Climate Change: Management Implications for Great Plains Rangelands

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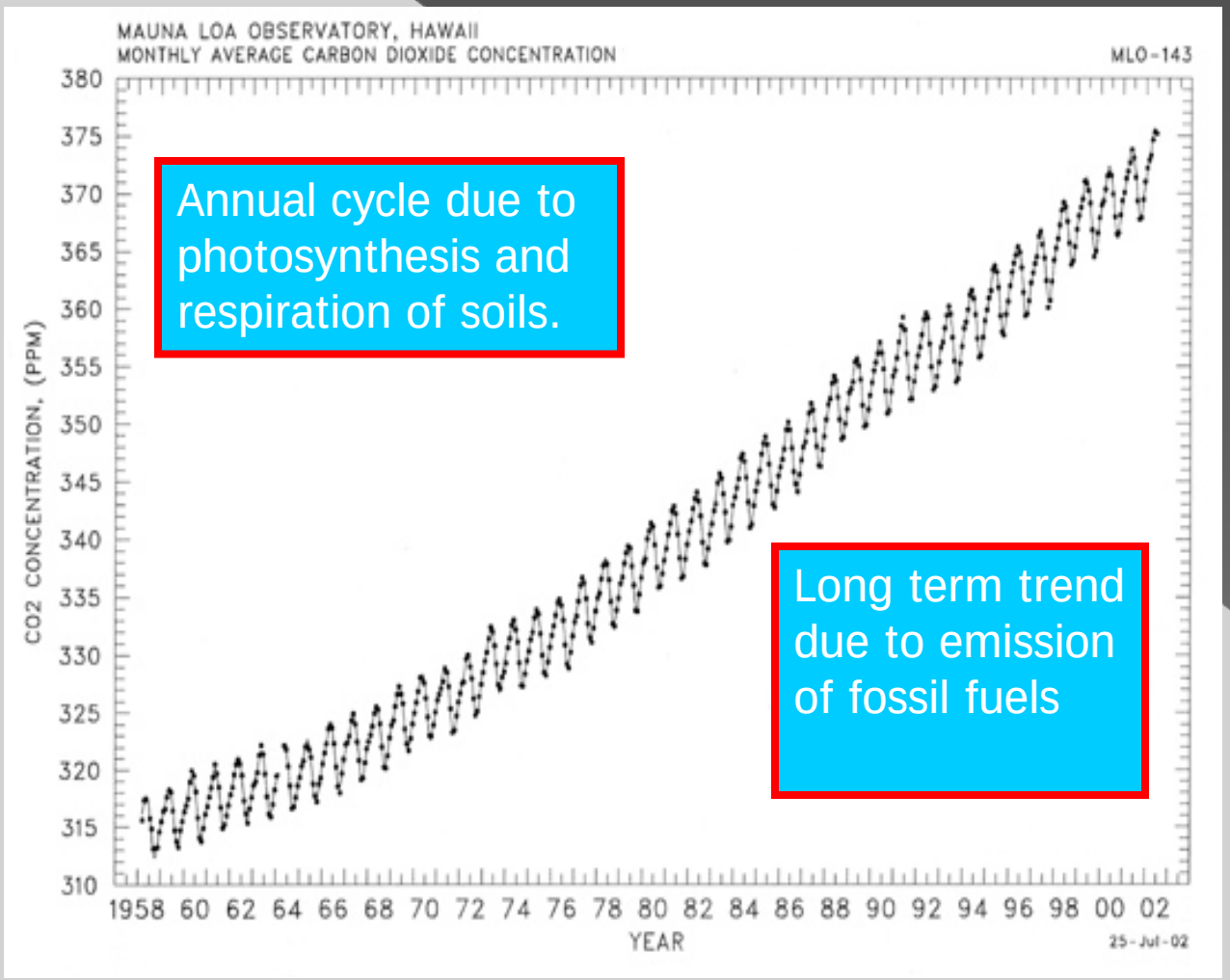
Jack A. Morgan

Road Map

- Climate Change – what we know & consequences
  - Climate
  - Vegetation
- Recent trends for Arthur, Nebraska
- Management implications
  - Tools
  - Decision support systems

WHAT WE KNOW: Atmospheric CO_2 concentrations measured accurately for many decades; they are steadily increasing.

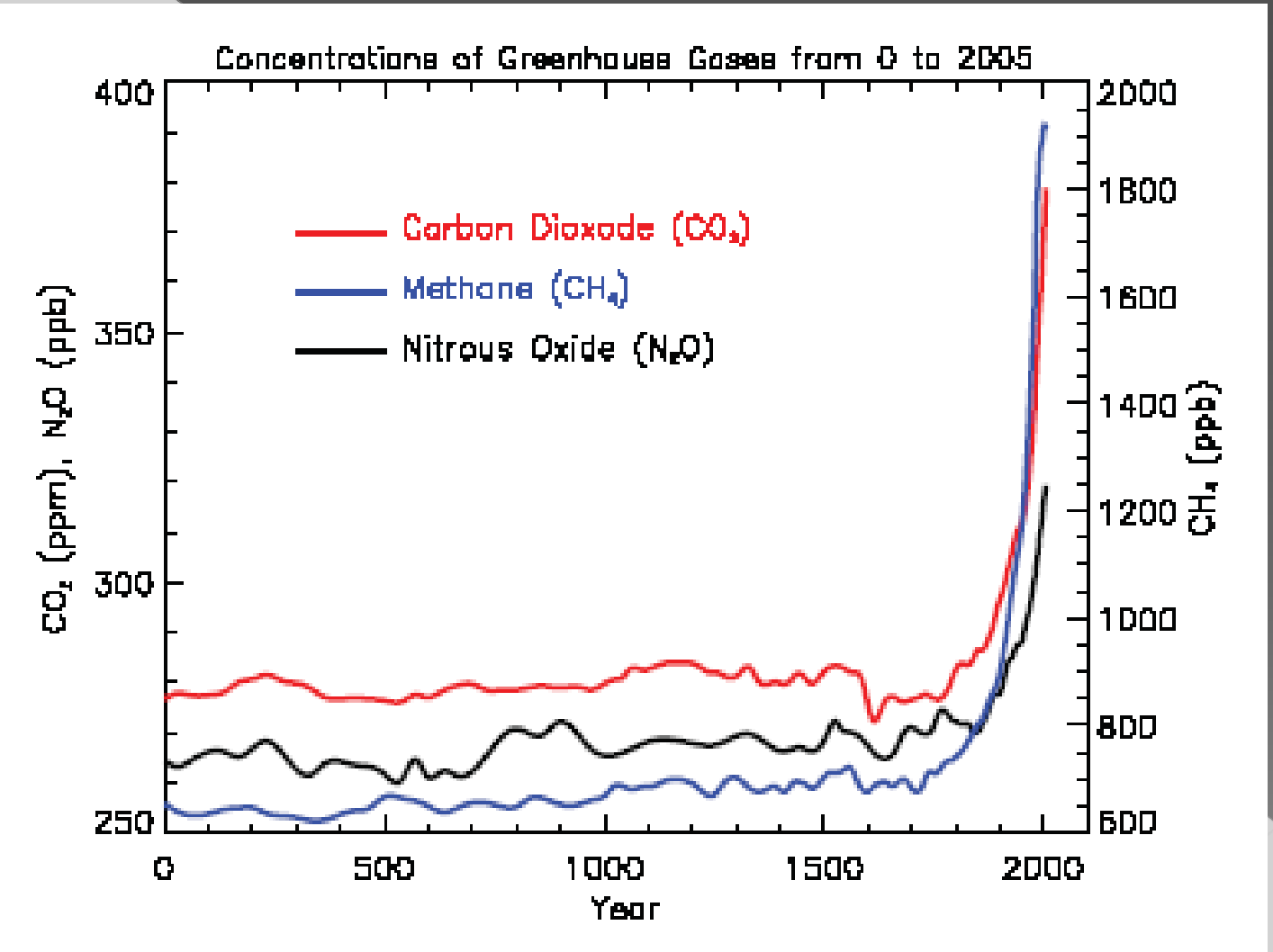


Charles David Keeling

1928-2005

2002 Nat'l Medal of Science

WHAT WE KNOW: Ice core sampling & other techniques indicate rising CO_2 in Earth's atmosphere is a relatively new phenomenon.



IPCC Working Group I Report, Chapter 2, 2007

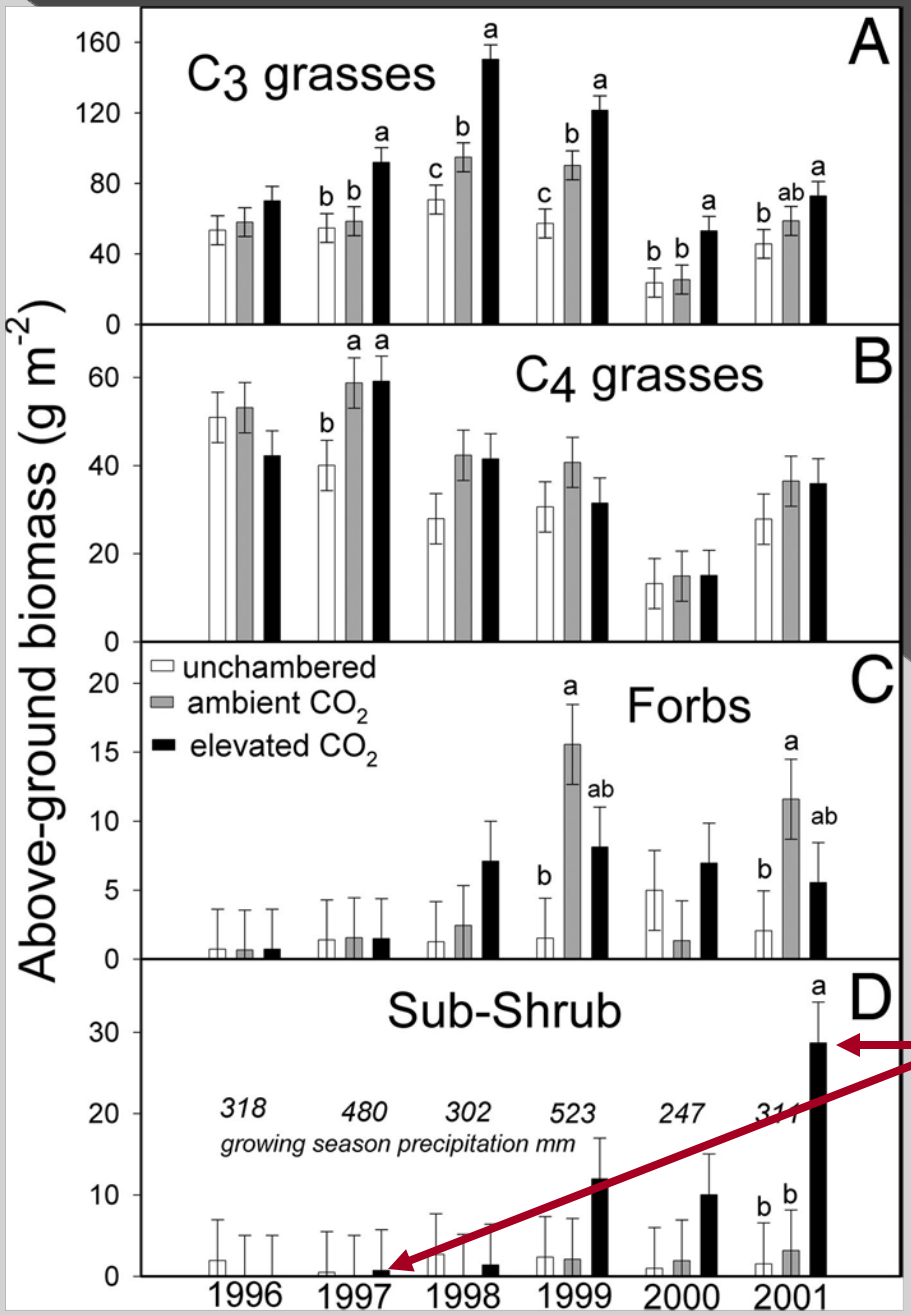
WHAT WE KNOW: A direct effect of rising CO_2: Stimulation of plant growth.

CO_2

Food, Glorious Food!

Nutrients, H_2O

Any change in light, water, nutrients or carbon dioxide will alter plant growth.



Responses of plant functional group NPP to CO_2 in the Colorado shortgrass steppe

Responders & Mechanisms:

C_3 vs. C_4	**photosynthesis**
P. smithii	**seedling recruitment**
A. frigida	**photosynthesis, soil water**

40-fold increase in *Artemisia frigida* between 1997 & 2001!

Morgan et al., 2007. PNAS104(37):14724-14729

Encroachment of woody plants into C_4 grasslands..... A plant community shift due in part to global change?

