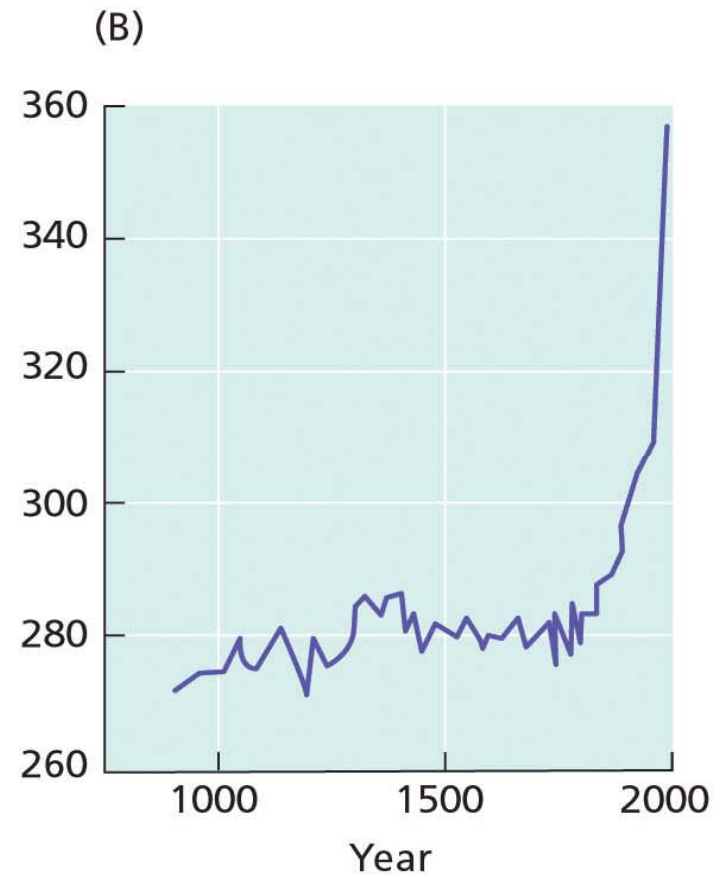
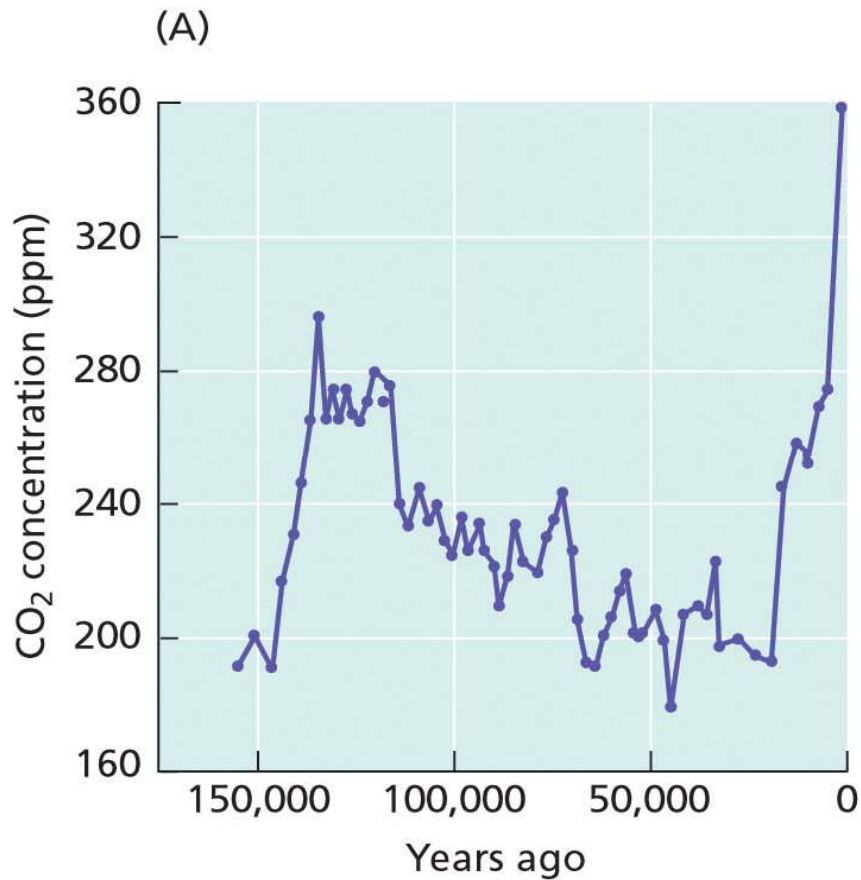


