Regional NPP and Carbon Stocks in Southwestern USA Rangelands:

Land-use Impacts on the Grassland-Woodland Balance

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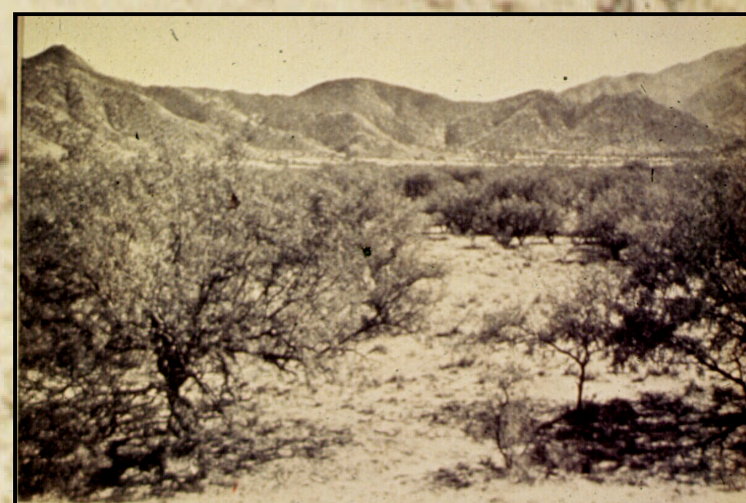
Big Questions

- What are the rates, dynamics, and ecological consequences of woody plant encroachment into grasslands?
- How do management practices influence these dynamics and affect future trajectories of change?



Determining Rates & Dynamics of Change

- Field Measurements
- Isotope Biogeochemistry

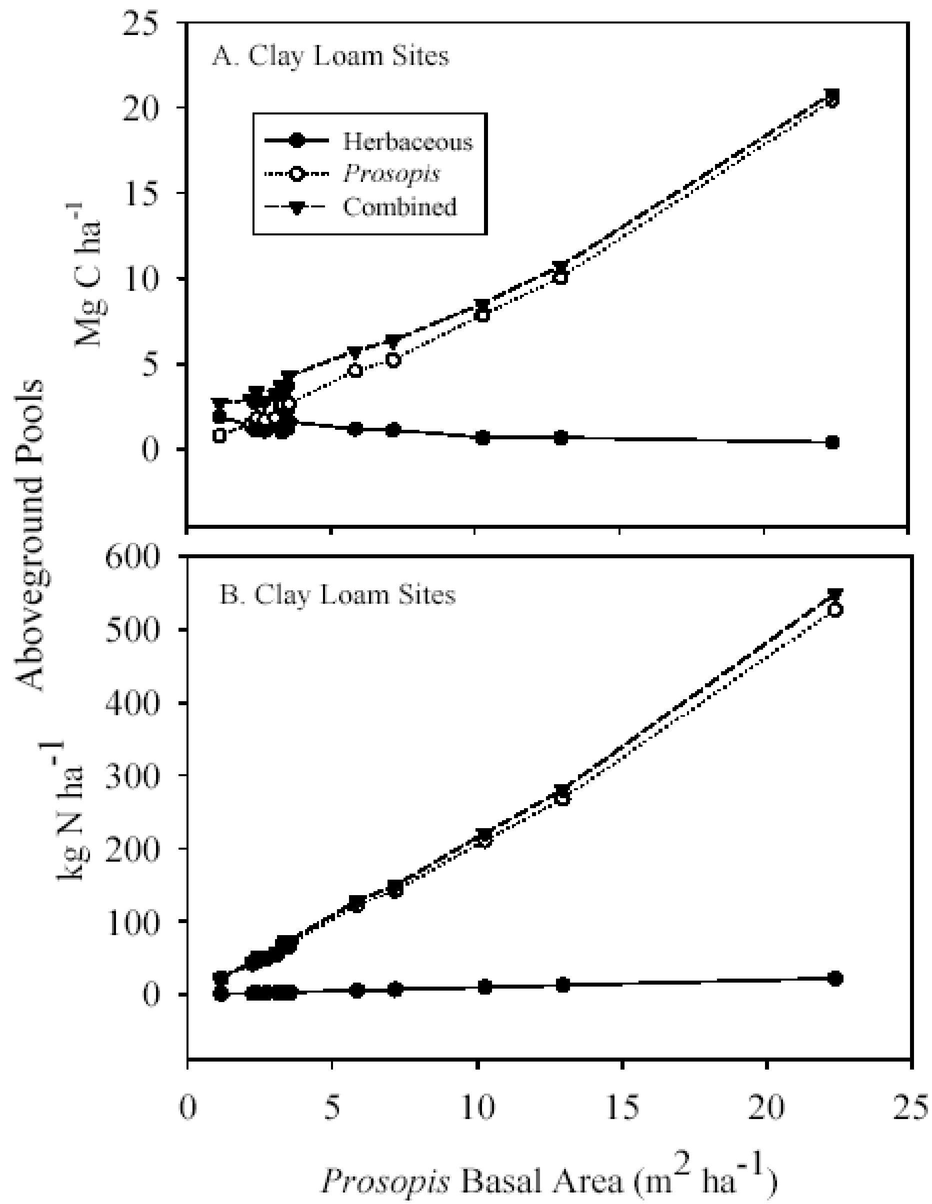
- Biophysical and biogeochemical properties
- Response to disturbance

