DROUGHT MONITORING AND PLANNING

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SOUTH CENTRAL
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What is Drought?

CAN YOU DEFINE DROUGHT?

- Can you easily define a tornado, severe thunderstorm, hurricane, volcanic eruption?
- What about drought? Precipitation deficits? Minimal soil moisture? Low streamflow? Plants wilting? Wildfires? Famine? Other?
- When did it begin & end? Where was it? How bad was it?
- **Drought – the condition that occurs when water resources are insufficient to meet water needs**; drought is a societal phenomenon

DROUGHT DEFINITIONS

- **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
- **Ecological drought** – prolonged & widespread deficit in naturally available water supplies, that create multiple stresses across ecosystems

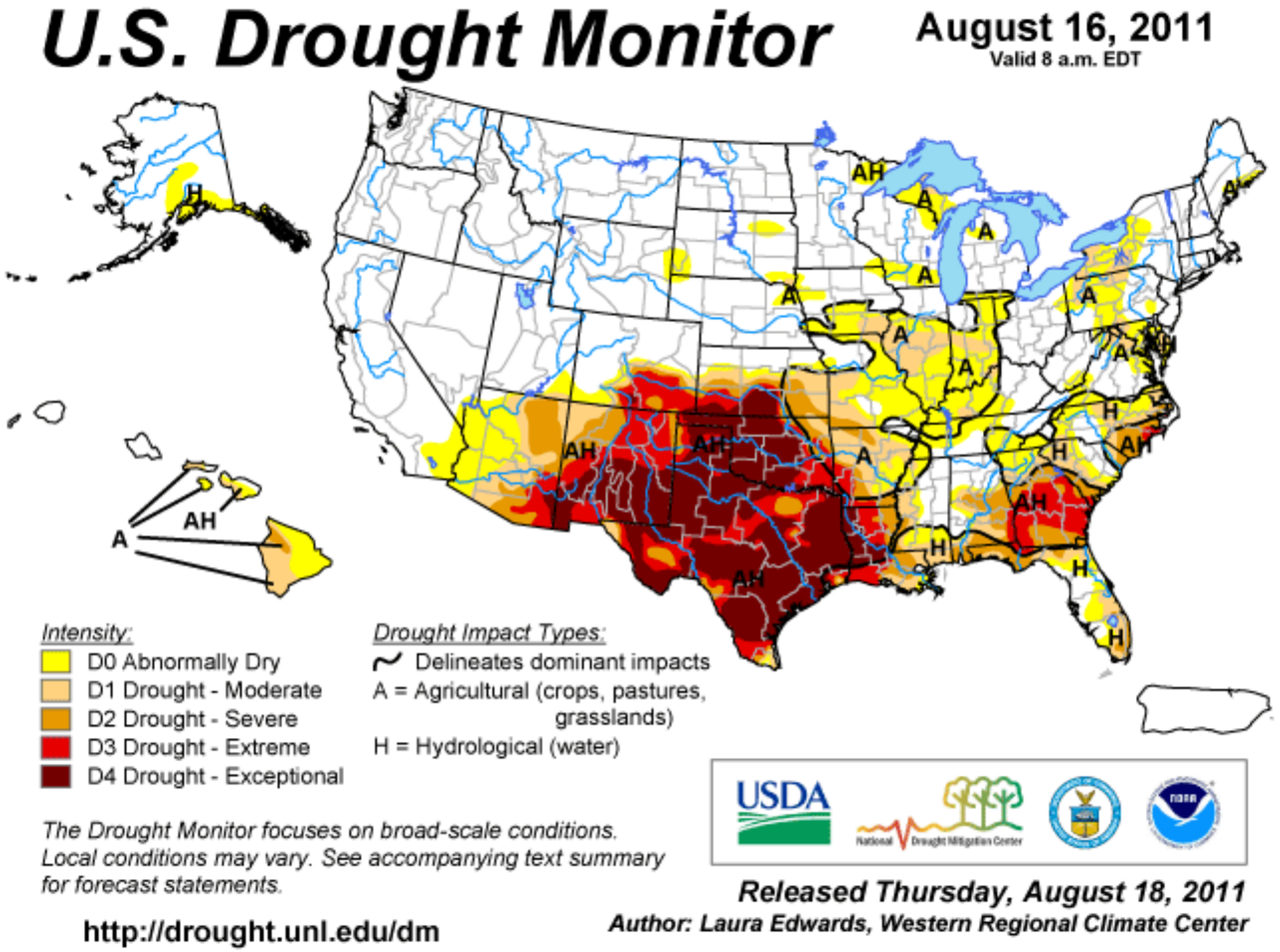
DROUGHT IMPACTS

- Few dry weeks – lawns start turning brown, crops show signs of stress
- Few dry months – crops begin failing, pastures go dormant, trees drop leaves
- Dry years – water supplies diminish, springs stop flowing
- Dry decade – land abandonment, social and economic failure

WHY MONITOR DROUGHT?

- **Drought is one of the most costly U.S. natural disasters**
  - Estimated annual losses at $6-8 Billion
  - 1988: $39 billion ($68B in 2007 U.S. dollars)
  - Europe, 2003: $13B USD; Canada, 2001-02: $5.7B USD
- **Oklahoma drought 2011-12**: Agricultural losses estimated at $1.6 billion in 2011 & $426 million in 2012
- **Texas drought 2011**: Agricultural losses estimated near $7.6 billion, 23,835 fires that burned >3.8 million acres, and 2,763 Texas homes destroyed