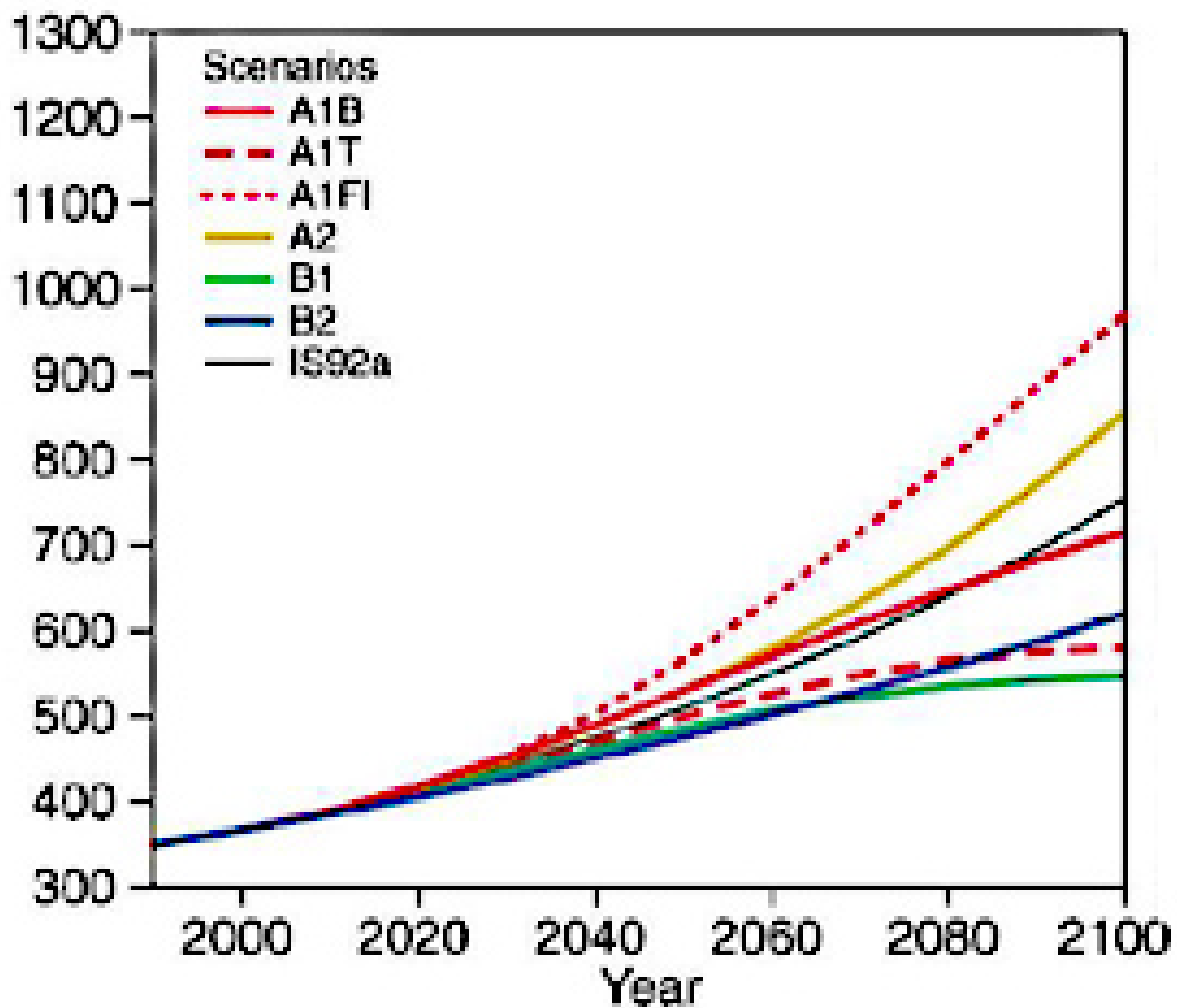
Arizona rangelands and rising atmospheric CO₂.

- Climate and Rangeland Workshop
- January 26, 2006
- San Carlos, Arizona
- George Koch
- Northern Arizona University

Atmospheric CO_2 is higher than in the past 400,000 years and is rising rapidly.



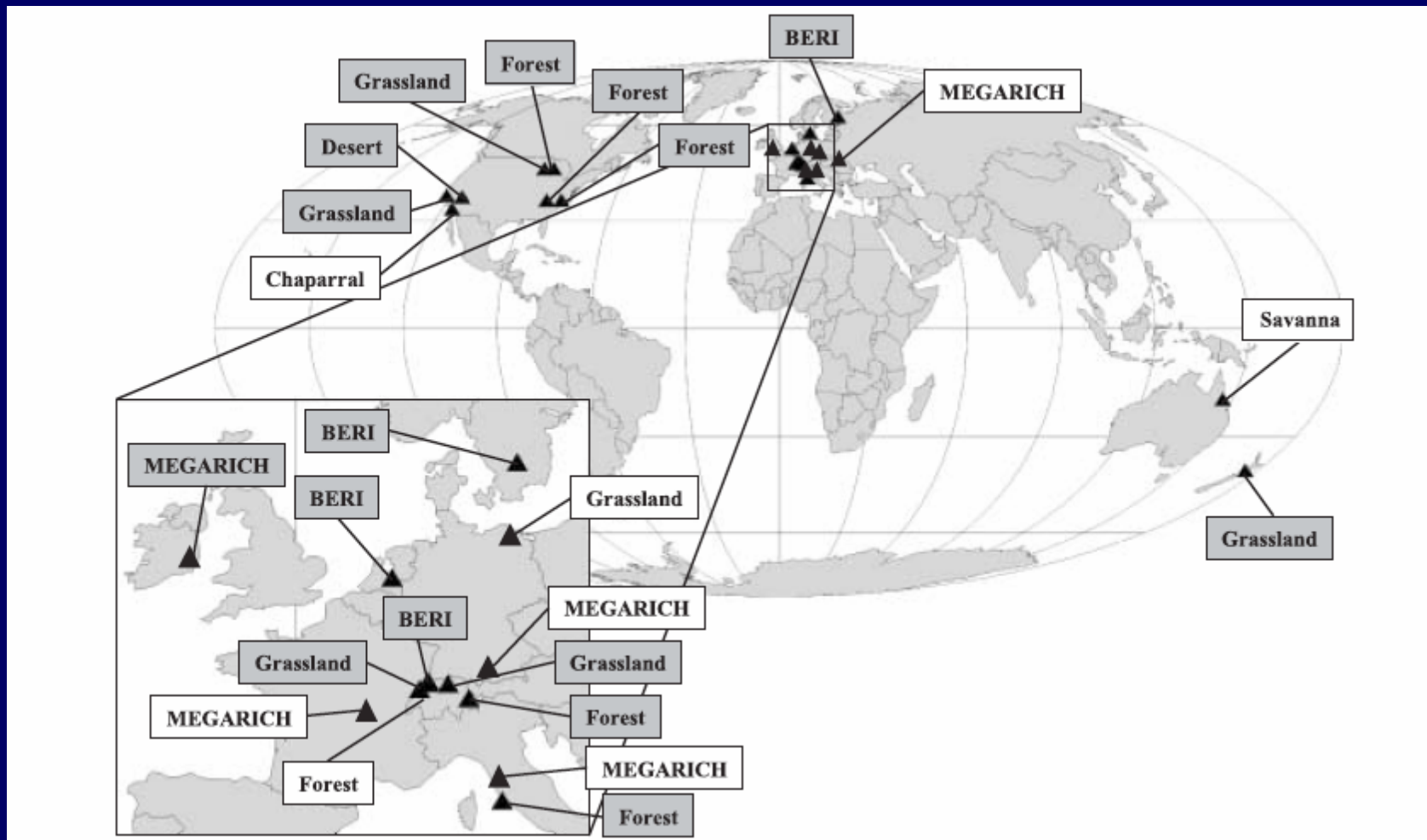
Trajectories of future CO₂ concentration, ppm



