Grass and Juniper Response to Modified Precipitation Seasonality and Warming

David D. Briske
Mark G. Tjoelker
Department of Ecosystem Science & Management
Astrid Volder
Department of Horticultural Sciences
Texas A&M University
College Station, Texas

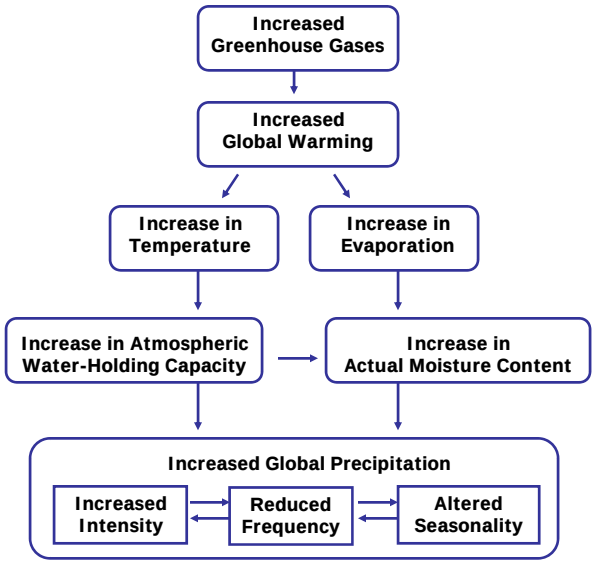
Texas Warming and Rainfall Manipulation Experiment (WaRM)

Woody Plant Invasion

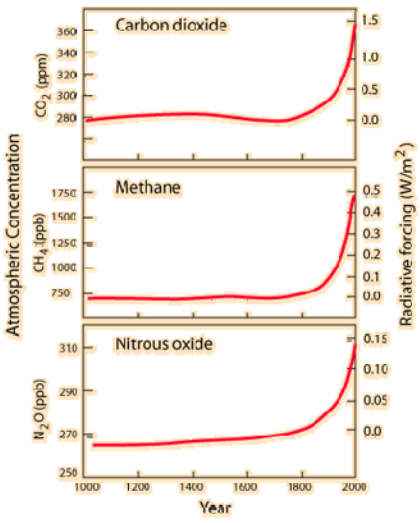
Proposed Mechanisms

- $C0_2$ enrichment
- Fire suppression
- Intensive grazing
- Seed distribution
- Climatic shifts
- Interactive effects