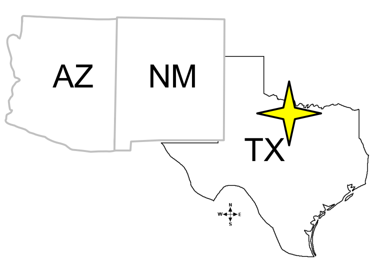
- Remote Sensing
- Ecosystem Simulation Modeling

- Regional-level biogeochemistry associated with natural variability & land-use pressure

Productivity and Biogeochemistry

- Temperate system - Increases in aboveground C & N pools due to increase in *Prosopis* (mesquite).
  - Ecosystem pools (*Prosopis* + herbaceous + litter+ upper 10cm soil) nearly doubled.
- Subtropical system - 1.3x and 10x increase in soil and plant C pools, resp. with woody increases over past 100 years
- Discrepancies between studies of changes in Soil Organic Carbon:
  - Jackson et al. (2002) → declines
  - Our work → no change or increase depending on soil type





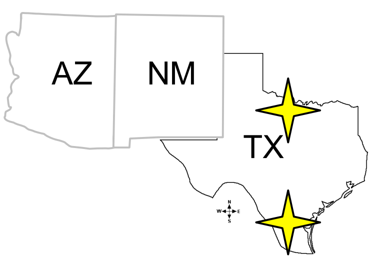
Waggoner Ranch
Vernon, TX

Brush Management

Remote detection of management dependent on degree of aboveground structural change

A. Gross scale change evident across decades. (e.g. mechanical)

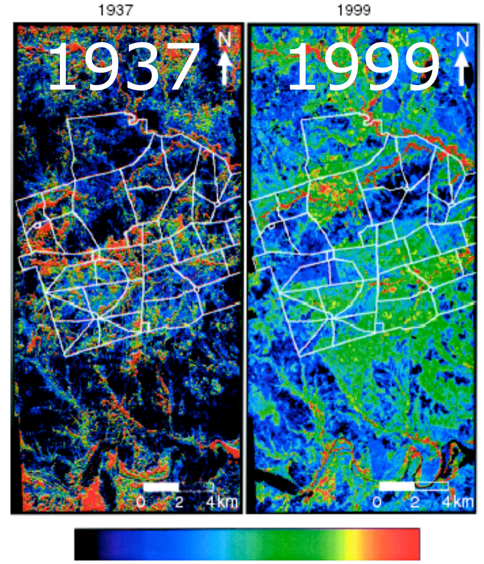
B. Variable effects on canopy and understory confound quantitative assessment. (e.g. herbicides)



La Copita Research Area, TX

A. North Texas

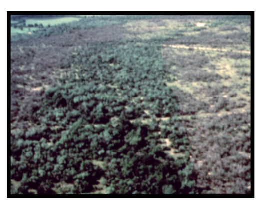
Fractional cover change over 63 years



Fractional woody cover

B. South Texas

Sub-decadal response to herbicides



Herbicide applications
(1986, 1987, 1990)

