Funding provided by NOAA
Sectoral Applications Research Project

MONITORING DROUGHT

Basic Climatology

Colorado Climate Center

DEFINING DROUGHT

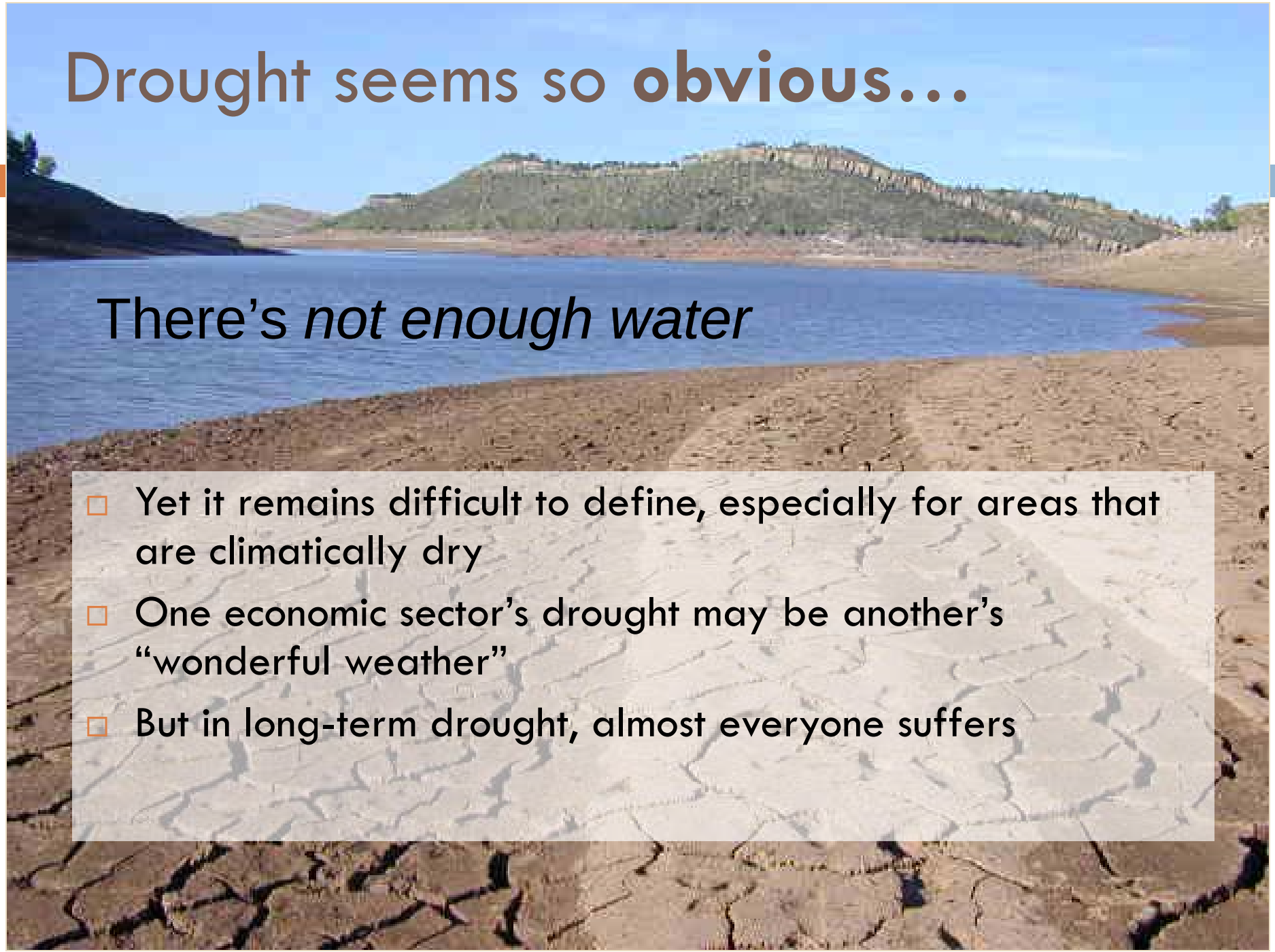
First off, just what is drought?

- Define a tornado
- Define a severe thunderstorm
- Define a hurricane
- Define a volcanic eruption
- When did it begin? Where was it? How bad was it? When did it end? Can you point to one on a map or radar display?
- *Okay, do the same for drought*

First off, just what is drought?

- Precipitation deficits?
- Soil moisture?
- Streamflow?
- Plants wilting?
- Wildfire?
- Famine?
- Other?

Drought seems so **obvious…**



There's *not enough water*

- Yet it remains difficult to define, especially for areas that are climatically dry
- One economic sector's drought may be another's "wonderful weather"
- But in long-term drought, almost everyone suffers

Drought defined by its impacts

- Meteorological Drought – departures from "normal" precipitation
- Agricultural Drought – soil / groundwater deficits that affect vegetation
- Hydrologic Drought – deficiency of water in watersheds, rivers; often lags agriculture impacts
- Socio-Economic Drought – shortage of some item (water, food, fish, natural values) that affects the balance of supply and demand

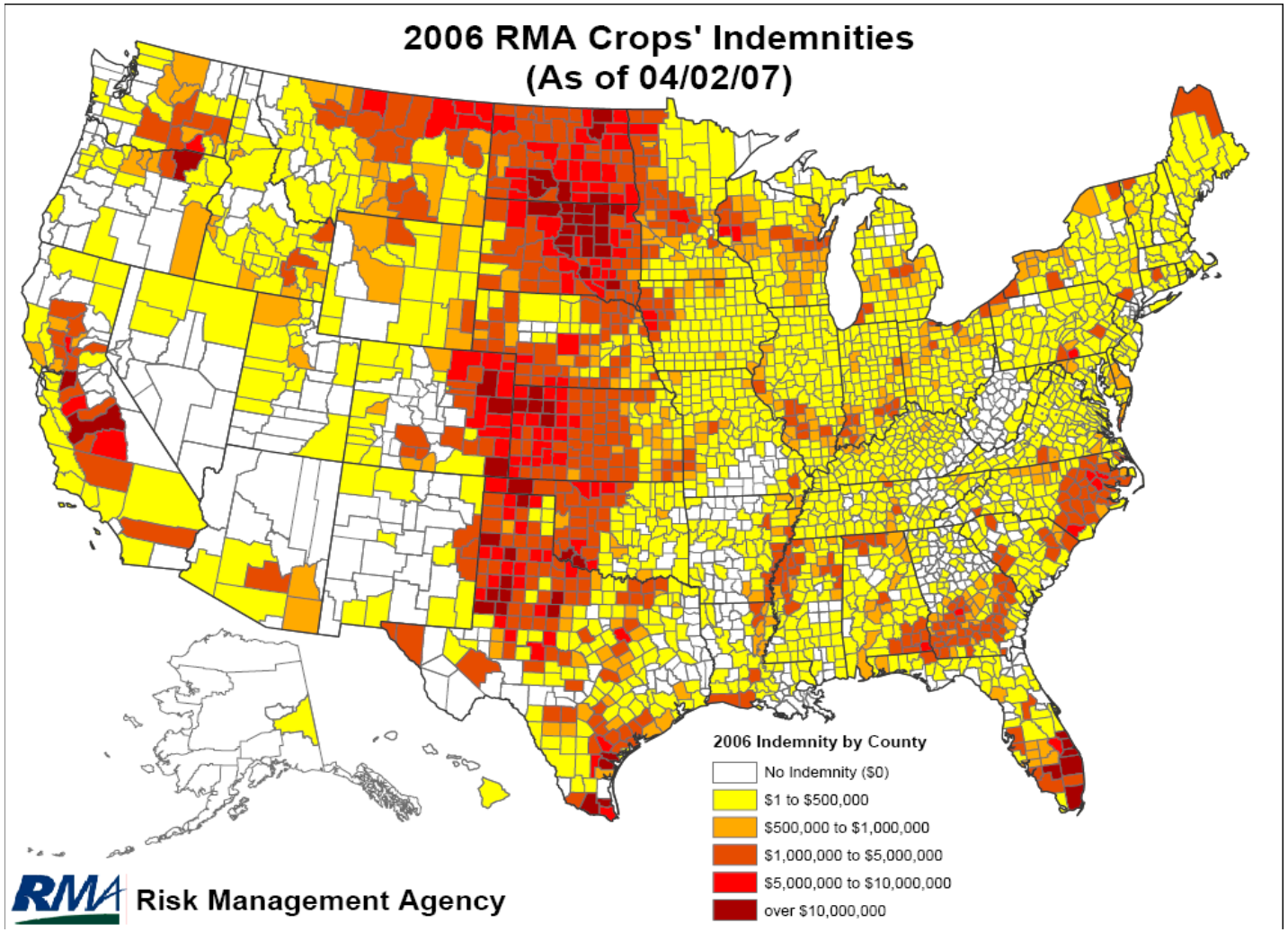
What is drought?

- Drought is the condition that occurs when ***water resources are insufficient to meet water needs.***
- … *in other words* …
- ***Drought is a social phenomenon.***
  - It's what it does to people that counts!
  - We read about droughts in the Sahel, but not the Sahara. *Why?* Because people live in the Sahel.

