



# LULCCs in Temperate Savannas: Impact of Woody Encroachment and Prescribed Burning on Soil Carbon Pools and Flux Rates

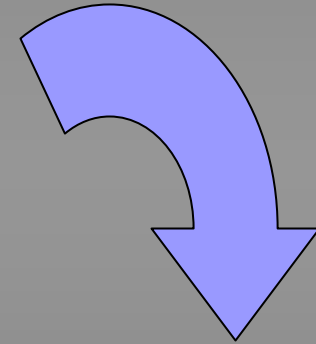
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# Land Use & Land Cover Change

- Global change driver
- Impacts/impacted by land use and management



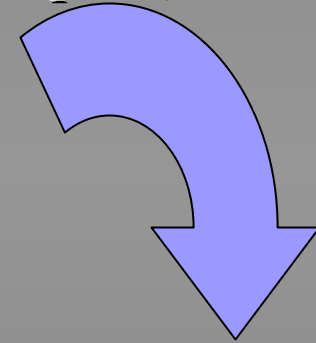
Ecosystem structure and function

- Biodiversity
- Nutrient and energy cycling
- Hydrology
- Climate feedbacks



# Woody plant encroachment

- Worldwide phenomenon
- *Prosopis glandulosa* (honey mesquite)
- Domestic grazing
- Fire suppression



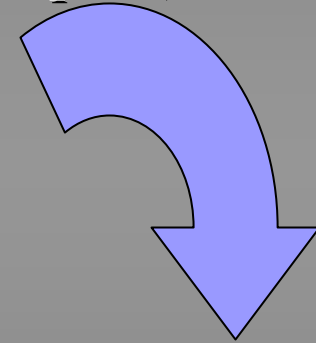
## Altered plant communities

- Biodiversity and conservation
- Livestock production
- Soil carbon and nitrogen



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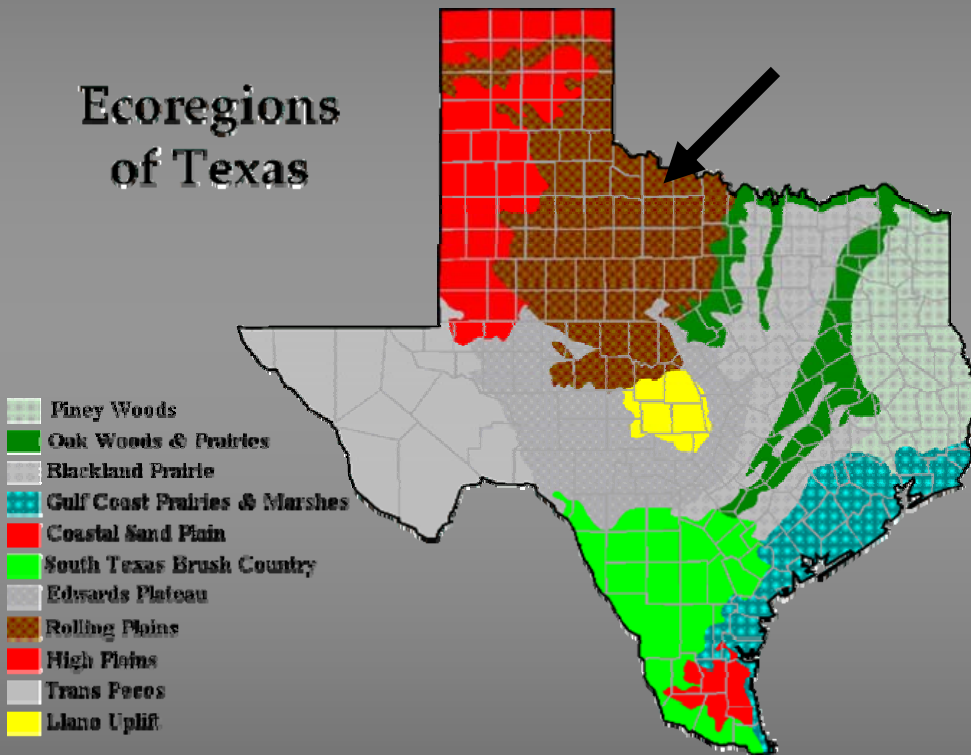
Altered plant communities

