Climate Change and Rangelands: What are the Management Implications?

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A Vision for Rangeland & Pasture Research

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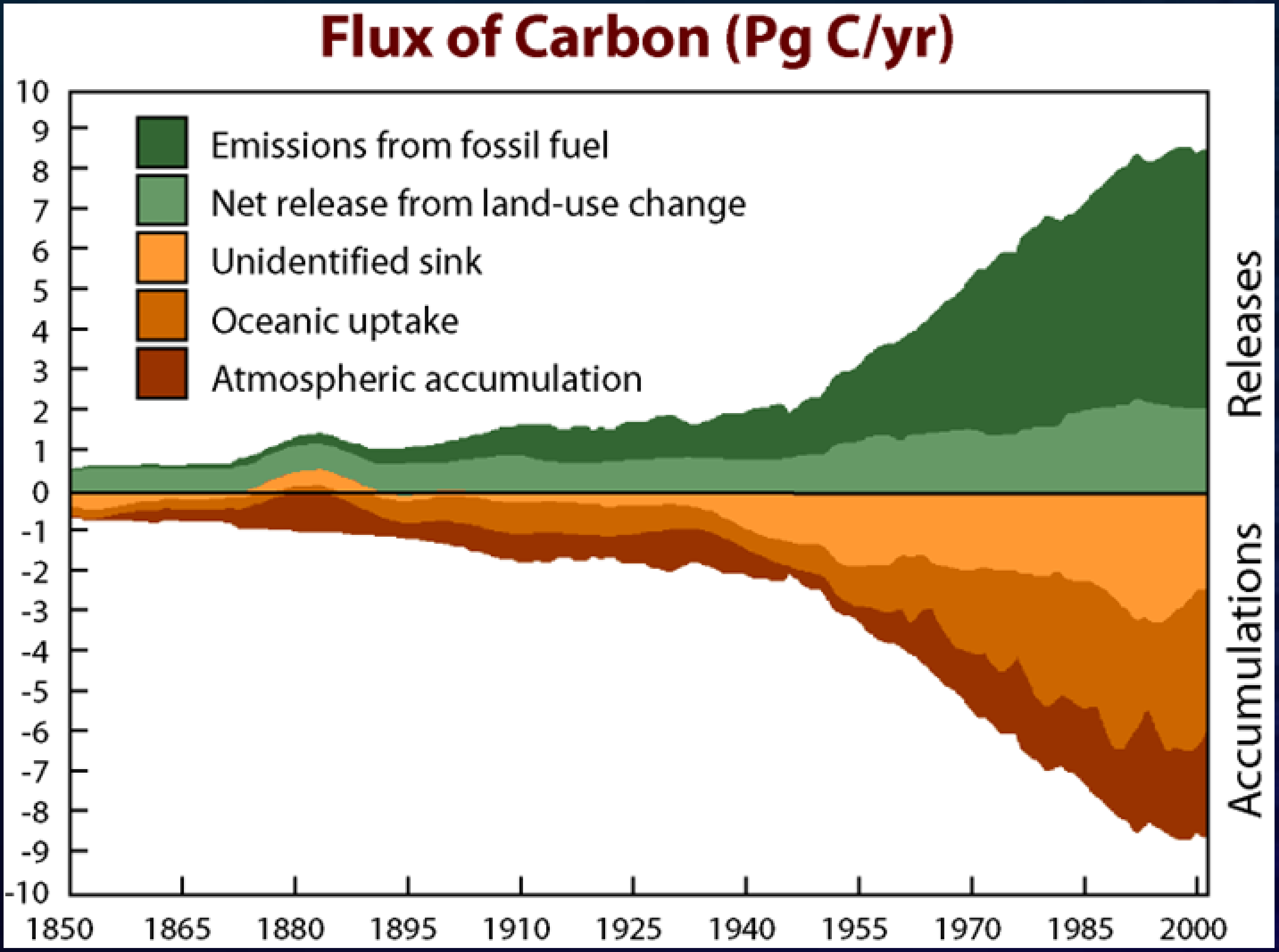
Climate change is not exactly a new concept- why would we expect climate to be static?

It seems that the speed and suggested cause of the change has created controversy.