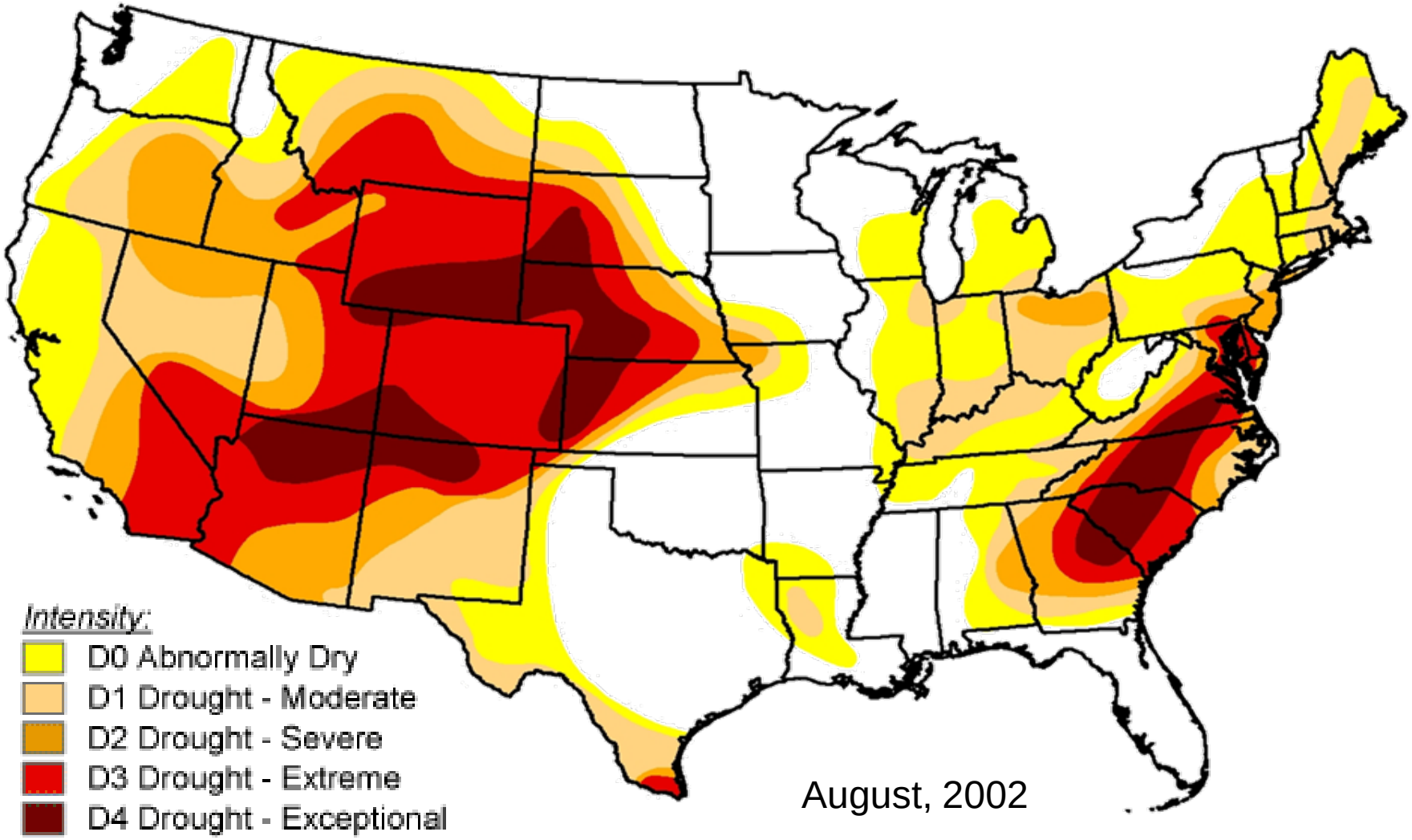
Why Monitor Drought Impacts?

- Drought is one of the **most costly** U.S. natural disasters
  - Estimated annual losses at **$6-8 billion** (1995)
  - **1988: $39 billion ($68B in 2007 $)**
  - **2002, 2003, 2004, 2005, 2006, 2007: ???**
  - Europe, 2003: **US$13B**
  - Canada, 2001-02: **US$5.7B**
- USDA/Risk Management Agency, 2006: US$1.71B indemnities
- Congress has appropriated approximately **$30 billion** in drought relief since 1988

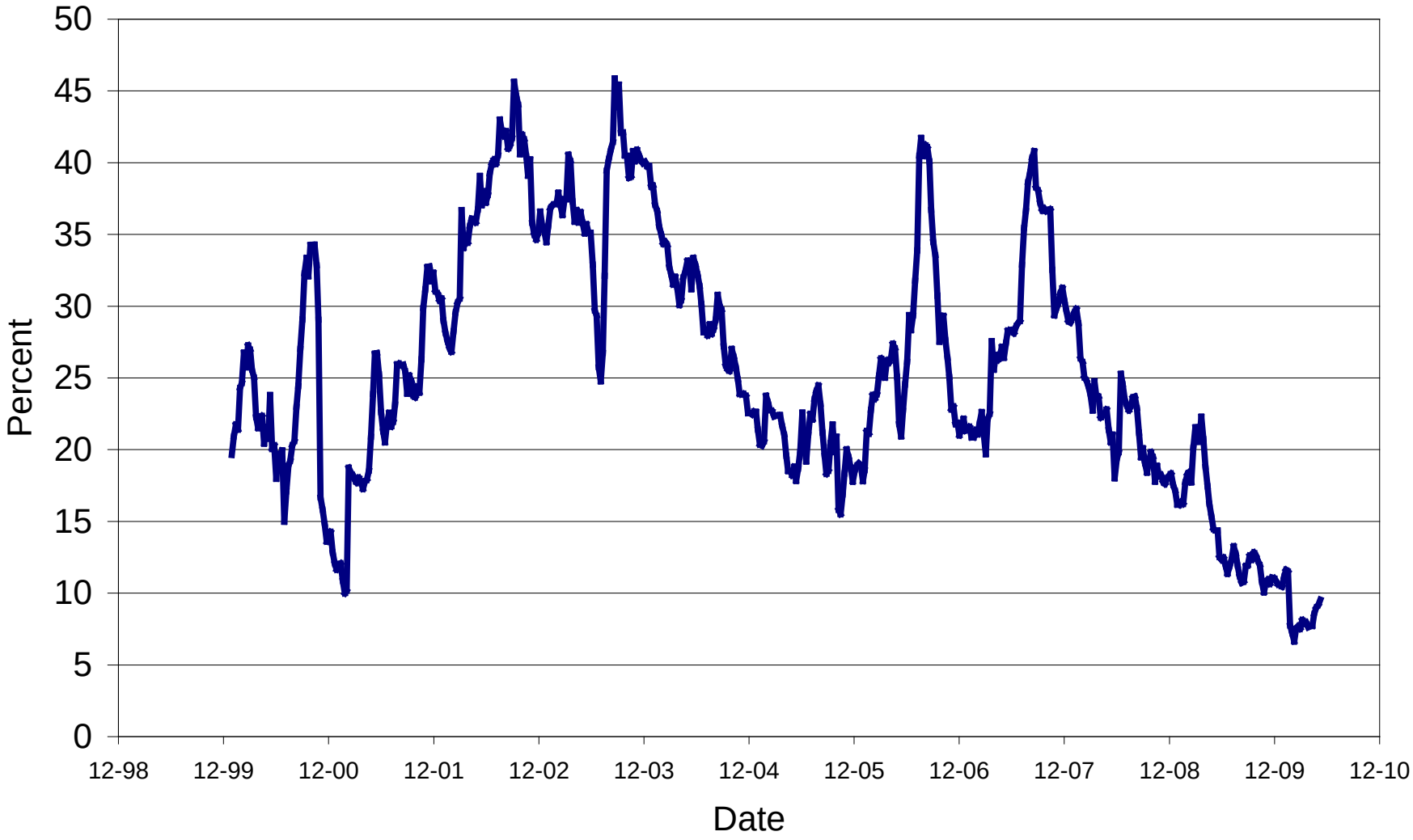
Economic Impacts of Drought



Approximate Peak of 2002 Drought -- Colorado's worst recent Drought



Percentage of US in Drought (D1-D4)



DROUGHT INDICATORS

Precipitation Departures

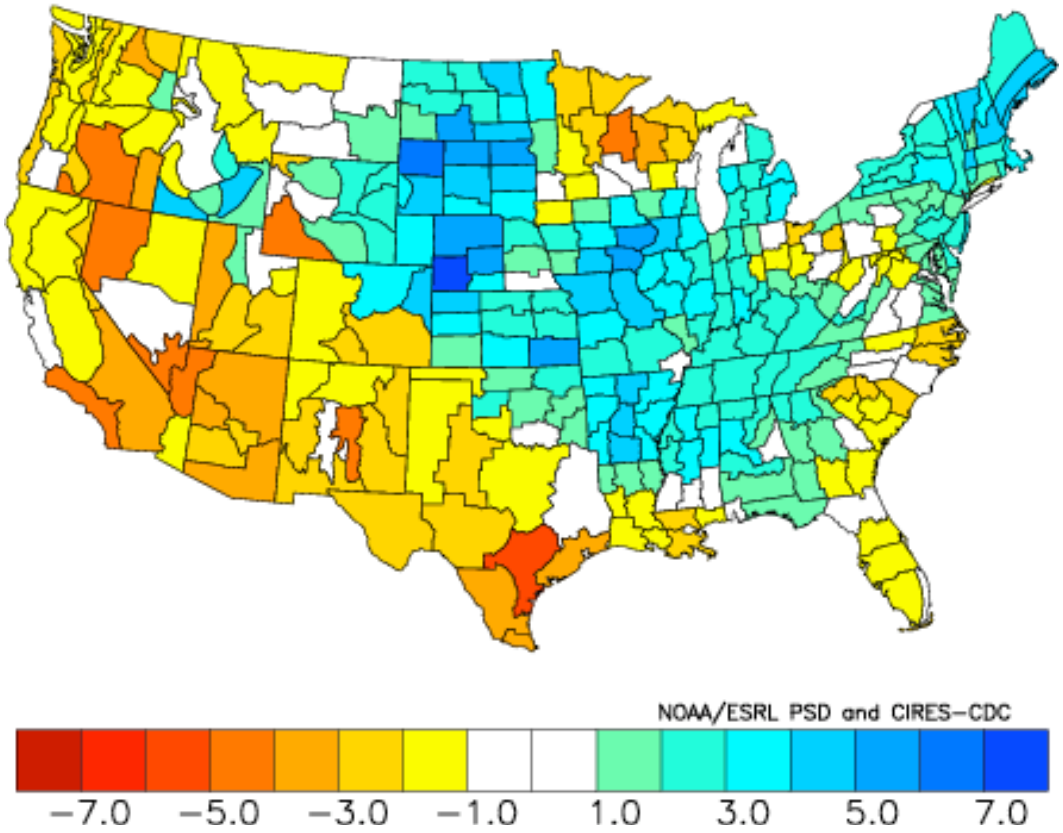
- Precipitation the key indicator for vegetation growth, water resources
  - Temperature effects also important, but precipitation dominates
- Measured virtually everywhere
- Easy to calculate
- Can be done for points or over areas (such as a state or climate division)

