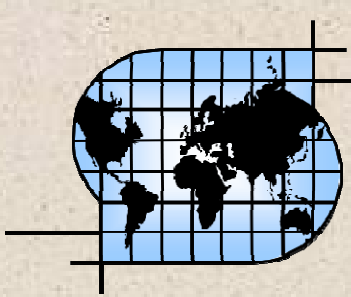
Simulating Historical Soil Carbon Dynamics in Semi-arid Rangelands

AM Thomson, RC Izaurralde, MP McClaran, SP McLaughlin, NJ Rosenberg

March 22, 2005
Baltimore MD

Pacific Northwest National Laboratory



JGCRI
Joint Global Change Research Institute

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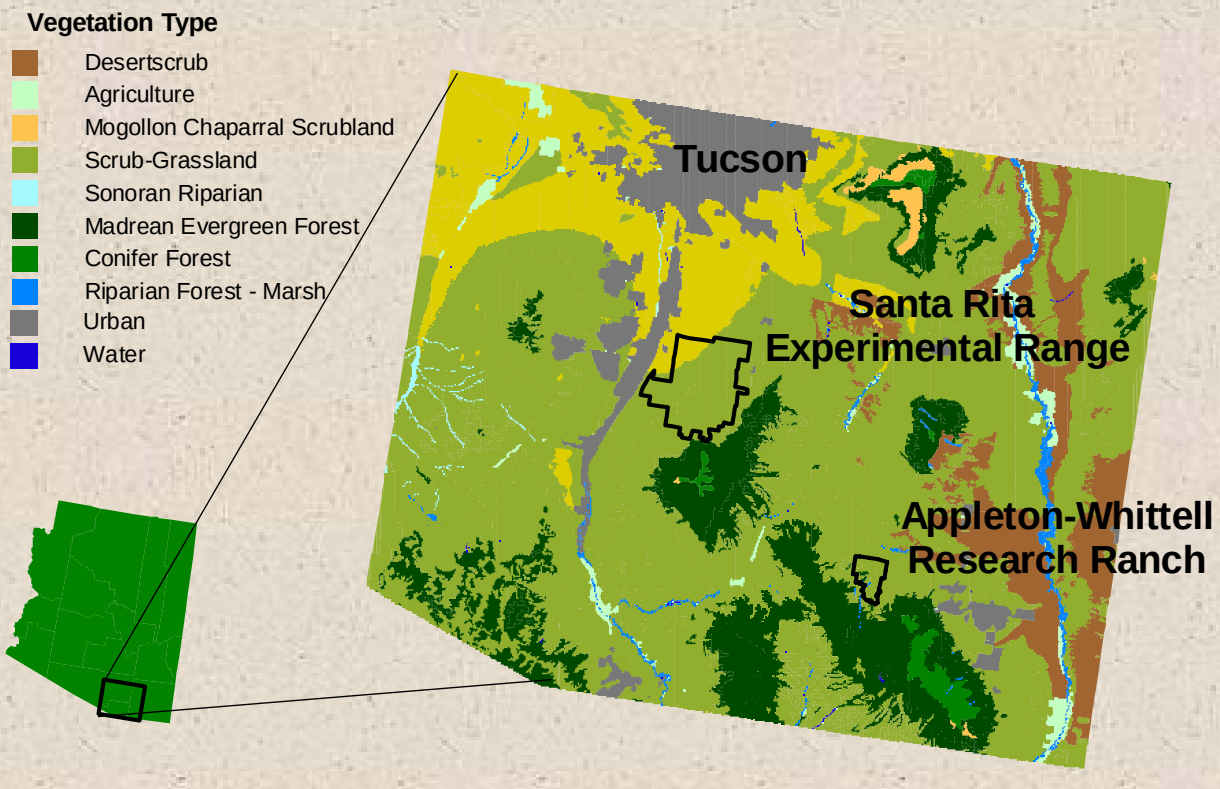
Study Purpose

- The Arizona State Lands Department manages large areas of land, primarily leased for cattle ranching.
- Could this land potentially be managed to sequester carbon?
- The physical potential is being evaluated through fieldwork, remote sensing and modeling.
- The economic potential is being evaluated based on the scientific results.
- Funding from NASA to examine these questions.

Study Sites and Treatments

- **Appleton – Whittell Research Ranch**
  - Cessation of livestock grazing in 1969
  - Intensive grazing under on adjacent private land from 1978
- **Santa Rita Experimental Range**
  - Mesquite encroachment (*Prosopis velutina*)
  - Livestock grazing rotations since 1970