- Biodiversity and conservation
- **Livestock production**
- **Soil carbon and nitrogen**



# Waggoner Ranch Experimental Site

## Ecoregions of Texas



Location: Wilbarger County, TX

Mean Annual Precipitation: 665 mm

Mean Annual Temperature: 16.1 °C

Soil Texture: 16% sand, 52% silt, 32% clay

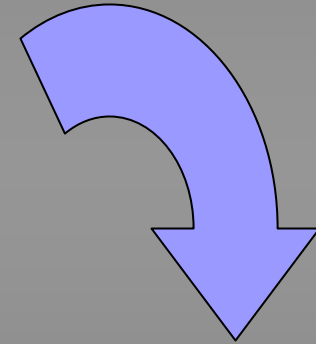
Soil pH : 7.0-7.21

Vegetation: Mixed grasses and *Prosopis glandulosa*

Fire regime: Repeated winter-only and summer-only fires

# Mesquite + Fire = ?

- Effects of fire
  - Combustion vs. stimulation
- Effects of mesquite
  - Ability to displace other species
  - Highly productive
  - Slowly decaying tissues



Soil organic carbon loss?  
Soil organic carbon storage?



# Mesquite + Fire = ?

Quantification of SOC pool sizes and flux rates

• Three carbon pools and their turnover rates

• Three vegetation types  
• Three fire treatments

Track changes and storage potential relative to LULCCs



# Approach

$$C_t = C_r + C_a e^{-k_a t} + C_s e^{-k_s t}$$

$C_t$  = total SOC

$C_r$  = resistant SOC (>centuries)

$C_a$  = active SOC (days)

$C_s$  = slow SOC (years)

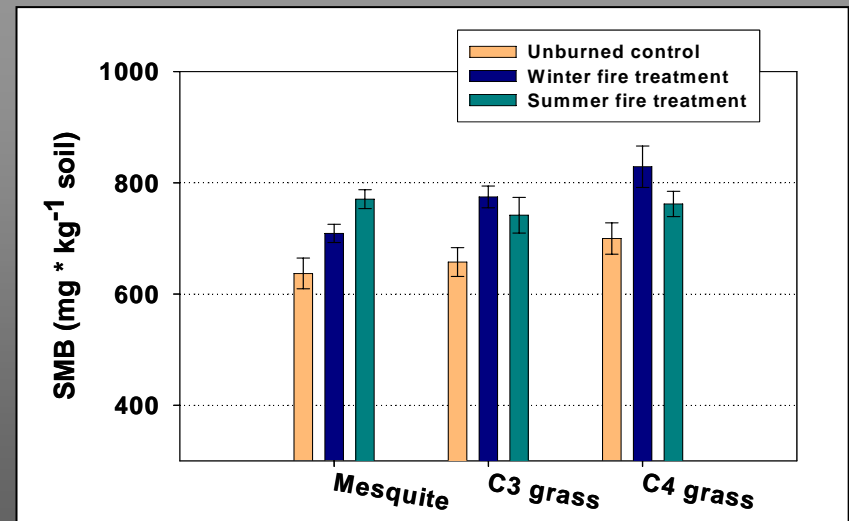
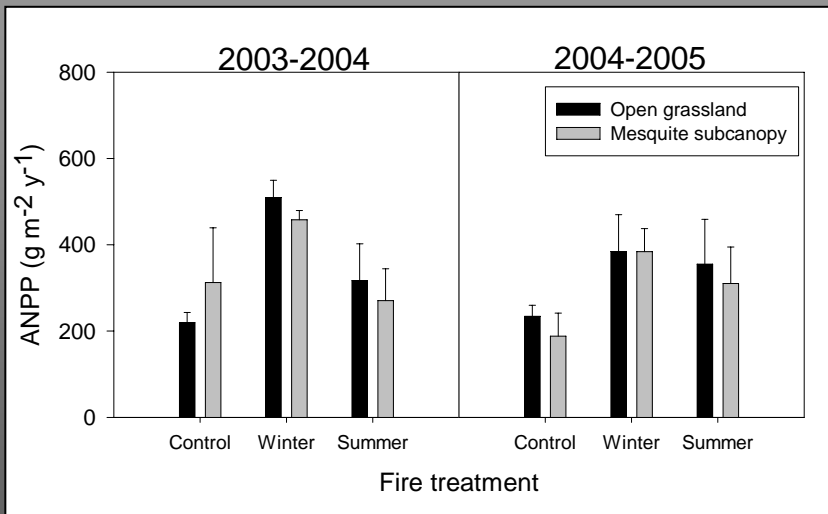
$k_a$  = active pool decay rate

