The *Office of Sustainability and Climate* welcomes you to a webinar on

Drought and Rangelands

AUDIO CONNECTION

1. Phone: mute your computer speakers and call 1-877-369-5243; access code: 0388934#

OR

2. Audio through the computer: Make sure your computer speakers are on and listen with speakers or headphones.

Note: Phone audio will allow you to both listen and speak up with questions. *If you listen through the computer, you will not be able to speak up with questions,* but will be able to type questions into the Q&A pod which will be answered by the appropriate speaker.

Drought and Rangelands

Cindi West – Director, Office of
Sustainability and Climate

Effects of drought on rangelands: modeling and empirical

Matt Reeves,

Research Ecologist

Rocky Mountain Research Station

& USDA Climate Hub liaison

USDA United States Department of Agriculture
Climate Hubs
http://www.usda.gov/climatehubs

Rangelands

Land on which the indigenous vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs and is managed as a natural ecosystem. If plants are introduced, they are managed similarly. Rangelands include natural grasslands, savannas, shrublands, many deserts, tundra, alpine communities, marshes, and wet meadows (SRM 1998) (p. 23).

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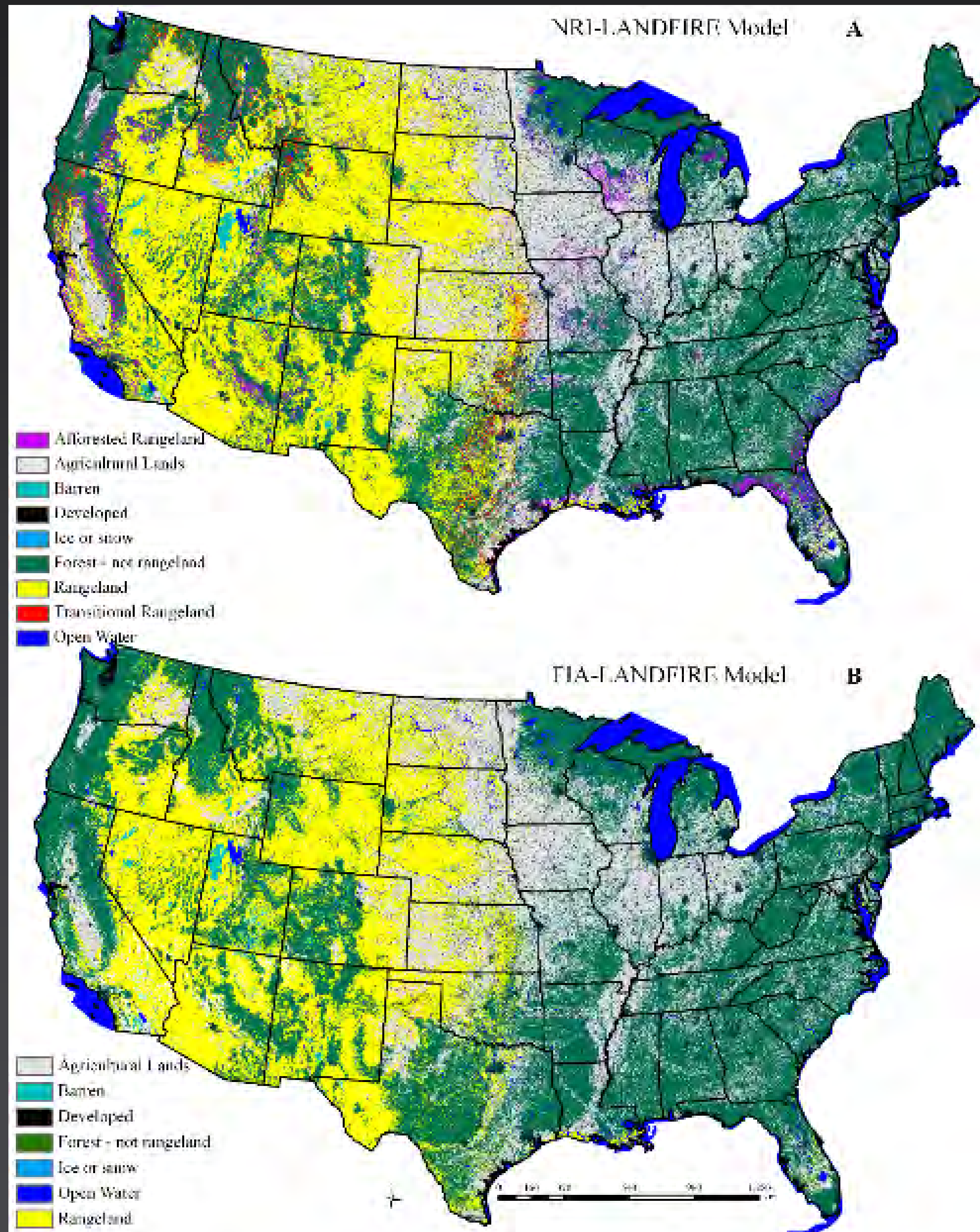
NRCS:
up to **25%**
cover by trees

USFS:
up to **10%**
stocking by trees

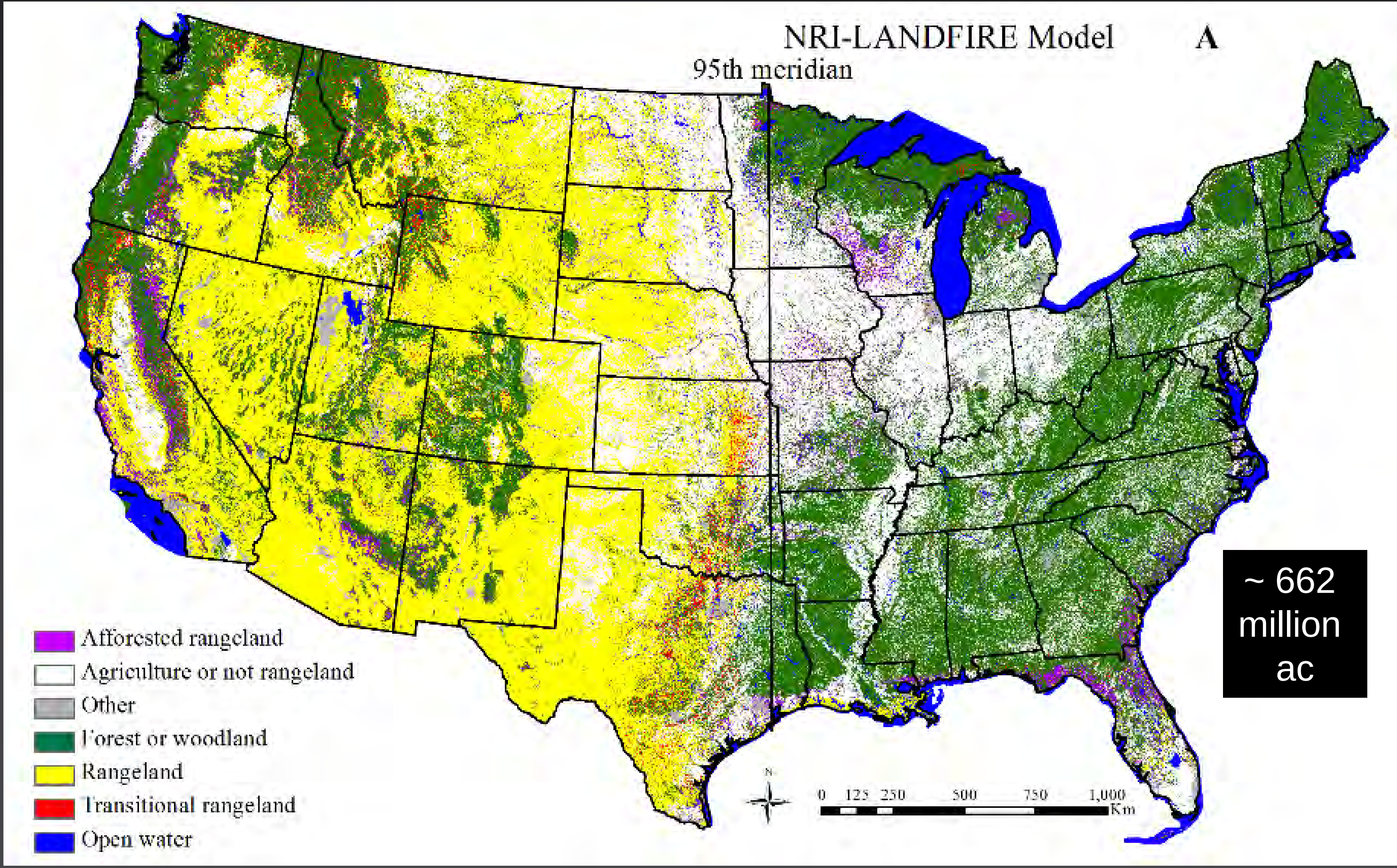
Rangelands



Reeves, M.C.; Mitchell, J.E. 2011.
Extent of coterminous US rangelands: quantifying implications of differing agency perspectives.
Rangeland Ecology and Management. 64(6): 1-12.

Rangelands

Our analysis mask:



~ 662 million ac

Drought

Meteorological: degree of dryness over a defined period of time

Agricultural: linking meteorological drought w/ ag impacts

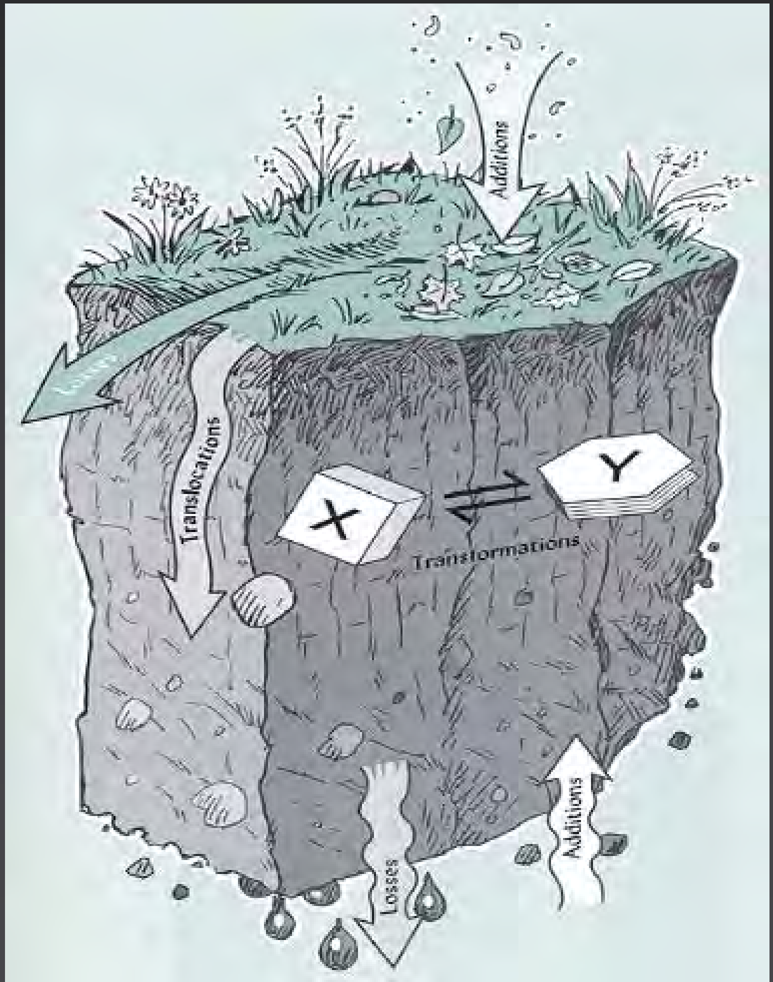
Hydrologic: precipitation deficits and their effect on the hydrologic system

Socio-economic: demand for an economic good exceeds supply as a result of a weather/climate induced related shortfall in water supply

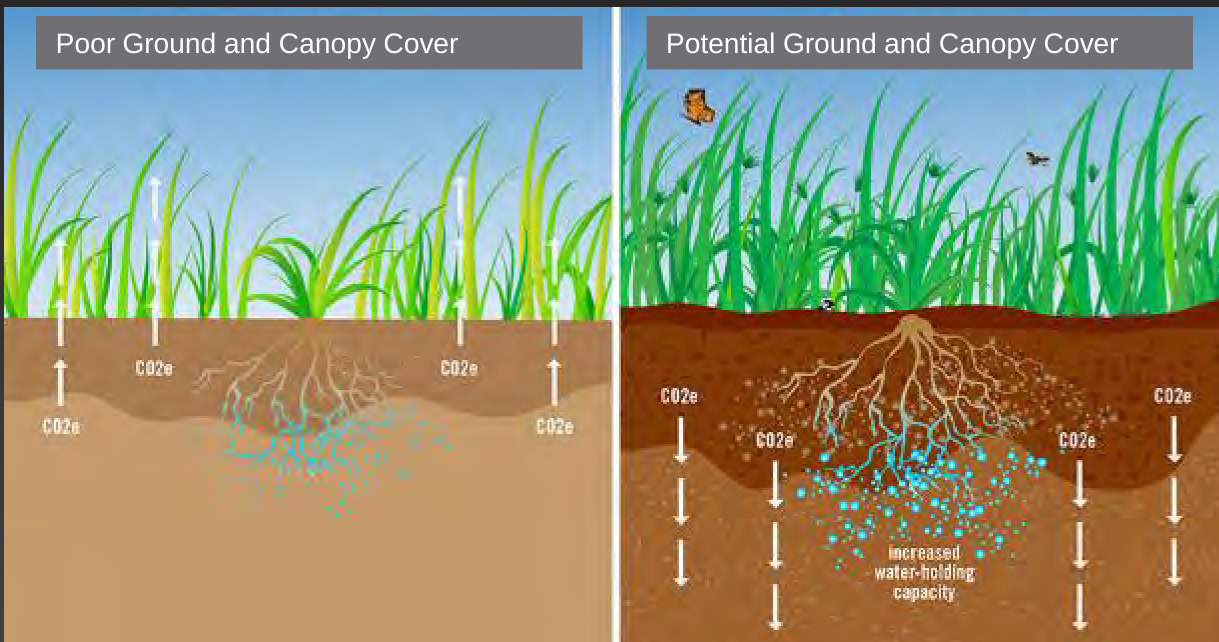
Wilhite, D.A. and Glantz, M.H., *Understanding the Drought Phenomenon: The Role of Definitions* (1985)

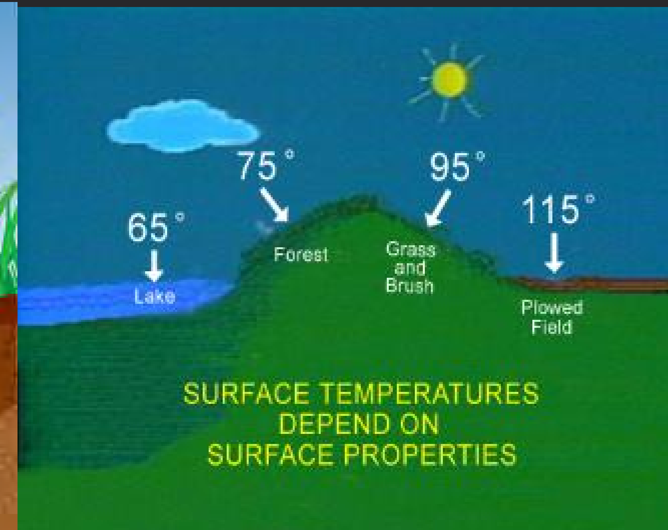
Drought: its more than plants wilting

- Soil temperature increase
- Soil organic carbon respiration increase
- Soil biology changes
- Soil nutrients
- Cation exchange capacity
- pH
- Salinization and acidification
- Bulk density
  - Water Holding Capacity
- Runoff and erosion