Palmer Drought Severity Index (PDSI)

- Developed in 1965 (first widely used soil moisture model)
- Uses temperature and precipitation departures to determine dryness
- Ranges from -4 (extreme drought) to +4 (extreme wet)
- Standardized to local climate
  - Based on departures from local climate normals
- Good for measuring long-term drought in relatively uniform regions
  - Not good for short-term drought / rapid changes
  - Not good for variable terrain (i.e., mountains)
- May lag emerging drought conditions by several months

Key drought indices

Palmer Drought Index - Sep 2009

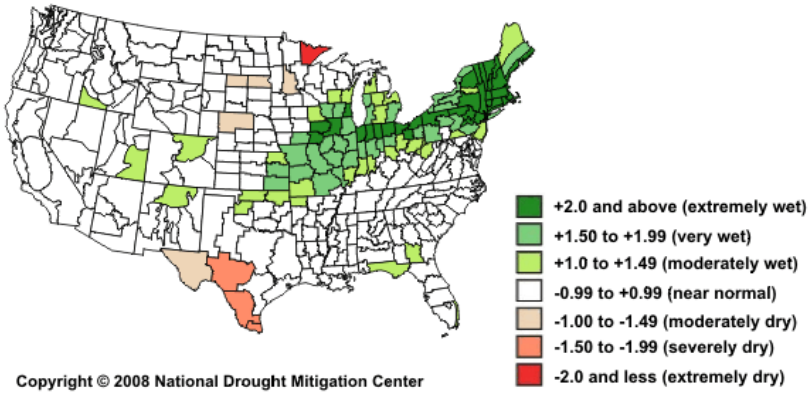


Standardized Precipitation Index (SPI)

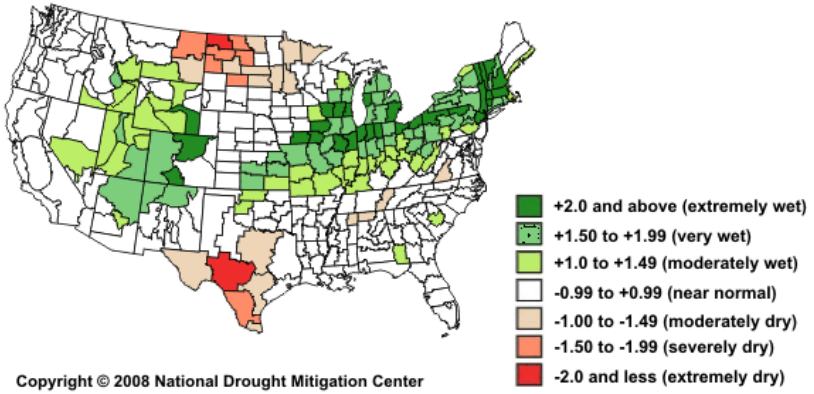
- Developed here at CSU in 1990s
- Can be produced for a variety of time periods, depicting both short-term and long-term conditions
- Based on precipitation over an accumulation period compared to the station's historical distribution
  - Statistical "unusualness" of a period
- PDSI uses a water-balance model to estimate evaporation based on temperature
- Values of -2 or less are extremely dry; +2 and greater are extremely wet

Standardized Precipitation Index (SPI)

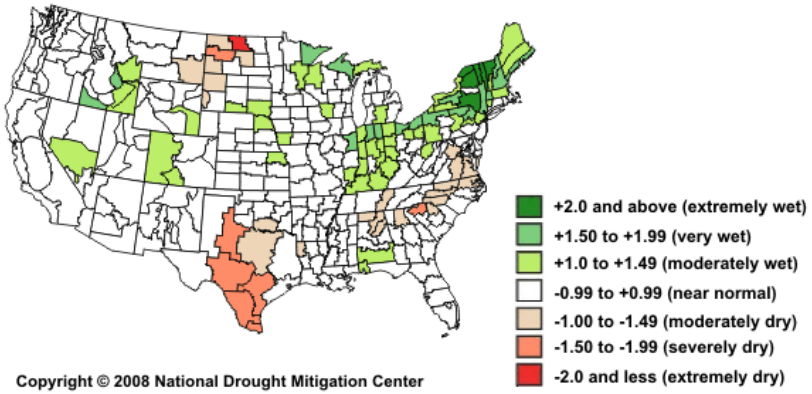
1-month SPI through the end of February 2008



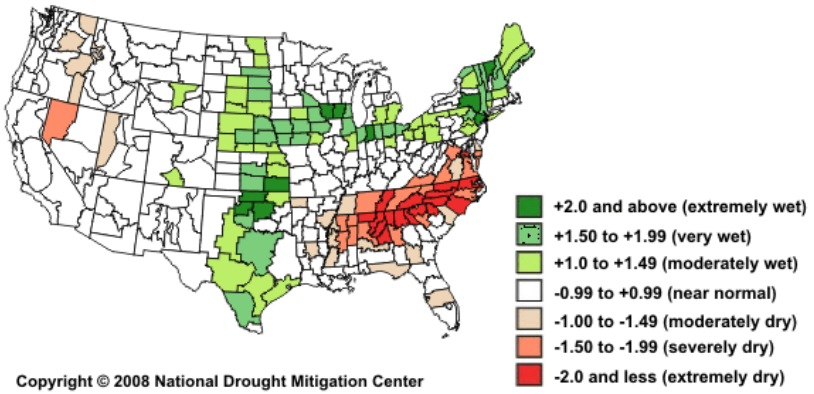
3-month SPI through the end of February 2008



6-month SPI through the end of February 2008



12-month SPI through the end of February 2008



Key drought indices

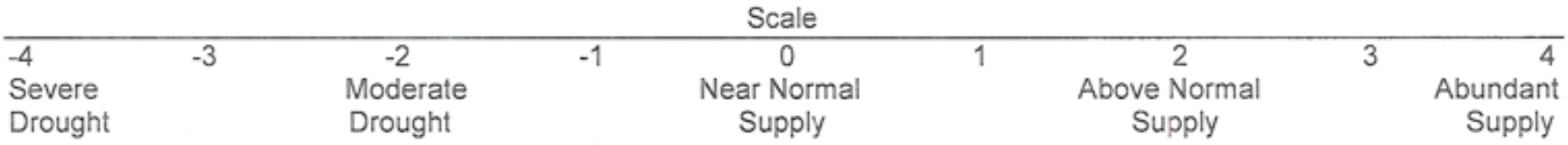
How often will different SPI values occur?

SPI Values		
2.0+	extremely wet	3% of time
1.5 to 1.99	very wet	13% of time
1.0 to 1.49	moderately wet	
-.99 to .99	near normal	68% of time
-1.0 to -1.49	moderately dry	13% of time
-1.5 to -1.99	severely dry	
-2 and less	extremely dry	3% of time

Key drought indices

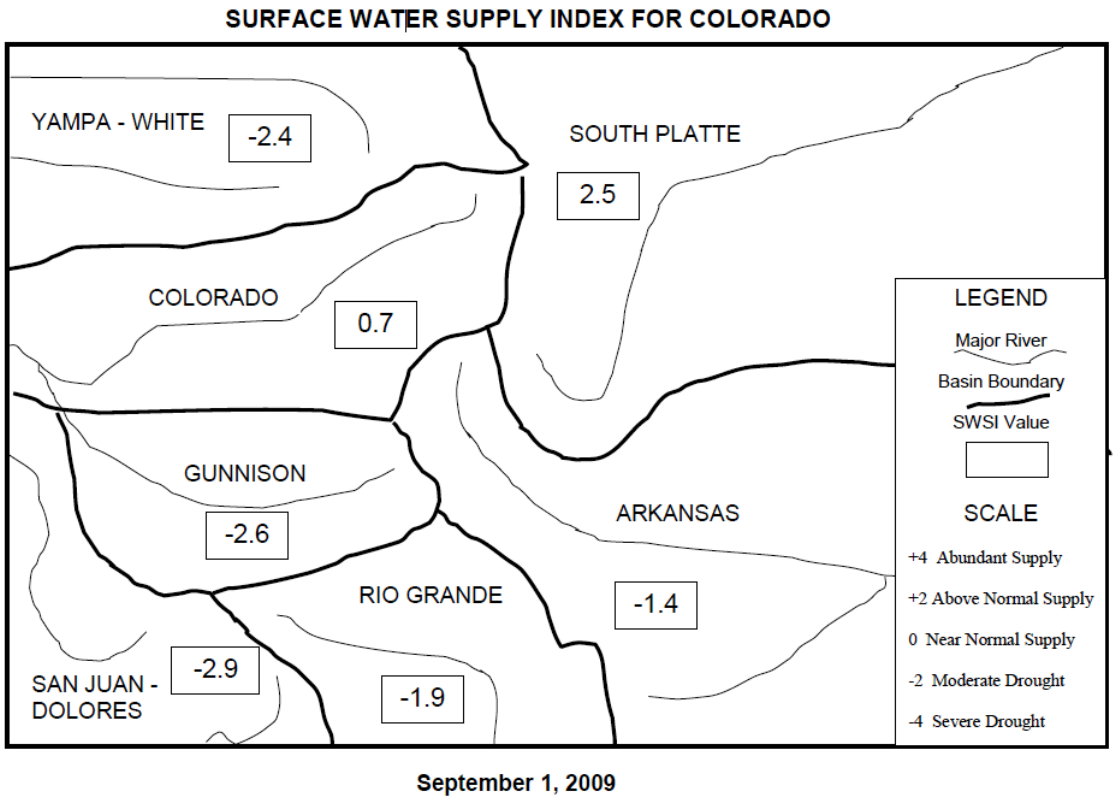
Surface Water Supply Index (SWSI)

- Based on observed precip, snowpack, streamflow, reservoir storage
- Computed by basin, with basin-specific weighting factors
- State & NRCS now revising how SWSI is calculated



Key drought indices

Surface Water Supply Index (SWSI)