Arizona rangelands and rising atmospheric CO₂.
George Koch
Northern Arizona University

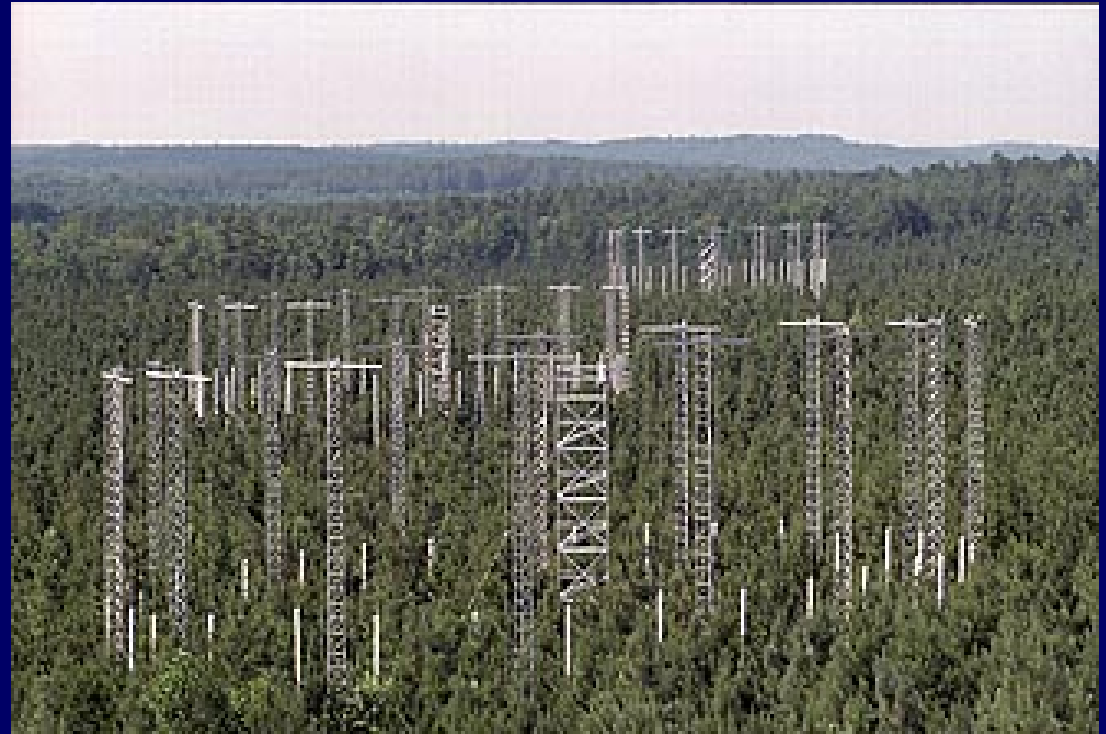
1. Basics on elevated CO₂ and plants
2. Productivity responses to elevated CO₂
3. Arizona rangelands in a high-CO₂ world
 - Productivity
 - Forage nutritional quality
 - Species composition
 - The shrub-herbaceous balance
 - Water balance

Major elevated CO₂ experiments (Some include water and fertilizer treatments)



Nowak et al., 2004

Field studies compare communities of plants exposed to ambient and experimentally increased CO_2 .