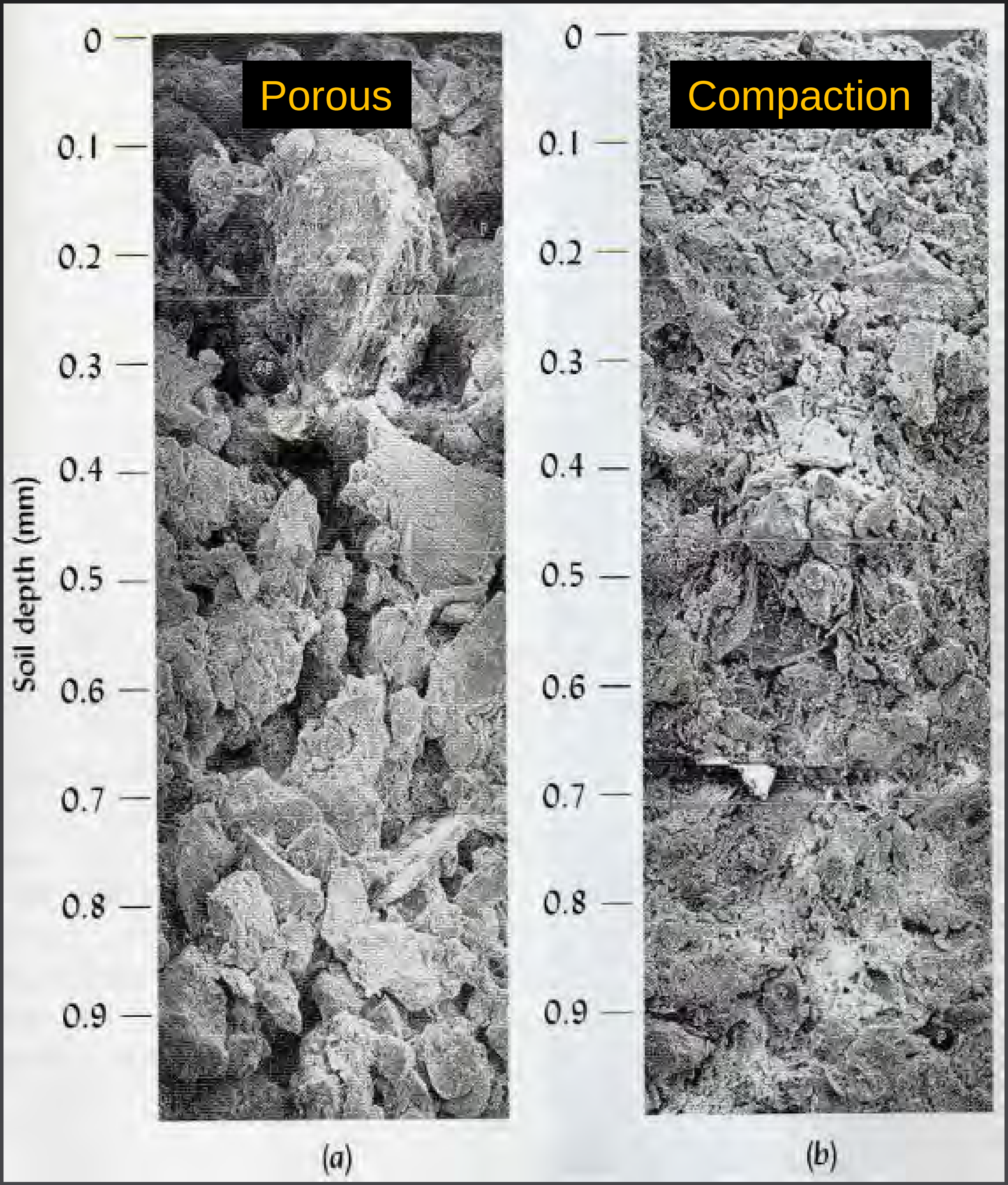


Soil Cover Matters

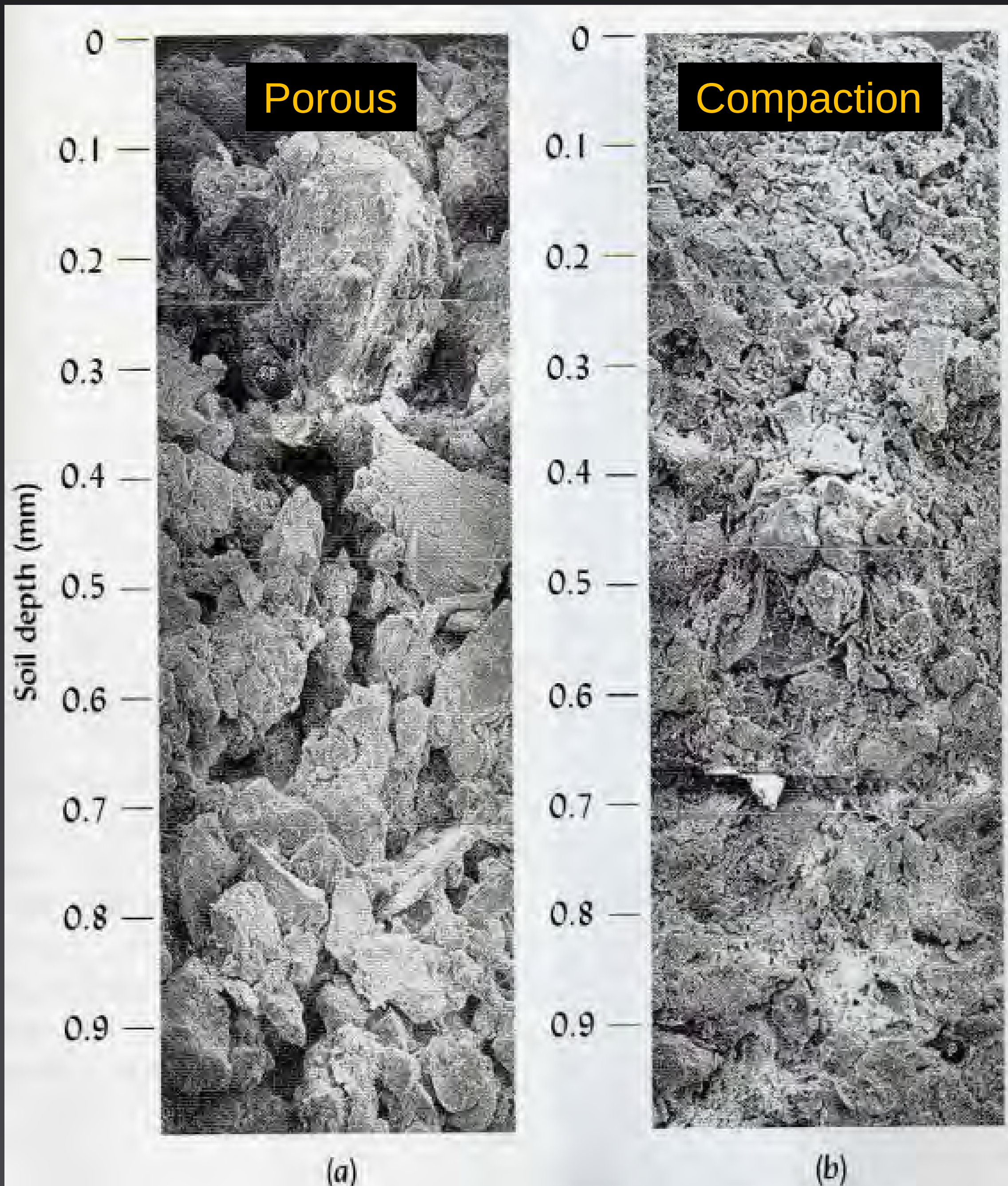




Soil should be one of our favorite things that we rarely see!

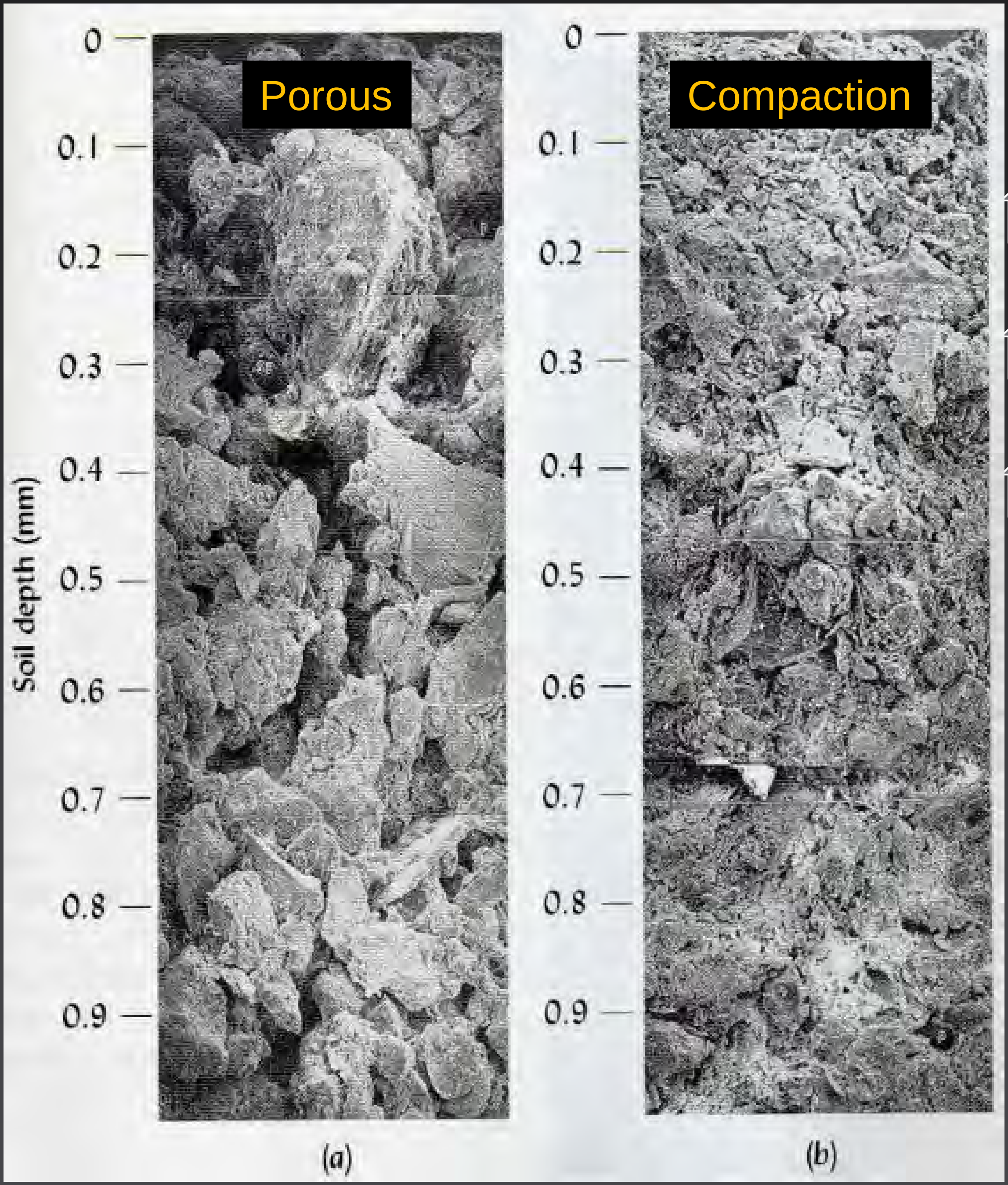


Courtesy:
Marlon Winger



Battle is won or lost here!

Courtesy: Marlon Winger

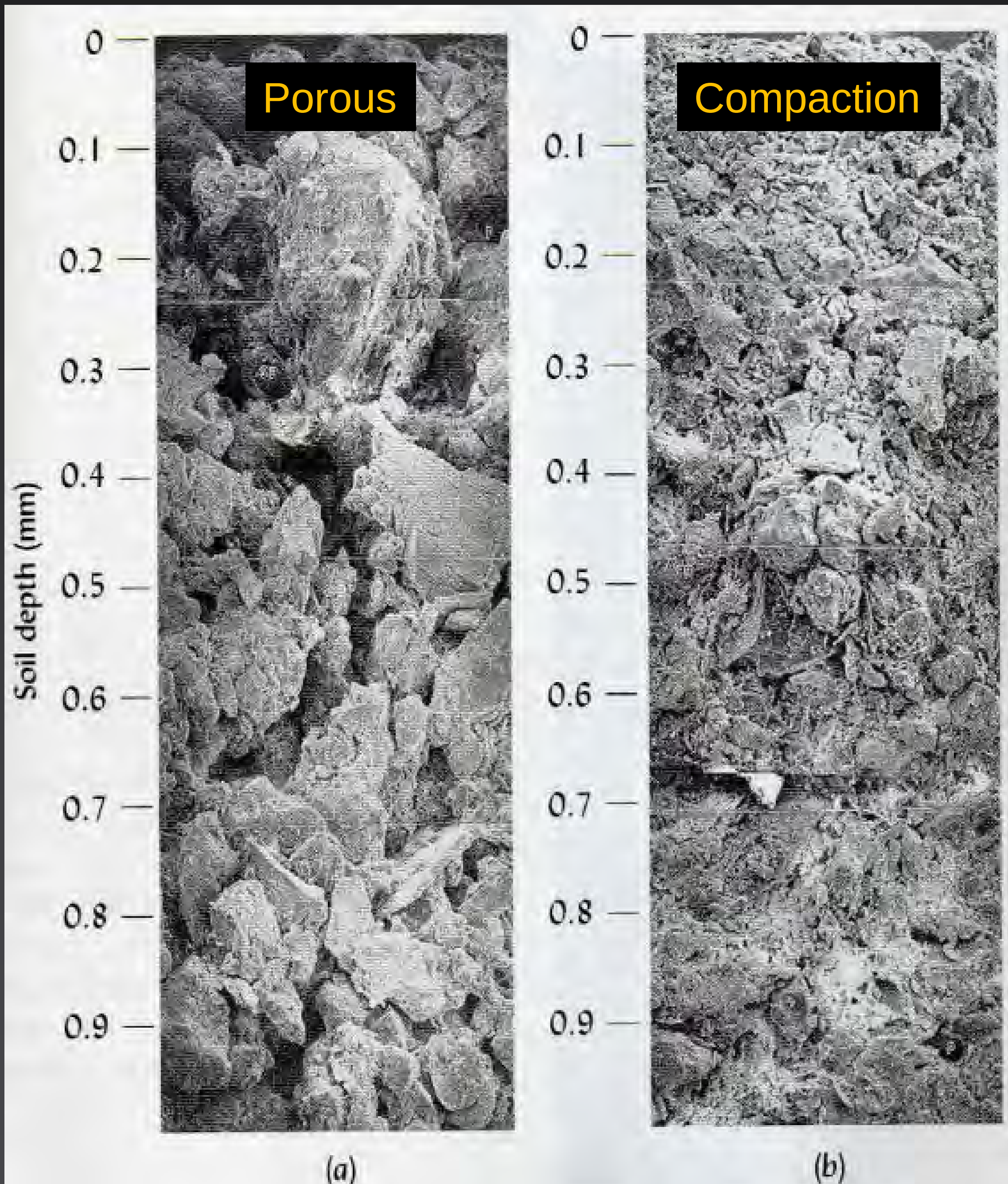


Increased infiltration

Increased microbial activity

Increased soil organic matter

Courtesy:
Marlon Winger



Increased infiltration

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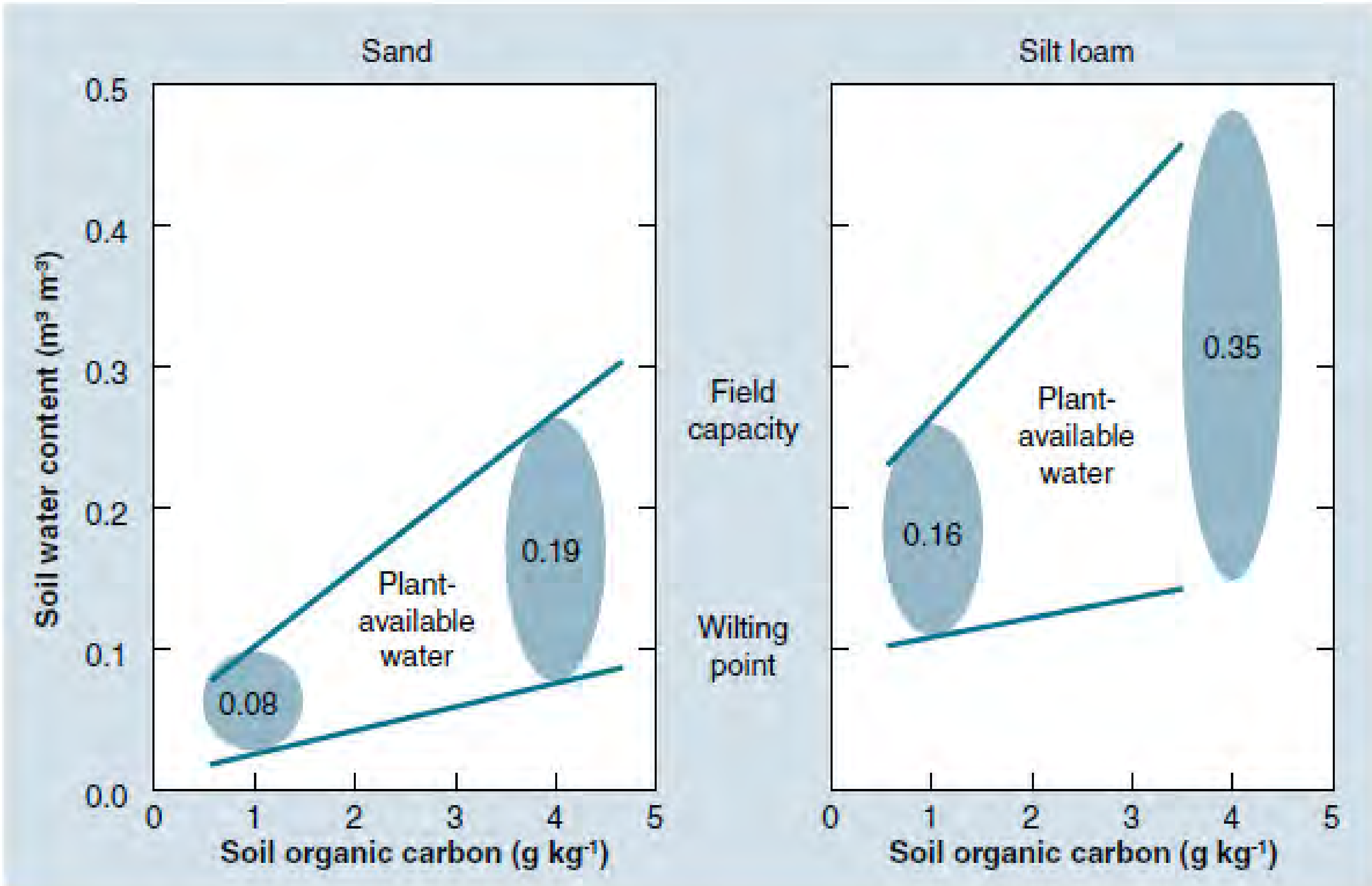
Courtesy: Marlon Winger

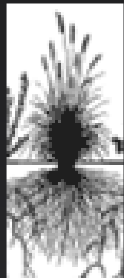


Courtesy:
Ben Rau

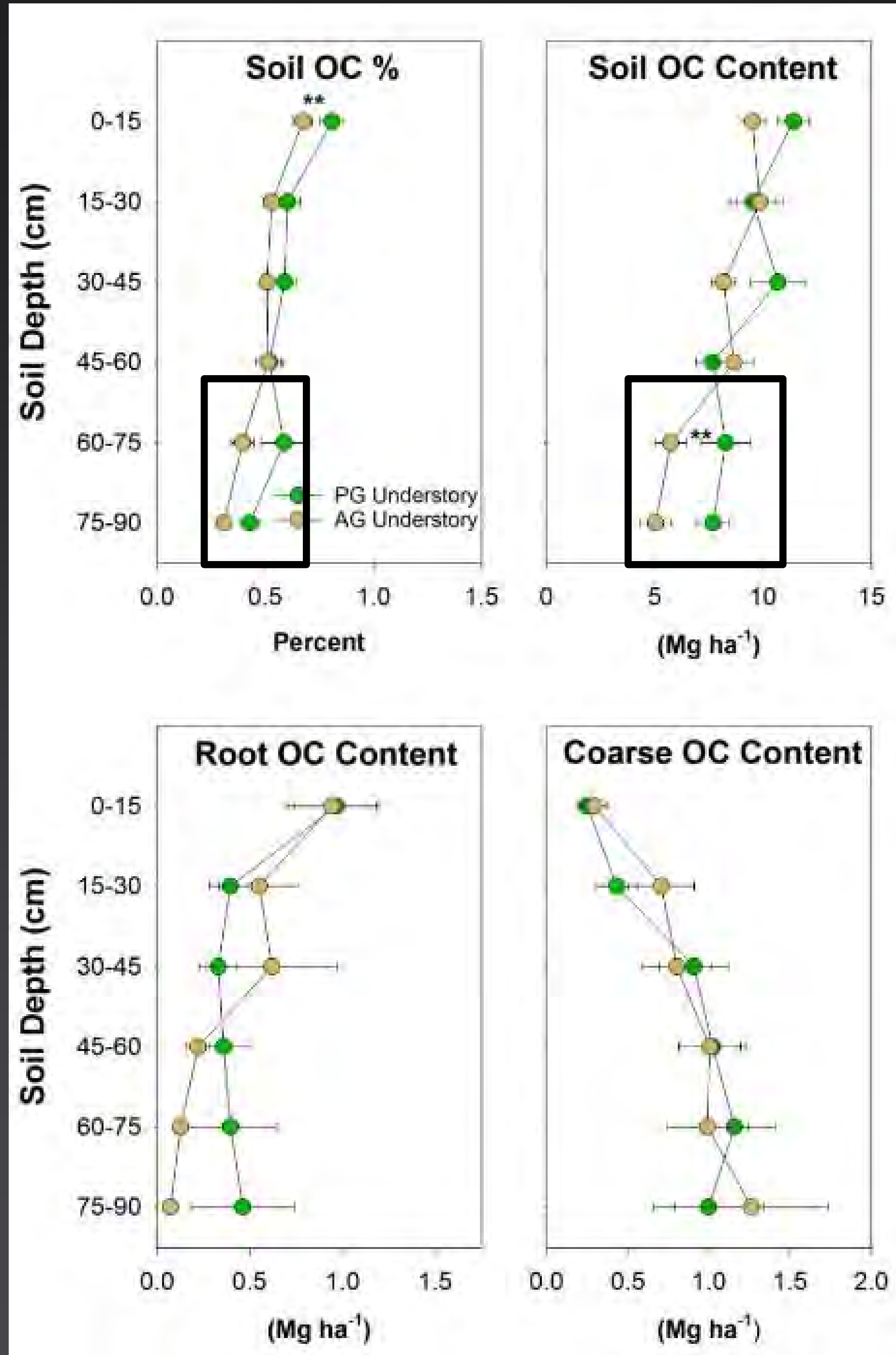
Is this landscape as resilient to drought as it could be?

Why or why not?