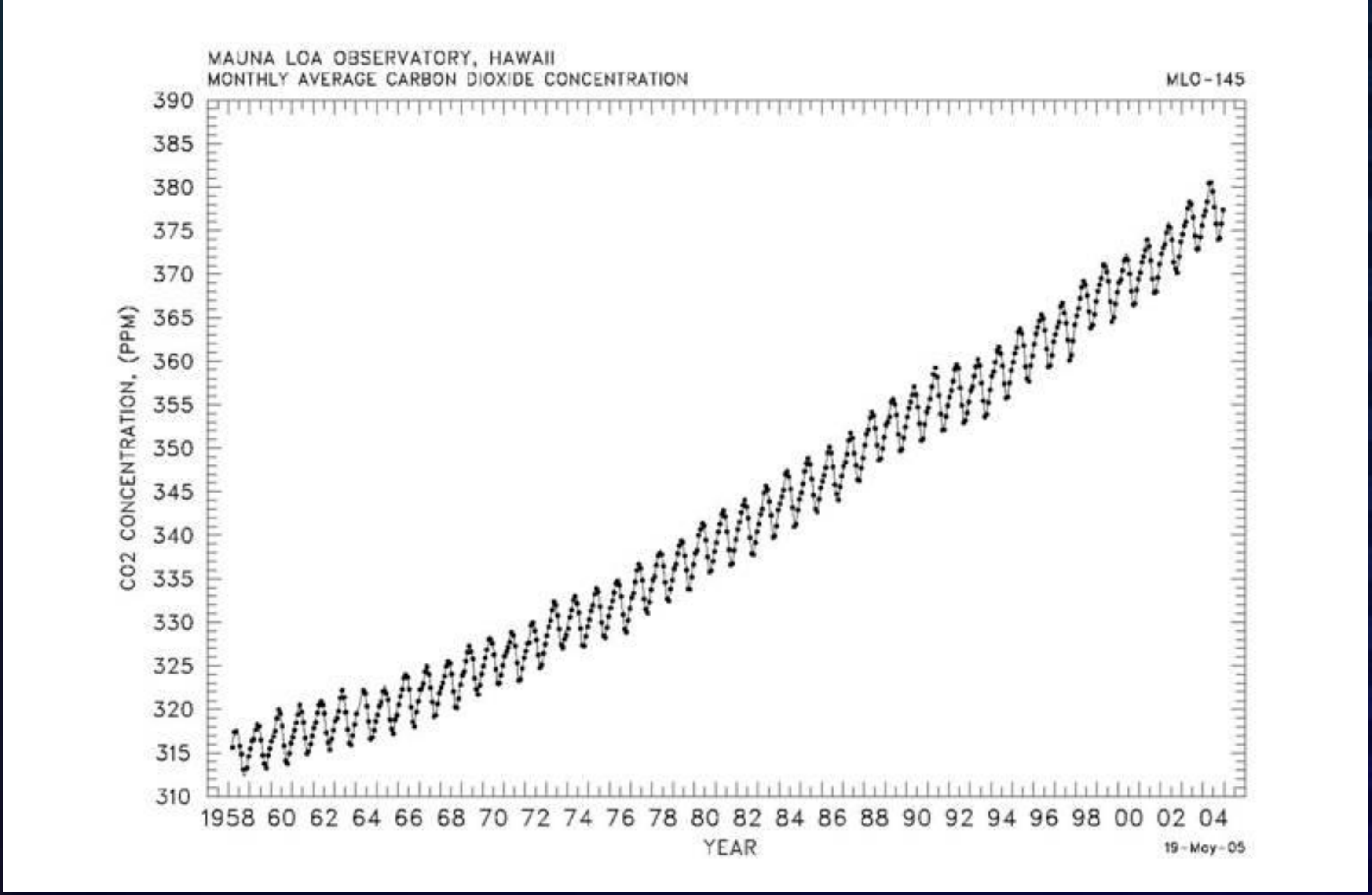
Let's break climate change into 2 separate issues:

1. Increasing atmospheric CO_2
2. Changes in precipitation, temperature, and humidity

Graph of CO_2 Sources and Sinks



Graph of Atmospheric CO_2 Concentration



Personal Observations

- During the past 26 years I've measured photosynthesis of something on a regular basis.
- When I started in 1983-84, ambient atmospheric CO_2 was ~ 330 ppm, now it is ~ 375 ppm.
- That is a 14% increase in CO_2 concentration.