$k_s$  = slow pool decay rate



# Active SOC

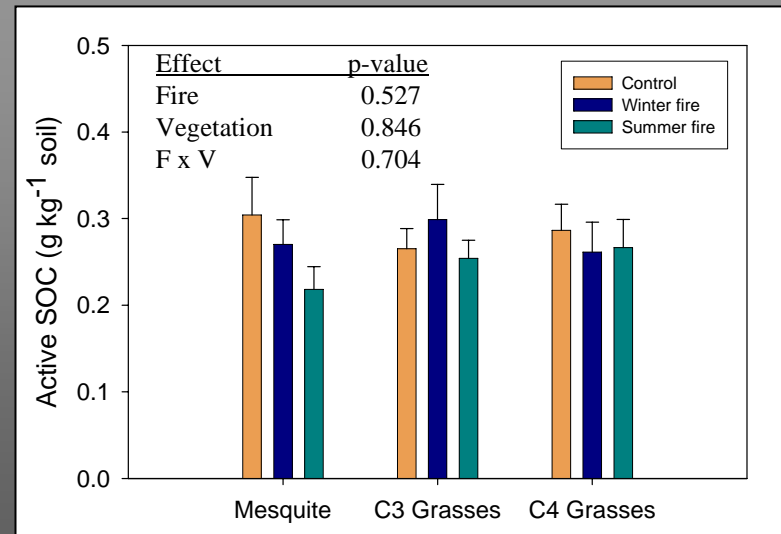
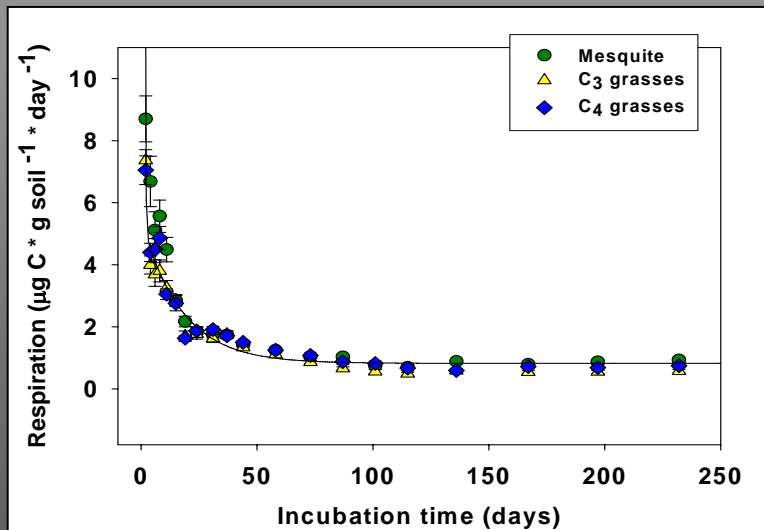
- Quantified via long-term incubation
- Hypothesis:  $C_a$  pool sizes would increase in burned sites, relative to the unburned control