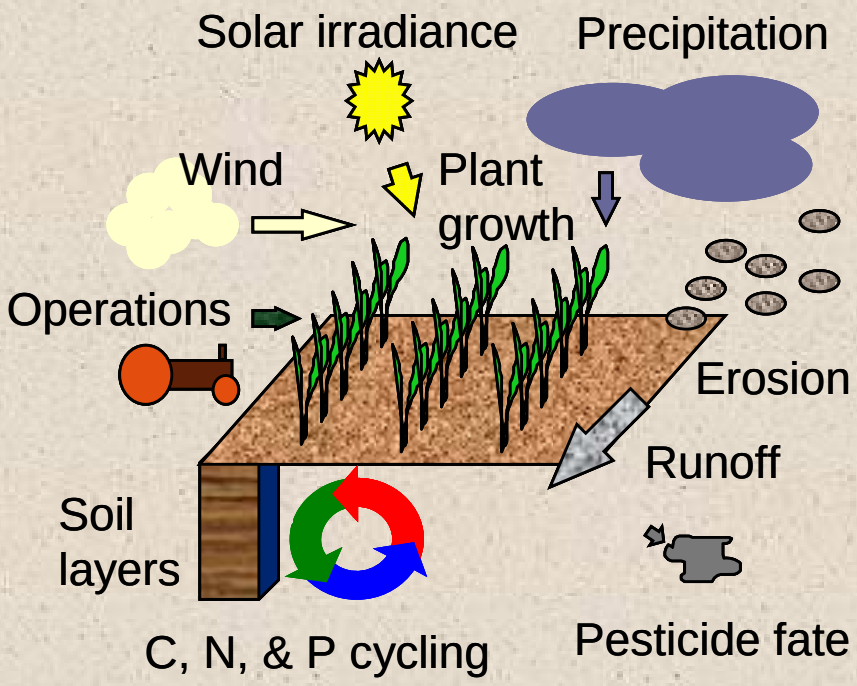


Historical vegetation change and management treatments

Location	Mesquite Treatment	Year	Grazing Treatment	Year Initiated
SRER Pasture C	Clear cut	1935	Rotation	1972
SRER Pasture D	Herbicide	1960	Rotation	1972
SRER Pasture D	Herbicide	1962	Rotation	1972
SRER Pasture E	Clear cut	1937	Rotation	1972
AWRR			Rest	1969
Private Ranch			Intensive (HRM)	1978

Agro-ecosystem Modeling

- EPIC – a process based daily time-step model
- Perennial C4 grasses
- Mesquite encroachment
- Livestock grazing
- Multiple soil layers initialized with fieldwork results
- Daily weather for 1950-2002