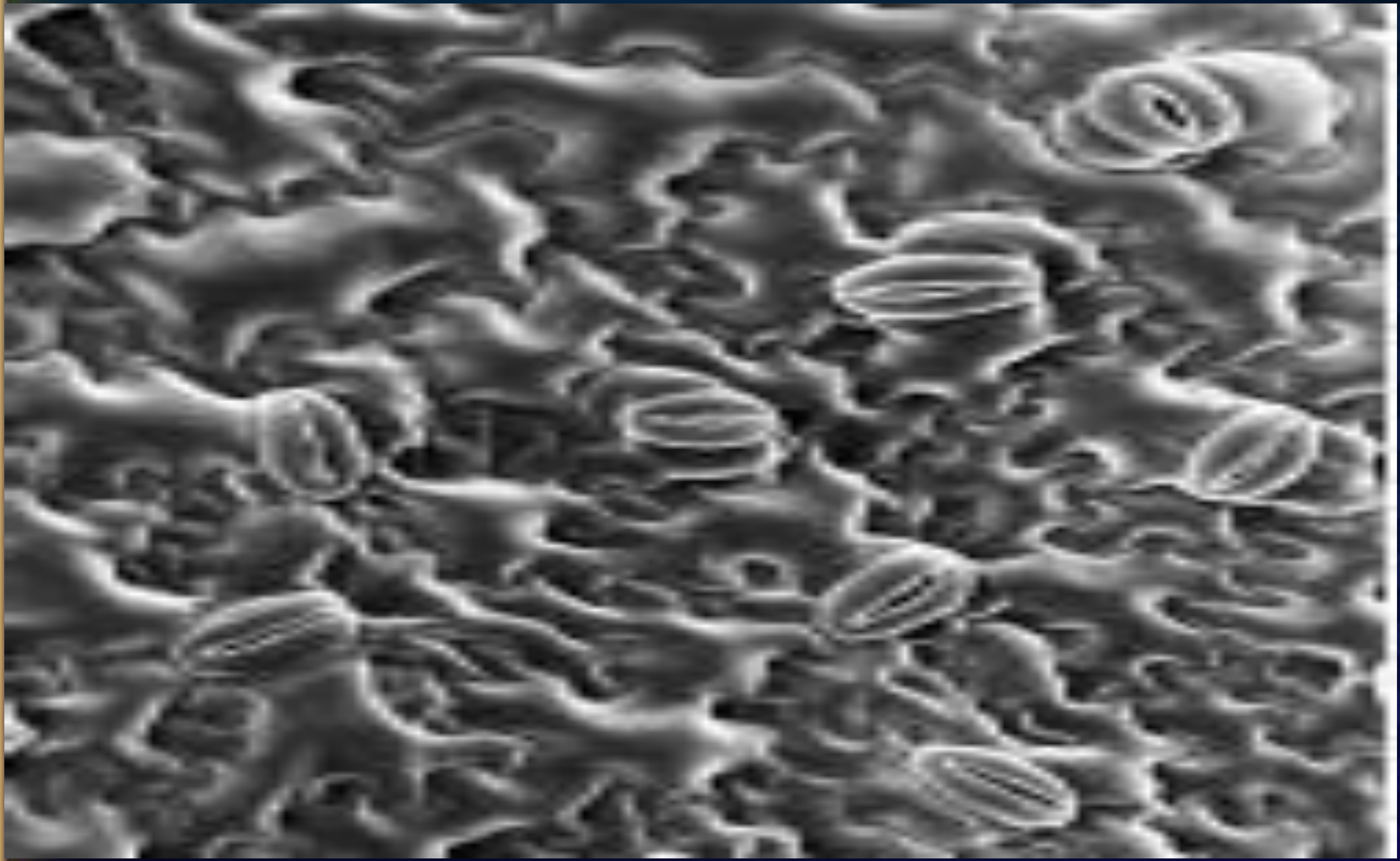
Preindustrial CO_2	Current CO_2
270-280 ppm	375 ppm

about a 34% increase

Increasing CO_2 also increases water use efficiency, and is effectively equivalent to increasing soil moisture.

The same increase in precipitation would be 12” (30.5 cm) to 16” (41 cm).

Leaf Surface



Ziska, Reeves and Blank, 2005. The impact of recent increases in atomospheric CO_2 on biomass production and vegetative retention of cheatgrass (*Bromus tectorum*): implications for fire disturbance. Global Change Biology 11: 1325-1332.

