



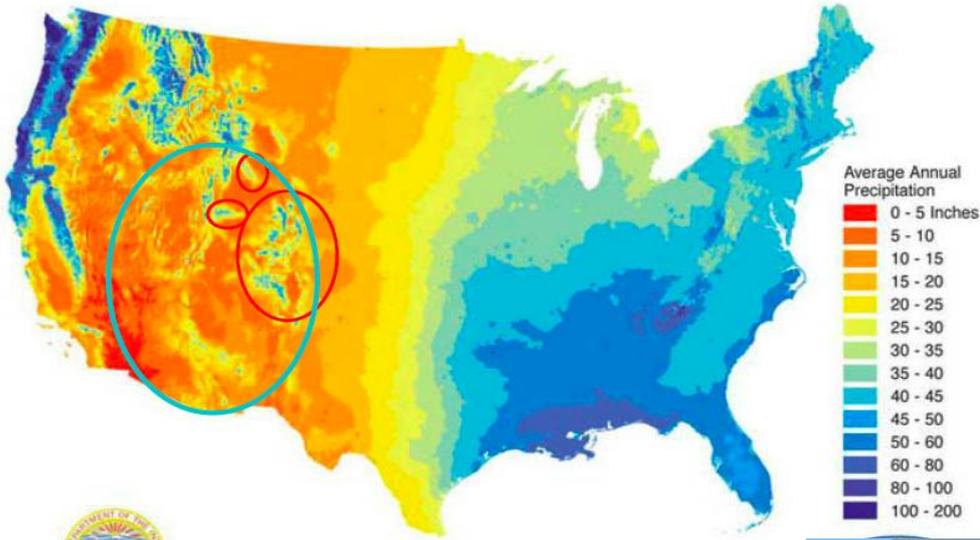
# The Great Drought of 2012: Science, impacts and early warning

Roger S. Pulwarty PhD  
Climate and Societal Interactions and  
National Integrated Drought Information System  
NOAA

NDMC, Dept. Interior (USGS, Reclamation), USDA, USACE,  
State Partners, SW Tribes, RISAs, RCCs,  
State Climatologists, RCSDs, Municipalities,  
NOAA Labs, CPC

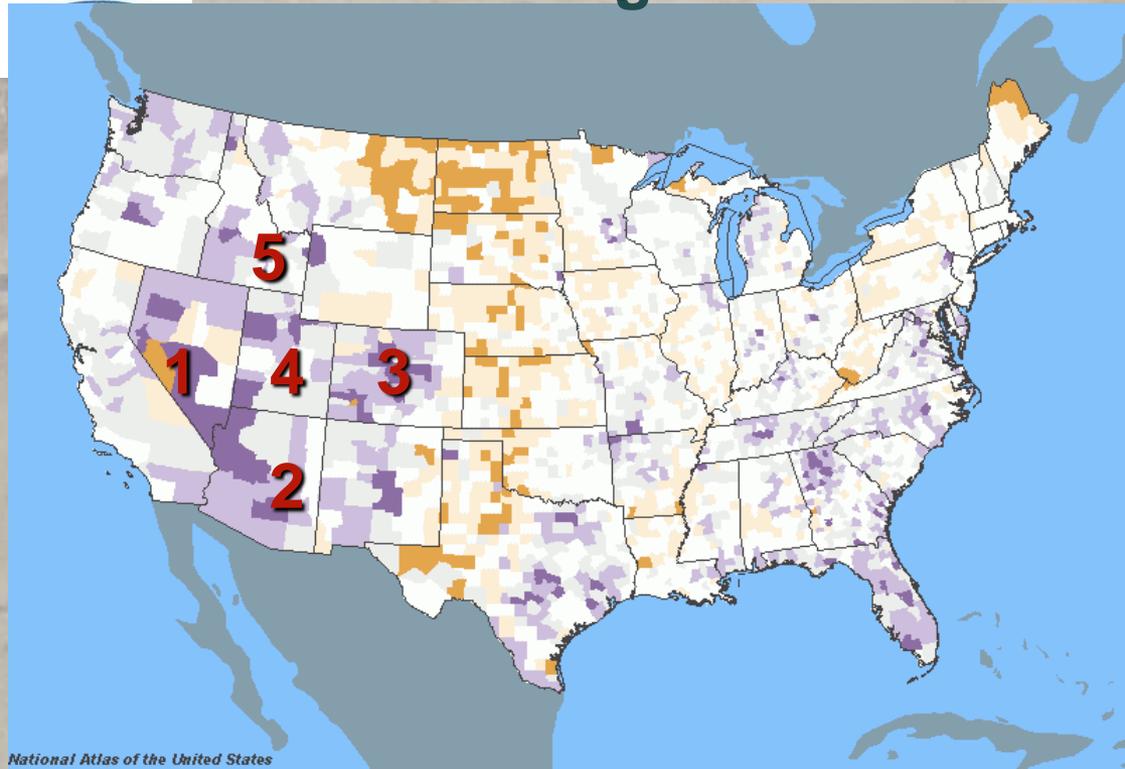


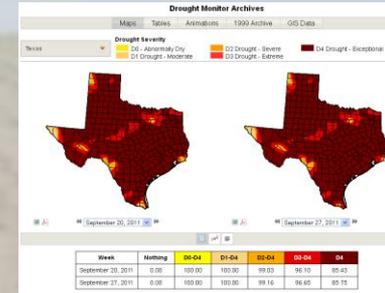
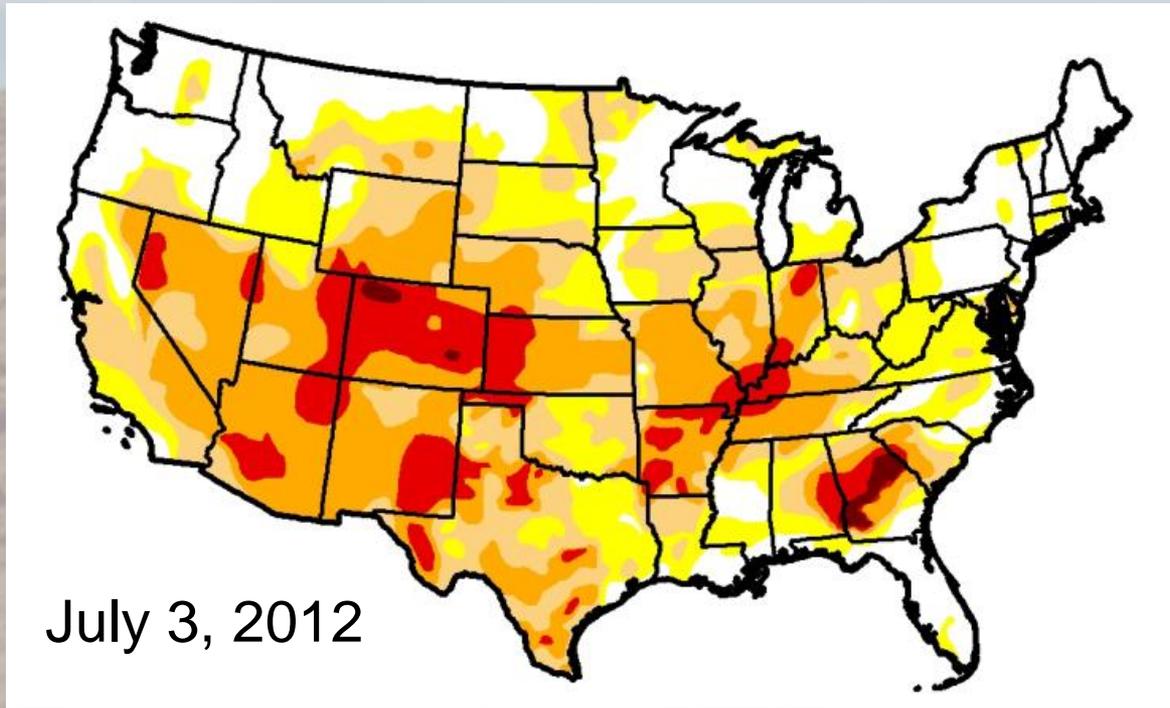
Average Inches of Annual Precipitation  
in the United States 1961-1990



# Average annual precipitation

# Population growth

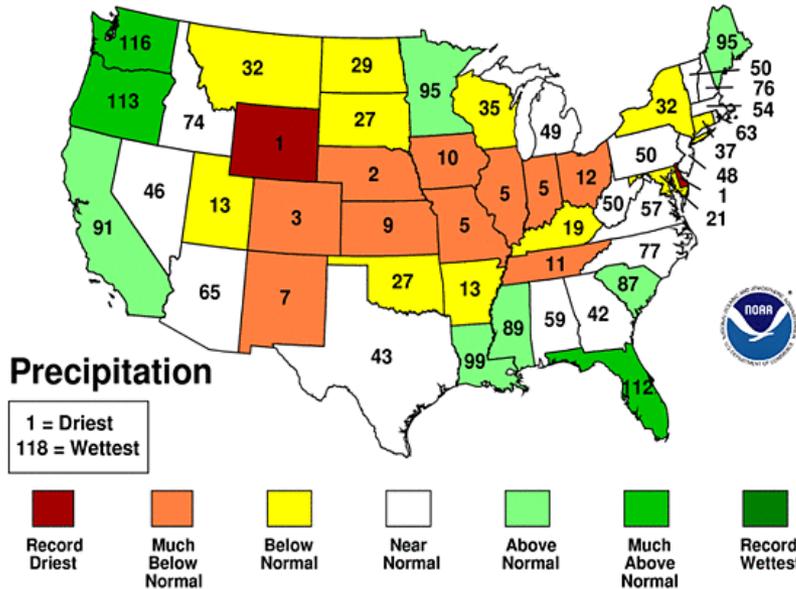




Over 63% of the contiguous United States in early September was suffering moderate to exceptional drought, nearly twice the land affected a year ago, according to the U.S. Drought Monitor. Using July data, the National Climatic Data Center reported that America is in the midst of its most expansive drought since December 1956.

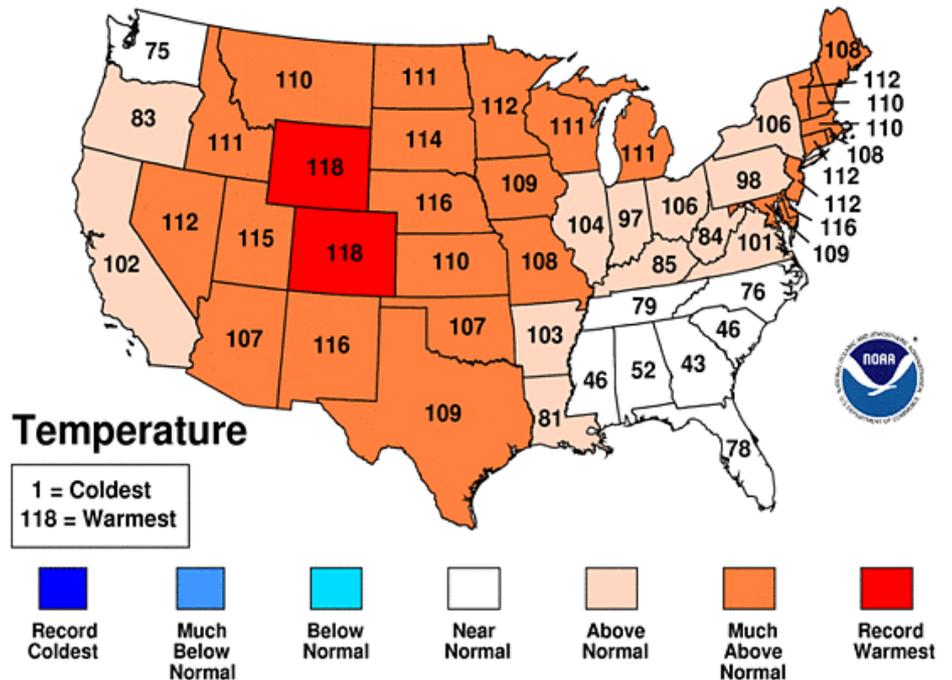
# March-August 2012 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



# June-August 2012 Statewide Ranks

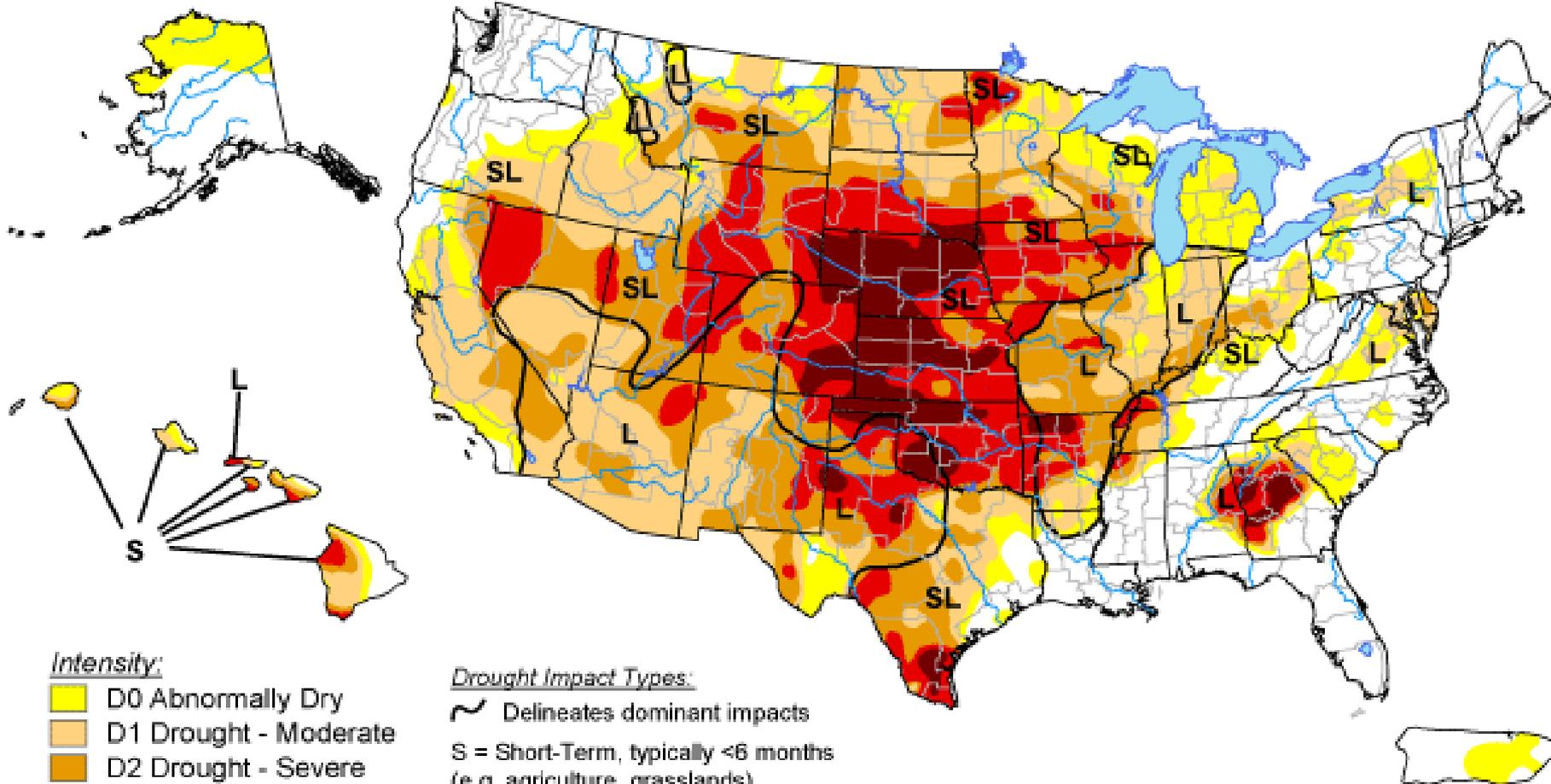
National Climatic Data Center/NESDIS/NOAA



# U.S. Drought Monitor

September 25, 2012

Valid 7 a.m. EDT



## Intensity:

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

## Drought Impact Types:

-  Delineates dominant impacts
- S = Short-Term, typically <6 months  
(e.g. agriculture, grasslands)
- L = Long-Term, typically >6 months  
(e.g. hydrology, ecology)

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

<http://droughtmonitor.unl.edu/>



Released Thursday, September 27, 2012

Author: Anthony Artusa, NOAA/NWS/NCEP/CPC

# Weather to Climate-A continuum and a deficit

Heat Waves

Storm Track Variations

Madden-Julian  
Oscillation

El Niño-Southern  
Oscillation + ?????

*Decadal Variability*

*Solar Variability*

*Deep Ocean  
Circulation*

*Greenhouse Gases*

30  
DAYS

1  
SEASON

3  
YEARS

10  
YEARS

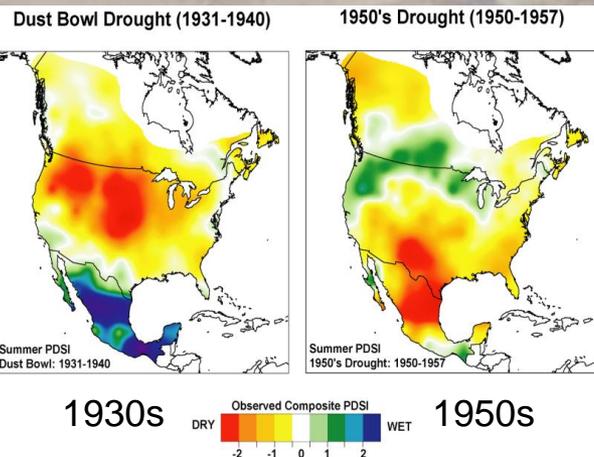
30  
YEARS

100  
YEARS

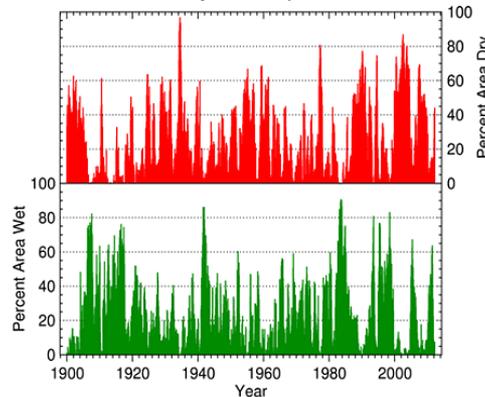
**SHORT-TERM**

**INTERANNUAL**

**DECADE-TO-CENTURY**



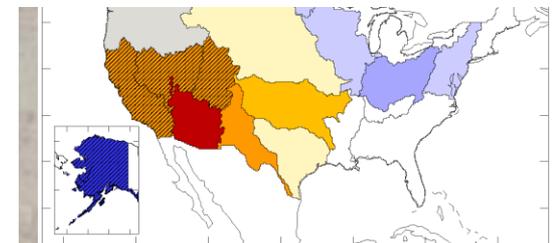
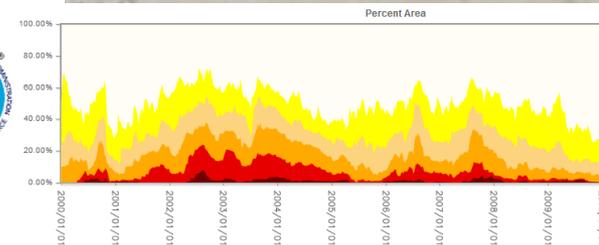
Western U.S. Percentage Area Wet or Dry  
January 1900 - April 2012



\*Based on the  
Palmer Drought Index

■ Moderate - Extreme Drought

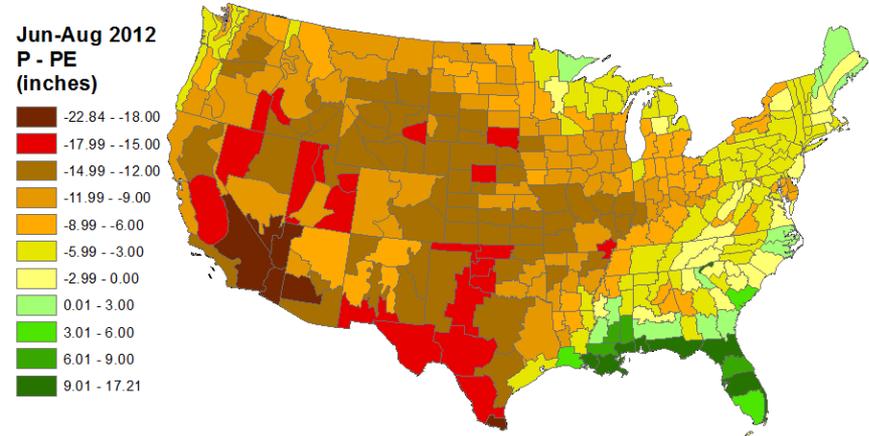
■ Moderate - Extreme Wet



# June-August 2012 Precipitation

Minus

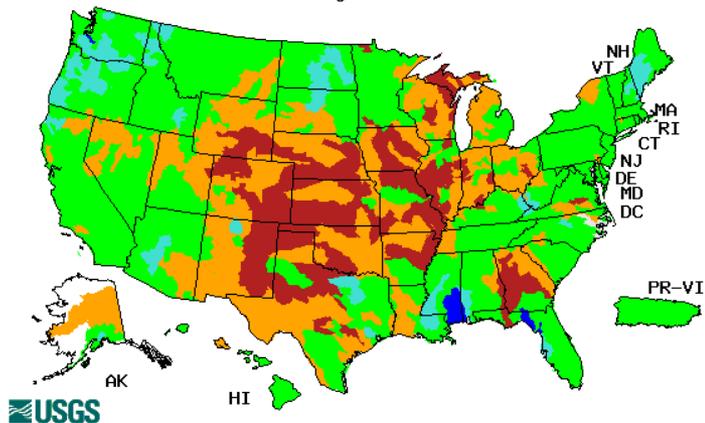
# June-August 2012 Potential Evapotranspiration



## Map of monthly streamflow compared to historical streamflow for the month of the year (United States)

State or Water-Resources Regions

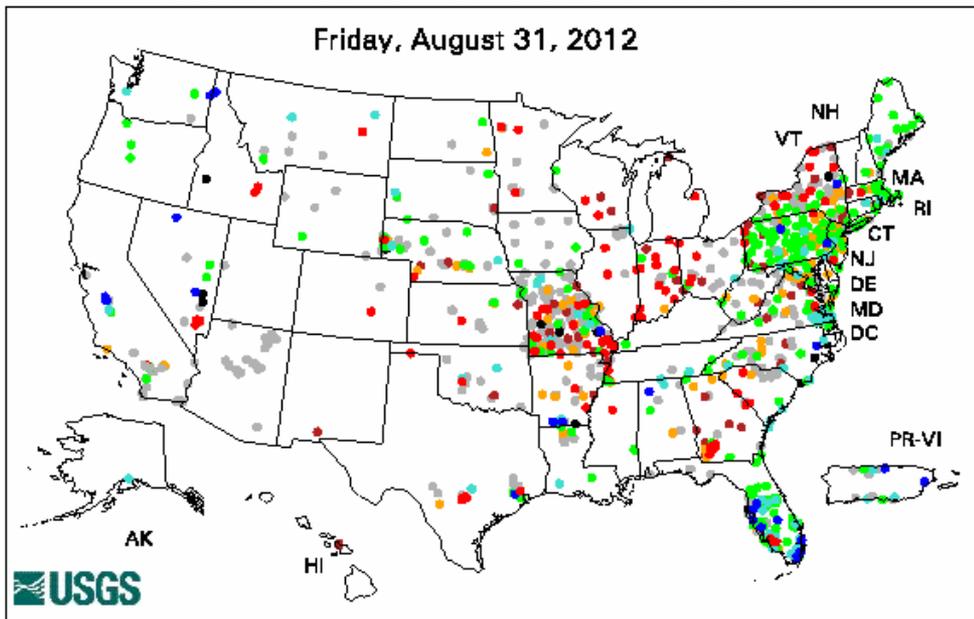
August 2012



Explanation - Percentile classes						
Low	<10	10-24	25-75	76-90	>90	High
	Much below normal	Below normal	Normal	Above normal	Much above normal	

## Real-Time Groundwater Level Network

Friday, August 31, 2012



Explanation - Percentile classes (symbol color based on most recent measurement)							
Low	<10	10-24	25-75	76-90	>90	High	Not Ranked
	Much Below Normal	Below Normal	Normal	Above Normal	Much Above Normal		

○ Real Time  
 □ Continuous  
 △ Periodic Measurements

Real-Time Groundwater Level Network Well Count: 1403

Map generated 8/31/2012 7:59:48 AM

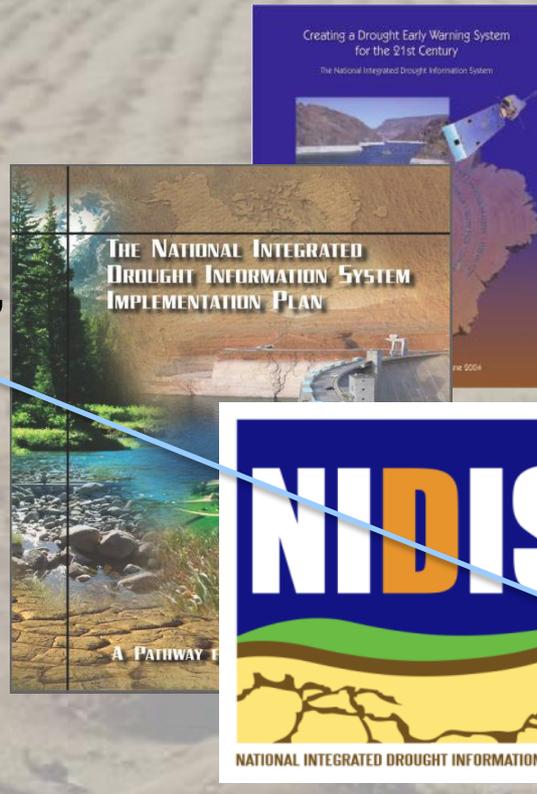
Groundwater Level network

# NIDIS Public Law 109-430

**Coping with Drought-Applications and Decision support Research Grants (RISAs, SARP)**

**Drought Prediction And Monitoring Climate Test Bed**

- CPC
- PSD
- IRI
- Academia
- NCDC Soil moisture sensors



**Drought Portal (NCDC, NDMC)**

**NIDIS Program**

**NIDIS Early Warning Information Systems**

– Design, Prototyping, Implementation(multi-agency, multi-  
1) 6/10/04

# National Integrated Drought Information System (NIDIS) Regional Drought Early Warning Systems

### Quarterly Climate Impacts and Outlook

#### Western Region

September 2012

**National - Significant Events for June - August 2012**

**Regional Impacts for June - August 2012**

**Climate and Weather**  
 High temperatures in the region to high temperatures reduced the benefits of precipitation when it occurred.  
**Drought and Water Resources Impacts**  
 Reservoir operators throughout much of the region continued to decline and the operational fall and winter season started well below normal for water supply. Lake Mead is at 51% of capacity. Lake Mead's 51% and Eastern Butte Lake 18%. California's reservoirs were below the median storage for the first time in six years.  
**Natural Resources**  
 Over 14,000 wildfires burned over 6.5 million acres. Firefighters estimate that warmer water and low flows, resulting in both voluntary and non-voluntary fishing cancellations as well as supplemental reservoir water releases. Large wild animals entered neighborhoods in pursuit of food. Juvenile salmon survival to harvest due to cooler than average inlet temperatures and high flow abundance. Status of adult Chinook salmon in 2013 and Coho in 2014 are likely to be higher than average.  
**Agriculture**  
 Agricultural productivity (such as the apple harvest in WA) was reduced due to hot drought. Cattle and sheep operations on public lands were reduced due to poor range conditions, while supplemental hay is in short supply and expensive.  
**Health**  
 Heat this year, combined with reduced cloud to favorable conditions of hot and dry weather with associated rainfall. Air quality and visibility were degraded by wildfire smoke.

