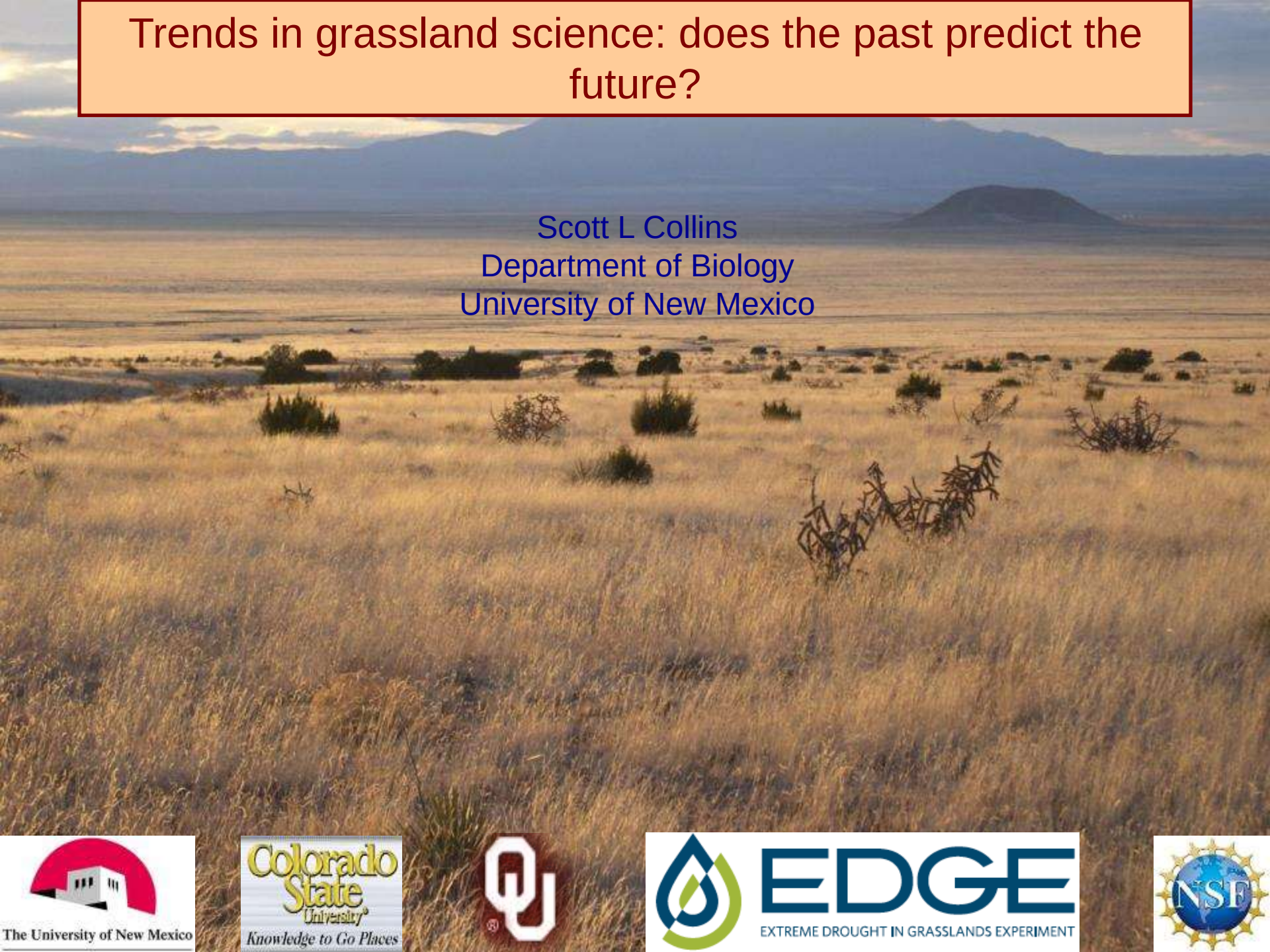
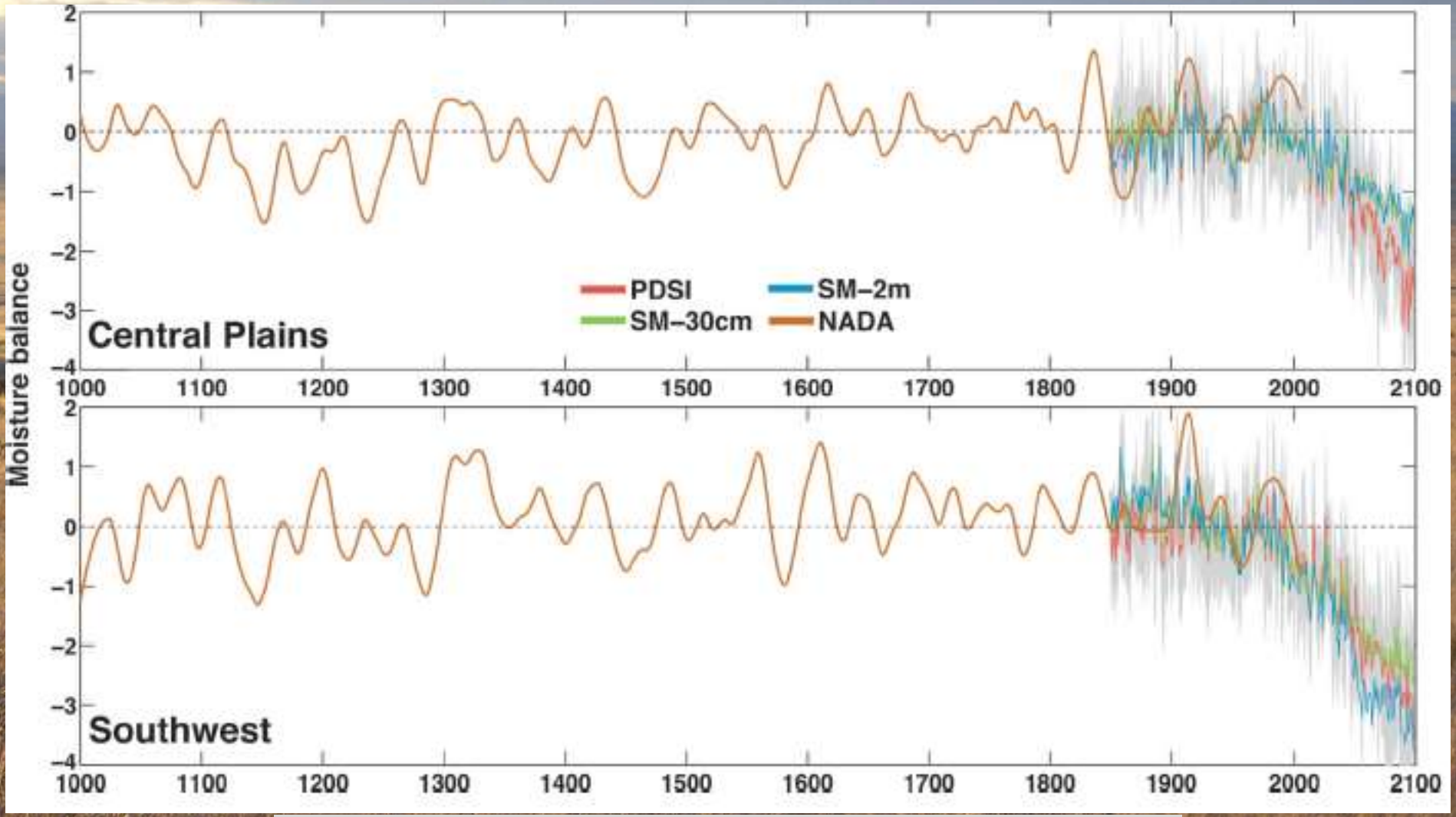
Trends in grassland science: does the past predict the future?

Scott L Collins
Department of Biology
University of New Mexico



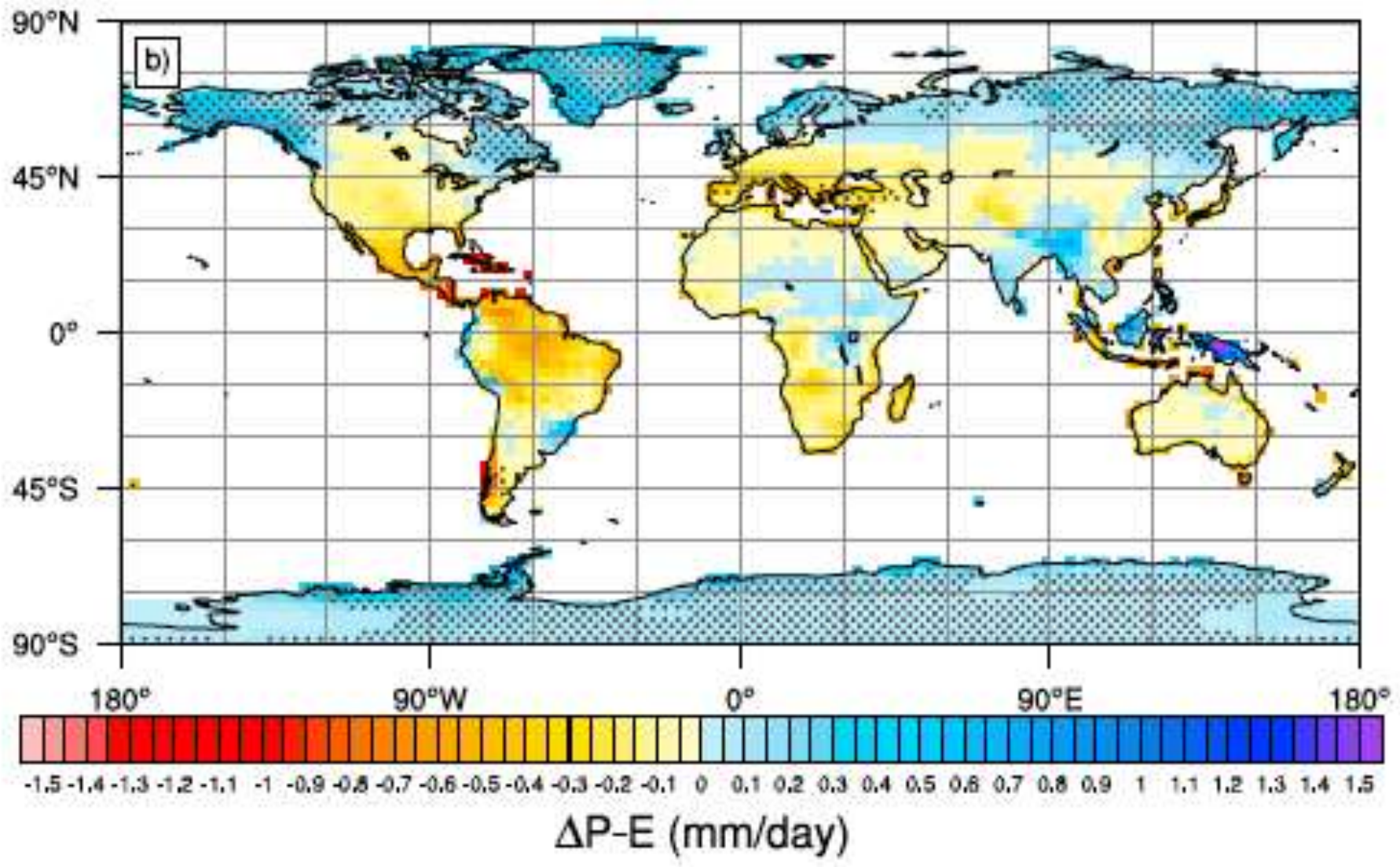
Climate predictions for late 21st Century



Regional average time series of the summer season moisture balance metrics from NADA and CMIP5 models. PDSI=Palmer Drought Severity Index. NADA=North American Drought Atlas.