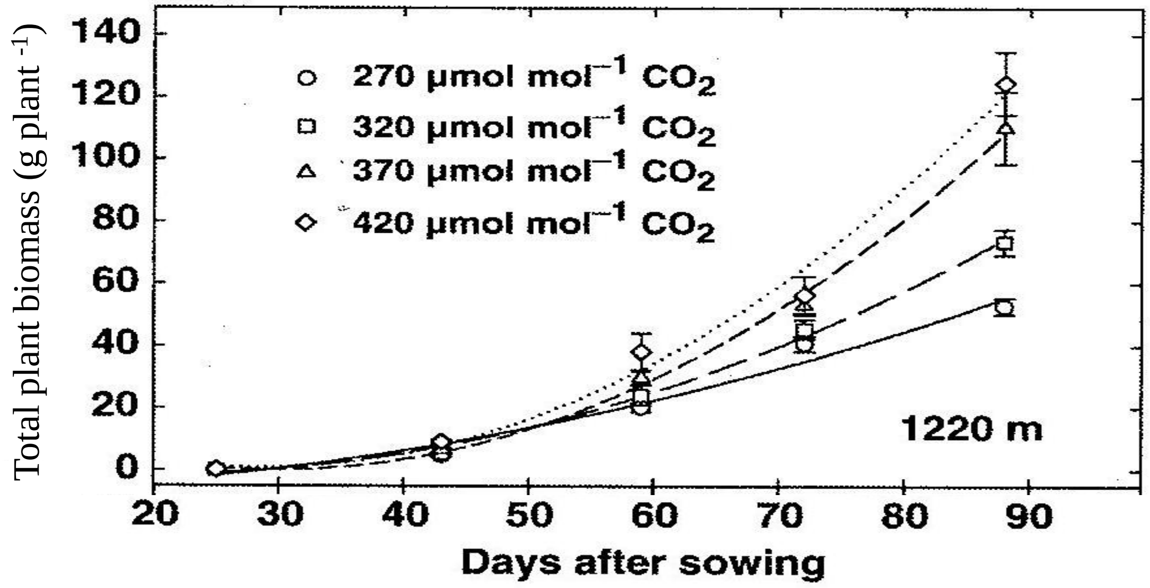


Fig. 1 Total biomass of cheatgrass (*Bromus tectorum* g per plant) over time (days after sowing, DAS) as a function of increasing [CO_2] for three populations collected at different elevations in northern Nevada. Significant [CO_2] differences were observed after 59 DAS. Bars are ± SE.

Fuel Loads Have Been Huge During Some Recent Years

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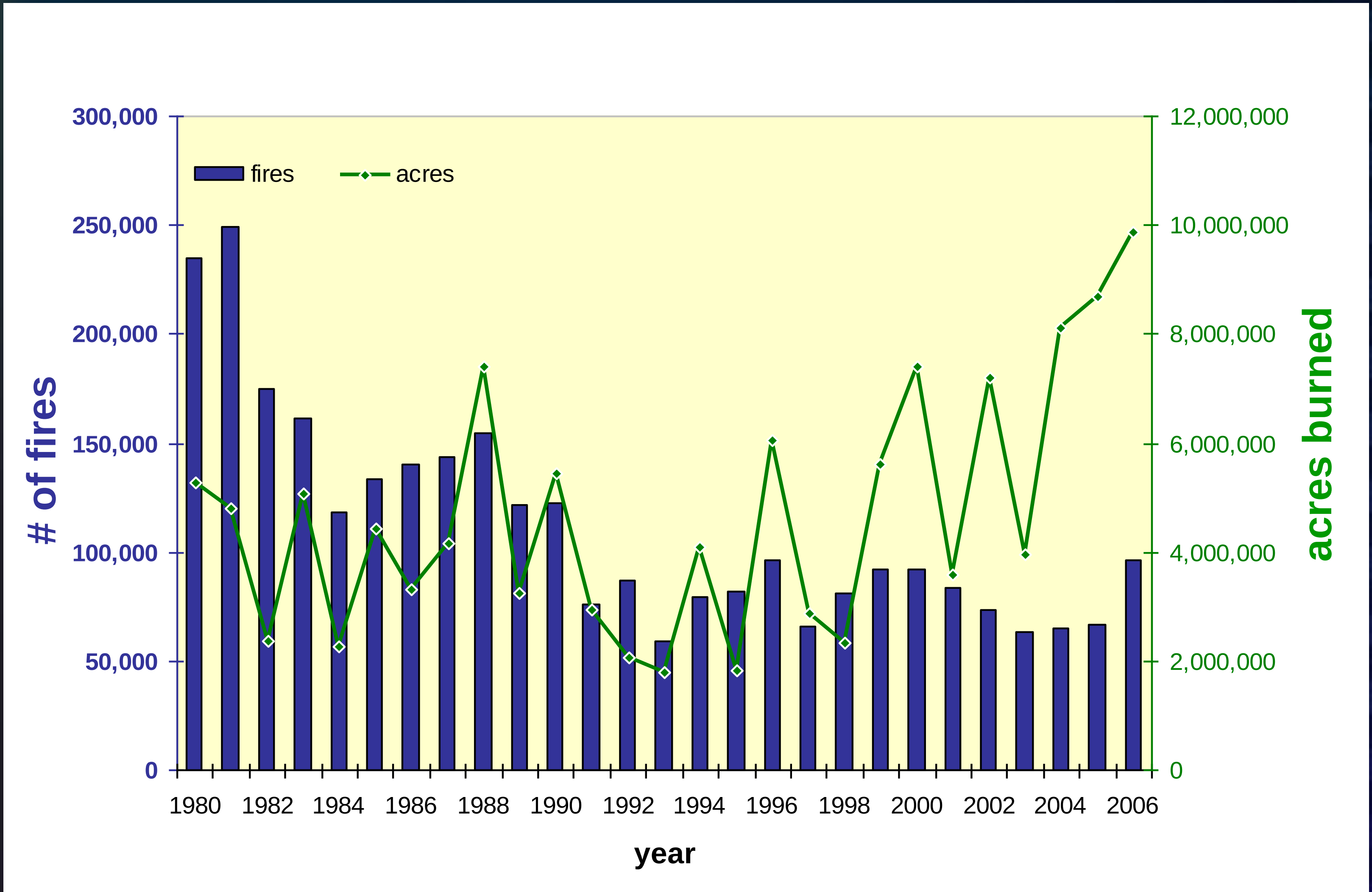
Total Wildland Fires, 1980-2006