Mesquite encroachment in SW over past two centuries

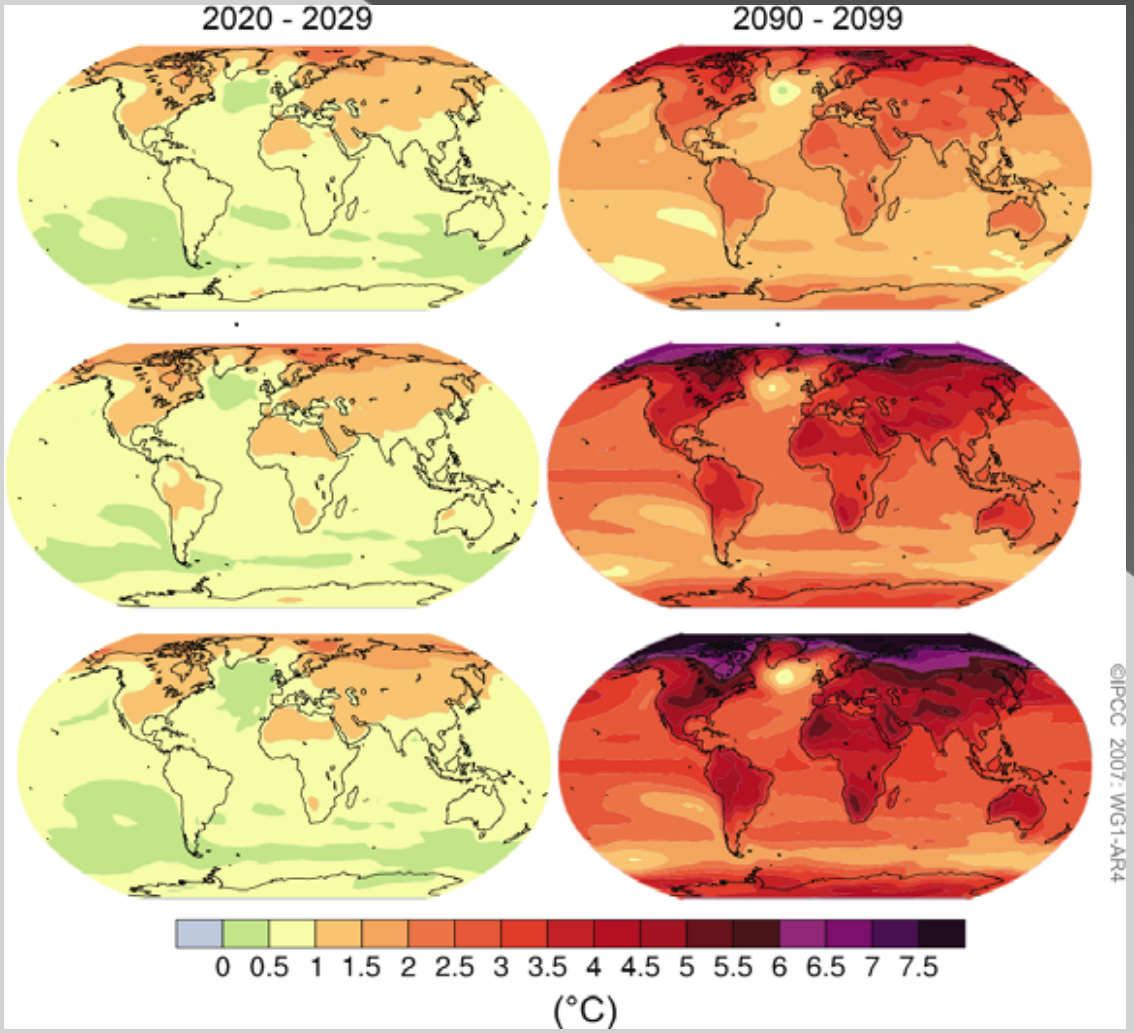
(photograph courtesy of ARS Jornada Experimental Range photo gallery).

Honey locust tree islands in Kansas Tallgrass Prairie. Present-day encroachment?

Fire removal, climate change, CO_2?

(photograph courtesy of Alan K. Knapp).

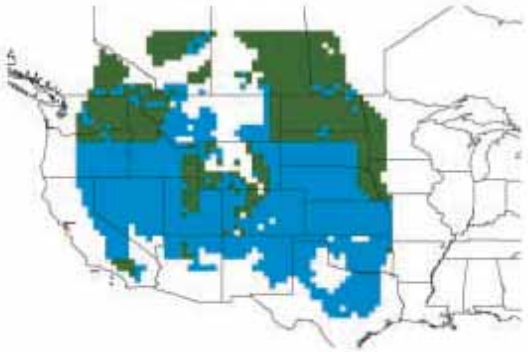
WHAT WE KNOW: Global average surface temperature has increased 0.74 C (1.2 F) in the last hundred years. Rate of warming has doubled in the past 50 years.

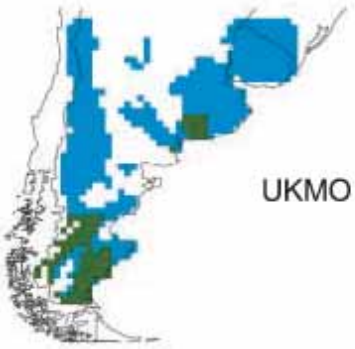


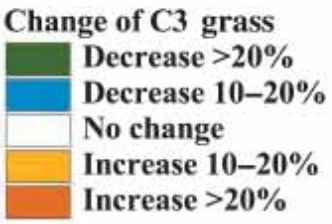
Predictions indicate future accelerated & extreme warming.

IPCC 2007: WG1-AR4

Functional Plant Group Modeling







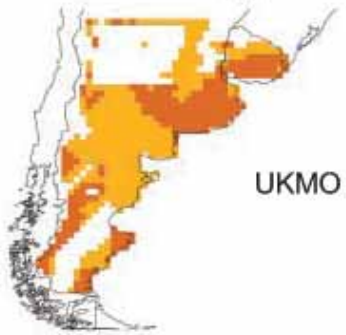
Modeled Future Relative Abundances (shrubs, C_3, C_4) in Grasslands of N & S America.

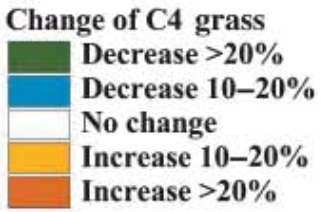
Based on:

- **GCMs**
- **Relative Abundance Equations precip, temp, soil water**

Based on observations & measurements obtained in the real world.

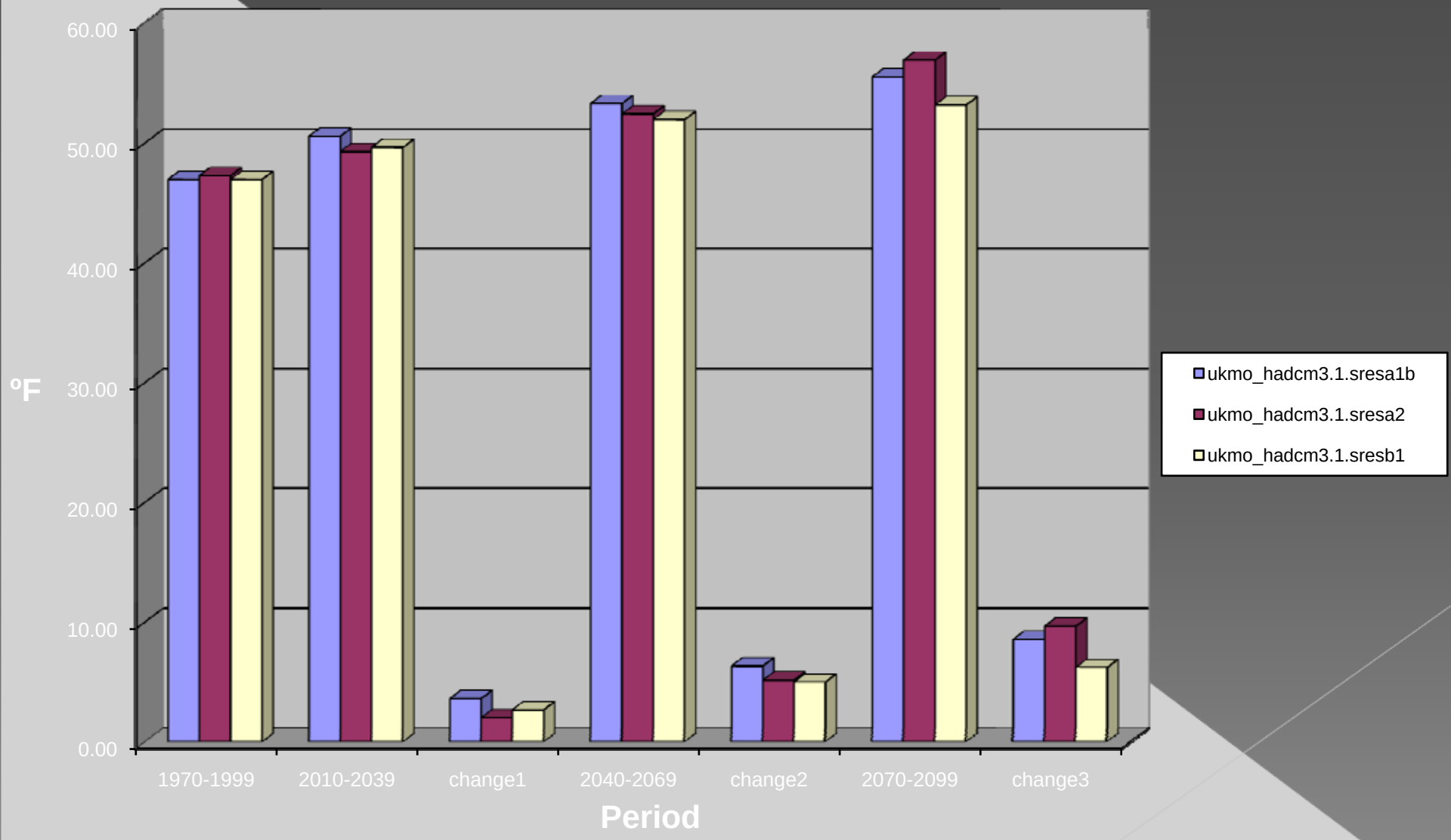
Approach does not capture CO_2 response





Epstein, Gill, Paruelo, Lauenroth, Jia and Burke. 2002. J. of Biogeography 29:875-8

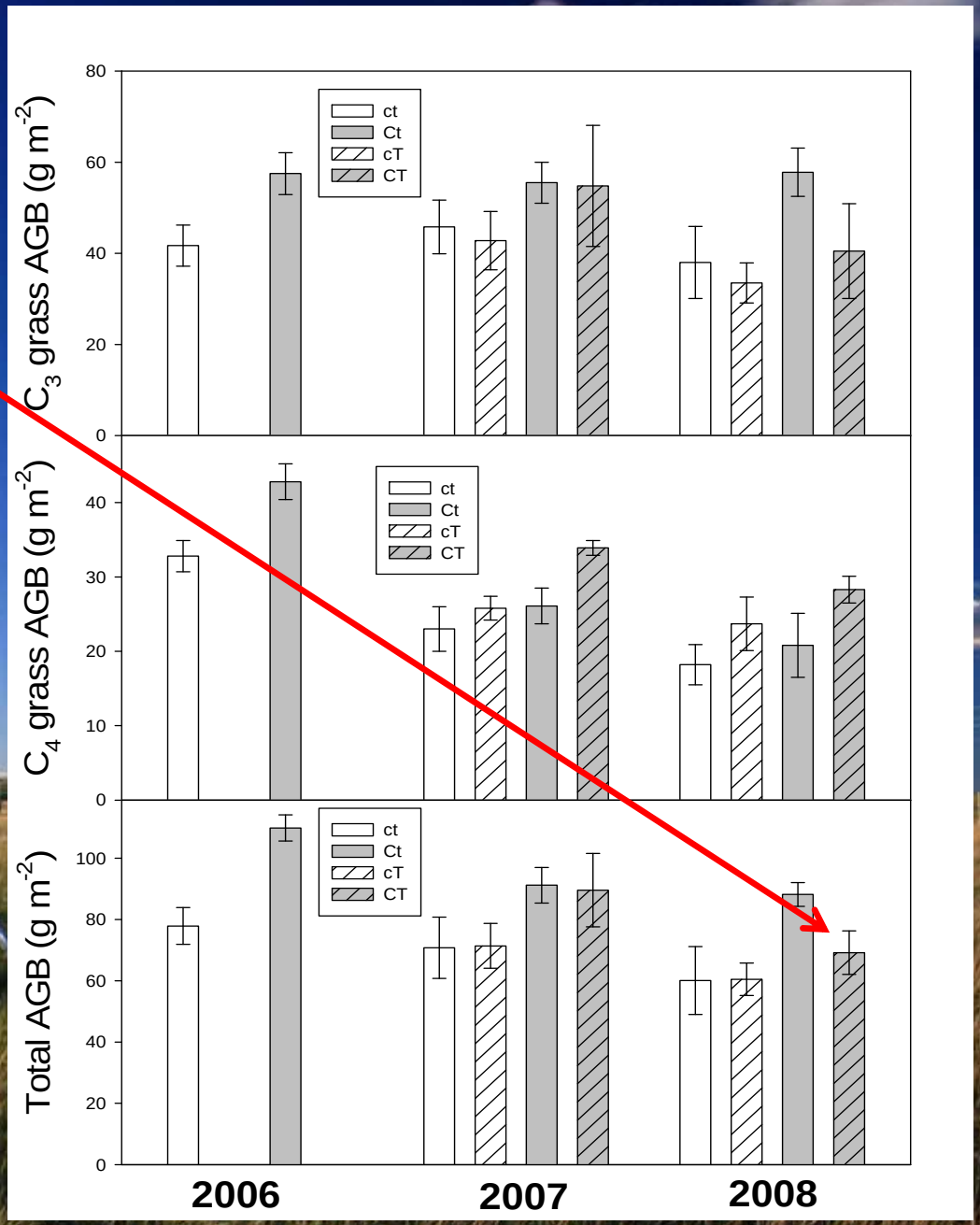
Arthur, Nebraska
Period-Mean Annual Temperature