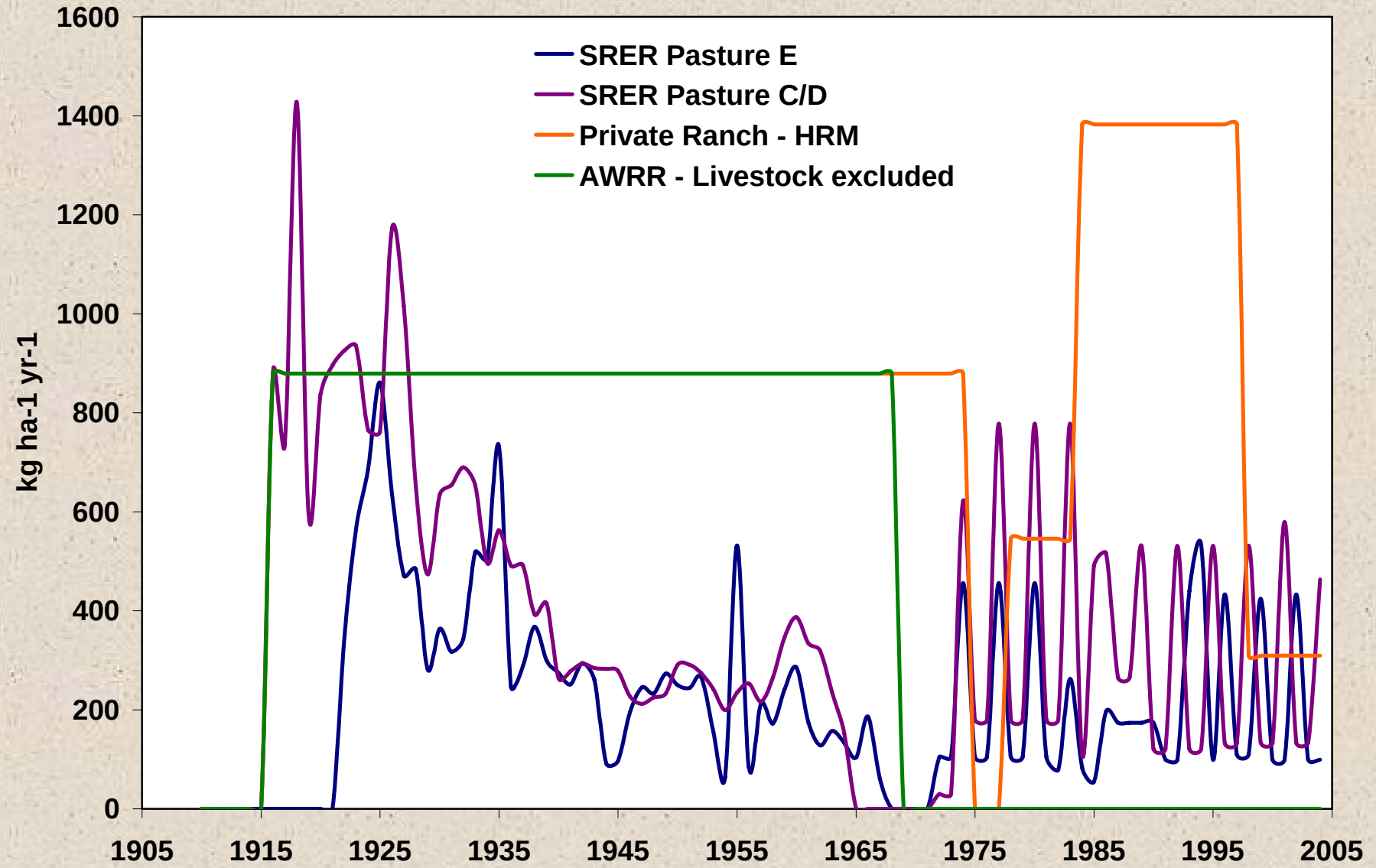


Representative EPIC modules

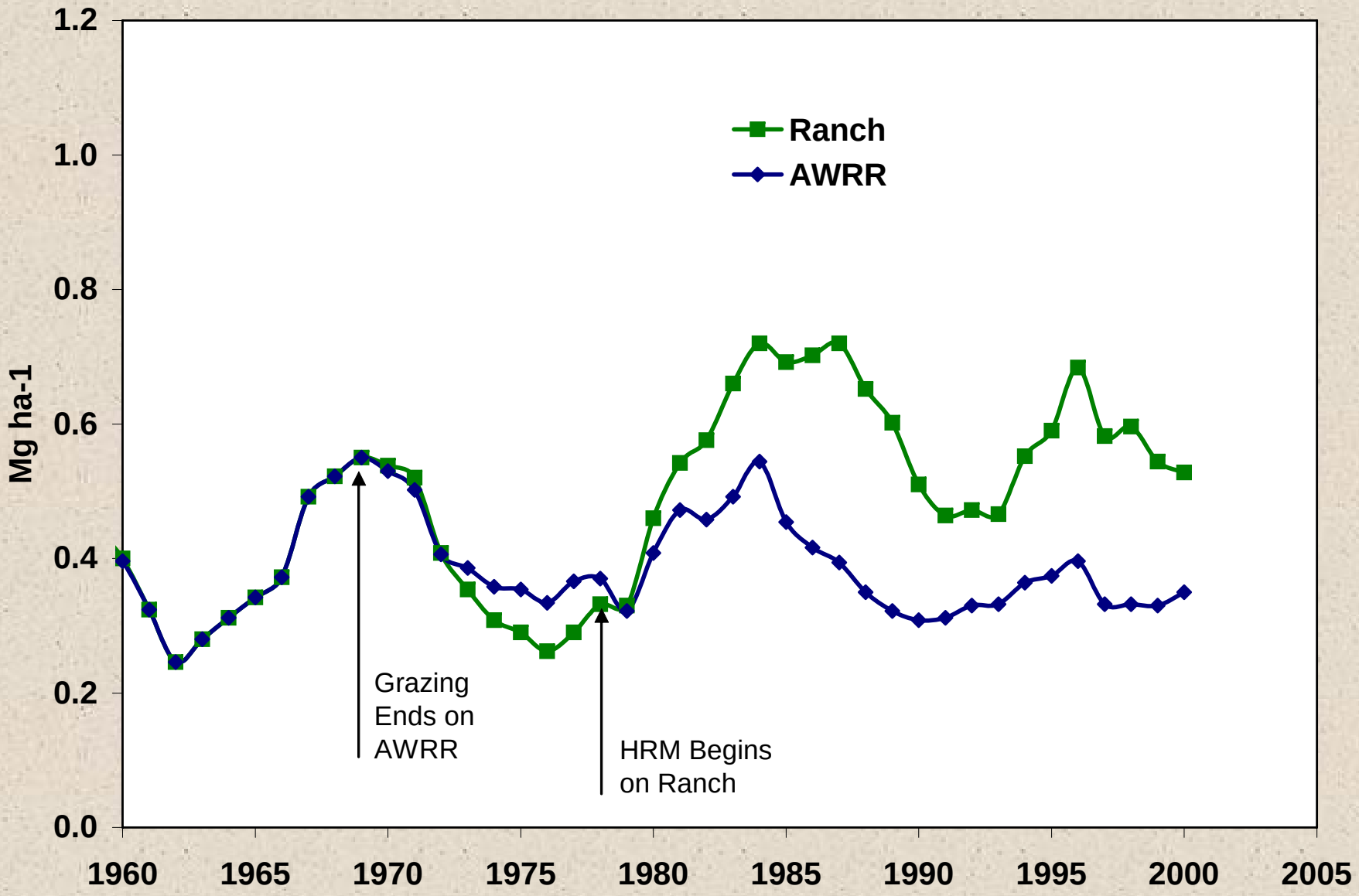
The Appleton-Whittell Research Ranch

- Grazed since the 1820’s
- AWRR grazing excluded in 1969
- Adjacent private ranch began Holistic Resource Management -an intensive grazing system - in the 1970’s