September 2009 - SWSI ranges from 2.5 to -2.9

Other useful drought indicators

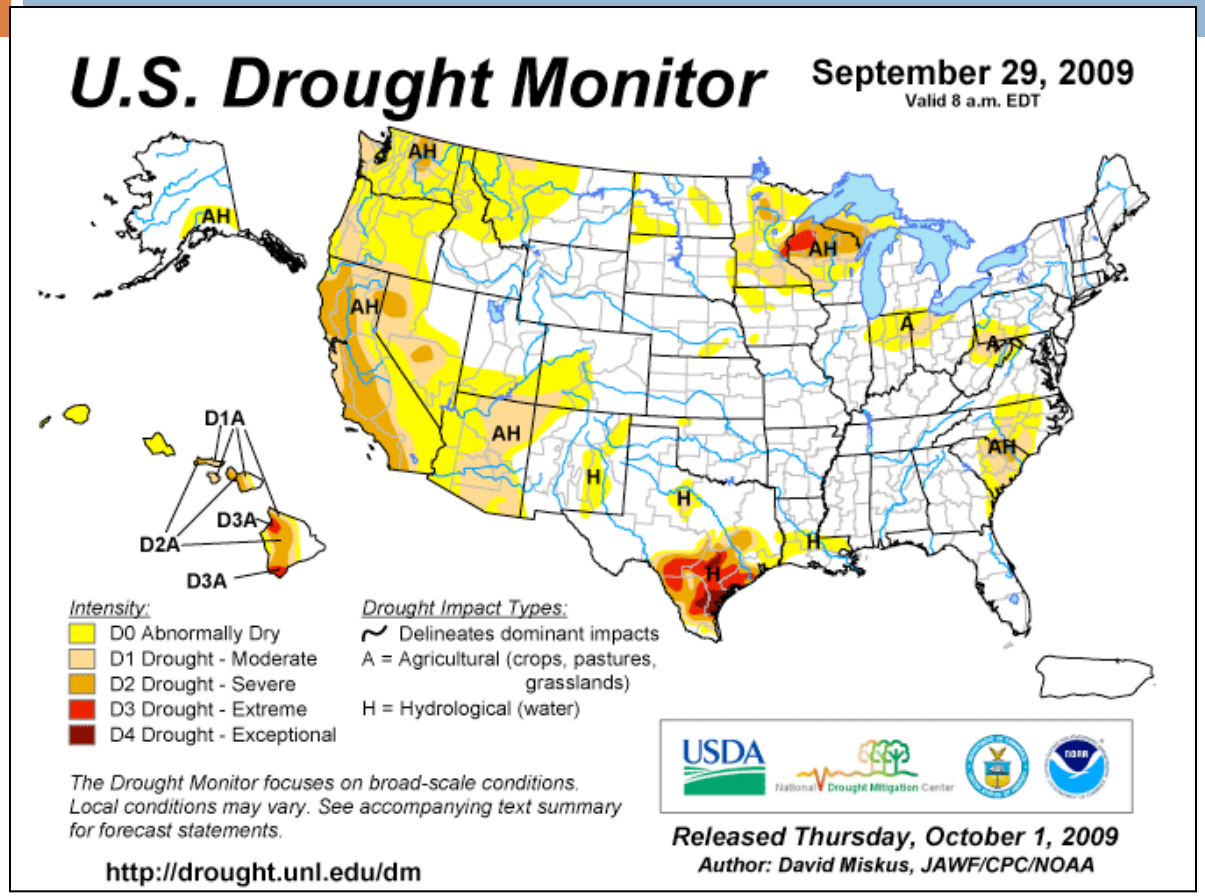
- Precip % of historical average
- Soil moisture (observed or modeled)
- Crop Moisture Index
- Recent/current streamflow
- Snowpack - esp. April 1 Snow Water Equivalent (SWE)
- Reservoir storage
- Fuel dryness

All of these are driven mainly by precipitation variability, with some contribution of temperature

Other Drought Tools

- Evaporation models
  - Often the missing link in drought understanding
  - Direct measurement difficult and disappearing (pan evap)
  - ET models are getting more sophisticated
- Soil Moisture
  - Integrates precipitation deficits over time
  - Lagging indicator but strongly related to impacts
  - Valuable for assessing recovery

Synthesis of multiple drought indicators



Blend of:

- Palmer Index
- SPI
- Streamflow
- Soil moisture

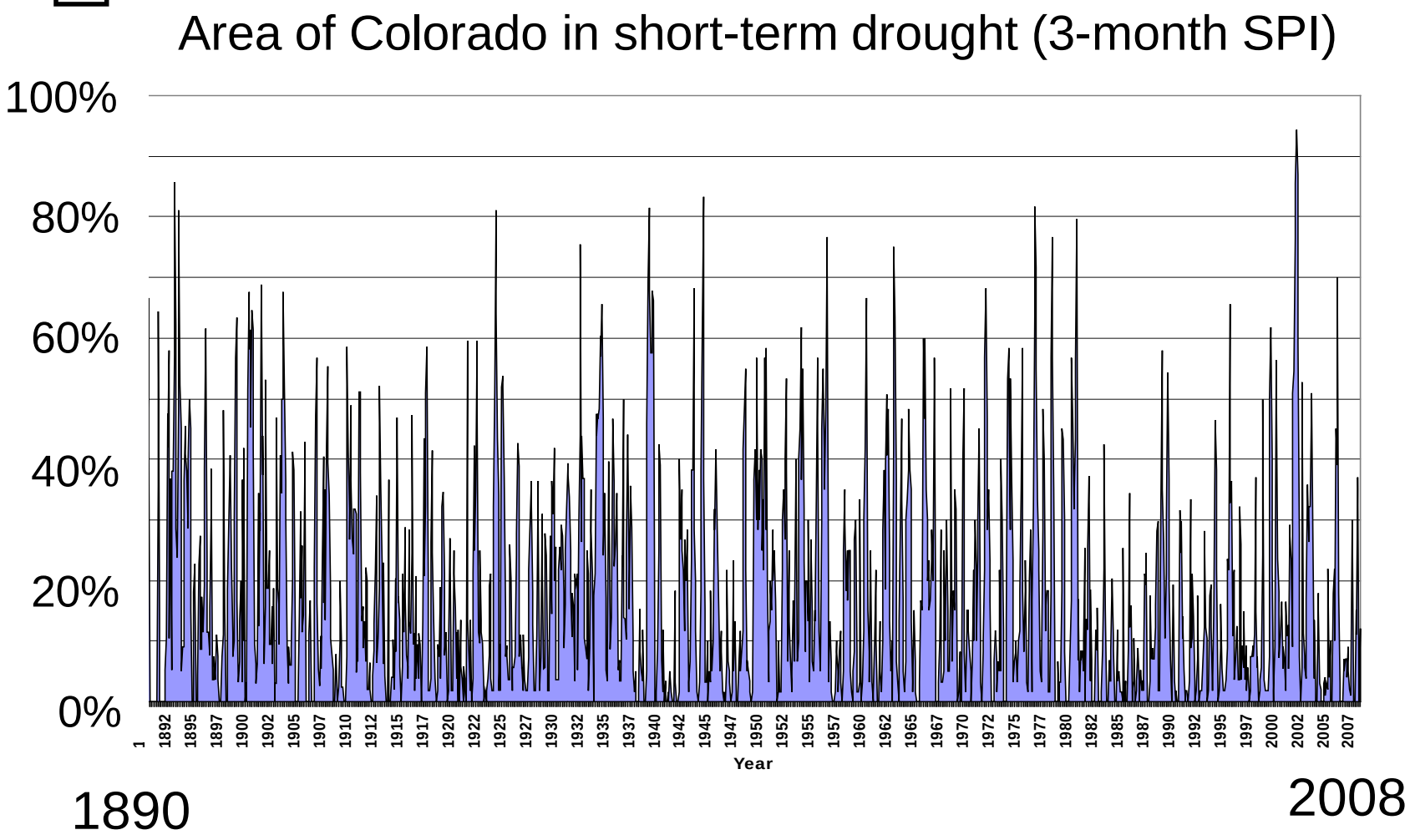
…tweaked by local observations

Updated weekly

Nolan working on more detailed Drought Monitor for Upper CO basin

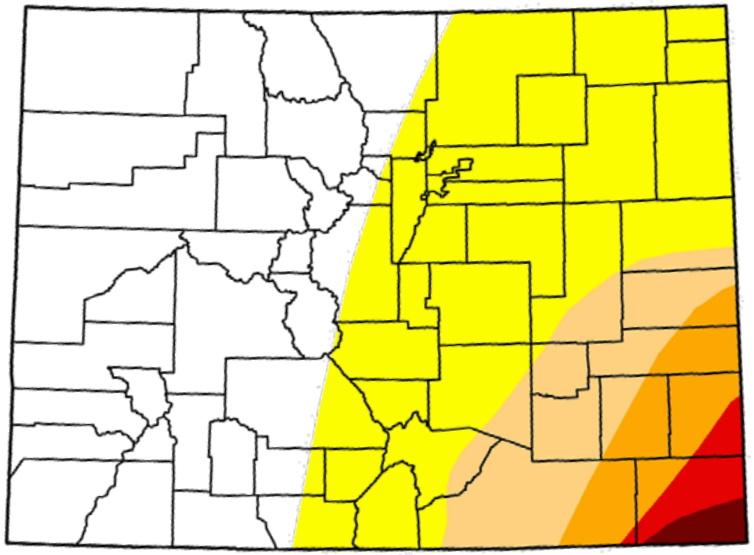
Lessons from the historic and paleo records of drought in Colorado