Prairie Heating & CO_2 Enrichment (Cheyenne)

c (current) & C (high) CO_2
t (current) & high (T) Temp

Heat can diminish CO_2 benefit

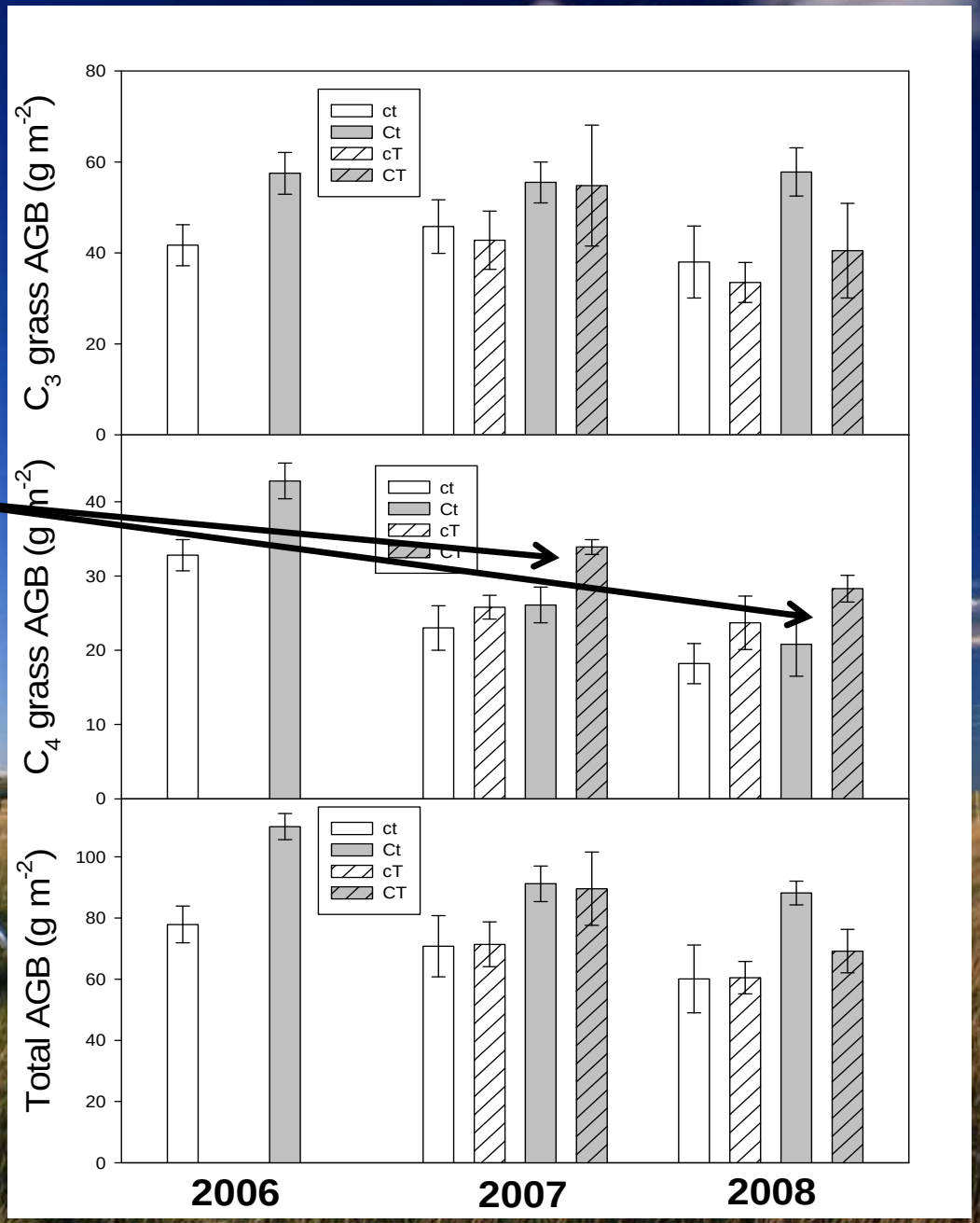


Prairie Heating & CO_2 Enrichment (Cheyenne)

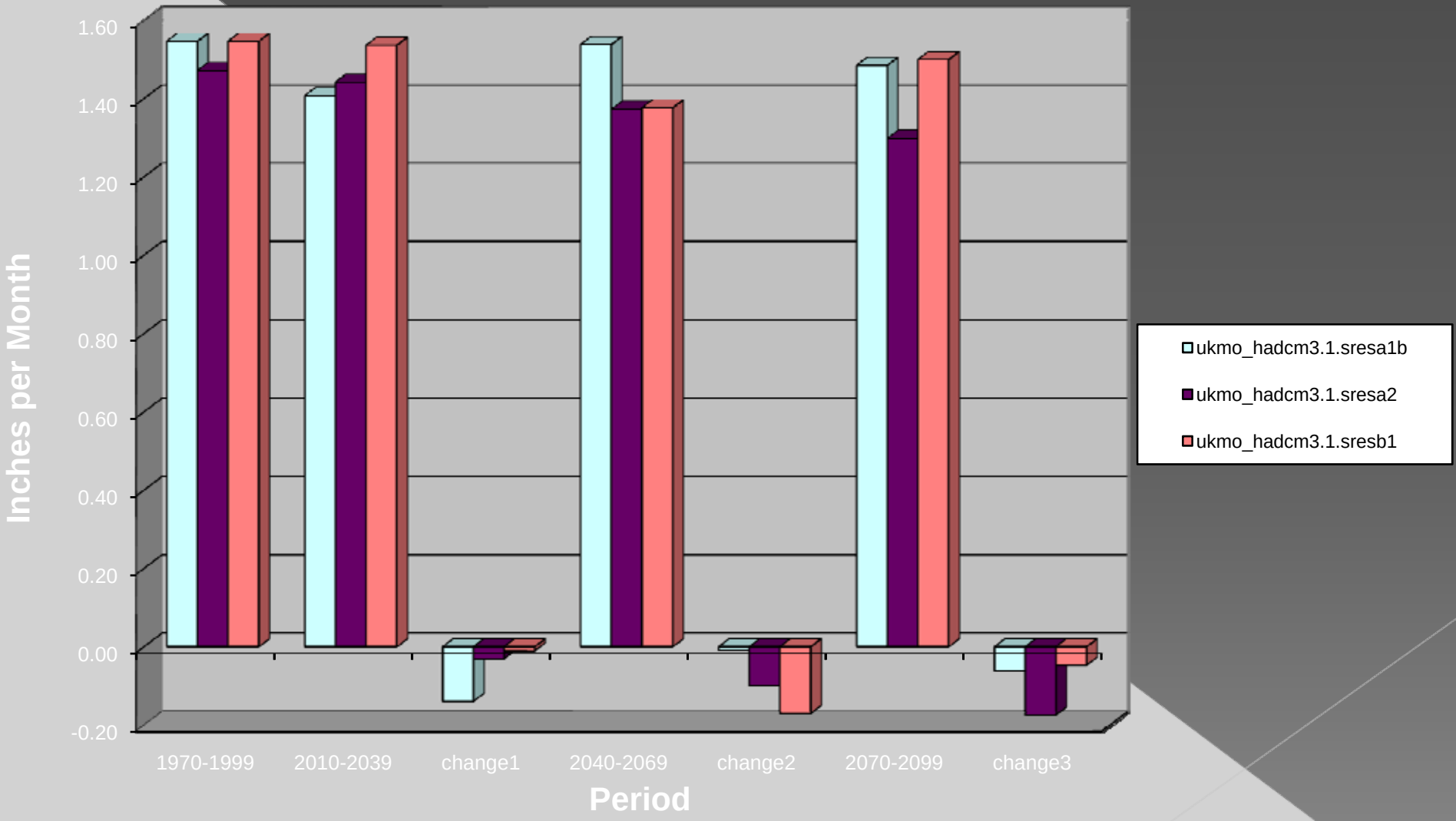
c (current) & C (high) CO_2
t (current) & high (T) Temp

Heat can diminish CO_2 benefit

High CO_2 & temp favors C_4



Arthur, Nebraska
Period-Mean Annual Precipitation:



IMPLICATIONS OF WHAT WE KNOW

- Longer growing season
- Desiccation due to warming
- Altered hydrologic cycle
  - atmosphere holds more water vapor
    - intense rainfall events
    - timing (altered seasonal precipitation; earlier loss of snow pack)
    - some regions more drought-prone
- Plant Species Change

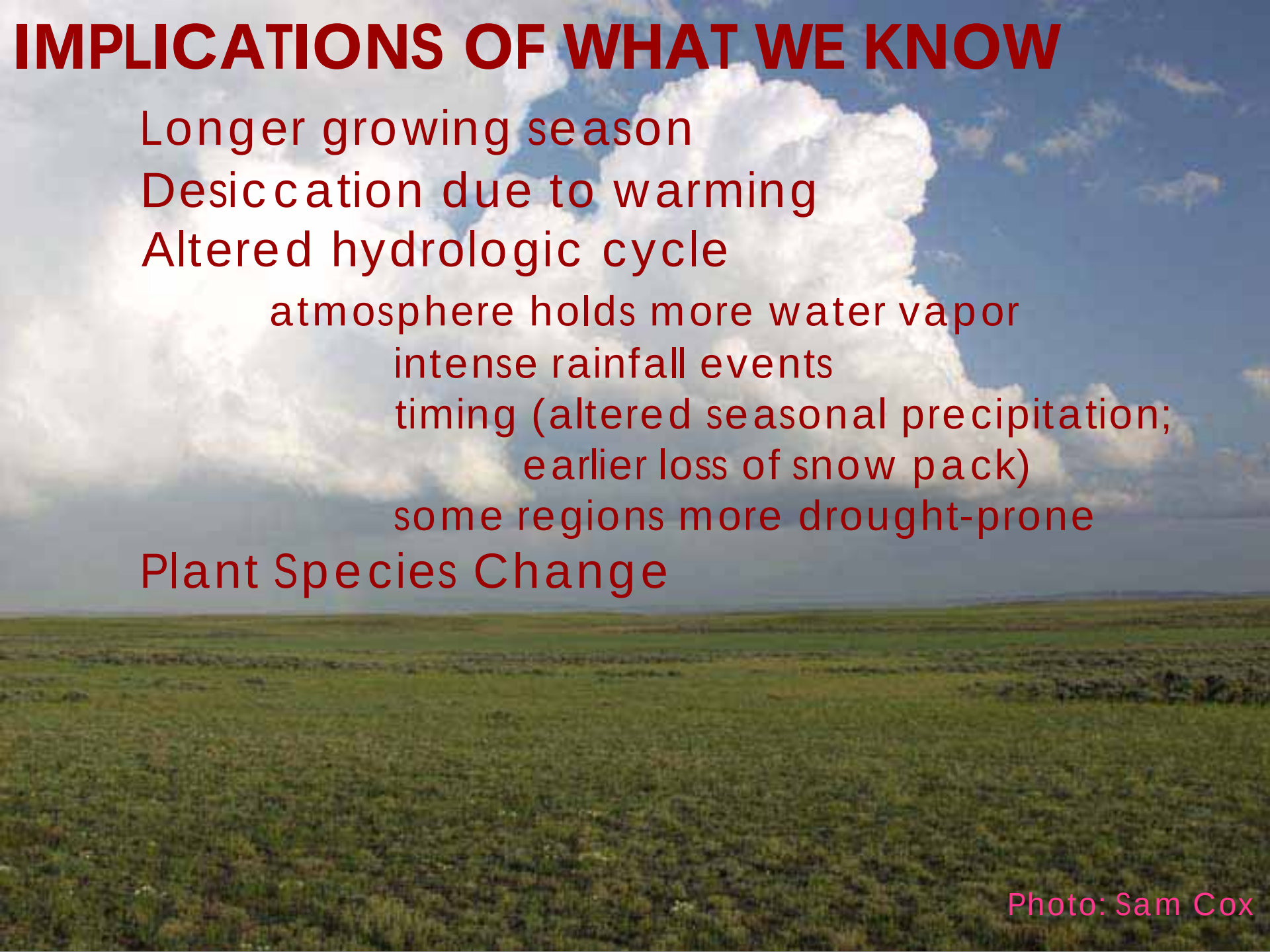


Photo: Sam Cox

What About Weeds? Will climate change facilitate invasion?

- CC decreases suitability for native species

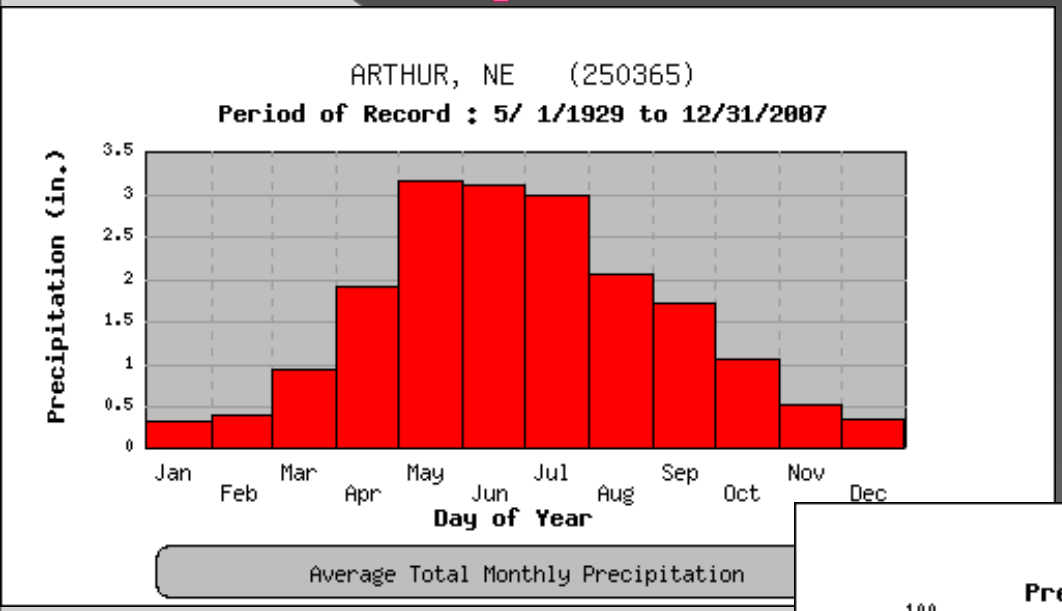
Invasive species have traits that make them likely to fill empty niches

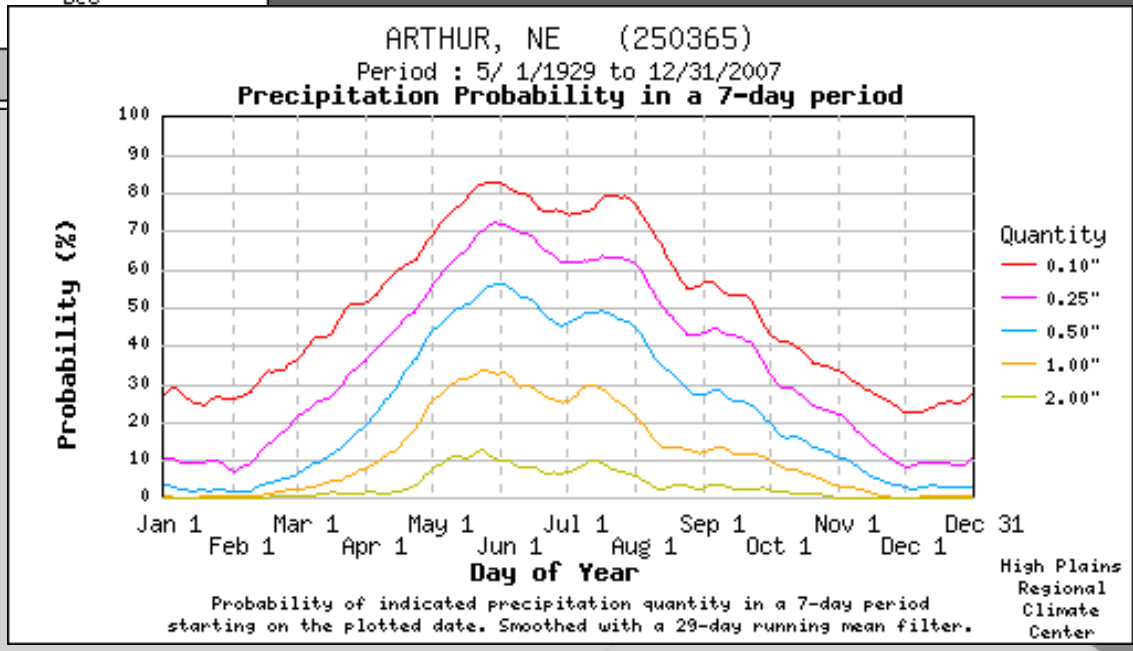
1) High seed production
2) Effective dispersal
3) Rapid growth
4) High plasticity
5) Rapid evolution