**Regional Outlook - for Fall 2012**

**Western Region Partners**

**NIFC Monthly and Seasonal Fire Potential**

**NIDA Seasonal Climate Outlook**

**California River Forecast Center**

**Western Region Quarterly Climate Impacts and Outlook**



### Quarterly Climate Impacts and Outlook

#### Central Region

September 2012

**National - Significant Events for June - August 2012**

**Significant Events for August and Summer 2012**

**Highlights for the Central Region**

Summer 2012 ranks as the warmest on record for Wyoming and Colorado, and as the top ten warmest for nine other states in the region. A 2.82 maximum temperature and high reservoir temperature records were set during the course of the summer in the region in stations with 80 or more years of record.

Drought expanded and intensified through August. At the peak of drought August 23rd, 77% percent of the Central Region was experiencing moderate to exceptional drought.

Hot, dry weather resulted in an active wildfire season throughout the region. At end of August there were 23 wildfires still active in Wyoming, Colorado, and North Dakota.

Six to ten inches of rain on June 19-20 caused catastrophic flooding in South, NM. Damages to the city infrastructure above are estimated at \$40 to \$60 million.

**Regional - Climate Overview for June - August 2012**

**Temperature and Precipitation Anomalies**

**Drought**

**US Drought Monitor**

**Temperature and Precipitation Anomalies**

Departure from Normal Temperature (F) 6/01/2012 - 8/01/2012

Percent of Normal Precipitation (%) 6/01/2012 - 8/01/2012

Average daily temperature ranged from 3°F to 7°F above normal in the eastern half of the region. To 7°F to 19° above normal in the western half. The very warm early July period was tempered by normal August temperatures across the region west of the Rockies.

Precipitation during the summer period ranged from less than 50 percent of normal in central Wyoming to 125 percent or normal from northeastern Minnesota across northern Lower Michigan. August rainfall was well above normal in the western Midwest, but summer rainfall in the region was only about 60 percent of normal.

**Drought**

The U.S. Drought Monitor in the eastern half of the region through August 2012 shows that 14% of the region is in the extreme Midwest, but summer rainfall in the region was only about 60 percent of normal.



### Fall Climate Impacts and Outlook

#### Hawaii and Pacific Islands Region

September 2012

**Hawaii and Pacific Islands - Significant Events and Impacts for Fall 2012**

**Highlights for Hawaii and the Pacific Islands Region**

**North and Northeast Hawaiian Islands - Drought persisted through the fall season with extreme drought on leeward slopes of Maui, Lanai, Oahu and the Big Island.**

**Southwest Hawaiian Islands (NWHI) - Tropical Storm Steve brought just south of Oahu, dropping 4 inches of rain over Oahu to four days.**

**Republic of the Marshall Islands (RMI) - On Kwajalein, 3.52 inches fell in 24 hours, marking the 8th highest 24-hour rainfall event recorded.**

**Federated States of Micronesia (FSM) - Typhoon Duhol produced gusty winds and heavy rainfall in Yap. There was extremely wet and widespread rain.**

**Republic of Palau - The sea level increased over three inches in May. May 2012 sea level rise was 3 inches above normal.**

**American Samoa - Strong SE trade winds drove sea levels higher than normal in the harbor.**

**Regional Climate Overview for Fall 2012**

**Official NOAA October Precipitation Outlook**

For October, there is an increased probability of above-normal precipitation in portions of south and east Texas. There are equal chances of either above- or below-normal precipitation in Oklahoma and West Virginia.

**Looking Forward Regional Fall Forecast**

MOICQ sees the conditions likely to persist through at least December. There are increased chances of wet conditions in the Texas and Oklahoma portions. There are decreased chances of wet conditions in southeast Texas and eastern Oklahoma.

### Quarterly Climate Impacts and Outlook

#### Southern Great Plains Region

Fall 2012

**National - Significant Events for June - August 2012**

**Regional Highlight - The Historic 2010 - 2012 Drought Continues**

**Climate Extremes**

Since October 1st 2010 - the approximate beginning of the current basin drought - nearly all locations in Texas, Oklahoma, and New Mexico have received substantially below-normal precipitation (right). Conditions have been further exacerbated by exceptional heat across much of the region.

**Oklahoma and Texas**

- Both states had their 24-month period since 1950 (ending Aug 31st)
- Oklahoma on par for its warmest year on record (since 1895)

**New Mexico**

- 24-month period ending Aug 31st was both driest and warmest on record (since 1895)

**Water Resources**

Among the most significant impacts of the combination of historic drought and heat has been the reduction in reservoir capacity in New Mexico and Texas.

**Regional Outlook - for Fall Season**

**Southern Plains Partners**

**Climate Assessment for the Southeast (Mississippi Basin)**

**Regional Drought Mitigation Center**

**National Integrated Drought Information System**

**National Oceanic and Atmospheric Administration**

**National Weather Service**

**NOAA Regional Climate Data Center**

**NOAA National River Forecasting Program**

**Southern States Specific Planning Program**

**Southern Regional Climate Center**

**NOAA National River Forecasting Board**

### Quarterly Climate Impacts and Outlook

#### Eastern Region

September 2012

**National - Significant Events for June - August 2012**

**Regional Impacts for June - August 2012**

**Available Reservoirs**

Available reservoir storage affected drought in parts of the West and the Midwest. In the West, 27% of reservoirs above the threshold are considered available for use.

**Cooler Summers**

Cooler summer temperatures in the East of the West led to more winter precipitation. Warming during the March-Cathartes period and earlier in the season led to a more typical than normal snowpack. The snowpack was above normal in the West, but below normal in the Midwest. The snowpack was above normal in the West, but below normal in the Midwest.

**Wet Summers**

The U.S. Drought Monitor in the Northeast shows that the highest on record precipitation in the Northeast occurred in the Northeast. The highest on record precipitation in the Northeast occurred in the Northeast. The highest on record precipitation in the Northeast occurred in the Northeast.

**Health**

Reservoir releases were reduced in the Northeast. The highest on record precipitation in the Northeast occurred in the Northeast. The highest on record precipitation in the Northeast occurred in the Northeast.

**Regional Outlook - for Autumn 2012**

**U.S. Seasonal Drought Outlook**

**3 Month Temperature Outlook**

**Eastern Region Partners**

**National Integrated Drought Information System**

**National Weather Service**

**NOAA Regional Climate Data Center**

**NOAA National River Forecasting Program**

**Southern States Specific Planning Program**

**Southern Regional Climate Center**

**NOAA National River Forecasting Board**

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### Quarterly Climate Impacts and Outlook

#### Eastern Region

September 2012

**National - Significant Events for June - August 2012**

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**Regional Outlook - for Autumn 2012**

**U.S. Seasonal Drought Outlook**

**3 Month Temperature Outlook**

**Eastern Region Partners**

**National Integrated Drought Information System**

**National Weather Service**

**NOAA Regional Climate Data Center**

**NOAA National River Forecasting Program**

**Southern States Specific Planning Program**

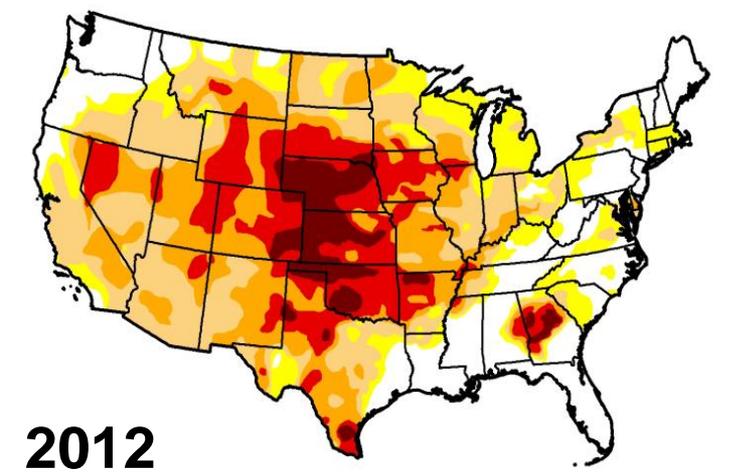
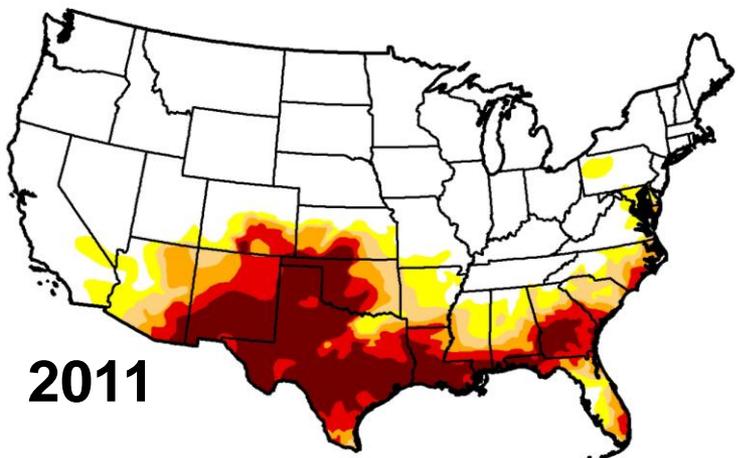
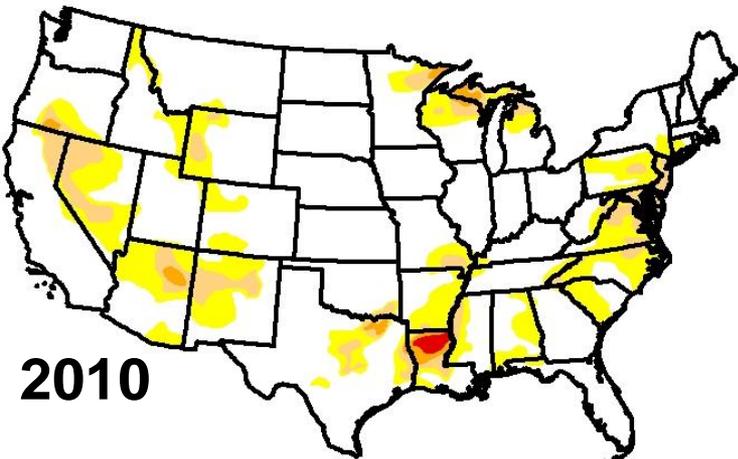
**Southern Regional Climate Center**

**NOAA National River Forecasting Board**

**NOAA National River Forecasting Board**

**NOAA National River Forecasting Board**





Two years ago (top left; U.S. Drought Monitor of 13 July 2010), much of the Upper Colorado and ACF basins were drought free.

One year later (center left; 12 July 2011), exceptional drought was covering much of the south-central and southeastern U.S.

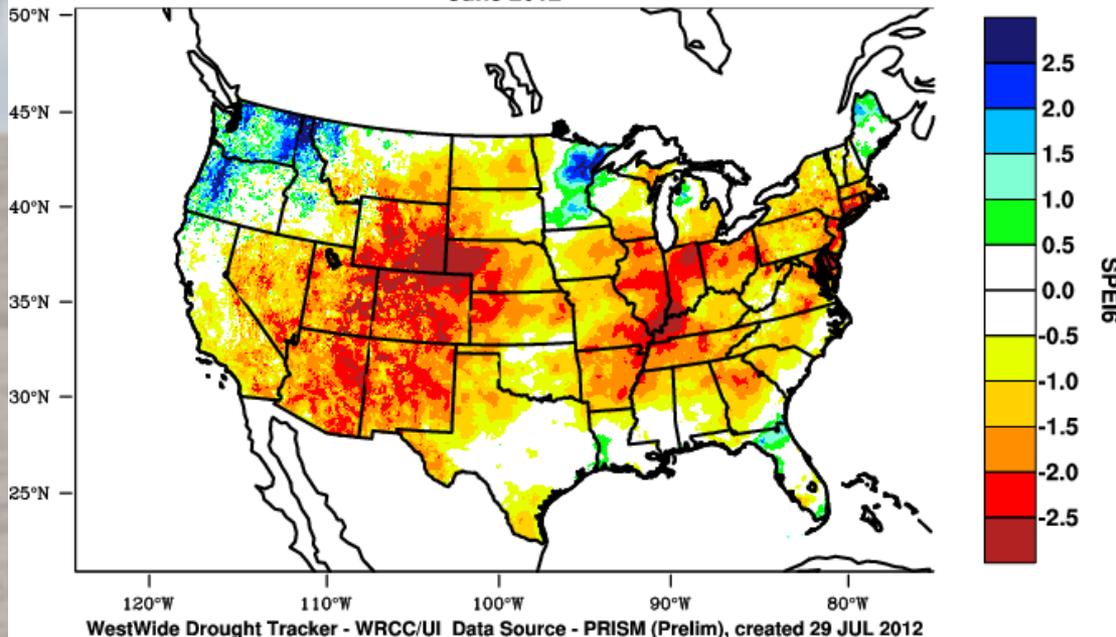
This summer (bottom left): drought is now covering much of the lower 48 states – talk about a growth business...

Was is the predictable outcome of La Niña?



Continental United States - 6 month SPEI

June 2012

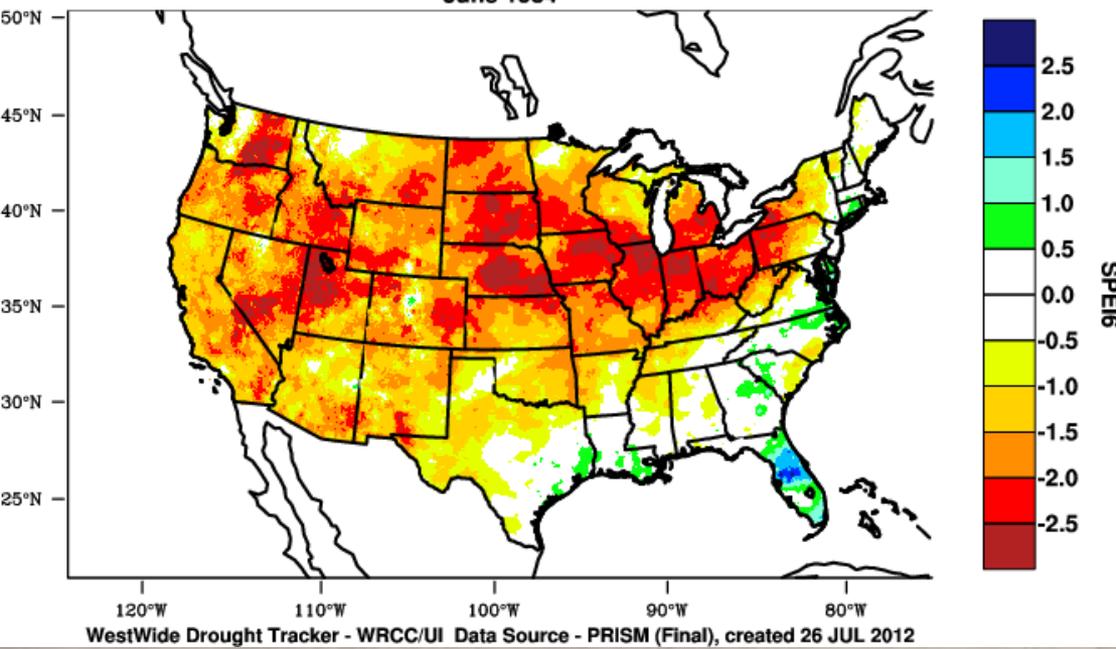


Standardized Precipitation  
Evapotranspiration Index

2012 6-month  
through June

Continental United States - 6 month SPEI

June 1934



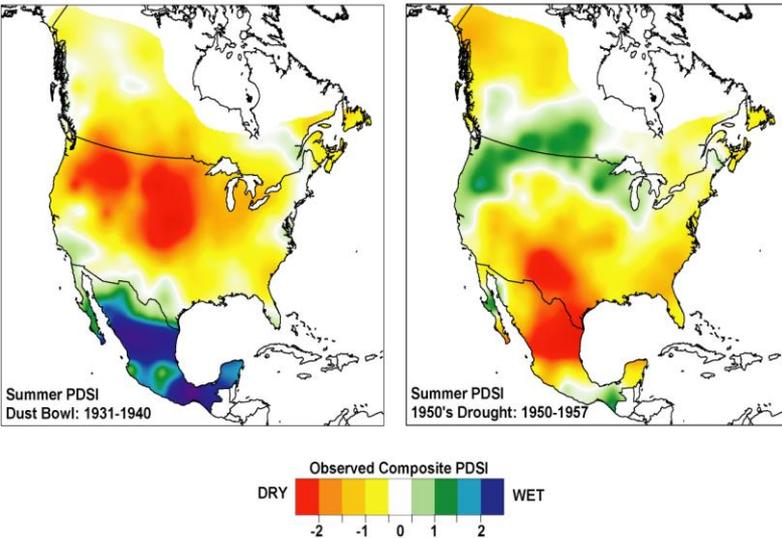
1934 6-month  
through June

1930s

1950s

Dust Bowl Drought (1931-1940)

1950's Drought (1950-1957)



August 31, 2012

# North American Drought Monitor

August 31, 2012

Released: Thursday, September 13, 2012

<http://www.ncdc.noaa.gov/nadm.html>

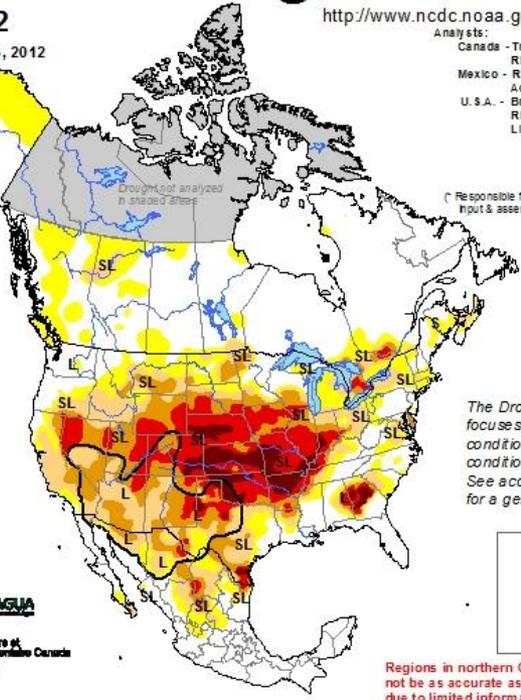
Analysts:  
 Canada - Trevor Hadwen  
 Richard Rieger  
 Mexico - Reynaldo Pascual  
 Adeline Albanil  
 Brian Fuchs  
 U.S.A. - Richard Heim\*  
 Liz Love-Brotak

Intensity:

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

Drought Impact Types:

- Delineates dominant impacts
- S = Short-Term, typically <6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically >6 months (e.g. hydrology, ecology)



(\* Responsible for collecting analysts' input & assembling the NA-DM map)

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

Regions in northern Canada may not be as accurate as other regions due to limited information.