Courtesy SageSTEP Project



Shallow roots annuals



SOC = resiliency

Deep roots perennials

Courtesy: Ben Rau

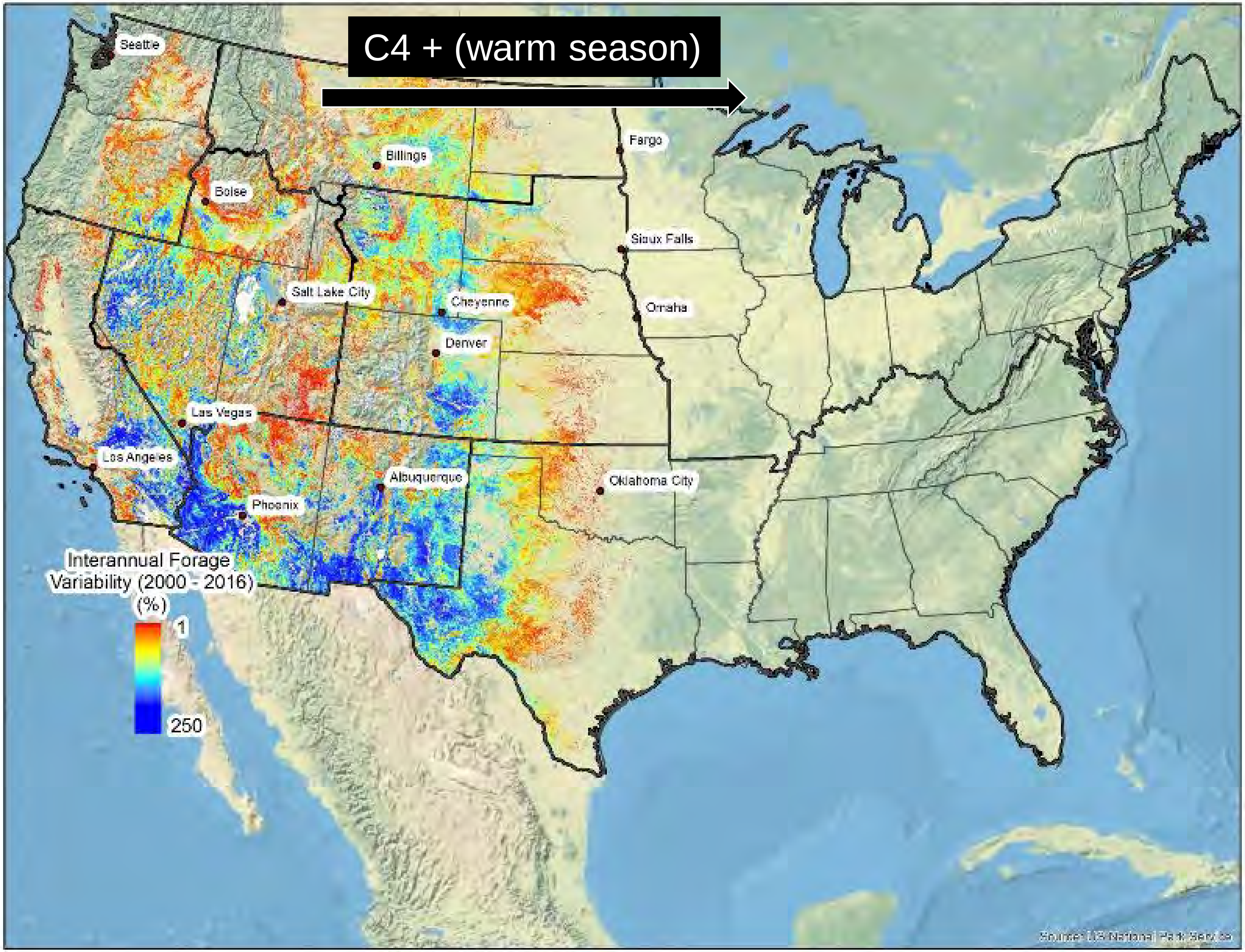
SageStep Project

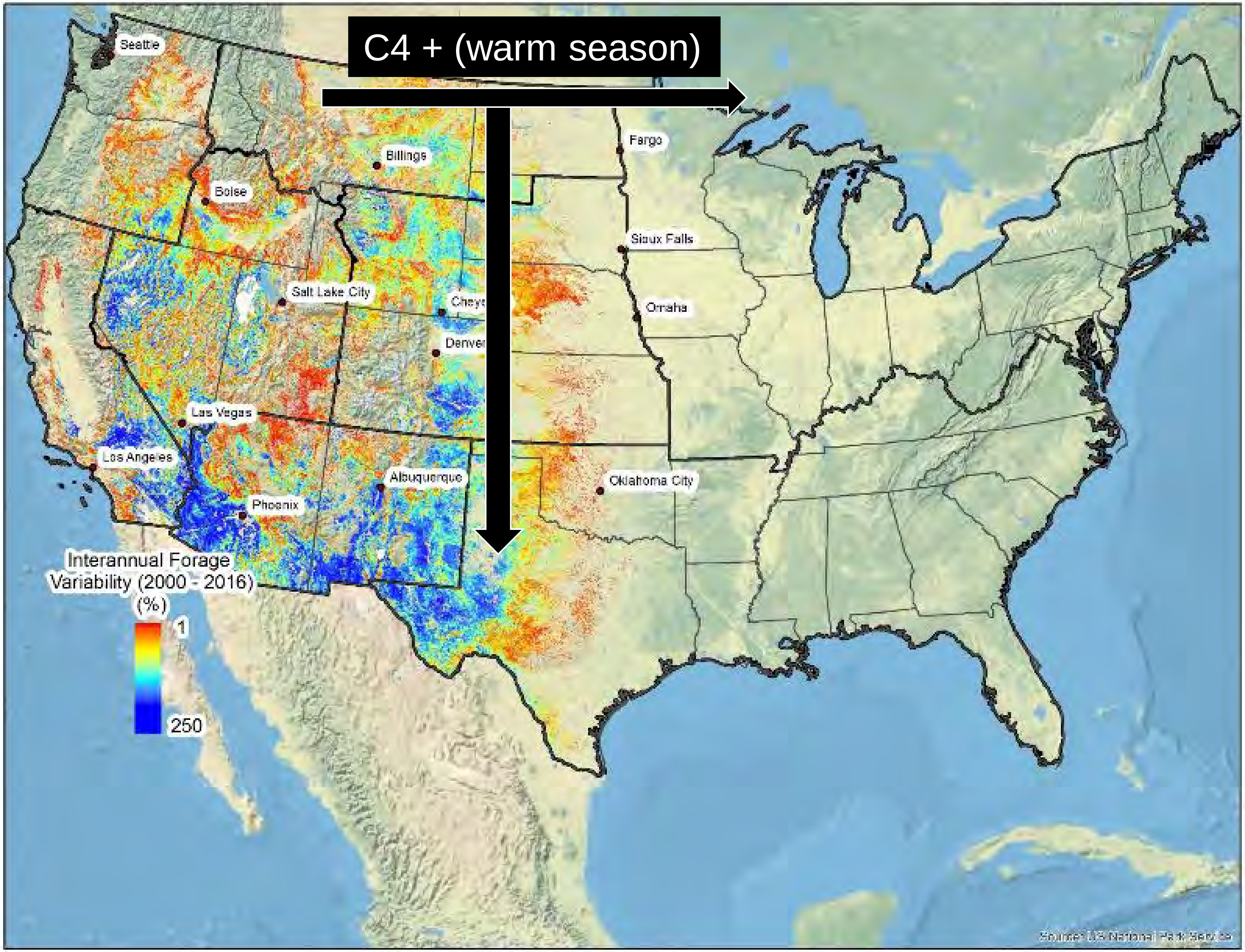
Maintain suitable cover or perennial species (especially herbs where appropriate)

Ensure suitable suite of photosynthetic pathways (where appropriate)

VS

Courtesy SageSTEP Project


C4 + (warm season)
Seattle
Billings
Fargo
Boise
Sioux Falls
Salt Lake City
Cheyenne
Omaha
Denver
Las Vegas
Los Angeles
Albuquerque
Oklahoma City
Phoenix
Interannual Forage Variability (2000 - 2016) (%)
1
250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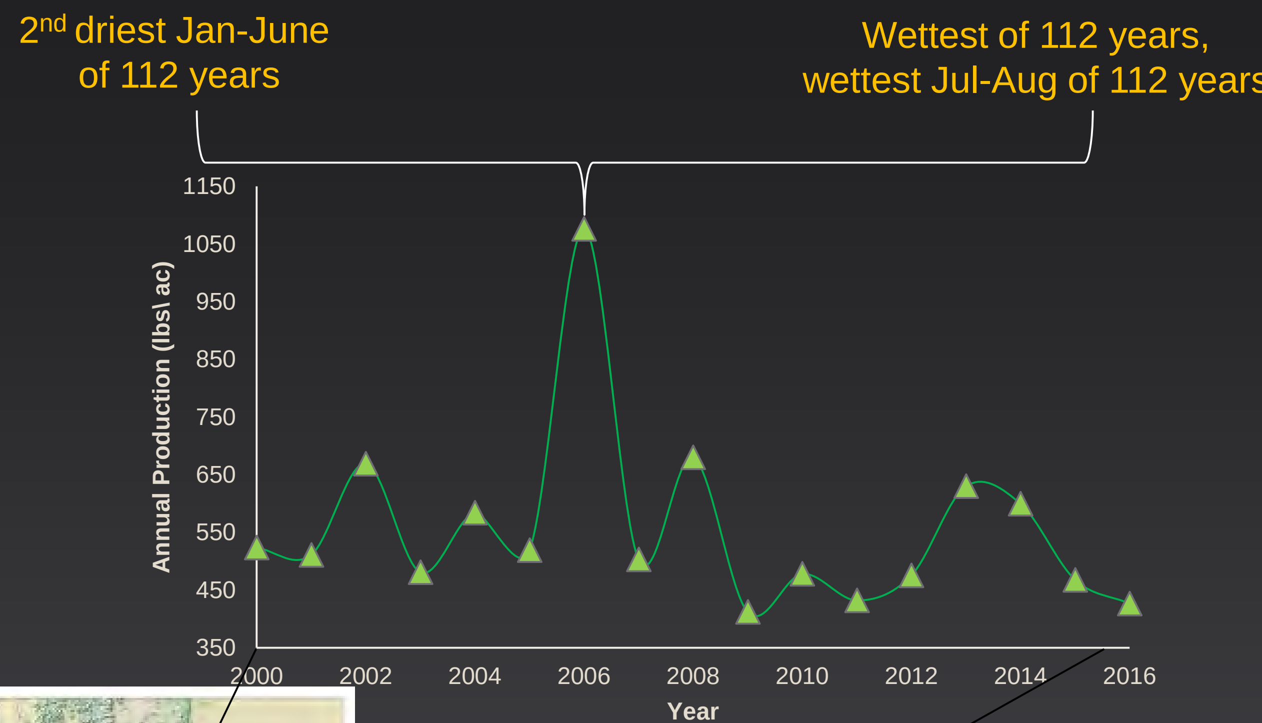
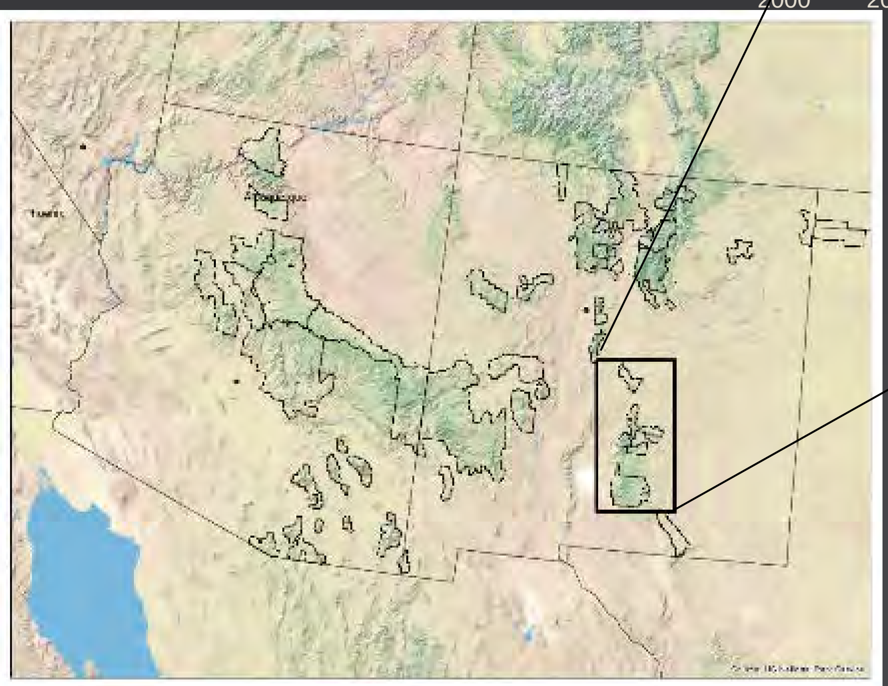
Interannual Forage
Variability (2000 - 2016)
(%)
1
250
Source: US National Park Service

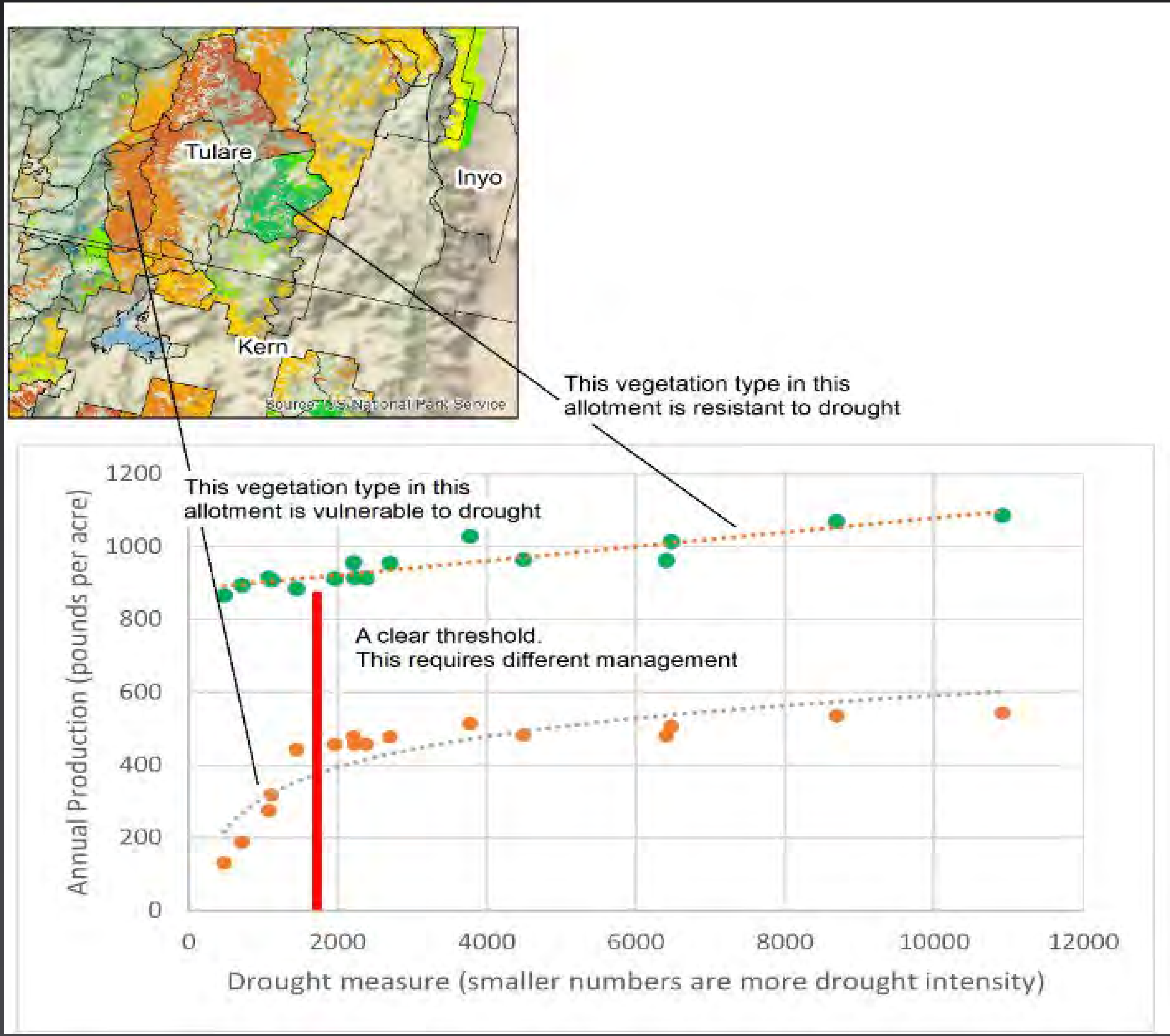




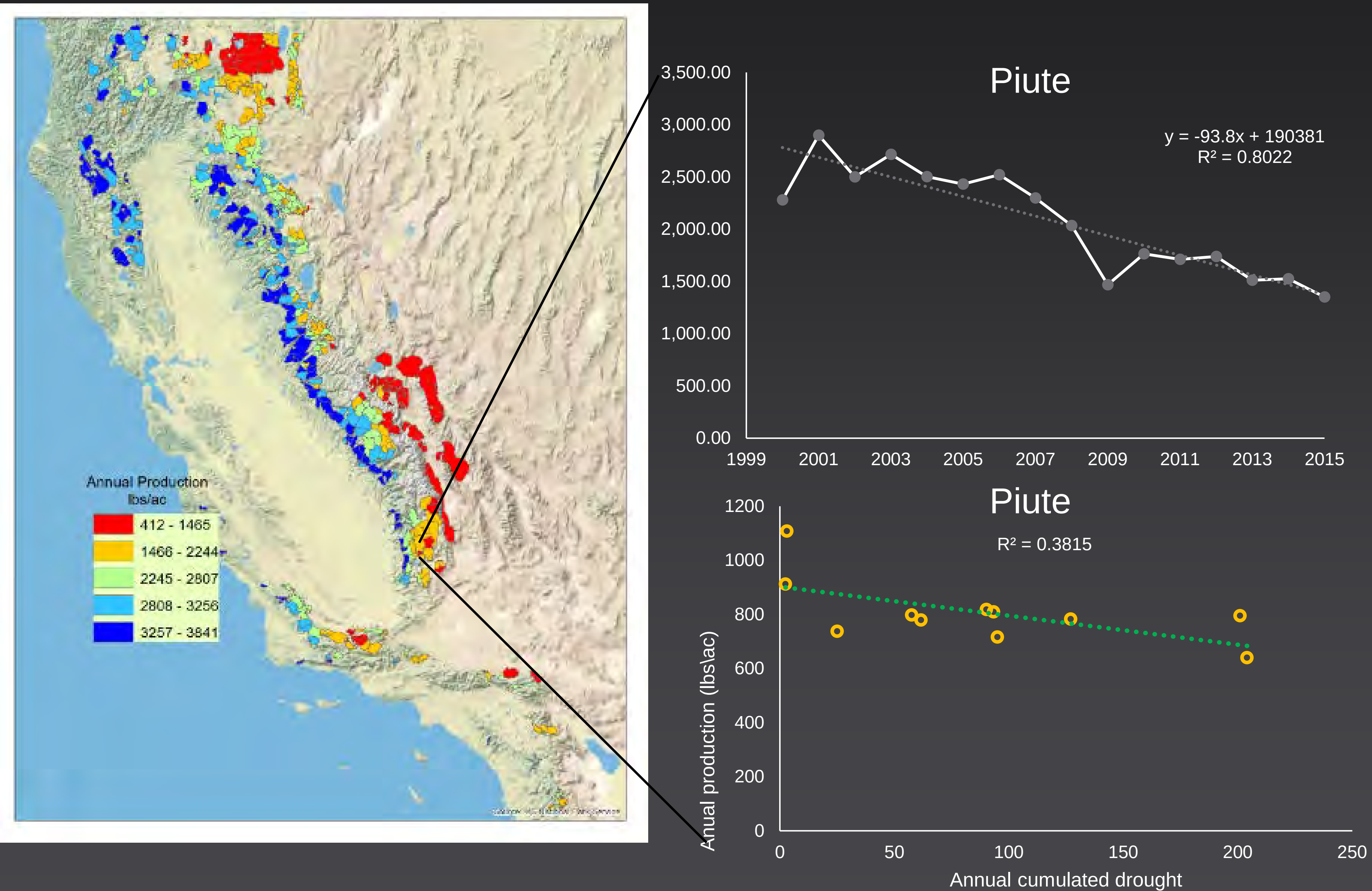
Short window for positive carbon balance