1. Basics on elevated CO_2 and plants

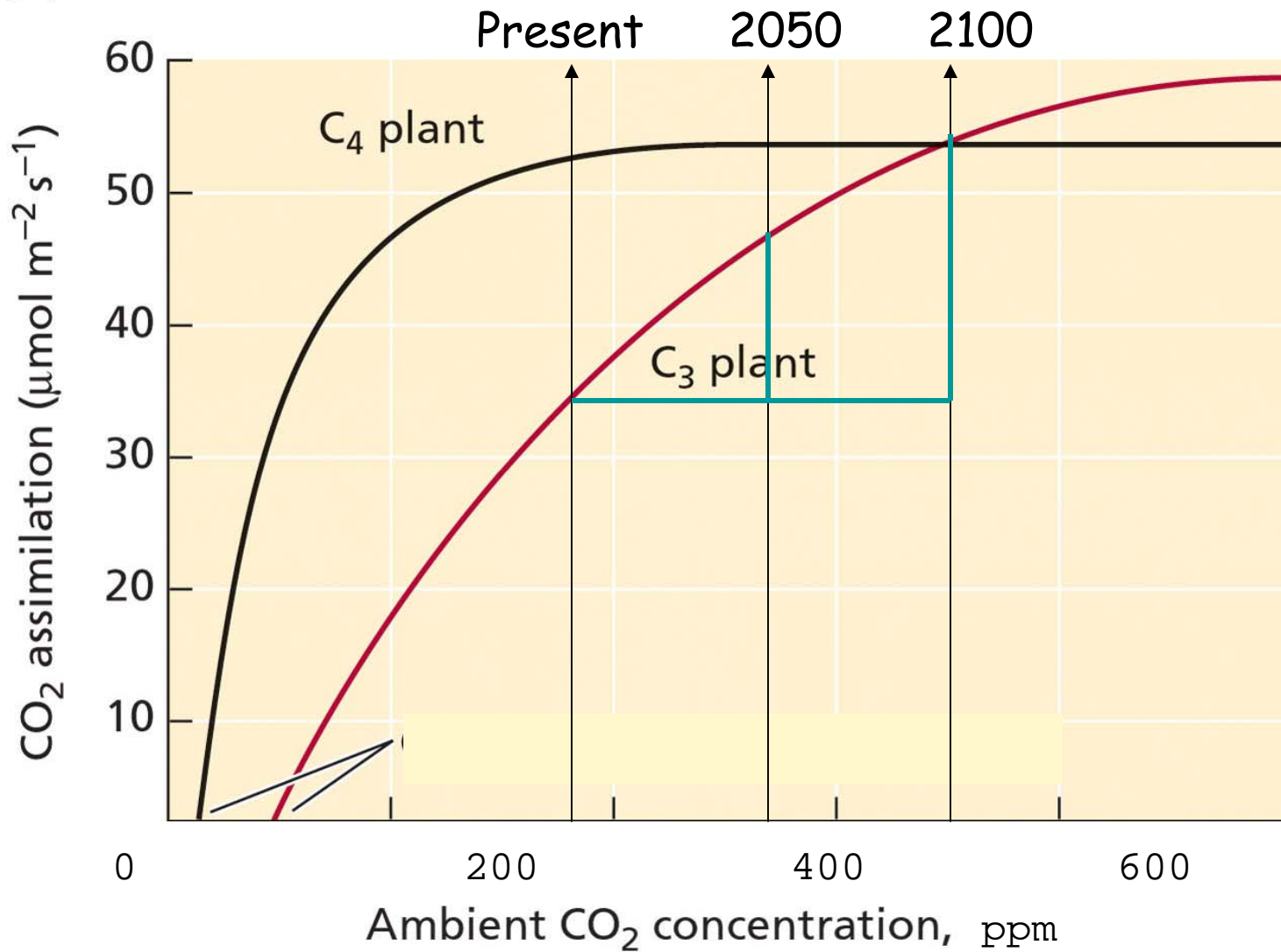
2. Productivity responses to elevated CO_2

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Elevated CO_2 stimulates photosynthesis of C_3 plants. C_4 plants show little increase.

(A)



"C4" plants show little photosynthetic stimulation by increased CO₂.

Some representative C4 plants

Black grama, *Bouteloua eriopoda*

Blue grama, *Bouteloua gracilis*

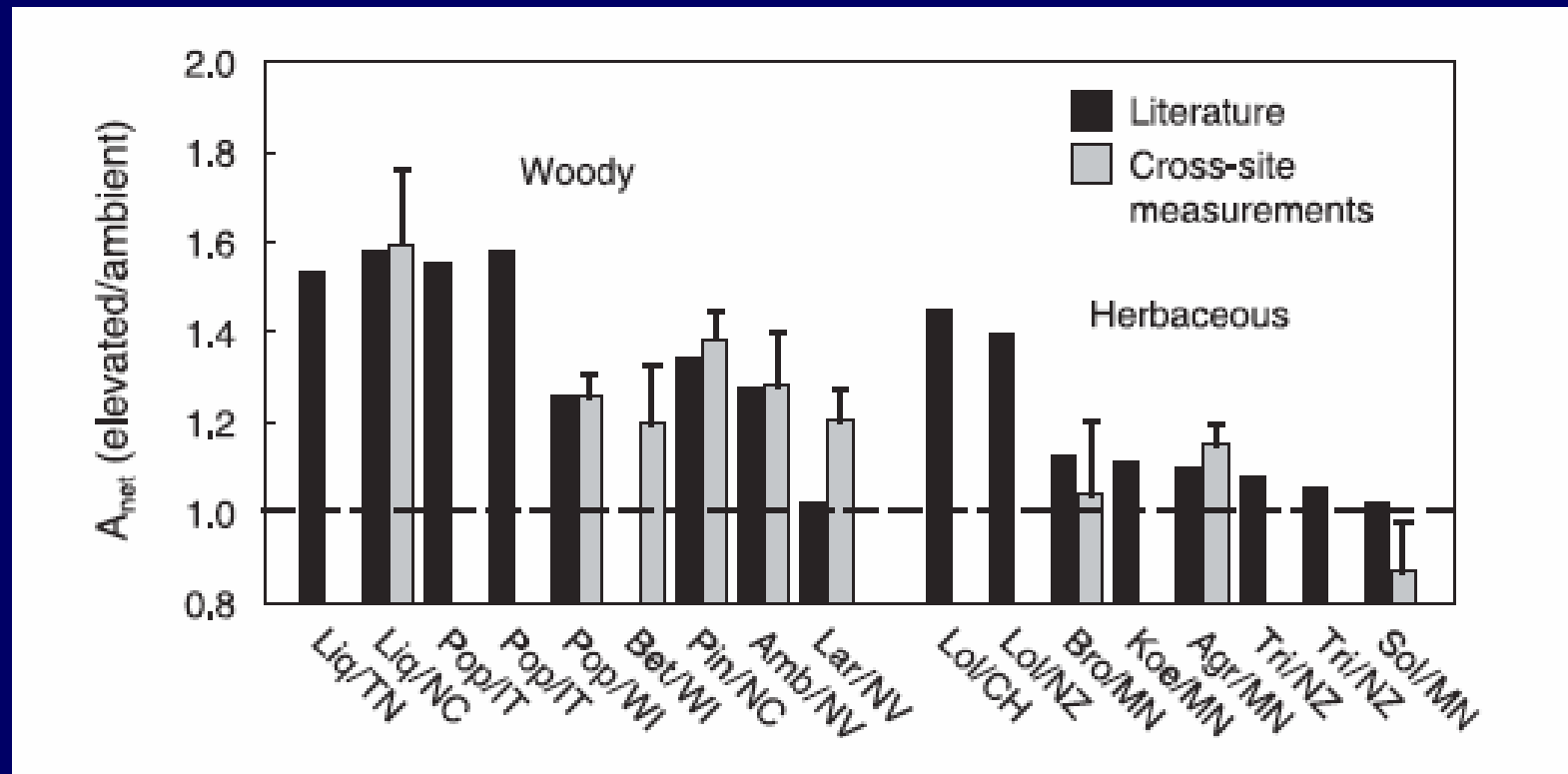
Hairy grama, *Bouteloua hirsuta*

Curly mesquite, *Hilaria belangeri*

Three-awn, *Aristida hamulosa*

Our shrubs and forbs are all C3 plants

- In field studies, photosynthesis is increased by 10% to 60% in elevated CO_2 compared to ambient CO_2 .