2002

## North American Drought Monitor

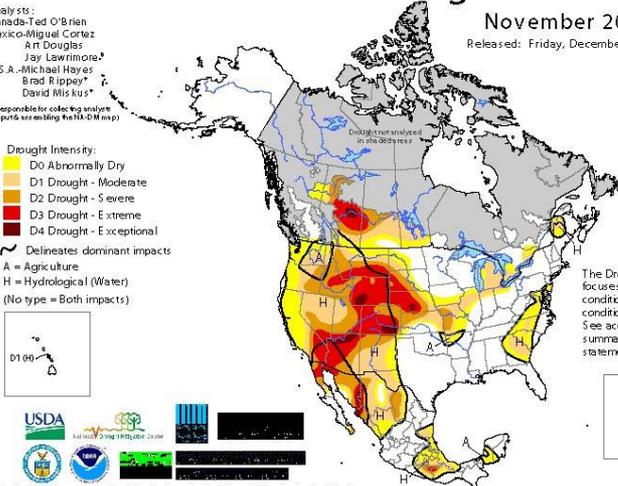
November 2002

Released: Friday, December 20, 2002

Analysts:  
 Canada-Ted O'Brien  
 Mexico-Miguel Cortez  
 Art Douglas  
 Jay Lawrimore\*  
 U.S.A.-Michael Hayes  
 Brad Rippey\*  
 David Miskus\*

(\*Responsible for collecting analysts' inputs & assembling the NA-DM map)

- Drought Intensity:
- D0 Abnormally Dry
  - D1 Drought - Moderate
  - D2 Drought - Severe
  - D3 Drought - Extreme
  - D4 Drought - Exceptional
- Delineates dominant impacts
- A = Agriculture  
 H = Hydrological (Water)  
 (No type = Both impacts)



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

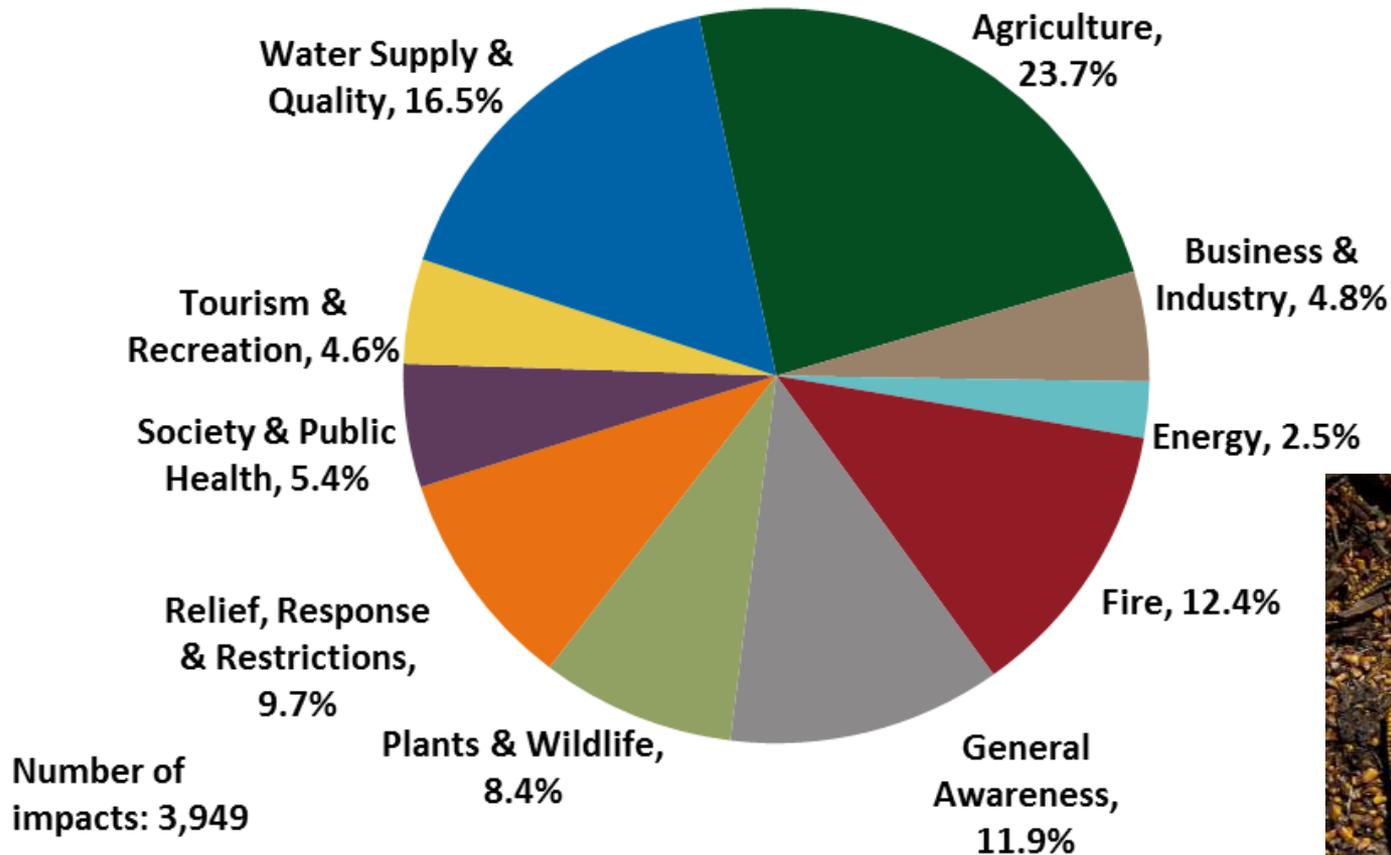


<http://www.ncdc.noaa.gov/oa/ncdc/monitoring/drought/nadm/nadm.html>

DEMO DEMO

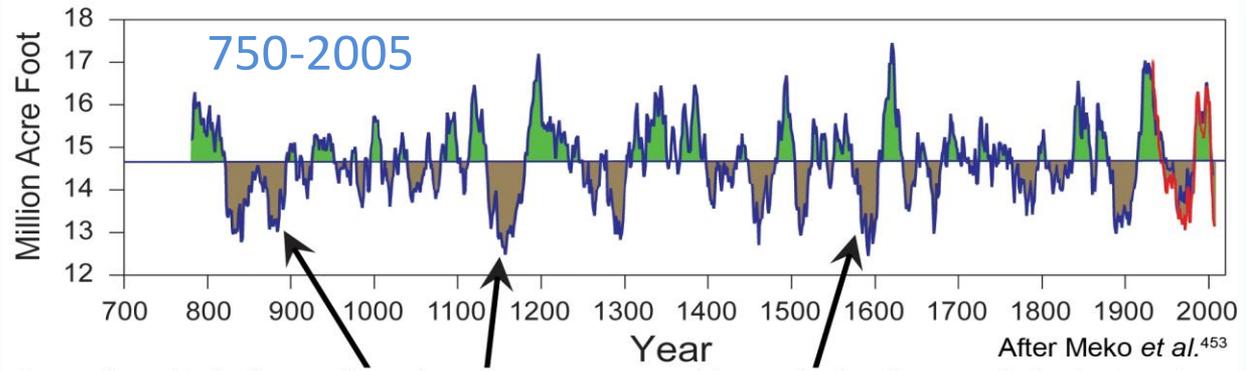
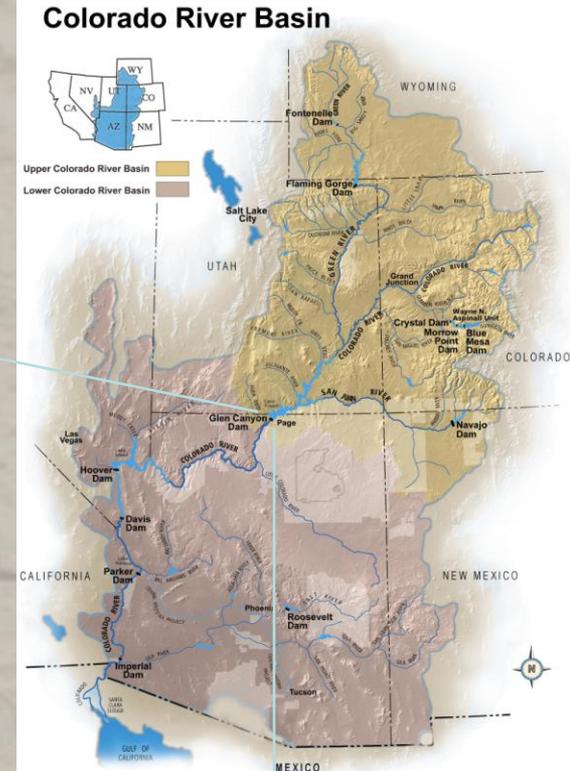
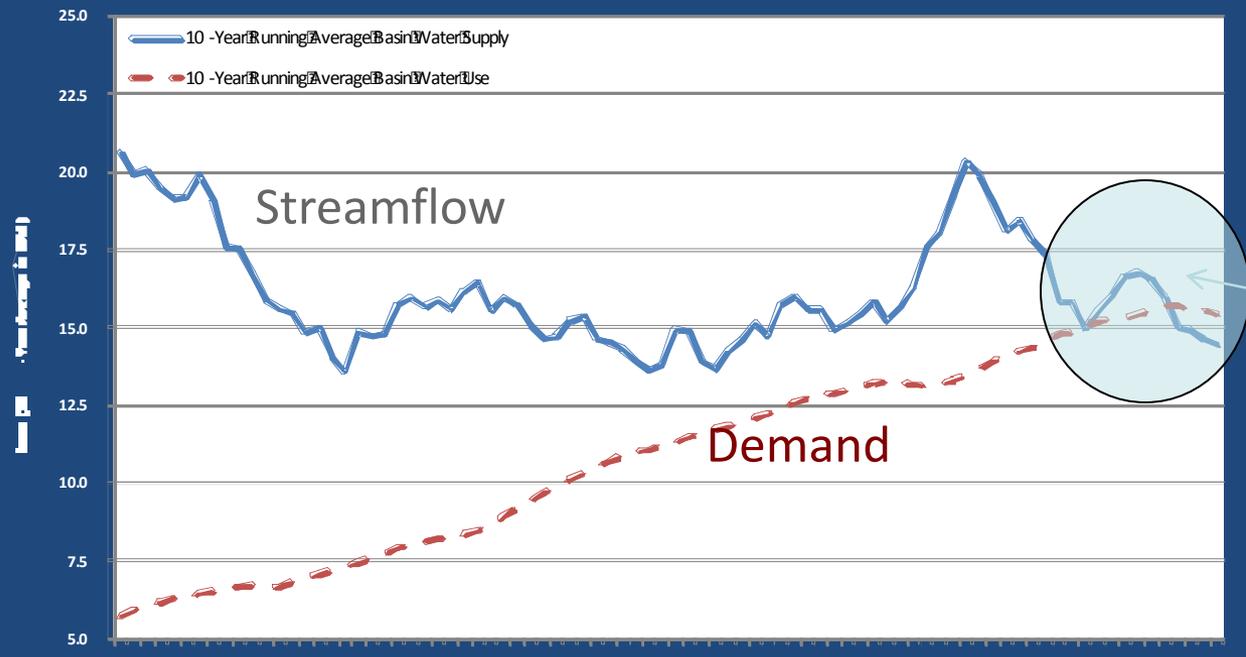
# 2012 Drought Impacts by Sector

Reports by category in the Drought Impact Reporter, January - August 2012



# Colorado River Water Supply & Use

Colorado River Basin Water Supply and Water Use  
10-Year Averages from 1923 to 2006



Some droughts in the past have been more severe and longer lasting than any in the last century.



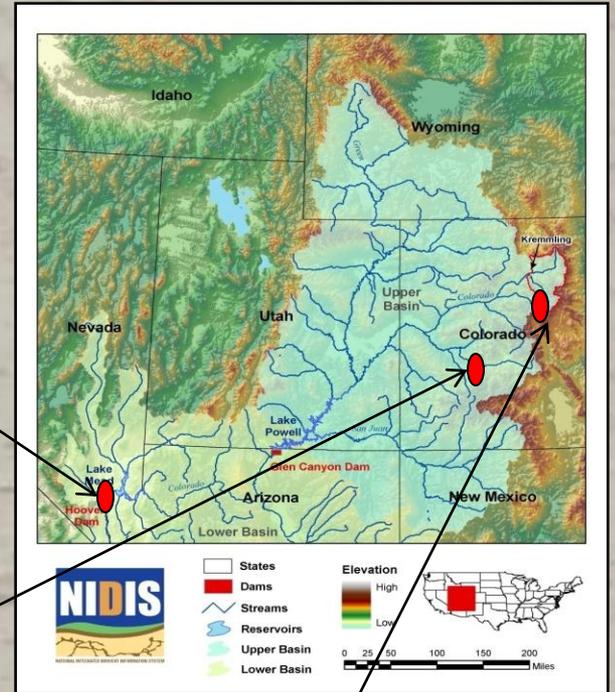
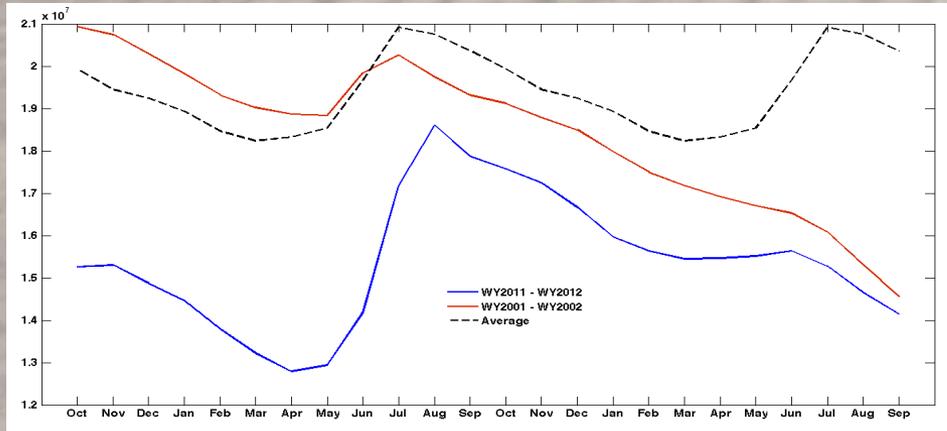
# Monthly storage

2001-2002

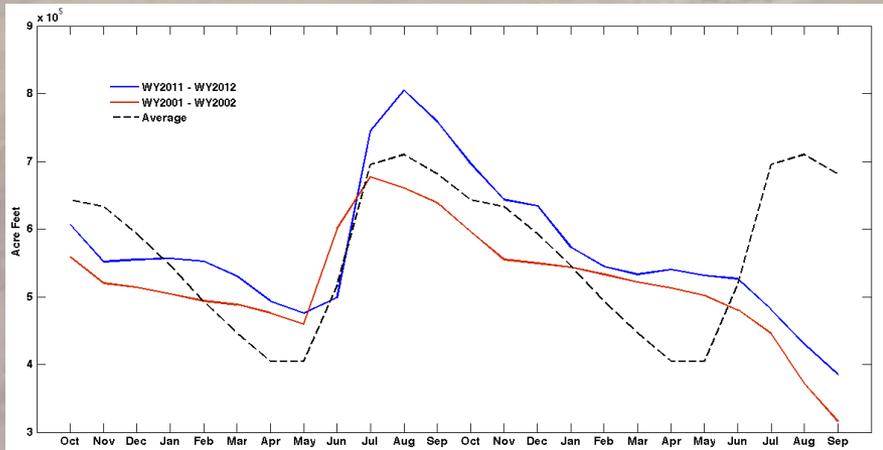
2011-2012

Average

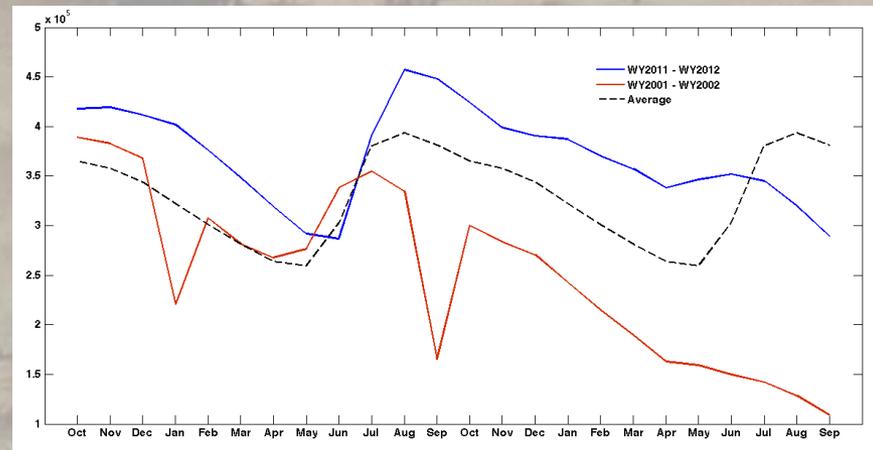
## Lake Powell



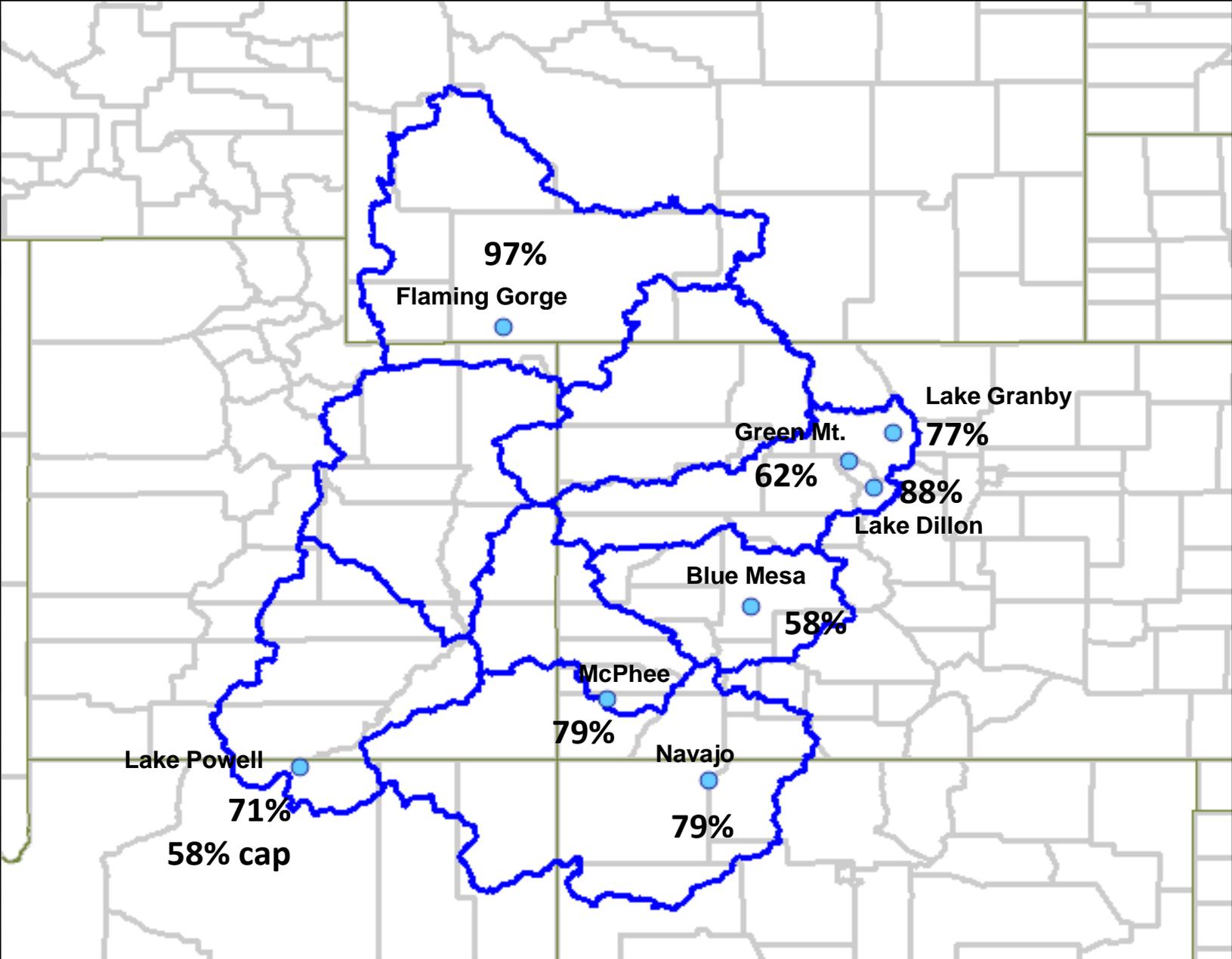
## Blue Mesa



## Lake Granby

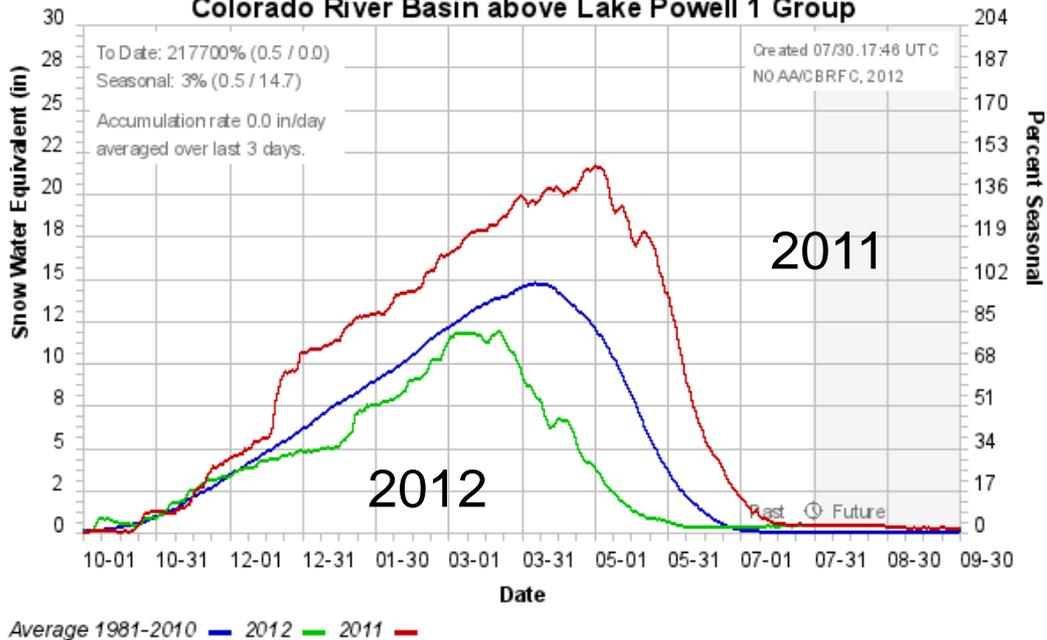


# September Average Reservoir Storage Volume



# Colorado Basin River Forecast Center

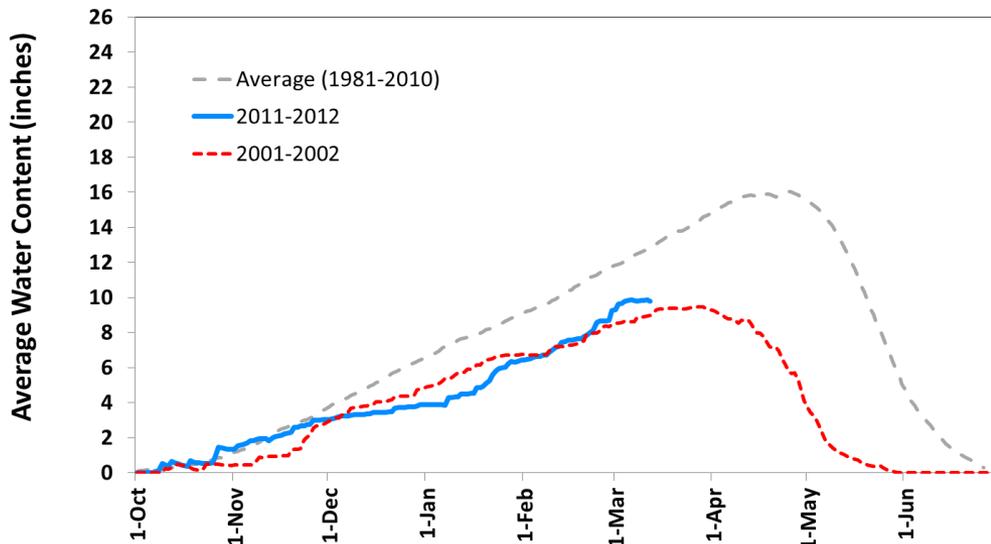
## Colorado River Basin above Lake Powell 1 Group



**Snowpack: Colorado River Watershed (liquid water content)**

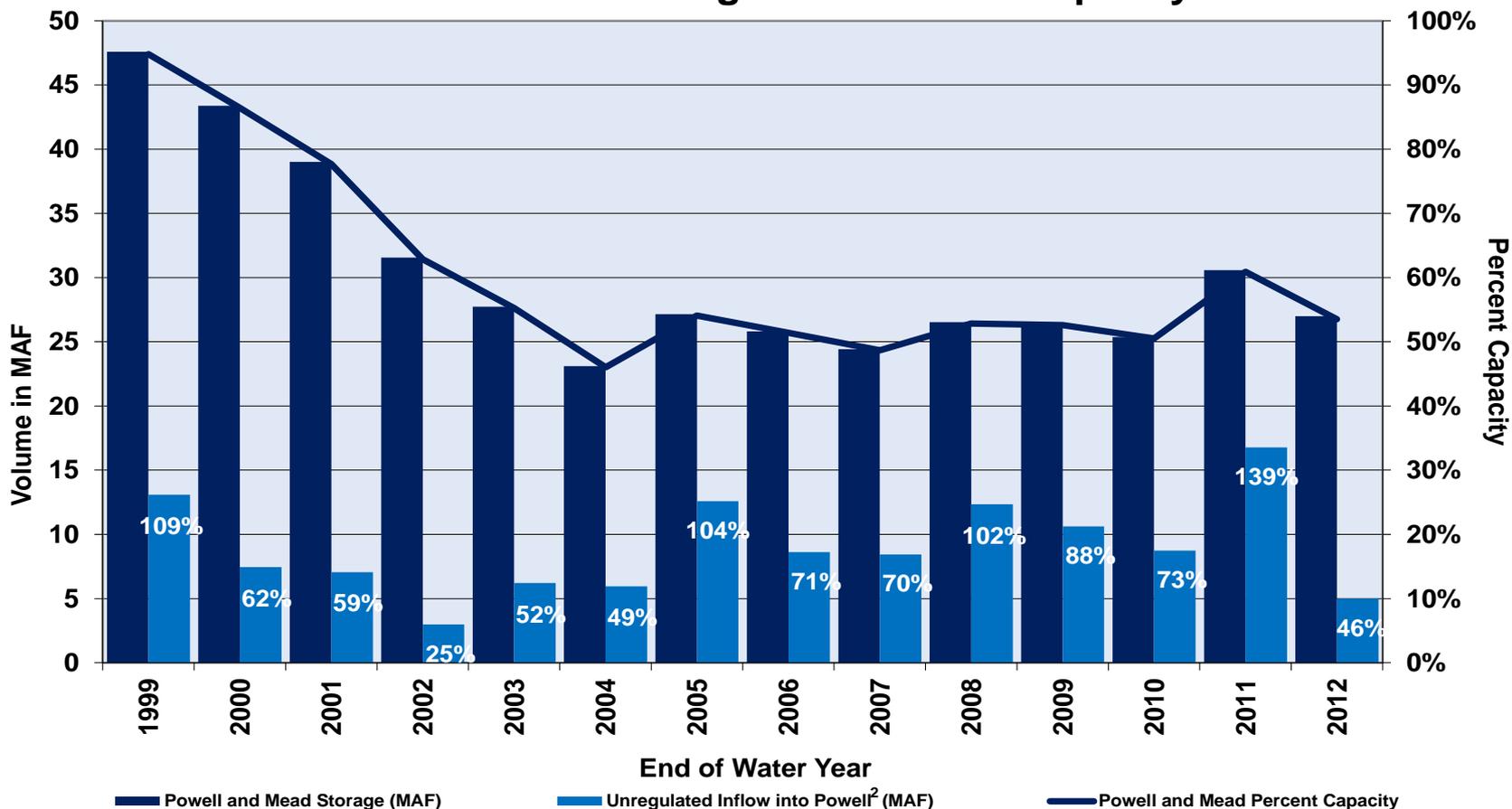


developed with Snotel data as of 7/30/2012



<sup>1</sup> Percent of average is based on the period of record from 1971-2000.