Cook et al. 2015 Science Advances

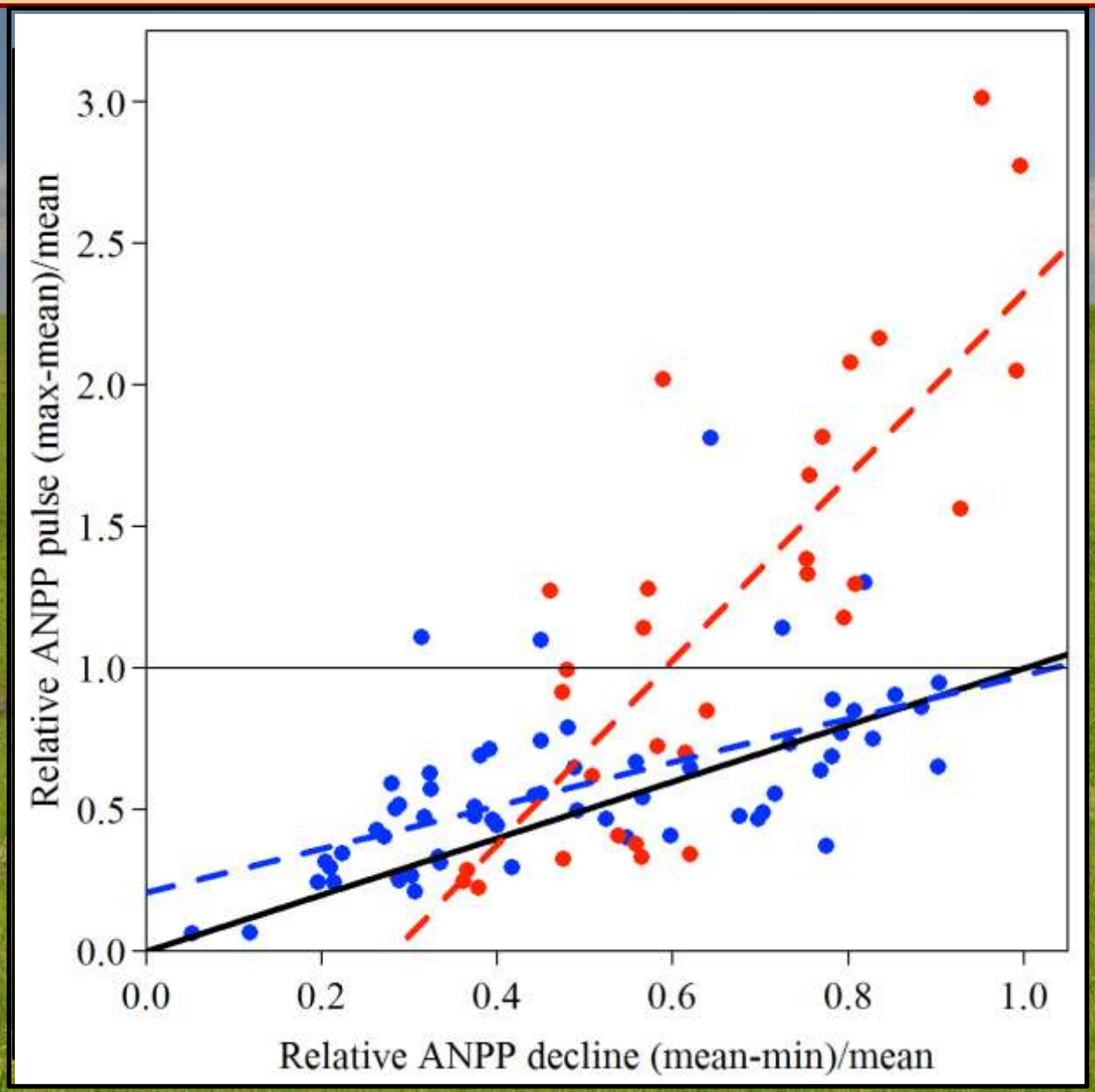
Climate predictions for late 21st Century



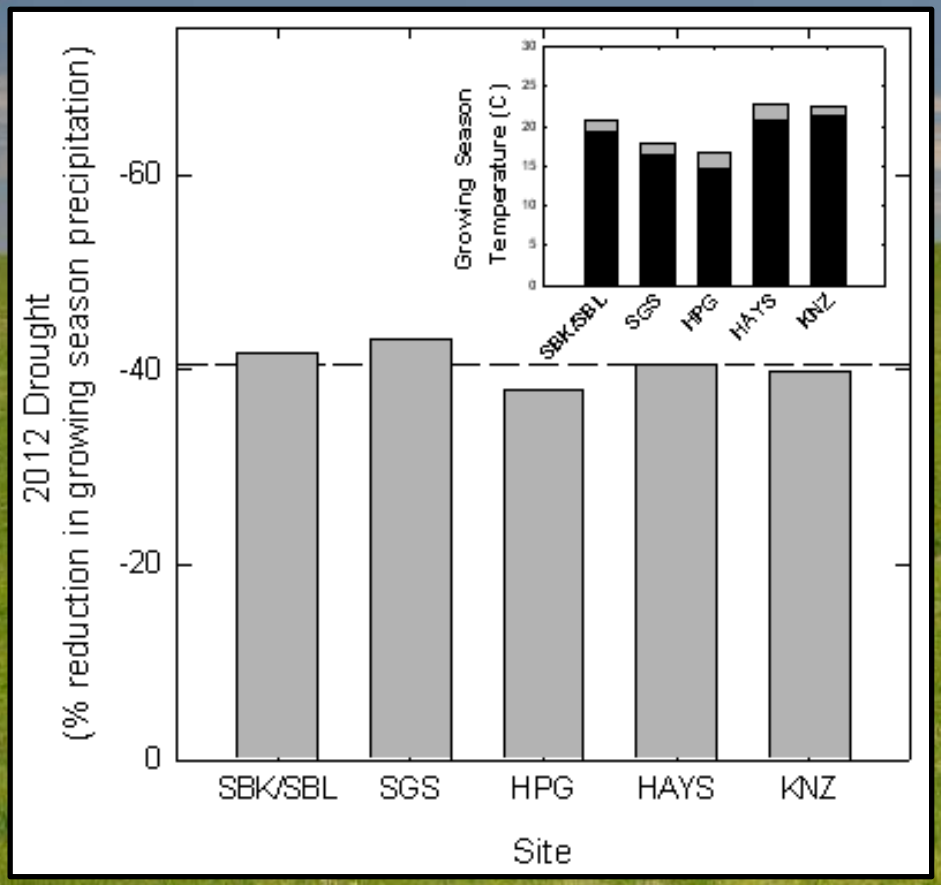
Changes in P-E comparing present day (1980-2000) and future climate (2080-2100).

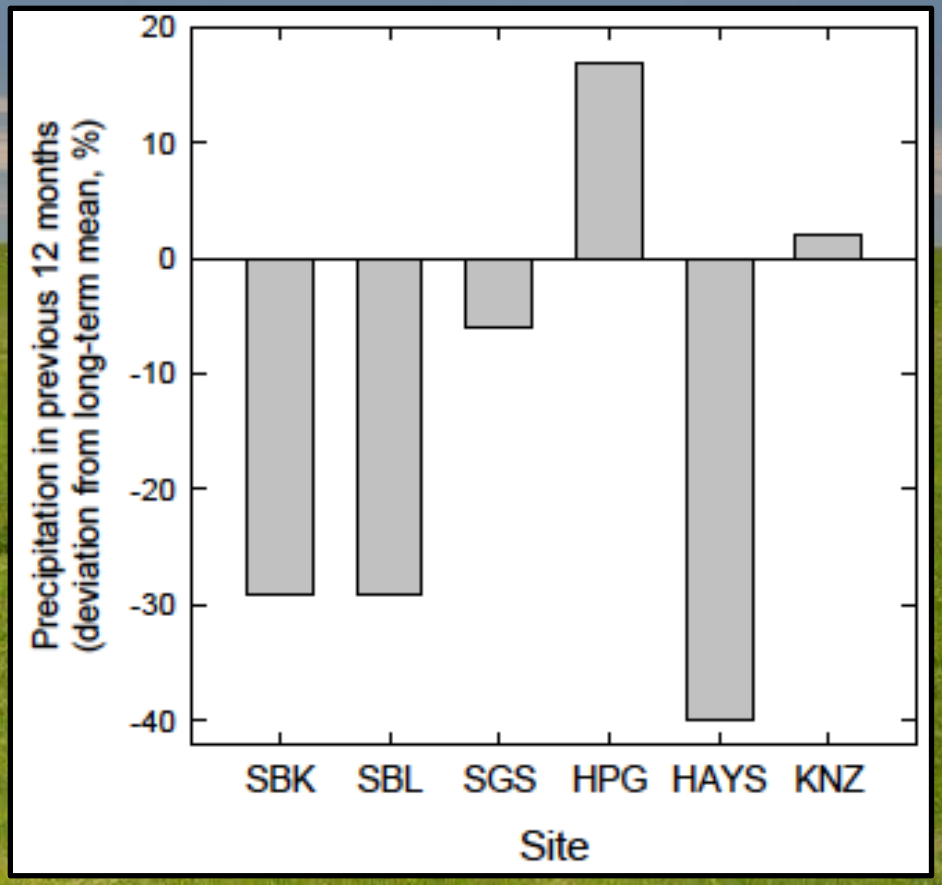
Greve & Seneviratne 2015 GRL

Ecosystems exhibit differential sensitivity to interannual rainfall variability



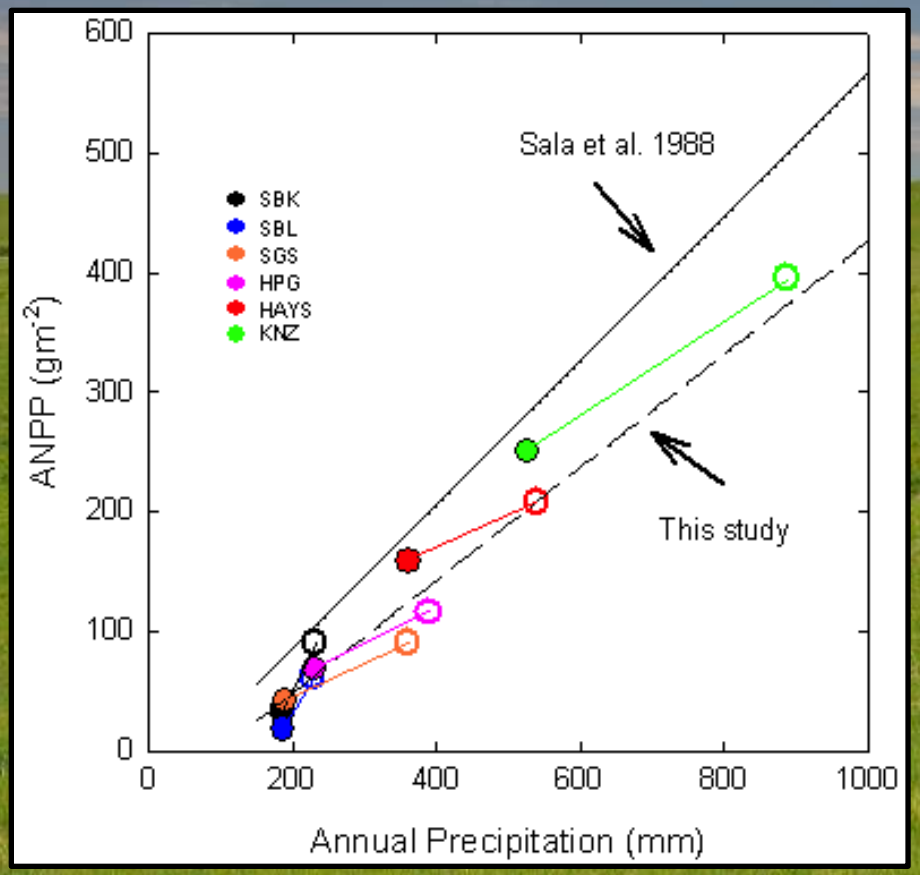
Regional drought in 2012 reduced precipitation by 40% below the long-term average at all EDGE sites