Nowak et al., 2004

- Elevated CO_2 increases water use efficiency of most plants; there is more photosynthesis and growth per unit of water used.

- Elevated CO_2 reduces plant tissue nitrogen concentration, particularly in herbaceous plants (average 14% decrease).

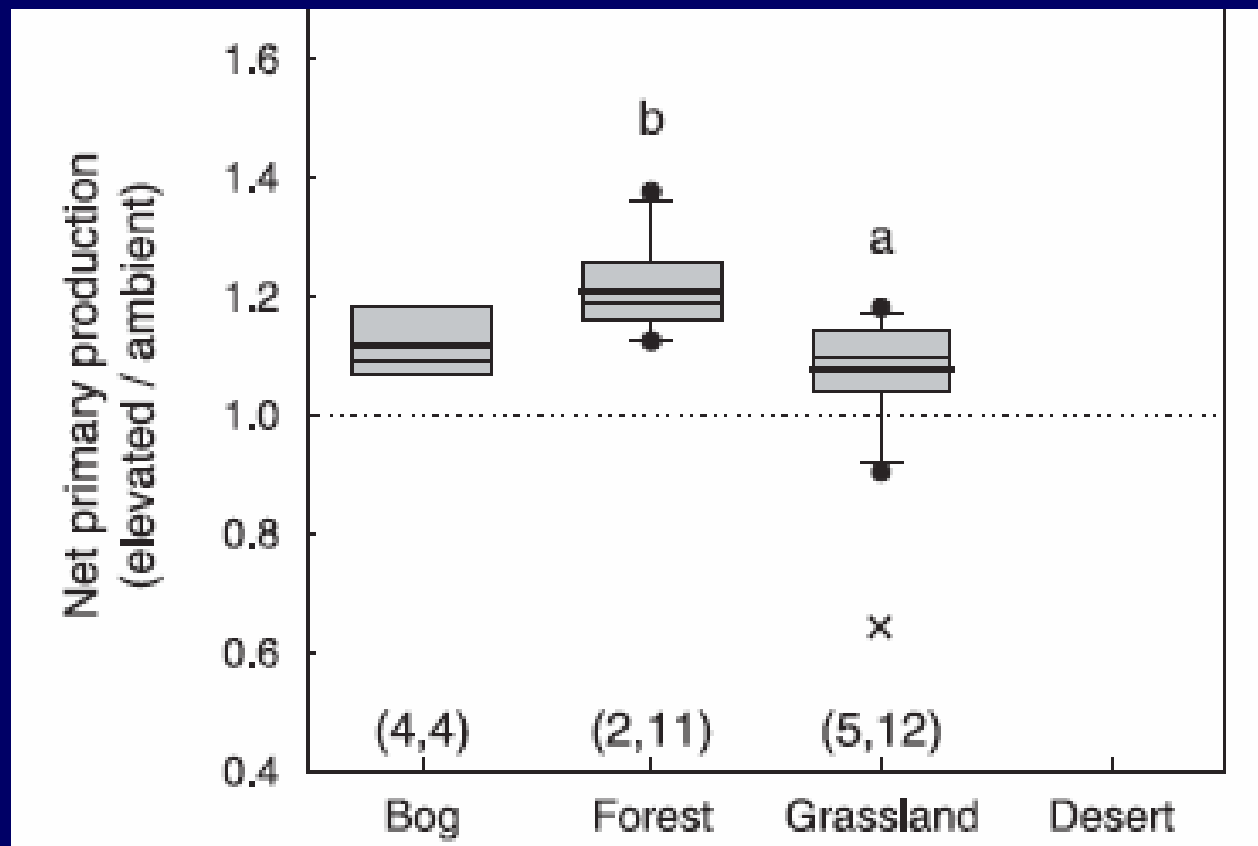
1. Basics on elevated CO_2 and plants