Short-term dryness occurs in parts of Colorado almost every year

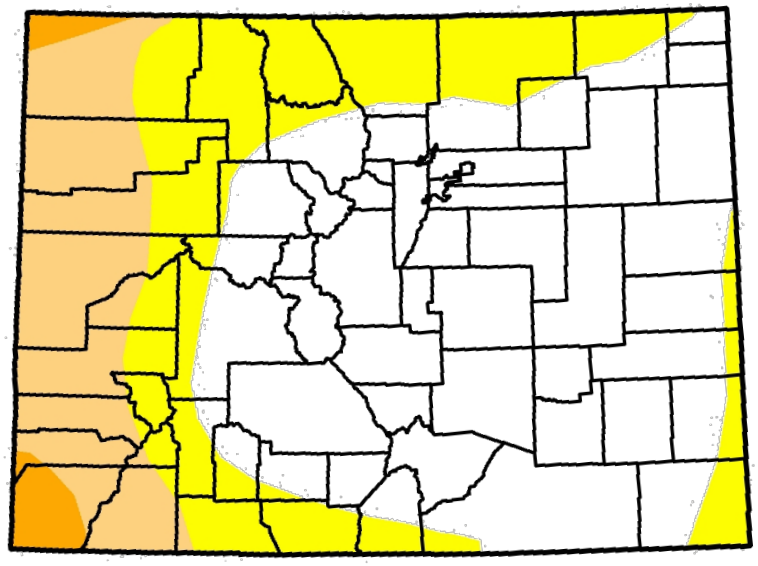


Short-term dryness occurs in parts of Colorado almost every year

July 8, 2008

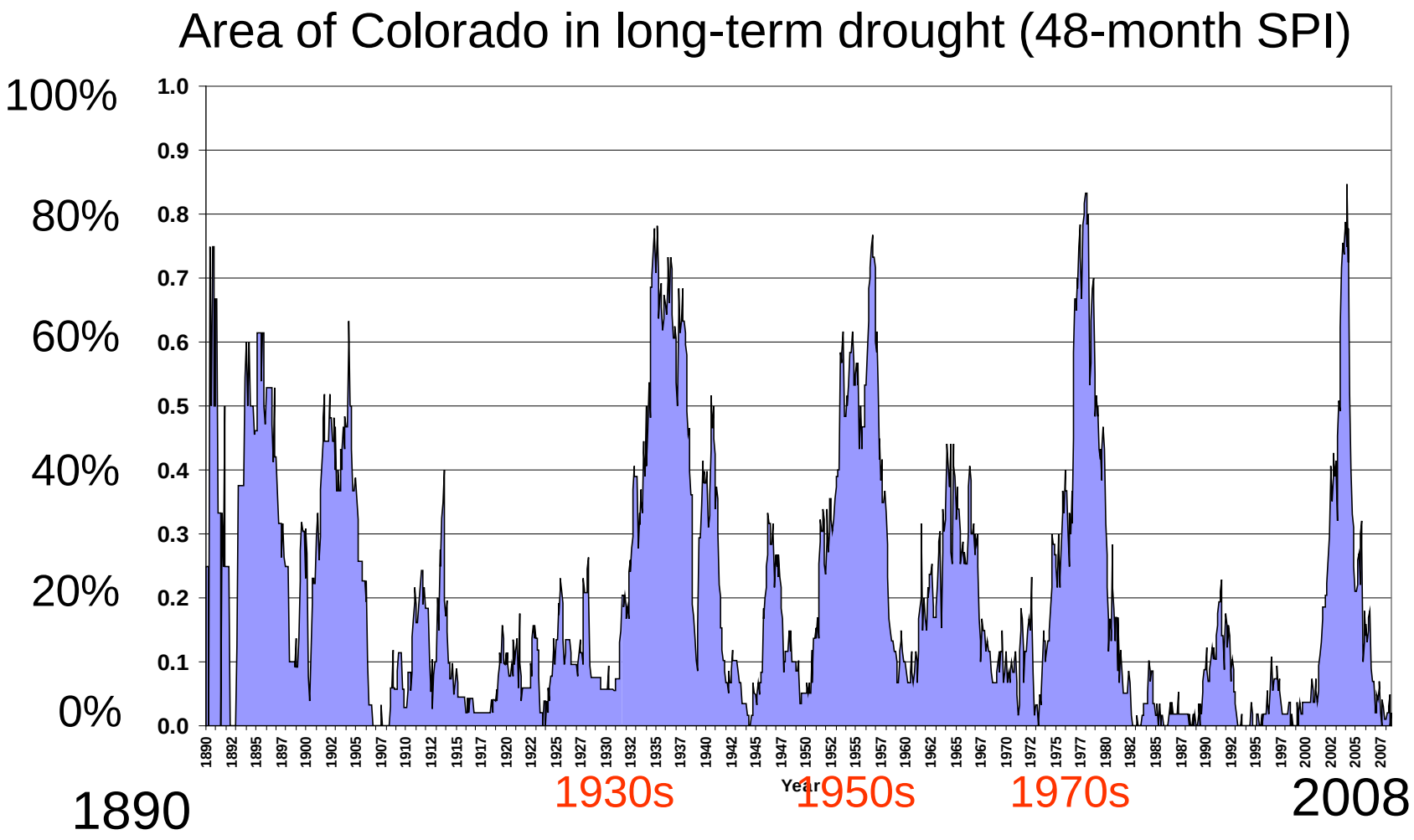


July 10, 2007



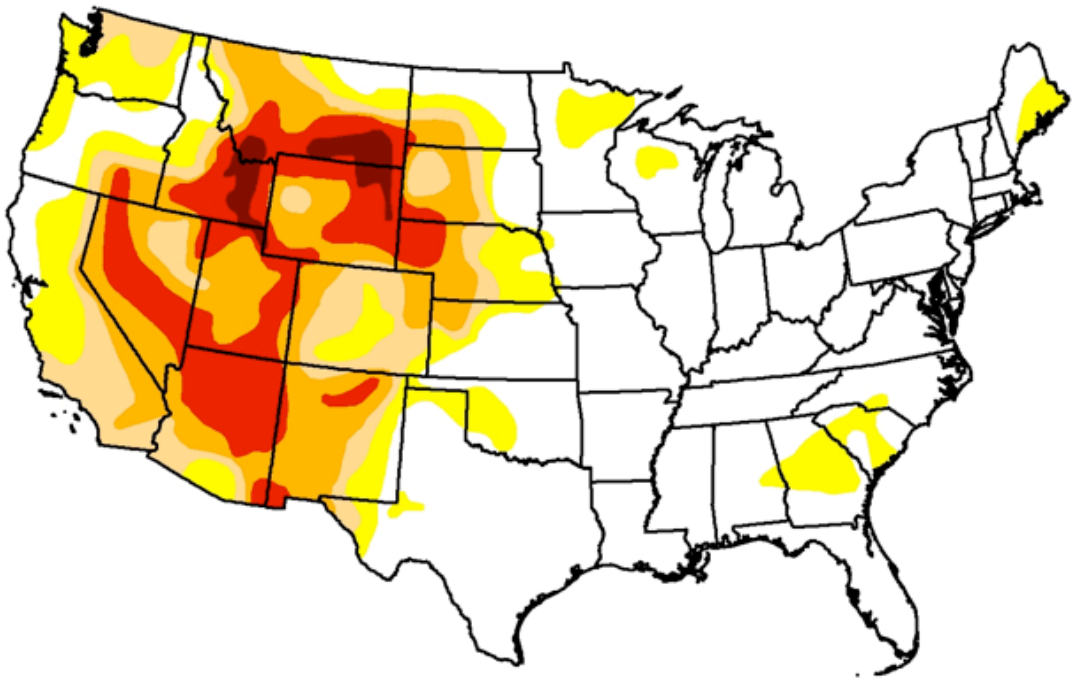
D0: Abnormally Dry
D1: Drought-Moderate
D2: Drought-Severe
D3: Drought-Extreme
D4: Drought-Exceptional

Multi-year droughts are infrequent (every 10-30 yrs) but have broader and deeper impacts



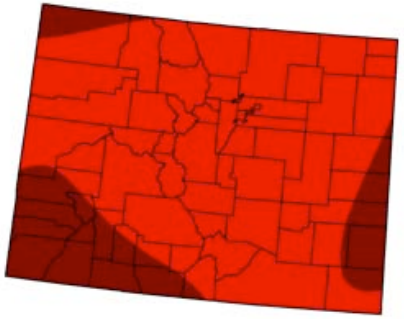
~20-year drought cycle? Not really…

Multi-year droughts are generally regional, caused by persistence of large-scale atmospheric circulation features



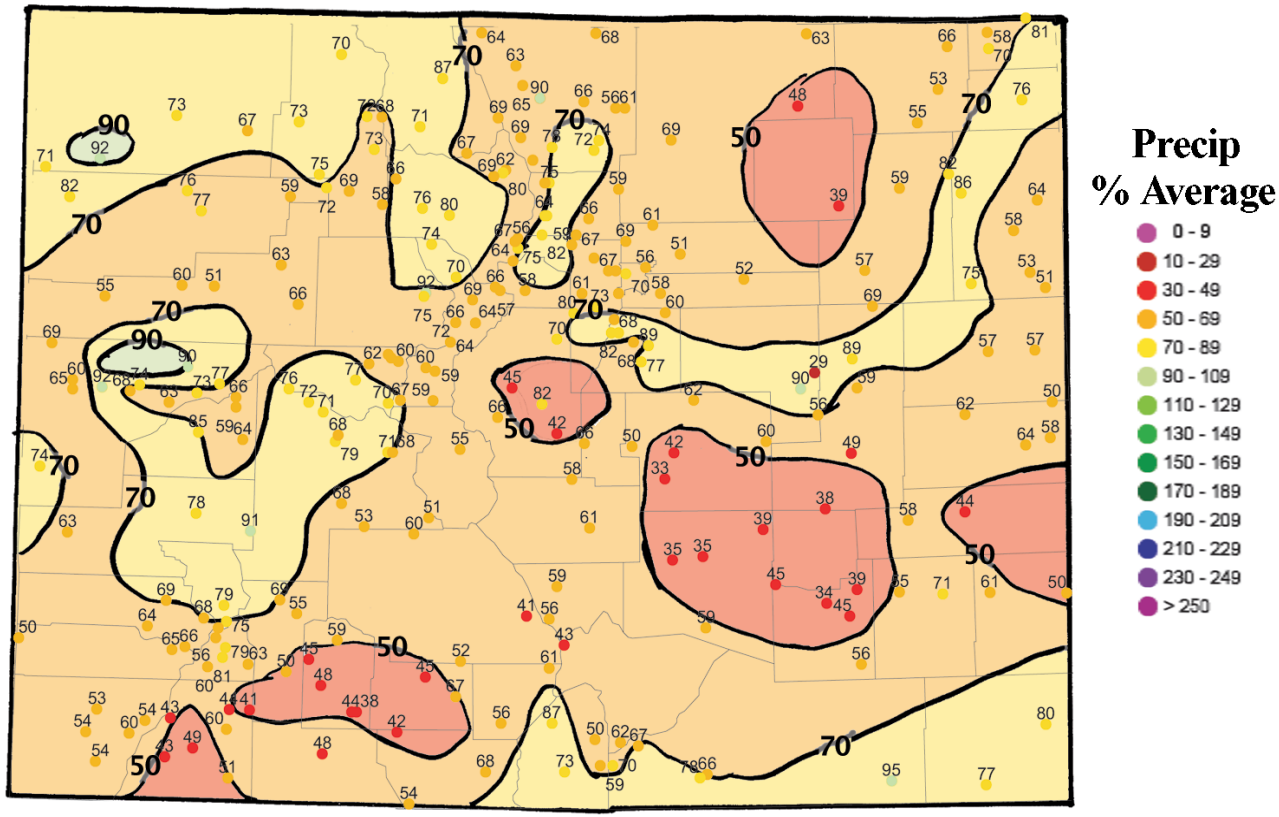
Drought Monitor for August 3, 2004 - the 5th year of dry conditions in Colorado and the West