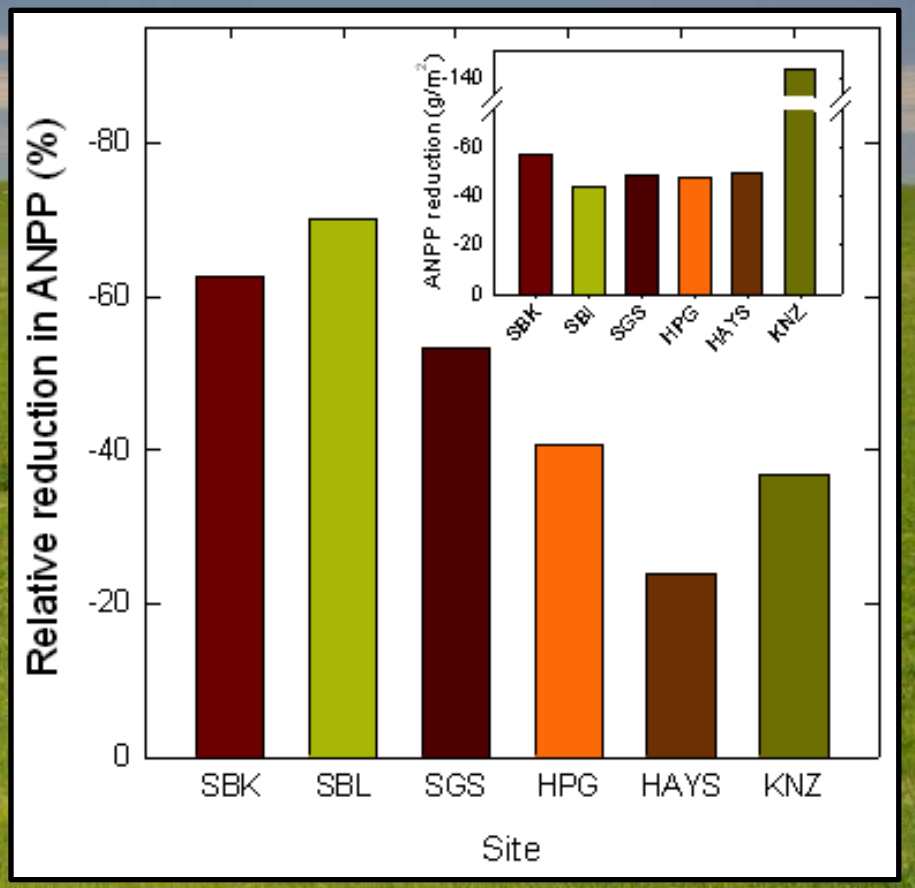




Knapp et al. 2015 Oecologia

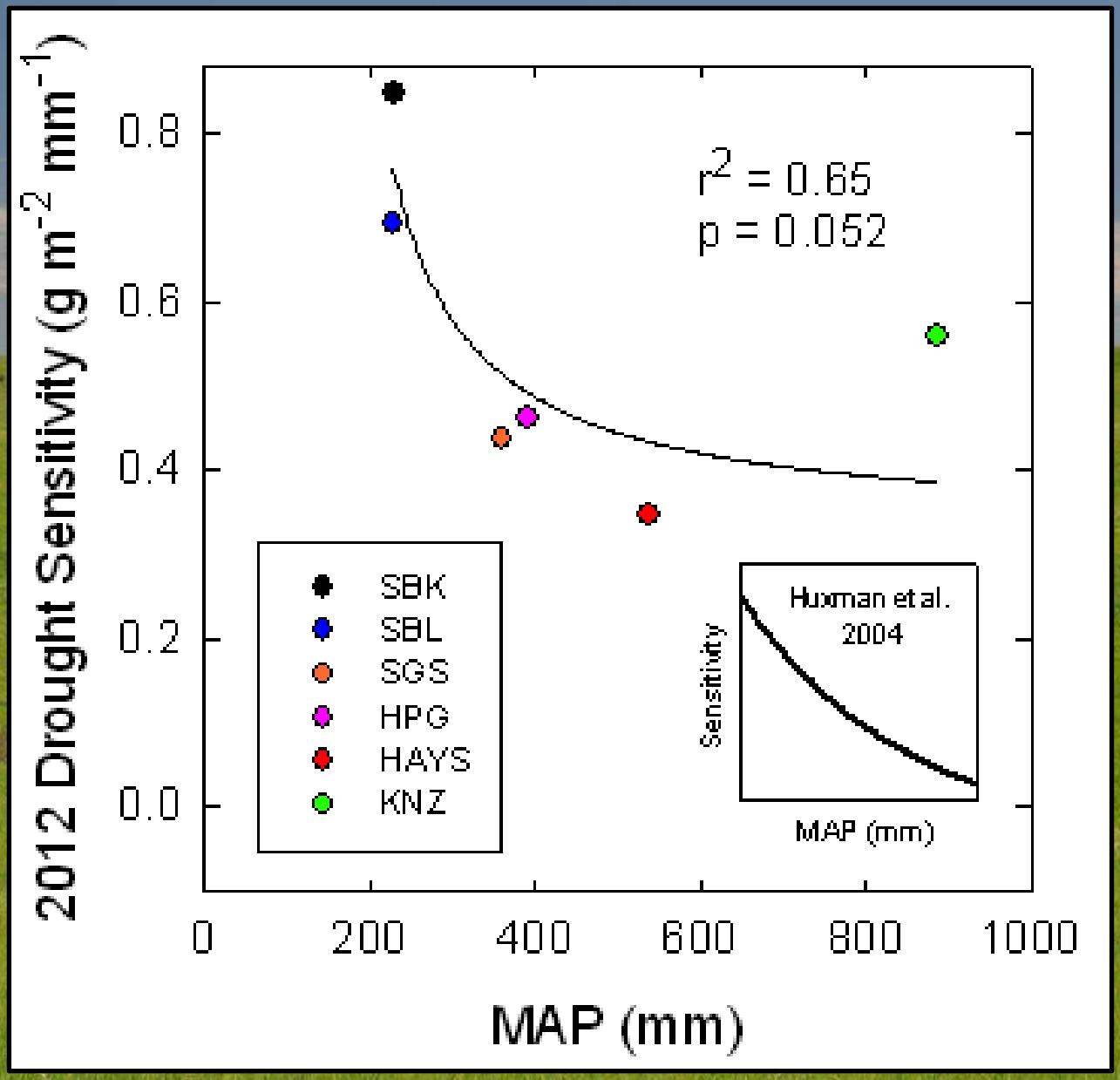
Sites exhibited differential sensitivity to this regional drought





Knapp et al. 2015 Oecologia

Arid sites were far more sensitive than mesic sites



Knapp et al. 2015 Oecologia

An increasing number of calls for coordinated climate change experiments

CONCEPTS & SYNTHESIS

EMPHASIZING NEW IDEAS TO STIMULATE RESEARCH IN ECOLOGY

Ecology, 90(12), 2009, pp. 3279–3289
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A framework for assessing ecosystem dynamics in response to chronic resource alterations induced by global change

MELINDA D. SMITH,[1,4] ALAN K. KNAPP,[2] AND SCOTT L. COLLINS[3]

Global Change Biology

Global Change Biology (2011) 17, 843–854, doi: 10.1111/j.1365-2486.2010.02265.x

OPINION

Coordinated approaches to quantify long-term ecosystem dynamics in response to global change

YIQI LUO*, JERRY MELILLO†, SHULI NIU*, CLAUS BEIER‡, JAMES S. CLARK§, AIMÉE T. CLASSEN¶, ERIC DAVIDSON‖, JEFFREY S. DUKES**, R. DAVE EVANS††, CHRISTOPHER B. FIELD‡‡, CLAUDIA I. CZIMCZIK§§, MICHAEL KELLER¶¶, BRUCE A. KIMBALL‖‖, LARA M. KUEPPERS***, RICHARD J. NORBY†††, SHANNON L. PELINI‡‡‡, ELISE PENDALL§§§, EDWARD RASTETTER†, JOHAN SIX¶¶¶, MELINDA SMITH‖‖‖, MARK G. TJOELKER**** and MARGARET S. TORN††††

Past, Present, and Future Roles of Long-Term Experiments in the LTER Network

SARAH E. HOBBIE, SCOTT L. COLLINS, TIMOTHY J. FAHEY,
April 2012 / Vol. 62 No. 4 • BioScience LANDIS, KIMBERLY J. LA PIERRE, JERRY M. MELILLO,
TIMOTHY R. SEASTEDT, GAIUS R. SHAVER, AND JACKSON R. WEBSTER

REVIEWS REVIEWS REVIEWS

Coordinated distributed experiments: an emerging tool for testing global hypotheses in ecology and environmental science

Lauchlan H Fraser[1*], Hugh AL Henry[2], Cameron N Carlyle[1,3], Shannon R White[4], Carl Beierkuhnlein[5], James F Cahill Jr[6], Brenda B Casper[6], Elsa Cleland[7], Scott L Collins[8], Jeffrey S Dukes[9], Alan K Knapp[10], Eric Lind[11], Ruijun Long[12], Yiqi Luo[13], Peter B Reich[14,15], Melinda D Smith[16], Marcelo Sternberg[17], and Roy Turkington[1]

esa ECOSPHERE

SYNTHESIS & INTEGRATION

Taking the pulse of a continent: expanding site-based research infrastructure for regional- to continental-scale ecology

DEBRA P. C. PETERS,[1,3,†] HENRY W. LOESCHER,[2] MICHAEL D. SANCLEMENTS,[2] AND KRIS M. HAVSTAD[1]

Methods in Ecology and Evolution

Methods in Ecology and Evolution 2014, 5, 65–73 doi: 10.1111/2041-210X.12125

Finding generality in ecology: a model for globally distributed experiments

Elizabeth T. Borer[1*], W. Stanley Harpole[2], Peter B. Adler[3], Eric M. Lind[1], John L. Orrock[4], Eric W. Seabloom[1] and Melinda D. Smith[5]

EDGE: Extreme Drought in Grasslands Experiment

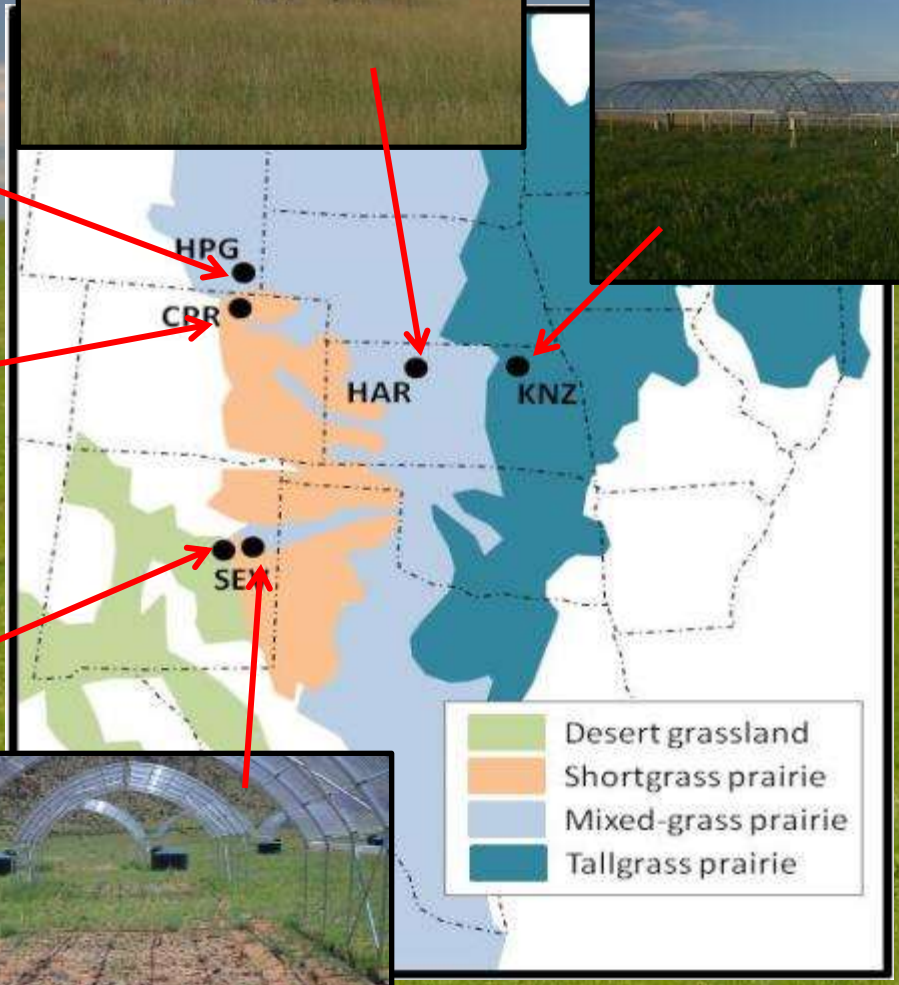
Research Objectives:

How important are the attributes of ecosystems *per se* versus the environmental context in which climate is changing in determining ecosystem sensitivity to climate change at regional scales?

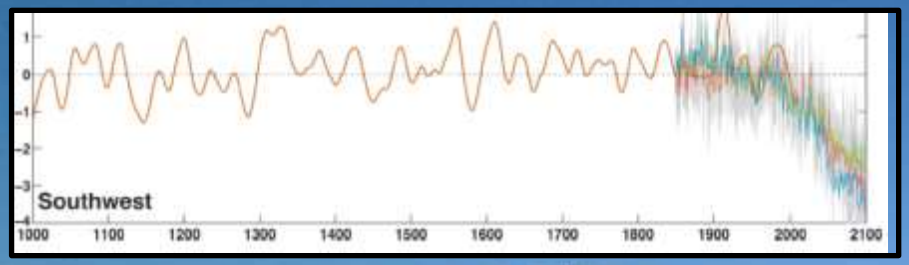
Approaches:

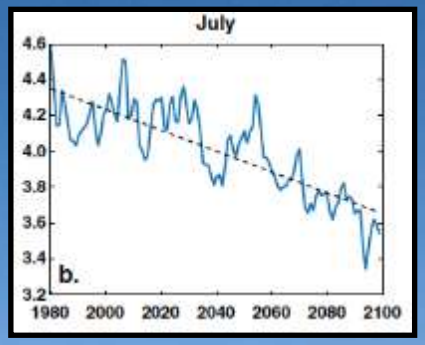
- **Modeling (TECO)**
- **Manipulative experiments**

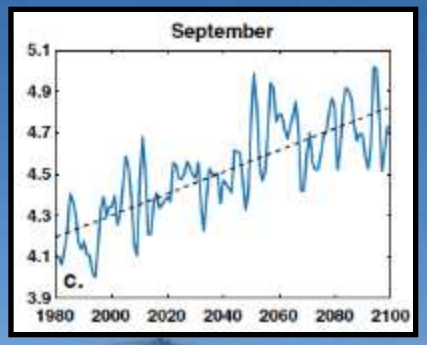
EDGE: Research platform



NM-EDGE: Extreme Drought in Grasslands Experiment







Chronic drought: Partial roof panels impose drought from April through September

Altered monsoon seasonality: Complete roof panels capture all rain in July and August. Rain is reapplied in September and October.