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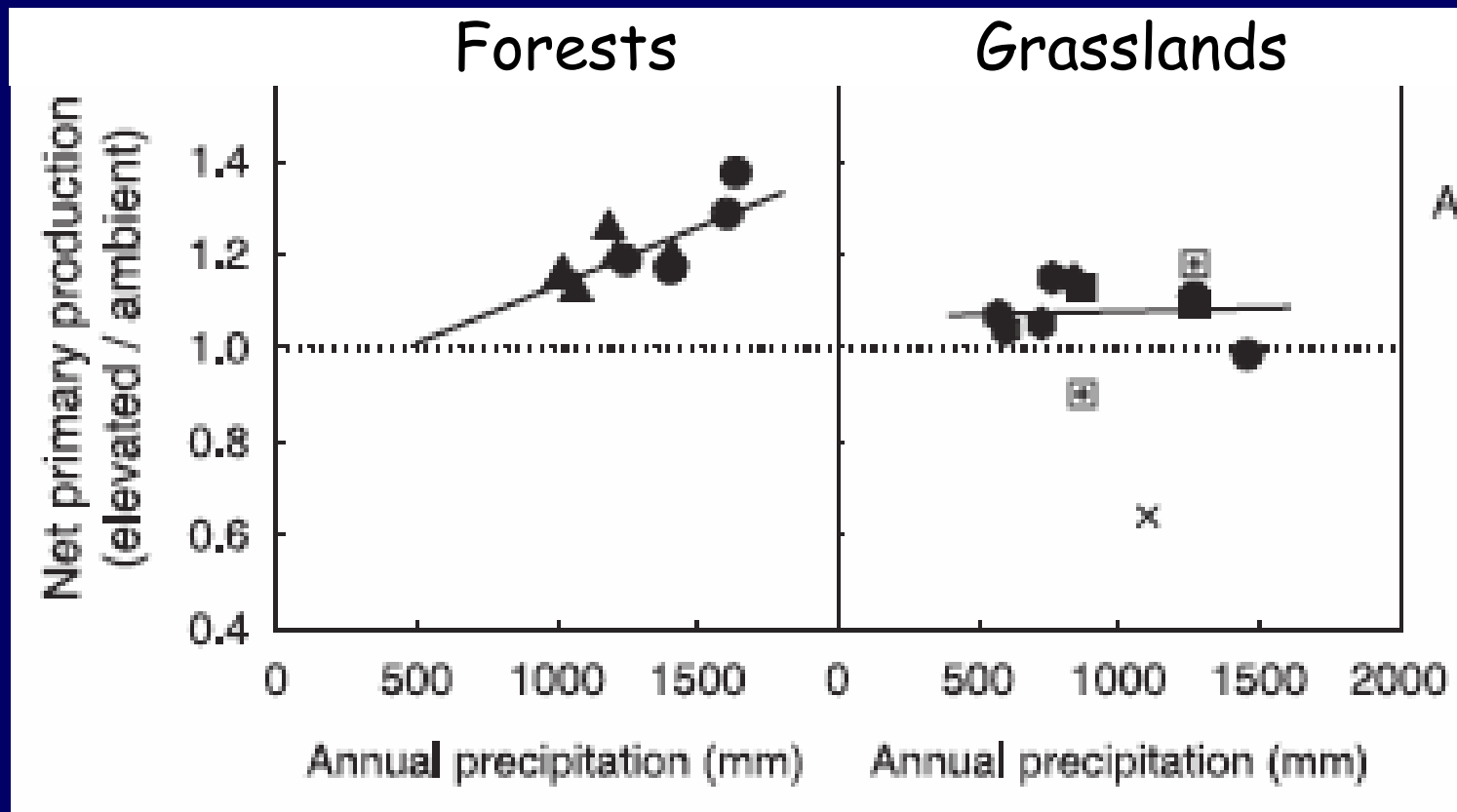
- Productivity
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- Productivity increases by an average of 12% in elevated CO_2



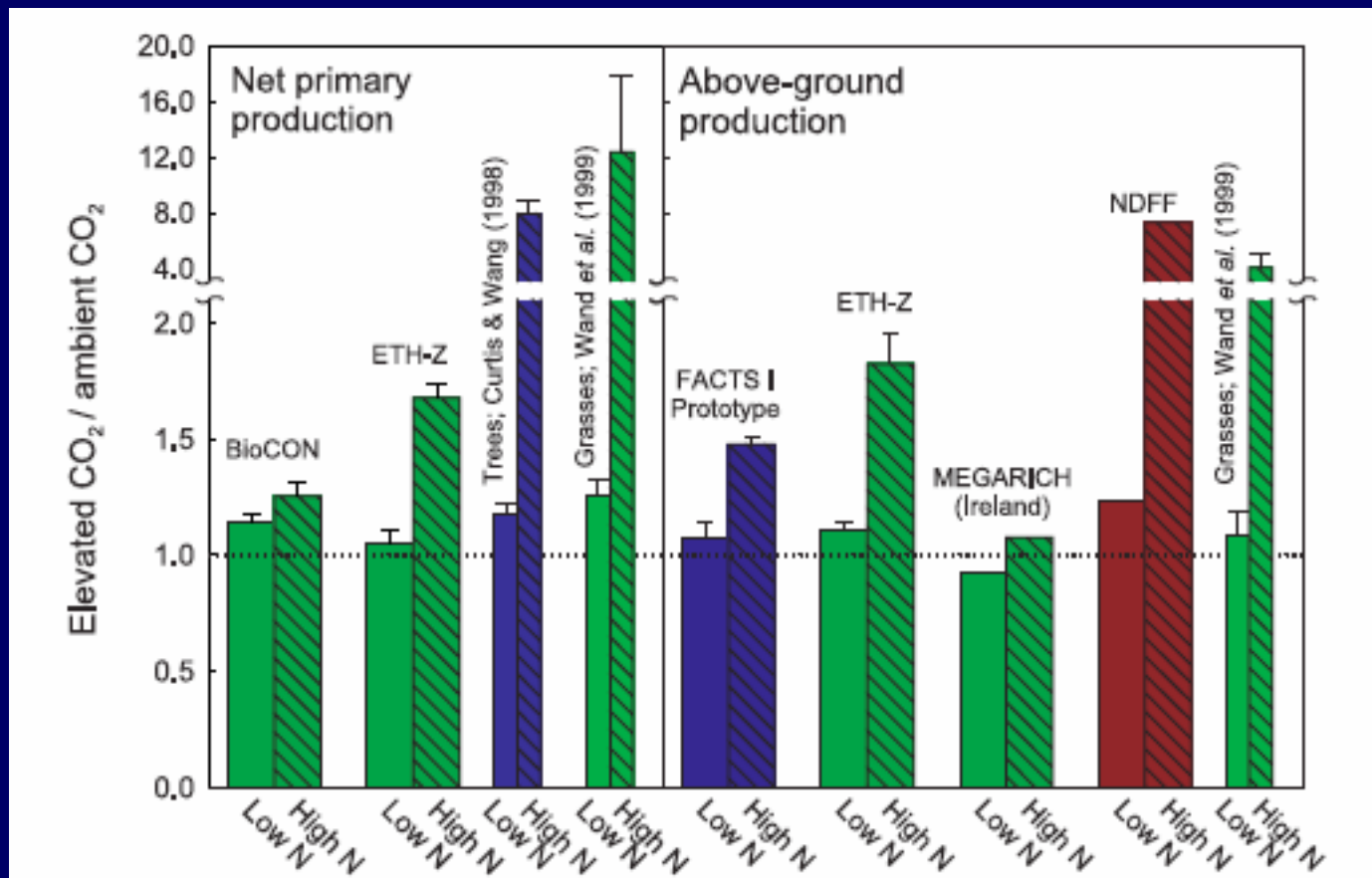
Nowak et al., 2004

- Stimulation of production by elevated CO_2 increases with more precipitation for forests but not grasslands.