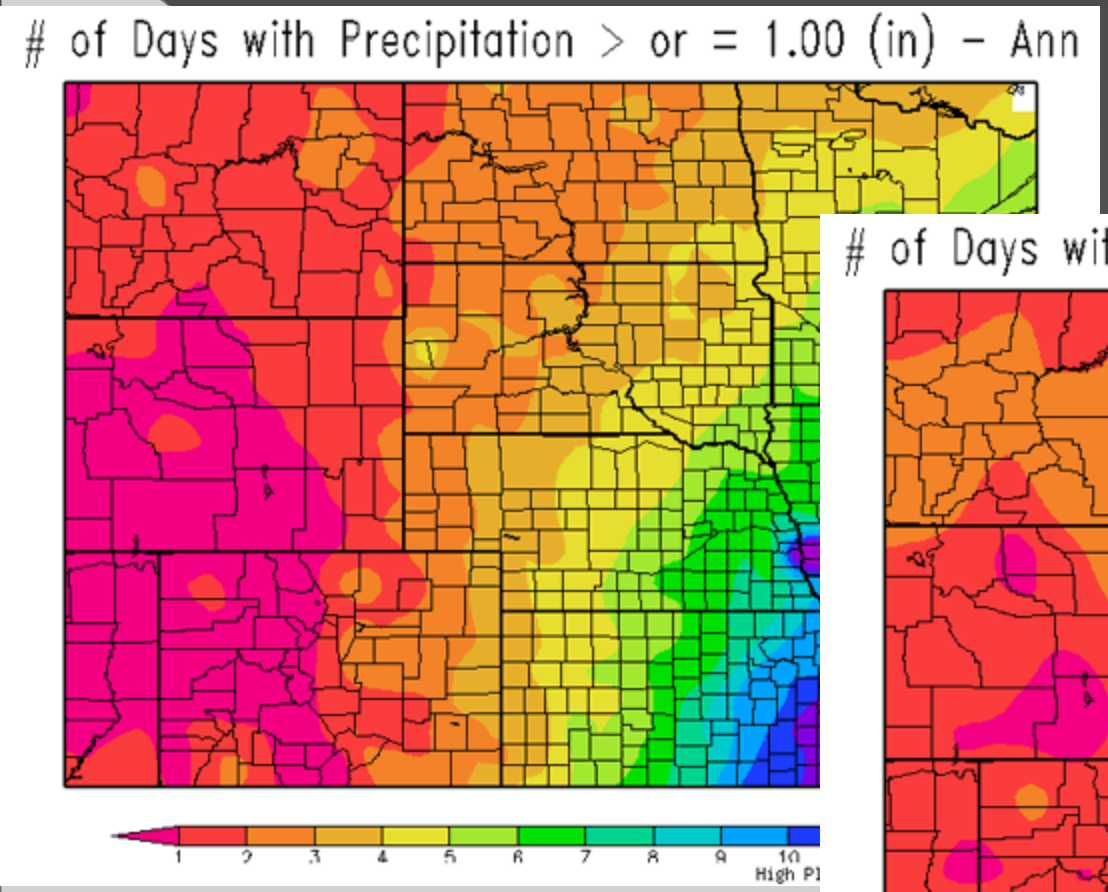
Dukes and Mooney 1999, Trends in Ecology and Evolution 14:135

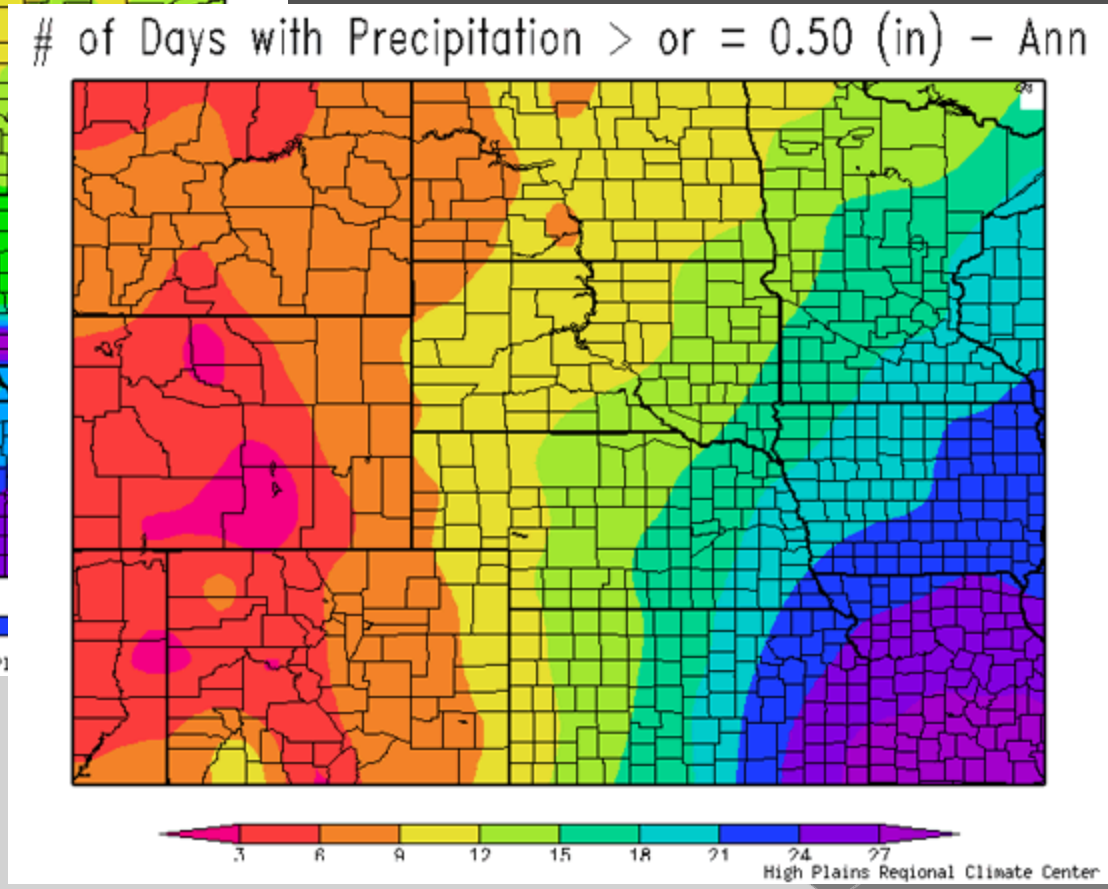
Recent Trends

Precipitation









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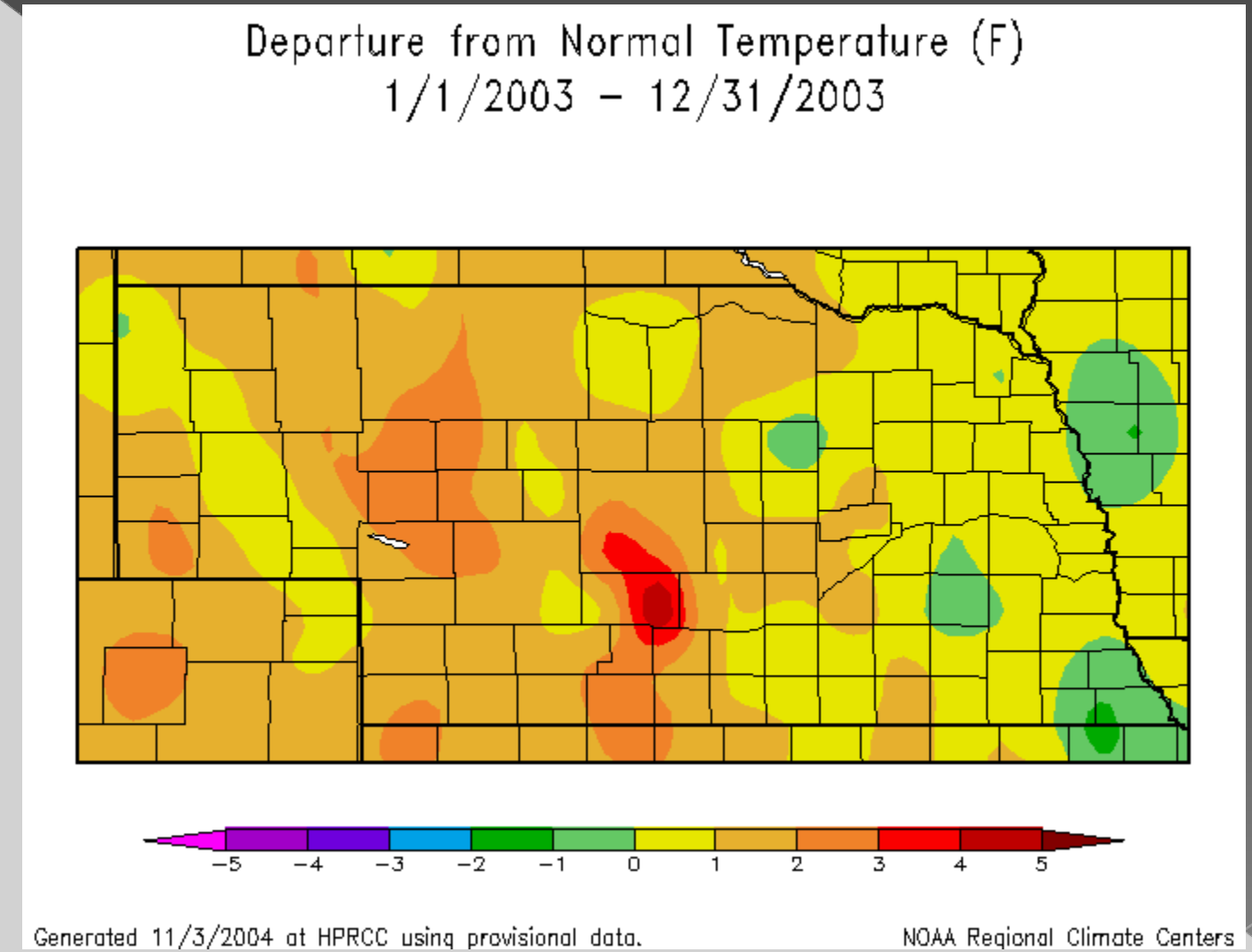
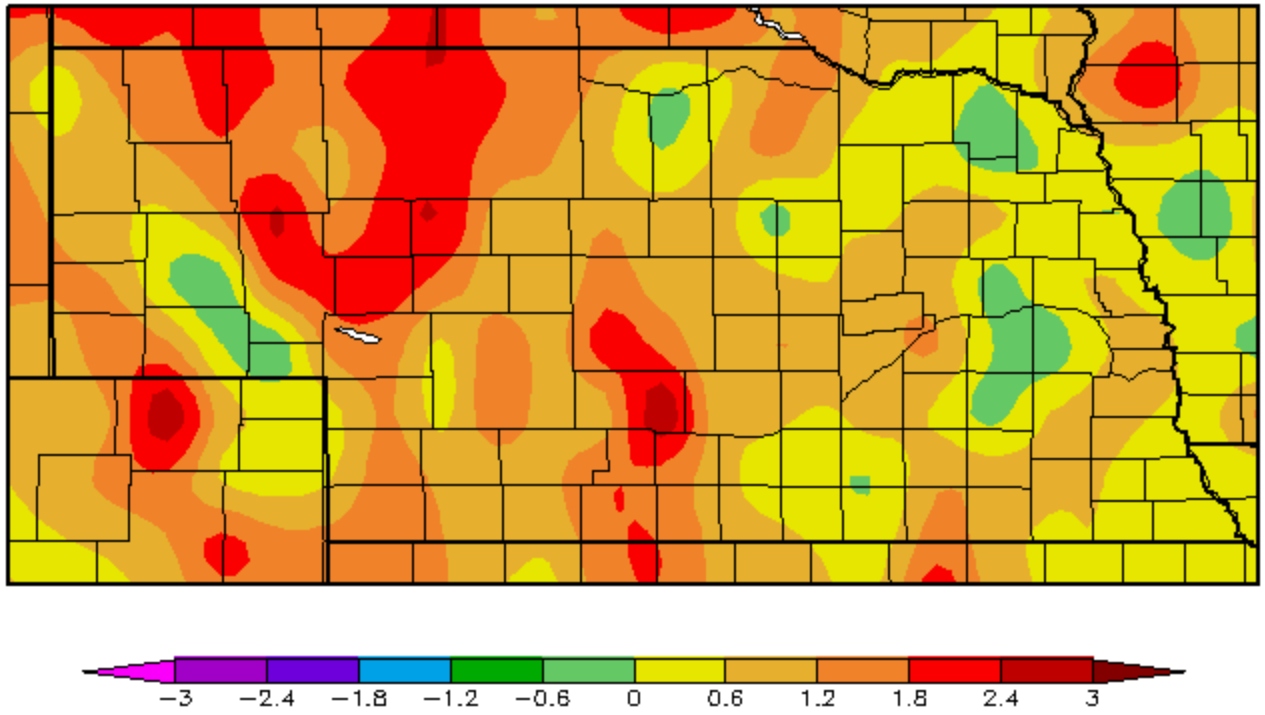


http://www.hprcc.unl.edu/maps/current/index.php?action=update_product&product=TDept