# Active SOC



- No differences with respect to fire treatment or vegetation
- Average pool size =  $0.27 \text{ g kg}^{-1}$  soil or  $\sim 2\%$  of total SOC
- Average MRT = 20 days

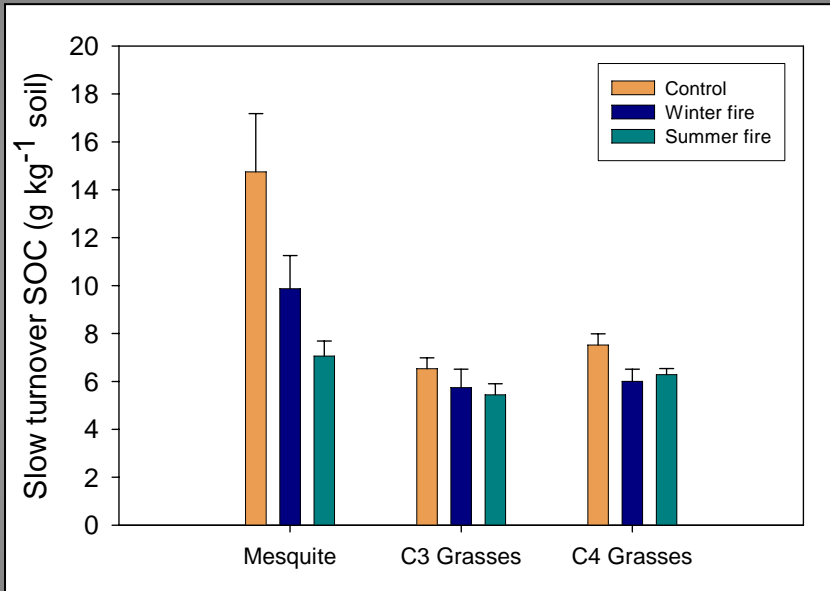


# Slow SOC

- Quantified via modeling approach
- Hypothesis:  $C_s$  pool sizes would be larger under mesquite, relative to grasses
  - Liao et al. (2005) found 400 to 700% increases in  $C_s$  pool size following mesquite establishment in southern Texas



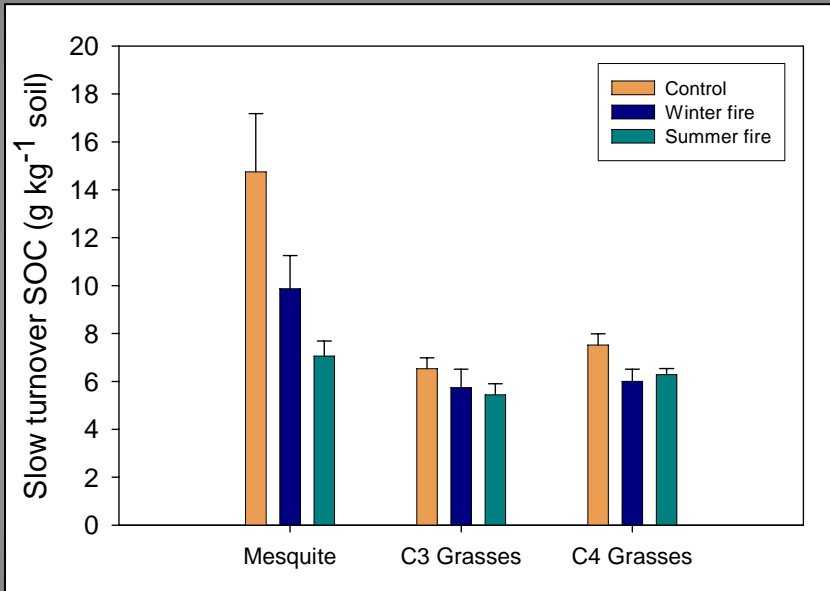
# Slow SOC



- Represents 50 to 60% of SOC
- Average MRT = 10 years
- Significant pool sizes differences related to both vegetation type and fire treatment

