.2}$: grazed ≠ un-grazed, community composition

$H_{2.1}$: bare < grass < tree bole

$H_{2.2}$: small tree = skeleton < large tree



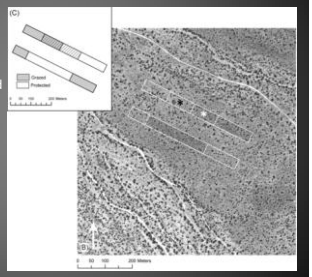




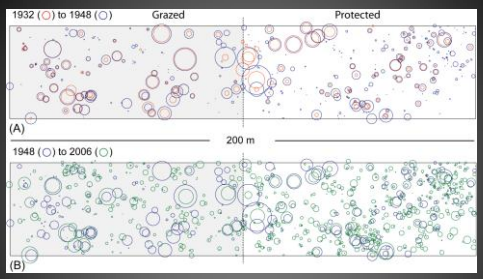
Santa Rita Experimental Range (SRER)

- Established 1903 for "ecological research related principally to range livestock production"
- Fenced, destocked and allowed ungrazed "recovery" until 1916
- Year round grazing practiced 1916-1972
- Rotational grazing implimented 1972-present

- 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

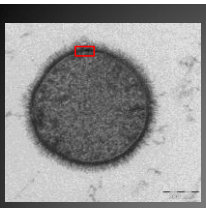


Mesquite Canopy Dimensions



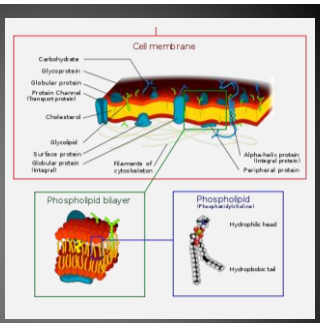
- Browning & Archer, 2011 – grazing slows tree establishment

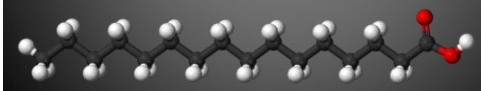
2 Grazing Treatments:	3 Sampling Locations:	3 Tree Classes:	
Ungrazed	Bare soil	Small, live	6 replicates
Grazed	Under grass clumps	Large, live	= 108 samples
	Under tree boles	Large, dead	



Bacillus subtilis

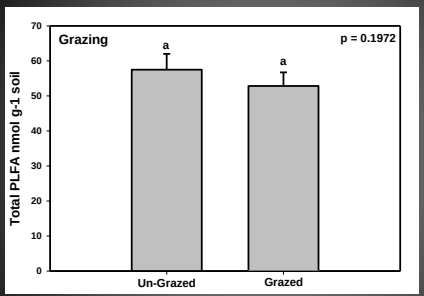
Phospholipid Fatty Acid Analysis (PLFA)





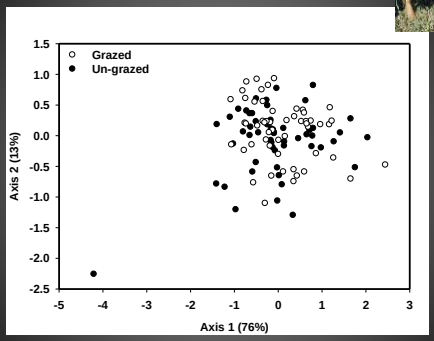
16:0 Palmitic Acid

$H_{1.1}$: grazed < un-grazed, biomass



- 79 years of cattle grazing removal had limited effects on total soil microbial biomass.

$H_{1.2}$: grazed ≠ un-grazed, community composition

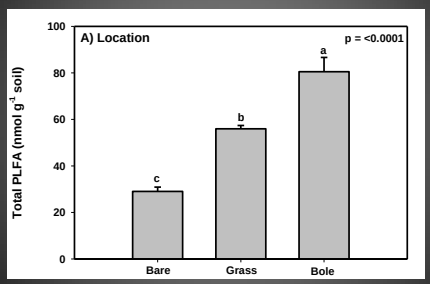


- The only PLFA with a significant main effect of grazing was 18:2n6 – a fungal biomarker.