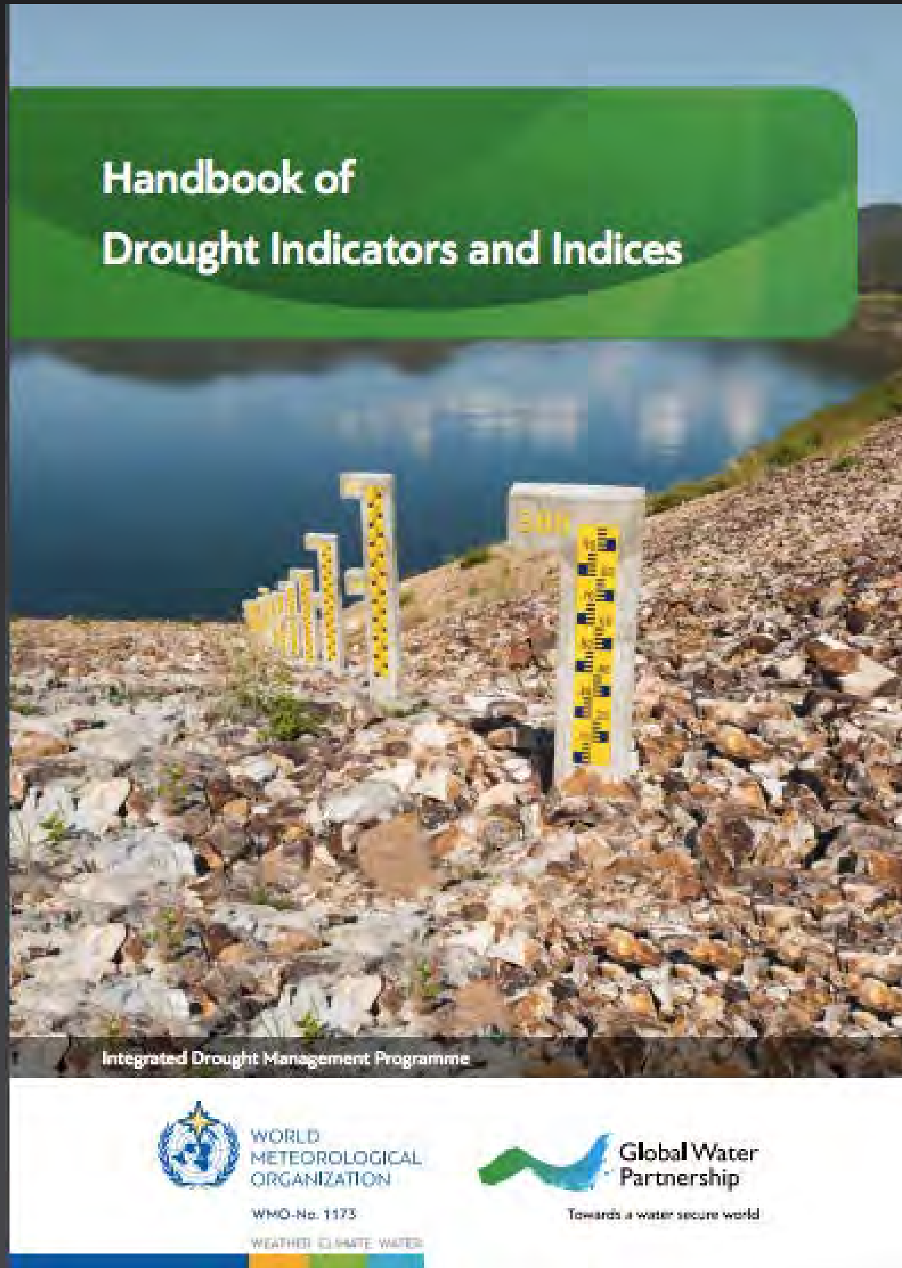
C4 + (warm season) helps

Evaluating drought resiliency: How is our management working?



Evaluating drought resiliency: How is our management working?




Handbook of
Drought Indicators and Indices
Integrated Drought Management Programme
WORLD
METEOROLOGICAL
ORGANIZATION
WMO-No. 1173
WEATHER CLIMATE WATER
Global Water
Partnership
Towards a water secure world

Meteorology	Page	Ease of use	Input parameters	Additional information
Aridity Anomaly Index (AAI)	11	Green	P, T, PET, ET	Operationally available for India
Deciles	11	Green	P	Easy to calculate; examples from Australia are useful
Keetch–Byram Drought Index (KBDI)	12	Green	P, T	Calculations are based upon the climate of the area of interest
Percent of Normal Precipitation	12	Green	P	Simple calculations
Standardized Precipitation Index (SPI)	13	Green	P	Highlighted by the World Meteorological Organization as a starting point for meteorological drought monitoring
Weighted Anomaly Standardized Precipitation (WASP)	15	Green	P, T	Uses gridded data for monitoring drought in tropical regions
Aridity Index (AI)	15	Yellow	P, T	Can also be used in climate classifications
China Z Index (CZI)	16	Yellow	P	Intended to improve upon SPI data
Crop Moisture Index (CMI)	16	Yellow	P, T	Weekly values are required
Drought Area Index (DAI)	17	Yellow	P	Gives an indication of monsoon season performance
Drought Reconnaissance Index (DRI)	17	Yellow	P, T	Monthly temperature and precipitation are required

Hydrology	Page	Ease of use	Input parameters	Additional information
Palmer Hydrological Drought Severity Index (PHDI)	27	Yellow	P, T, AWC	Serially complete data required
Standardized Reservoir Supply Index (SRSI)	28	Yellow	RD	Similar calculations to SPI using reservoir data
Standardized Streamflow Index (SSFI)	29	Yellow	SF	Uses the SPI program along with streamflow data
Standardized Water-level Index (SWI)	29	Yellow	GW	Similar calculations to SPI, but using groundwater or well-level data instead of precipitation
Streamflow Drought Index (SDI)	30	Yellow	SF	Similar calculations to SPI, but using streamflow data instead of precipitation
Surface Water Supply Index (SWSI)	30	Yellow	P, RD, SF, S	Many methodologies and derivative products are available, but comparisons between basins are subject to the method chosen

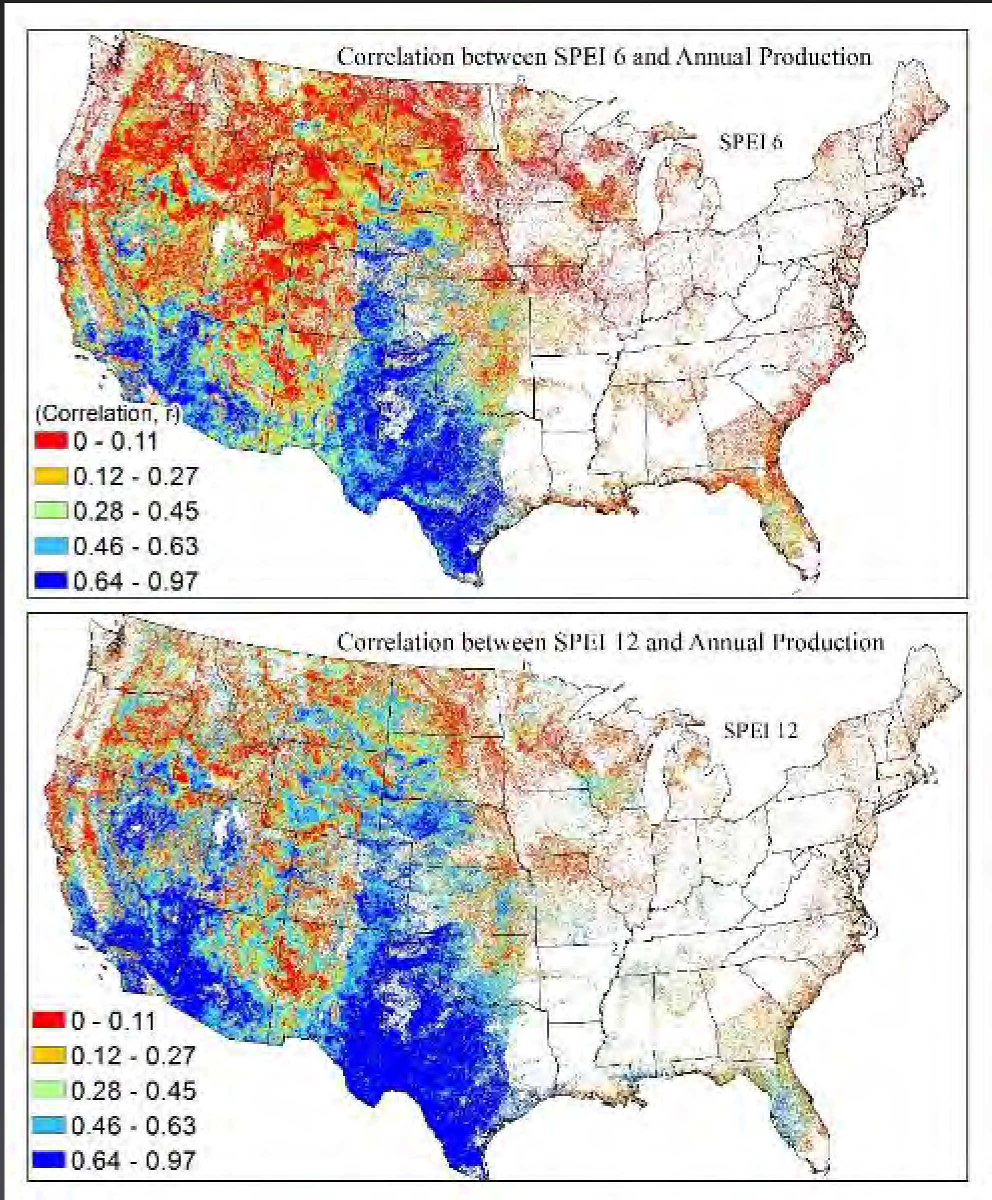
Remote sensing	Page	Ease of use	Input parameters	Additional information
Enhanced Vegetation Index (EVI)	32	Green	Sat	Does not separate drought stress from other stress
Evaporative Stress Index (ESI)	33	Green	Sat, PET	Does not have a long history as an operational product
Normalized Difference Vegetation Index (NDVI)	33	Green	Sat	Calculated for most locations
Temperature Condition Index (TCI)	34	Green	Sat	Usually found along with NDVI calculations
Vegetation Condition Index (VCI)	34	Green	Sat	Usually found along with NDVI calculations
Vegetation Drought Response Index (VegDRI)	35	Green	Sat, P, T, AWC, LC, ER	Takes into account many variables to separate drought stress from other vegetation stress

Soil moisture	Page	Ease of use	Input parameters	Additional information
Soil Moisture Anomaly (SMA)	25	Yellow	P, T, AWC	Intended to improve upon the water balance of PDSI
Evapotranspiration Deficit Index (ETDI)	26	Red	Mod	Complex calculations with multiple inputs required
Soil Moisture Deficit Index (SMDI)	26	Red	Mod	Weekly calculations at different soil depths; complicated to calculate
Soil Water Storage (SWS)	27	Red	AWC, RD, ST, SWD	Owing to variations in both soil and crop types, interpolation over large areas is challenging

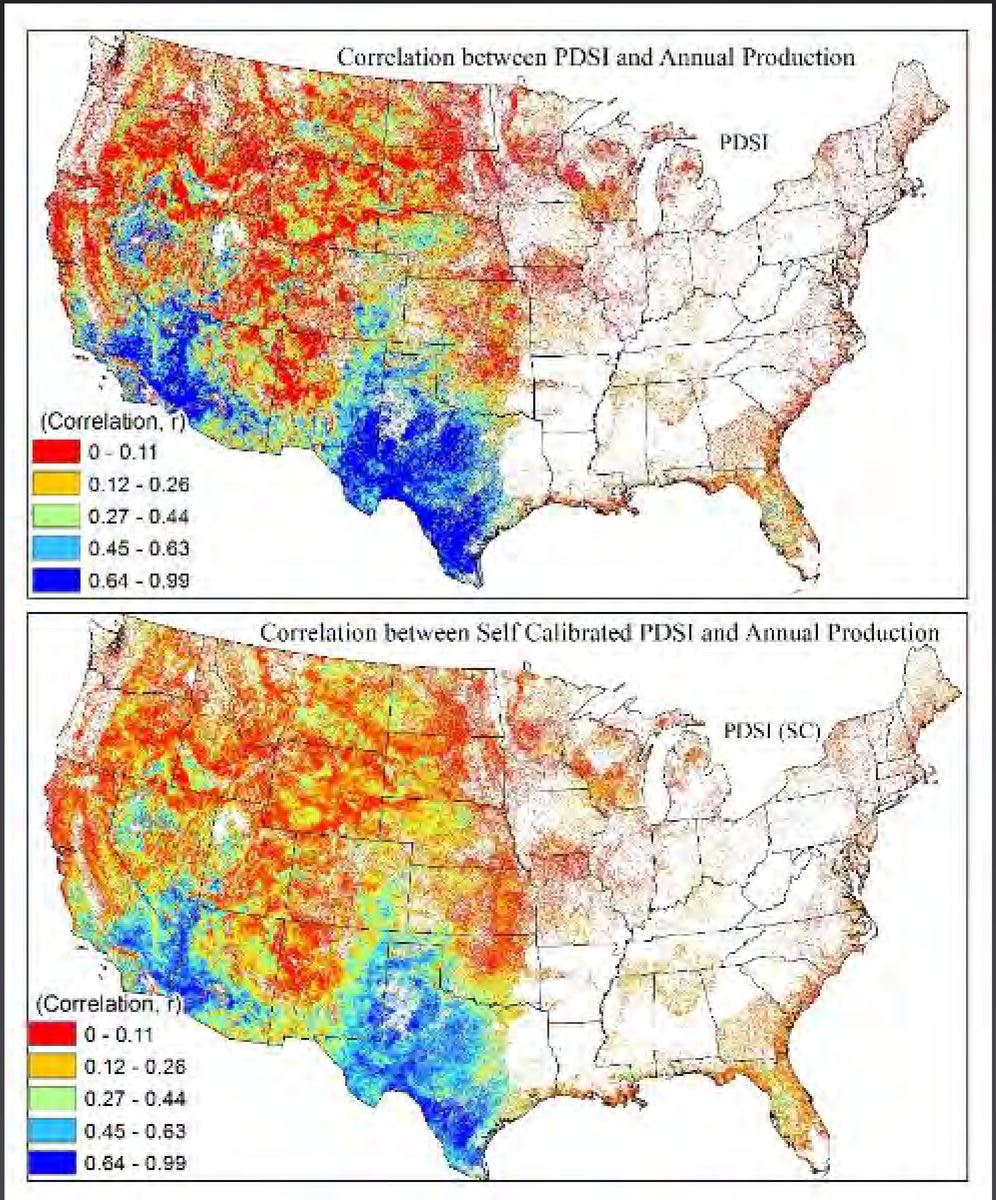
Composite or modelled	Page	Ease of use	Input parameters	Additional information
Combined Drought Indicator (CDI)	38	Green	Mod, P, Sat	Uses both surface and remotely sensed data
Global Integrated Drought Monitoring and Prediction System (GIDMaPS)	38	Green	Multiple, Mod	An operational product with global output for three drought indices: Standardized Soil Moisture Index, SPI and Multivariate Standardized Drought Index
Global Land Data Assimilation System (GLDAS)	39	Green	Multiple, Mod, Sat	Useful in data-poor regions due to global extent
Multivariate Standardized Drought Index (MSDI)	40	Green	Multiple, Mod	Available but interpretation is needed
United States Drought Monitor (USDM)	41	Green	Multiple	Available but interpretation is needed

Courtesy: Chad McNutt

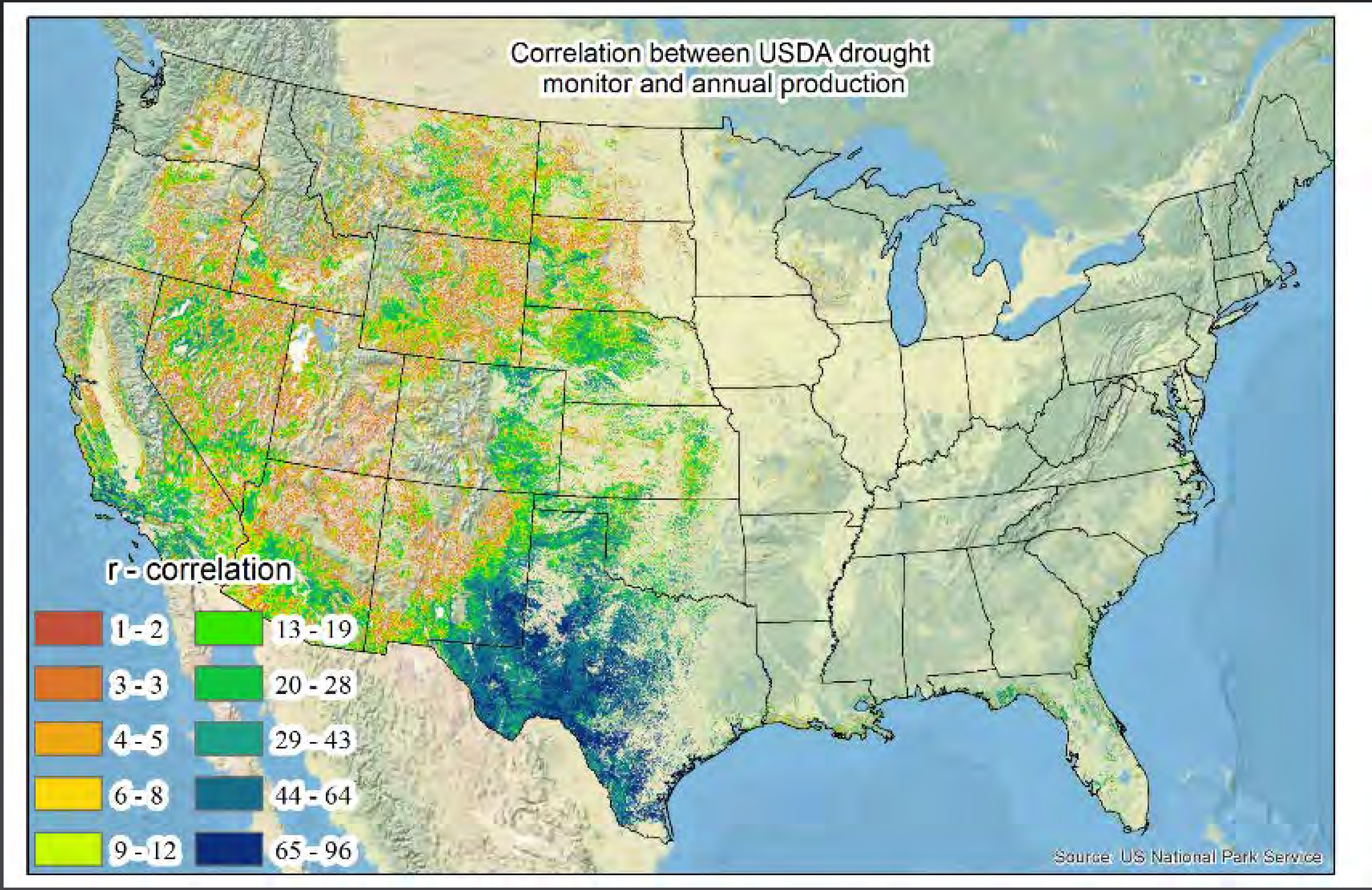
Correlation between annual rangeland production and the Standardized Precipitation - Evapotranspiration Index (2000 – 2016)



Correlation between annual rangeland production and the Palmer Drought Severity Index (2000 – 2016)



Correlation between annual rangeland production and the USDA Drought Monitor (2000 – 2016)