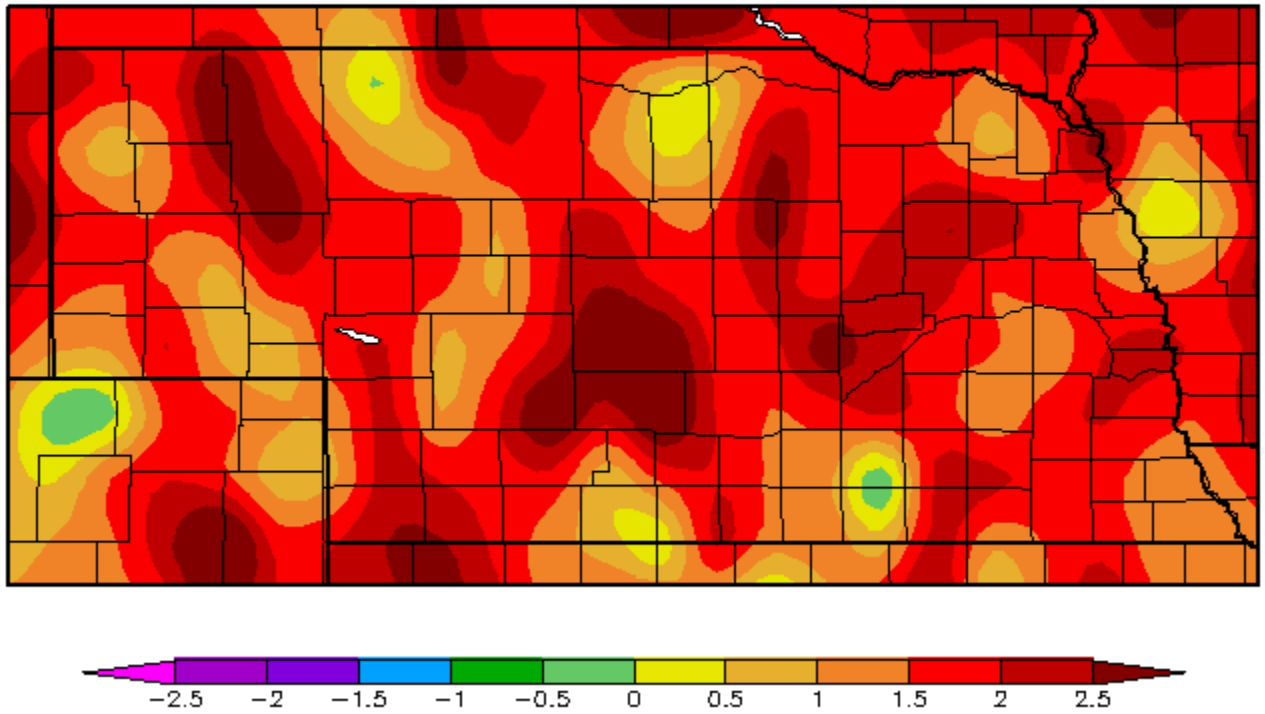
Departure from Normal Temperature (F)
1/1/2004 – 12/31/2004



Generated 7/20/2005 at HPRCC using provisional data.

NOAA Regional Climate Centers

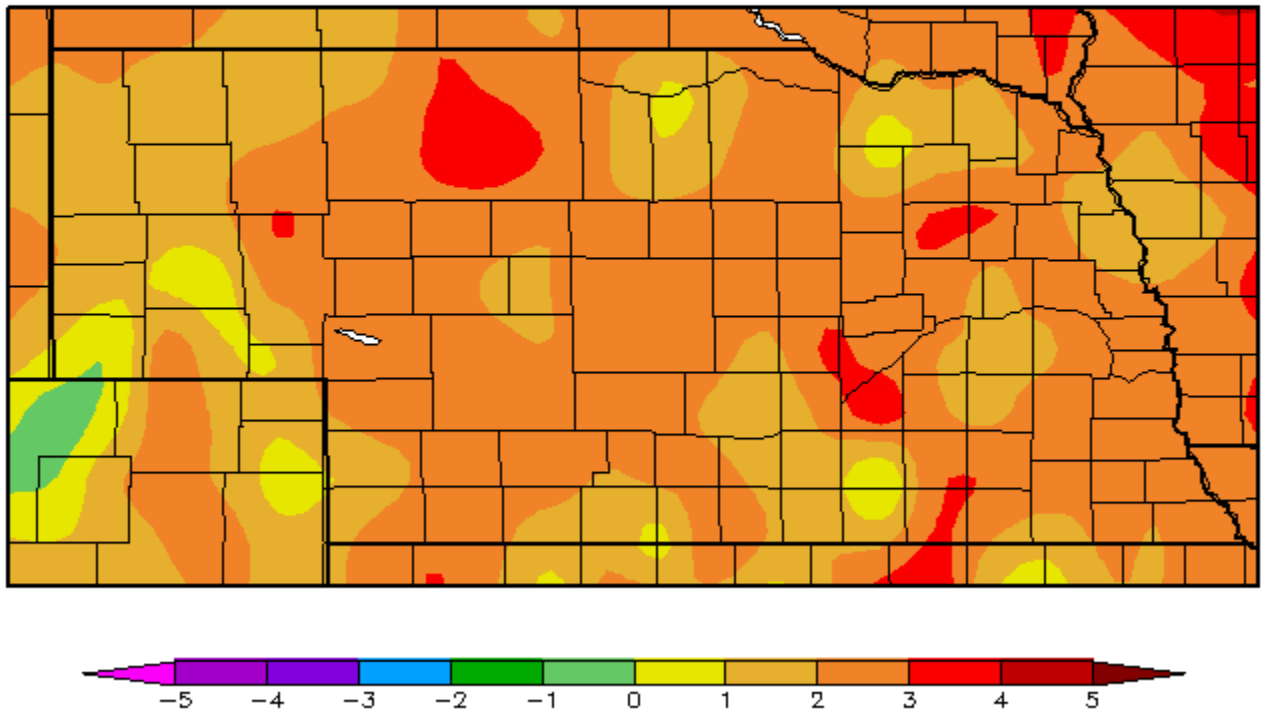
Departure from Normal Temperature (F)
1/1/2005 – 12/31/2005



Generated 5/12/2006 at HPRCC using provisional data.

NOAA Regional Climate Centers

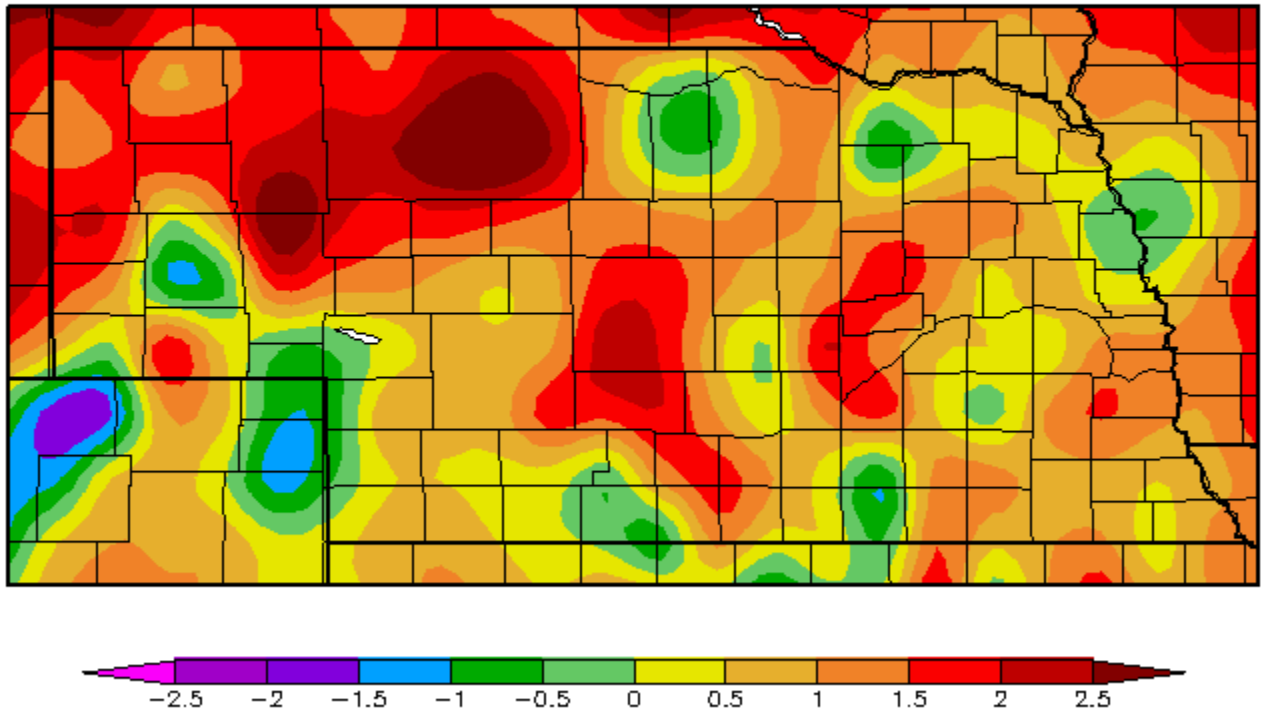
Departure from Normal Temperature (F)
1/1/2006 – 12/31/2006



Generated 3/12/2007 at HPRCC using provisional data.

NOAA Regional Climate Centers

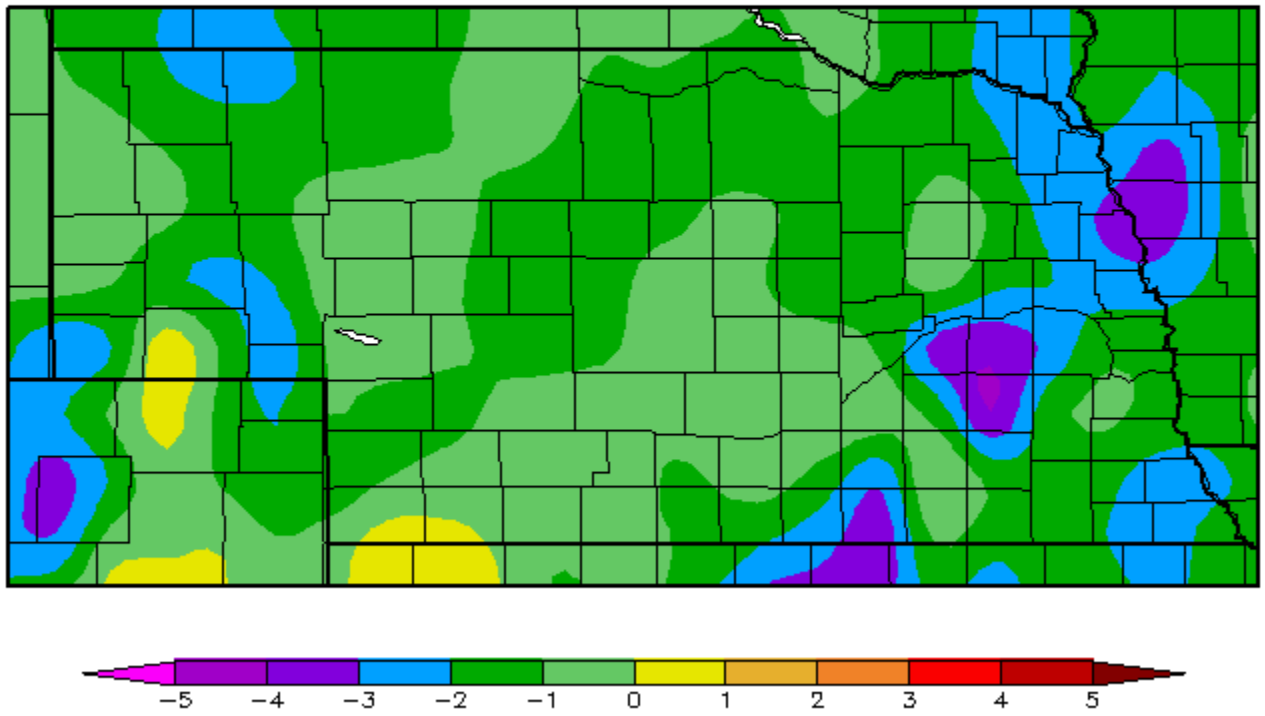
Departure from Normal Temperature (F)
1/1/2007 – 12/31/2007



Generated 9/17/2008 at HPRCC using provisional data.