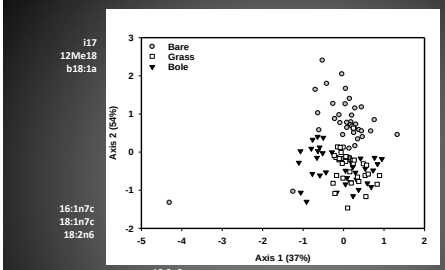
Effect	DF n, d	16:1n5 F	16:1n5 p	18:1n9c F	18:1n9c p	18:2n6 F	18:2n6 p	Group Total F	Group Total p
Grazing	1, 90	1.29	0.2597	0.60	0.4415	4.27	**0.0416**	2.91	0.0912
Location	2, 90	52.29	**<0.0001**	49.95	**<0.0001**	38.46	**<0.0001**	58.01	**<0.0001**
Tree	2, 90	1.07	0.3485	9.81	**0.0001**	12.57	**<0.0001**	12.23	**<0.0001**
Grazing*Location	2, 90	0.04	0.9644	0.01	0.9879	2.06	0.1337	0.82	0.4443
Grazing*Tree	2, 90	4.02	**0.0213**	2.96	0.0570	0.74	0.4777	2.10	0.1290
Location*Tree	4, 90	2.56	**0.0442**	6.26	**0.0002**	11.18	**<0.0001**	9.56	**<0.0001**
Grazing*Location*Tree	4, 90	4.31	**0.0031**	0.58	0.6750	1.12	0.3528	1.32	0.2693

grazing reduction = 73%

$H_{2.1}$: bare < grass < bole



$H_{2.1}$: Microbial community structure will differ across these locations

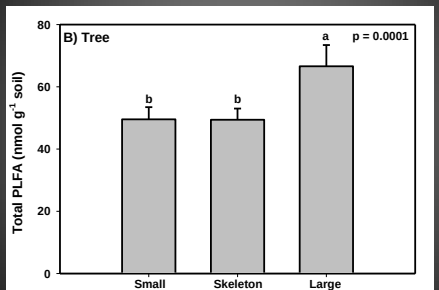


MRPP

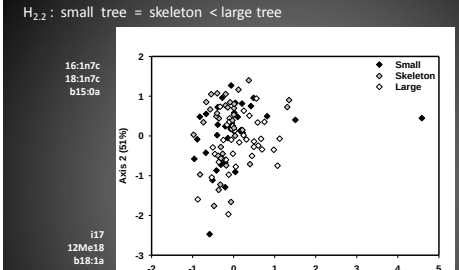
Location		
Comparison	A	p
Grass*Bole	0.1444	**0.0000**
Bare*Bole	0.0185	**0.0062**
Bare*Grass	0.1741	**0.0000**

- A = chance corrected within group agreement statistic
- Bonferroni adjusted (p<0.016).
- A values of 1 indicate data are identical within groups, and values near zero indicate variation within groups is approaching expectation by chance.

$H_{2.2}$: small tree = skeleton < large tree



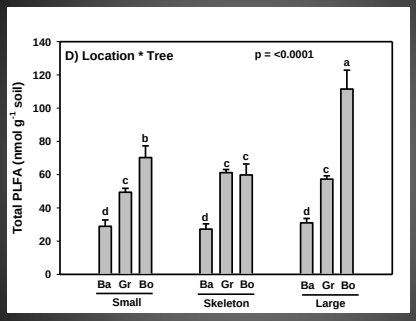
$H_{2.2}$: small tree = skeleton < large tree



MRPP

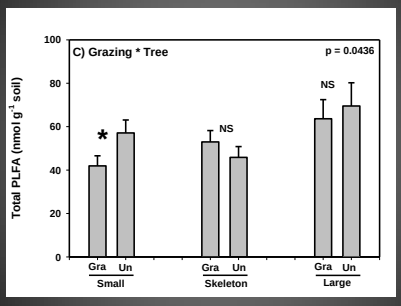
Tree		
Comparison	A	p
Skeleton*Large	0.0353	**0.0003**
Large*Small	0.0106	0.7940
Small*Skeleton	0.0078	0.0797

- 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