Drought: Ecosystem Services

The 2013 calf crop was called the lowest since 1949 at 33.9 million head

Cargill to Close West Texas Feedlot Due to Drought

Rangeland obligates may be strained
- (e.g. fewer forbs = less arthropods = reduced forage for sage grouse)

Reduced fecundity or survival of young ungulates (e.g. antelope)

Loss of forage & water for all herbivores

Increased erosion, increased fire activity…maybe

Key management concepts

- Reduce or prevent invasive species; e.g. cheatgrass
- Maintain perennial grass vigor & cover
- Focus on appropriate grazing regimes
- Promote more appropriate fire regimes

Effects of drought on rangelands: modeling and empirical

THANK YOU

Matt Reeves,

mreeves@fs.fed.us

406 546 5875

USDA United States Department of Agriculture
Climate Hubs
http://www.usda.gov/climatehubs

Questions & Answers

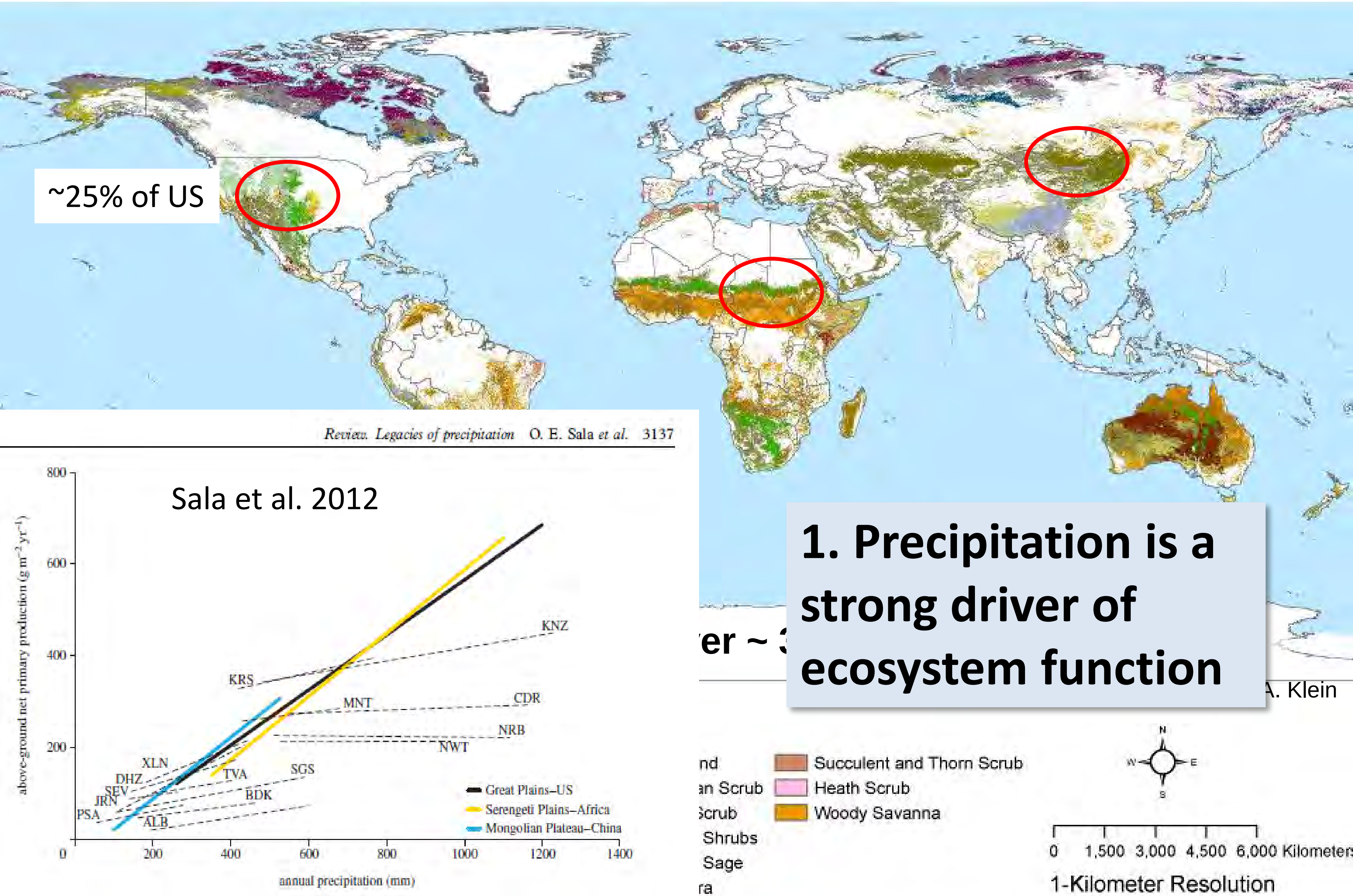
- By phone: **Dial #2 to enter the queue.**
- On your computer: **Type your question into the Q & A pod on the left side of your screen.**

Effects of drought on rangelands: experimental studies

Melinda D. Smith
Department of Biology
Colorado State University

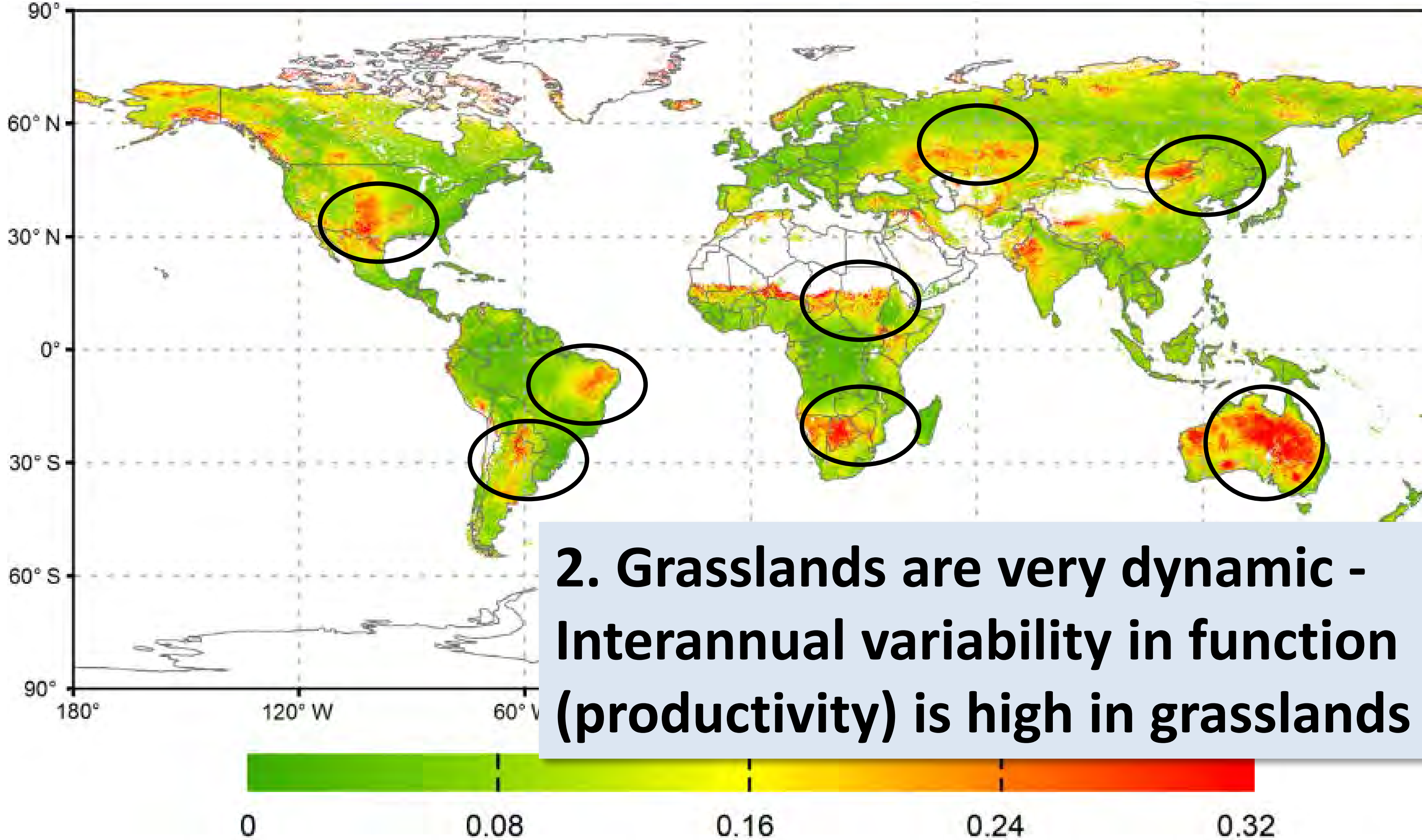
Drought and Rangelands Webinar
7 June 2017

The big picture – What we know



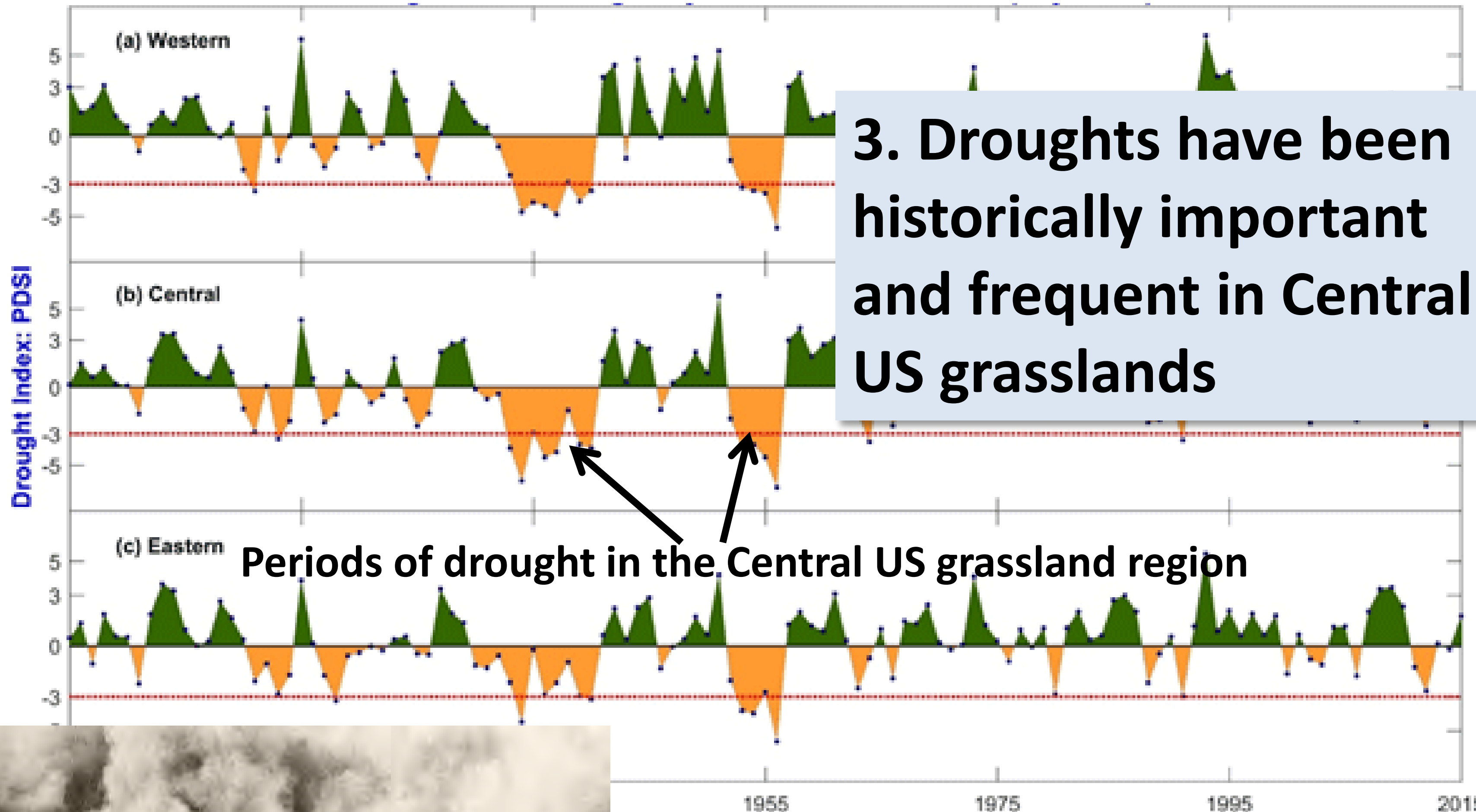
1. Precipitation is a strong driver of ecosystem function

2. Grasslands are very dynamic - Interannual variability in function (productivity) is high in grasslands



The interannual variability (i.e., the coefficient of variation or CV) of annual gross primary productivity (GPP) over the period 2000–2014 from the MODIS GPP product (MOD17A3). From: Xiao et al. 2016. Biogeosciences, 13, 3665–3675

3. Droughts have been historically important and frequent in Central US grasslands



Average PDSI for Kansas growing season (May to October) over 1895 to 2015: (a) Western, (b) Central, and (c) Eastern third of Kansas. The orange shaded areas represent unusual dryness and the green shaded areas represent unusual wetness. The dotted red lines (PDSI = -3) are indicators of severe drought occurrence as defined by PDSI.

CLIMATOLOGY

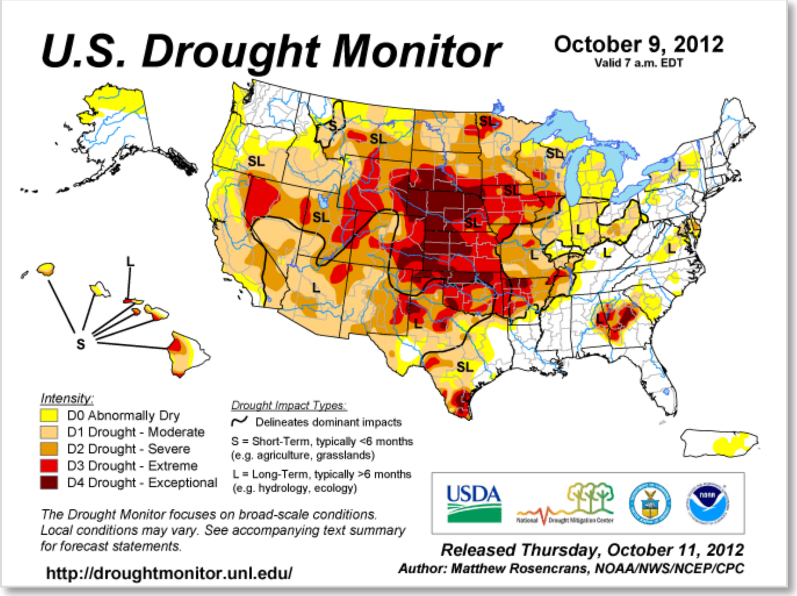
Unprecedented 21st century drought risk in the American Southwest and Central Plains

10.1126/sciadv.1400082

Benjamin I. Cook,[1,2]* Toby R. Ault,[3] Jason E. Smerdon[2]

In the Southwest and Central Plains of Western North America, climate change is expected to increase drought severity in the coming decades. These regions nevertheless experienced extended Medieval-era droughts that were more persistent than any historical event, providing crucial targets in the paleoclimate record for benchmarking the severity of future drought risks. We use an empirical drought reconstruction and three soil moisture metrics from 17 state-of-the-art general circulation models to show that these models project significantly drier conditions in the later half of the 21st century compared to the 20th century and earlier paleoclimatic intervals. This desiccation is consistent across most of the models and moisture balance variables, indicating a coherent and robust drying response to warming despite the diversity of models and metrics analyzed. Notably, future drought risk will likely exceed even the driest centuries of the Medieval Climate Anomaly (1100–1300 CE) in both moderate (RCP 4.5) and high (RCP 8.5) future emissions scenarios, leading to unprecedented drought conditions during the last millennium.

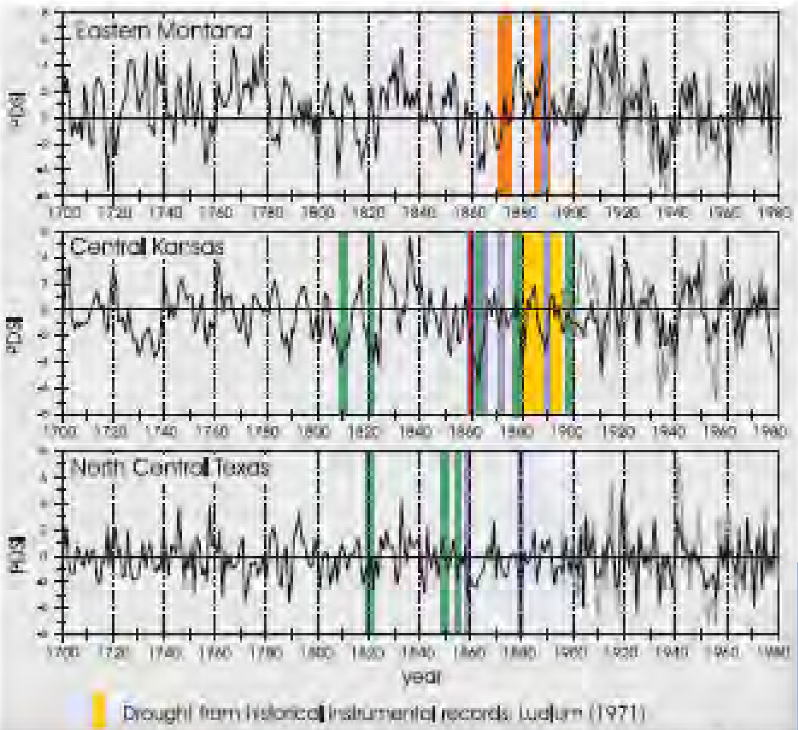
4. Droughts are forecast to become more frequent and severe in the Central US grassland region