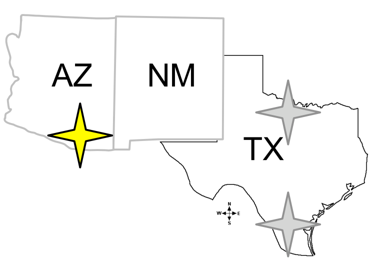
Spectral mixture analysis
(Difference: 1987 - 1985)

Importance of Historical Documentation

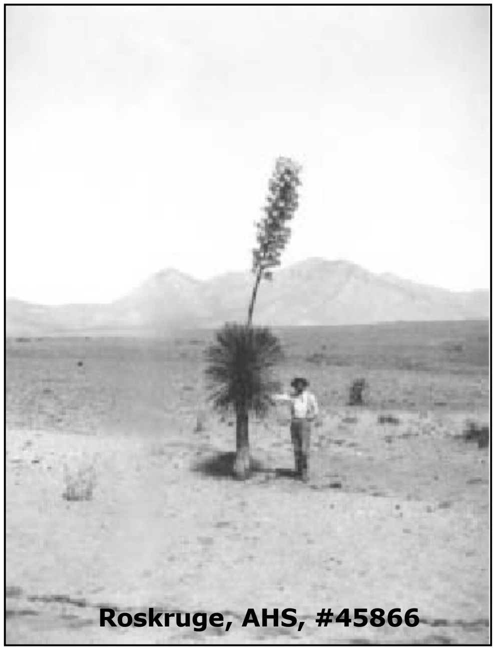
Santa Rita Experimental Range, Arizona

A history in range ecology and management since 1903

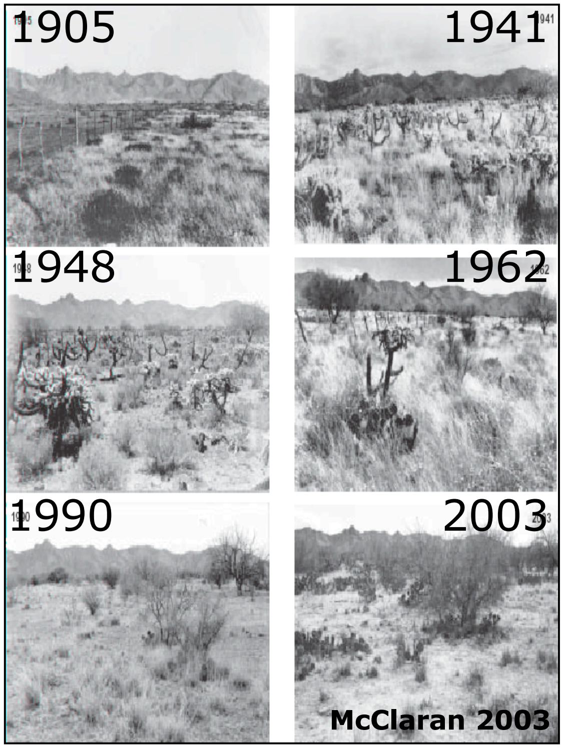
- Documented contrasts in grazing and brush management
- Elevation (PPT) and landform contrasts
- Repeat photography
- Long-term transect and spatial data
- Vegetation manipulation and grazing experiments



SRER, AZ

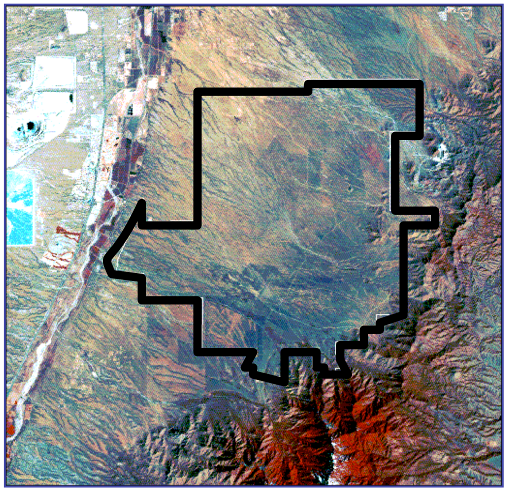


Heavy, uncontrolled grazing and drought (1891)