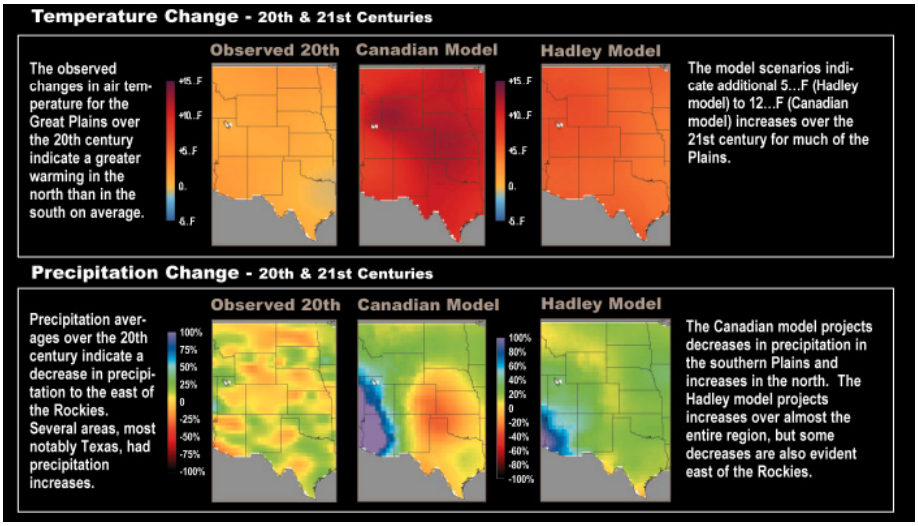
Climate Change Summary



Climate Change Controversy



Regional GCM Projections



Documented Climate Change Patterns

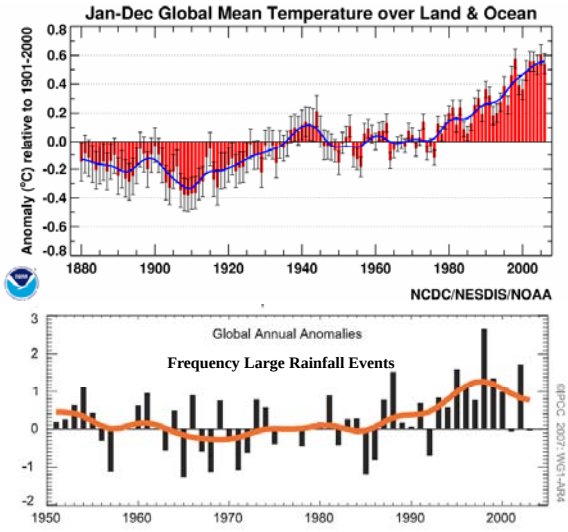


Figure TS.10. *(Top) Observed trends (% per decade) over the period 1951 to 2003 in the contribution to total annual precipitation from very wet days (i.e., corresponding to the 95th percentile and above). White land areas have insufficient data for trend determination. (Bottom) Anomalies (%) of the global (regions with data shown in top panel) annual time series of very wet days (with respect to 1961–1990) defined as the percentage change from the base period average (22.5%). The smooth orange curve shows decadal variations (see Appendix 3.A). {Figure 3.39}*

Primary Research Questions

How will the following climate change scenario affect a C4 grass and juniper growth, photosynthesis and competition?

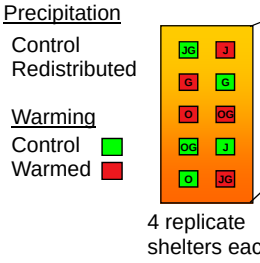
•Larger, but less frequent rainfall events
•Shift from summer to spring and autumn precipitation
•Constant warming

What are the implications for climate change on C4 grasses and juniper in the Great Plains?

Factorial Experimental Design

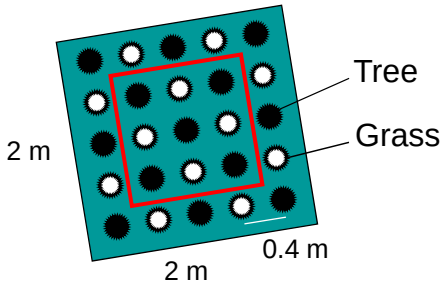
- Five species mixtures (three monocultures and two tree-grass combinations)
- Two precipitation patterns (redistributed and control)
- Two warming treatments (+1.5 °C warmed and control)

Eight rainfall exclusion shelters (9 x 18 m) and two "open" controls



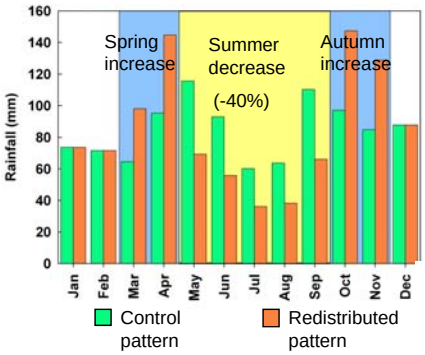
4 replicate shelters each

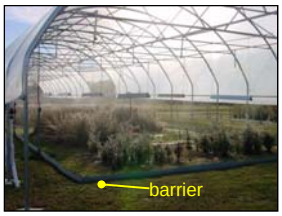
Tree-grass Species Combinations



Competitive matrix

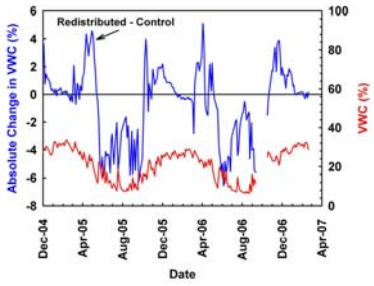
Precipitation Redistribution Intensifies Summer Drought





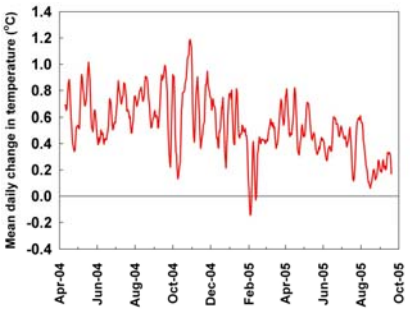
Rainfall exclusion shelter with overhead irrigation