NOAA Regional Climate Centers

Departure from Normal Temperature (F)
1/1/2008 - 12/31/2008



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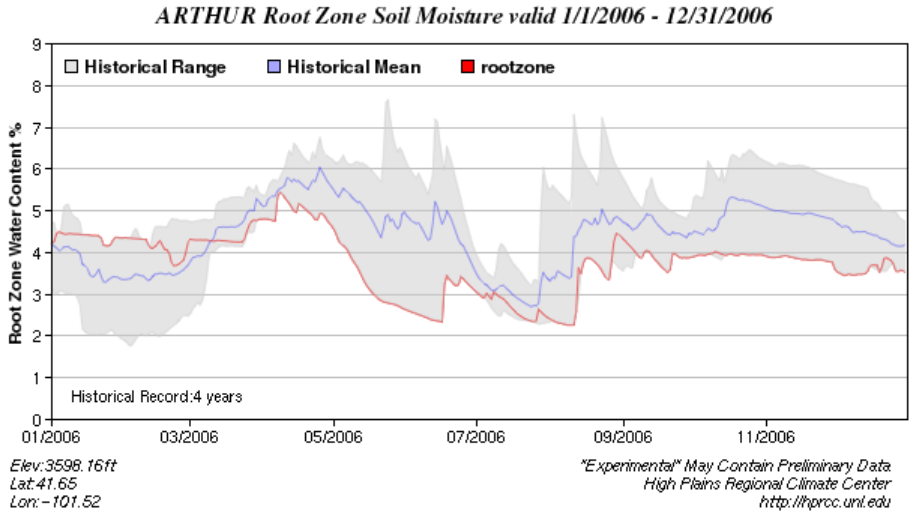
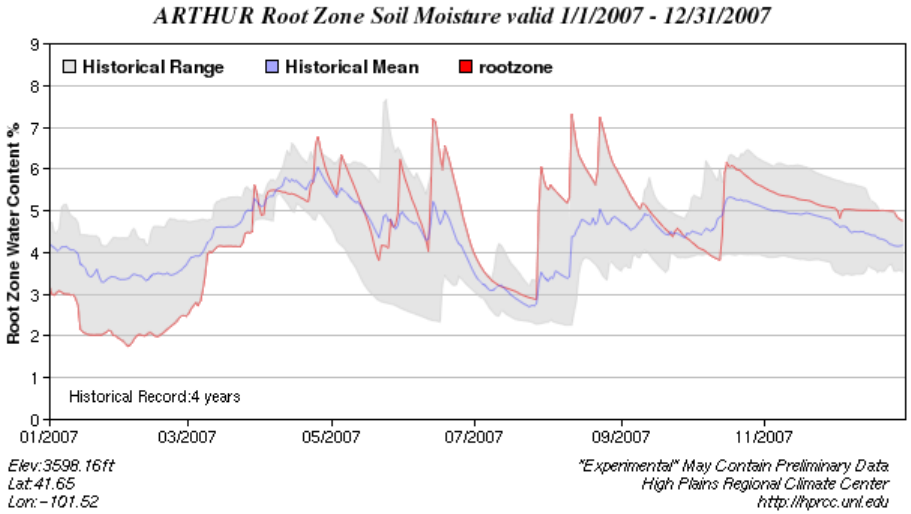
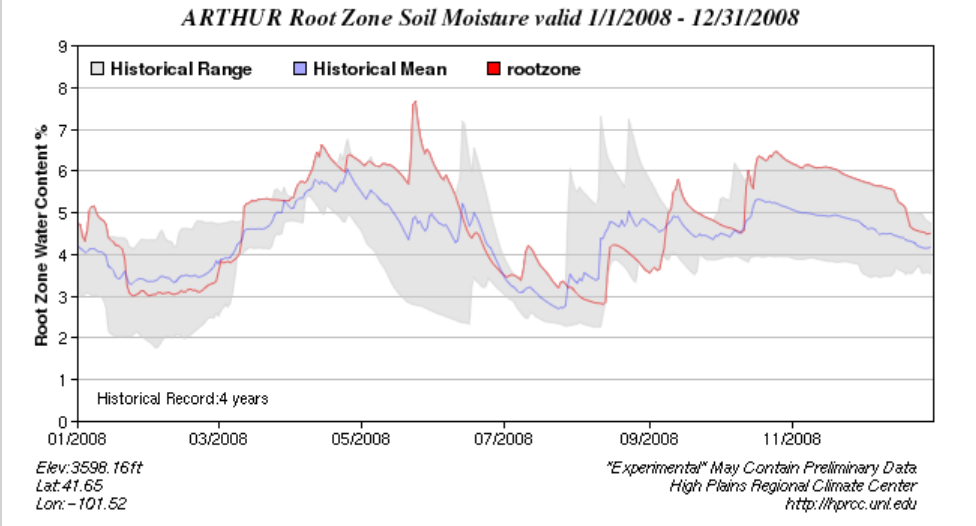
NOAA Regional Climate Centers

Soil Moisture



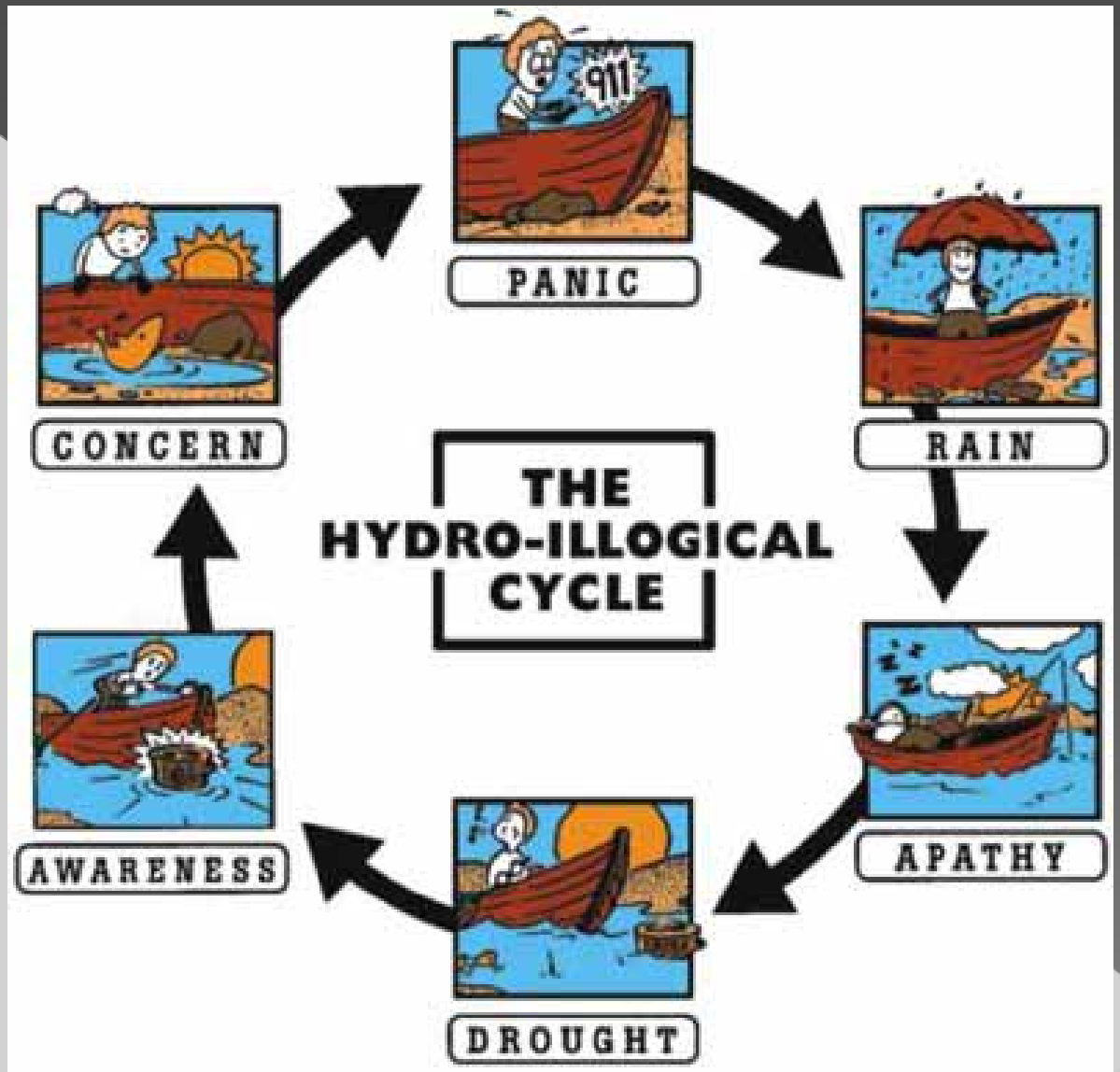




http://www.hprcc.unl.edu/awdn/soilm/index.php?station=a250369&plot_type=soilm&year=past&action=View+Plot

Tools

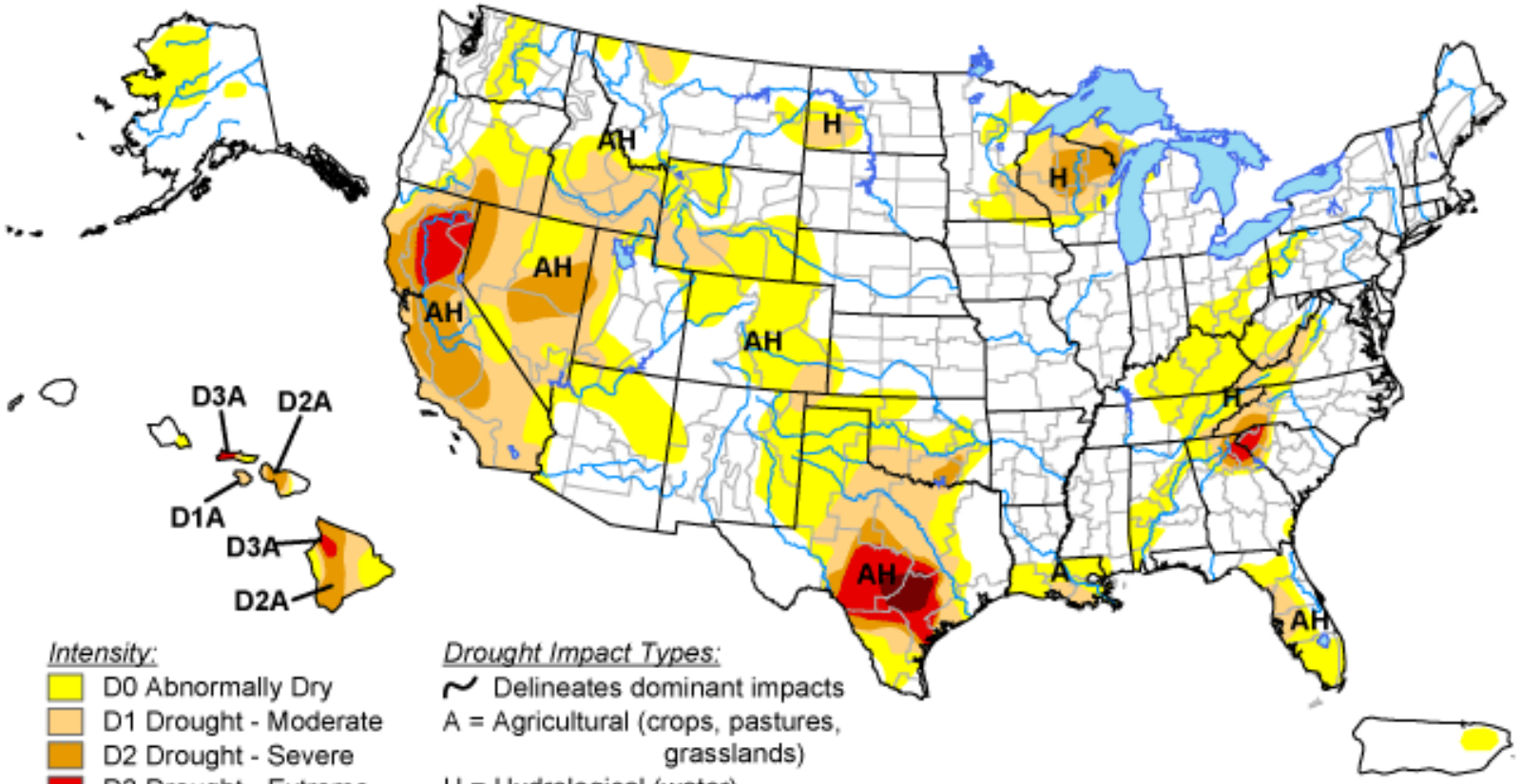
- The Hydro-illogical cycle
- Reflective and Predictive Web-based products
- Decision Support Systems