2002 - *Extreme drought*



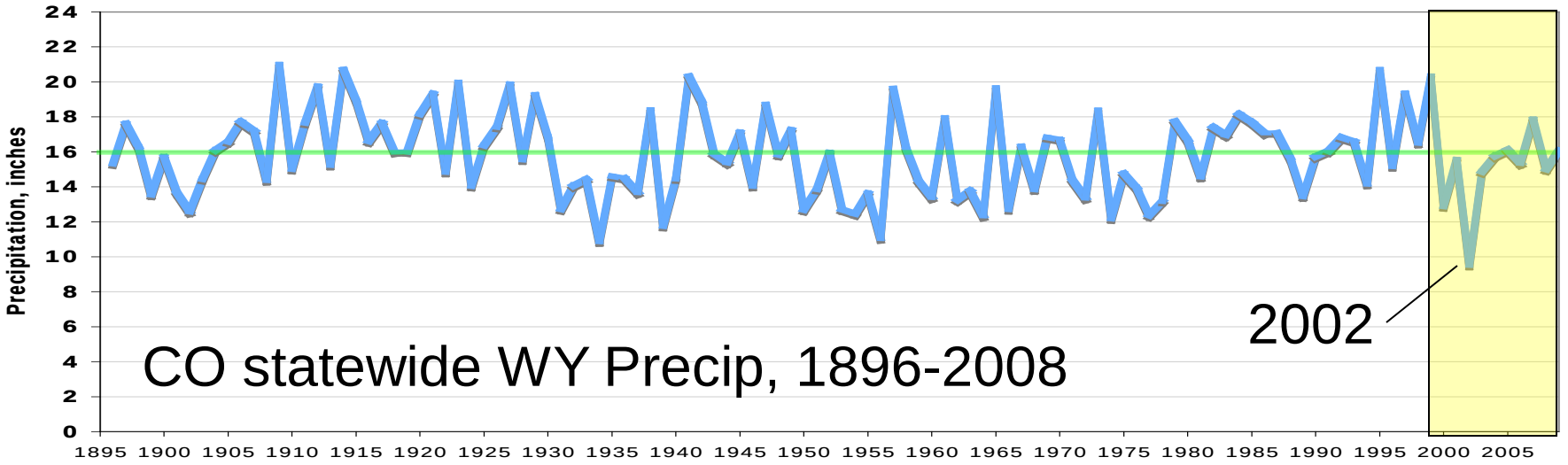
Drought Monitor
August 1, 2002

2002 Water-year Precip % of normal



- All of CO below normal (1st time), most of CO <70% of normal

The 2000s and 2002 in a long-term (~100 yr) context



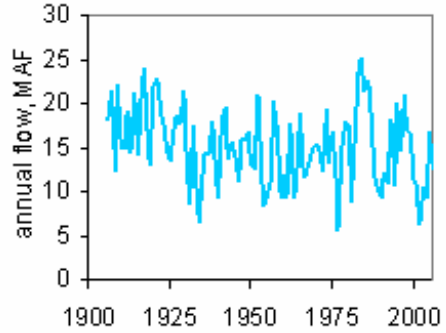
- As a 1-year drought, 2002 was the most severe across Colorado by many measures: precip, flow, PDSI, SWSI…, (though not necessarily at every location)
- As a 3-year drought, 2000-02 (or 2002-04 in SW CO) was still quite severe, close to the worst
- At longer time scales, previous droughts (1930s, 1950s, 1970s) were generally worse than the 2000s statewide

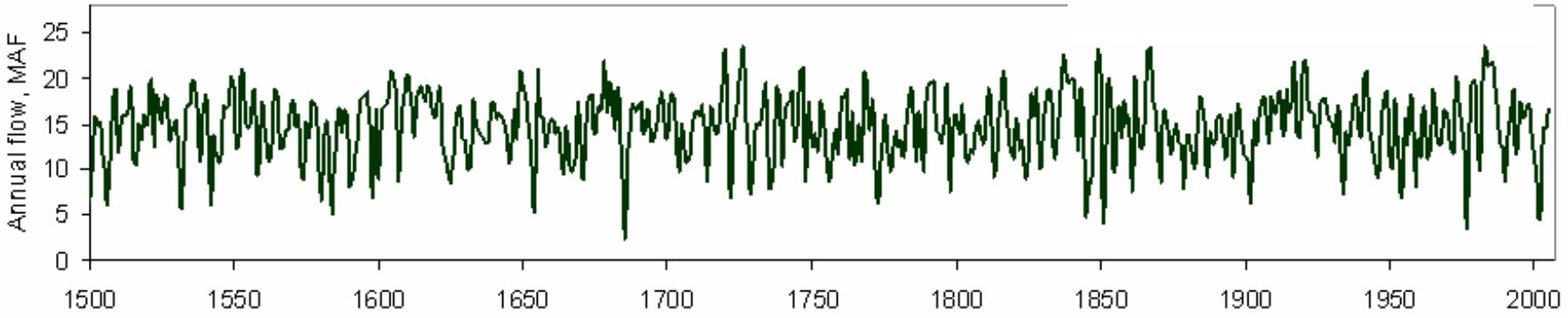
The 2000s and 2002 in a really long-term context

Tree-ring records provide a longer window onto past drought in Colorado and elsewhere

Tree-ring record:
400-1000+ years

Observed climate and hydrology:
~100 years





In semi-arid climates like Colorado, tree growth is limited by moisture availability

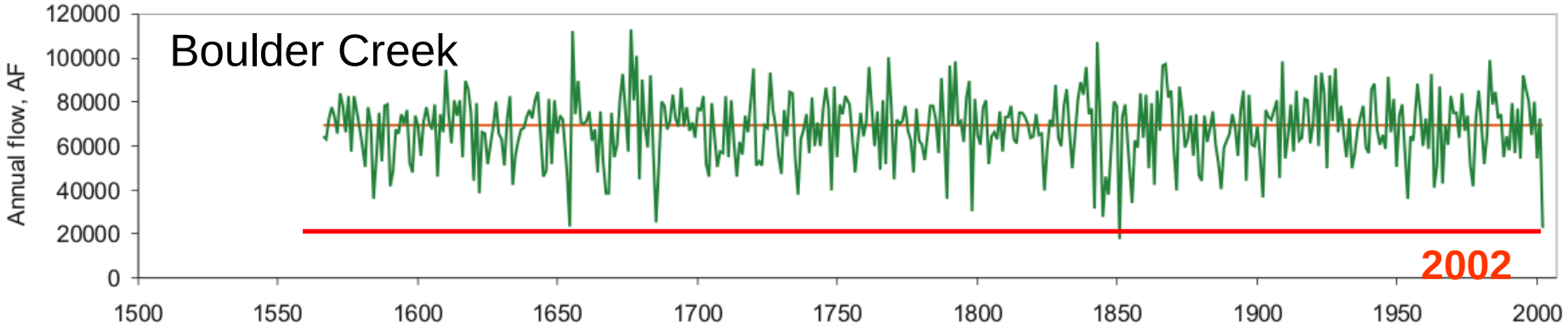
So:

– a dry year leads to a *narrow* growth ring

– a wet year leads to a *wide* growth ring

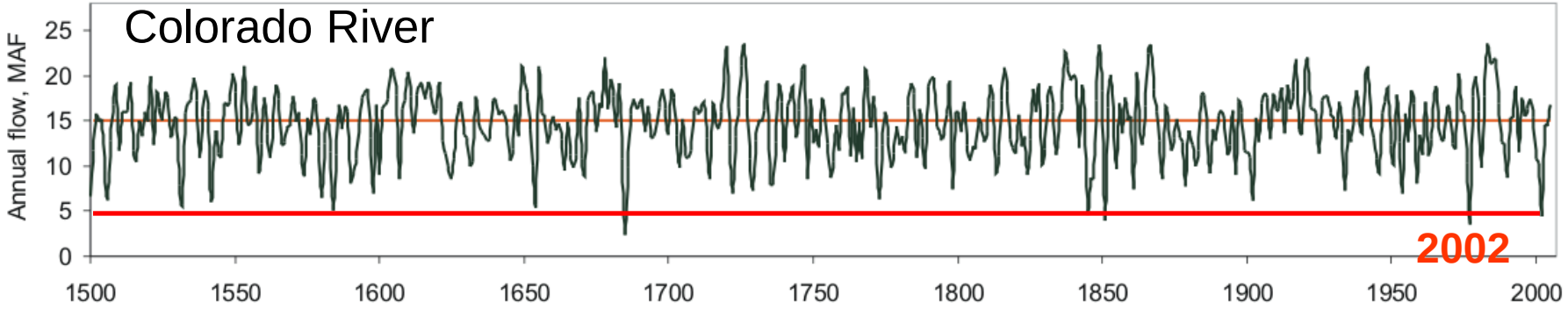
And so ring-widths can be used to reconstruct precipitation, streamflow, and drought indices