National Interagency Fire Center data

Nevada Wildfires

- 3.9 million acres from 1999 to 2005
- Total harvested acres in Oregon for 2005 (grains, forages, seeds, field crops, fruits and nuts, specialty crops) = 3.0 million acres

Why the Fire Numbers?

- Basically one explanation is the “CO2 fertilization effect”
- Annuals tend to be well positioned to take advantage of increasing CO2
- Increasing atmospheric CO2 has the same impact as increasing soil moisture

Knapp, Soule and Grissino-Mayer, 2001. Detecting potential regional effects of increased atmospheric CO_2 on growth rates of western juniper. Global Change Biology 7: 903-917.

Compared climate/growth relationships (using tree-ring chronologies during 1896-1949 (low CO_2) and 1950-1998 (higher CO_2).

	early 20th century	later 20th century
overall growth		23% greater
matched drought years		63% greater
matched wet years		30% greater

Measurements taken at 7 sites in central Oregon.

Bend, Midgley, and Woodward. 2003. The importance of low atmospheric CO_2 and fire in promoting the spread of grasslands and savannas. Global Change Biology 9: 973-982.

- At 180 ppm CO_2 (last glacial period)- they predicted trees would be absent from grassy ecosystems in South Africa. Slow sapling growth.
- At 270 ppm CO_2 (preindustrial)- some trees, but at low densities.
- Large increase in trees from preindustrial to current CO_2 levels. Growth rates of saplings allowed them to reach fire-proof size quickly.
- They feel this pattern matches the palaeo-records.

These are some of the responses we might attribute to increasing atmospheric CO_2

- Higher overall plant productivity
- Shifts in species composition (often not understood)
- More cheatgrass biomass → fires?
- Faster woody plant establishment (juniper)
- Other invasives also seem to do well

Conclusions Regarding Climate

- We are probably already experiencing changes in vegetation patterns.
- Productivity is likely to increase, but there may also be risks to some community types. What if cold winters kept cheatgrass in check in some areas?

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The Great Habitat Squeeze

- Juniper has been expanding at the mid elevation range
- Cheatgrass and medusahead have been expanding at the lower elevations
- Various other weeds have been displacing native habitats in other settings (eg. leafy spurge in WY, ND, SD)

Implications for Conservation

- More attention to plant competition and fire resistance may be needed at lower elevations
- Maintaining habitat at the upper elevations should be a priority (we need to keep the quality habitats that we have)

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The Toolbox is Pretty Limited for Annual-Dominated Systems

- We really don’t have good solutions for restoring annual grass-dominated systems
- There are situations where cheatgrass is responding to a short-term increase in soil nitrogen
- Distinguish between a transient response and longer-term threat

Weeds and Sage-Grouse

- Annual grasses will create a loss of lower-elevation habitats. Increasing CO_2 levels may increase the productivity of cheatgrass and the risk of fires (at increasingly higher elevations)