2011 DROUGHT IN SOUTH-CENTRAL U.S.



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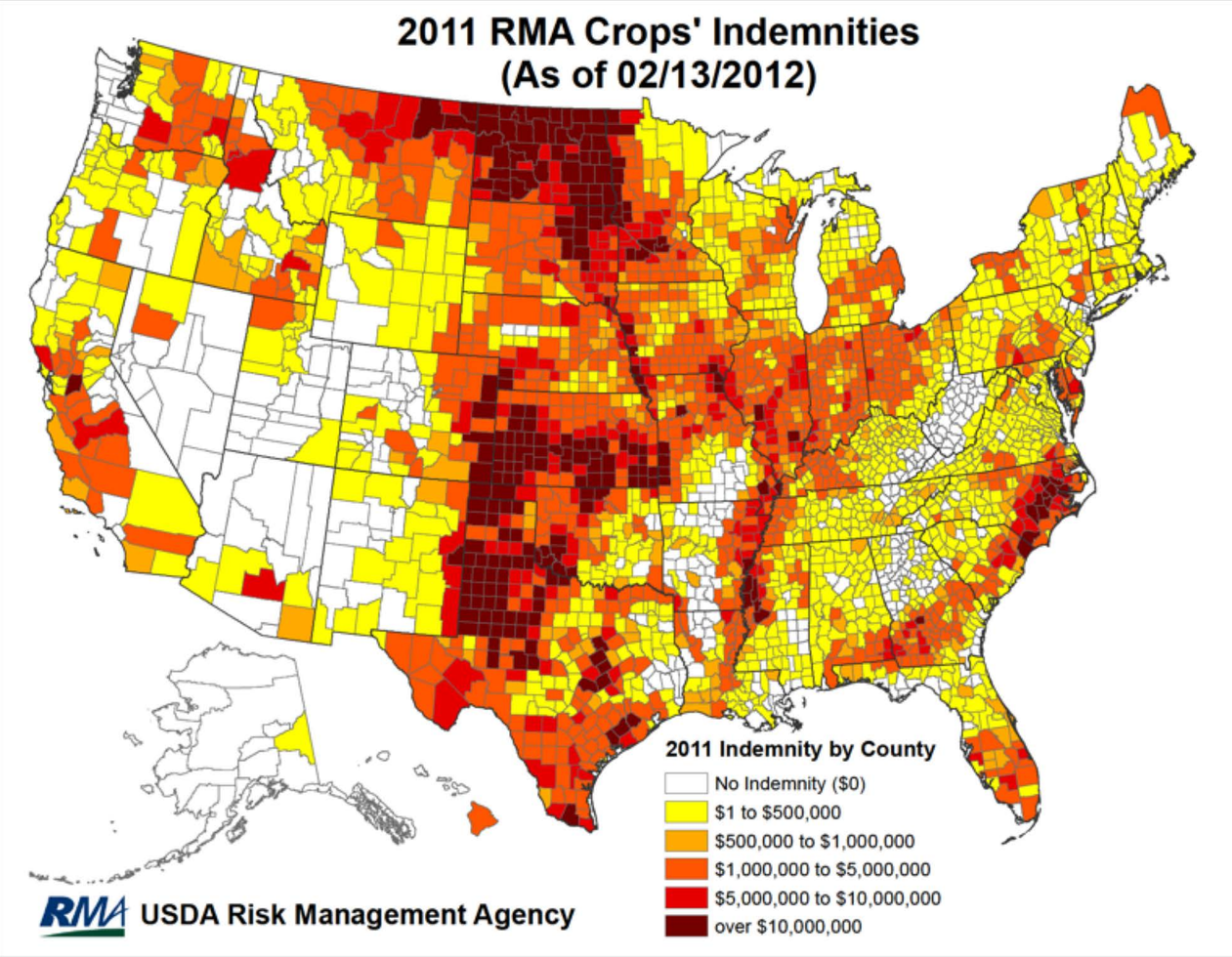
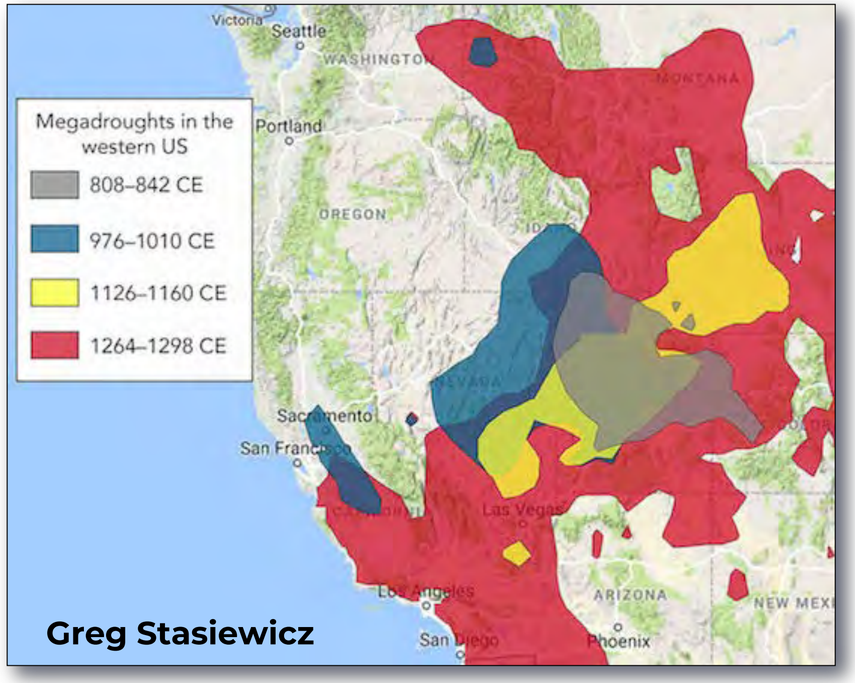
CROP INSURANCE CLAIMS INCLUDE DROUGHT



Historical Droughts

MEGADROUGHTS

- **Megadrought** – prolonged drought lasting **two decades or longer**
- Occurrences in arid & semi-arid regions have led to collapses of civilizations (e.g., empires in China, Cambodia, Mesoamerica, & Bolivia)



- **Megadroughts from 1130–1300 led to migration events** of pueblos away from Grand Canyon in 1150 & Mesa Verde cliff dwellings in 1300

CIVIL WAR DROUGHT

- Drought from mid-1850s to mid-1860s
- Bison moved to river valleys in search of grasses, but so did Plains Indians, European settlers, & domestic livestock
- **Competition between bison & humans caused starvation of herds in American Plains**

DROUGHT OF 1890–1896

- “Rain follows the plow” belief brought settlers to cultivate semi-arid & arid lands of Plains
- After relatively wet period (1877–1890), drought returned & farmers struggled to keep up production