http://drought.unl.edu/plan/cycle.htm

U.S. Drought Monitor

January 20, 2009
Valid 8 a.m. EST



Intensity:
- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

Drought Impact Types:
- ~ Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

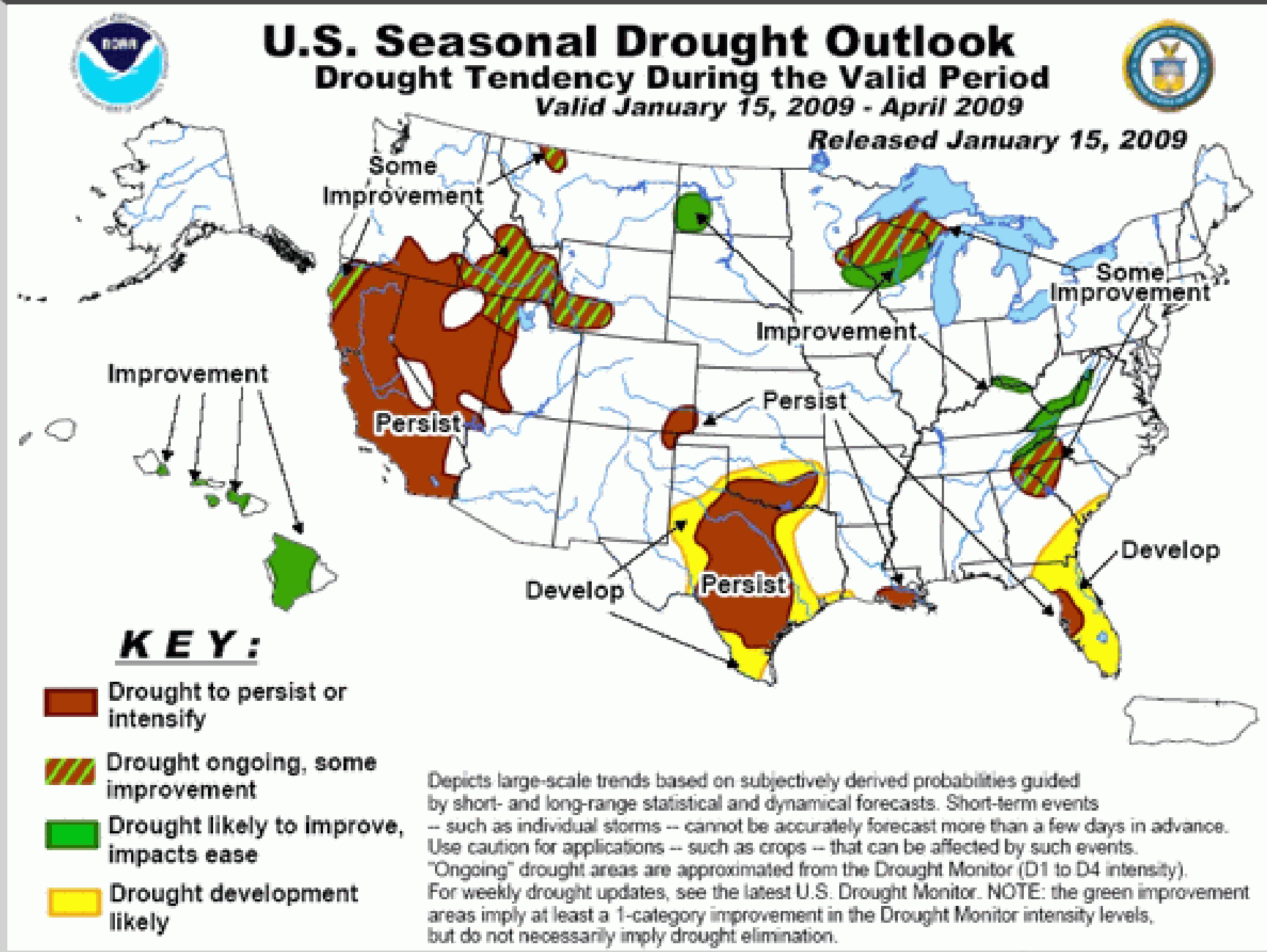
http://drought.unl.edu/dm

USDA National Drought Mitigation Center

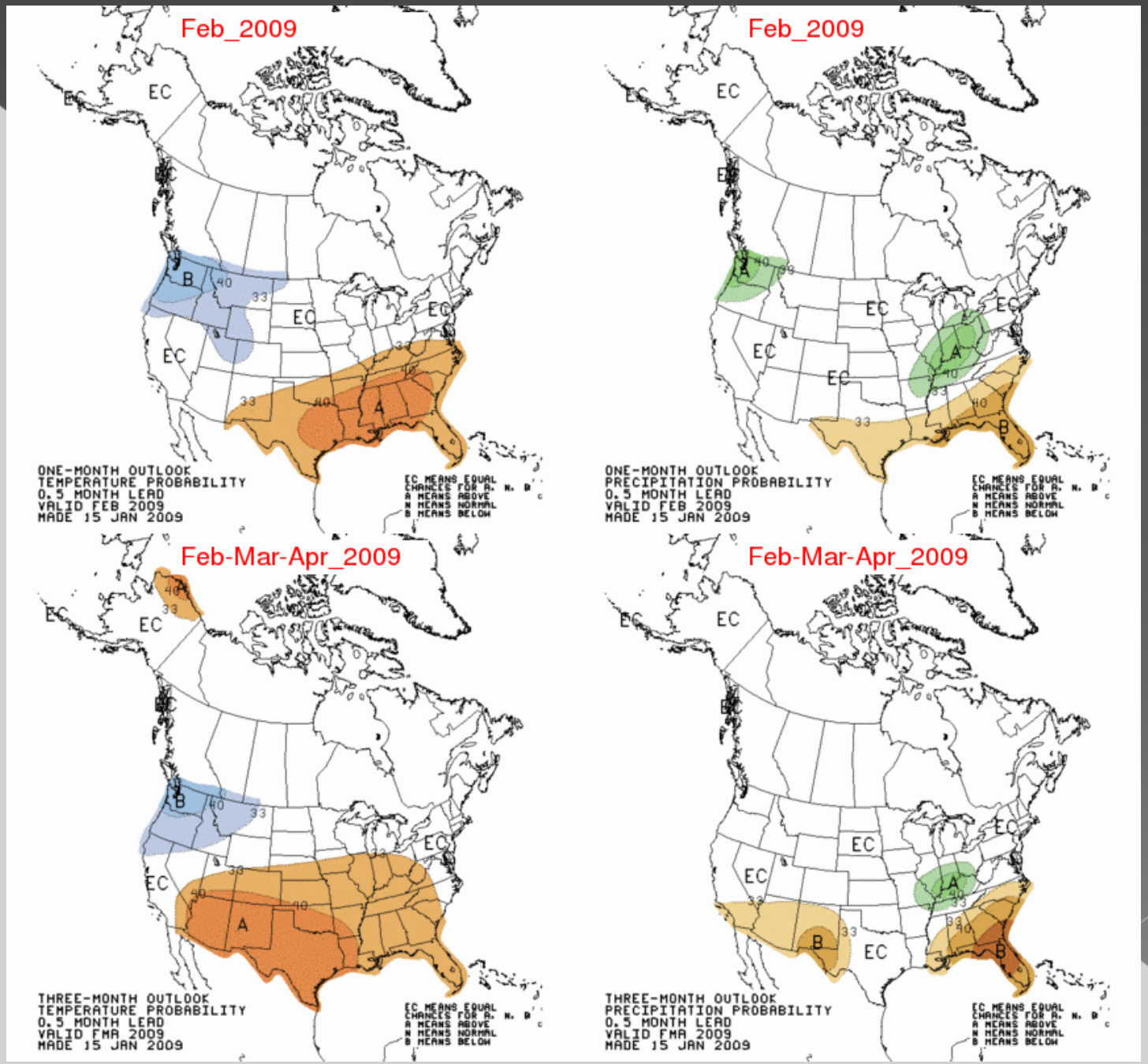
Released Thursday, January 22, 2009

Author: Laura Edwards, Western Regional Climate Center

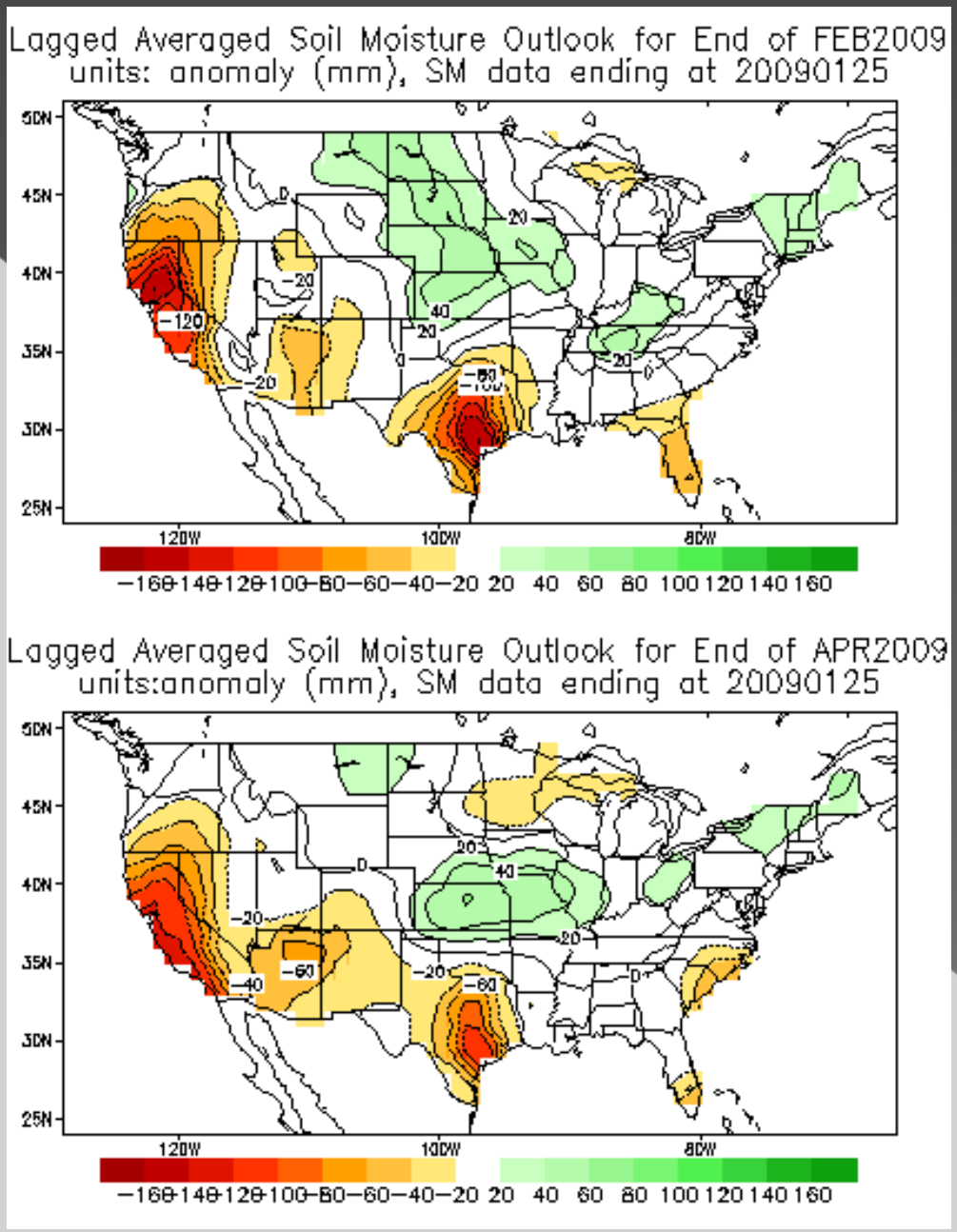
http://www.drought.unl.edu/dm/monitor.html



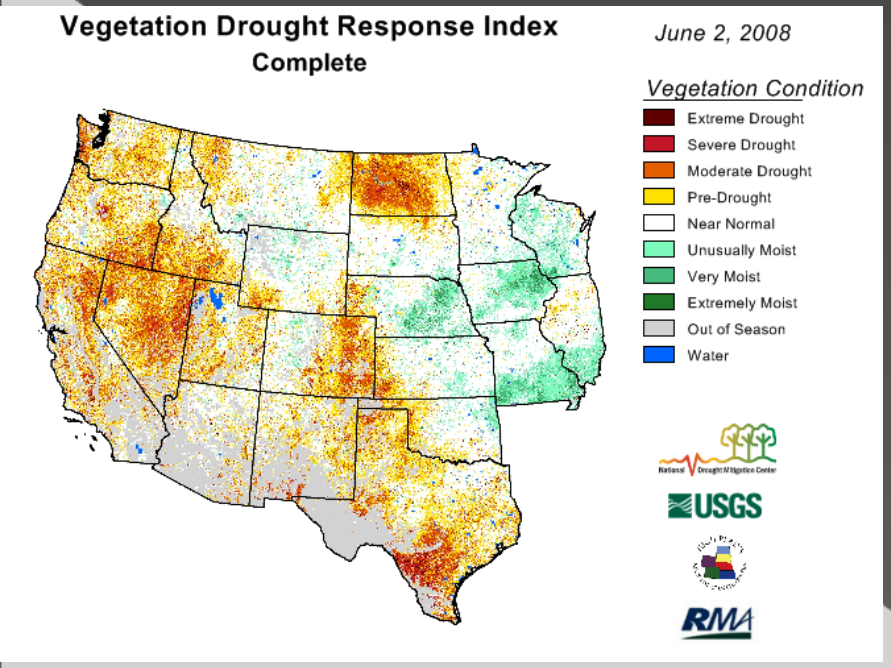
http://www.cpc.ncep.noaa.gov/products/expert_assessment/seasonal_drought.html

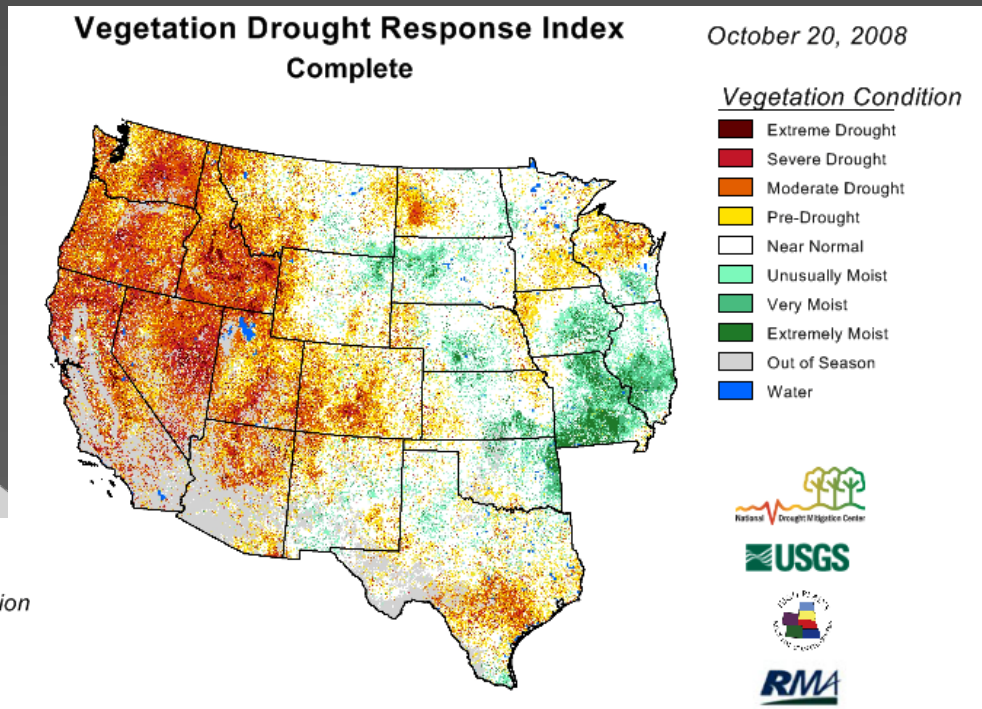


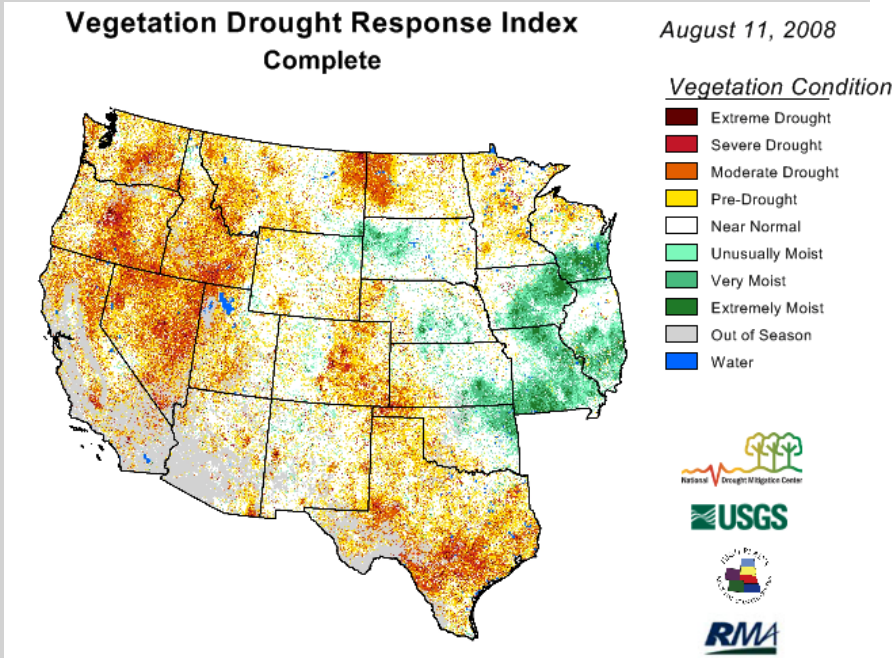
http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/page2.gif