Effect	p-value
Fire	0.040
Vegetation	0.003
F x V	0.120

# Slow SOC

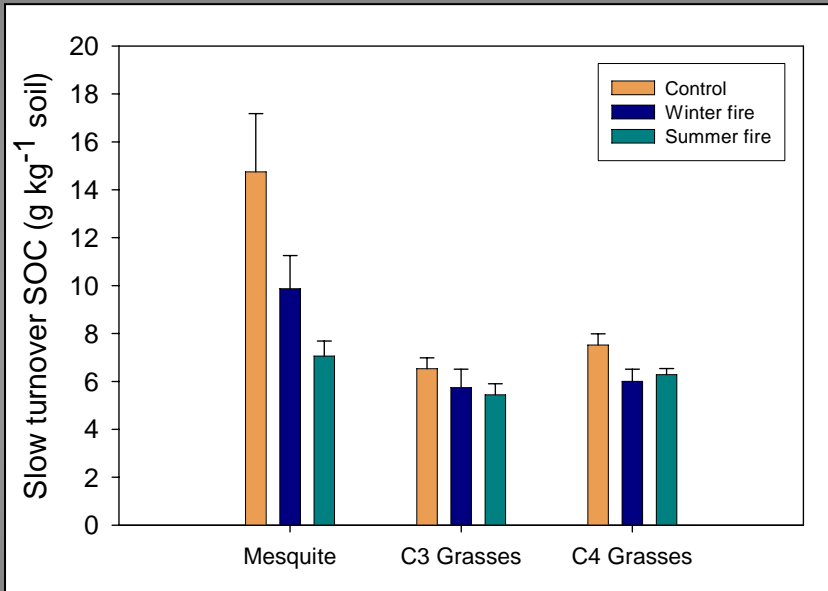


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$C_s$  pools were 30 to 130% greater under mesquite

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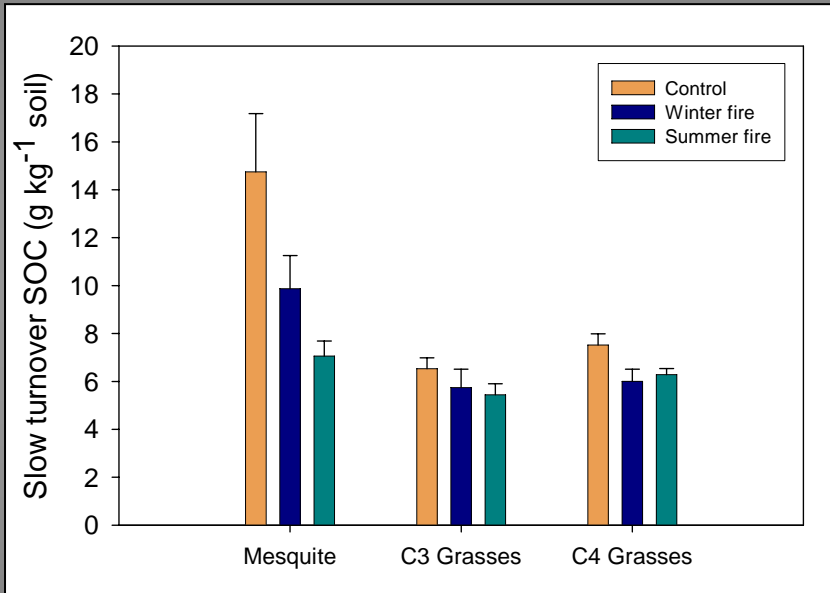
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- Represents 50 to 60% of SOC
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$C_s$  pools were 30 to 130% greater under mesquite

$C_s$  decreased 8 to 50% with fire treatment

# Slow SOC



Effect	p-value
Fire	0.040
Vegetation	0.003
F x V	0.120

- Increase with mesquite
  - Highly productive
  - Slowly decaying tissues
- Decrease with fire
  - Disruption to productivity
  - Removal of surface litter
  - Modified physical environment