Livestock grazing history



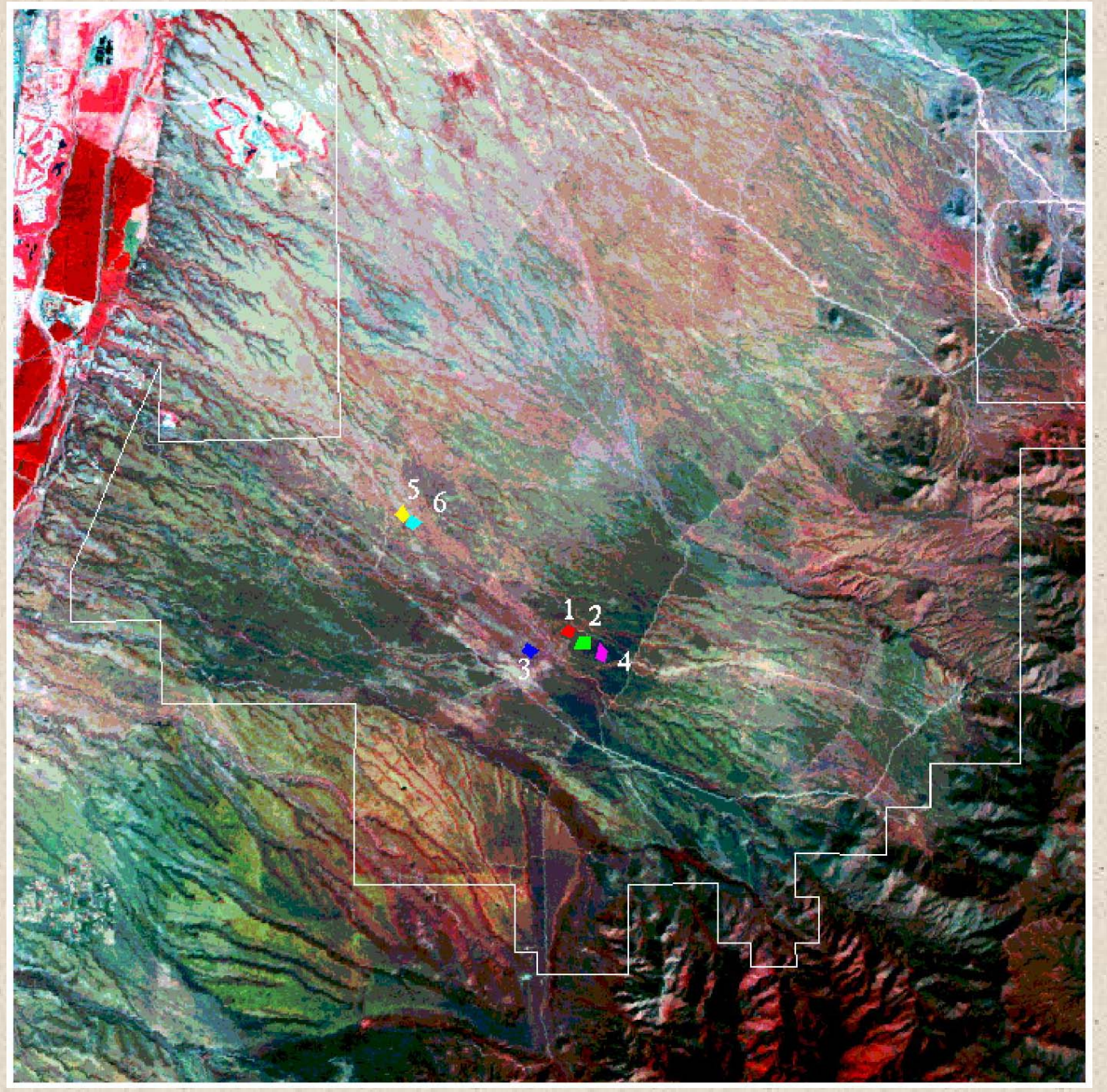
Summer growing season herbaceous biomass



Impact of grazing treatments on soil C

- Field work shows higher soil C on the livestock exclusion site.
- Due to a recent wildfire, there are no replicates for this part of the study.
- EPIC was initialized with the soil from the grazed site and projects a loss of soil C for both sites over the simulation period.

SRER Study Sites



H. Fang et al., 2005

EPIC simulations on the SRER sites

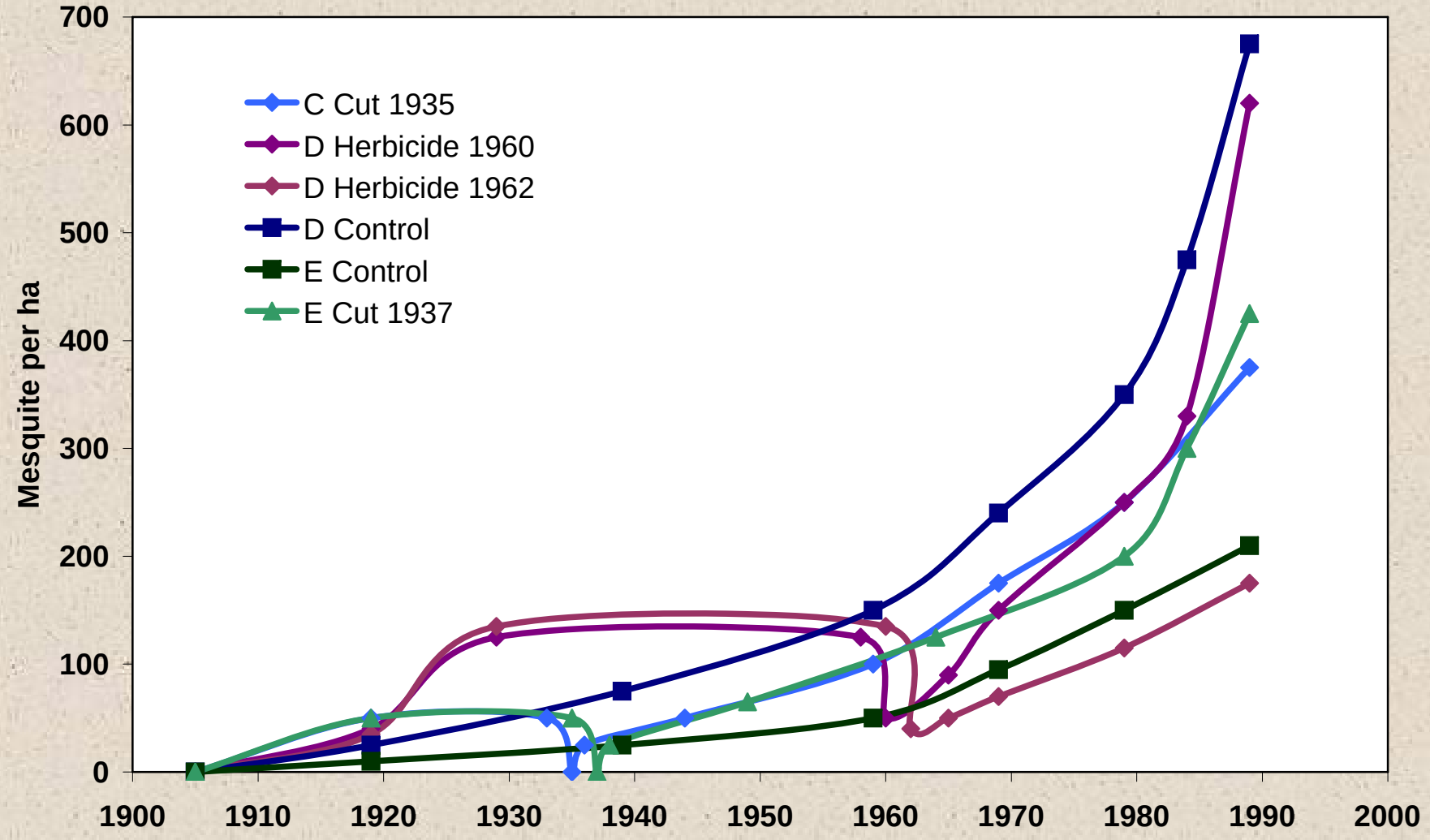
- Soil properties initialized using fieldwork from control sites in 2002
- Sites simulated as open grassland and with mesquite encroachment
- Detailed grazing history for 100 years