Nowak et al., 2004

- The stimulation of production by elevated CO_2 is much greater when nitrogen is added to soil.
- Nitrogen availability strongly constrains the production response to elevated CO_2 .



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Predicted change due to elevated CO₂ (550 ppm)

- | | |
|------------------------------|--|
| • Plant productivity | 0% to 20% increase |
| • Forage nutritional quality | 0% to 30% reduction in tissue nitrogen conc. |
| • Species composition | C3 shrubs and forbs will increase relative to C4 grasses |
-
- | | |
|------------------------------------|--|
| • Woody encroachment of grasslands | Will be stimulated by elevated CO ₂ |
| • Water balance | Strongly dependent on accompanying climatic change |

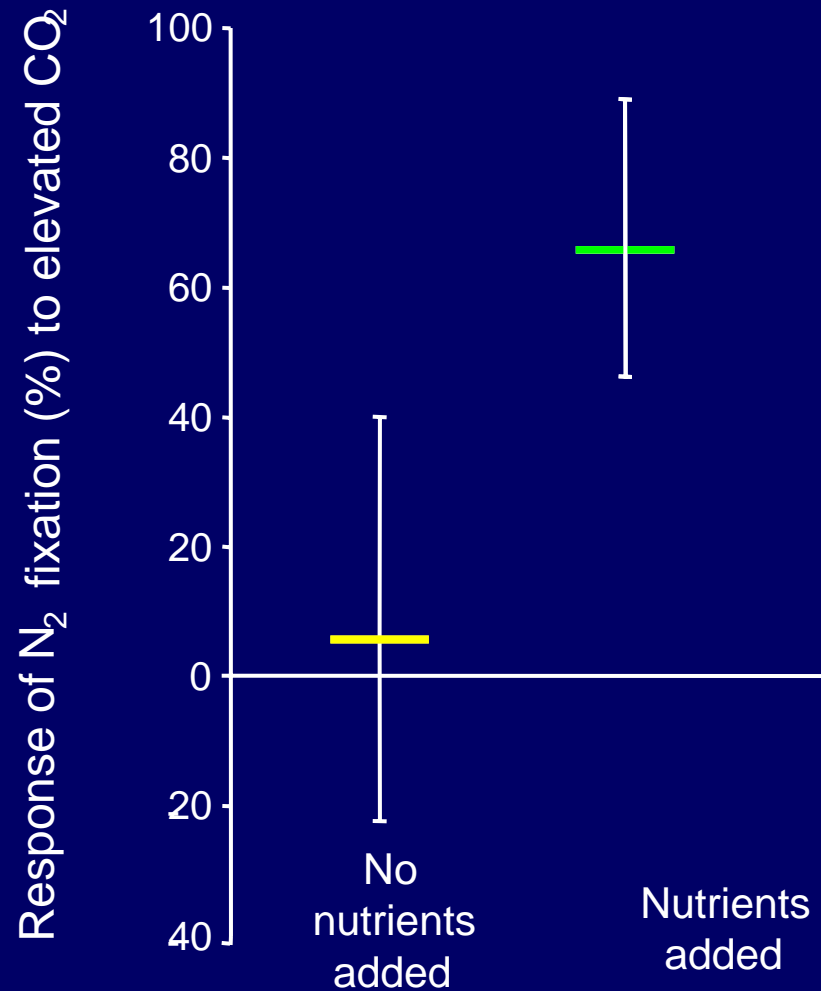
Does global change increase the success of biological invaders? JS Dukes and HA Mooney, 1999

"The most responsive species to elevated CO₂ in the desert was an invasive C₃ annual grass (Smith et al., 2000), while production of another invasive species, a C₃ woody vine, increased threefold in a forested ecosystem (Belote et al., 2003)."