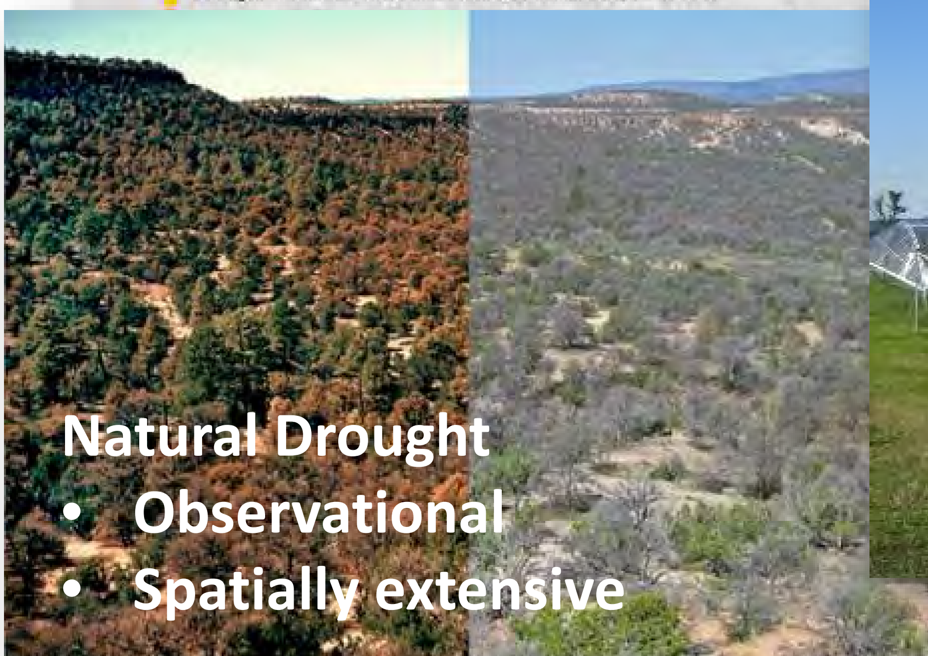


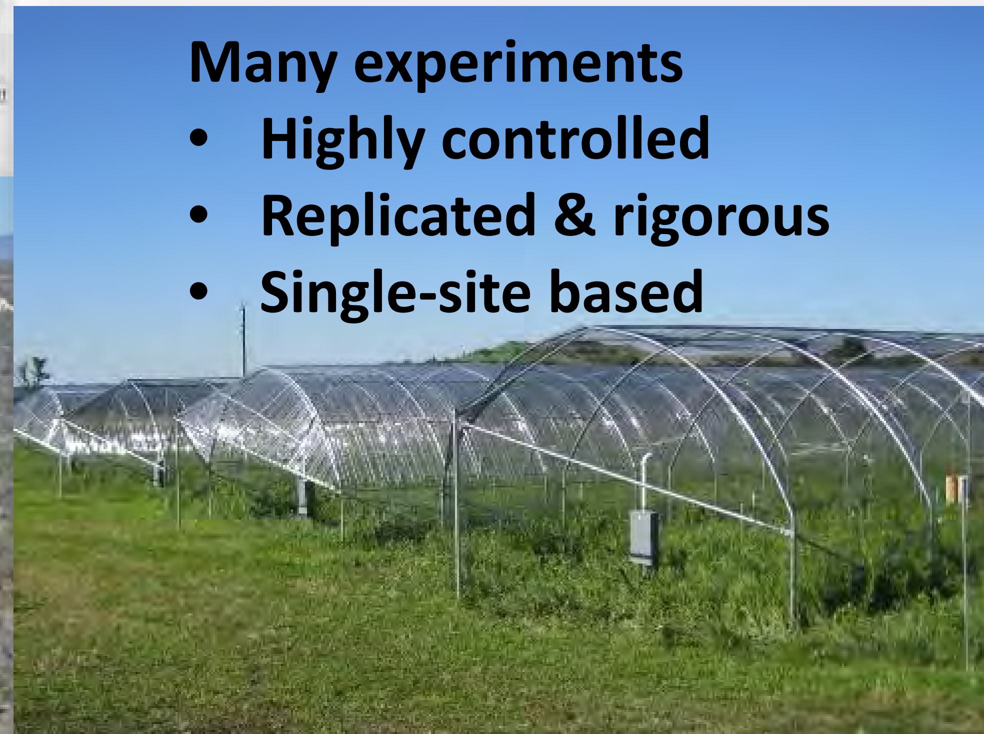
We know much about drought from many types of studies

Historical reconstructions (e.g., Woodhouse & Overpeck 1998)

- Long-term
- Observational



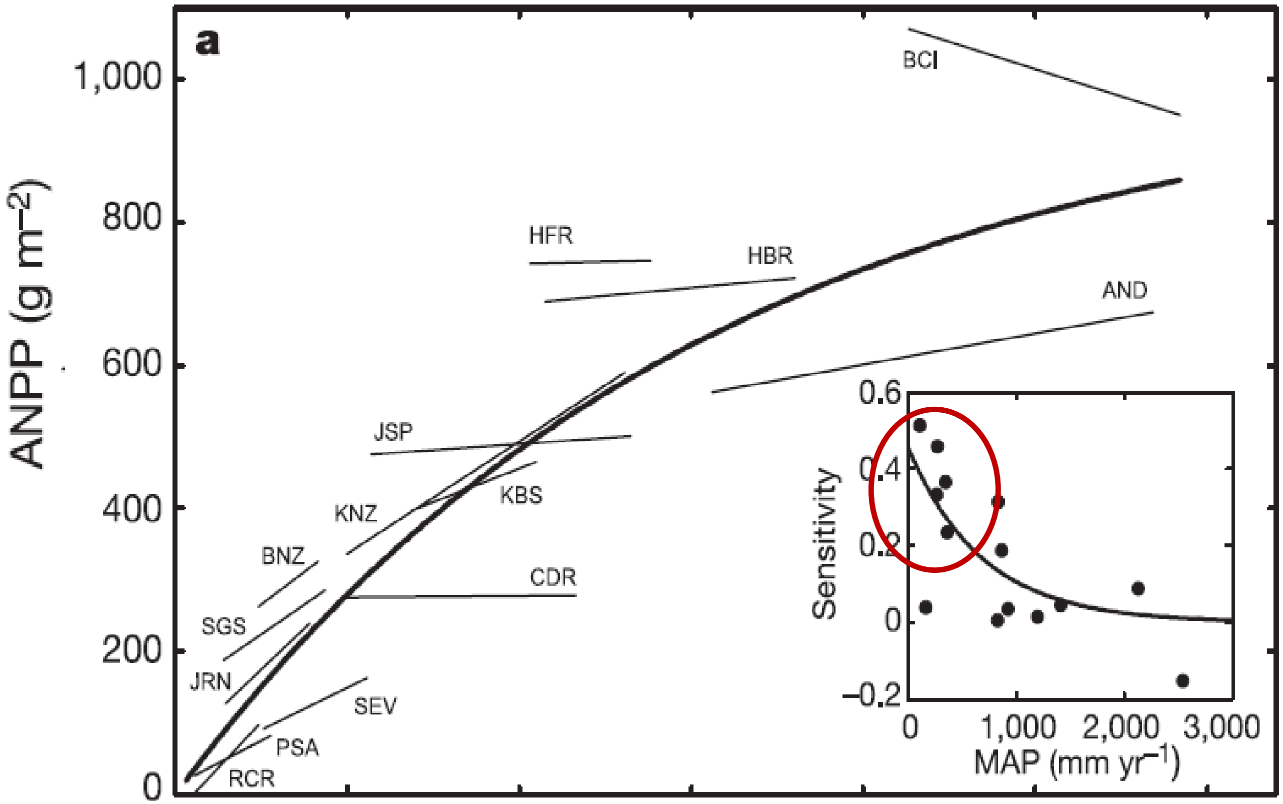




Drought experiments in the US

In almost all cases, neither the treatments imposed nor the response variables measured are comparable – thus we know surprisingly little about the ***relative sensitivity of rangeland/grassland ecosystems to drought***

Spatial model predicts differential sensitivity to drought



Arid grasslands are more sensitive to precipitation change and drought than mesic grasslands...

Huxman *et al*. 2004, Nature

Alternate prediction: Arid grasslands are dominated by stress tolerant plants and should be relatively insensitive to drought compared to mesic grasslands.

ARTICLE

Received 10 Jan 2014 | Accepted 29 Aug 2014 | Published 6 Oct 2014

DOI: 10.1038/ncomms6102

OPEN

Middle-Eastern plant communities tolerate 9 years of drought in a multi-site climate manipulation experiment

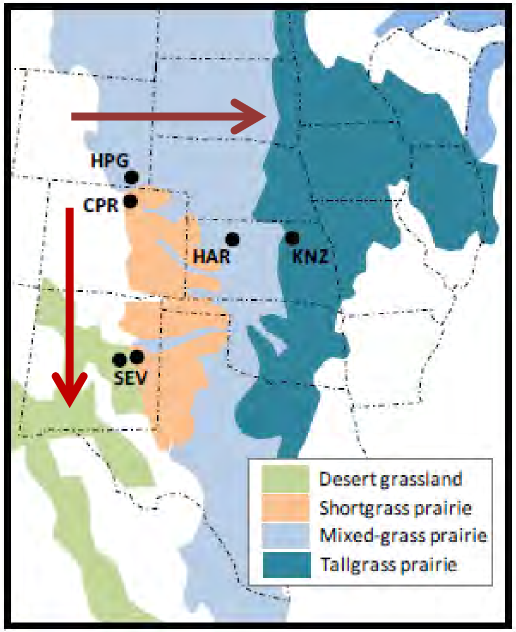
Katja Tielbörger[1], Mark C. Bilton[1], Johannes Metz[1], Jaime Kigel[2], Claus Holzapfel[3], Edwin Lebrija-Trejos[4], Irit Konsens[2], Hadas A. Parag[1,3] & Marcelo Sternberg[4]

biomass, species composition, species richness and density. The lack of a clear drought effect challenges studies classifying dryland ecosystems as most vulnerable to global change. We attribute this resistance to the tremendous temporal and spatial heterogeneity under which the plants have evolved, concluding that this should be accounted for when predicting future biodiversity change.

EDGE

EXTREME DROUGHT IN GRASSLANDS EXPERIMENT

With identical or comparable treatments and measurements



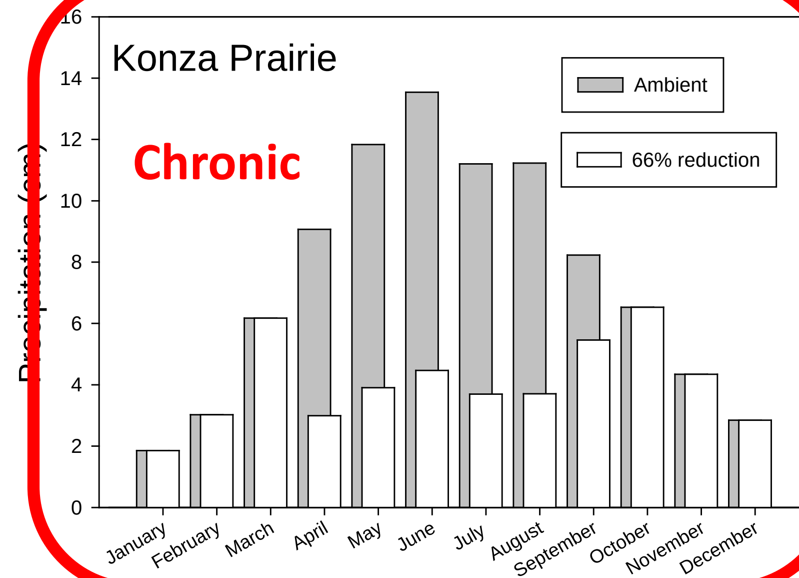
A distributed, multi-site "extreme drought" experiment in 6 grasslands

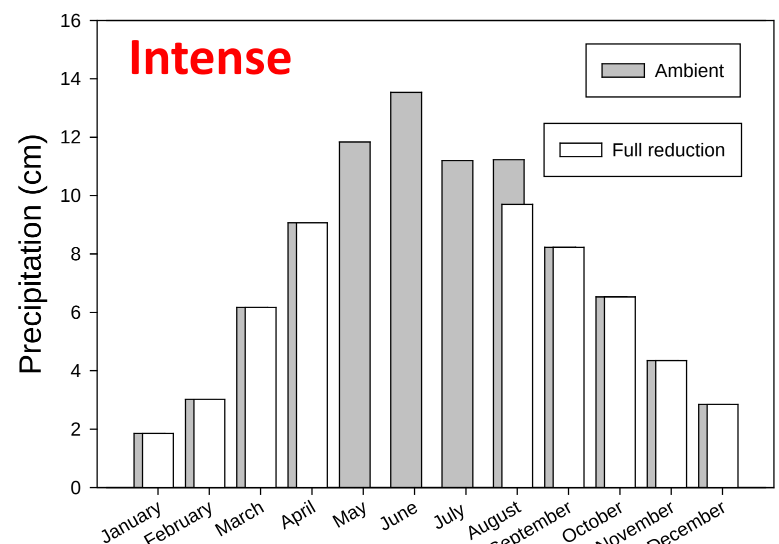
EDGE
EXTREME DROUGHT IN GRASSLANDS EXPERIMENT

Drought Treatments

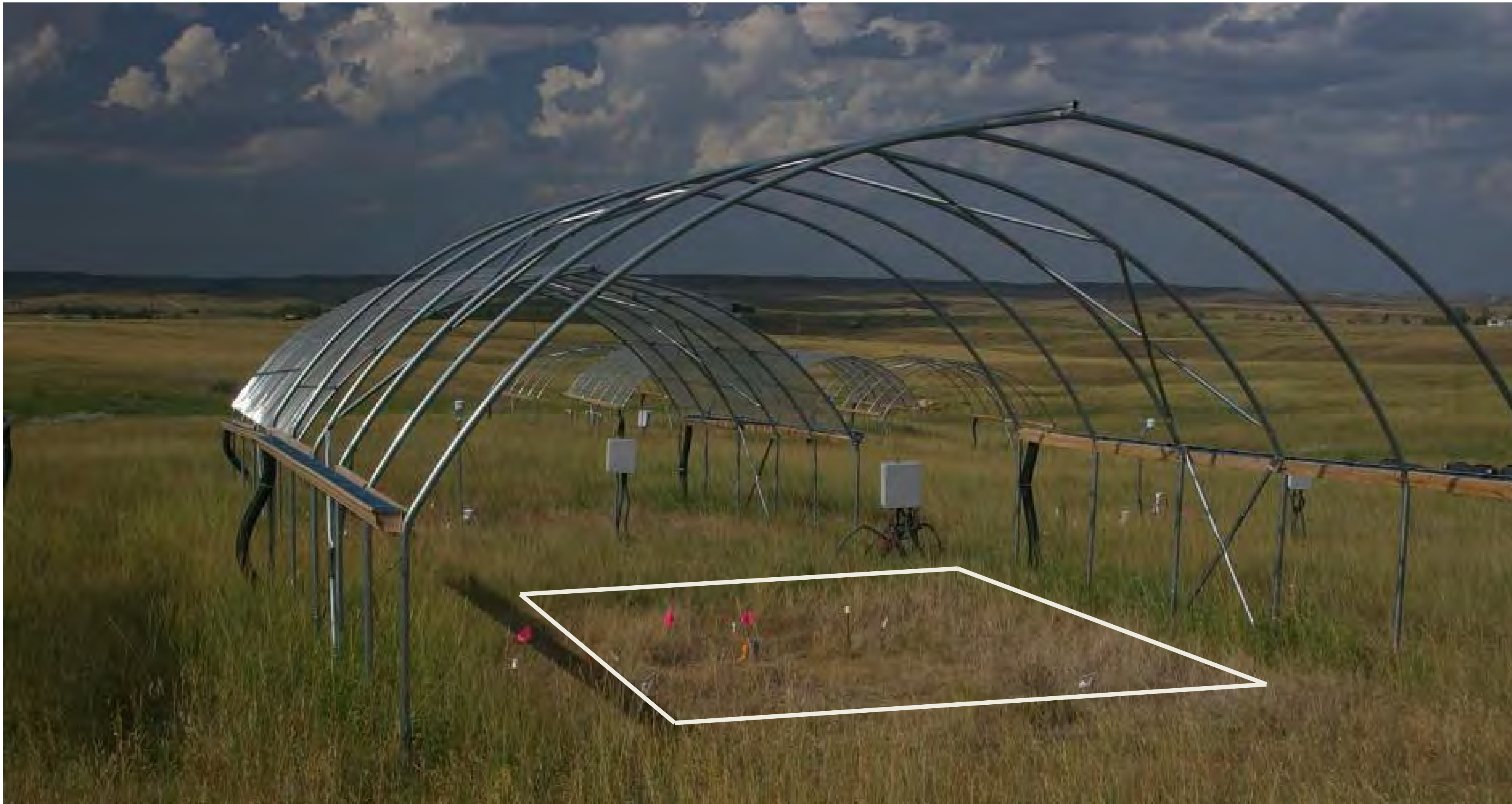
45-50% reduction in annual precipitation – 4 consecutive years will result in most extreme drought in modern records

66% reduction in growing season precipitation



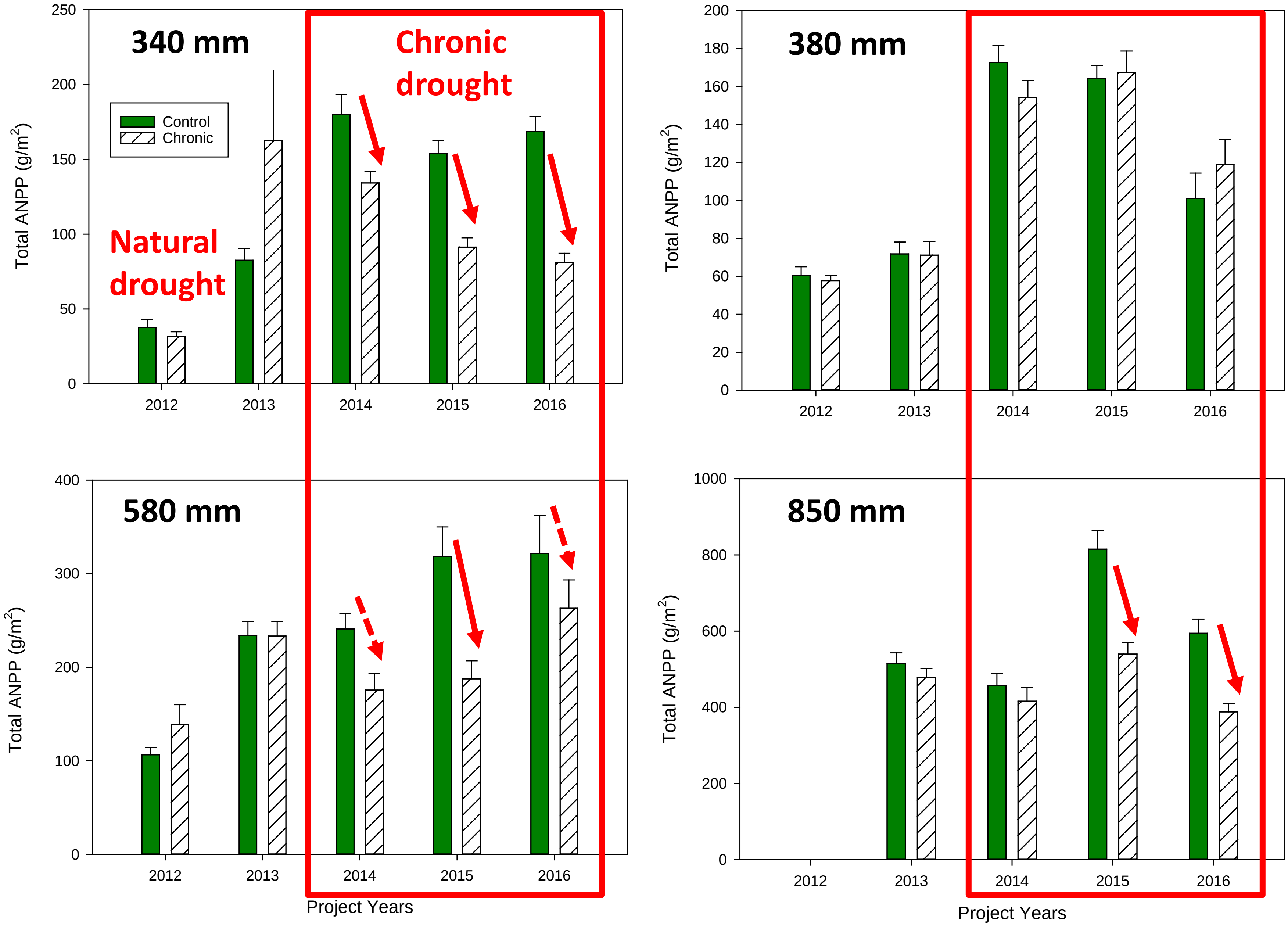


Effects of chronic drought on productivity

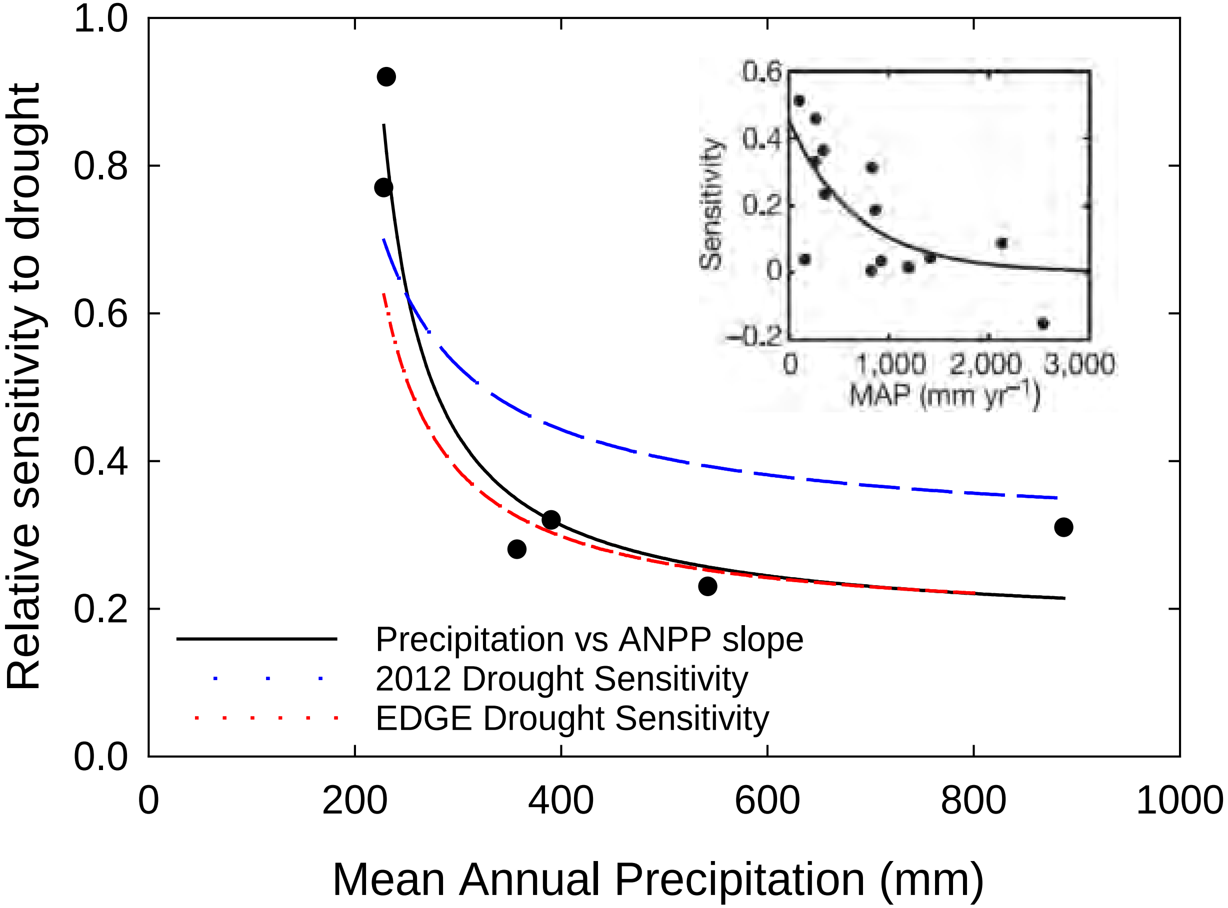


Hays, KS Southern Mixed Grass

Effects of chronic drought over time



How does sensitivity of productivity to chronic drought vary across rangelands?