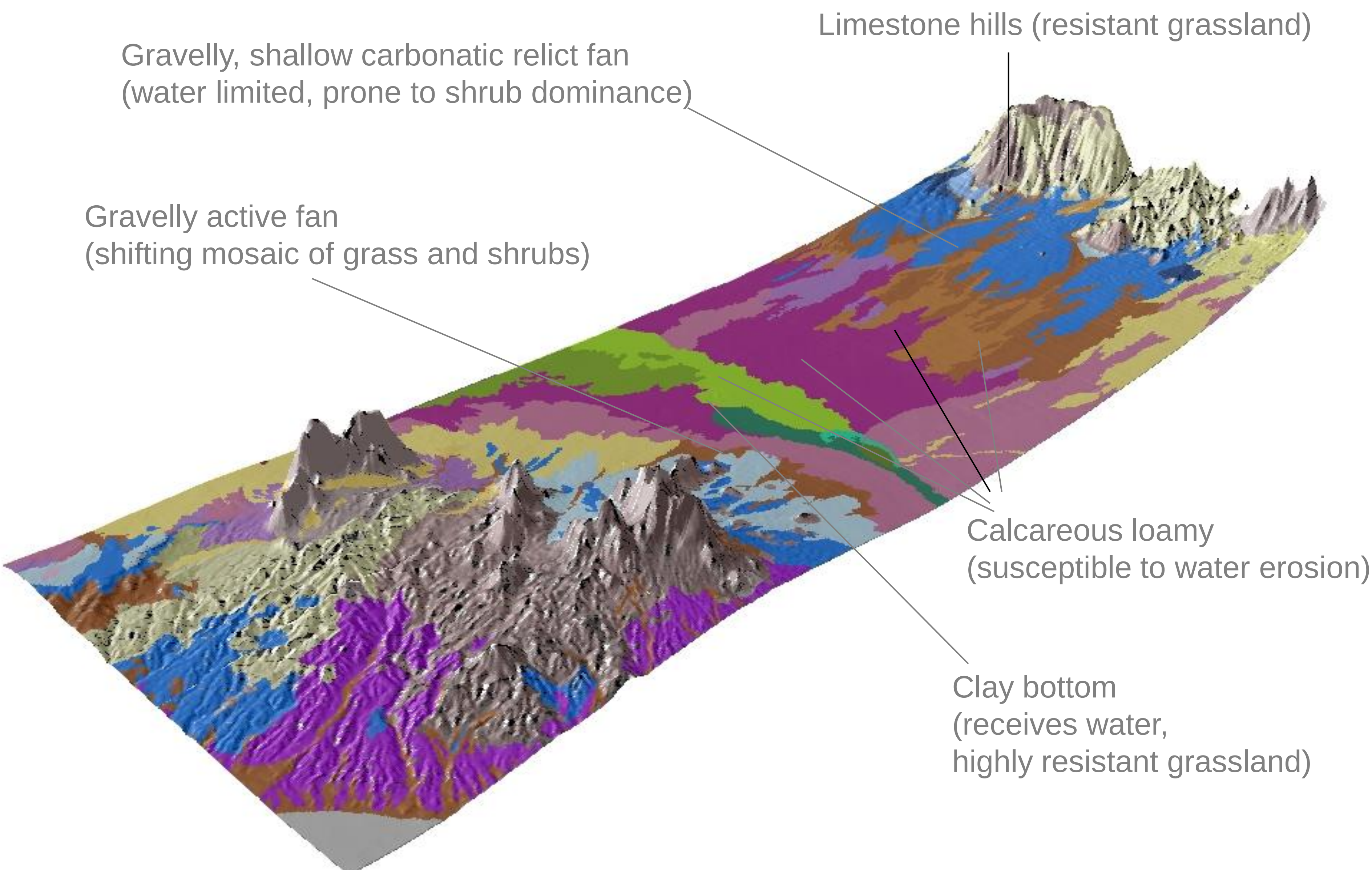
- Solutions will likely involve multiple steps and treatments, rather than anything simple (sorry, no Calvary on the horizon)

State and Transition Models

Really a way to organize knowledge about vegetation change on specific sites.

The concept is not that complicated, but going through the process of developing a STM often makes us very aware of our knowledge limitations.