## Unregulated Inflow into Lake Powell Powell-Mead Storage and Percent Capacity



<sup>1</sup> Values for water year 2012 are projected. Unregulated inflow is based on the latest CBRFC forecast. Storage and percent capacity are based on the July 2012 24-Month Study.

<sup>2</sup> Percentages at the top of the light blue bars represent percent of average unregulated inflow into Lake Powell for a given water year. Water years 1999-2011 are based on the 30-year average from 1971 to 2000. Water year 2012 is based on the 30-year average from 1981-2010.

In the Colorado River's 100-year recorded history, 1999 through 2010 ranks as the second-driest 12-year period,



Barr Lake

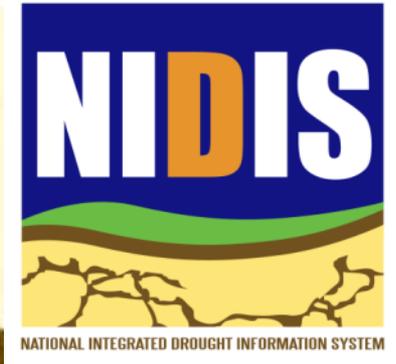
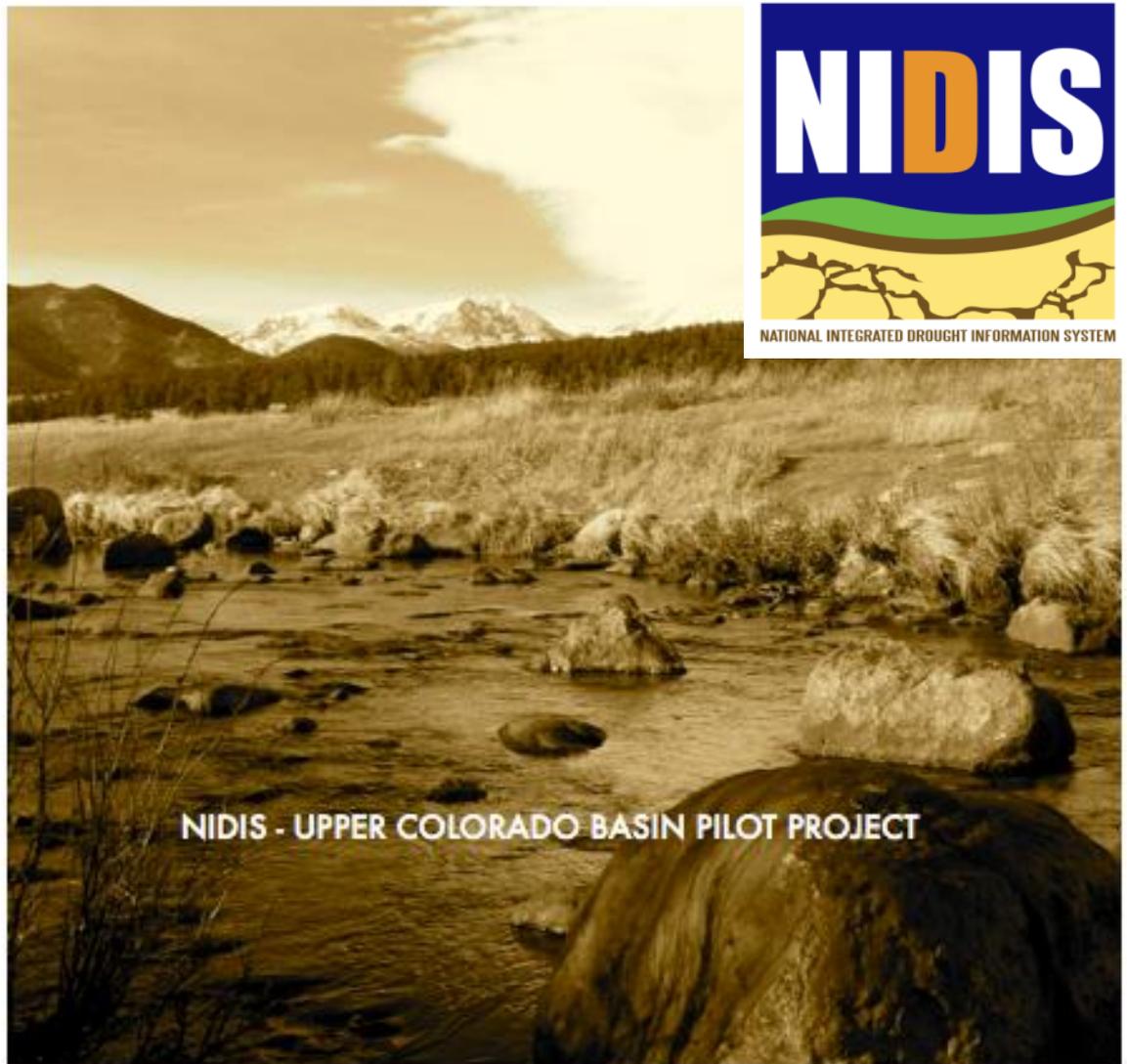


South Platte-Weld County



B. Biggs Metro  
Wastewater  
Reclamation

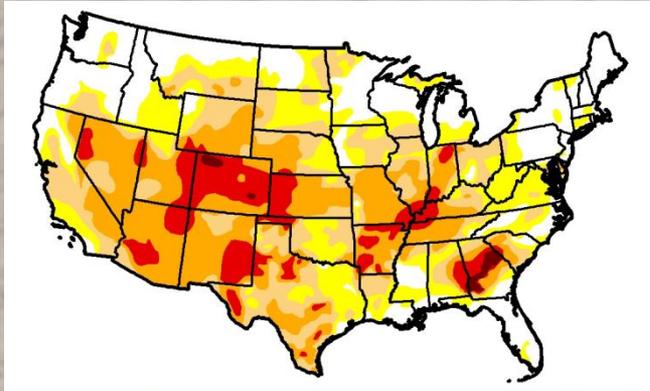
# Summer 2012



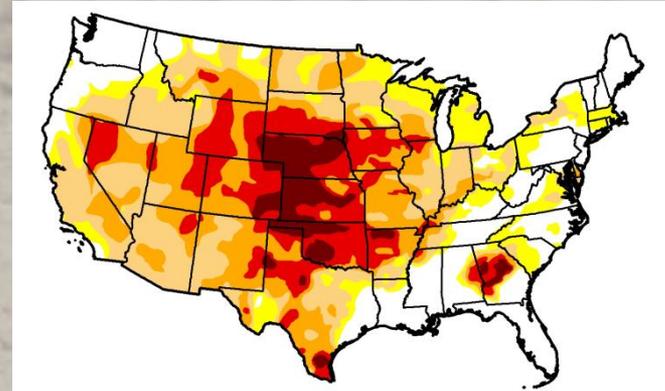
NIDIS - UPPER COLORADO BASIN PILOT PROJECT

Weekly Climate, Water & Drought Assessment

# Experiences from 2012



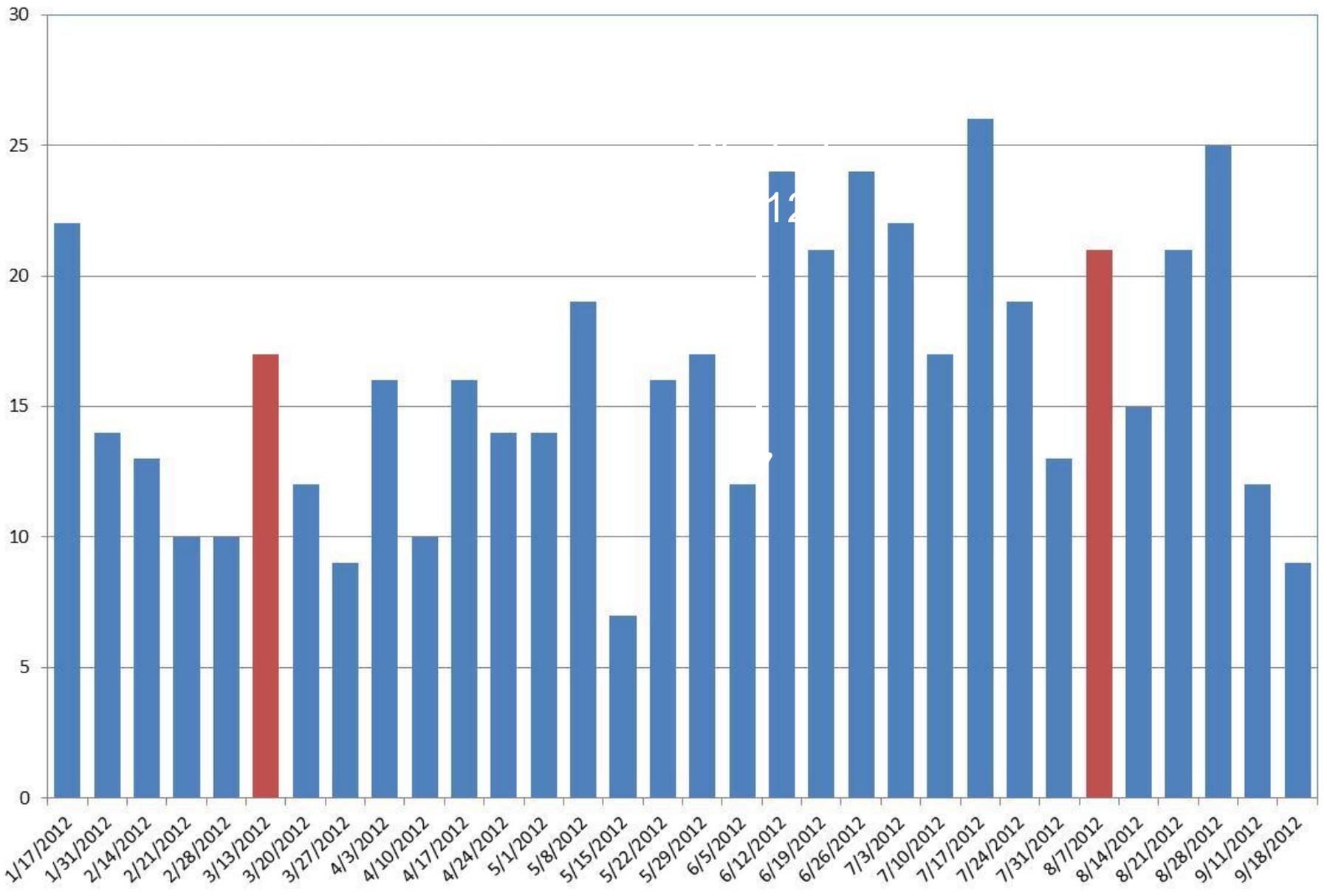
July 3, 2012



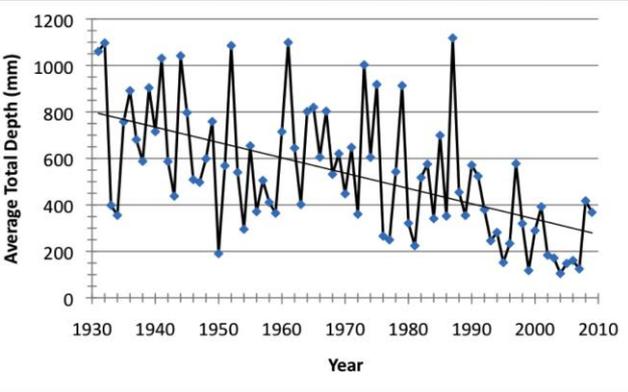
September 18, 2012

- The drought goes on for the UCRB and our NIDIS drought monitoring efforts.
- Started webinars mid-January, by February weekly and stayed that way through the present
- D4 in two different areas of the state, it transitioned from NW Colorado to SE Colorado over just a few months, but the Upper Basin is not out of the woods yet!
- Highest attendance in June, July and August as conditions continued to deteriorate.

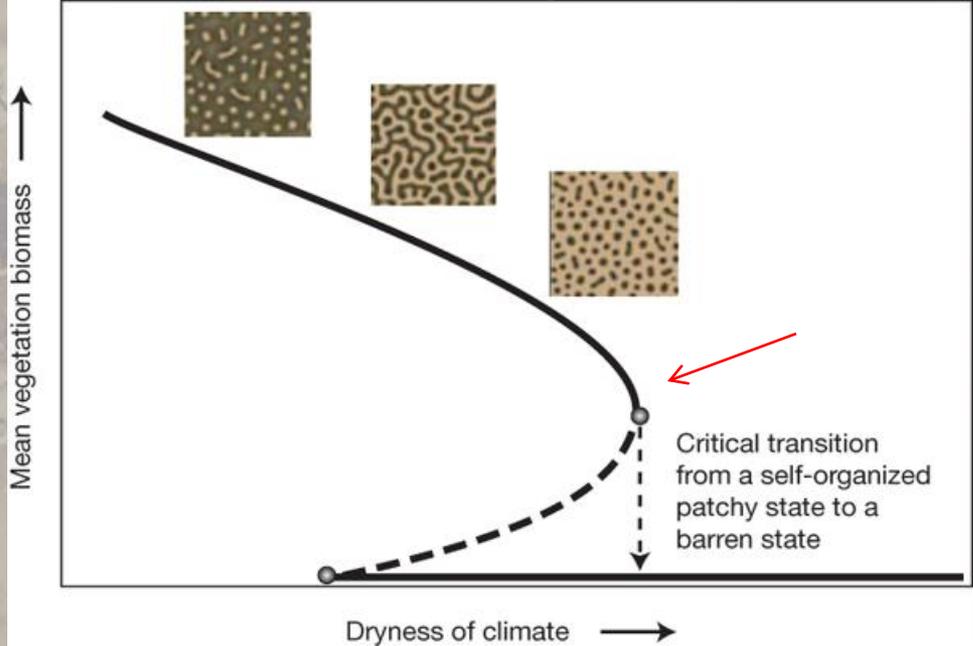
# NIDIS Weekly Webinar Attendance 2012



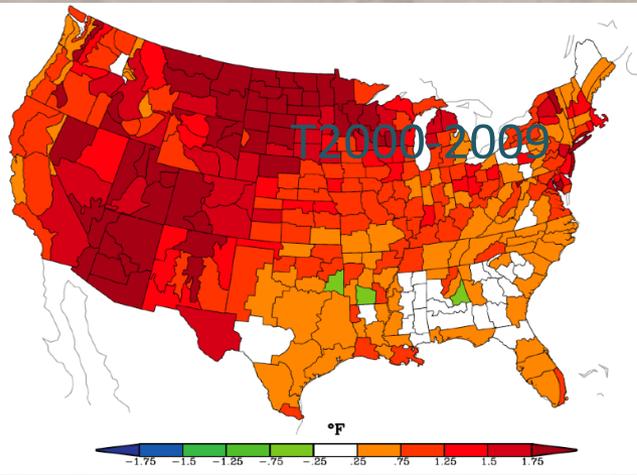
# Landscape changes- Tribal Lands in the Four-Corners Region



Mean vegetation biomass



Dryness of climate



(Nature, 2009)

# Sand Dune Mobility = $W/(P/PE)$

***Stable Sand Dunes***  
 **$= P/PE > 0.31$**

***Partly Active Dunes***

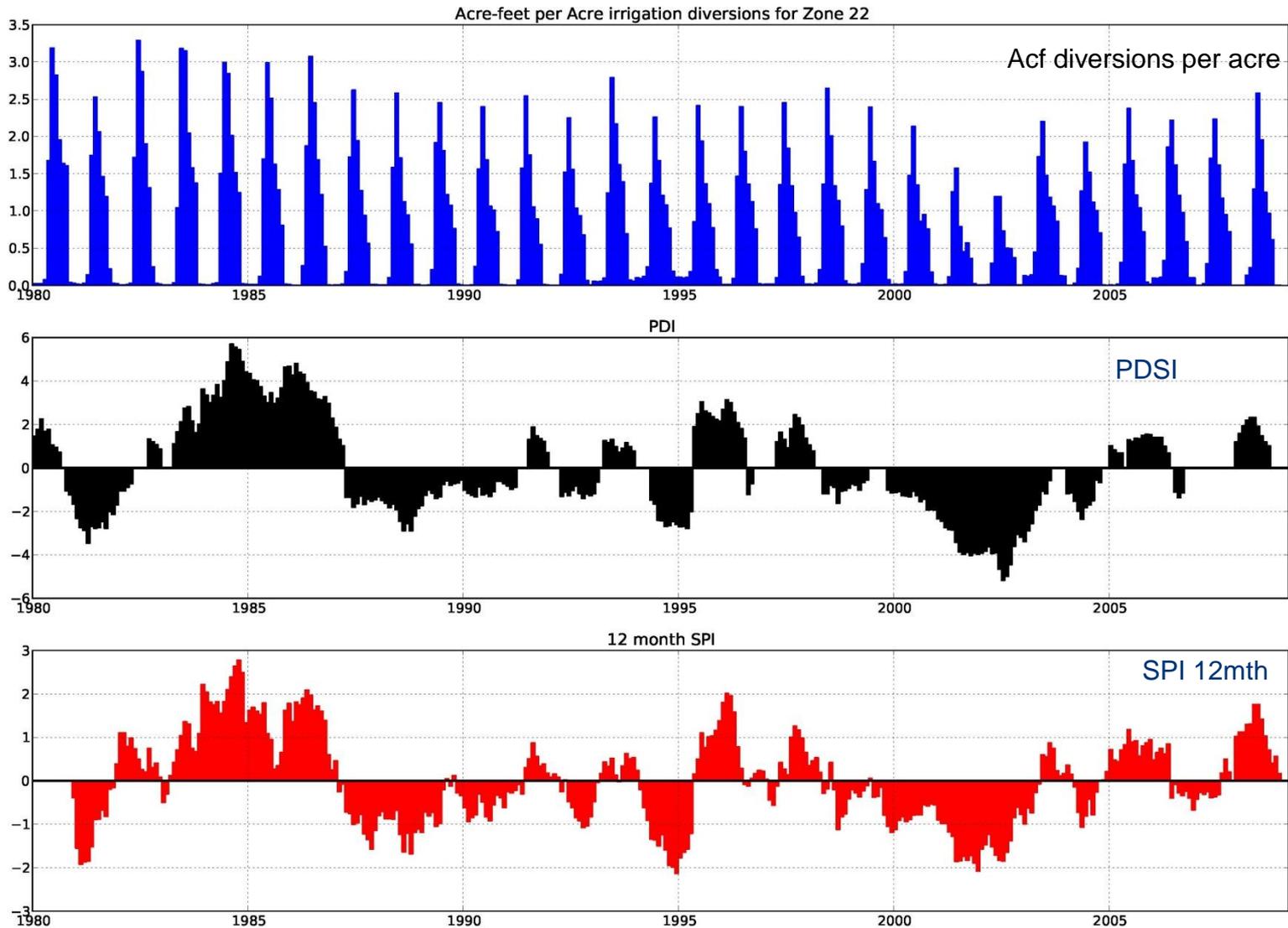
***Fully Active Dunes***  
 **$= P/PE < 0.125$**





# Relating Drought Indices to management

## Irrigation diversions



# Uses of Drought Information-Municipal water (Denver, Boulder)

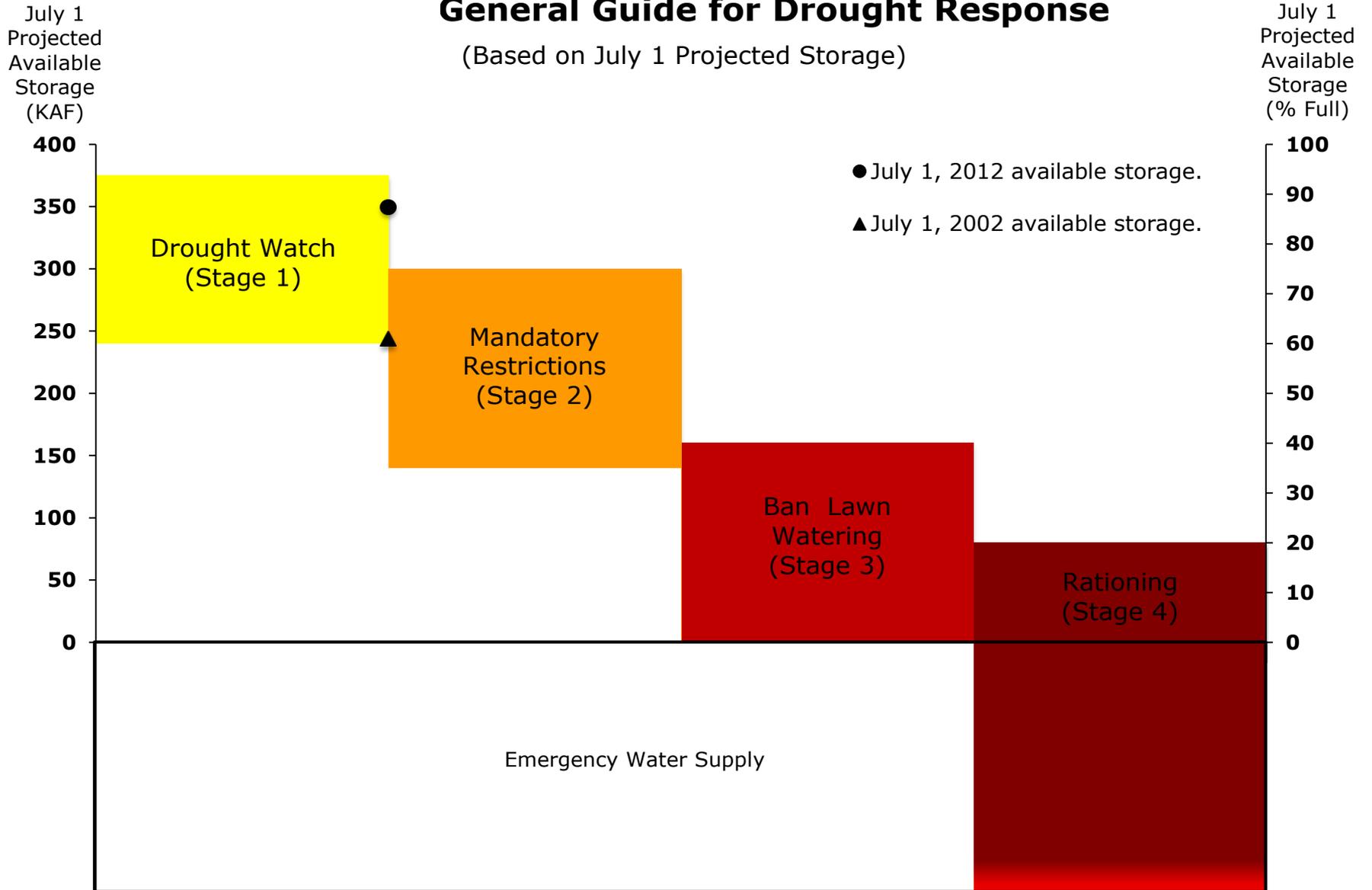


Drought Stage	Water Budget Reductions	Penalties for Violating Water Use Limitations
<b>Moderate</b> <i>(Storage Index 0.85 to 0.70)</i>	More emphasis on basic water use reduction measures and wise water use practices. Use of water monitors to track usage. Target high volume water users. Required budget reductions sufficient to achieve overall <b>8%</b> reduction in water use.	Fines for violating water conservation and water waste per the Boulder Revised Code. Examples: fines for sidewalk or driveway washing or sprinklers spraying streets).
<b>Stage II Serious</b> <i>(Storage Index 0.70 to 0.55)</i>	Keep the following vegetation alive: Trees, shrubs, vegetable and flower gardens and lawns. Required budget reductions sufficient to achieve overall <b>14%</b> reduction in water use.	Penalize block 5 water use for several months with flow restrictors
<b>Stage III Severe</b> <i>(Storage Index 0.55 to 0.40)</i>	Keep the following vegetation alive: major trees, major shrubs, and limited vegetable gardens. Greatly reduce outdoor water use and non-essential uses. Required budget reductions sufficient to achieve overall <b>22%</b> reduction in water use.	Implement Stage II plus fines for “more limited” uses. Examples: lawn watering between 10 am - 6 pm subject to warnings and fines; fines for repeat water waste offenders; fine blocks 4, 5 water use.
<b>Extreme</b> <i>(Storage Index less than 0.40)</i>	Sustain some mature trees, but recognize there may be a major die-off of lawns, trees, and shrubs. Implement aggressive public education and outreach program. Required budget reductions sufficient to achieve overall <b>40%</b> reduction in water use.	Stage II and III penalties and flow restrictors; consider moratorium on building permits; consider termination of water service for extreme water waste offenders.