# Resistant SOC

- Quantified via acid hydrolysis and elemental analysis
- $C_r$  is thought to be relatively resistant to change
- Hypothesis:  $C_r$  would be greater under mesquite than under the grasses



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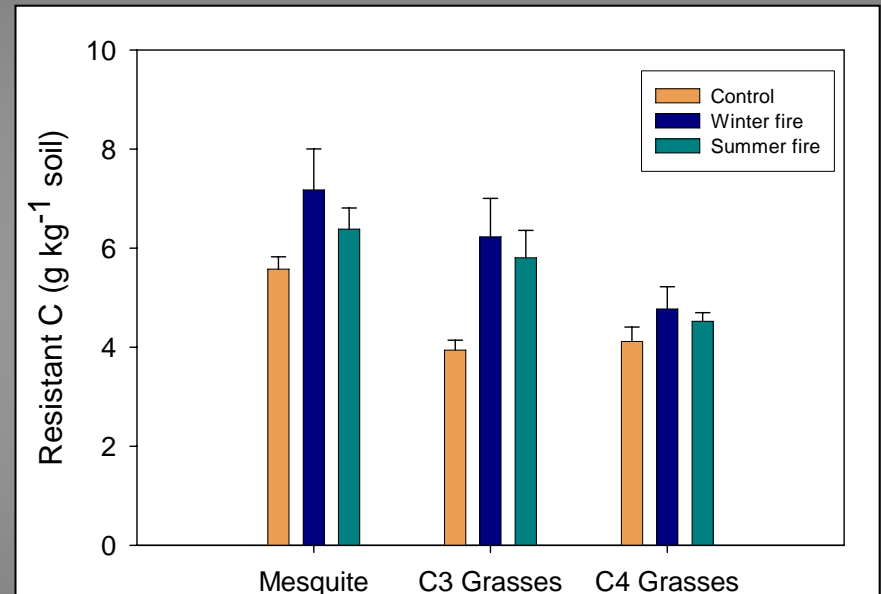


## Mesquite

Liao et al. (2005) found  $C_r$  to have increased 400 to 600% in mesquite woodlands.