SRER Vegetation Change

1938

2001

Woody encroachment by velvet mesquite



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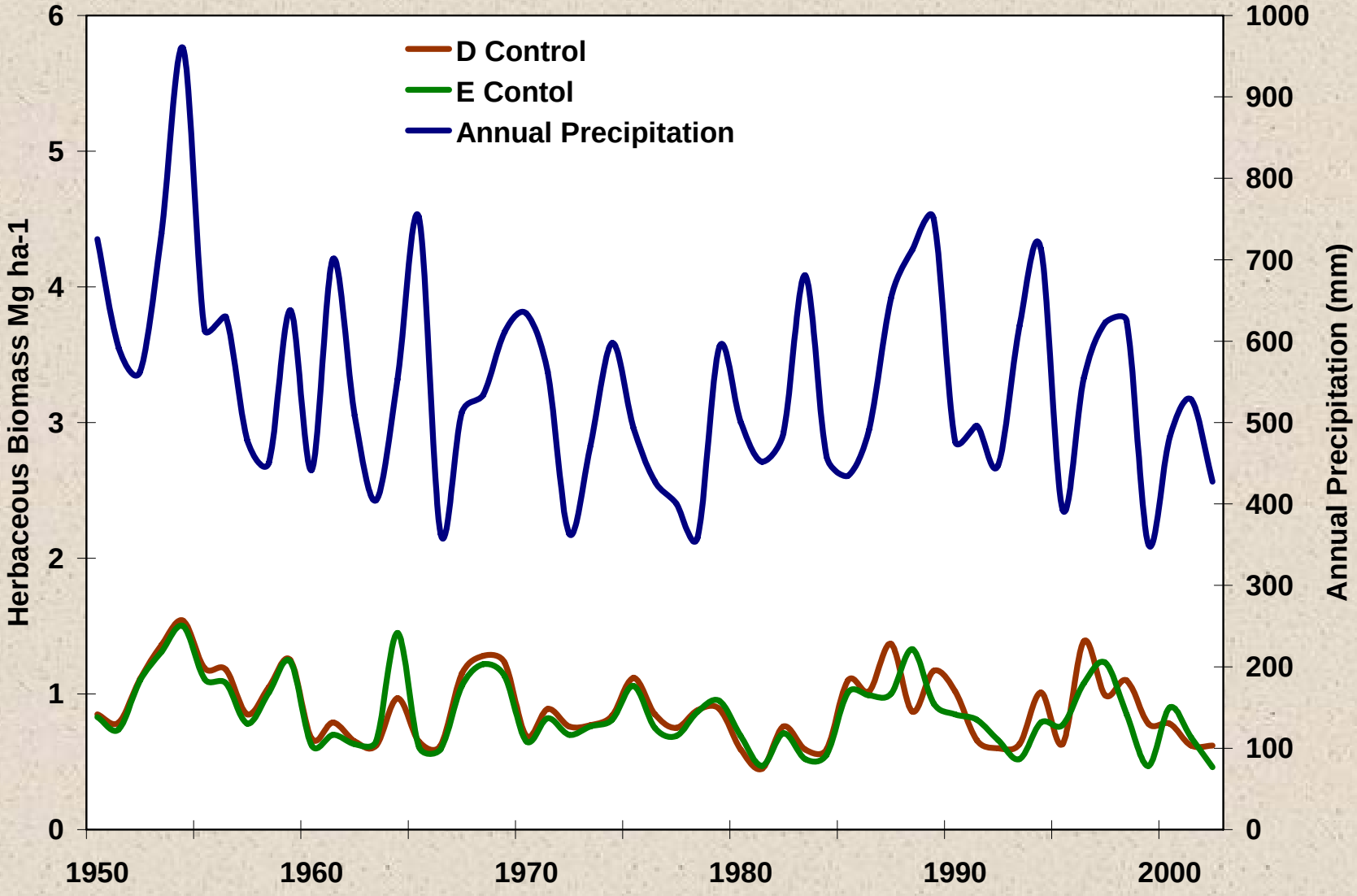
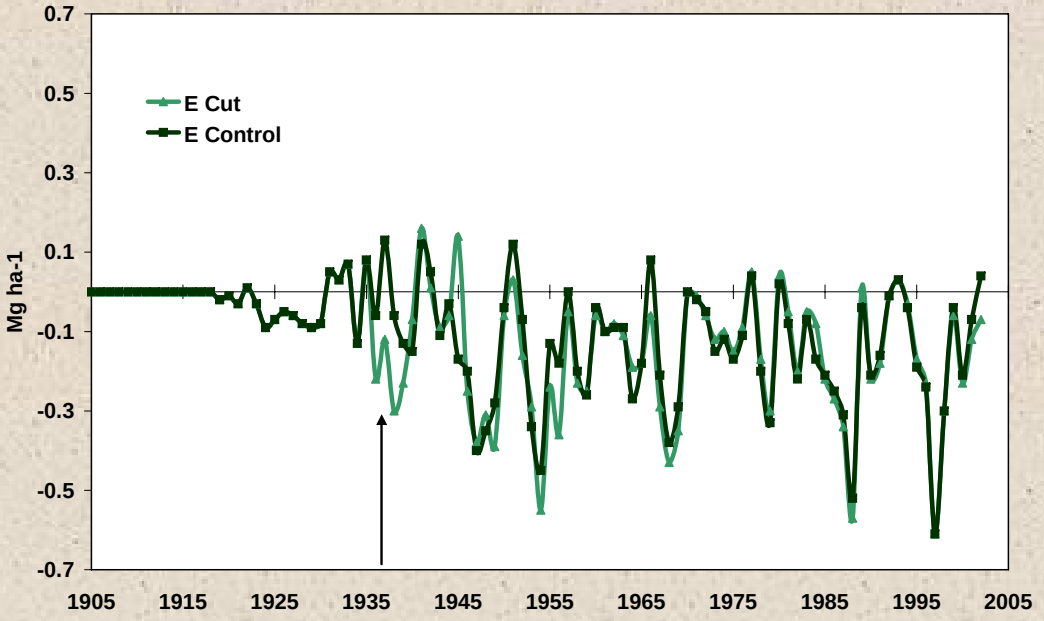
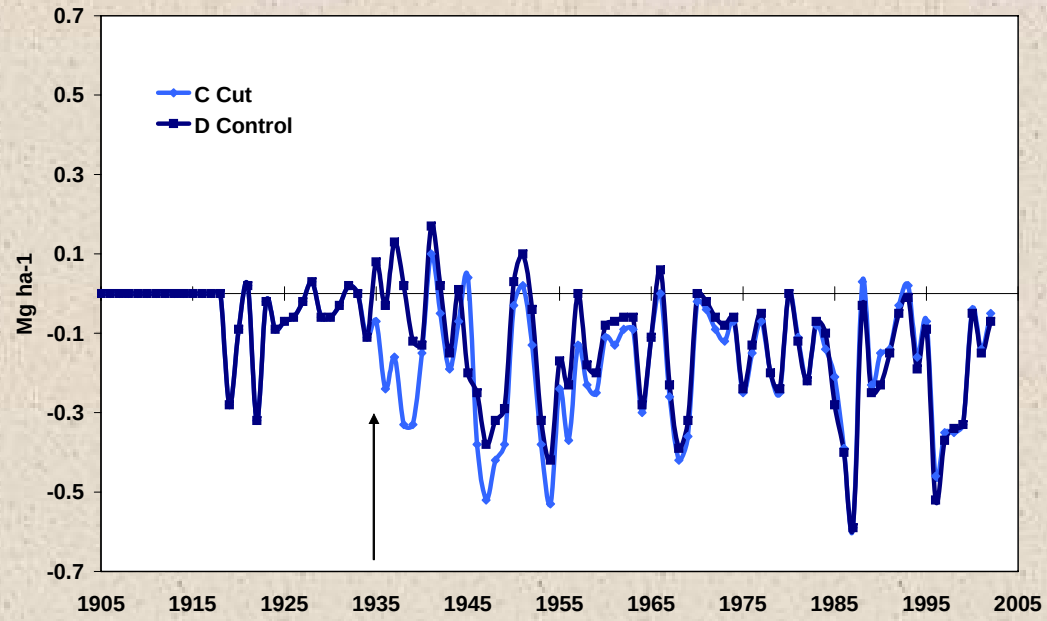