Reconstructed annual flows, 1500-2005



5 Lowest annual reconstructed flows since 1566

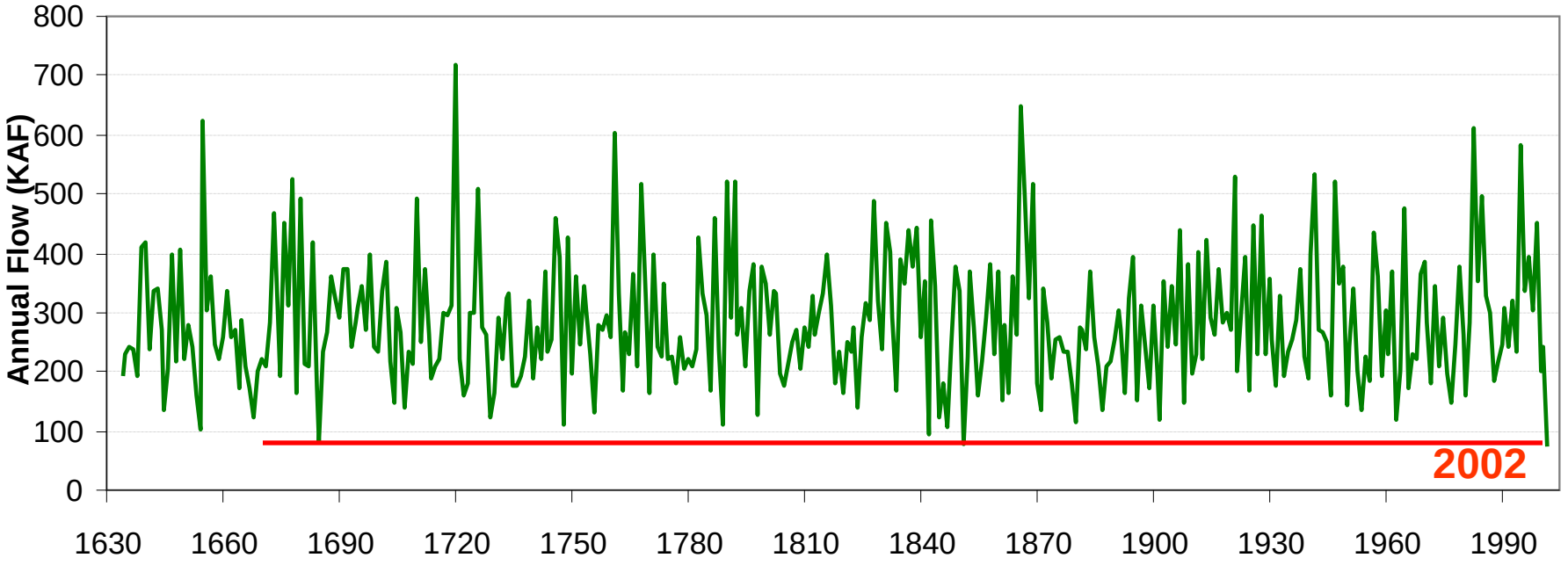
1851, **2002**, 1654, 1685, 1845



5 Lowest annual reconstructed flows since 1500

1685, 1977, 1851, **2002**, 1845

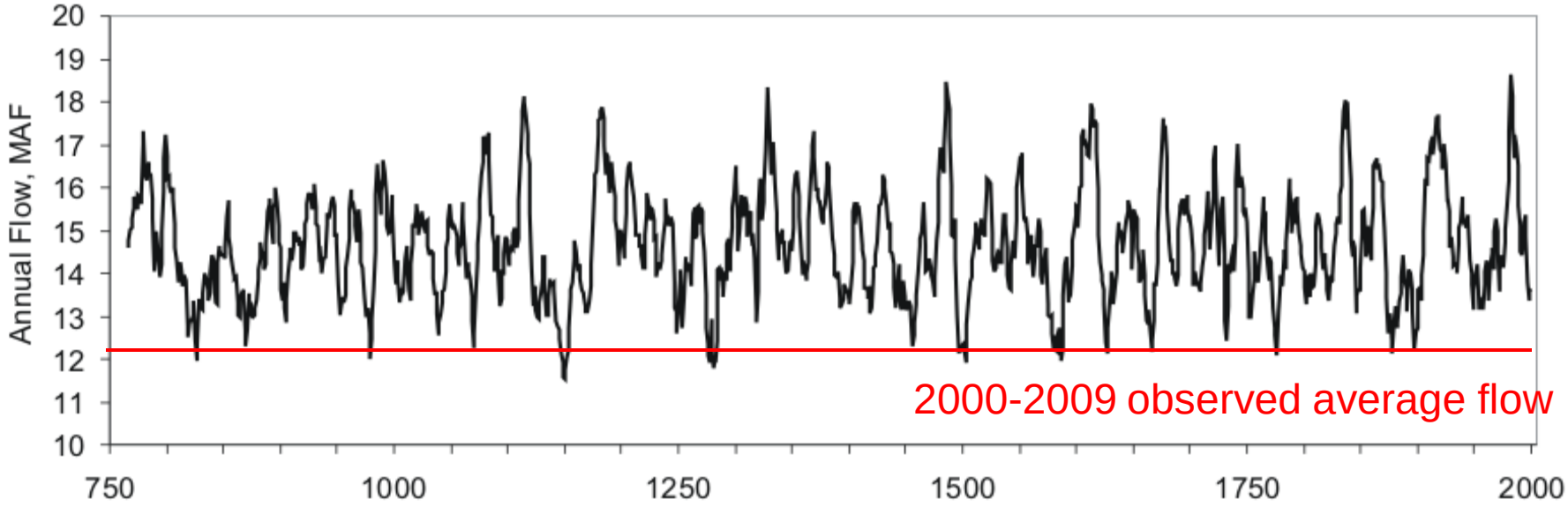
Reconstructed annual streamflow, South Platte River, 1634-2002



5 Lowest annual reconstructed flows since 1634

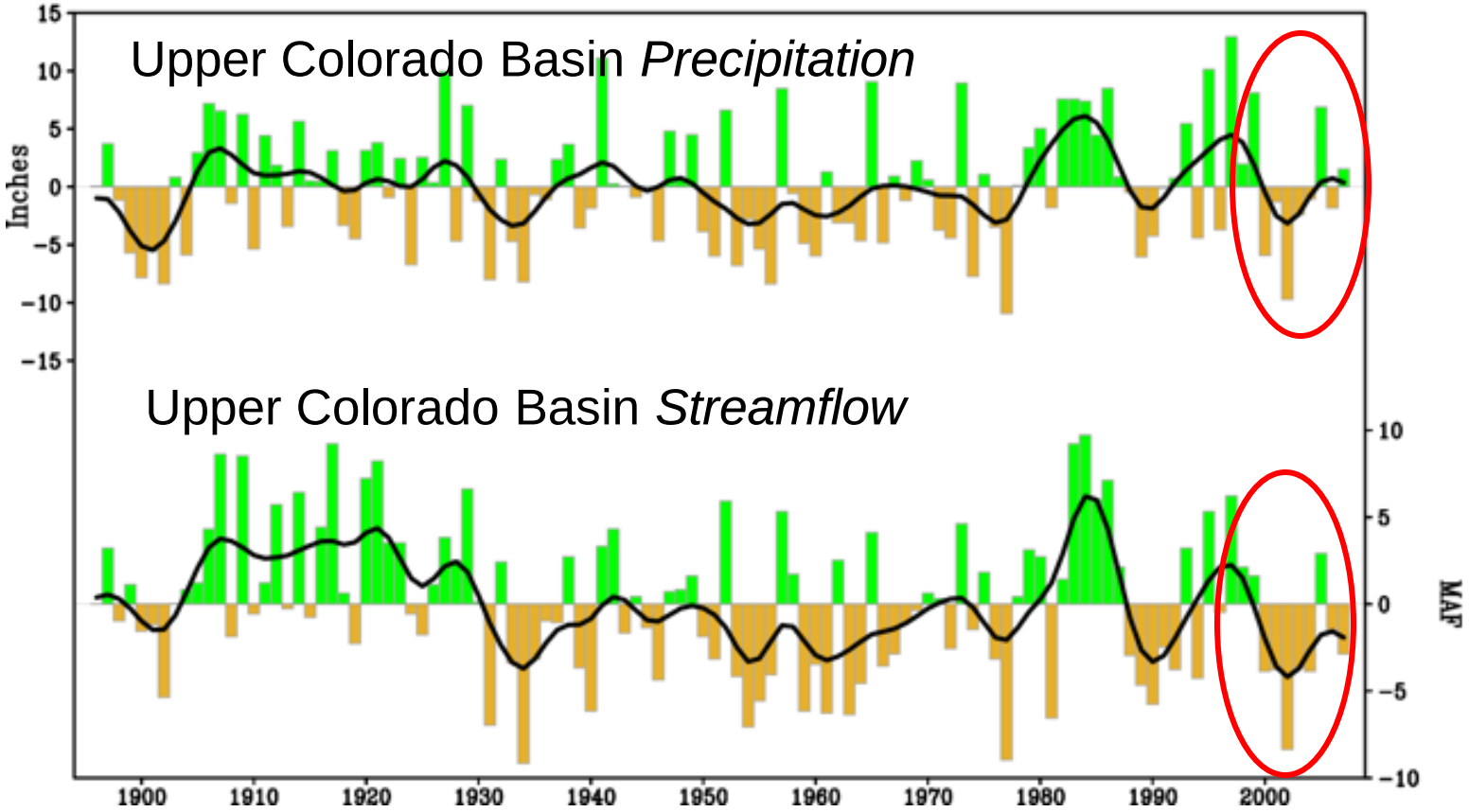
2002, 1851, 1685, 1842, 1654

Reconstruction of Colorado River streamflow, 762-2005, with 10-year running mean



- Mean observed flow for 2000-2009 is ~12.1 MAF
- Six 10-year periods before 1900 with reconstructed mean flow lower than 12 MAF (lowest: 1146-1155)