NM-EDGE: Extreme Drought in Grasslands Experiment

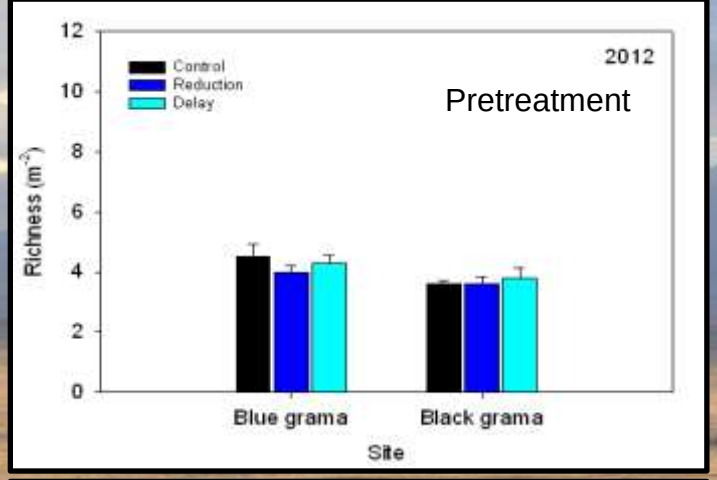
Treatments:

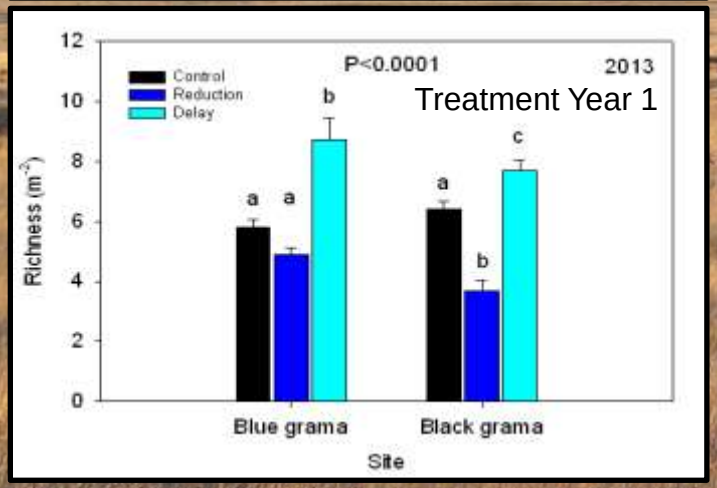
- Ambient rainfall
- A 66% reduction in seasonal precipitation
- Six week shift in the summer monsoon

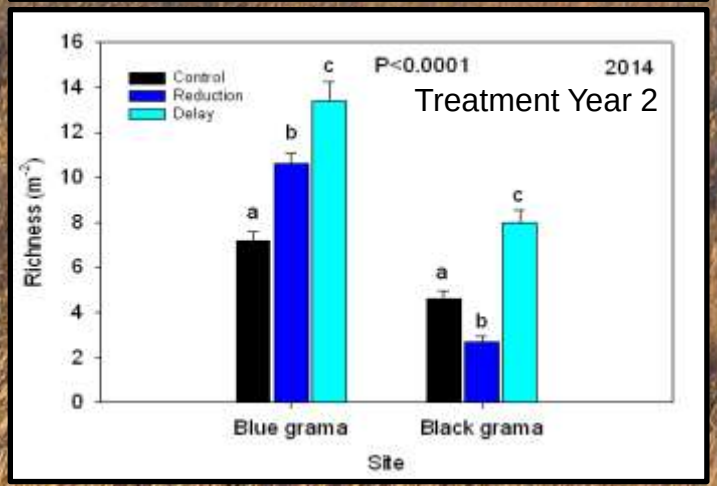
Response variables:

- Above and belowground NPP
- Soil respiration
- Plant community composition
- Soil N availability

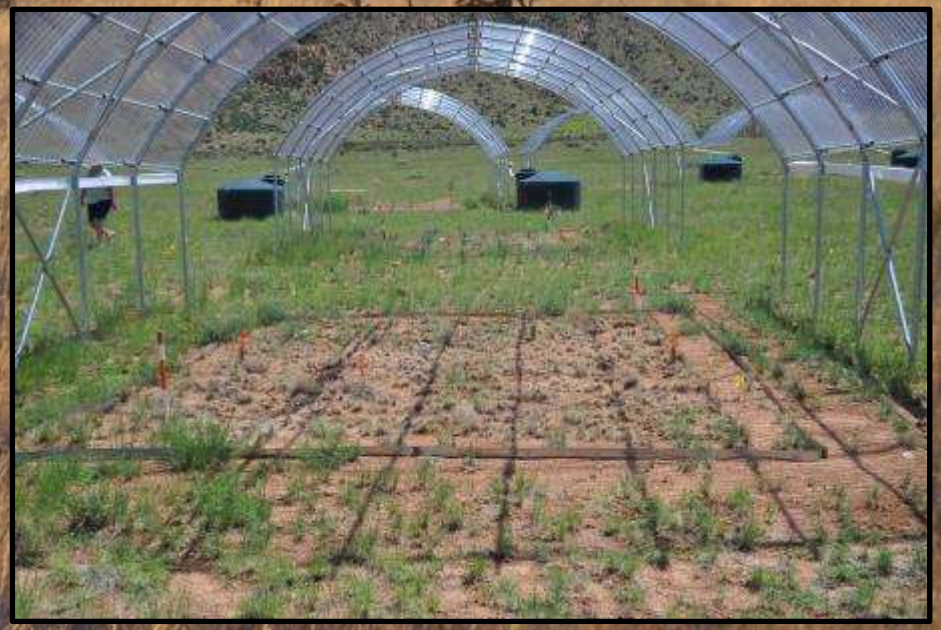
NM-EDGE: Species richness



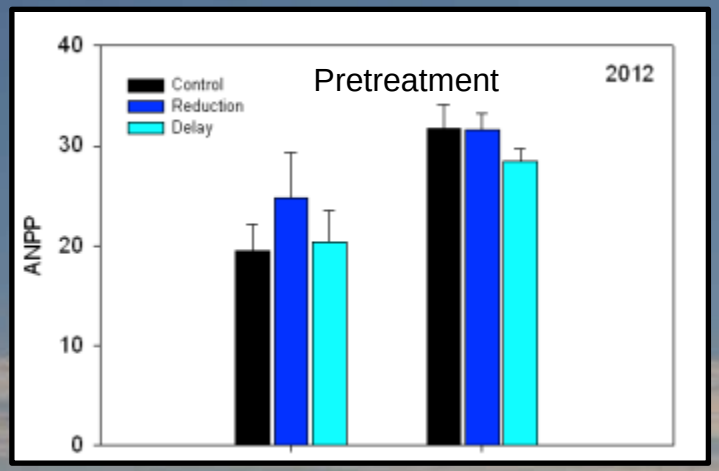


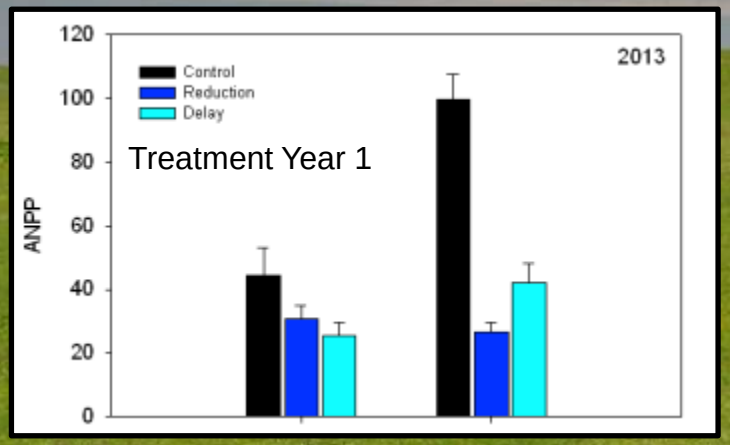


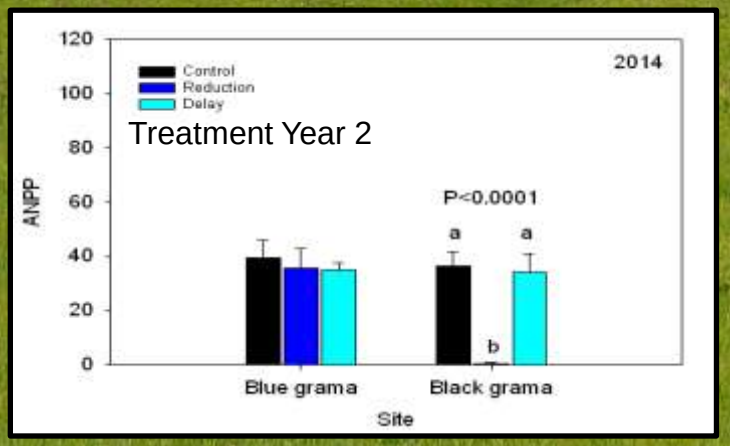
- No significant pretreatment differences in richness
- Year 1 richness declined with drought at the black grama site, but increased in the delayed treatment
- Year 2 richness again highest in delay treatments, and lowest under drought at the black grama site