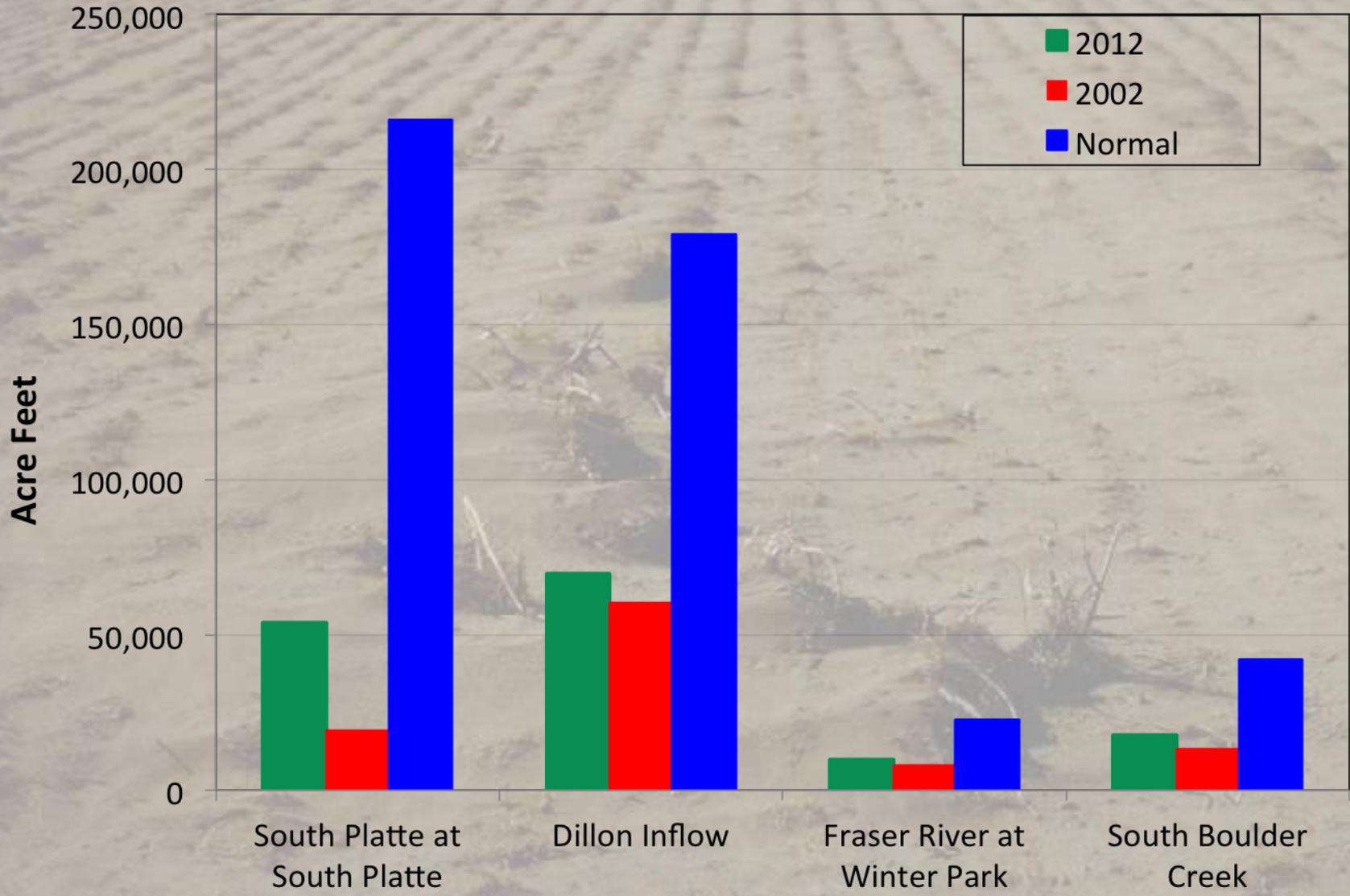
# Denver Water

## General Guide for Drought Response

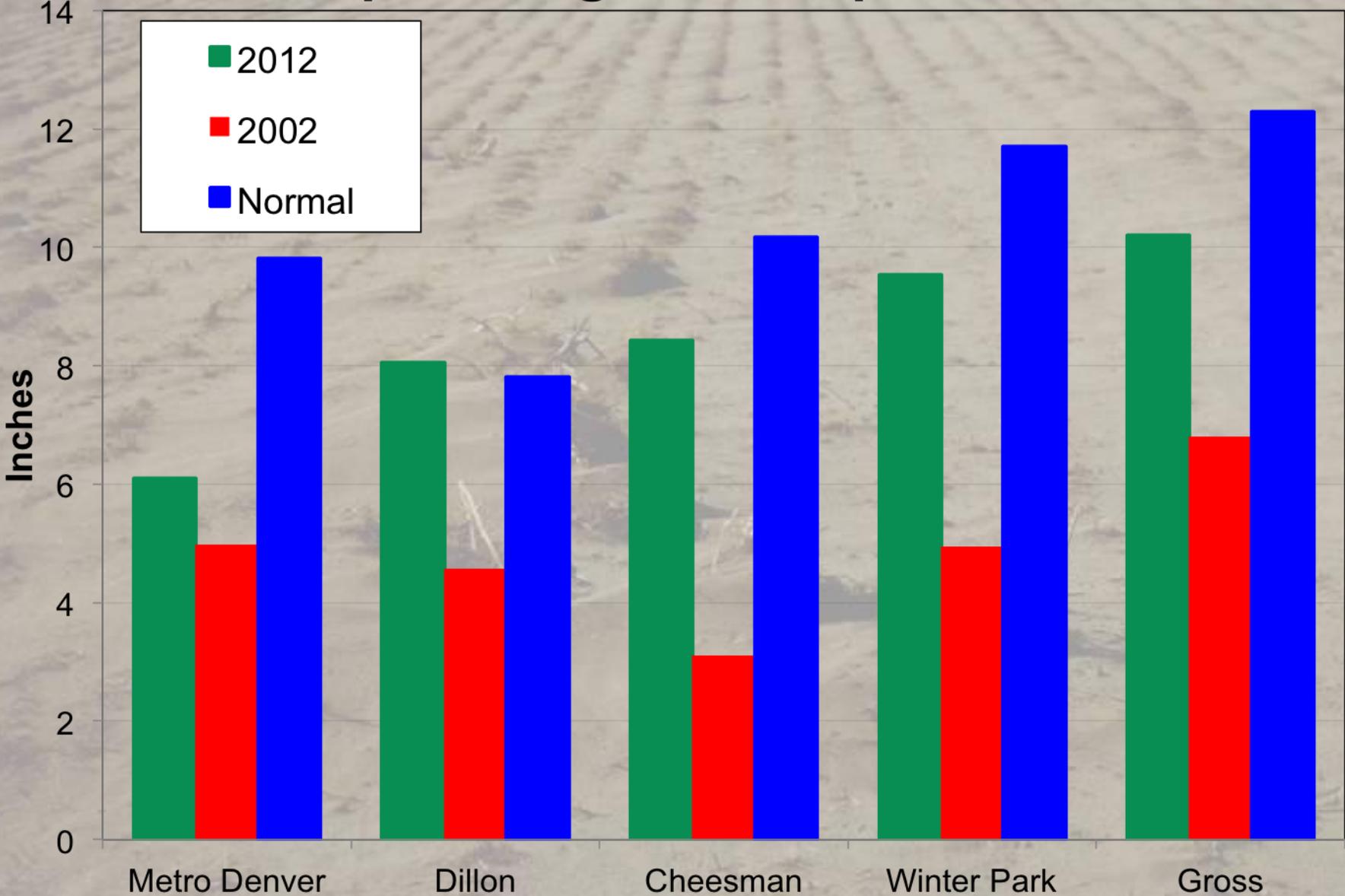
(Based on July 1 Projected Storage)



# April - August Natural Streamflow



# April - August Precipitation





# Wildfires threaten Colorado's summer tourism

By Thomas Peipert  
The Associated Press

Updated: 06/26/2012 05:05:13 PM MDT

## Wildfires threaten summer Rocky Mountain tourism



## Colorado wildfires spark concerns over tourism fallout

By Jayne Clark, USA TODAY

Updated 6/26/2012 6:00 PM



## Vicious wildfires spread to Colo. tourist centers

By THOMAS PEIPERT | Associated Press – Mon, Jun 25, 2012

## Mass evacuations ordered as wildfires rage in Colorado

*32,000 people flee homes in the Colorado Springs area, including parts of the Air Force Academy, and Boulder is under threat.*



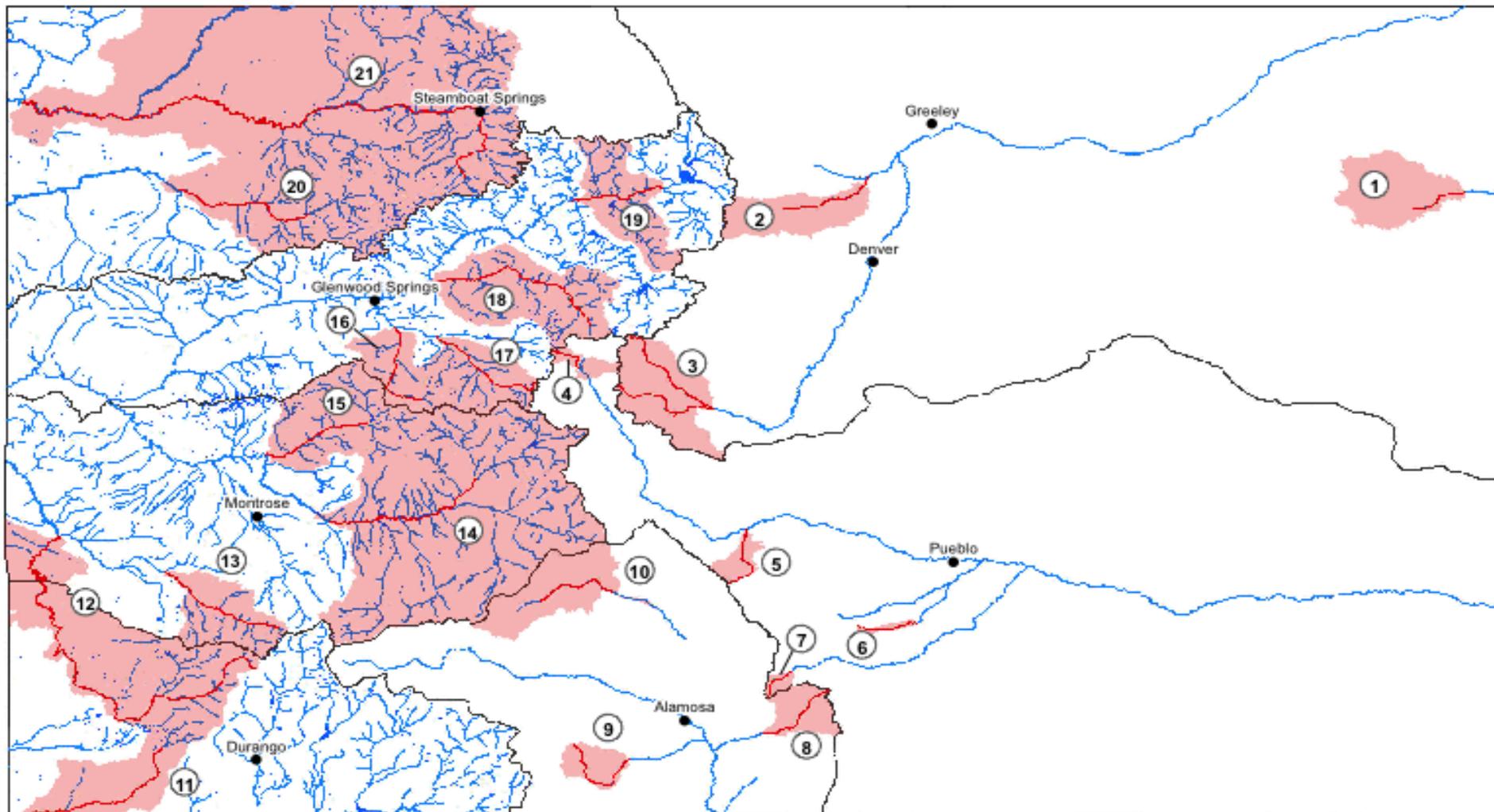
### WESTERN WILDFIRES



# Water Use and Weather (April 1 – September 23)

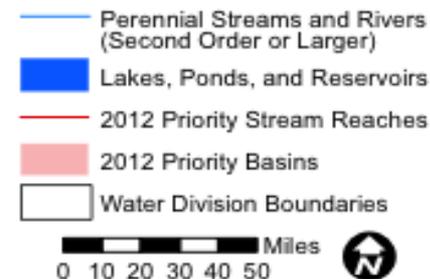
Year	Use (MG)	Avg High Temperature (°F)	Precipitation (inches)
2002	51,200	81.8	6.8
2006	50,500	79.5	7.6
2005-2011 Avg	45,300	78.7	11.0
2012	48,300	83.5	7.4

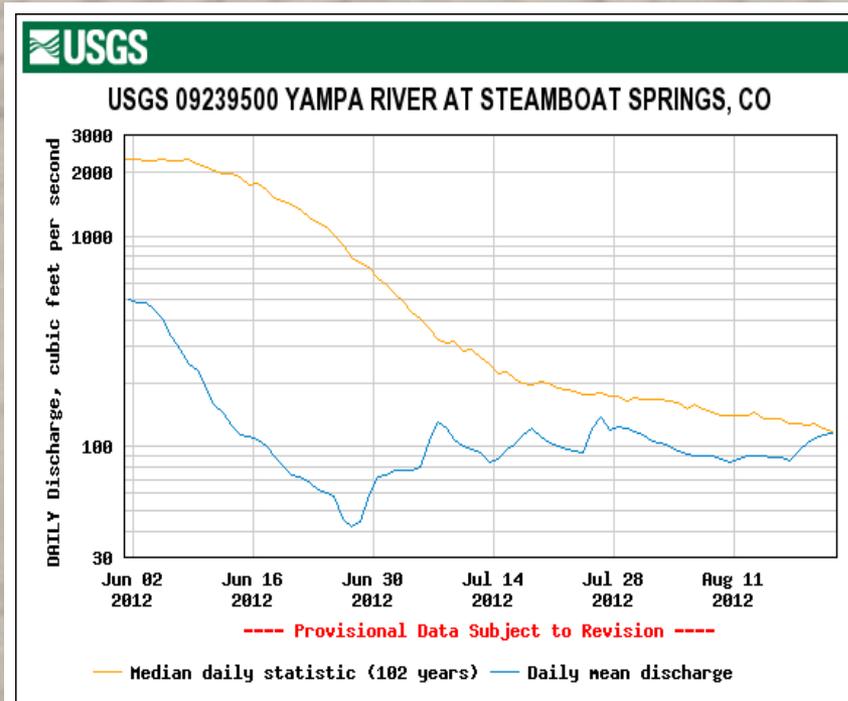
# Colorado Water Trust Short-Term Leasing Program 2012 Priority Streams and Basins



## Priority Stream Basins

- |  |  |
|--|--|
| 1. North Fork of the Republican River upstream from Holy Joe Creek         | 12. Dolores River upstream from the San Miguel River         |
| 2. Boulder Creek   | 13. San Miguel River upstream from Horsefly Creek            |
| 3. Middle and South Forks of the South Platte River above their confluence | 14. Gunnison River upstream from the Crystal Dam             |
| 4. Lake Fork of the Arkansas River   | 15. North Fork of the Gunnison River                         |
| 5. Texas Creek   | 16. Crystal River  |
| 6. Greenhorn Creek upstream from Graneros Creek                            | 17. Roaring Fork River upstream from the Frying Pan River    |
| 7. Huerfano River upstream from Stanley Creek                              | 18. Eagle River  |
| 8. Sangre de Cristo Creek upstream from Ute Creek                          | 19. Colorado River between Windy Gap Reservoir and Kremmling |
| 9. La Jara Creek upstream from Hot Creek                                   | 20. White River upstream from Piceance Creek                 |
| 10. Saguache Creek upstream from the North Branch of the Saguache          | 21. Yampa River  |
| 11. Mancos River   |  |





**Yampa River streamflow increased to levels that allowed the river to re-open for recreational uses (Source A. Beattie CO River Trust)**

# Regional Outlooks

## Quarterly Climate Impacts and Outlook Western Region Spring 2012

National - Significant Events for March - May 2012

### Significant Events for May and Spring 2012

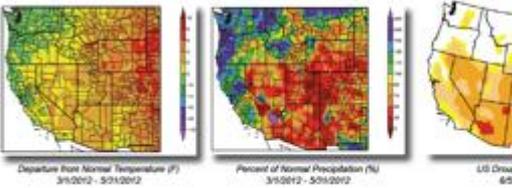


### Highlights for

Mountain snowpack in the West is increasing due to below and above-average snow. Sub-par mountain snow rapidly disappeared in the West due to high wind, drought conditions in the Southwest, and development and spread of critical fire conditions. Southwest winds in the West which combined with high regional variability and an Equatorial Pacific sea surface temperature that is transitioning from La Niña conditions. These conditions continue through the summer.

Regional - Climate Overview for March - May 2012

### Temperature and Precipitation Anomalies



The temperature anomalies shown in the left panel indicate that most of the interior West had above-normal temperatures, with slightly cooler-than-normal temperatures in the Northwest and the northern and central California coast.

The Pacific Northwest and much of California had well above-normal precipitation, while most of the interior West precipitation was normal. Oregon had the wettest spring in the last 118 years and Washington had the third wettest temperature and precipitation data courtesy of the High Plains Regional Climate Center, www.hprcc.unl.edu.

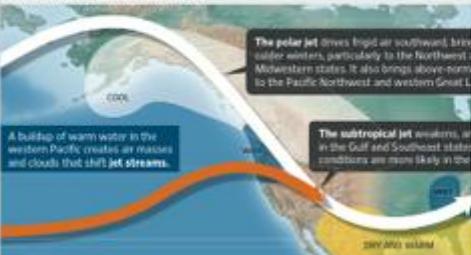
The US Drought Monitor shows anomalously dry to extreme drought conditions in many parts of the West. (The DMI collaborative product from the USDA, NOAA and National Drought Mitigation Center, www.droughtmonitor.unl.edu)

Contact: Robert Webb (Robert S. Webb@noaa.gov) Western Region Quarterly Climate Impacts and Outlook

### Snow, Rain, Heat and Gloom of Night

This year's La Niña weather pattern is expected to be a weak one, peaking in the winter months exacerbate conditions in vulnerable areas devastated by the floods, tornadoes, wildfires and drought. Last year broke the record for the number of climate-related disasters that caused billion-dollar U.S., according to the National Oceanic and Atmospheric Administration.

### How does it affect the U.S.?



### Forecasts for the first three months of the year



### What will it mean for 2012?

Government and businesses are watching for disruptive—or beneficent—weather. Some preparations:

- Retail/Energy**
  - Decreased energy consumption from cold Northeastern winter in mild to late January, once warm patterns in region subside.
  - Relatively short, intense winter expected for the upper Great Lakes region and Northwest spans retail sales in spring and early summer.
  - Gas concern like behavior in Pacific Northwest begins commerce in spring and summer if precipitation is lower than last year.
  - Lake Tahoe (it) begins efforts to dry start, but good season for winter sports still possible if winter weather goes coastal keeping rain away from mountains.
- Agriculture**
  - Cattle ranchers in New Mexico cautiously optimistic for spring weather than predicted December good for shrubby forests. In Texas, possible extension of drought may further squeeze hay and feed resources.
  - Spring breaks early in South, permitting longer planting season for cotton, wheat, corn and soy.
  - Florida citrus growers concerned about a recent dry stretch extending and threatening a year of orange crop.
  - Grim news for soybean growers on Atlantic and Gulf coasts if winter is warm and dry—better conditions for a pest that can kill soybeans.
- Government**
  - Spring drought and Southwest 1. But in worst-case scenario, dry, hot spring and summer worsen drought and trigger further water-use restrictions.
  - Drought distresses local ecosystems, reducing shrimp, oyster and fish harvests for fishing industry still recovering from 2007 drought and 2010 Gulf of oil.
  - After last year's record floods, Army Corps of Engineers is racing to make repairs to levees near confluence of Ohio and Mississippi rivers. Corps is spending some \$50 million to repair about 75 miles of critical levees along Missouri River. Expects to have 3% more space for floodwaters in Montana and Dakota.

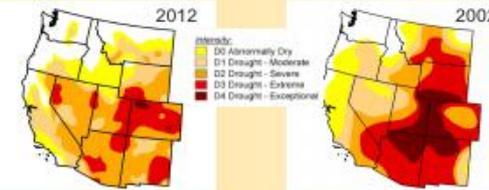
Source: National Oceanic and Atmospheric Administration, Florida, Army Corps of Engineers, The Foreman, Appalachian River Journal, Keith T. Ingram, Southwest Climate Center, Red Cross, Lower Colorado River Authority, Willard Bergman, Meteorology Center, Georgia State U., David R. Bell, Boulder Research Laboratory, Meteorology Information Systems, Ben Marley (Cable News), Associated Press, and Southern California Edison Association. Multiple Image Credits to various sources.

## The 2012 Drought in Colorado, Utah and Wyoming

A July 2012 update from the Western Water Assessment and the National Integrated Drought Information System

Under a second winter of La Niña, drought conditions emerged midway through the 2012 water year, with low snowpacks melting out early during a very dry and warm spring. Spring and early summer runoff over most of the region was well below average, with flows similar to 2002 and other benchmark drought years. Continued dry and hot conditions in June dried out vegetation and led to very large and intense wildfires in all three states, along with widespread rangeland, pasture, and dryland crop losses.

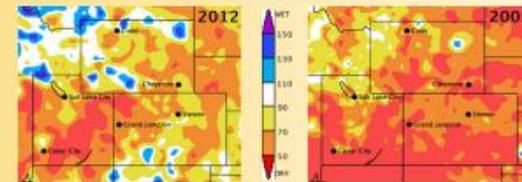
### Drought Conditions as of early July



According to the July 10 US Drought Monitor, severe or worse drought conditions cover nearly all of Colorado, most of Utah, and about half of Wyoming. In early July 2002, conditions were generally worse than 2012 across the three-state region, except for north-central Colorado and far northwestern Utah. The severity of the drought classification (D1-D4) is based on hydro-meteorological variables such as precipitation, soil moisture, streamflow and temperature. Note that the Drought Monitor is now based on more detailed spatial input compared to 2002.