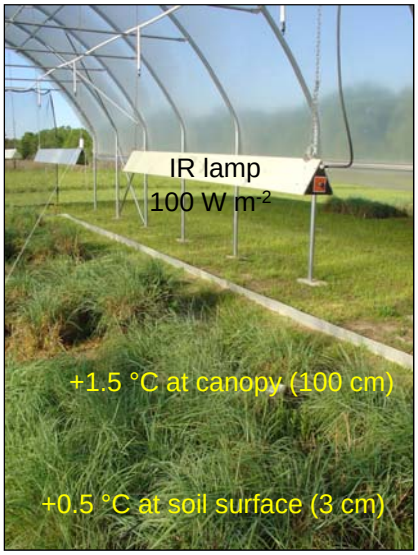
Total annual precipitation (1018 mm) and the **number** and **frequency** of events are identical between the two rainfall regimes.



Warming Increases Canopy and Soil Temperature

Soil surface temperature increase (3 cm depth)





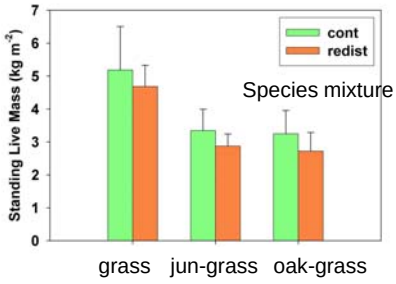
Warmed plots are heated 24 hrs per day.

Tiller Growth Reduced in Juniper-grass

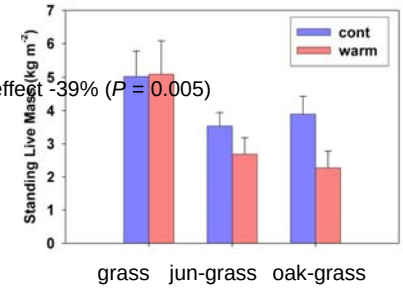
ots

Tiller mass density (+SE), May 2006
Plant basis (kg m^{-2}) = tiller mass x tiller density

Precipitation effect -12% (*ns*)



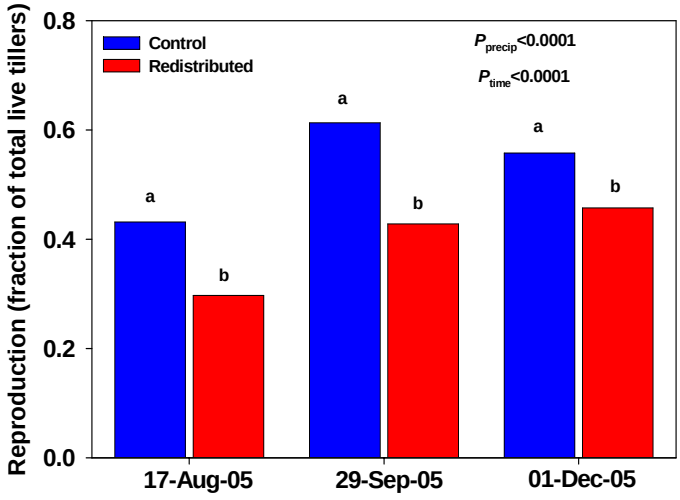
Warming effect -19% (*ns*)



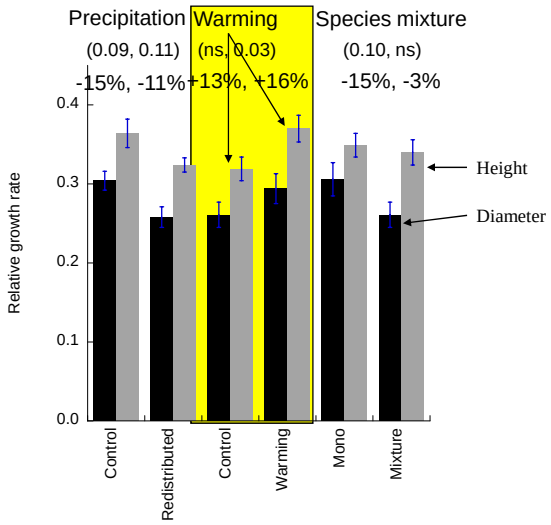
Species mixture effect -39% ($P = 0.005$)