- Federal government began assisting with irrigation in 1902 Reclamation Act

THE DUST BOWL

DUST BOWL

- Dust Bowl was associated with **high temperatures**
- **Wind & rain erosion** were huge concerns
- Many **valuable lessons were learned** about farming techniques, conservation practices, agri-business decisions, community support

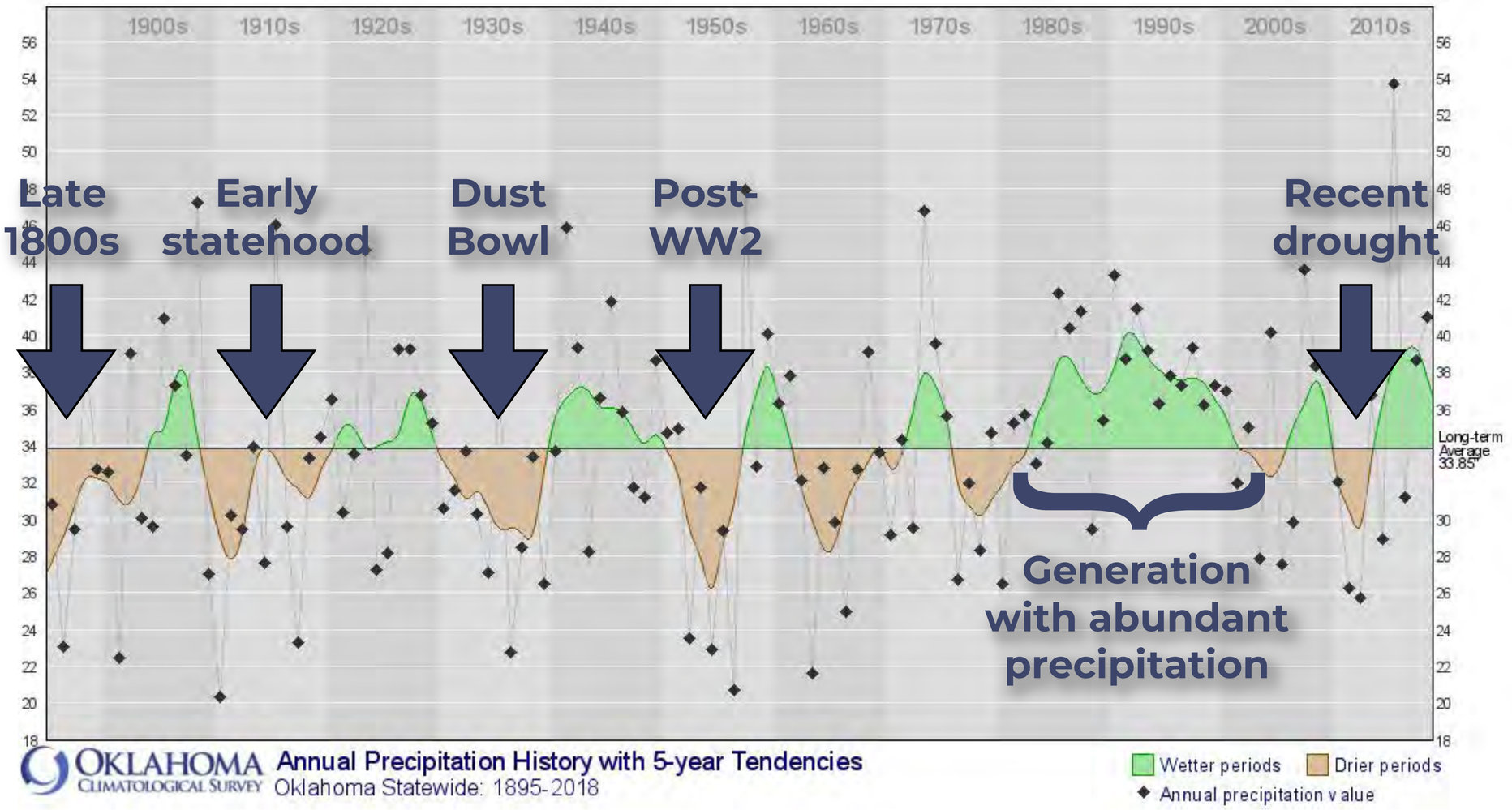
DUST BOWL IMPACTS

- Migration of 2.5 million people
- 500,000 homeless
- Creation of the Soil Conservation Service resulted after “Black Sunday,” when millions of tons of soil blew from the Plains to Washington D.C.