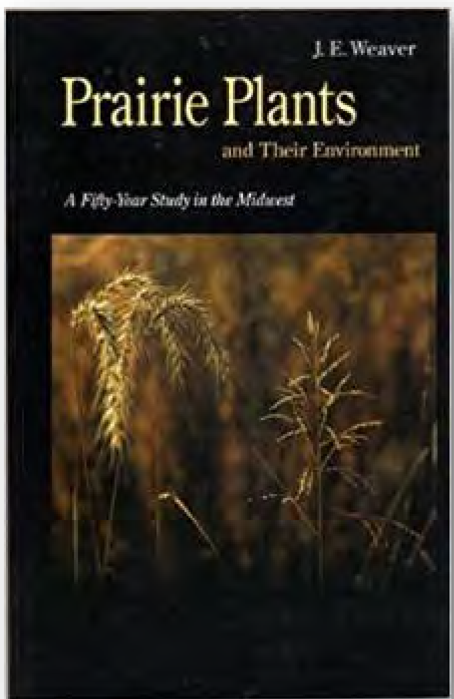
Sensitivity to a natural drought and Year 1 experimental results were similar: Sensitivity to drought was greatest in more arid grasslands

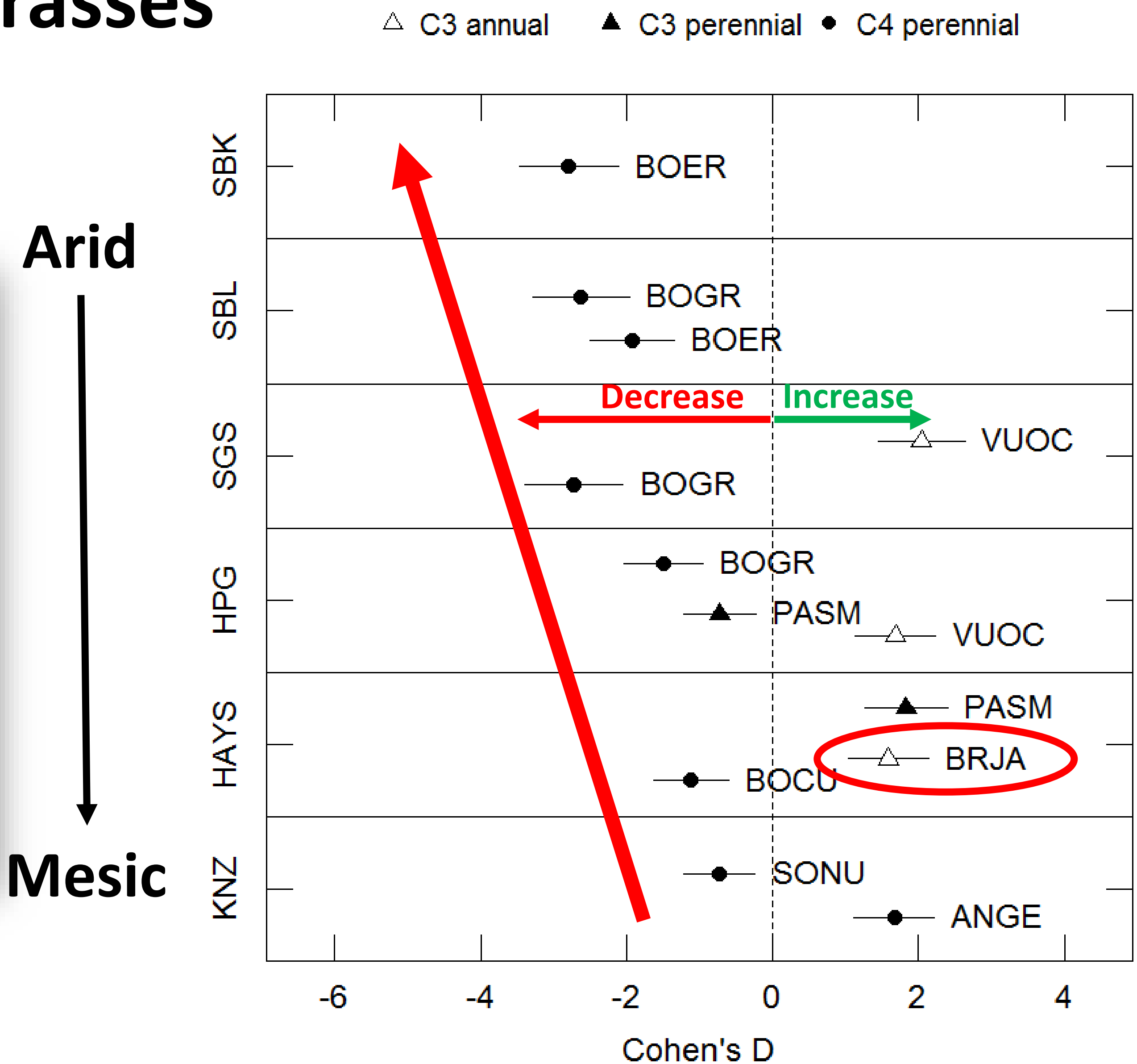
Sensitivity = reduction in ANPP per mm reduction in rainfall

What about plant community composition?

- Rapid change in plant community composition for arid rangeland
- Mesic rangelands only affected in year 3 of drought
- No consistent effects on species richness or diversity

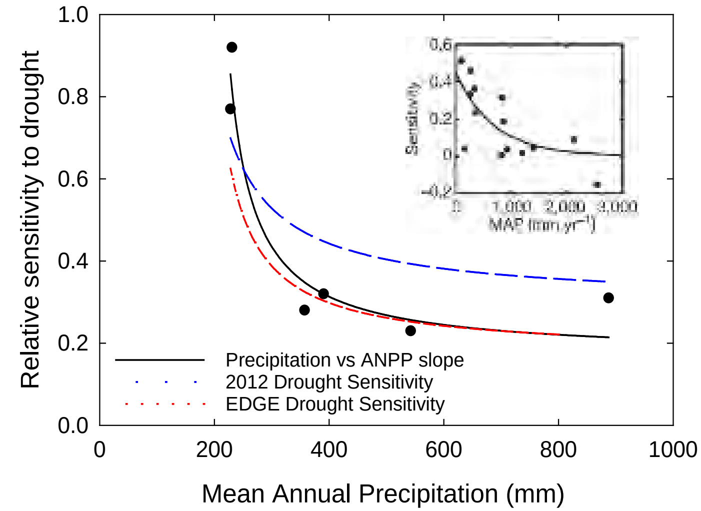
Differential sensitivity of dominant grasses



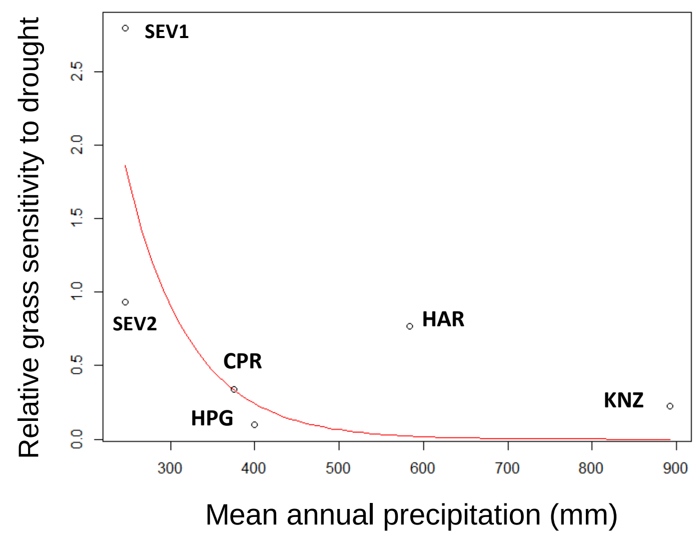


Summary of grassland sensitivity to drought

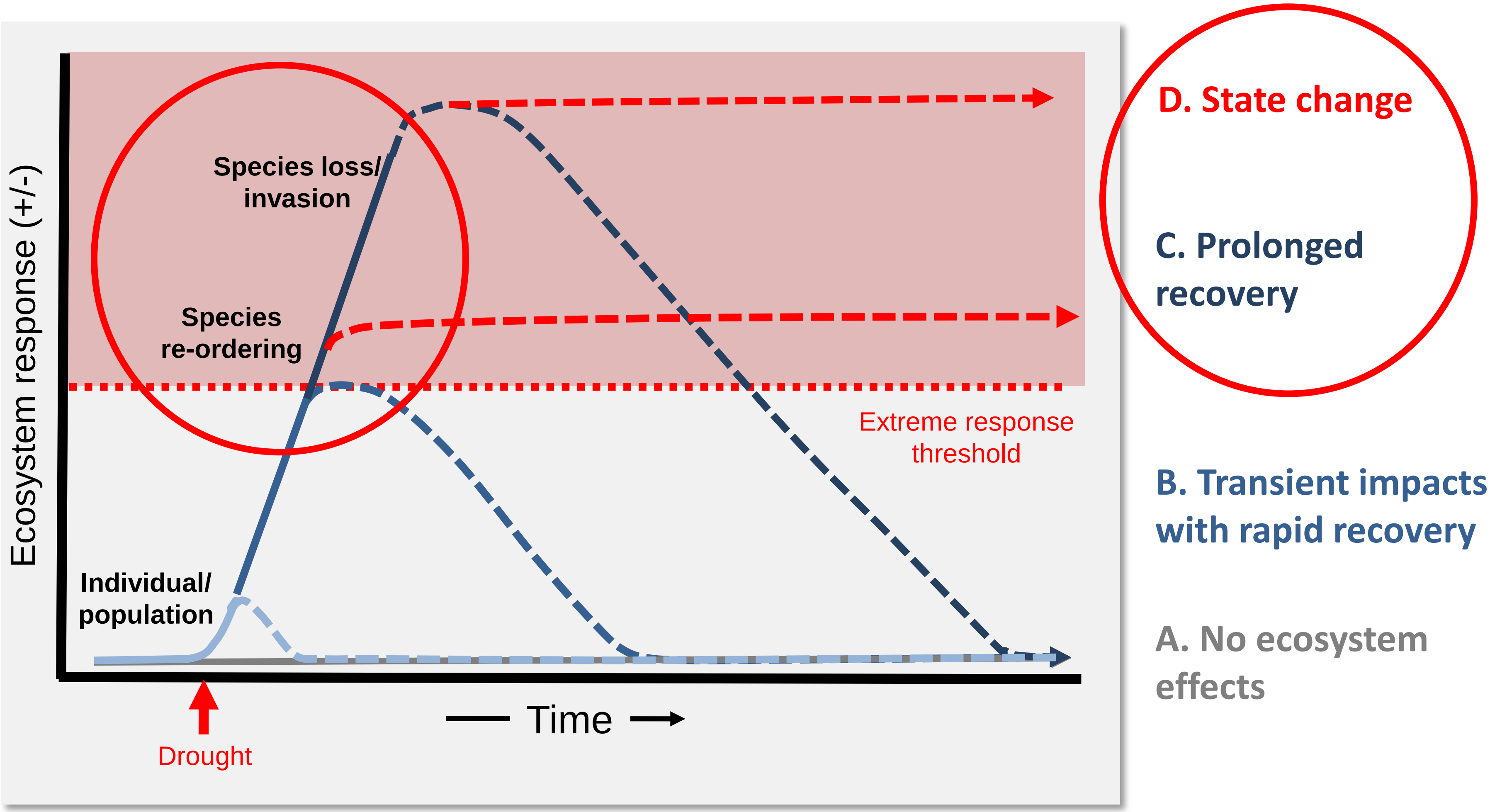
- Arid rangelands are more sensitive in <u>both</u> their 1) productivity and 2) plant community responses to drought than mesic rangelands.



Overall, these results suggest that arid rangelands are likely to be more vulnerable to intensification of drought in the future.



Greater sensitivity may foretell prolonged recovery post-drought…



Smith (2011) *J. Ecology*

Rangelands and Drought: Future prospects

- Need experiments to assess **interactions** between drought and grazing

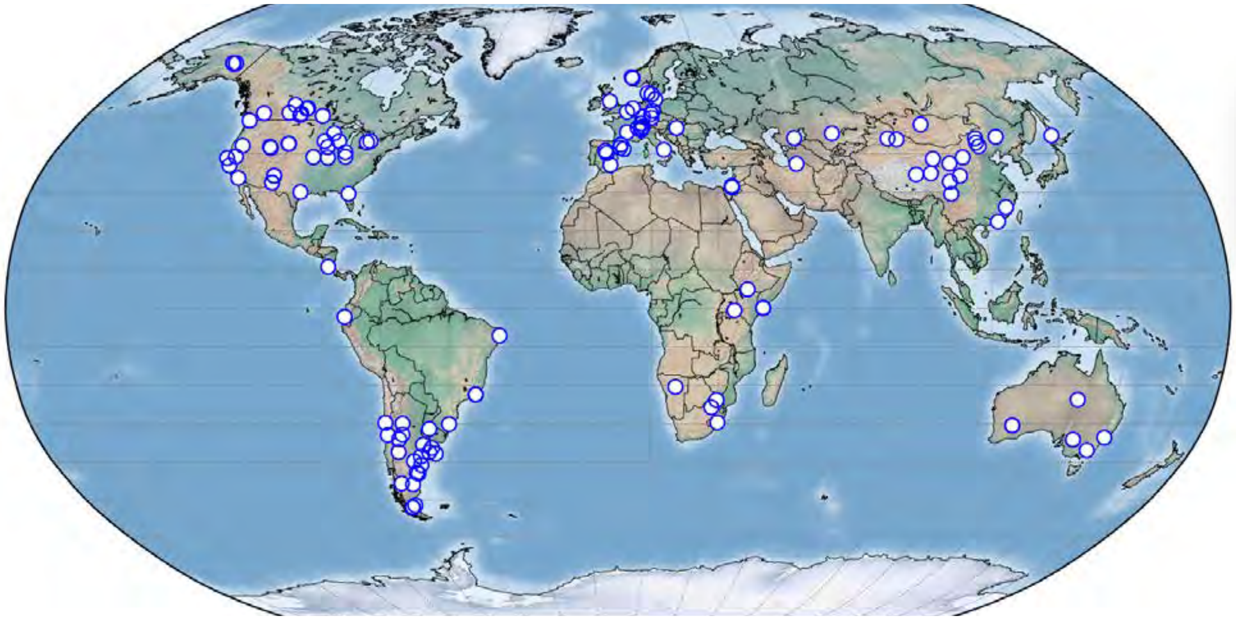
- Need for additional multi-site, multi-year drought studies

droughtNET

www.drought-net.org

- Need to focus on not only on drought impacts but also *recovery dynamics*

Questions?



droughtNET

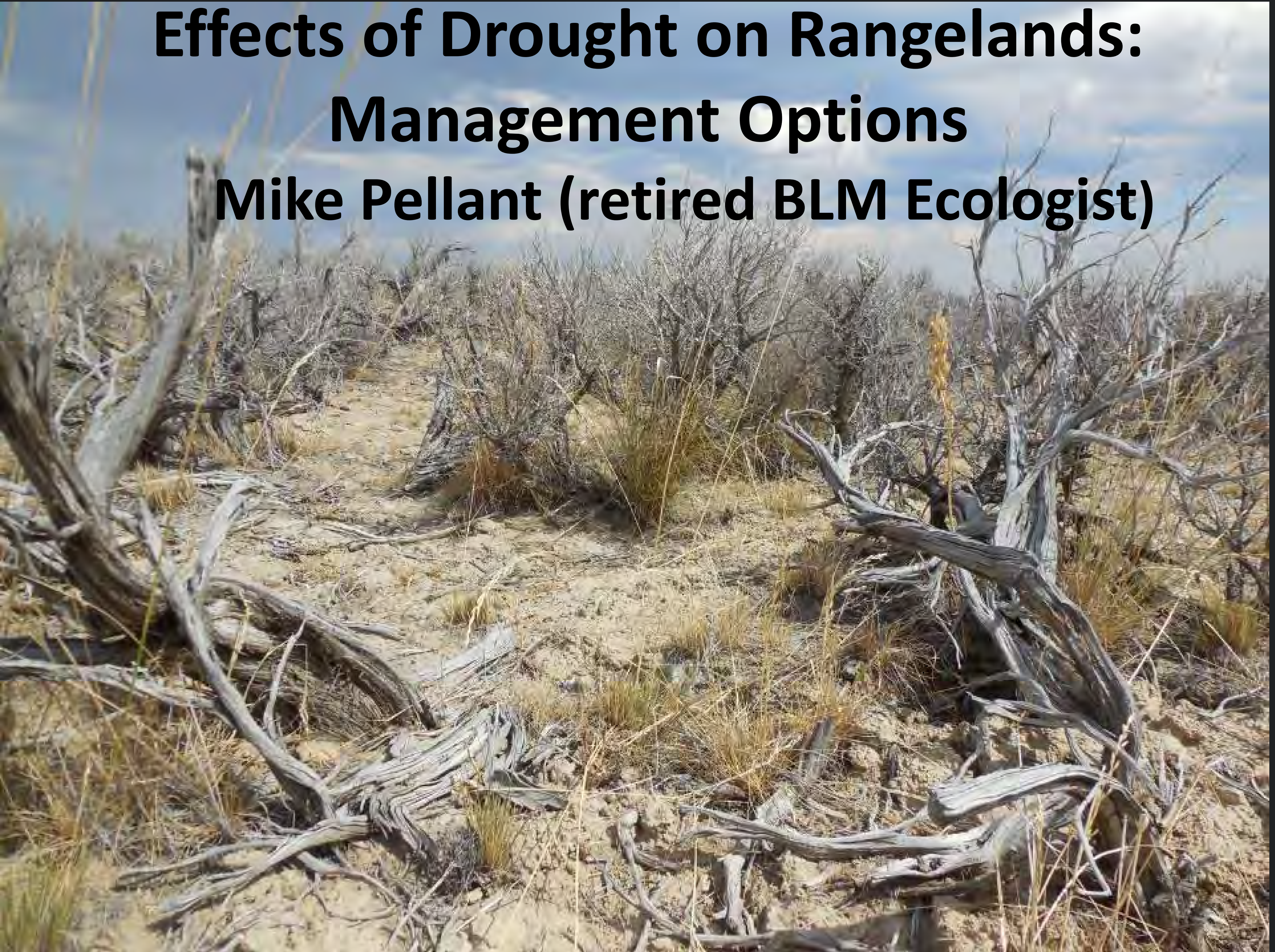
143 registered sites and growing…

Questions & Answers

- **By phone:** **Dial #2 to enter the queue.**
- **On your computer:** **Type your question into the Q & A pod on the left side of your screen.**

Effects of Drought on Rangelands: Management Options

Mike Pellant (retired BLM Ecologist)



Presentation Outline

– Components of drought and implications for rangeland management

– Management options before, during and after drought

Types of Drought

- Meteorological
- Agricultural (rangelands)
- Hydrologic
- Socio-economic

Thurow and Taylor (1999)-"Viewpoint: the role of drought in range management"

Meteorological Drought

– Significant decrease from the climatologically expected precipitation

– Compare annual to “average” annual precipitation (not directly correlated to effects on plants).