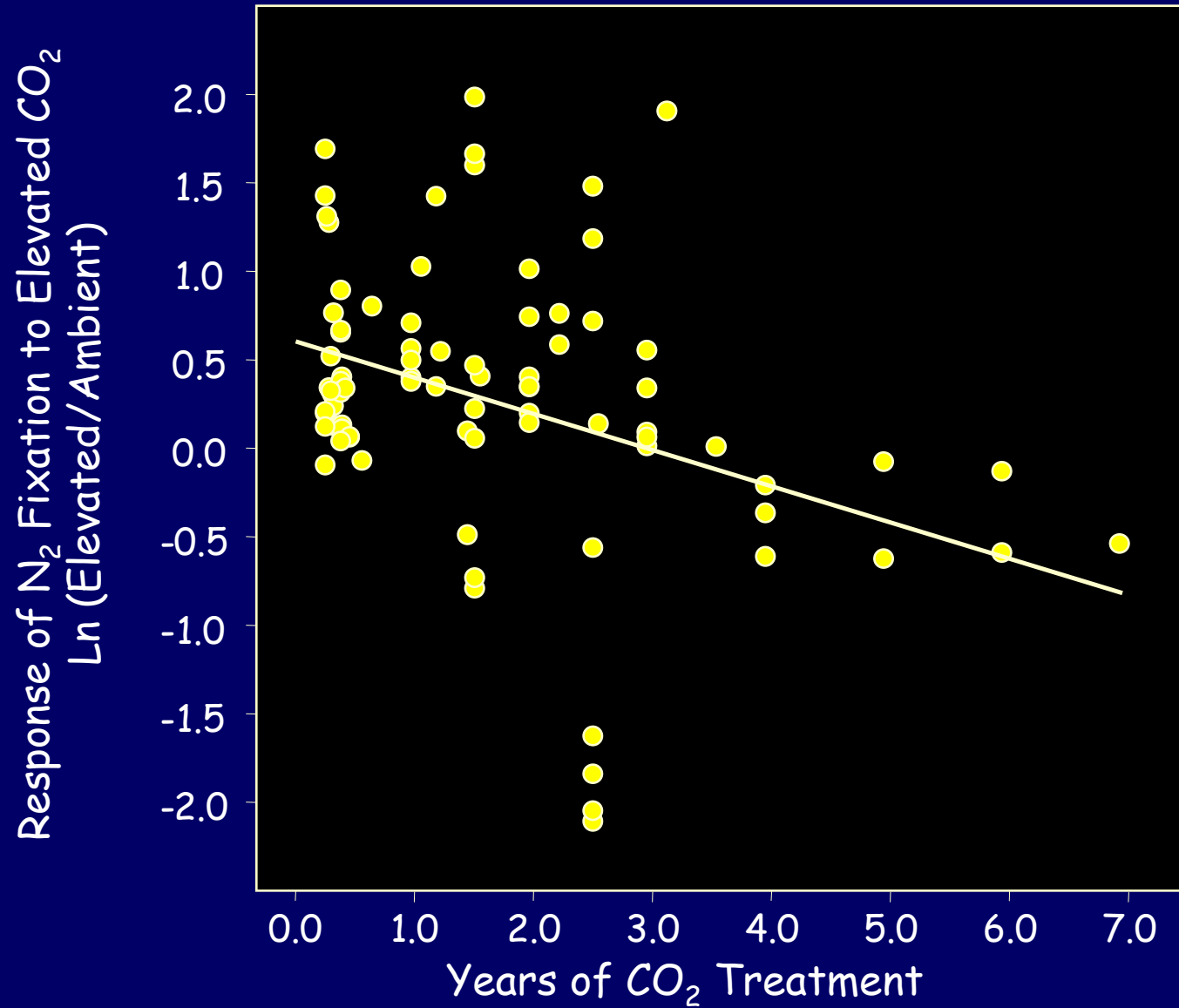
Nowak et al. 2004



Meta-analysis: Responses are larger when other (non-N) nutrients are added (n=83 observations)

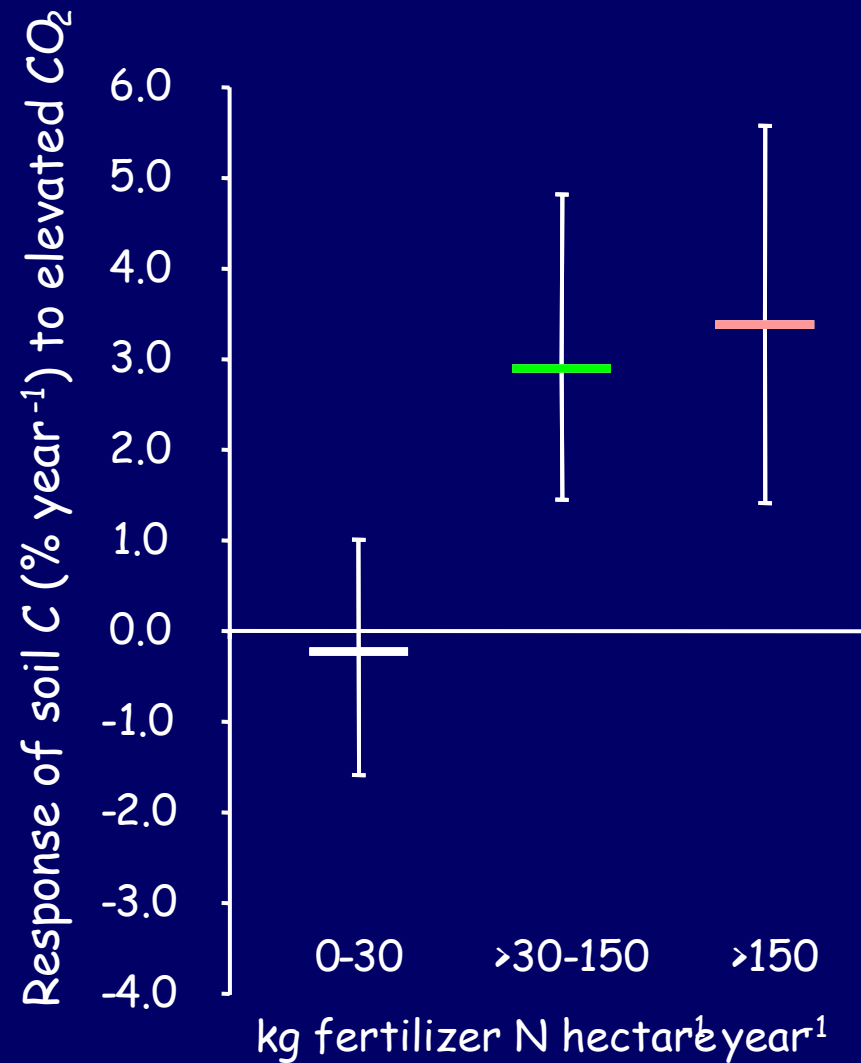


Responses decline through time



Van Groenigen, Six, Hungate, et al., in review

CO₂ increases soil C only when N is also added (meta-analysis: n=69 observations)



Van Groenigen, Six, Hungate, et al., in review

Issues

- Productivity
- The shrub-herbaceous balance
- Herbaceous species composition
 - black grama
 - blue grama
 - AZ fescue
 - squirreltail
- Water balance
- Invasive plants