Warming temps may already be changing drought effects, even without precipitation trend



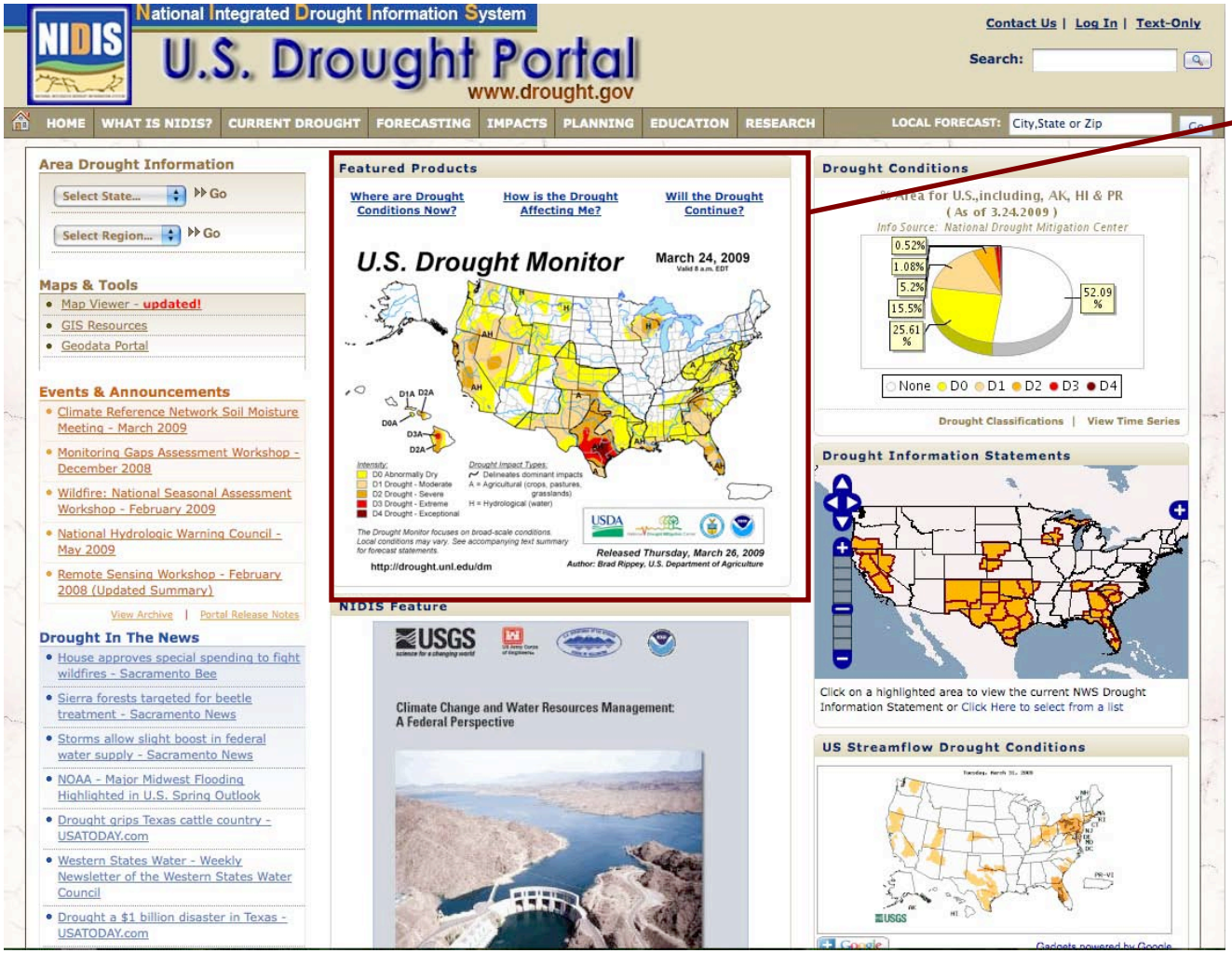
- Some evidence that 2000s streamflows show greater impacts of temperature than in previous droughts

Recap

- Drought is insufficient water to meet needs, so it's fundamentally driven by deficits of precipitation - temperature also a factor
- Drought is assessed by a suite of indicators over both time and space
- The record in Colorado shows frequent short-term drought and periodic long-term drought – but no predictable cycles
- The 2000s drought (inc. 2002) was extreme but still within the bounds of past natural variability (historical and paleo)
- The nature of drought may be changing as temperatures warm further, making impacts worse than we would expect from experience

NIDIS Drought Portal

http://www.drought.gov



Drought Monitor
Drought Impact Reporter
Drought Outlook

The Drought Monitor Concept

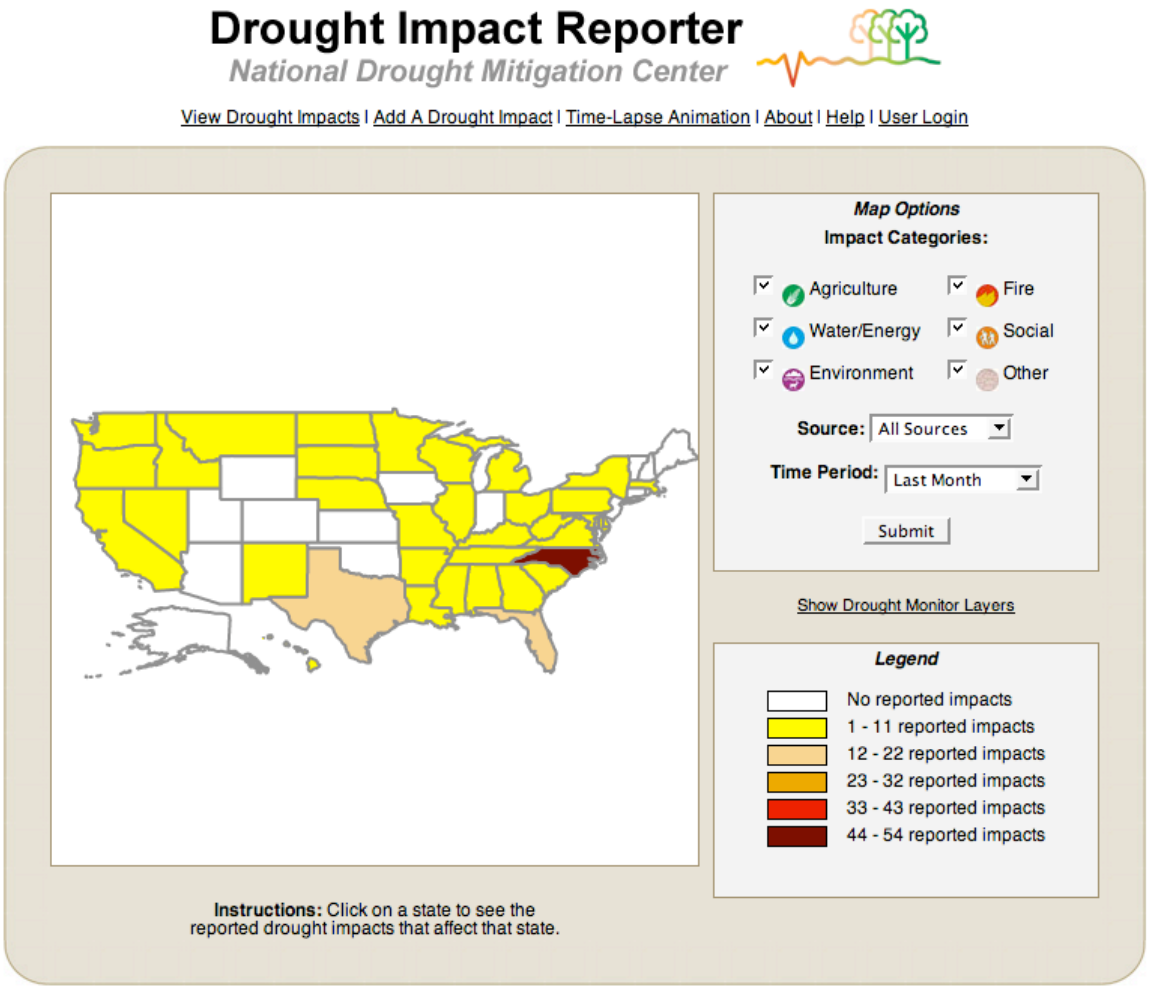
- A consolidation of indicators into one comprehensive national drought map
- Trying to capture these characteristics:
  - the drought's magnitude (duration + intensity)
  - spatial extent (how widespread)
  - how often similar conditions occur
  - Impacts
- Rates drought intensity by **percentile ranks**
- An assessment – not a forecast, not a declaration

Who Makes the Drought Monitor?

- A ***partnership*** between the National Drought Mitigation Center, USDA and NOAA's Climate Prediction Center and National Climatic Data Center ***(authors)***
- Incorporate relevant information and products from all entities (and levels of government) dealing with drought (Regional Climate Centers, State Climatologists, federal/state agencies, etc.) ***(experts)***
- The **Drought Monitor** is ***updated weekly*** and provides a general up-to-date summary of current drought conditions across the 50 states, Puerto Rico and the Pacific possessions

NIDIS Drought Portal

Drought Impact Reporter



Drought Impact Reporter

Available on CoCoRaHS Home Page

The Importance of Reporting

Here was a useful comment from a volunteer in Texas.

5/9/2010 TX-BST-35 TX Bastrop "A drought is starting. We have not had significant rain for about a month. The spring grasses started to die back about 2 weeks ago, the summer grass is not coming up. It should be up at this time. The patches that I shredded last week are brown. Last week I still had alot of rye grass and some oats left. My horses finished the stand of oats and have eaten down most of the rye grass that was growing in the sun. The grass in the shade is still doing OK."

This is a good example of descriptive observations that really help.

NIDIS and us

Remember, we produce many drought monitoring products here specificly for Colorado

We host “Webinars” providing frequent detailed updates on climate and water supply information

Visit our Website for more information:

http://ccc.atmos.colostate.edu

Good news -- real good news!

- We are almost done for the day
- If you possibly can, please stay to complete the evaluation summary.