EDGE: Net Primary Production

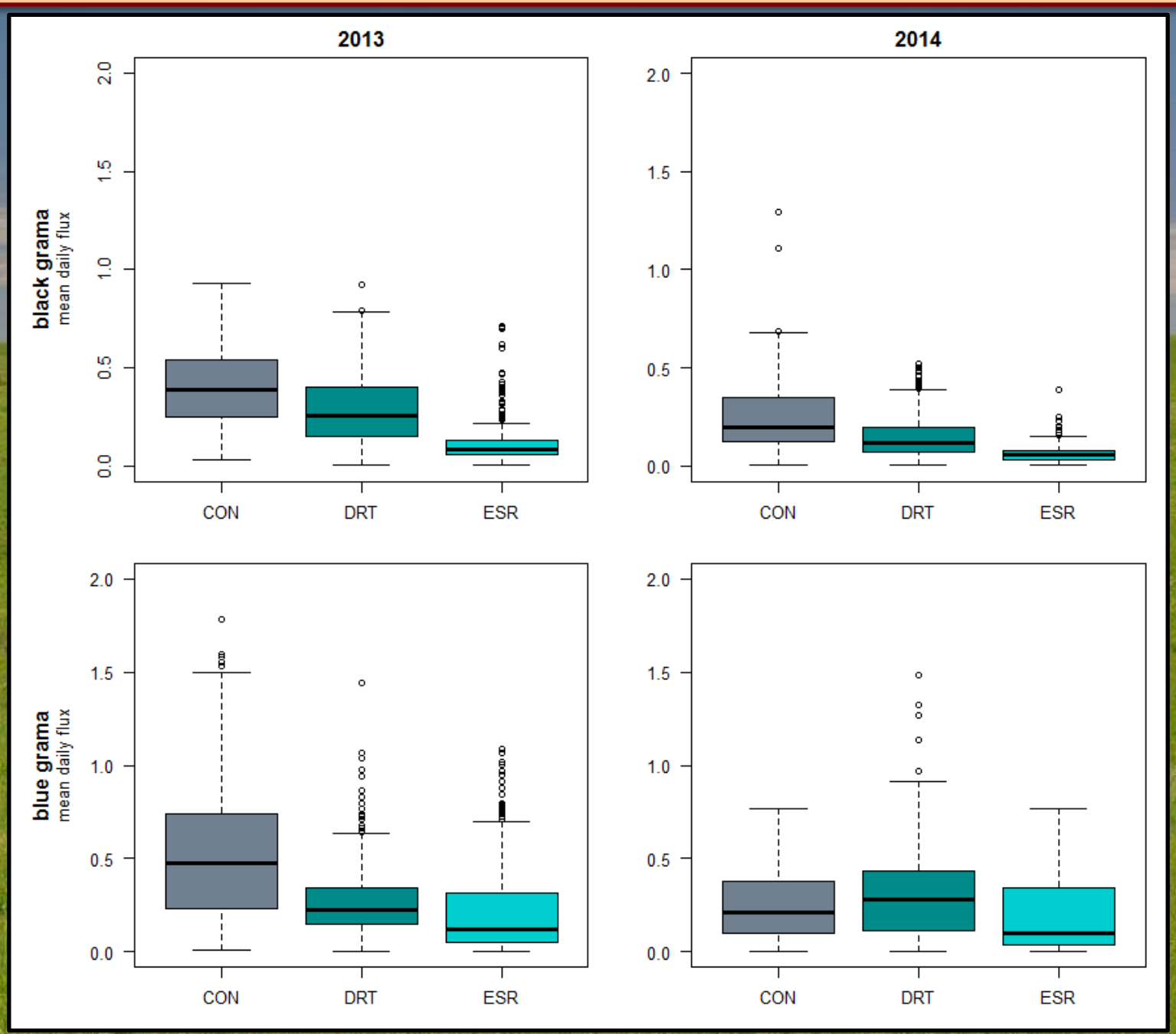




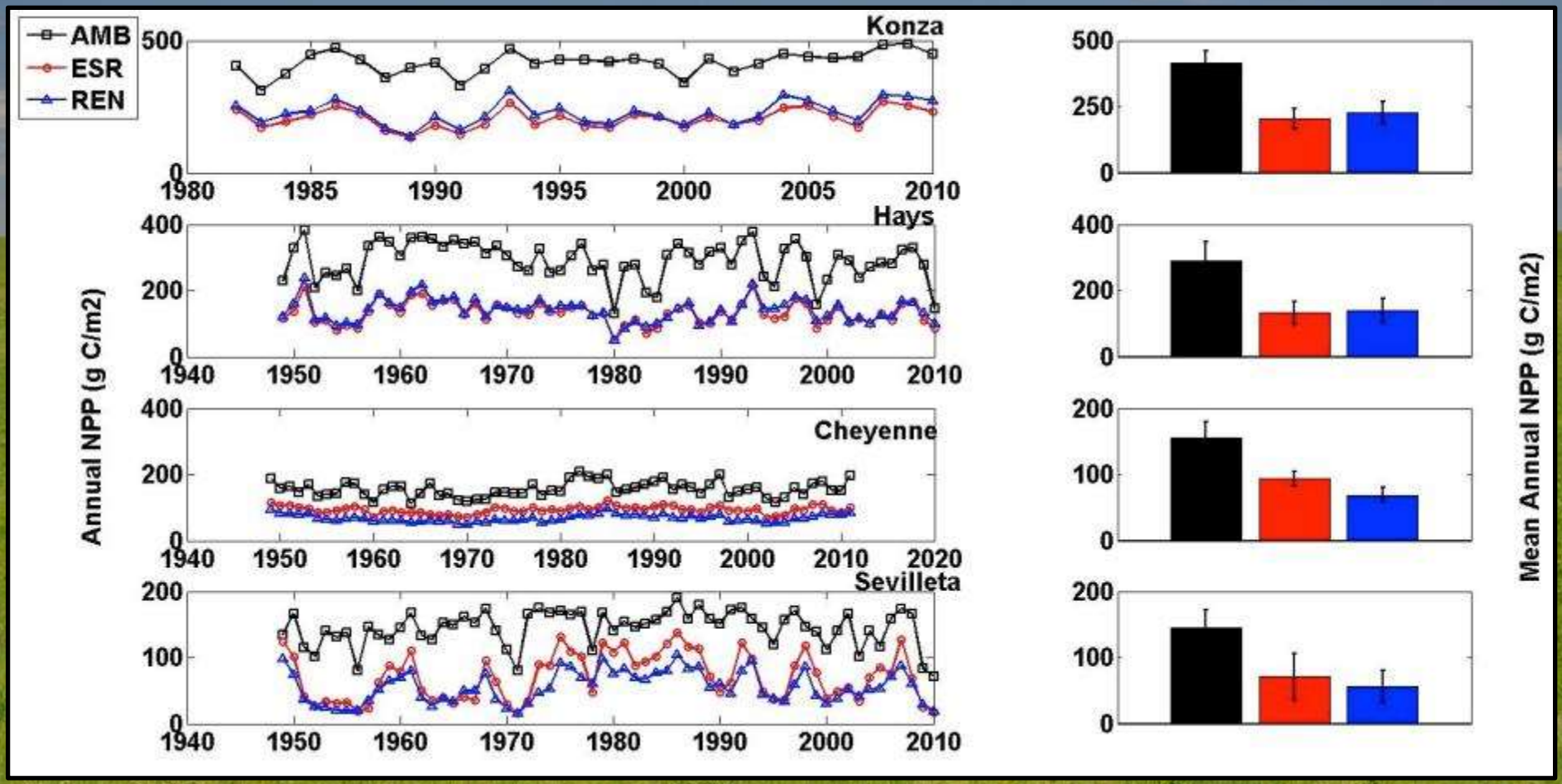


- No significant pretreatment differences in NPP
- Year 1 no recovery at either site with late season rains
- Year 2 NPP recovered with late season rains
- Year 2 very low NPP at black grama site under drought

Seasonal mean soil respiration was reduced by 60% in response to drought

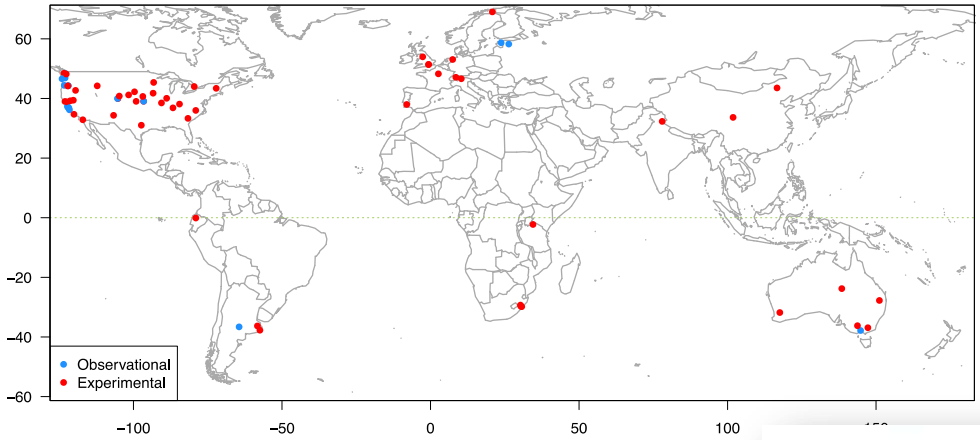


TECO Model: spin up



Shi et al. 2014 Biogeosciences

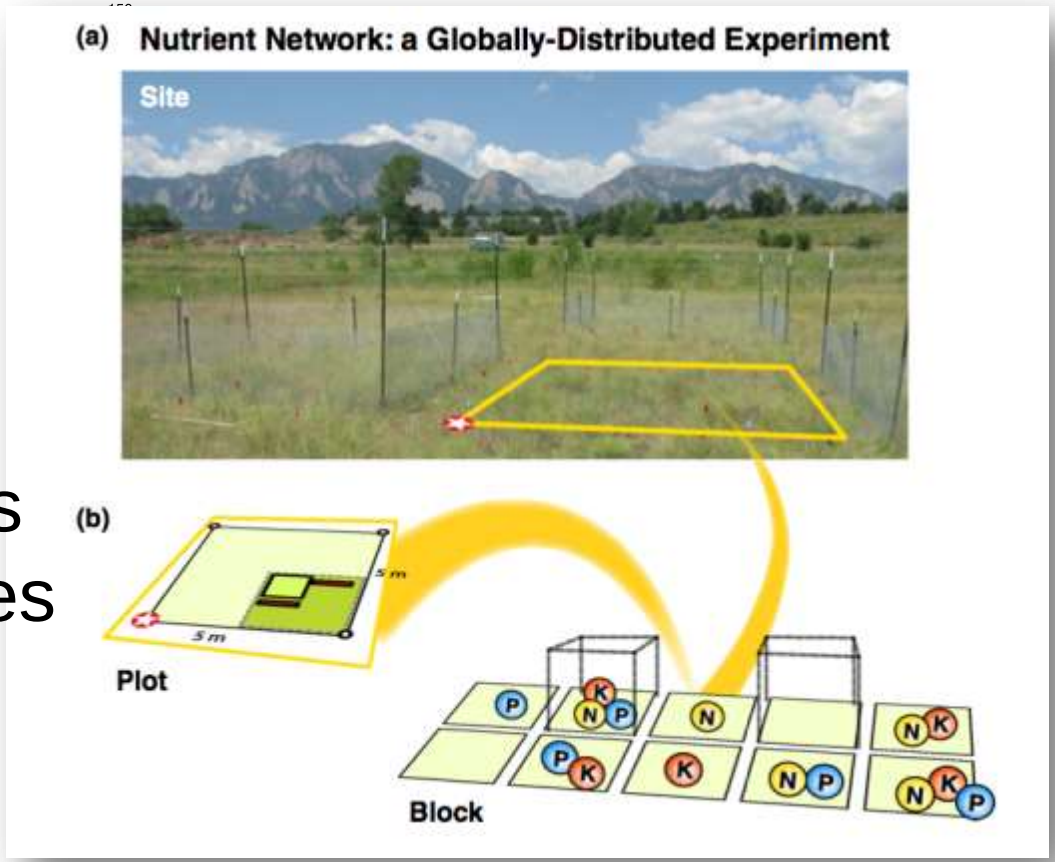
A model for international collaboration: The Nutrient Network



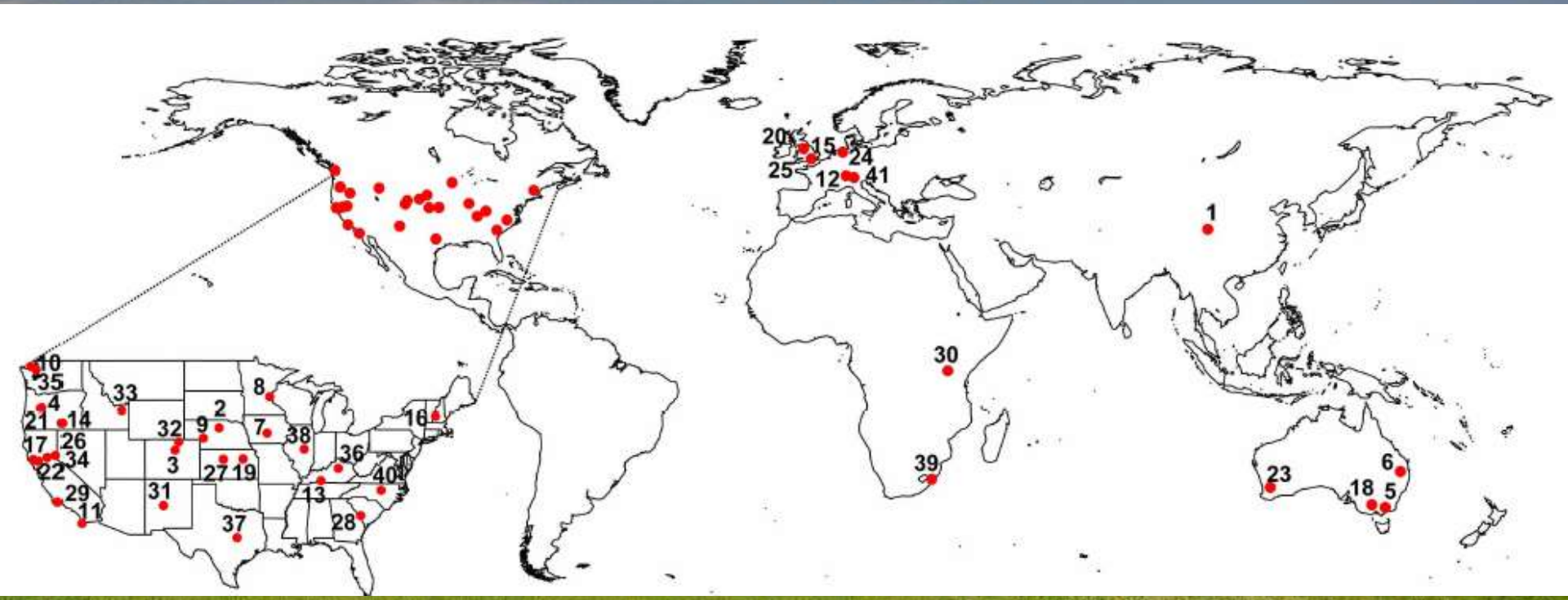
nutrient network

1. Add N, P, K at identical rates across <u>all</u> sites

2. Exclude herbivores with identical fences



Sites currently participating in the Nutrient Network



drought NET

- NSF-funded Research Coordination Network

  PIs: Melinda Smith (CSU), Osvaldo Sala (ASU), Rich Phillips (Indiana U)