US Drought Monitor for July 10, 2012 (left) and July 9, 2002 (right) (Source: www.droughtmonitor.unl.edu/monitor.html)

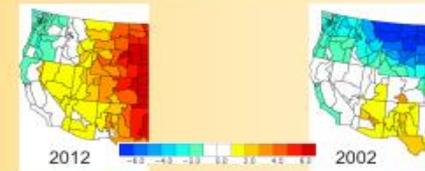
### Water Year Precipitation through June



Percent of average (1995-2010) precipitation for the current water year to date, October 2011-June 2012 (left), with October 2001-June 2002 (right) for comparison. (Source: NWS COOP and SNOTEL data; Gary Bates, NOAA ESRL Physical Science Division)

For the water year to date (October 2011 through June 2012), a mixed first five months followed by an extremely dry March-June added up to dry conditions across all of the region, except for pockets in northern and southwest Wyoming, and southern Colorado. The driest areas, with less than 70% of average precipitation, included many of the key mountain headwaters in western and northern Colorado, and in Utah. But as dry as water year 2012 has been, 2002 was drier over the same period in nearly all parts of the region.

### Spring and Early Summer Temperatures



March-May temperatures in 2012 (left) were 2° to 7° F above normal across the 3-state region, much warmer than the same period in 2002 (right). (Source: NOAA ESRL PSD Climate Analysis Branch, plotted from NOAA NCDC divisional data: http://www.esrl.noaa.gov/psd/data/usclm/dmvs/)

For an expanded version of this overview, including additional graphics and text, see the Special Issue of the Western Water Assessment Intermountain West Climate Summary at www.colorado.edu/IWCS/2012\_July.html

## Western Govs-NIDIS Regional Outlook

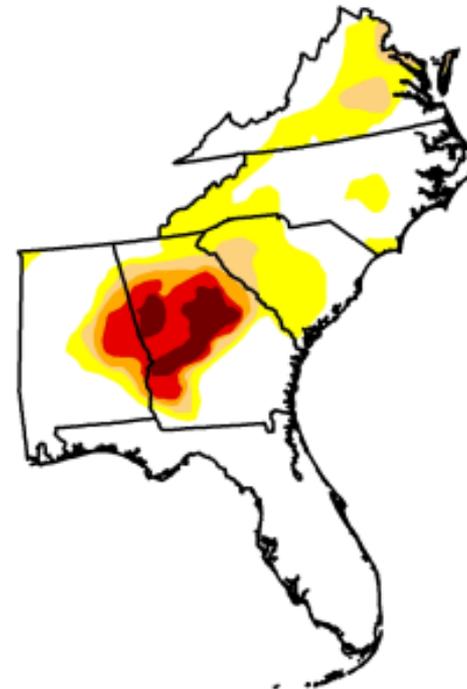
# U.S. Drought Monitor

## Southeast

September 18, 2012  
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	62.76	37.24	17.36	11.50	8.47	3.30
Last Week (09/11/2012 map)	62.60	37.40	17.36	11.50	8.47	3.46
3 Months Ago (06/19/2012 map)	41.26	58.74	35.08	20.92	8.63	3.02
Start of Calendar Year (12/27/2011 map)	40.38	59.62	43.05	28.62	18.71	0.00
Start of Water Year (09/27/2011 map)	42.24	57.76	41.82	31.77	23.48	0.00
One Year Ago (09/13/2011 map)	39.54	60.46	45.29	32.22	24.37	0.00



Intensity:



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

<http://droughtmonitor.unl.edu>

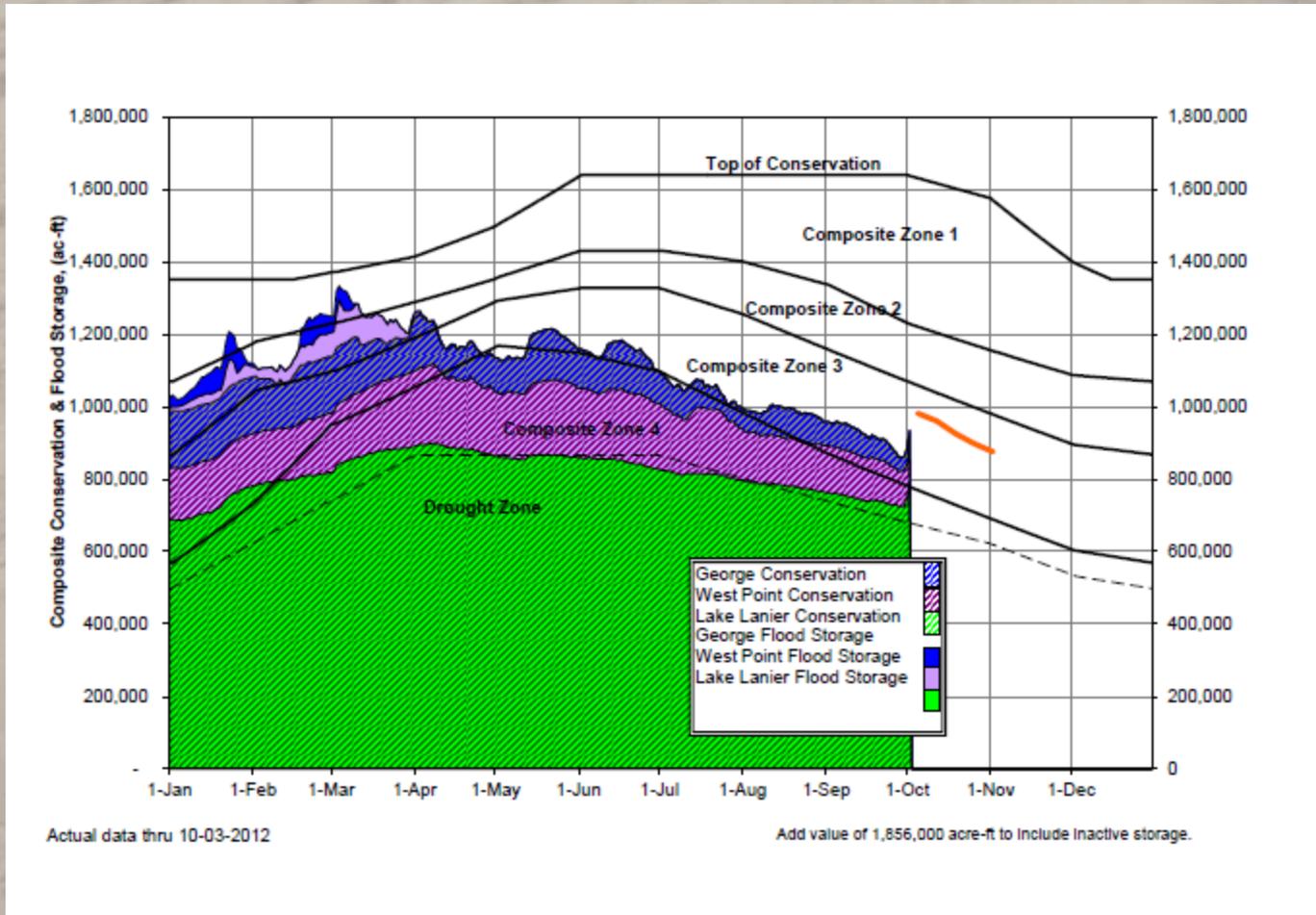


Released Thursday, September 20, 2012  
David Simeral, Western Regional Climate Center

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

# ACF Basin Composite Storage

(Lakes Lanier, Westpoint and George)



# 1-Month Streamflow Forecasts

## Apalachicola Watershed

Southeast River Forecast Center

Lake Lanier Inflows

September 24<sup>th</sup> – October 24<sup>th</sup>  
2012

-  Above Normal
-  Near Normal
-  Below Normal

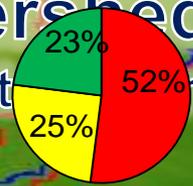


# 3-Month Mean Daily Streamflow Forecasts

## Apalachicola Watershed

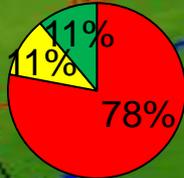
Southeast River Forecast

September 24<sup>th</sup> – December 24<sup>th</sup>  
2012

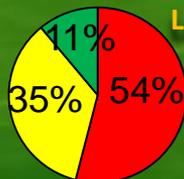


Lake Lanier Inflows

- Above Normal
- Near Normal
- Below Normal



Whitesburg



Lovejoy



West Point



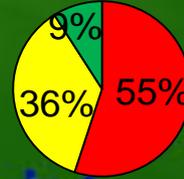
Carsonville



Columbus



WF George



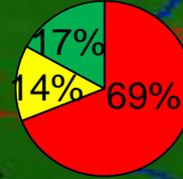
Albany



Columbus



Woodruff



Blountstown



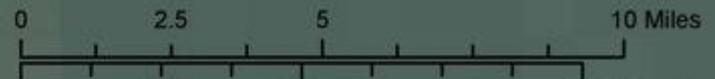
# Apalachicola National Estuarine Research Reserve

East Bay

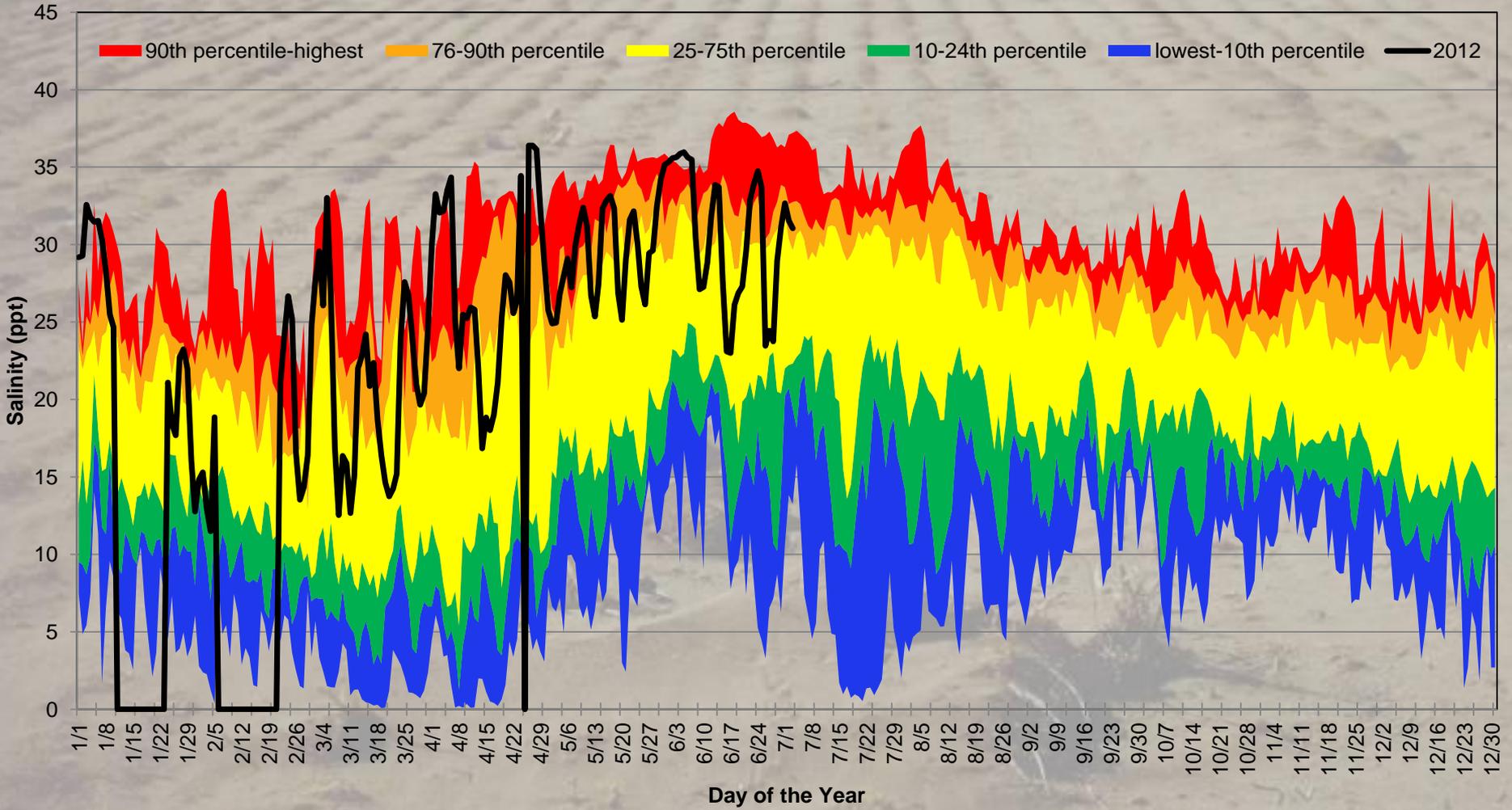
Cat Point

Dry Bar

-  Trawling
-  Oysters
-  Sea Turtles
-  Shore Birds
-  Water Quality
-  Erosion
-  Nutrients
-  Weather Station

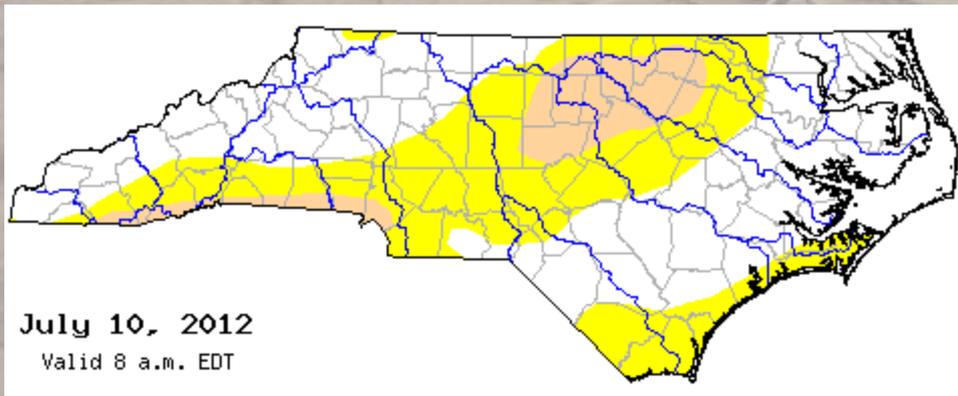


# Daily Salinity at Dry Bar



# Management Triggers

## NORTH CAROLINA Drought Management Advisory Council



<http://www.ncdrought.org/>

### Drought Classification and Response Actions

#### D1 - Moderate Drought

The NCDMAC advises all water users in the counties that are indicated on the US Drought Monitor Map as suffering from Moderate Drought (D1) conditions to enact the following precautions in addition to previous advisories until further notice:

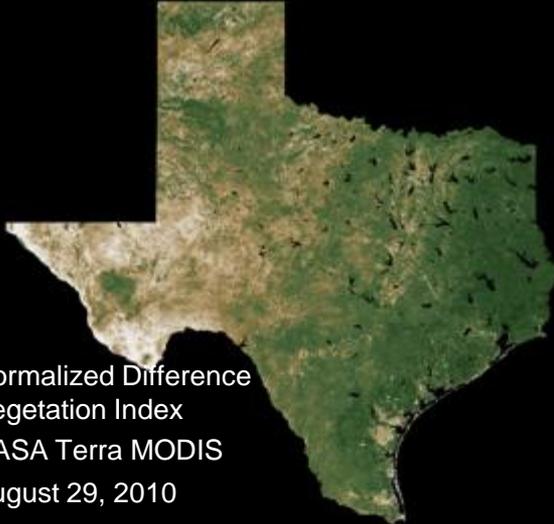
- » Adhere to local water use restrictions.
- » Participate, as appropriate, in regional and local coordination for the management of water resources.
- » Stay informed on drought conditions and advisories ([www.ncdrought.org](http://www.ncdrought.org)).
- » Project water needs and available water supply for a ninety day period from the issuance of this advisory.
- » Assess your vulnerability to the drought conditions and adjust water usage to prolong available supply.
- » Inspect water delivery system components (e.g. irrigation lines, fixtures, processing equipment, water system lines, etc.), repair leaks and ensure that existing equipment is operating as efficiently as possible.
- » Minimize nonessential uses of water.
- » Implement available public awareness and educational outreach programs emphasizing the need to conserve water.

#### D0 - Abnormally Dry

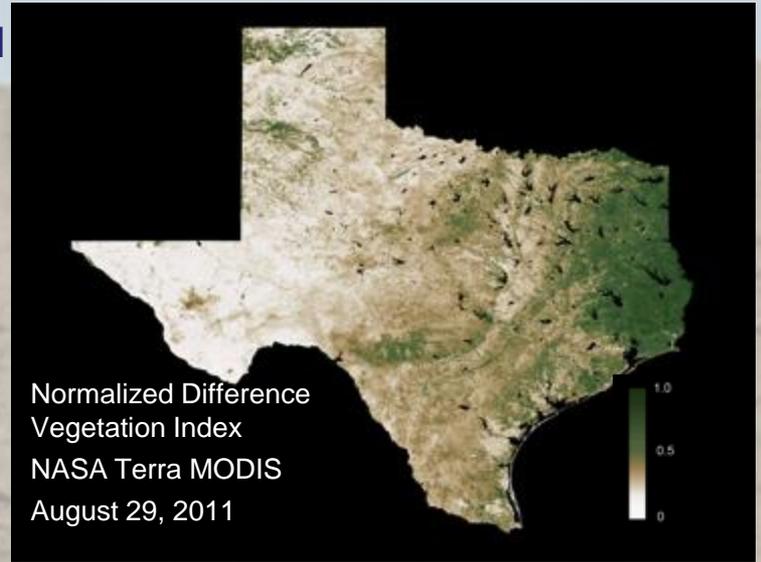
The NCDMAC requests all water users in the counties that are indicated on the US Drought Monitor Map as suffering from Abnormally Dry (D0) conditions to closely monitor their water supply source for diminished capacity and take precautions to prepare for impending drought conditions.

- » Review and be prepared to implement your Water Shortage Response Plans at the appropriate time.
- » Participate, as appropriate, in regional and local coordination for the management of water resources.
- » Stay informed on drought conditions and advisories ([www.ncdrought.org](http://www.ncdrought.org)).

MODIS telemetry  
 received and processed  
 by the MAGIC DBRS  
 Center for Space  
 Research, University of  
 Texas at Austin



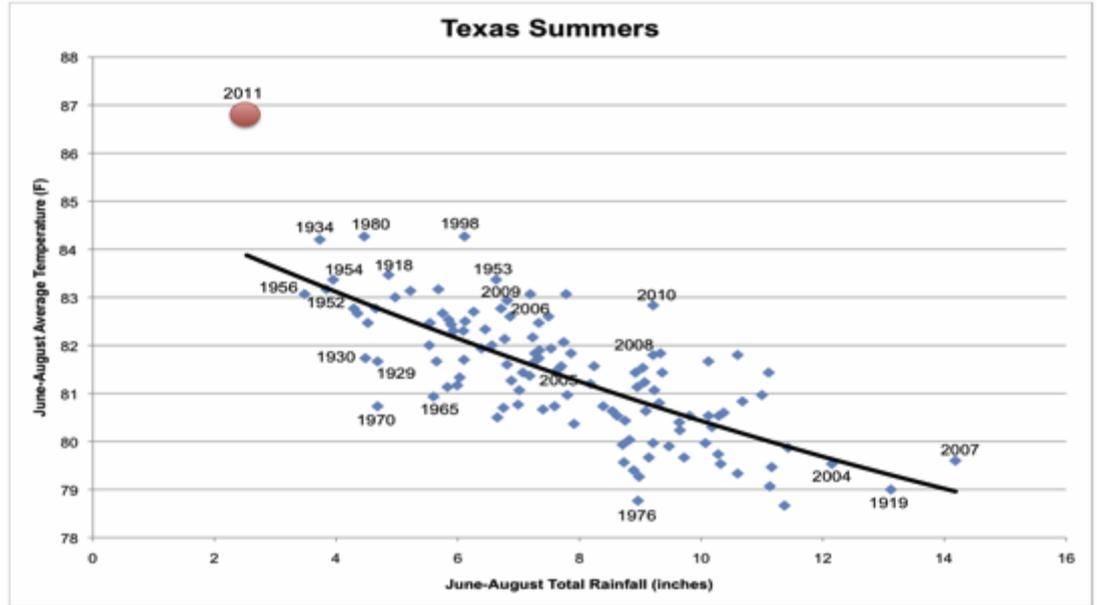
Normalized Difference  
 Vegetation Index  
 NASA Terra MODIS  
 August 29, 2010



Normalized Difference  
 Vegetation Index  
 NASA Terra MODIS  
 August 29, 2011



June-Aug T (°F)



June-Aug rainfall (in)

Nielson-Gammon, Bewley, Rose

# MANAGING DROUGHT

## IN THE SOUTHERN PLAINS

You are invited to join us in a webinar (web-based seminar) series to discuss drought conditions, impacts and resources available to help manage drought in the Southern Plains. Webinars will be held on the 2nd Thursday of each month at 11:00 A.M. Central Time. A shortened briefing will also be offered on the 4th Thursday. The content is geared toward a general audience – anyone who has responsibility to manage or assist others in managing drought and its related impacts.

If you would like to join in these webinars, you need to register via the SCIPP website: <http://www.southernclimate.org> or e-mail [scipp@mesonet.org](mailto:scipp@mesonet.org). For each webinar, you will receive an e-mail with the link to access the webinar. Each webinar will last 45-60 minutes.

Each webinar will include an overview of the current drought assessment and outlook, summary of impacts across the region, and a topic or resource, such as La Niña or wildfire conditions. You will have an opportunity to suggest topics for following webinars. The primary focus is in the states most heavily impacted from the current drought - Texas, Oklahoma and New Mexico – but participation from surrounding states is encouraged.

The webinar series is sponsored by a partnership of the National Integrated Drought Information System (NIDIS), National Oceanic and Atmospheric Administration (NOAA), National Drought Mitigation Center, Southern Climate Impacts Planning Program, Climate Assessment for the Southwest, and the region's State Climatologists.

Information from the webinars will be posted on a website linked through <http://www.southernclimate.org>. A two-page summary will be produced and posted for each webinar. Please pass on this announcement to relative organizations or groups that are involved in managing or monitoring drought and its related impacts.

To register or for more information, contact:  
Southern Climate Impacts Planning Program  
<http://www.southernclimate.org>  
405-325-2541 or [scipp@mesonet.org](mailto:scipp@mesonet.org)

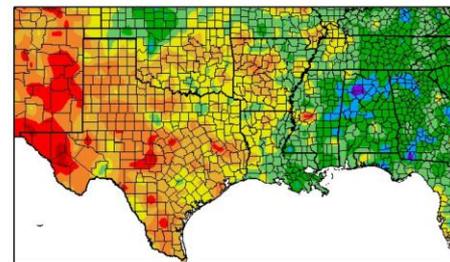
- Webinar Topics:
- La Niña
  - Cattle & Livestock
  - U.S. Drought Monitor
  - Ecological Impacts
  - Seasonal Forecasting
  - Flash Drought
  - Water Supply
  - Wildfire
  - Drought Ready Communities
  - Agricultural Impacts



RISA/SCIPP is holding bi-weekly discussions of the drought and its impacts, on the 2nd and 4th Thursdays of each month at 11:00 a.m. Central Time.

Departure from Normal Temperature (F)  
8/1/2012 - 8/31/2012

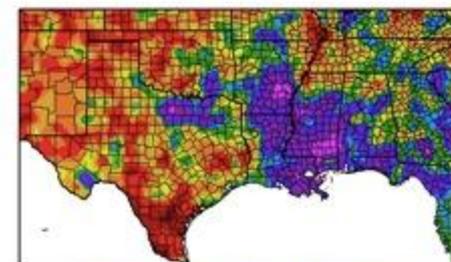
T



Generated 9/11/2012 at HPRCC using provisional data. Regional Climate Centers

Percent of Normal Precipitation (%)  
8/1/2012 - 8/31/2012

P



Generated 9/11/2012 at HPRCC using provisional data. Regional Climate Centers

Departures from 1971-2000 normal average temperatures and precipitation for August 2012, across the South.