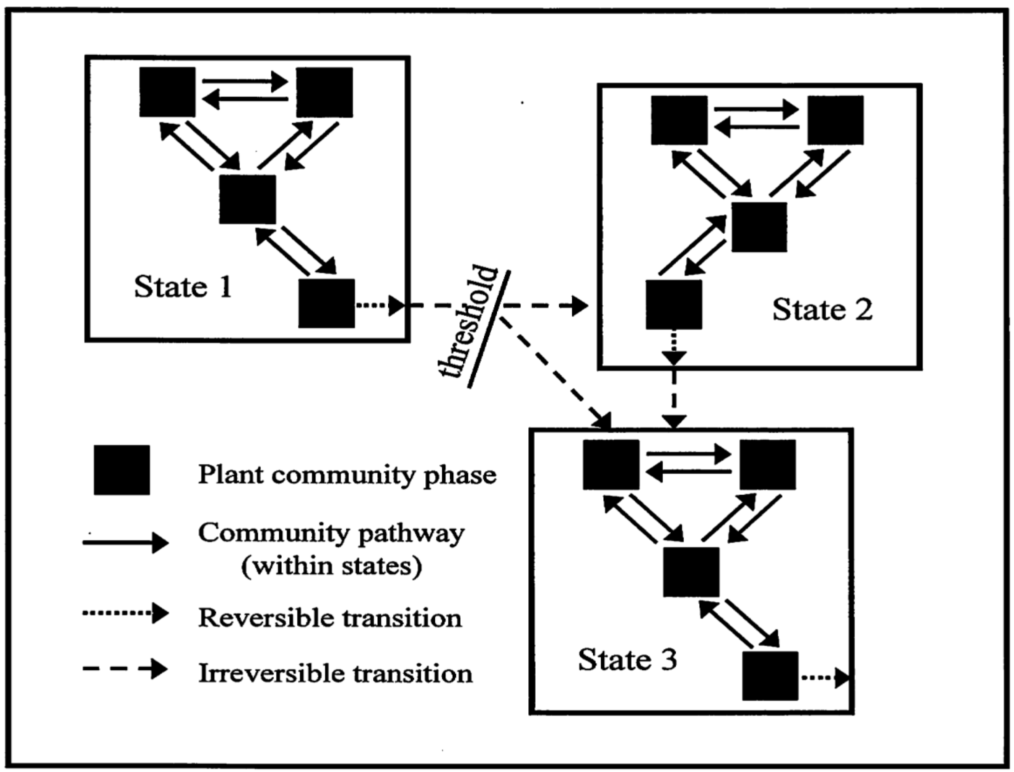
Ecological sites comprise a functional landscape mosaic



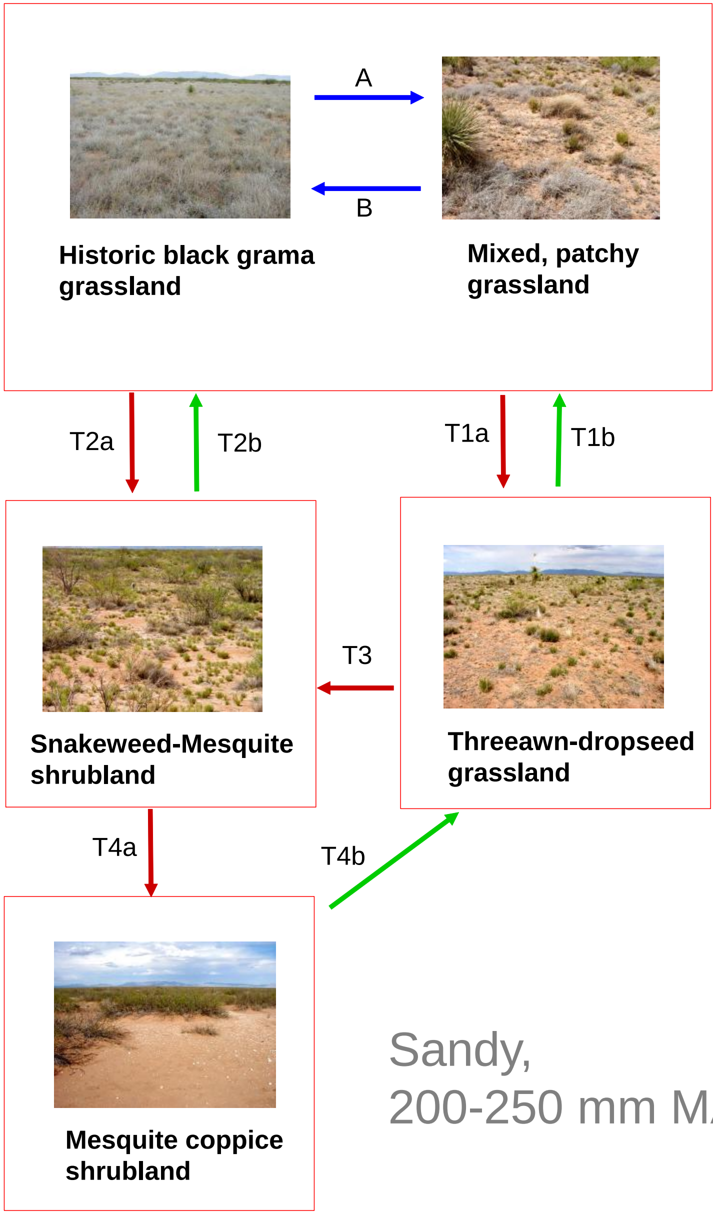
Mosaic organization repeats across physiographic regions