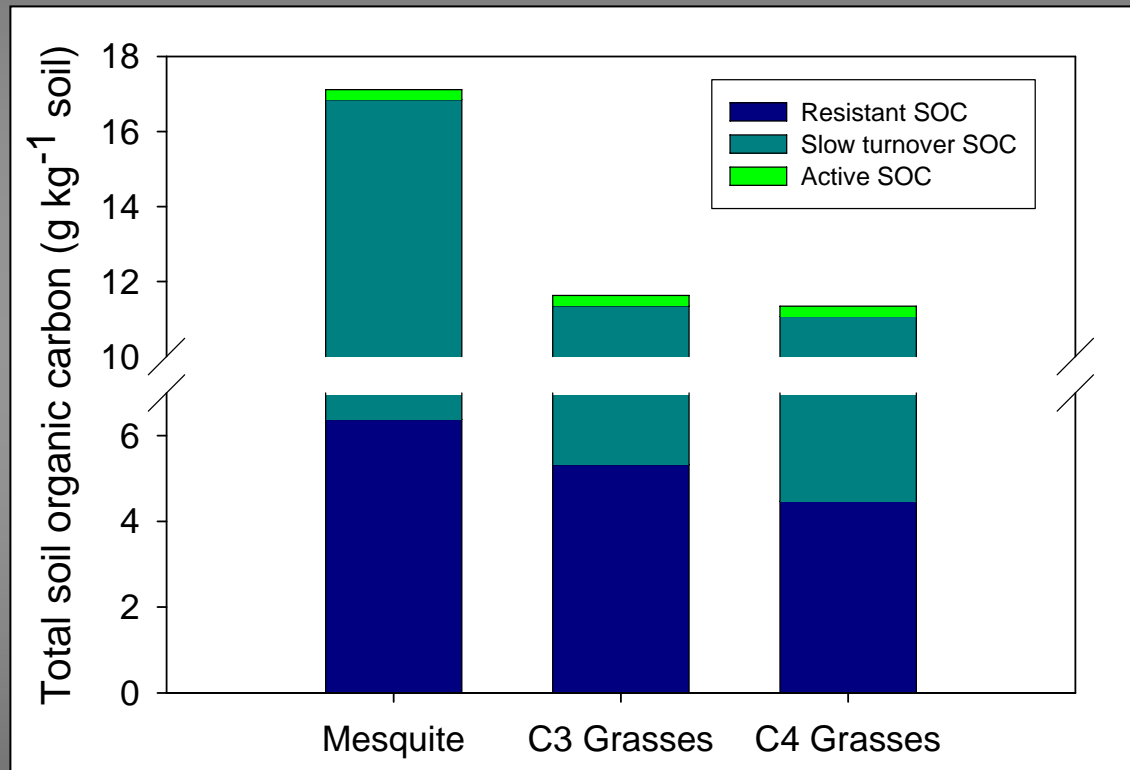
# Resistant SOC

- Significant differences among vegetation types
- Increasing trends with fire
- Roots



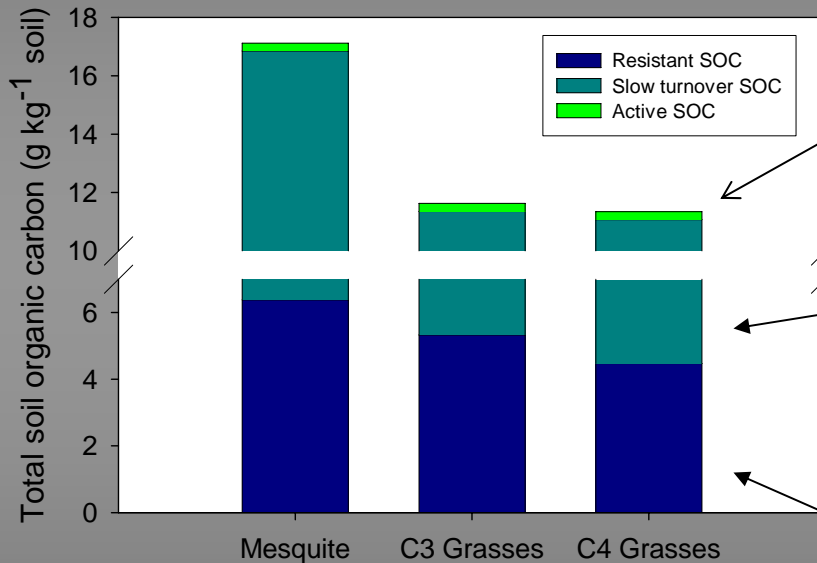
Effect	p-value
Fire	0.193
Vegetation	0.001
F x V	0.122

# Total SOC



<u>Effect</u>	<u>p-value</u>
Fire	0.088
Vegetation	0.001
F x V	0.122

# Total SOC



Active pools unchanged

Slow pools affected by vegetation change and fire treatment.

Resistant pools differ with vegetation type.

Effect	p-value
Fire	0.088
Vegetation	0.001
F x V	0.122

# Summary

- Vegetation (i.e. mesquite) is a major driver of SOC dynamics in this system
- Slow SOC pool was the most sensitive to change
  - Effects of mesquite
  - Effects of fire
- Growth in slow SOC may represent “short term” sequestration – stability is unknown
- Implications for management



# Thank You

- Department of Energy
  - GCEP
- Texas A&M University
  - Tom Boutton, Julia Liao, Wylie Harris, Edith Bai, Lori Biederman, Feng Liu, Ilsa Kantola, Kirk Jessup, Darrin Moore
  - Frank Hons, Xiaoyan Dai
- Texas Agricultural Experiment Station
  - Jim Ansley, Mike Castellano, Betty Kramp