# Promoting the “drought impact reporting” idea to volunteers...

- \* **14,000+ volunteers covering all 50 states and now into Canada!!**

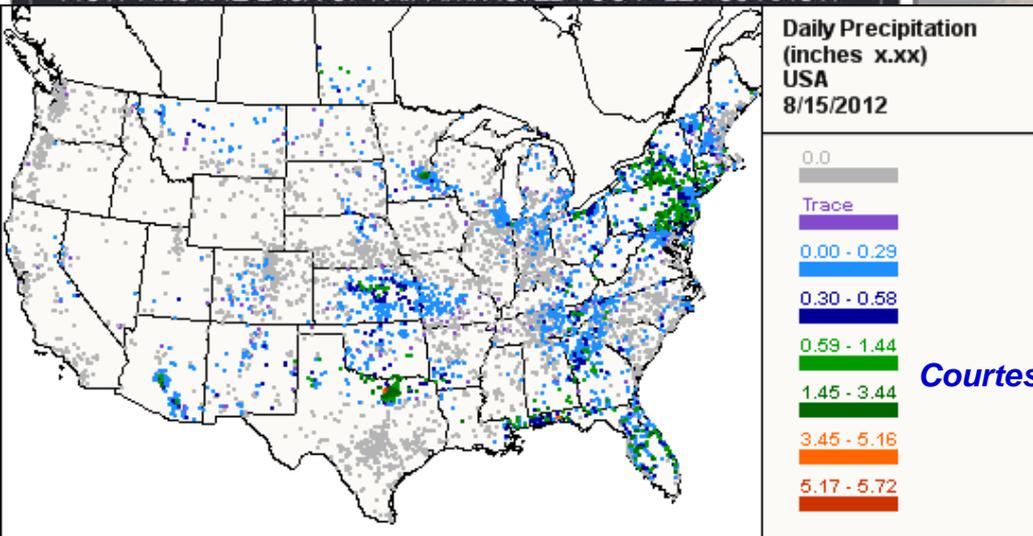
- \* **CoCoRaHS “Message of the Day”**

- \* **Monthly e-mail reminders**

- \* **Guide to reporting drought impacts**

- \* **Banners on the Web**

*Courtesy: Henry Reges, Colorado State University*

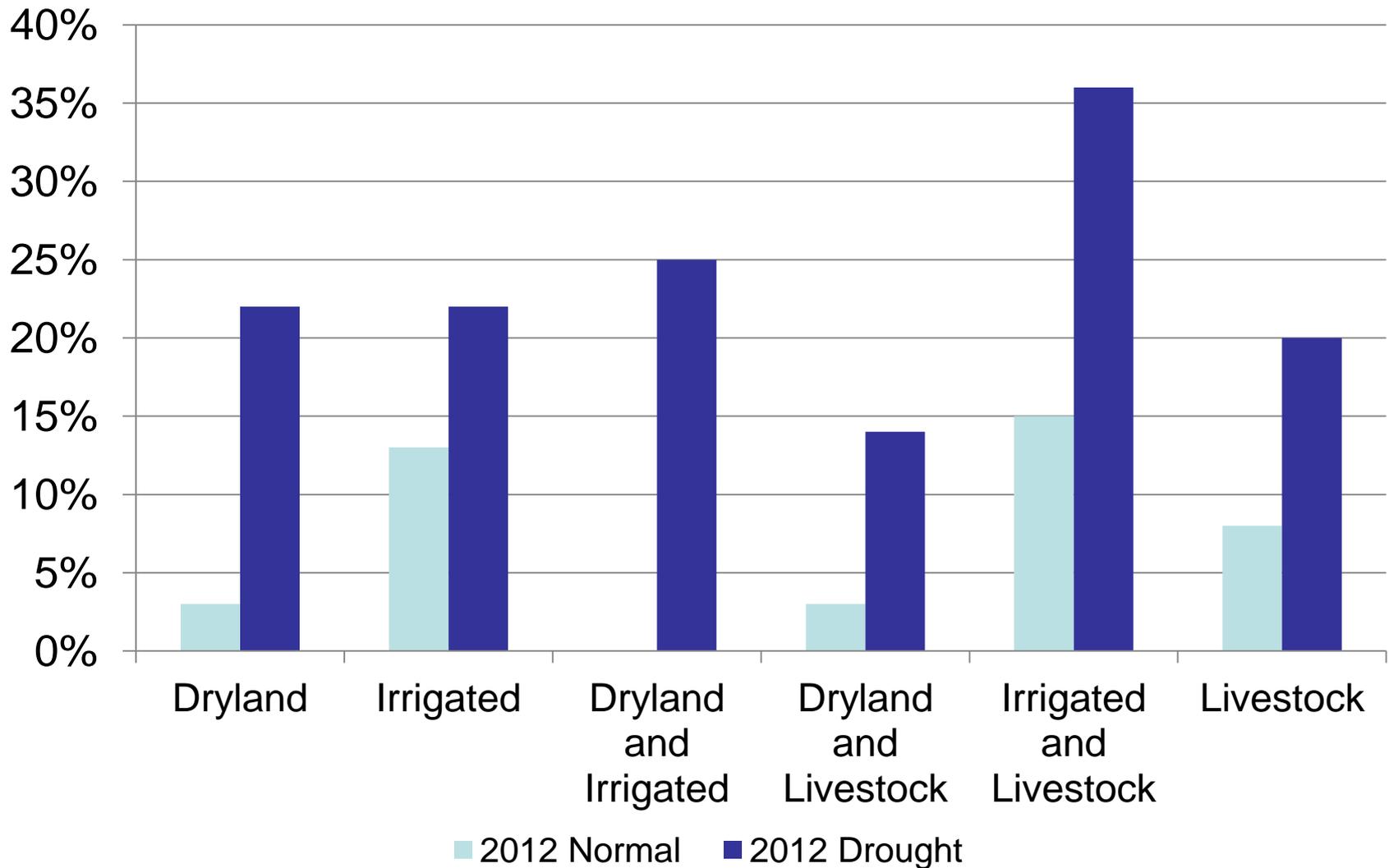


## Drought Impacts on Harvested Acres and Yields (S.Colorado)

<b>Please enter the following information about your 2011...</b>	<b>% Difference in planted and harvested acreage</b>	<b>% Difference in actual and expected yields</b>
<b>dryland wheat crop.</b>	73%	46%
<b>dryland corn crop.</b>	91%	40%
<b>dryland sorghum crop.</b>	84%	24%
<b>irrigated barley.</b>	95%	81%
<b>irrigated potatoes.</b>	100%	101%
<b>irrigated wheat.</b>	100%	82%

# How likely are you to leave farming?

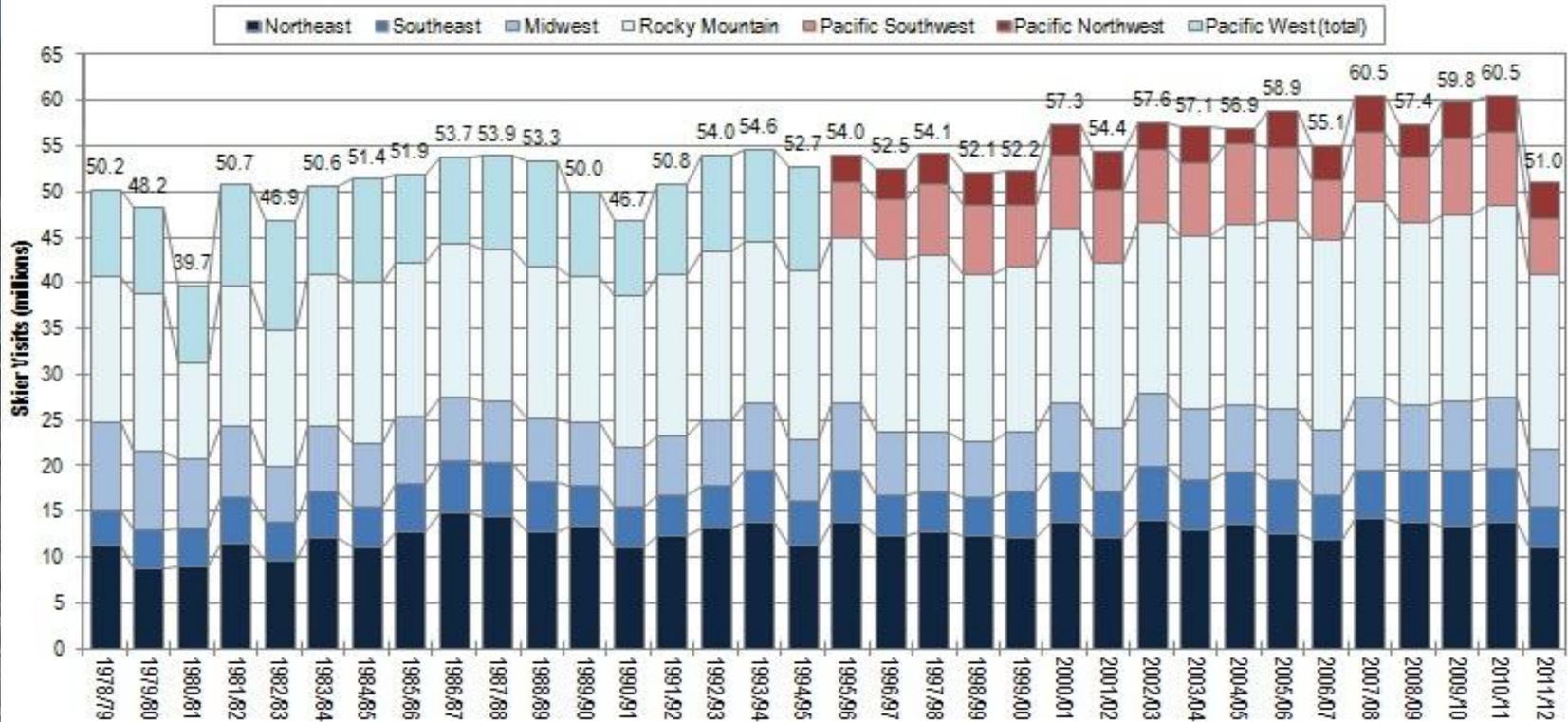
(0% certain to stay, 100% certain to leave)



# Drought Impacts on Businesses

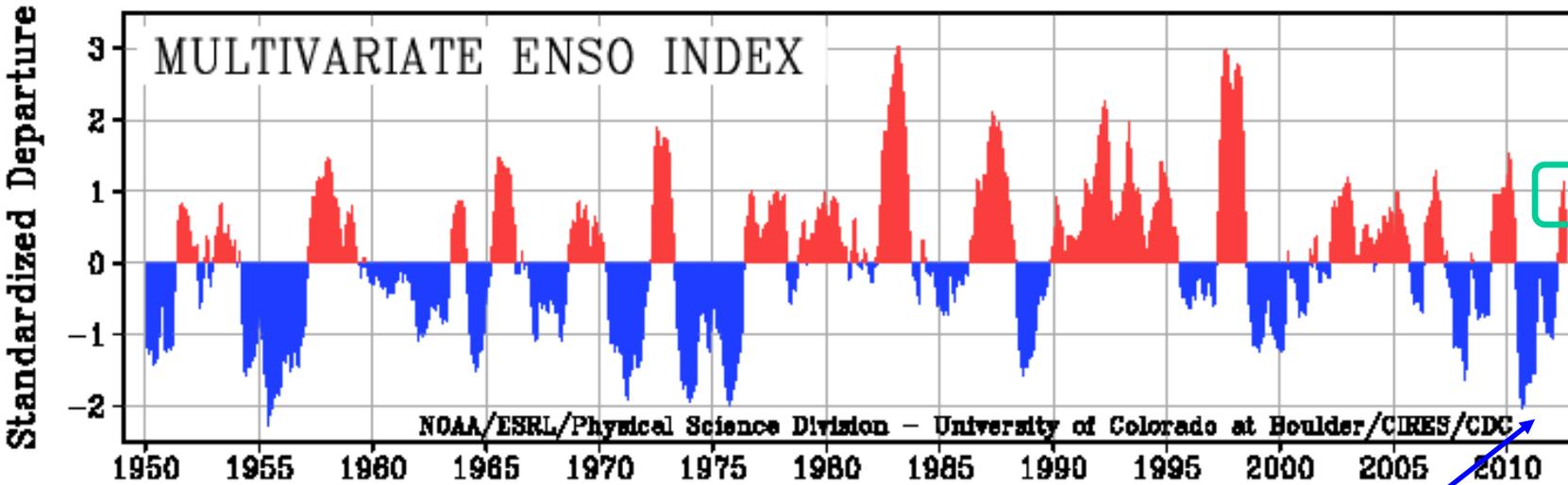
- Anecdotal stories from our business members reflect a range of effects from this year's drought. Many businesses say that perception of low water, fire, and other aspects of the drought have affected people coming out to visit and spend money. Some businesses changed the way they marketed themselves and added other types of services to stay competitive this summer-
- **“Our outfitting business was down \$118,000 this summer relative to last. This represents a 58% decline”- western slope outfitting company.**

# National Skier Visits 1978-2012

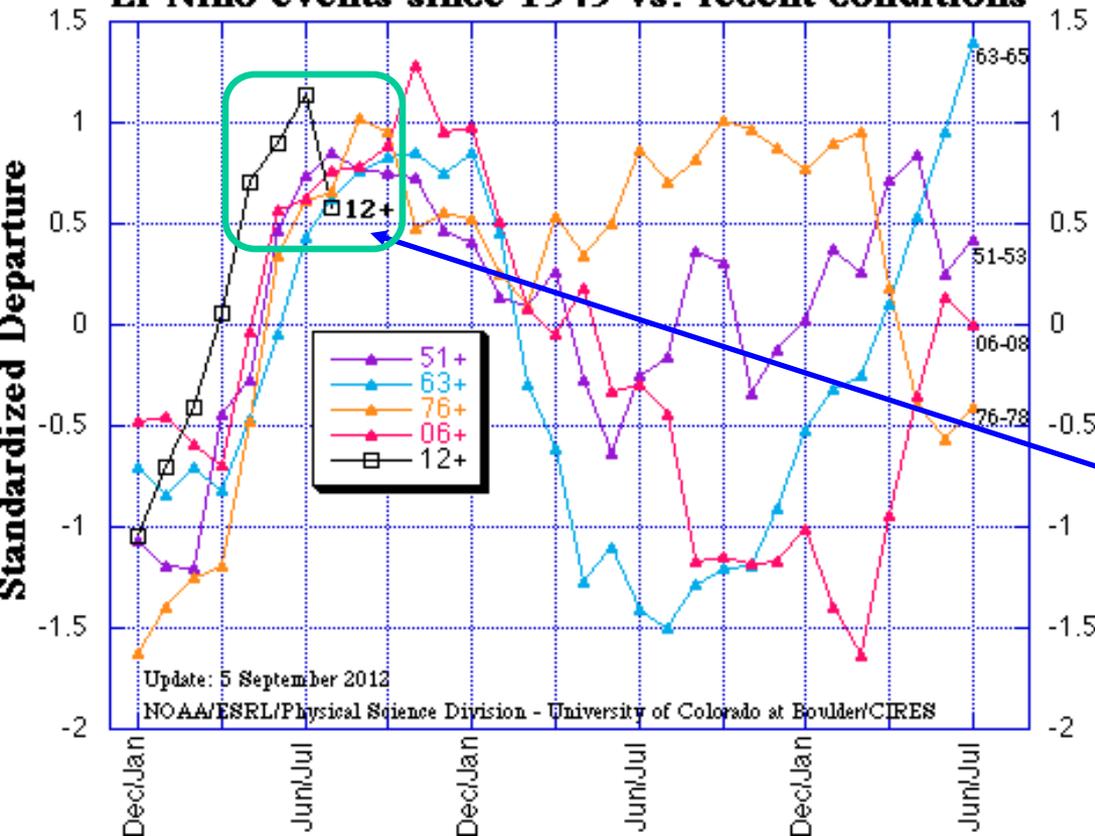


# The current conditions

- **40:** Number of states with drought-designated counties as determined by the federal government, making them eligible for emergency aid
- **63%:** Amount of the contiguous U.S. experiencing moderate to exceptional drought conditions
- **33%:** Amount of the contiguous U.S. last year, indicating 30% more of the country now faces such conditions
- **#1:** The historic rank for July 2012, nationally, in temperature, making it the hottest July since records were first kept in 1895
- **123.4:** The bushels of corn per acre predicted by the USDA, the lowest yield since 1995 (**4 billion lower than forecast**) :



**Multivariate ENSO Index (MEI) for four weak El Niño events since 1949 vs. recent conditions**



**2010-12 La Niña event reached its biggest peak since the mid-70s in late 2010, followed by a brief excursion to ENSO-neutral conditions during mid-2011; it reached a second peak last winter, and is now being followed by a weak El Niño event.**

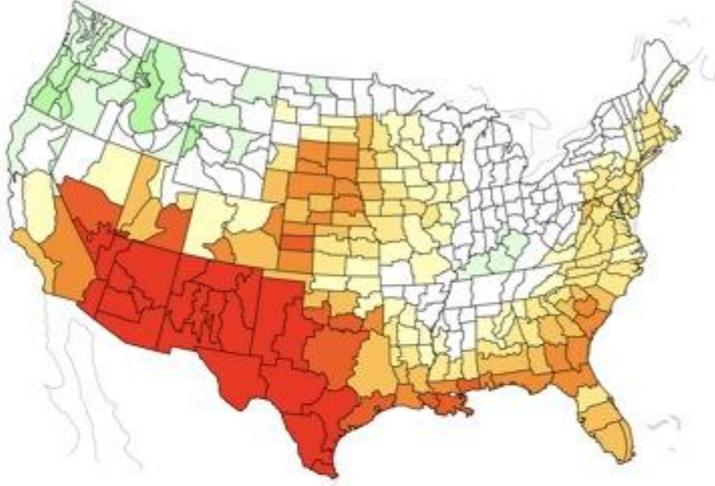
<http://www.esrl.noaa.gov/psd/ens/o/mei>

# Climate Model Simulations of Historic La Niñas

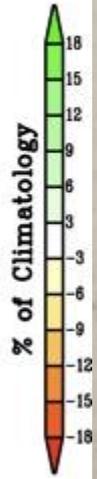
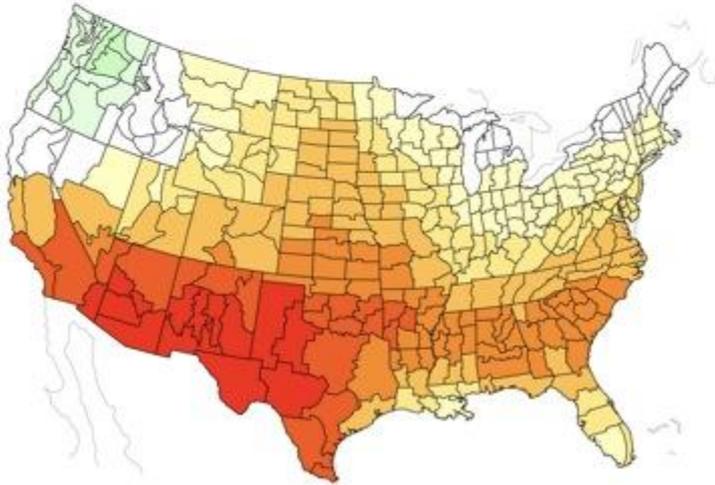
*Creating Perfect SST Analogs....24 simulations for each La Niña Since 1950*

Oct–Jun PPT Departures during La Nina

Observed

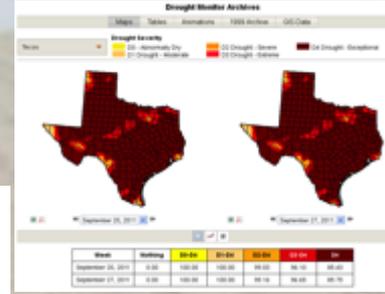
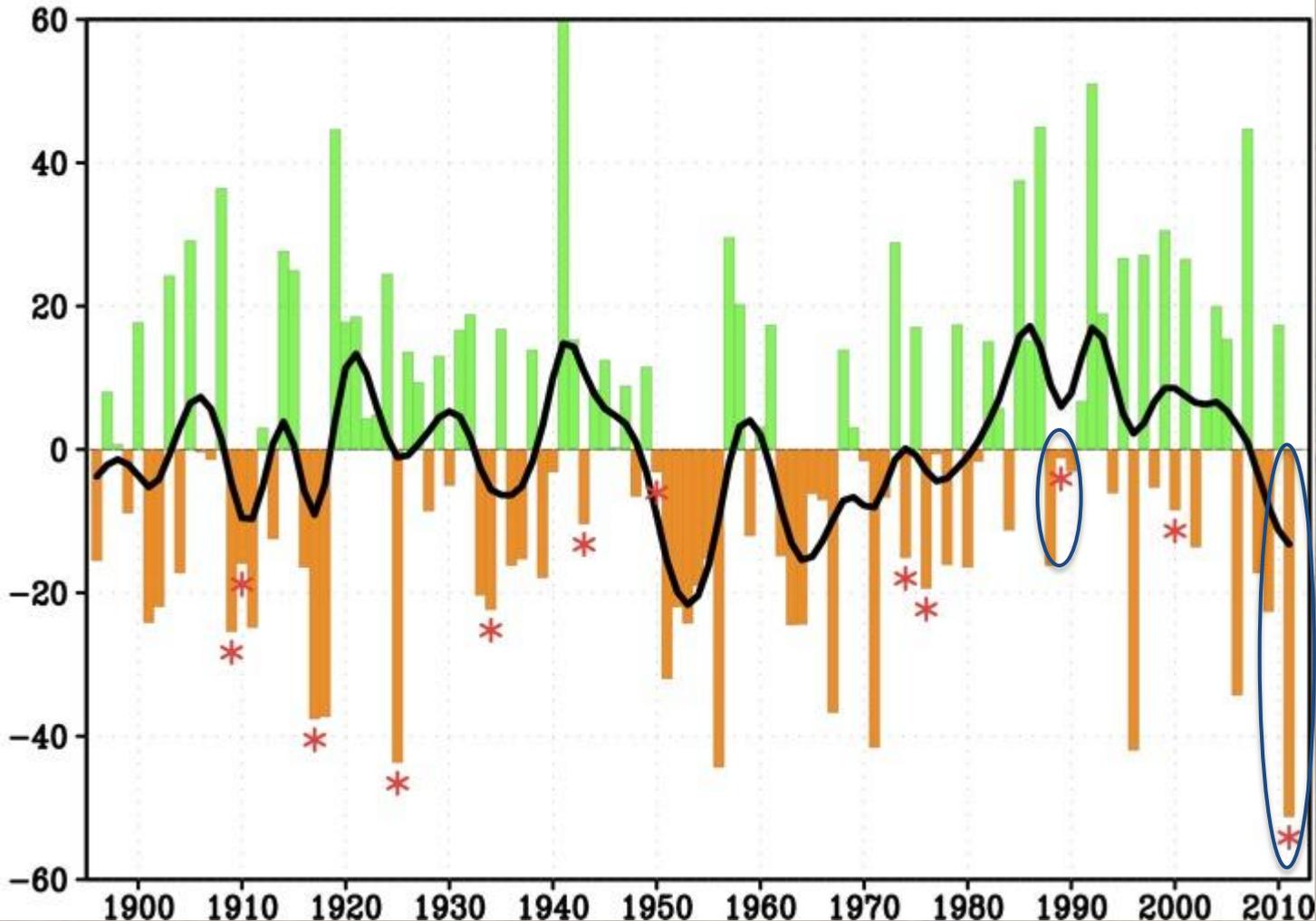