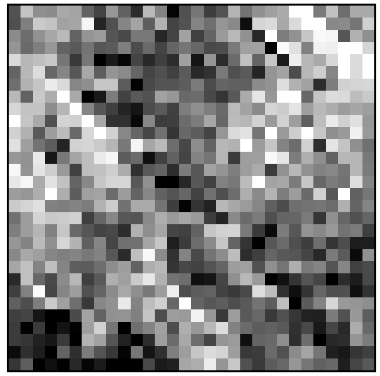


Repeat photography
1905 - 2003

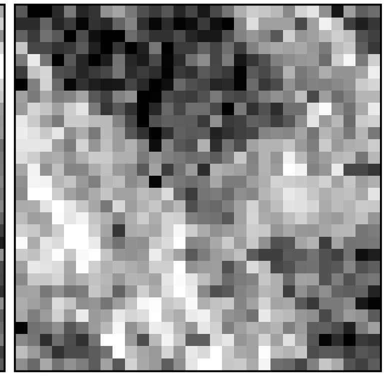
Ecosystem studies, land cover history, & remote sensing



Santa Rita, AZ   Landsat TM



Classified aerial photo 9/02, resampled at 30m



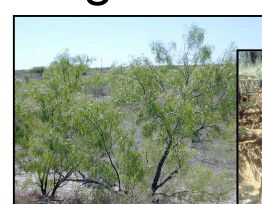
Spectrally unmixed TM image, 6/02

Mapping Change

(1966 - 2003) - aerial photos & Landsat

Field and History

- Productivity, biogeochemistry
- Belowground pools of carbon and nitrogen
- Response to management

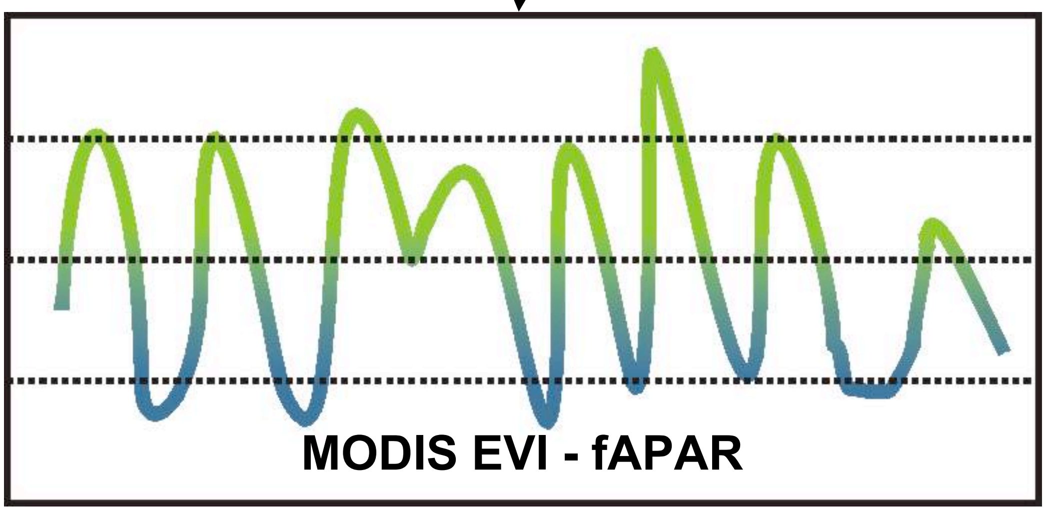


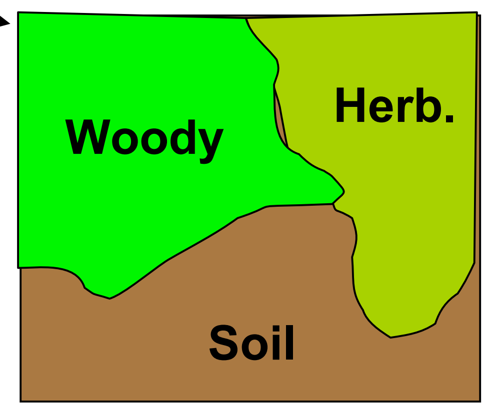
Spatial Modeling of NPP Following Woody Encroachment