General STM Format

- ***At-risk community phase is the plant community most vulnerable to exceeding the resilience limits of the state.***



Synthesize and communicate mechanisms in state-and-transition models



Succession/disturbance

Threshold/transition

Restoration/remediation

Sandy,
200-250 mm MAP

Key to arrows

A. Continuous grazing or drought, recovery with prescribed grazing (**B**).

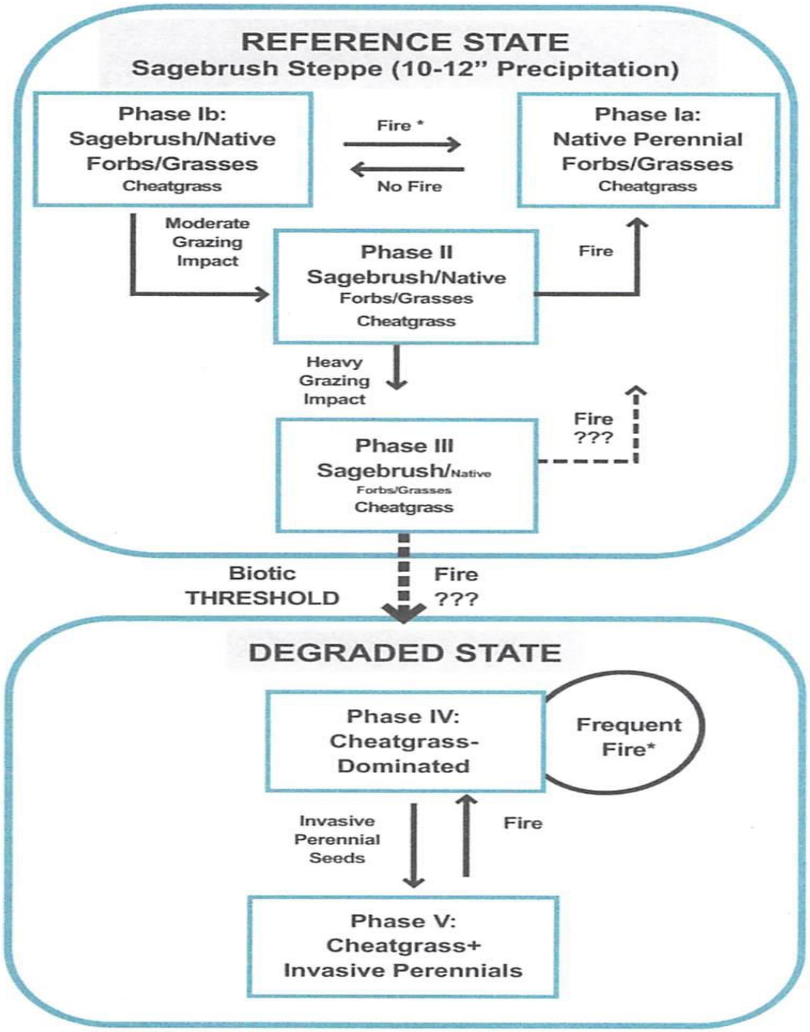
T1a. Continued grazing causes black grama loss. Restoration with plantings and 2 consecutive summers of above-average rainfall (**T1b**).

T2a. Continuous grazing, winter rain, plus lack of fire leads to mesquite proliferation and black grama extinction. Restoration with shrub control, plantings, summer rain, and fire management (**T2b**).

T3. Mesquite spread with high winter rain

T4a. Inappropriate stocking during drought with soil disturbance leads to high soil erosion rates in shrub interspaces. Restoration of some grass cover with bulldozing, seeding and summer rain (**T4b**.)

SAGE/CHEAT
Sagebrush Steppe
State-and-Transition Model



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