Simulated



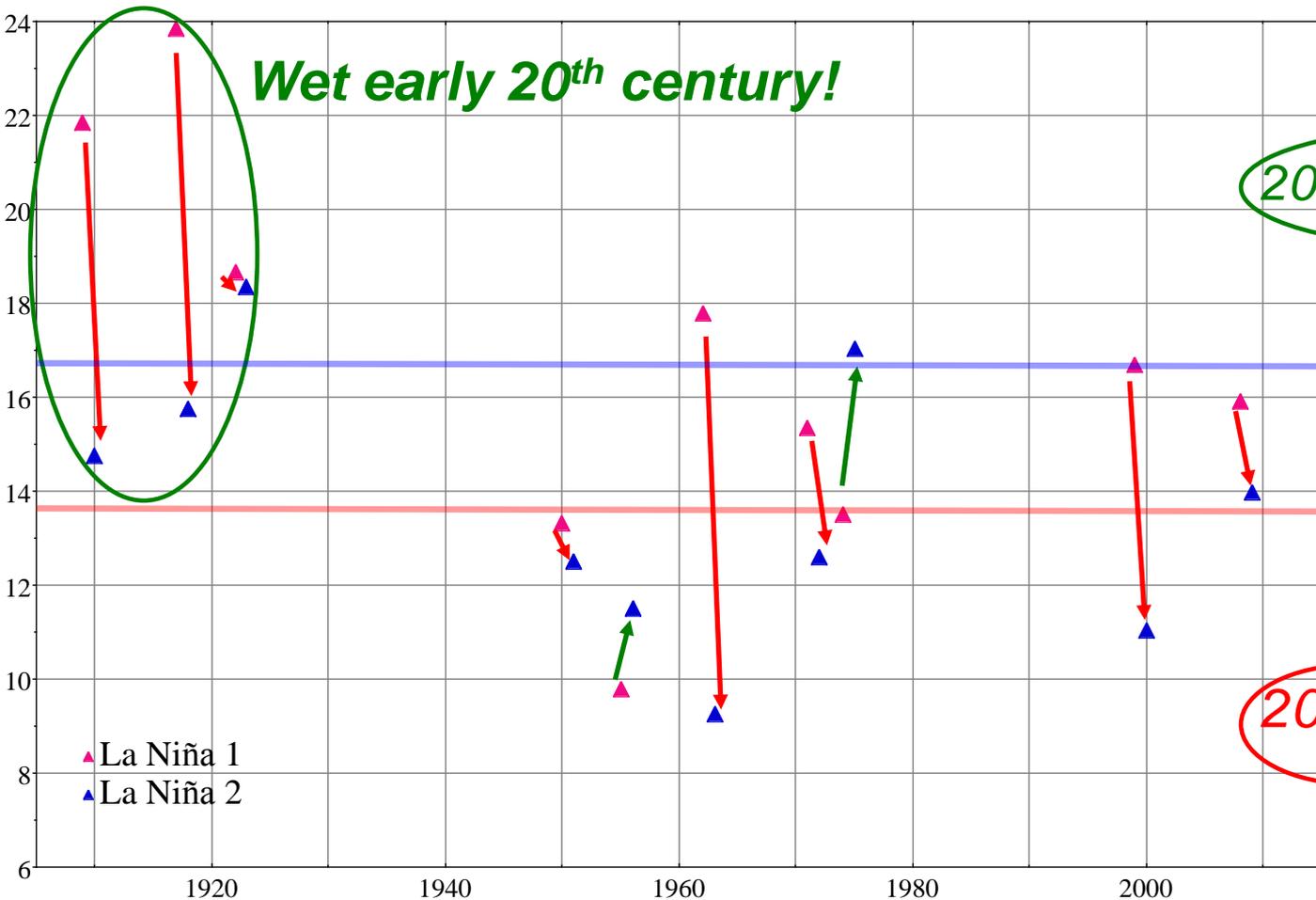
*What role did this particular La Niña play in causing this record drought?*

Southern Plains October–June PPT: 1896–2011



# 'Double-dip' Las Niñas

Lees Ferry Natural Flow (MAf)



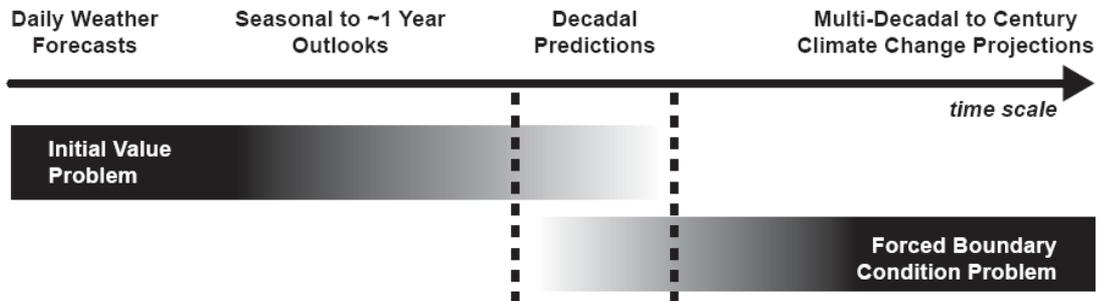
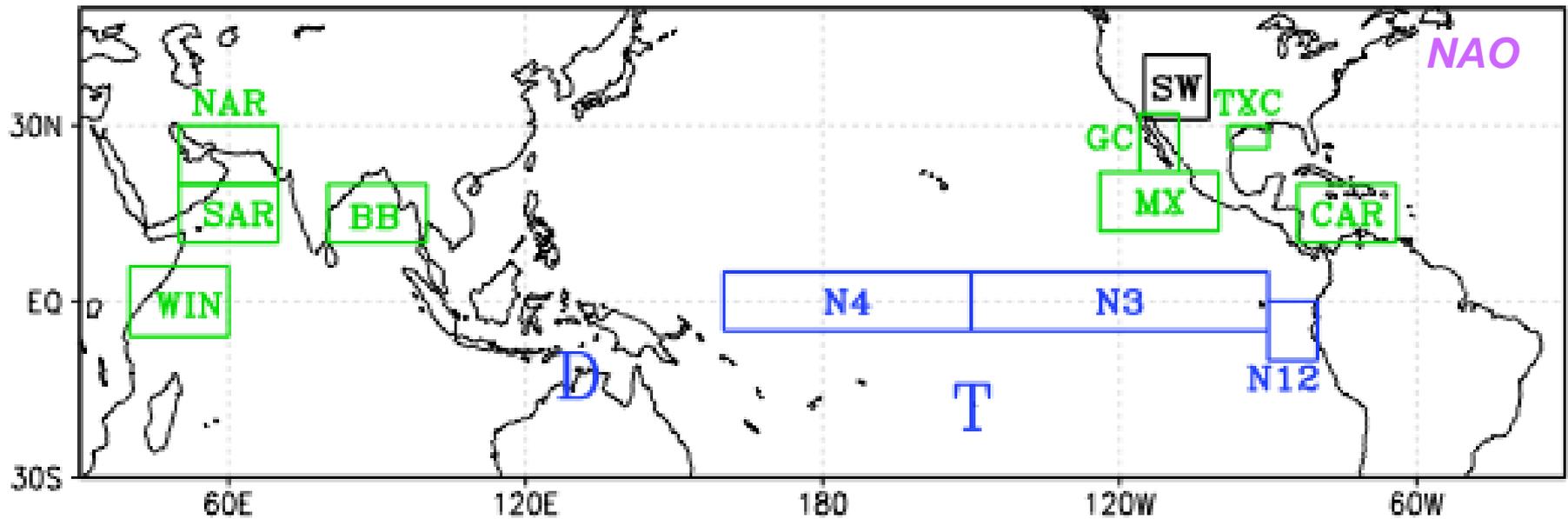
Mean flow for Year 1:  
16.7 MAf ( $\Delta = +1.7$ MAf)

Mean flow for Year 2:  
13.7 MAf ( $\Delta = -1.3$ MAf)

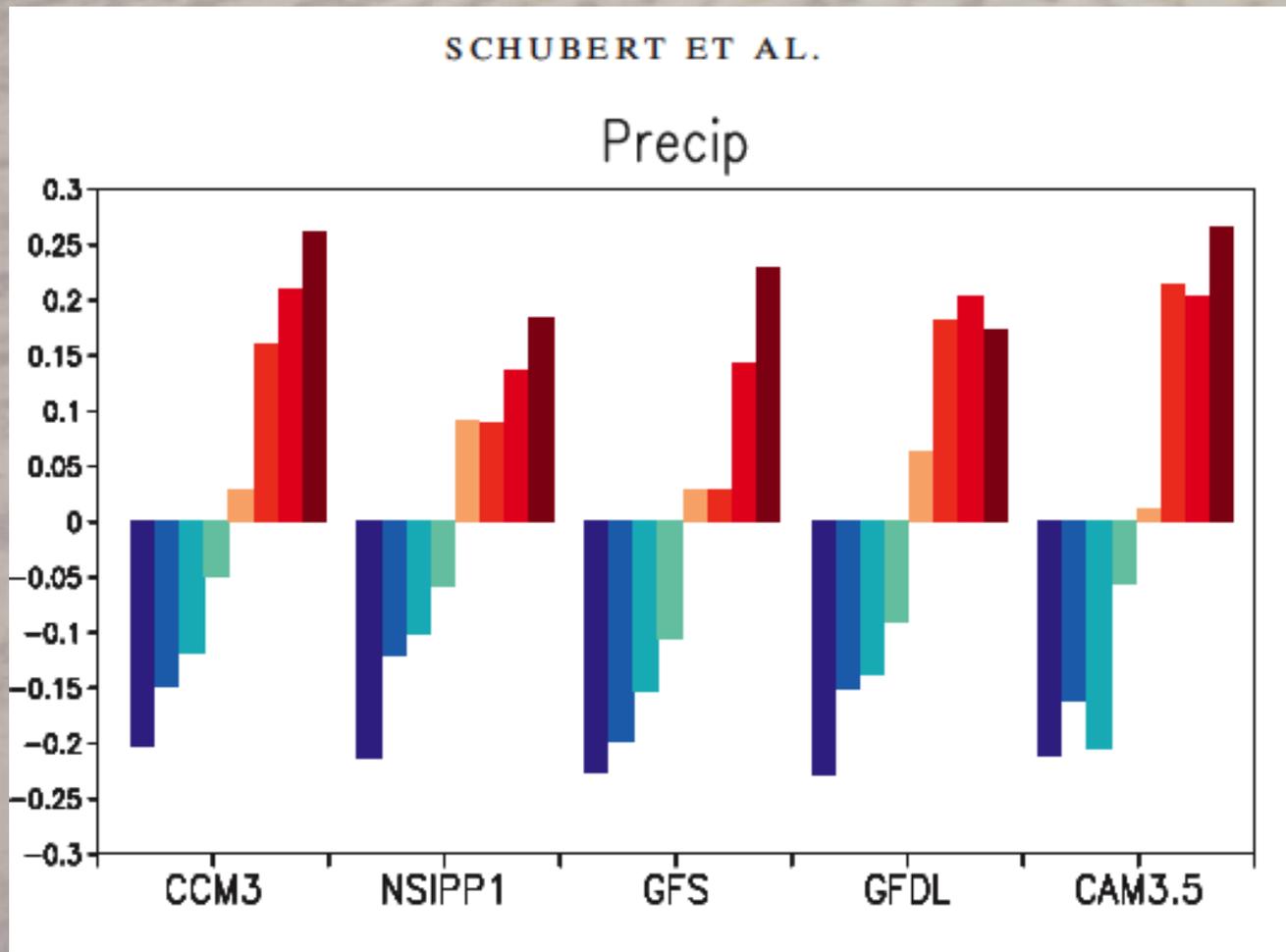
Natural flow data courtesy  
of James Prairie (Bur. Rec)

Before 2010, a drop in runoff has been typical (8 of 10 cases) for 2<sup>nd</sup> La Niña year runoff for the Colorado River. This reduction tends to be biggest for cases that start out wet – so, the decline in 2012 runoff vs. 2011 is not unexpected!

# Useful predictor regions for the US Southwest



# Other interannual climate drivers (National scale)



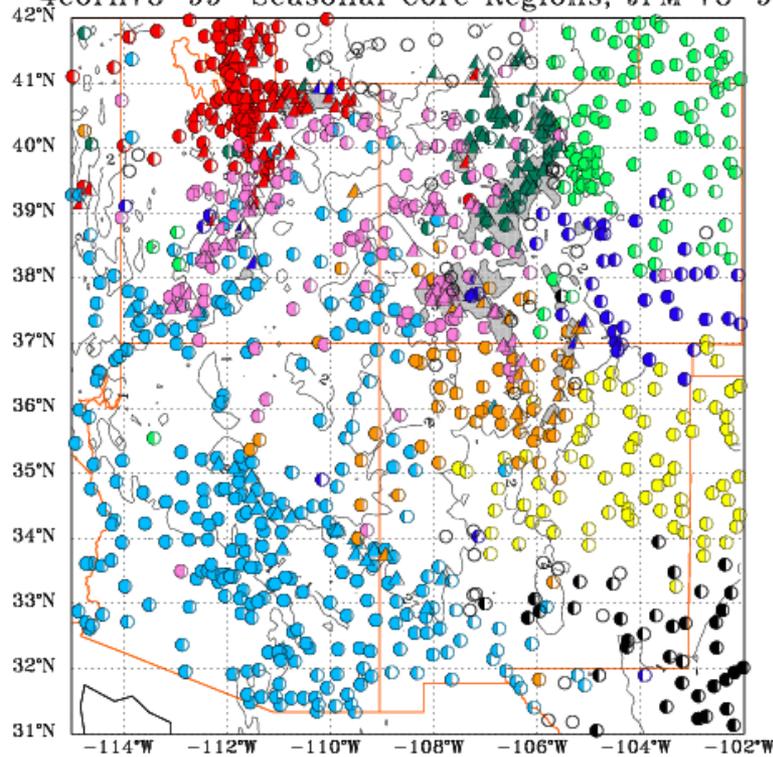
## Pacific versus Atlantic

In five different General Circulation Models, a cold Pacific combines with a warm North Atlantic to produce most pervasive drought conditions in continental U.S.

PcAw PcAn PcAc PnAw PnAc PwAw PwAn PwAc

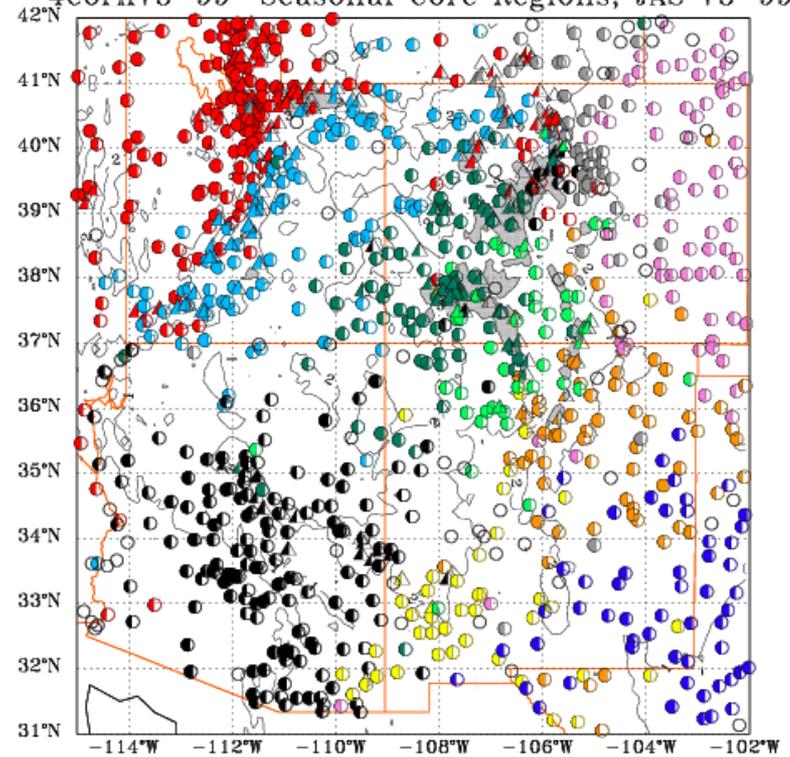
# Interior Southwest 1<sup>st</sup> generation ‘climate divisions’

4corn78-99 Seasonal Core Regions, JFM 78-99



COOP	SNOTEL	IND	IND
●	▲	1	6
●	▲	2	7
●	▲	3	8
●	▲	4	9
●	▲	5	

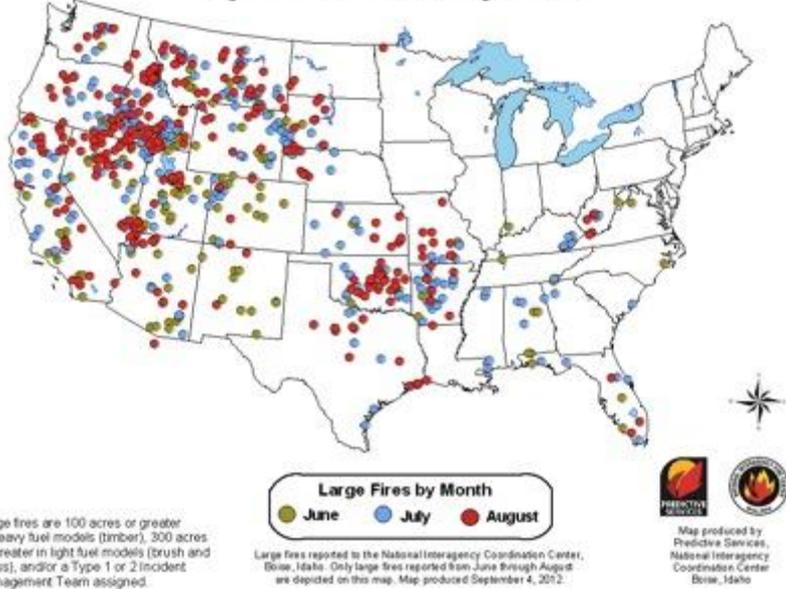
4corn78-99 Seasonal Core Regions, JAS 78-99



COOP	SNOTEL	IND	IND
●	▲	1	6
●	▲	2	7
●	▲	3	8
●	▲	4	9
●	▲	5	10

Climate tends to show similar anomalies at a time where the coloring is the same. Fractional fill-in for each station symbol is proportional to locally explained variance by “core region” time series. This formed the basis for a decade of seasonal forecasting.

Large Wildfires - June to August, 2012



## Other factors to consider: *Wildfires*

Smoke reduces incoming solar radiation, inhibits convection, and overseeds clouds – major factor during summers of 2000, 2002, and 2012

# Are we better off?

- The number of states, communities, and institutions with improved capacity to inform risk management and reduce exposure to climatic risks
- The number of staff in or working with those institutions trained to develop and communicate local drought information and help reduce impacts
- The number of research projects that conduct and update drought impacts and user needs assessments in drought-sensitive parts of the US and
- The percentage of the Western U.S. population covered by adequate climate risk and early warning information systems

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
U.S. HOUSE OF REPRESENTATIVES

HEARING CHARTER

*Drought Forecasting, Monitoring, and Decision-Making: A Review of the National Integrated Drought Information System*

Wednesday, July 25<sup>th</sup>, 2012  
10:00 a.m. to 12:00 p.m.  
2318 Rayburn House Office Building

**PURPOSE**

On Wednesday, July 25<sup>th</sup>, 2012, the Committee on Science, Space, and Technology will hold a legislative hearing to examine the state of drought forecasting, monitoring, and decision-making and the role the National Integrated Drought Information System (NIDIS) serves in drought planning. Additionally, the Committee will receive testimony on draft legislation entitled, "The National Integrated Drought Information System Reauthorization Act of 2012." Witnesses have been asked to provide comments on and suggestions to this discussion draft

992 literally looks like a desert. I was there last weekend.  
993 First of all, Dr. Pulwarty, I would like to send a  
994 compliment your way. The Lower Colorado River Authority in  
995 Texas that you are familiar with has told me that they very  
996 much appreciate your willingness to disseminate information  
997 to them, to the landowners, to the farmers, to the  
998 policymakers as well, and they appreciate that good  
999 communication.

Hon. L. Smith.  
TX)

9/20/2012- S.3584

A bill to reauthorize NIDIS and for other purposes. Sponsor: [Sen Pryor](#),

[Mark L.](#) [AR], D.Moran (KS) (introduced 9/20/2012)

[Cosponsors](#) Pryor, Moran Boren (1) Referred to the Committee on Commerce, Science, and Transportation.

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Really  
due to-  
Bob Rose  
Texas-  
LCRA

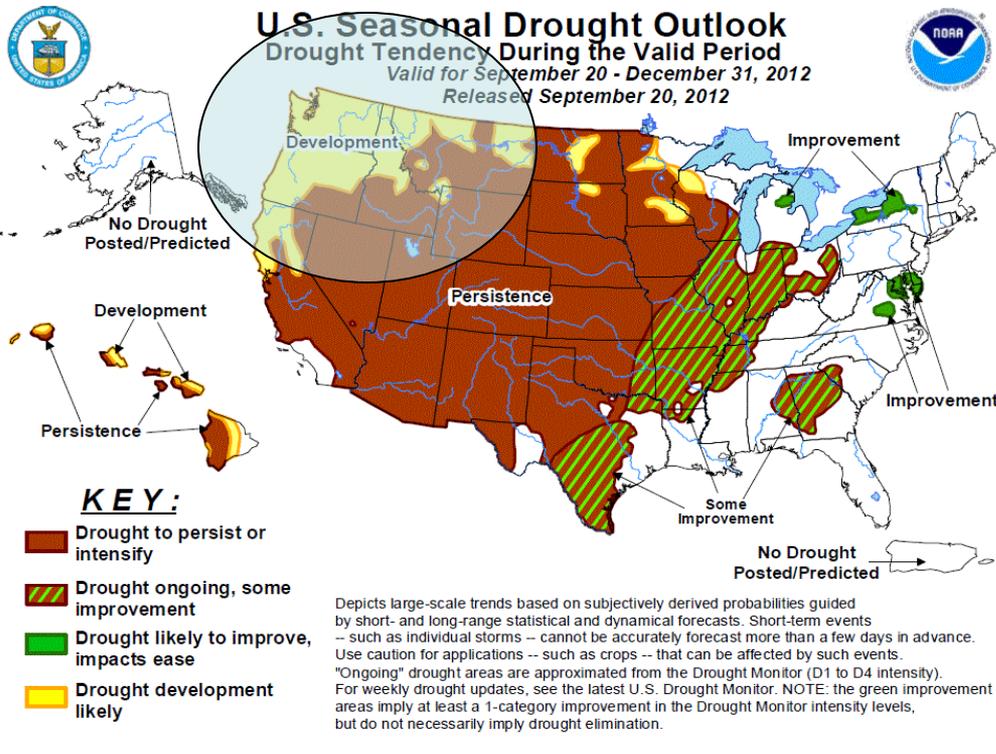
**A BILL**

To reauthorize the National Integrated Drought Information System, and for other purposes.

1 Be it enacted by the Senate and House of Representa-



# Drought 2012-A focusing event ? If so, how can/should it be used?



Quarterly Climate  
Impacts and Outlook

The Western States  
Fall 2012

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National Outlook — Significant Events for Summer 2012

### Extreme Drought Persists Across the Western States

NY and CO had their warmest summer on record while WY and NE had their driest summer on record. NY was record warm for Aug.

As of Aug 28 nearly 63% of the contiguous U.S. was experiencing drought conditions, with drought intensifying across the Central Plains. WA, WY, and NE had their driest Aug on record.

Hurricane Isaac made landfall in LA on Aug 28 with winds of 80 mph.

Several large wildfires burned across the Western and Central US, charred over 3.8 million acres, the most on record for Aug.

Hurricane Isaac's slow approach led to a large storm surge and flooding rains.

TX had its wettest spring on record partially due to rainfall from Hurricane Isaac and Tropical Storm Debby.

All summer temperatures were near average, while precipitation totals were 19.3% above average.

The average U.S. temperature during summer was 74.4°F, 3.9°F above average. The total seasonal rainfall on record. Precipitation averaged across the nation during summer, was 7.88 inches, 0.86 inch below average, marking the 14th driest such year.

**Central US:**

- Summer 2012 ranks as the warmest on record for Wyoming and Colorado.

**Southern Great Plains:**

- 91% of Oklahoma was in extreme drought as of Sept. 1, up from 3% on June 1.

**Western US**

- Though drought conditions endured, the southwest monsoon brought some rain and relief to Arizona, Nevada, Utah and Colorado.

**Pacific Islands:**

- Drought persisted through the rainy season, with extreme drought on leeward areas of Maui, Lanai, Molokai and the Big Island.

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Regional Outlook — Climate Overview for Summer 2012

#### Drought in the West

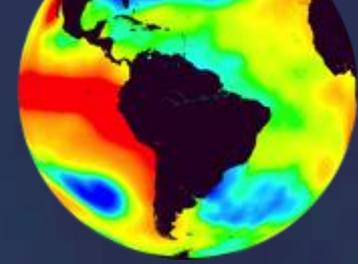
**Intensity:**

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

#### Departure from Normal Temp. (F) June — August 2012

**Left—US Drought Monitor:** Above-average temperatures and below-average precipitation contributed to intense drought conditions that have continued late into summer and into fall. September 25, 2012.

**Right — Departure from Normal Temperature:** Average daily temperatures were as much as 5 degrees above average in the West. The very warm June-July period was tempered by near-normal August conditions in much of the Rockies.



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♻️ DENVER WATER



<http://go.funnycu>