Mean tiller mass (g) did not differ among treatment combinations

Proportion Reproductive Tillers



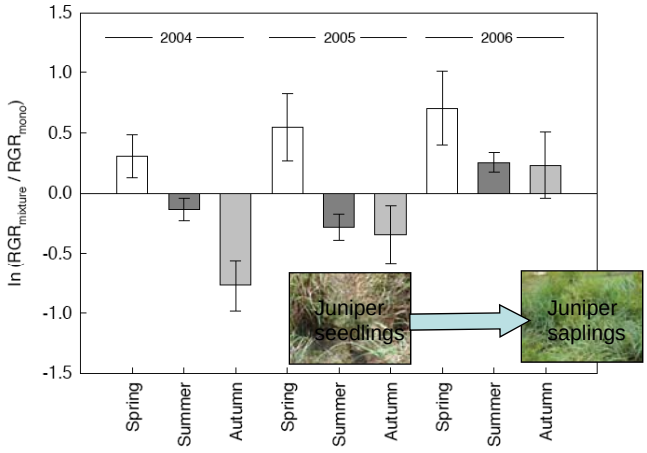
Juniper Growth Response to Warming



Mean relative growth rate (±SE), 3-year study period

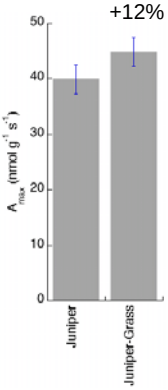
Competition - facilitation Shift in Juniper-Grass

Mean ratio of height relative growth rate (±SE)



Spring photosynthesis

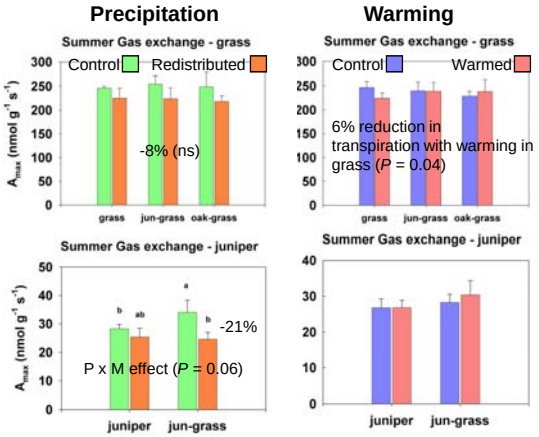
+12%



Photosynthetic Response to Rainfall and Warming

Little bluestem showed little response to either treatments

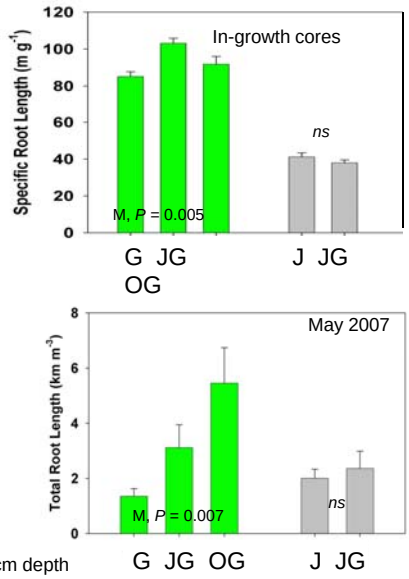
Juniper showed reduced rates with summer drought when grown with grass



Fine Root Length in Grass Enhanced by Juniper

Specific root length (m g^{-1}) increases 10-25% in little bluestem when grown with trees

Root length production in spring in little bluestem increases when grown with trees



Means (+SE) of soil core collections to 20 cm depth

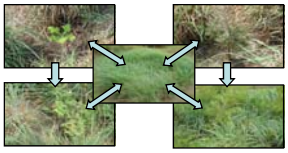
Summary: Precipitation Redistribution

- Juniper (-15%) growth was reduced more than little bluestem plant mass.
- Leaf-level photosynthesis in summer was reduced in juniper, especially when grown with little bluestem (-20%).
- Little bluestem showed a modest response with the exception of a 30% decrease in reproductive tillers.

Summary: Warming

- Juniper growth enhanced by warming (+13, +16) and little bluestem had reduced aboveground mass (-30%) when grown with juniper.
- Leaf net photosynthesis did not differ between warming treatments in either grass or juniper.
- Why did juniper growth increase even though photosynthesis did not?
- Why did the C4 grass not show a positive response to warming?