http://www.cpc.ncep.noaa.gov/soilmst/img/cas_w_mon.lead1.gif



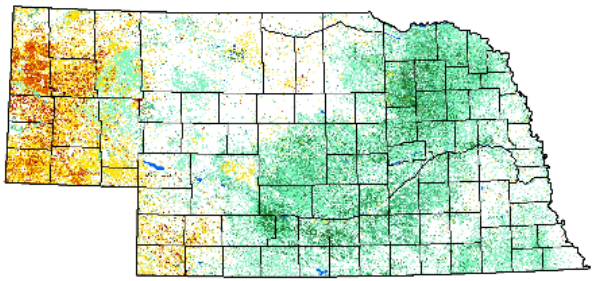




http://drought.unl.edu/vegdri/VegDRI_archive.htm

Vegetation Drought Response Index
Complete: Nebraska

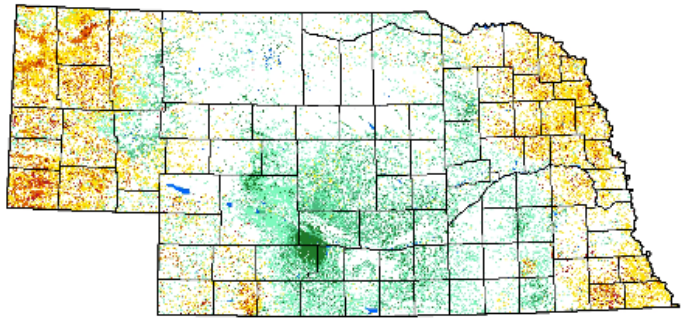
June 2, 2008



Vegetation Condition
- Extreme Drought
- Severe Drought
- Moderate Drought
- Pre-Drought
- Near Normal
- Unusually Moist
- Very Moist
- Extremely Moist
- Out of Season
- Water

Vegetation Drought Response Index
Complete: Nebraska

October 20, 2008



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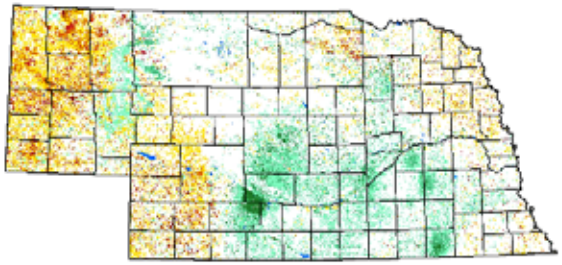
Vegetation Drought Response Index
Complete: Nebraska

August 11, 2008



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- Extreme Drought
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- Very Moist
- Extremely Moist
- Out of Season
- Water

Decision Support Systems

A user-oriented Interface for Forage and Stocking Decision Making using the GPFARM-Range Model

(Under development)

Model Inputs

Site name:
Ranch size:
Animal type (e.g. cattle):
Weather type (e.g. historical)

Forage forecast

Weather forecast sources:
e.g. NOAA, NASA, IRI, OTHER
Forecast: V. Good, Normal, Poor

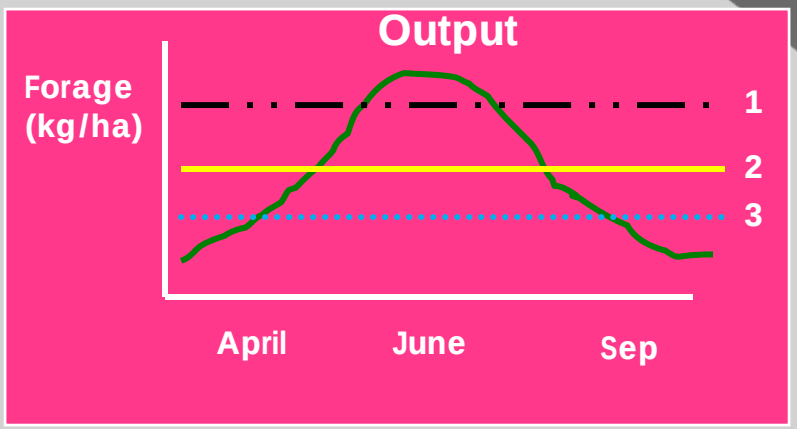
GPFARM-Range Model

Stocking and Forage demand rates:

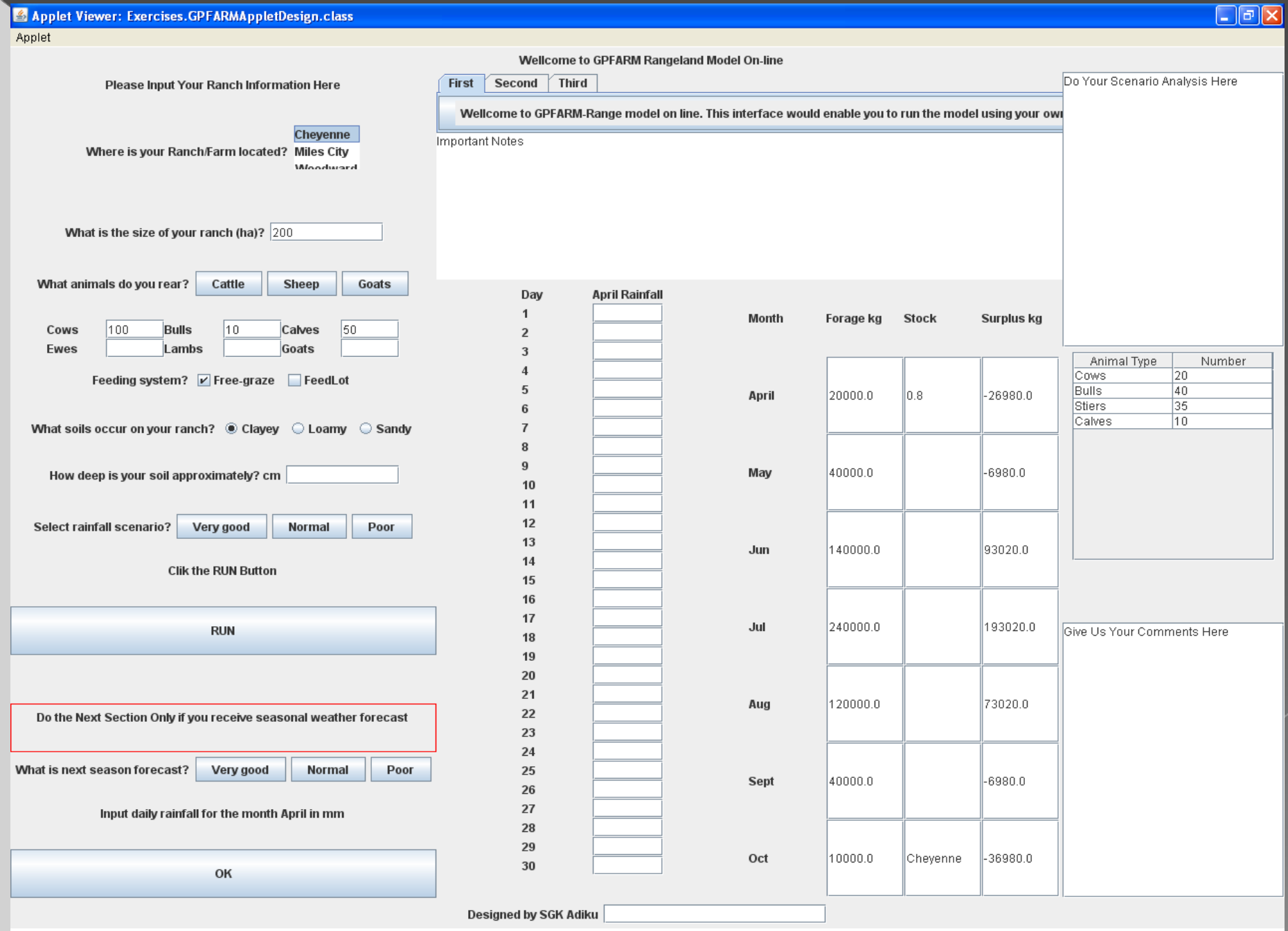
1*: *High

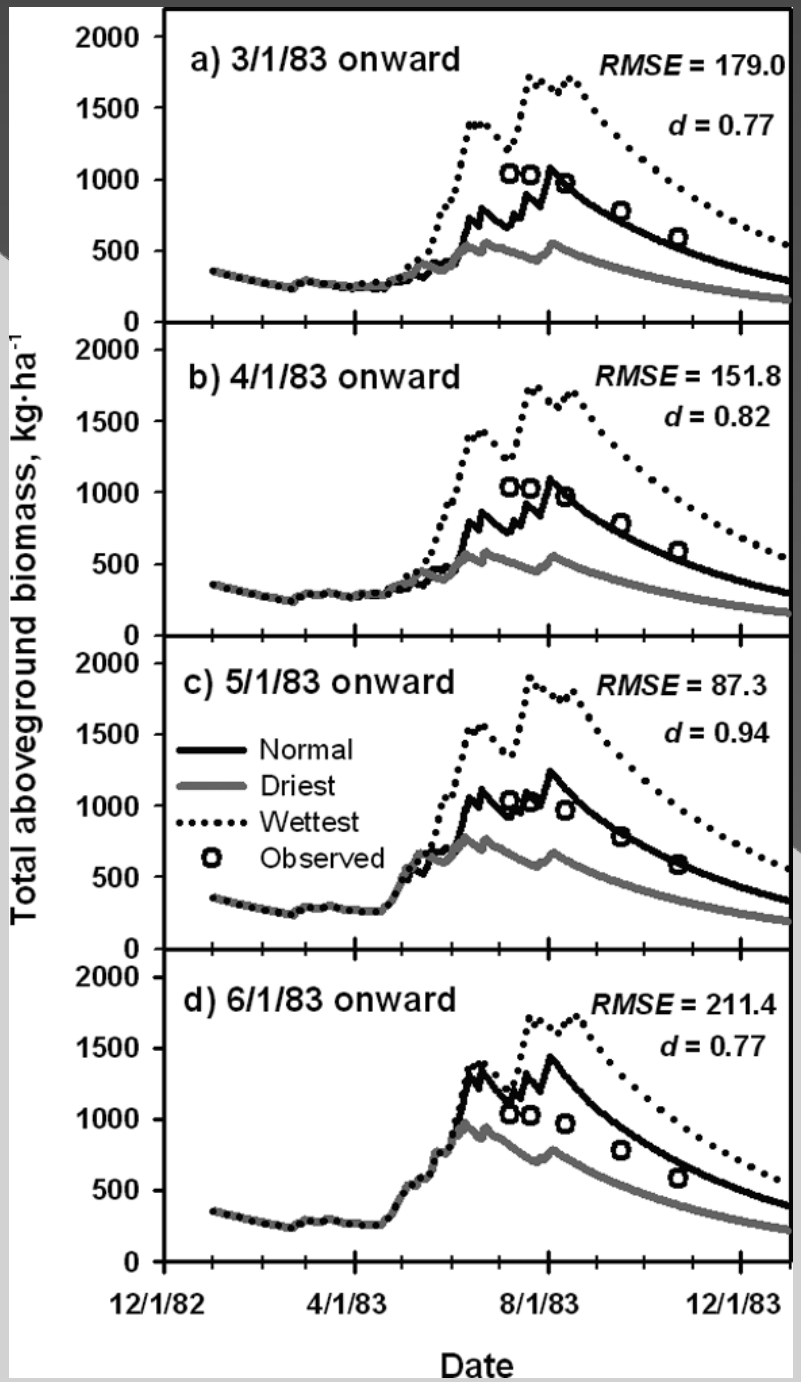
2: Moderate

3: Low



- The interface (next slide) enables User to run the GPFARM-range on the web.
- The model outputs the monthly forage production.
- Depending on stocking rate, the output shows periods of forage surplus/deficit.
- Ranchers can adjust stocks to minimize forage shortages.


Applet Viewer: Exercises.GPFARMAppletDesign.class
Applet
Wellcome to GPFARM Rangeland Model On-line
Please Input Your Ranch Information Here
First
Second
Third
Wellcome to GPFARM-Range model on line. This interface would enable you to run the model using your ow
Important Notes
Do Your Scenario Analysis Here
Where is your Ranch/Farm located?
Cheyenne
Miles City
What is the size of your ranch (ha)? 200
What animals do you rear?
Cattle
Sheep
Goats
Cows 100
Bulls 10
Calves 50
Ewes
Lambs
Goats
Feeding system?
Free-graze
FeedLot
What soils occur on your ranch?
Clayey
Loamy
Sandy
How deep is your soil approximately? cm
Select rainfall scenario?
Very good
Normal
Poor
Clik the RUN Button
RUN
Do the Next Section Only if you receive seasonal weather forecast
What is next season forecast?
Very good
Normal
Poor
Input daily rainfall for the month April in mm
OK
Day
April Rainfall
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
Month
Forage kg
Stock
Surplus kg
April
20000.0
0.8
-26980.0
May
40000.0
-6980.0
Jun
140000.0
93020.0
Jul
240000.0
193020.0
Aug
120000.0
73020.0
Sept
40000.0
-6980.0
Oct
10000.0
Cheyenne
-36980.0
Animal Type
Number
Cows
20
Bulls
40
Stiers
35
Calves
10
Give Us Your Comments Here
Designed by SGK Adiku
Applet started.
start
Inbox - Microsoft Out...
Java - Adikupractice/...
Applet Viewer: Exerci...
12:36 PM



Andales et al. 2006

Management Implications

Implications

- Stocking Rate!!!
- Good Stewardship!!!
- Plan!!!
- Flexibility/Adaptivity of livestock operations will be paramount
  - Kind, type and size of livestock
  - Within grazing season modifications in number of grazing animals
  - Movement of livestock across geographic areas
- Predictive power and accuracy will be essential for operations
  - Reduce risk!

Questions?