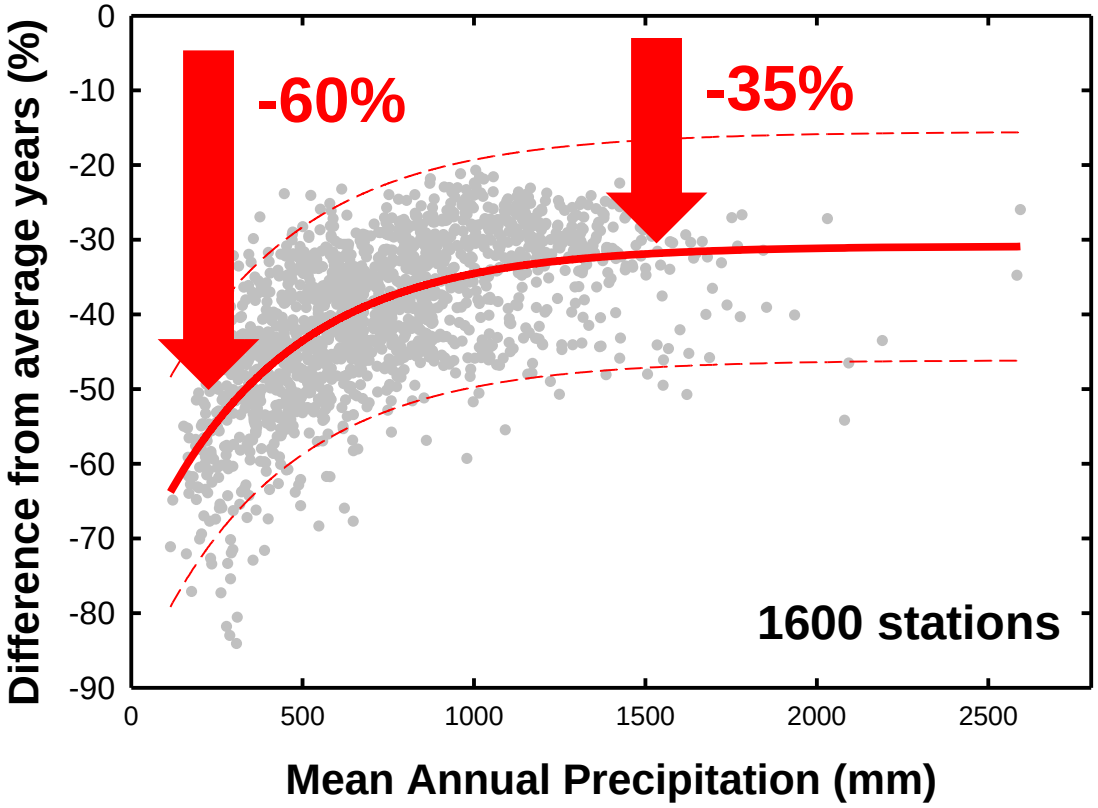
Overarching goal: advance our general understanding of how terrestrial ecosystems may vary in their response to drought,…

And more specifically to assess the mechanistic basis for differential sensitivities of terrestrial ecosystems to drought.

How de we manipulate drought comparably across ecosystems

Passive approach – reduce a fixed amount of each rainfall event

Reductions in precipitation differ among ecosystems for drought years



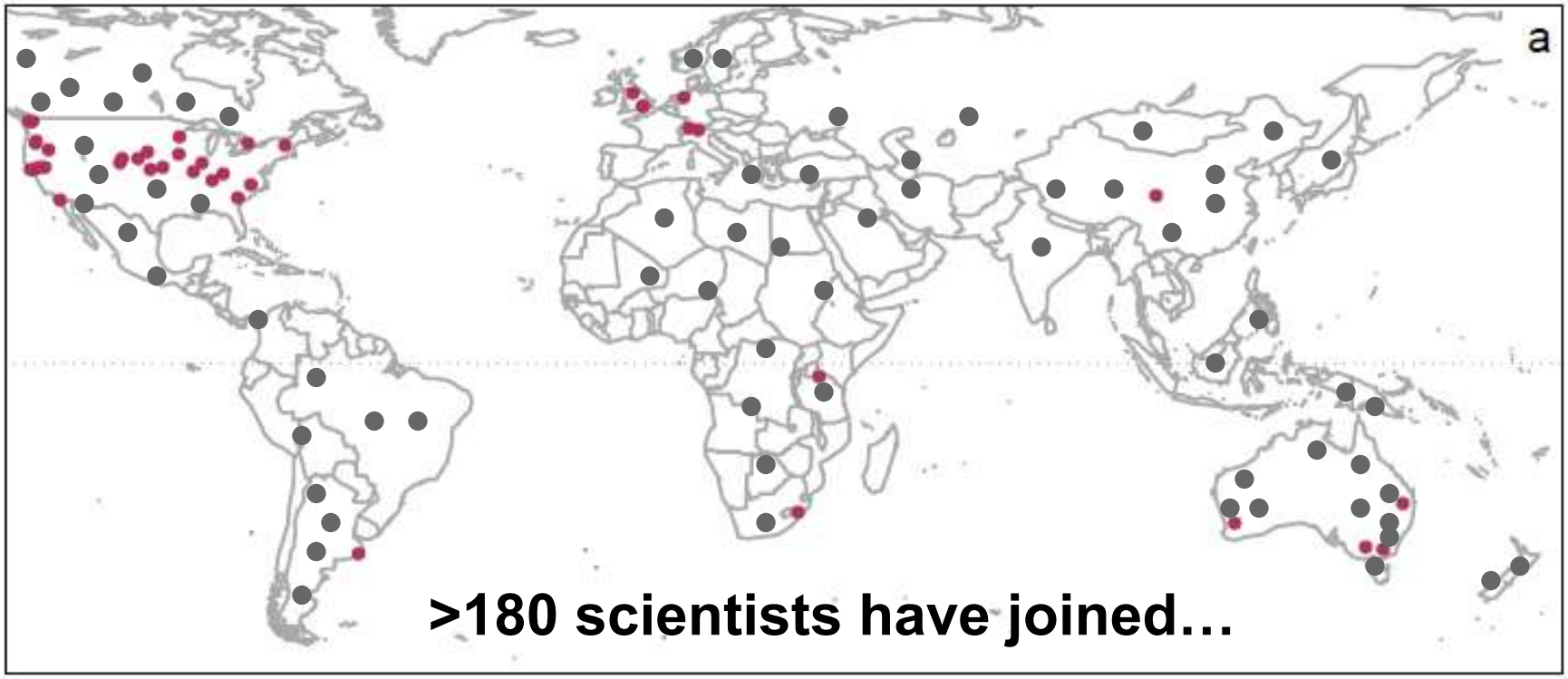
Extreme dry years: < 10% of 100 year record

Deviation in precipitation from average years differs considerably with mean annual precipitation

Knapp et al. 2015 Global Change Biology

droughtNET

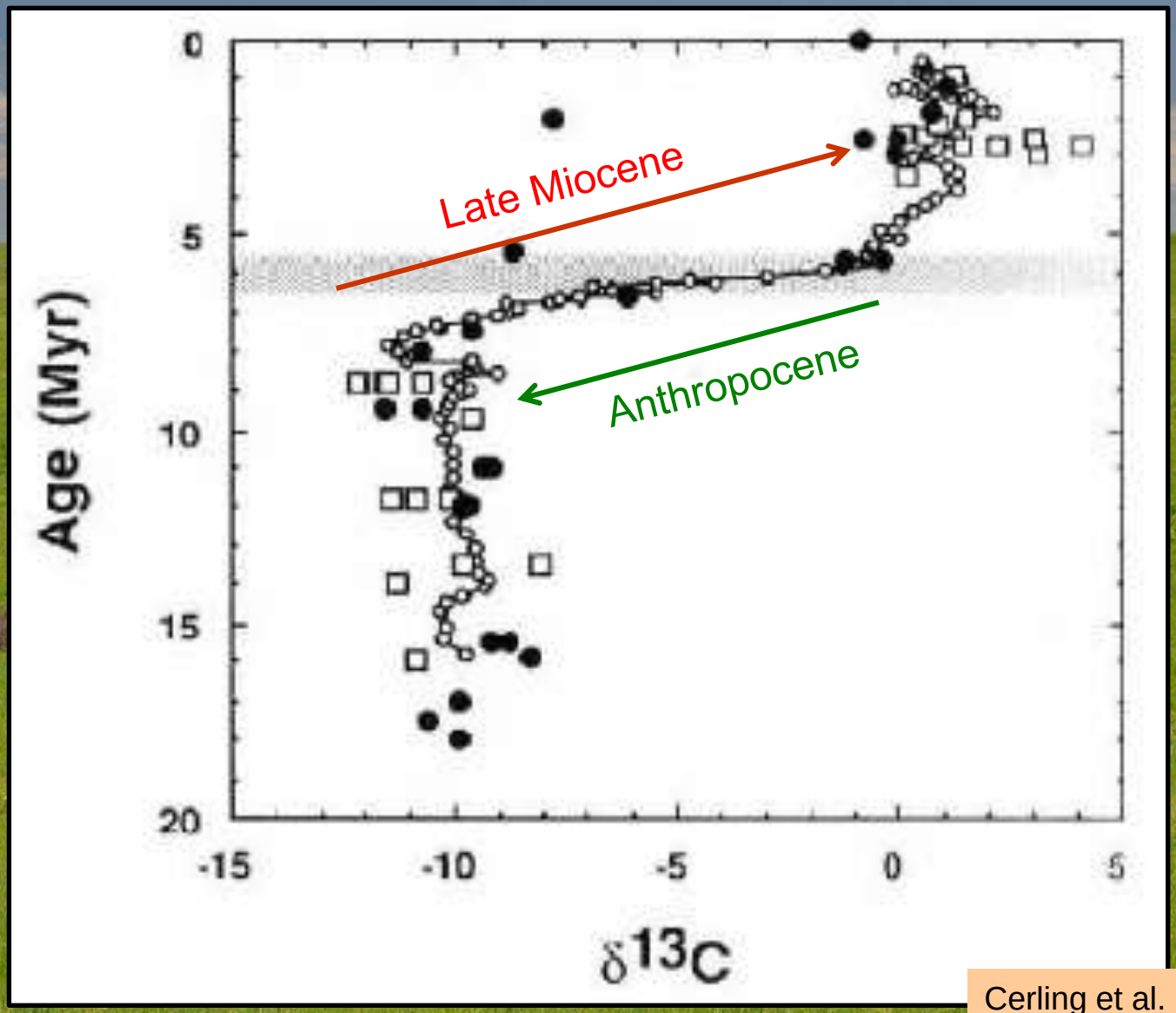
Goal….



- Please join us!