Mesquite encroachment impact on herbaceous biomass





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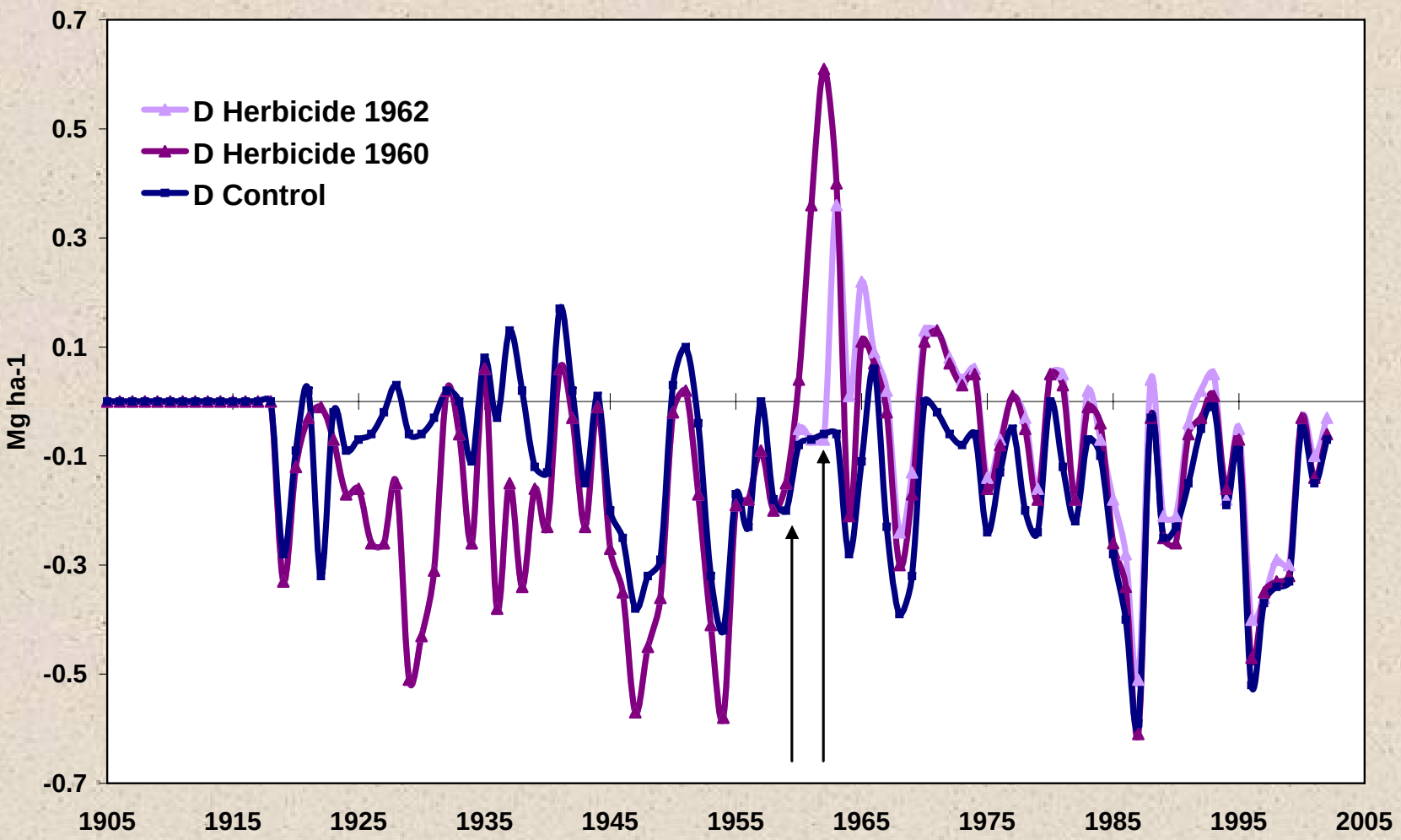
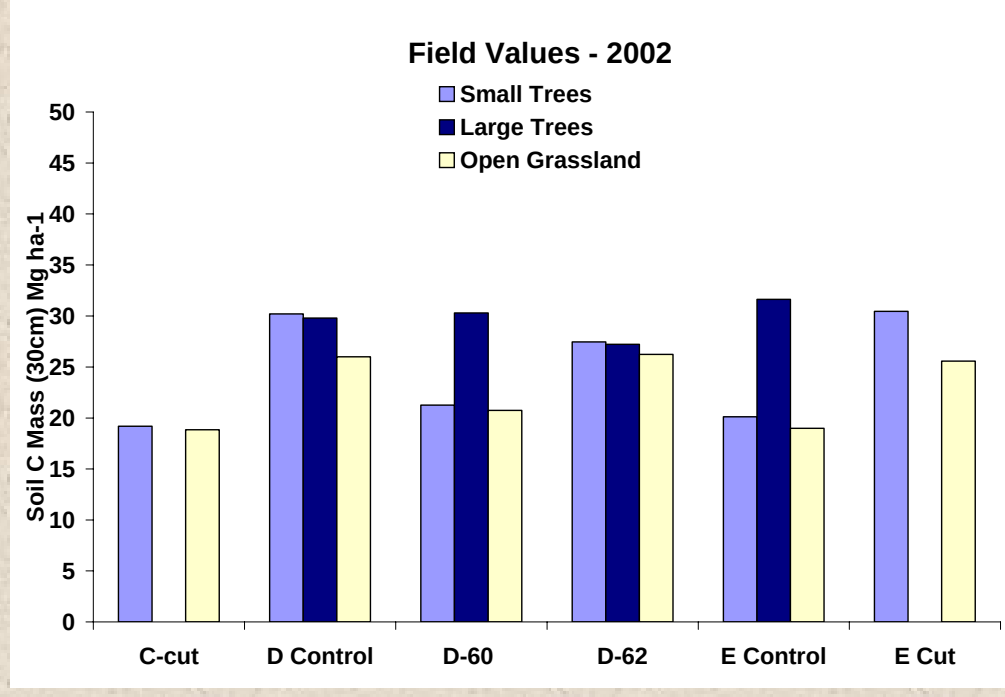
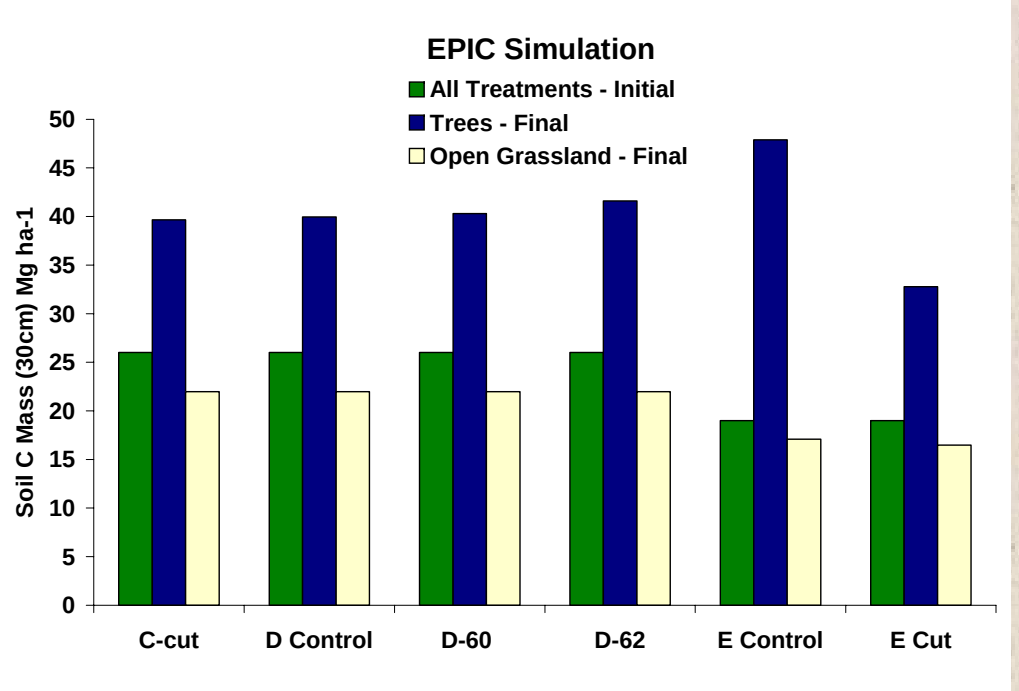
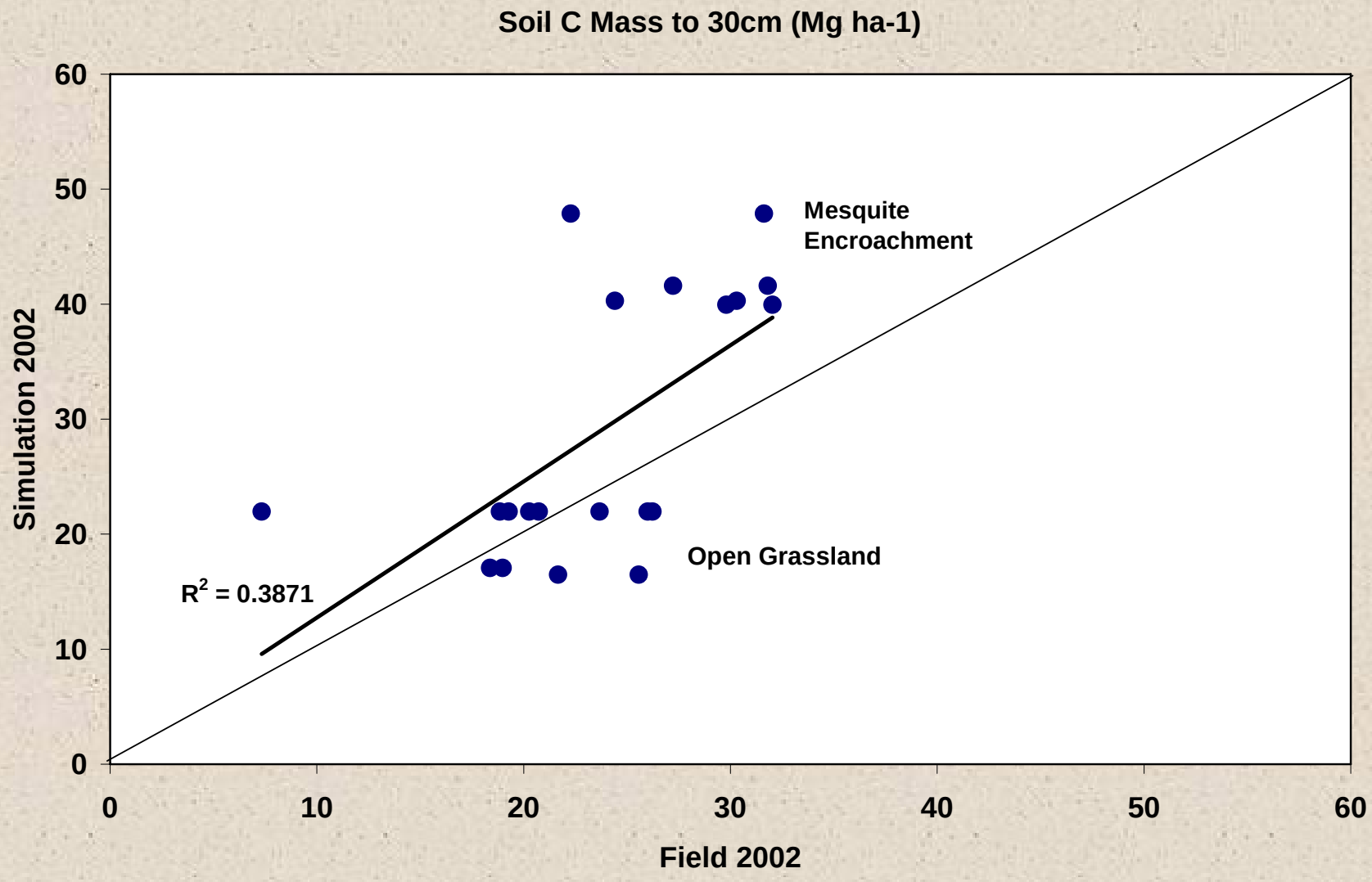


Soil C Mass to 30 cm





Soil C Results



Modeling challenges

- We are overestimating the impact of mesquite on soil C levels
  - N-fixation in the model
  - Overestimation of mesquite biomass
  - Lack of data for calibration
- Initial soil properties are unknown

Future work

- Improved treatment of woody encroachment in EPIC
- Simulations of rangeland ecosystems under climate variability and change
- Simulations of potential management options and the impact on soil carbon
- Economic analysis of soil C sequestration potential on Arizona state-owned lands