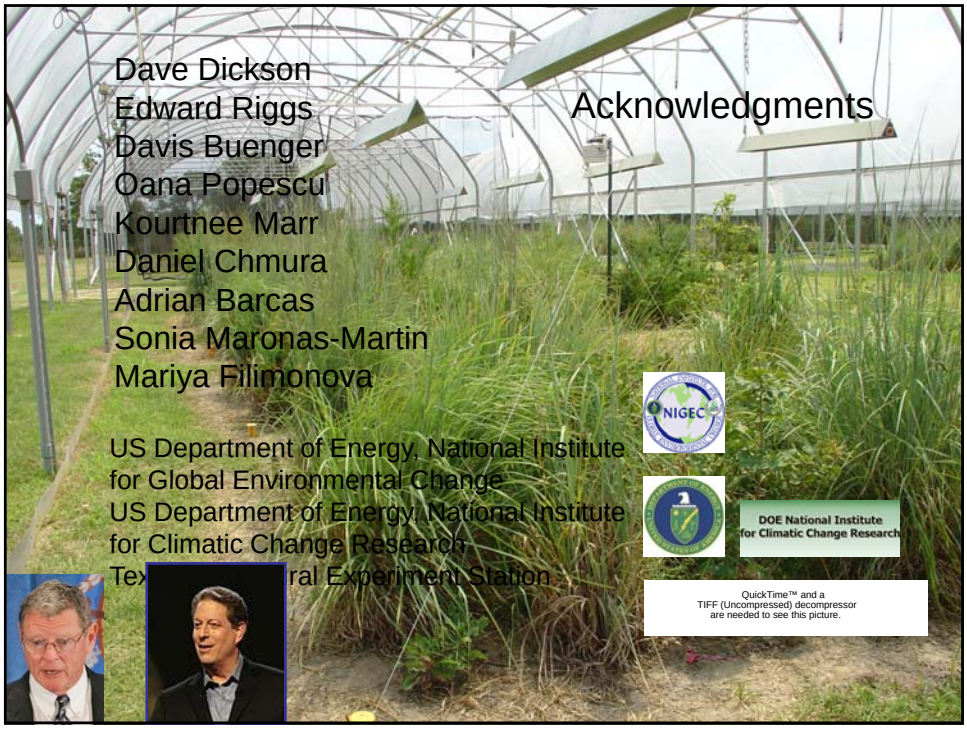
Summary: Competitive Interactions



- Competition effects alone were of equal or greater importance than either precipitation or warming effects.
- Grass-juniper interactions varied between competition during the summer and grass facilitation of juniper growth in the spring.
- Juniper growth negated the competitive effects of grass by third growing season.

Implications for Juniper Invasion

- Photosynthesis, growth and competitive ability of C4 grass may show modest declining in response to intensified drought, but will persist.
- Growth and competitive ability of juniper may increase because positive response to warming exceeds negative response to intensified drought.
- In the absence of fire and if regeneration can continue, juniper will likely increase in warmer, drier climates of the future.



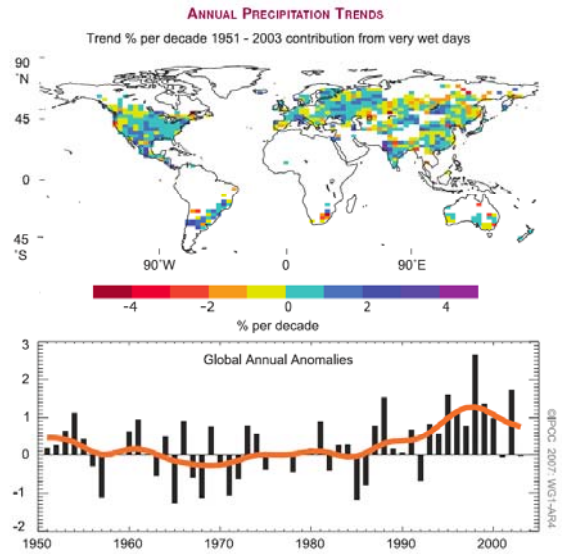


Figure TS.10. *(Top) Observed trends (% per decade) over the period 1951 to 2003 in the contribution to total annual precipitation from very wet days (i.e., corresponding to the 95th percentile and above). White land areas have insufficient data for trend determination. (Bottom) Anomalies (%) of the global (regions with data shown in top panel) annual time series of very wet days (with respect to 1961–1990) defined as the percentage change from the base period average (22.5%). The smooth orange curve shows decadal variations (see Appendix 3.A). (Figure 3.39)*