Agricultural Drought

– Water deficits limit vegetation production, survival, reproduction and soil protection

1984

2003

Hydrologic Drought

– Period when surface and groundwater availability is inadequate to supply established uses

Socio-economic Drought

– Drought that affects peoples' behavior, options or depresses earning power

Presentation Outline

– Components of drought and implications for rangeland management

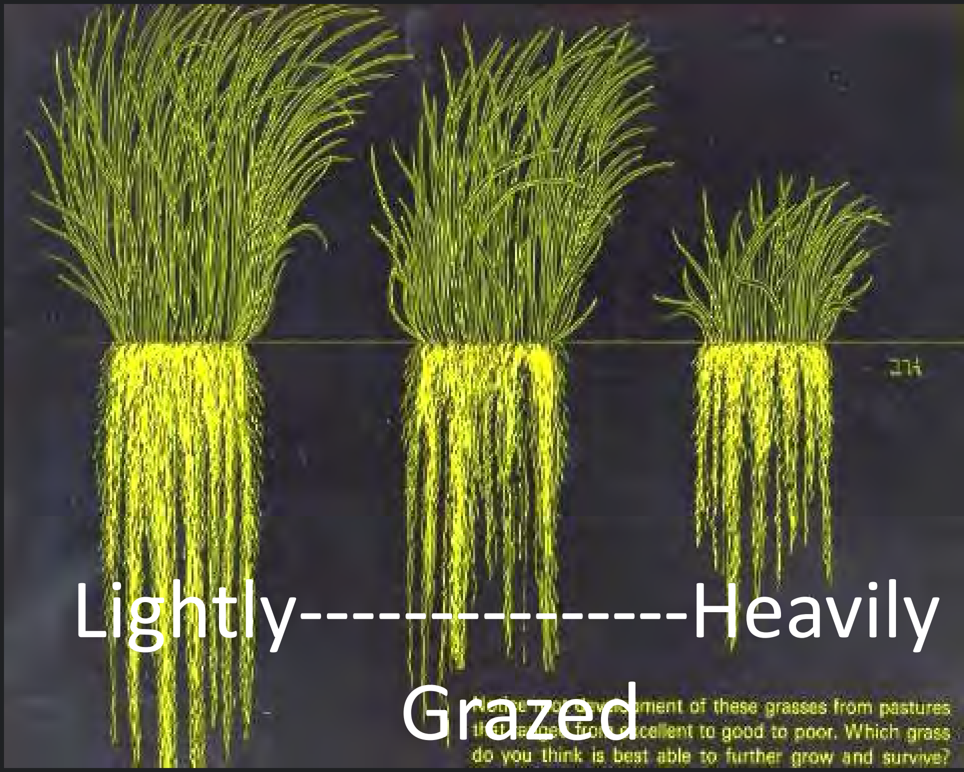
– **Management options before, during and after drought**

Management options **pre-drought**

- Maintain or improve resistance and resilience (R&R) of rangelands
  - Resistance to change or degradation during drought
  - Resilience to promote timely biotic recovery after drought

Management options pre-drought

– Key R&R components includes:
  - Good vigor of desirable vegetation
  - Above ground production that promotes a healthy root system



Management options pre-drought

– Key R&R components

- Plant diversity relative to site potential

Management options pre-drought

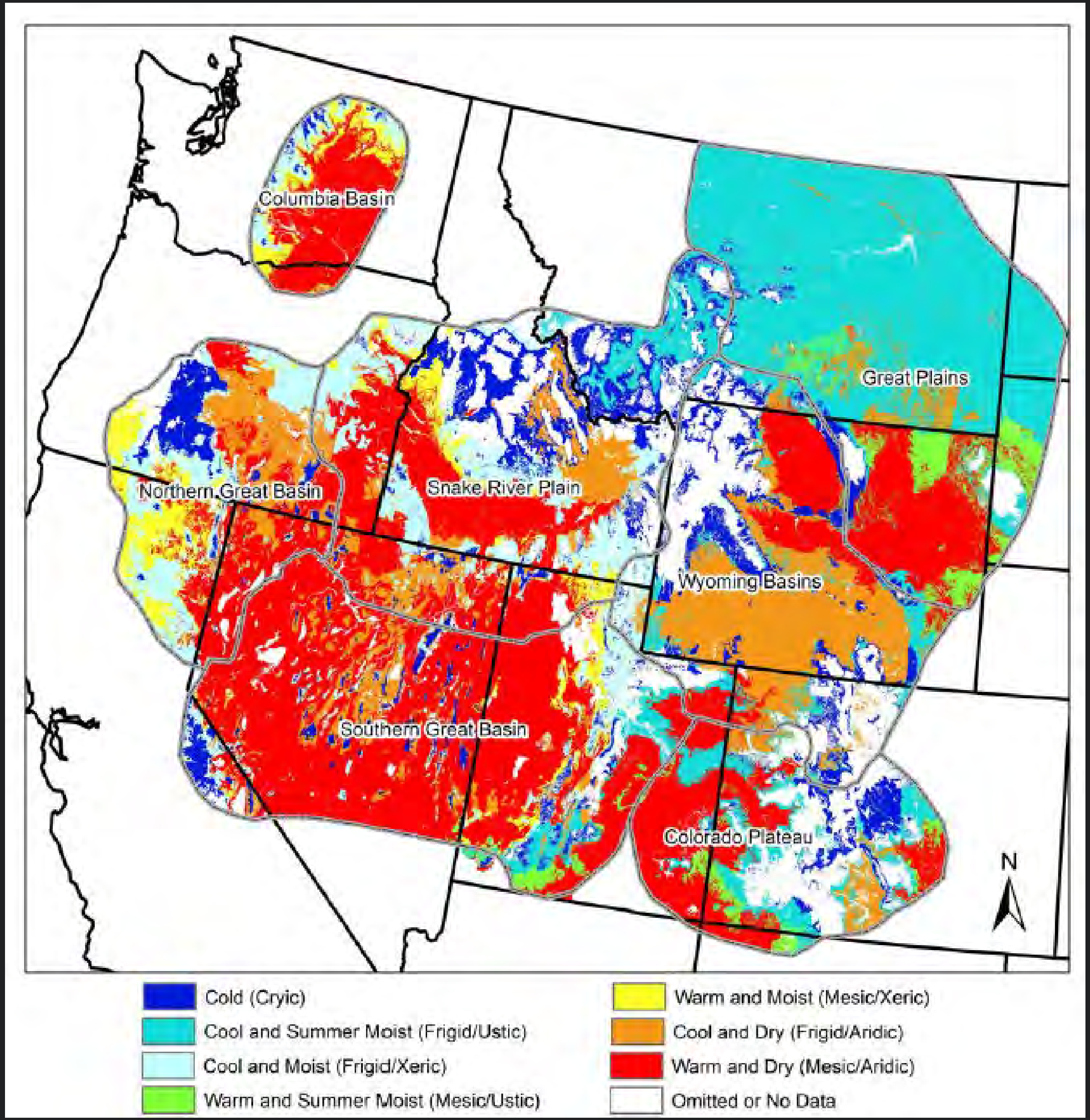
- Key R&R components
  - Adequate plant, litter and biological soil crust cover to minimize soil erosion

Management options pre-drought

– Key R&R components
    - Minimize invasive species issues


Management options pre-drought

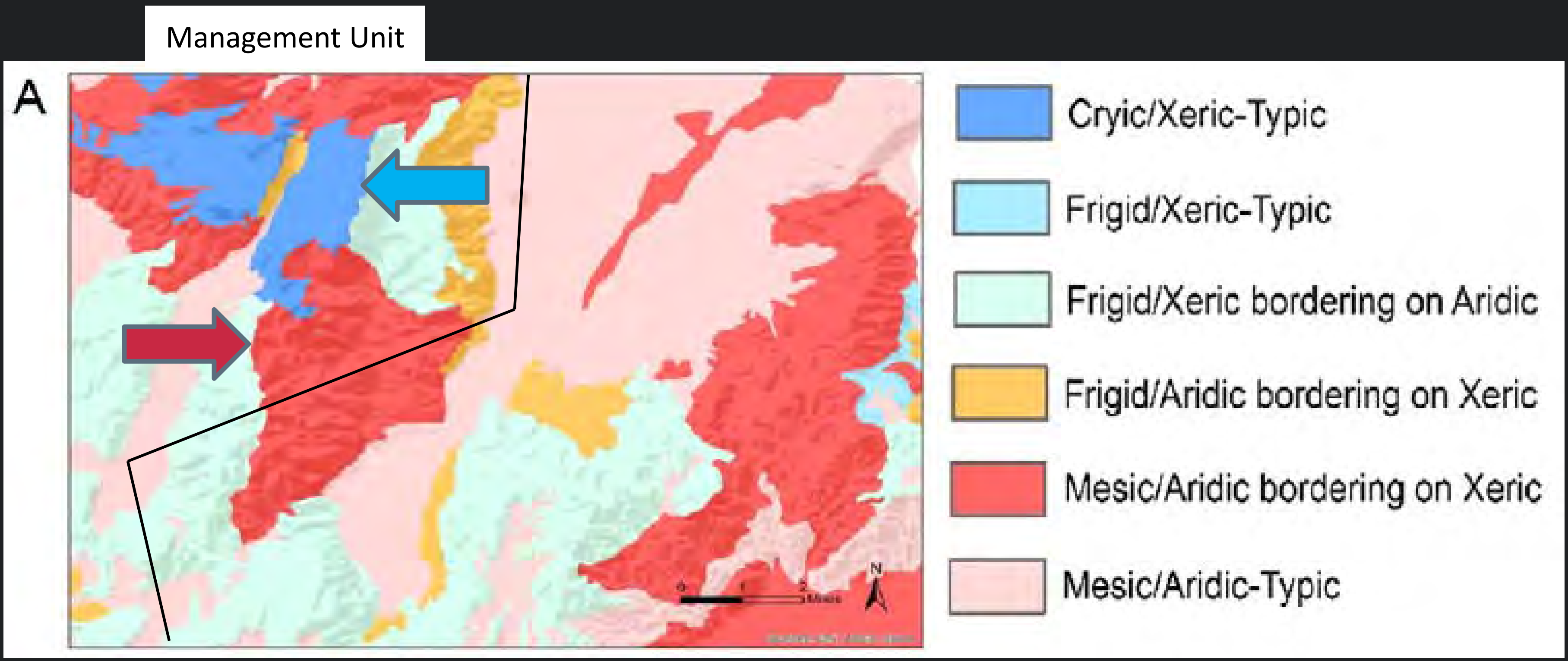
Spatial portrayal of resistance & resilience using soil moisture and temperature regimes



Management options pre-drought

Tapping Soil Survey Information for Rapid Assessment of Sagebrush Ecosystem Resilience and Resistance

Maestas et al. 2016



Resistance & Resilience Resources

Contents lists available at ScienceDirect
Rangeland Ecology & Management
journal homepage: http://www.elsevier.com/locate/rama

Using Resilience and Resistance Concepts to Manage Persistent Threats to Sagebrush Ecosystems and Greater Sage-grouse

Jeanne C. Chambers [a,*], Jeremy D. Maestas [b], David A. Pyke [c], Chad S. Boyd [d], Mike Pellant [e], Amarina Wuenschel [f]

USDA United States Department of Agriculture

Using Resistance and Resilience Concepts to Reduce Impacts of Invasive Annual Grasses and Altered Fire Regimes on the Sagebrush Ecosystem and Greater Sage-Grouse: A Strategic Multi-Scale Approach

Jeanne C. Chambers, David A. Pyke, Jeremy D. Maestas, Mike Pellant, Chad S. Boyd, Steven B. Campbell, Shawn Espinosa, Douglas W. Havlina, Kenneth E. Mayer, and Amarina Wuenschel

Forest Service Rocky Mountain Research Station General Technical Report RMRS-GTR-326 September 2014

USDA United States Department of Agriculture

Using Resilience and Resistance Concepts to Manage Threats to Sagebrush Ecosystems, Gunnison Sage-Grouse, and Greater Sage-Grouse in Their Eastern Range: A Strategic Multi-Scale Approach

Jeanne C. Chambers, Jeffrey L. Beck, Steve Campbell, John Carlson, Thomas J. Christiansen, Karen J. Clause, Jonathan B. Dinkins, Kevin E. Doherty, Kathleen A. Griffin, Douglas W. Havlina, Kenneth F. Henke, Jacob D. Hennig, Laurie L. Kurth, Jeremy D. Maestas, Mary Manning, Kenneth E. Mayer, Brian A. Mealor, Clinton McCarthy, Marco A. Perea, and David A. Pyke

Forest Service Rocky Mountain Research Station General Technical Report RMRS-GTR-356 December 2016

Management options **during** a drought

- Prepare for and regularly assess resource conditions (vegetation, water, soils, etc.)
- Coordinate and communicate with stakeholders
- Identify triggers and quickly implement and monitor management actions

Management options during a drought

– Livestock
  - Improve distribution
    - * Expected use (predicted)
    - * Use pattern mapping
  - Reduce amount of vegetation use (utilization)
  - Evaluate water availability

Management options during a drought
Expected Use Maps (Livestock)

Guenther et al. 2000. Expected-use GIS Maps. Rangelands 22:18-20.

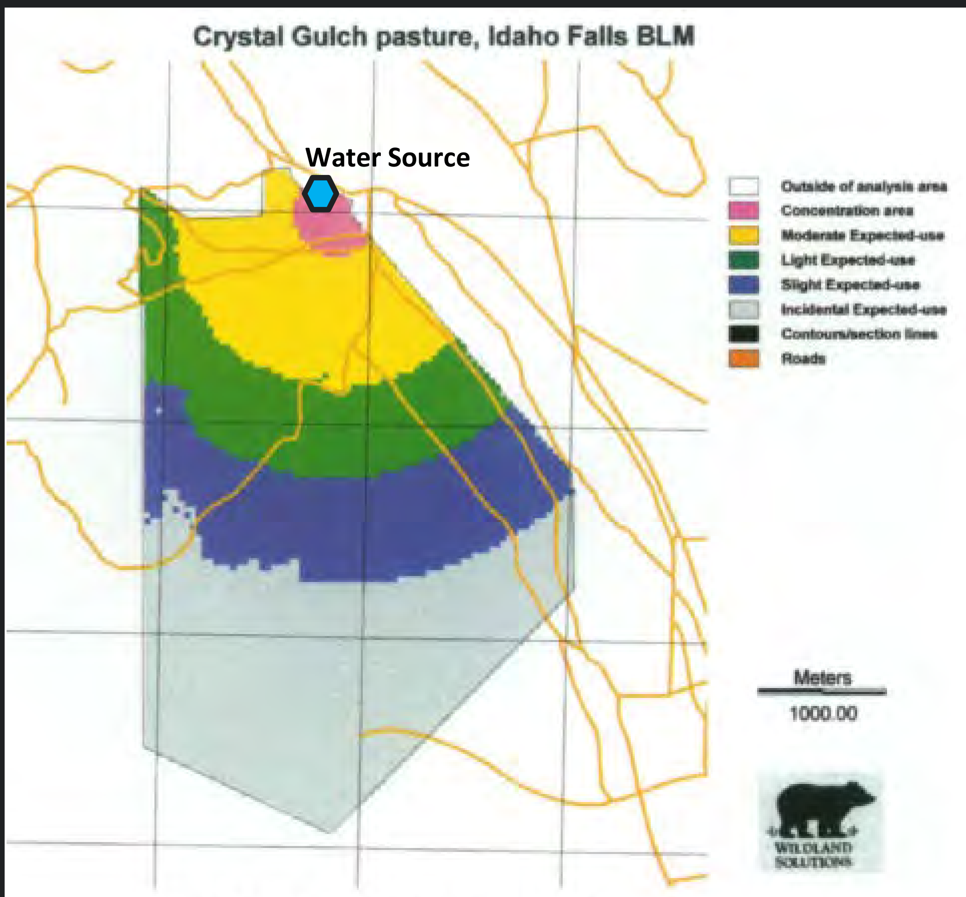


Figure 1: Expected-use map of a pasture with a single water source and relatively gentle terrain.

Based on Slope & Distance from Water

Incidental use areas—Areas that are expected to receive 0–5% use.

Slight use areas—Areas that are expected to receive 5–20% use.

Light use areas—Areas that are expected to receive 20–40% use.

Moderate use areas—Areas that are expected to receive 40–60% use.

Concentration areas—Areas that are expected to exceed 60% use.

Management options during a drought-Intensity of vegetation use

- Reduce livestock and utilization levels
- Remove livestock when use targets are reached

Management options during a drought- Water availability

– Move or remove livestock with loss of water availability and/or vegetation overuse

Management options during a drought- Water availability

– Manage permanent water sources to minimize impact to vegetation, soils, wildlife, and other resources

Management options during a drought- Water availability

– Move water in portable troughs to improve livestock distribution and meet wildlife needs

Management options after a drought-Restore resistance and resiliency

– Vegetation production often precedes full plant (shoot and root) recovery

Management options after a drought- Restore resistance and resiliency

– Promote reproduction of desirable plants (germination and establishment) to mitigate plant mortality

Management options after a drought-Restore resistance and resiliency

– Promote recovery of plant, litter, and biological crust cover to reduce erosion potential and increase in invasive plants

Effects of Drought on Forests and Rangelands in the United States:

A Comprehensive Science Synthesis

Gen. Tech. Report WO-93b January 2016

Forest Service Gen. Tech. Report WO-93b January 2016

Conclusions

1. Drought is complex requiring an integrated and coordinated approach to manage rangeland vegetation, water, and soils
2. Drought management (before, during and after) should focus on maintaining or regaining resistance and resilience.
3. Be patient, recovery after a drought is as important as management during a drought


Contact Info:
Mike Pellant
Rangeland Solutions LLC
rangelandsolutions@mail.com

Questions & Answers

- **By phone:** **Dial #2 to enter the queue.**
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Thank you

for attending today's webinar!

A recording of this session will be available shortly at the Climate Science Webinar Portal:
http://climatewebinars.net/webinars/drought-rangelands