The TerraFlux Model (Asner et al. 2001)

$$NPP_{pixel} \sum_{t=1}^{12} \sum_{i=1}^{x} \left[fAPAR(t) \bullet PAR(t) \bullet \varepsilon(i,t) \bullet F(i) \right]$$

where t = month of year, i = vegetation type
fAPAR = fractional PAR absorption
PAR = downwelling photosynthetic active radiation
ε= light-use efficiency
F = sub-pixel cover fraction of vegetation types



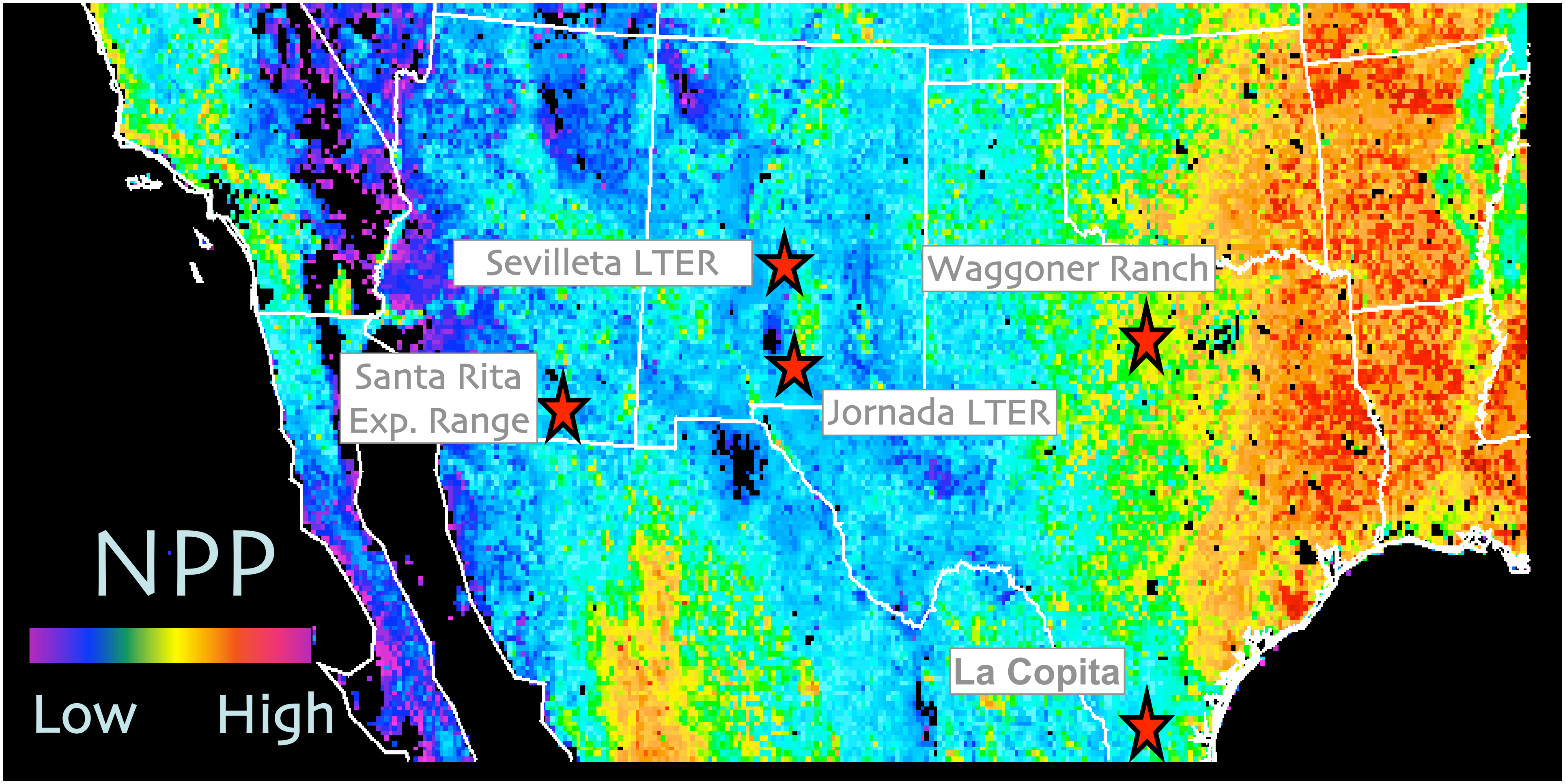


Landsat Unmixing

Light-use Efficiency (ε) is a function of:

1) Water Availability
2) Nitrogen availability
3) Air temperature
4) Competition for resources:
    a) Rooting depth and profile
    b) Soil physics
    c) Ground water
    d) N-fixation
    e) N gas diffusion and recapture

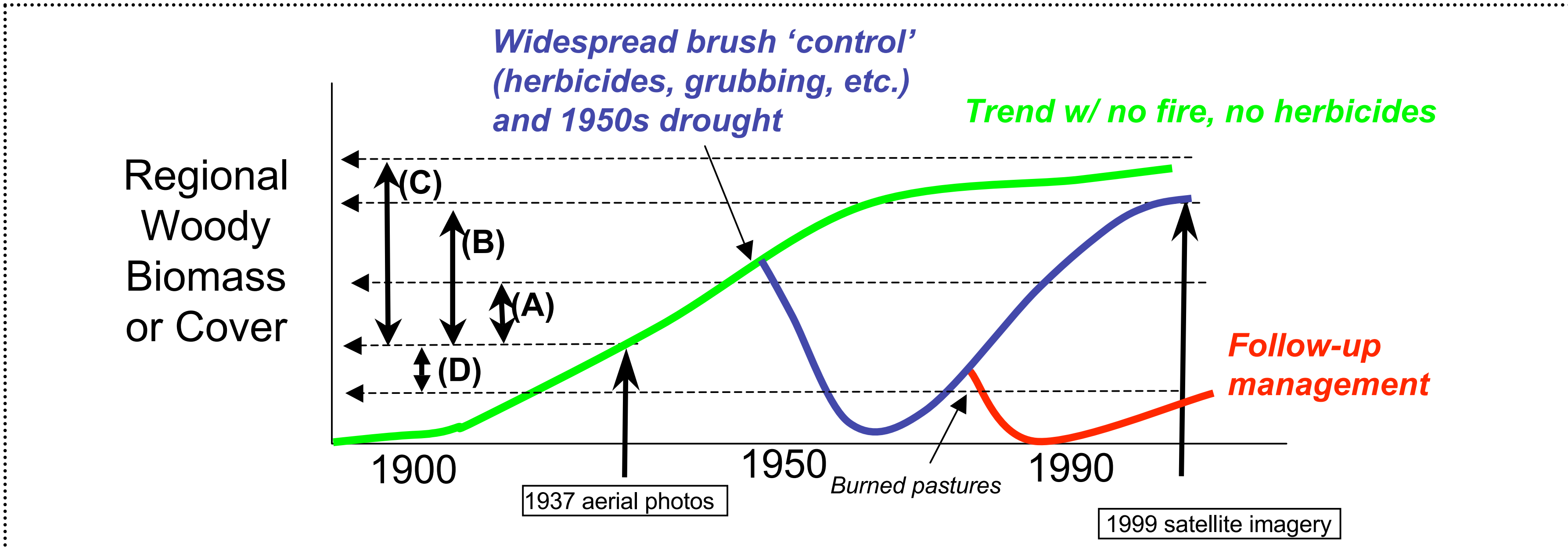
TerraFlux is being modified for inter-vegetation effects on light-use efficiency



- Intensive sites located on a spatial precipitation gradient and, hence, potential productivity.

- Landscape studies used to understand range of response to management and guide Terra-Flux modifications for regional assessment.

Challenges to assessing regional woody plant cover and dynamics



- Potential mismatch of remote sensing and ecosystem & disturbance dynamics may mislead carbon pool estimates
- Setbacks and rates of recovery from disturbance depend on:
  - Type, intensity and spatial extent of disturbance
  - Soil type
  - Environmental conditions proceeding and following disturbance
  - Regenerative traits

Significant Results

1. Aboveground carbon pools increase 2 to 10 times with woody plant encroachment in temperate and tropical grassland systems, respectively.
2. Belowground soil organic carbon (0-10cm) showed no change to doubled values depending on soil type and disturbance.
3. Nonlinearities in response to management require knowledge of sufficient temporal resolution and historical land use to capture and understand sources of variation.
4. Field observations, remote sensing and ecosystem modeling are necessary in combination to understand the biogeochemical properties and dynamics of land management impacts on grasslands undergoing woody plant encroachment.