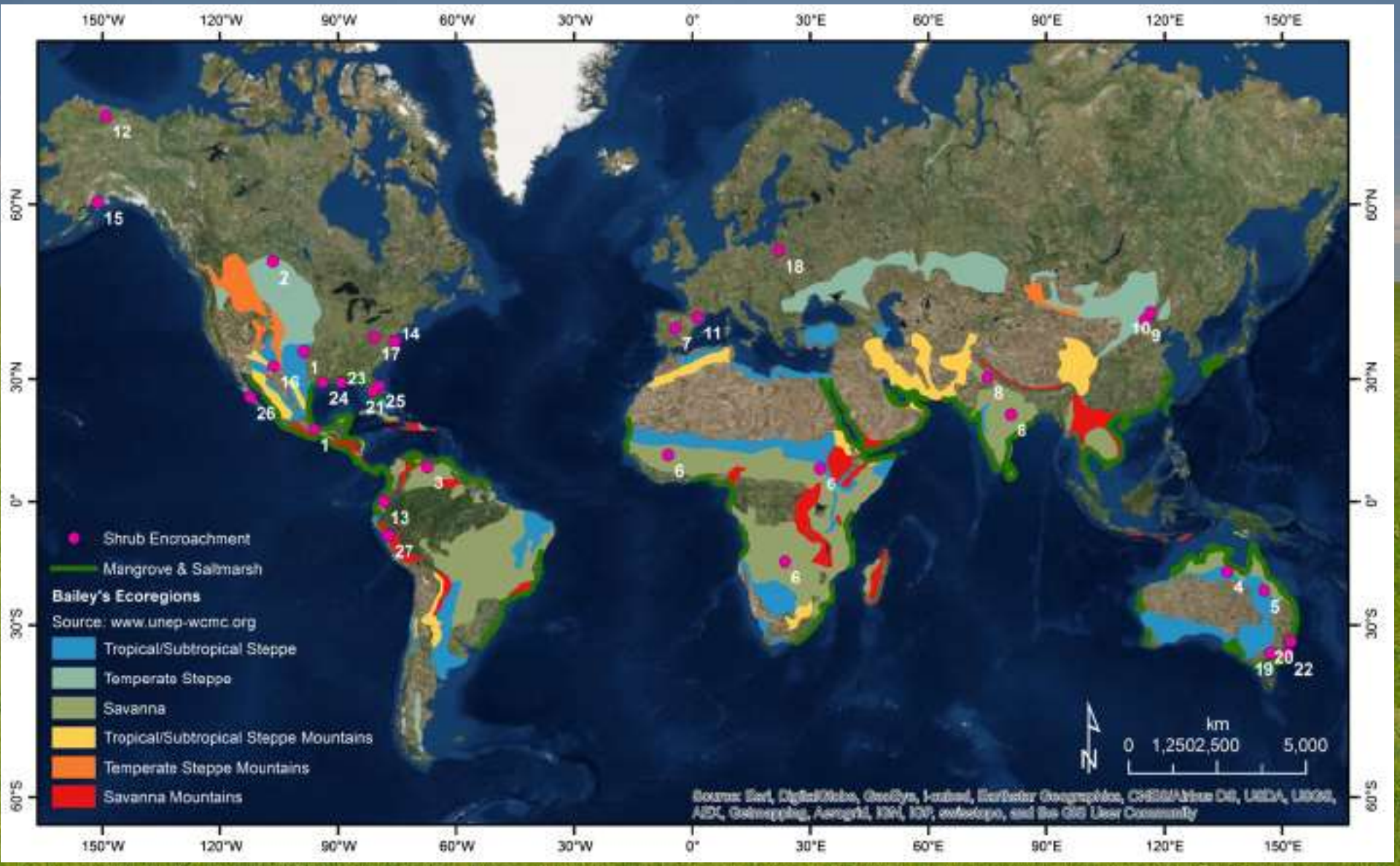
www.drought-net.org

Carbon isotope signatures from horse tooth enamel from Pakistan and the USA showing the transition from C3 woodland to C4 grassland in the late Miocene



Cerling et al. 1993 Nature

Global map of woody plant encroachment into grassland

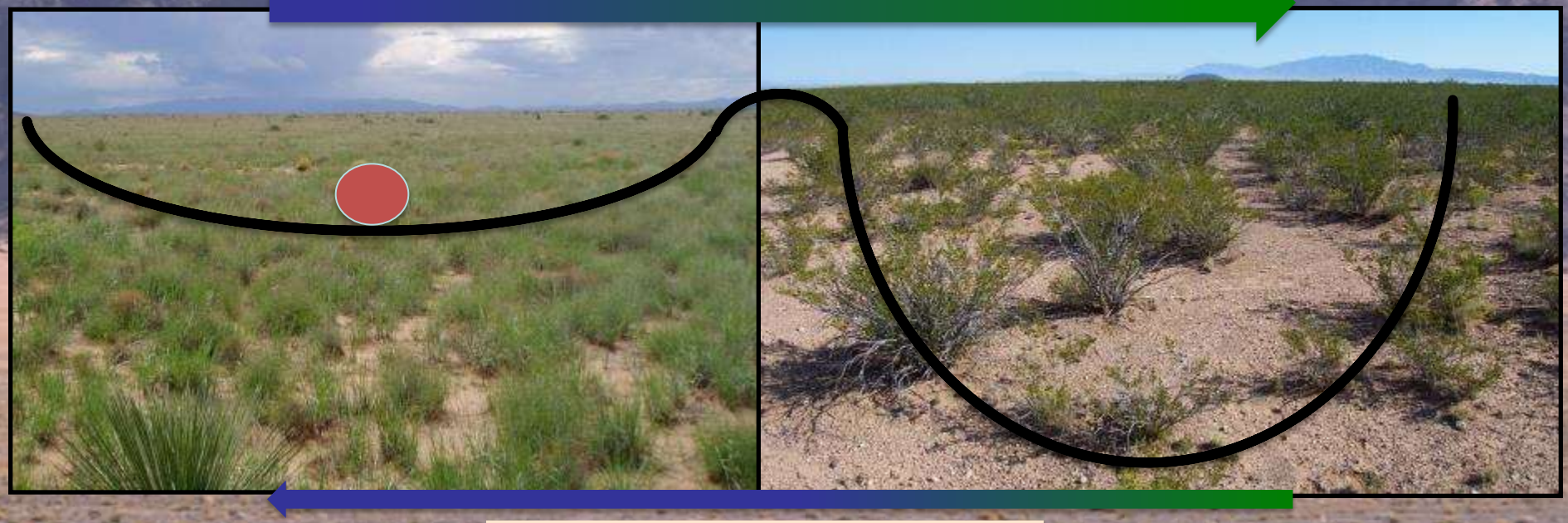


Saintilan & Rogers 2015 New Phytologist

Bush encroachment: alternative stable states

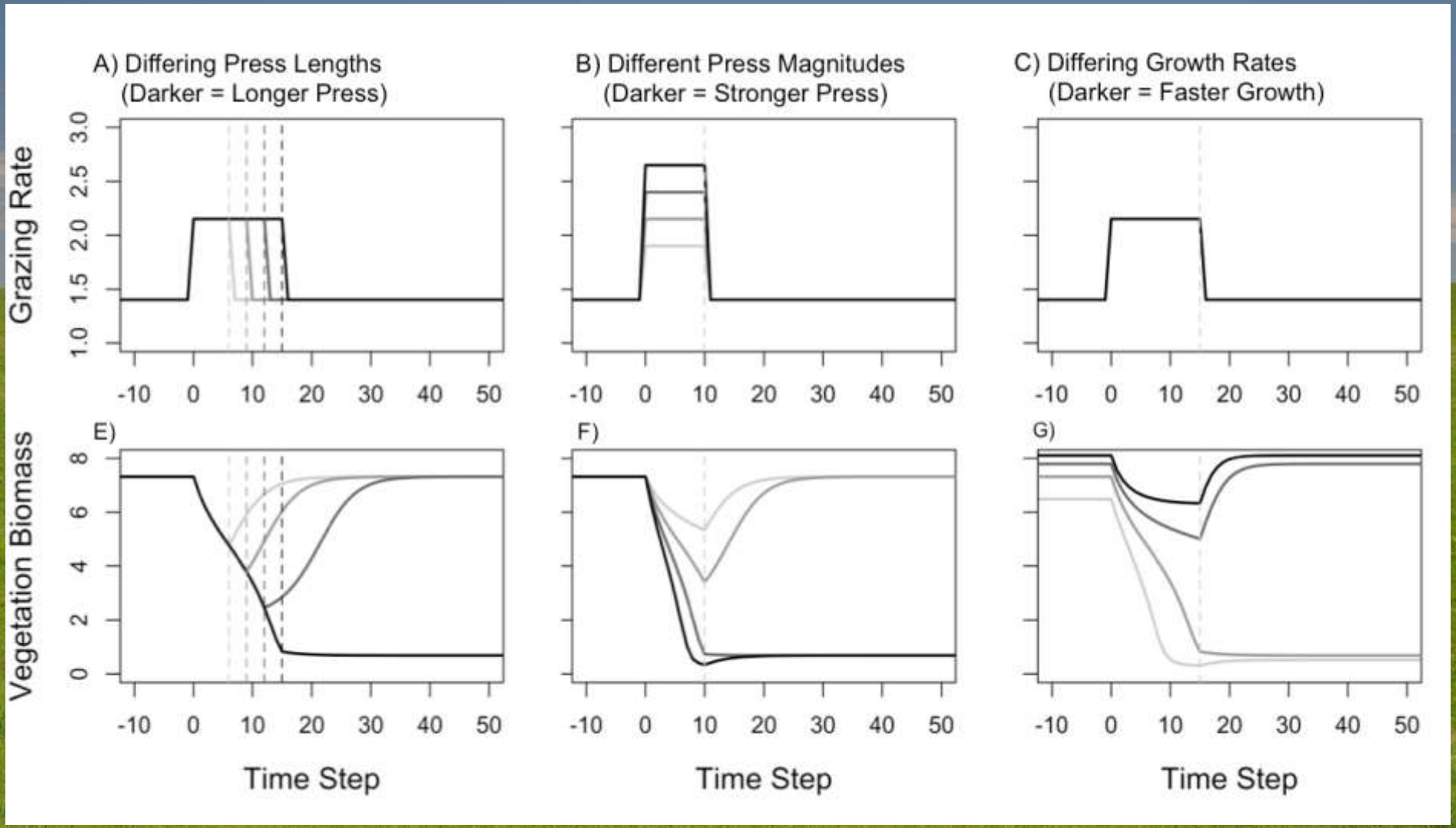
CAUSES
Grazing
Drought
Warming
Elevated CO_2
Precipitation seasonality

CONSEQUENCES
Warmer nights
Higher erosion rates
Greater nutrient losses
Lower diversity
Higher CO_2 sequestration



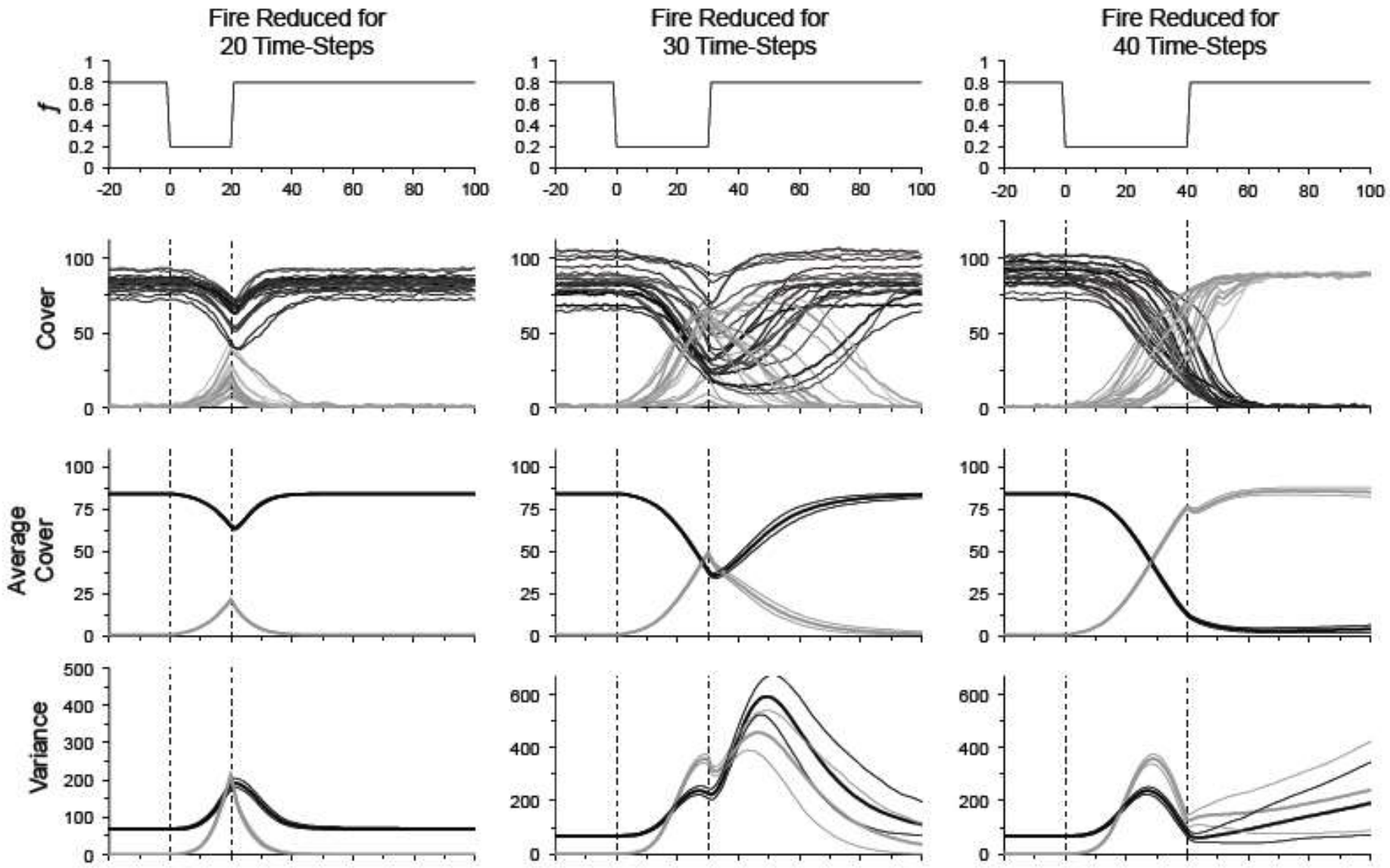
Fire
Extreme cold
Increased summer precipitation

Grazing as a driver of alternative stable states in mesic grassland



Ratajczak et al. in prep.

Fire frequency as a driver of alternative stable states in mesic grassland



Ratajczak et al. in review

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EDGE Pis & Collaborators:

Will Pockman – UNM
Kristin Vanderbilt - UNM
Melinda Smith - CSU
Alan Knapp - CSU
Yiqi Lou - OU
Michelle Thomey - Postdoc
Matt Petrie – Grad RA
Nate Gehres – Technician

Alternative stable state collaborators:

Zak Ratajczak – U Virginia
Paolo D'Odorico – U Virginia
Jesse Nippert – Kansas State
Nate Brunsell – U Kansas
Brandon Bestelmeyer – USDA
Sujith Ravi – Temple University
Forest Isbell – U Minnesota

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Megan McClung
Chandra Tucker
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Amaris Swann
Rina Ouellette
Jim Thibault
Ben Specter

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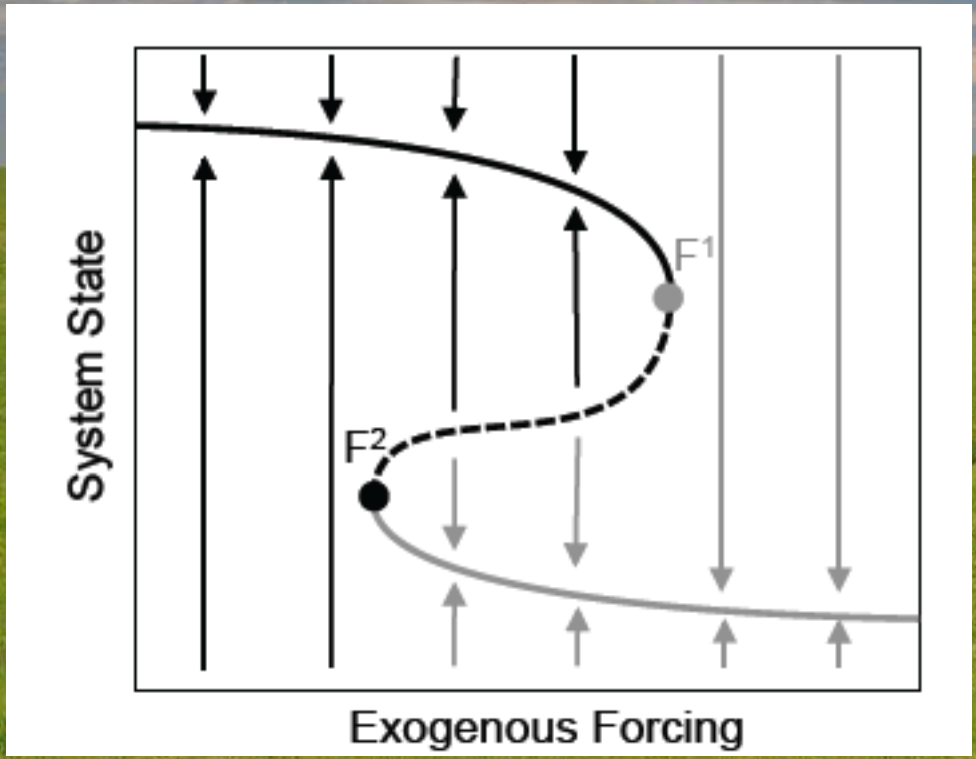
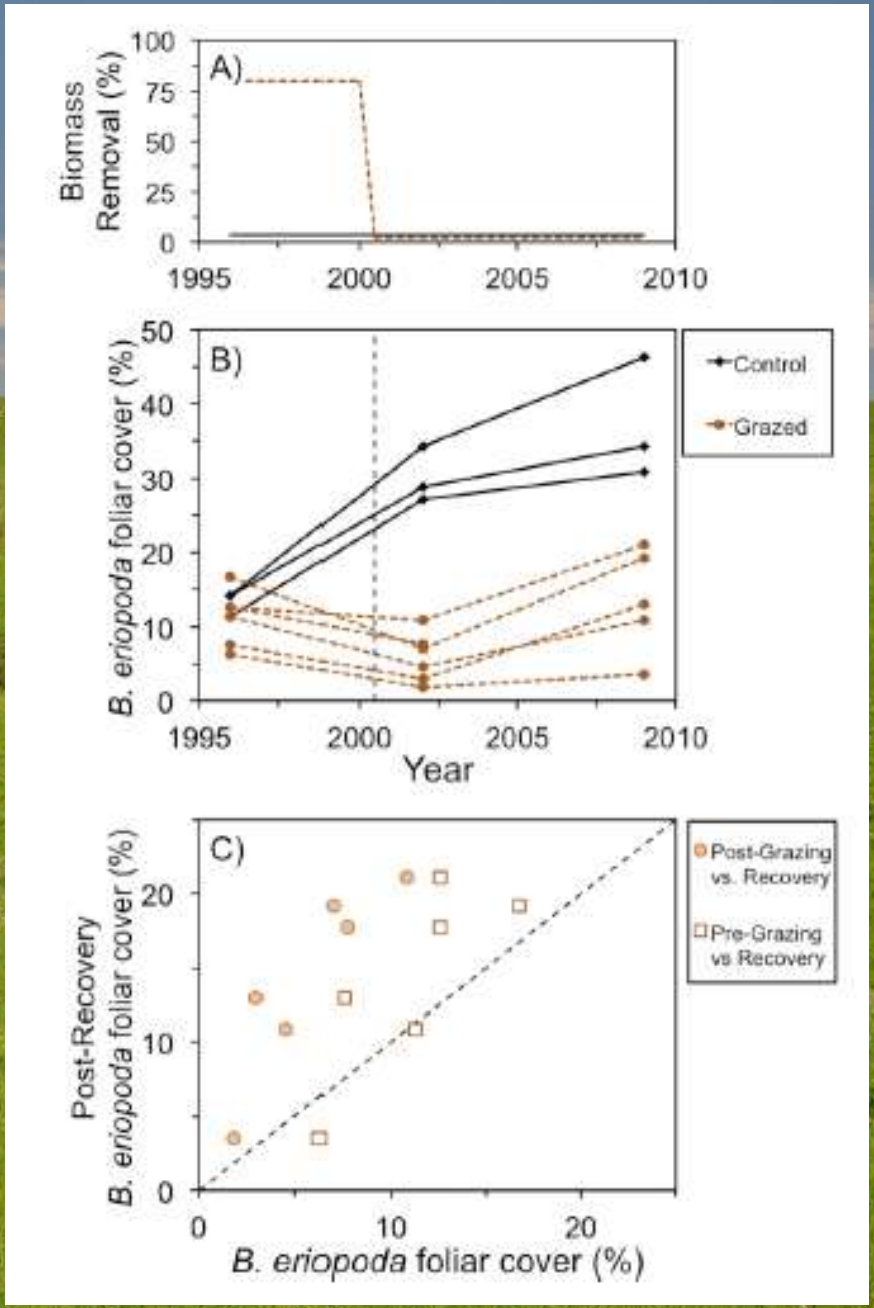
NSF LTER

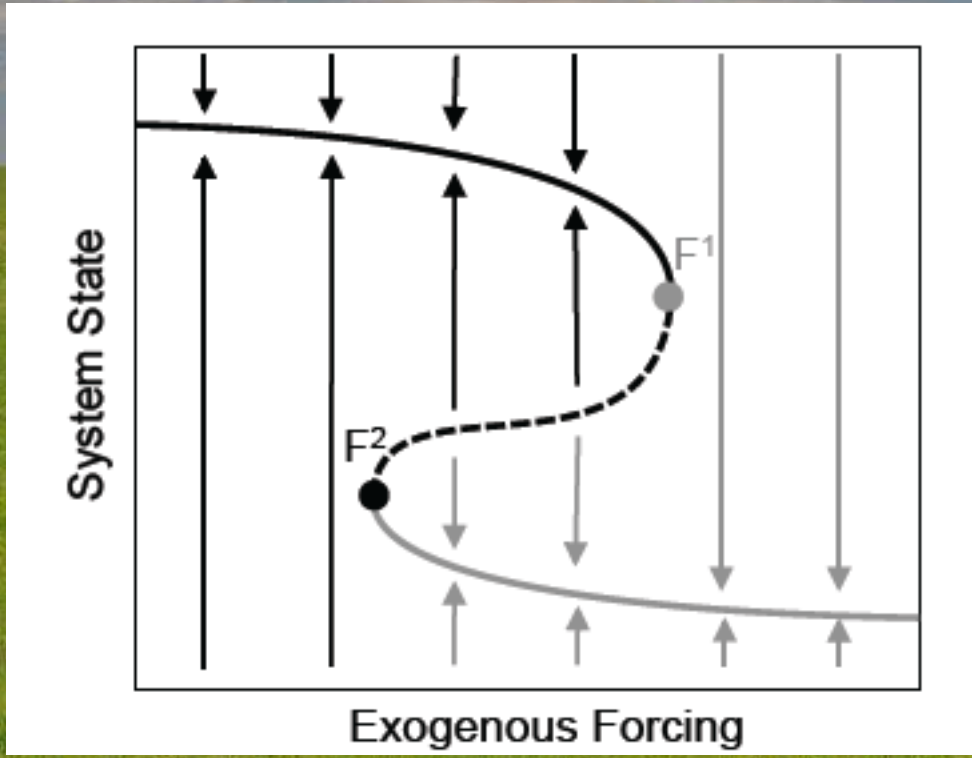
Grazing as a driver of alternative stable states in desert grassland

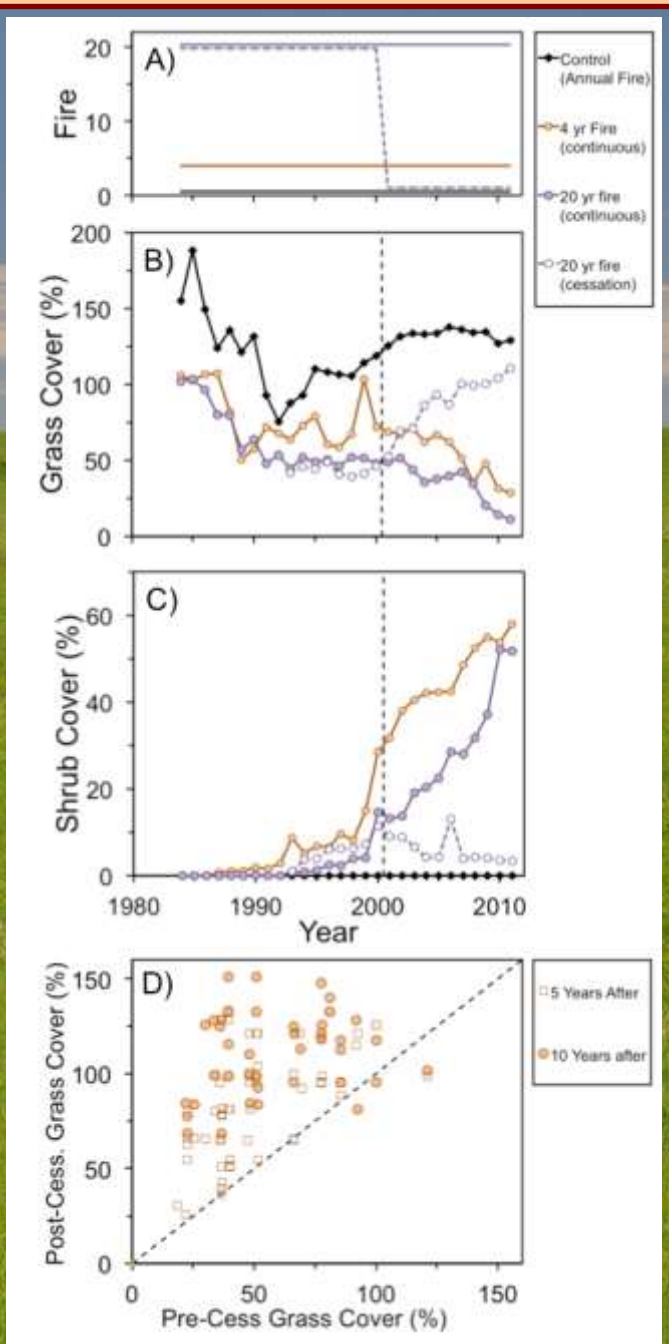




Ratajczak et al. in prep

Fire frequency as a driver of alternative stable states in mesic grassland





Ratajczak et al. in prep