OKLAHOMA LAKES = RESERVOIRS

After Dust Bowl, dams installed to build reservoirs

HISTORICAL DROUGHTS IN OKLAHOMA



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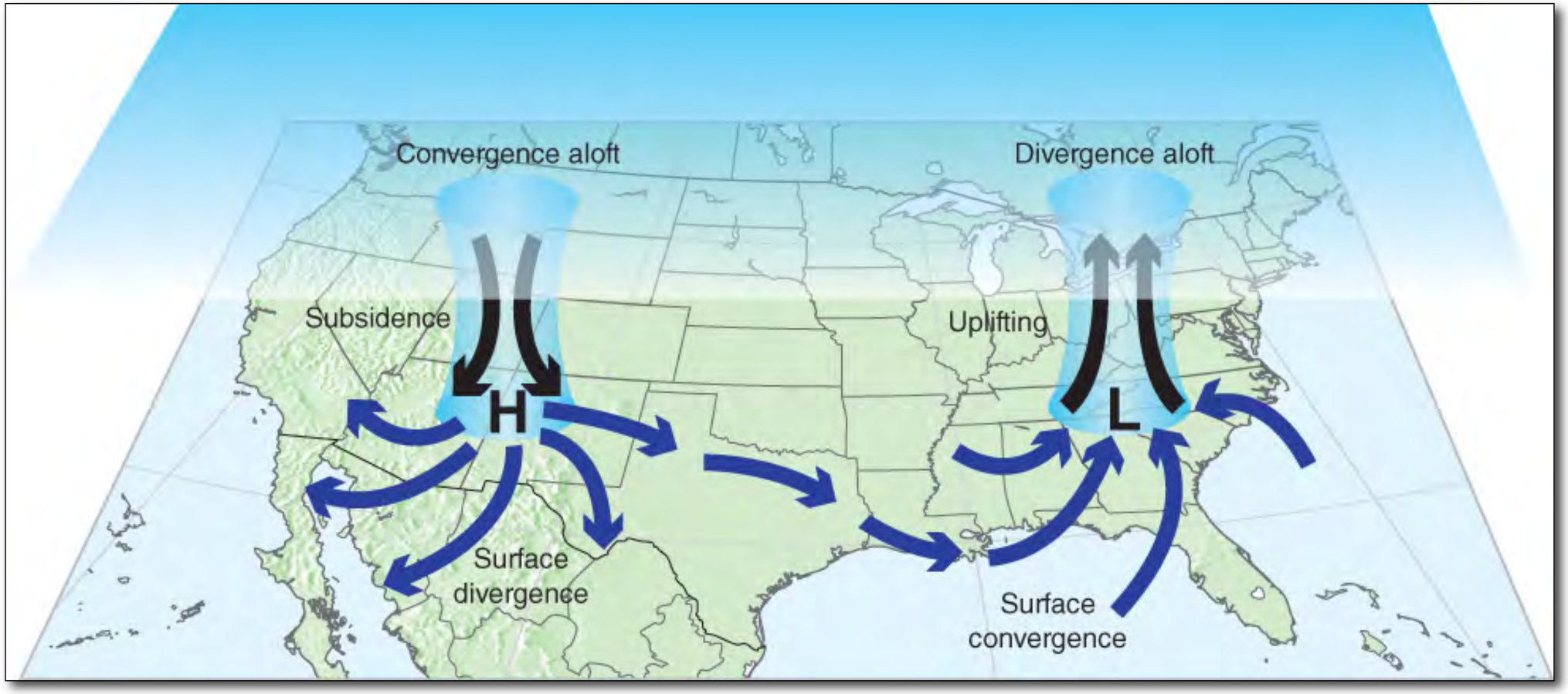
Causes of Drought

HIGHS & LOWS (NORTHERN HEMISPHERE)

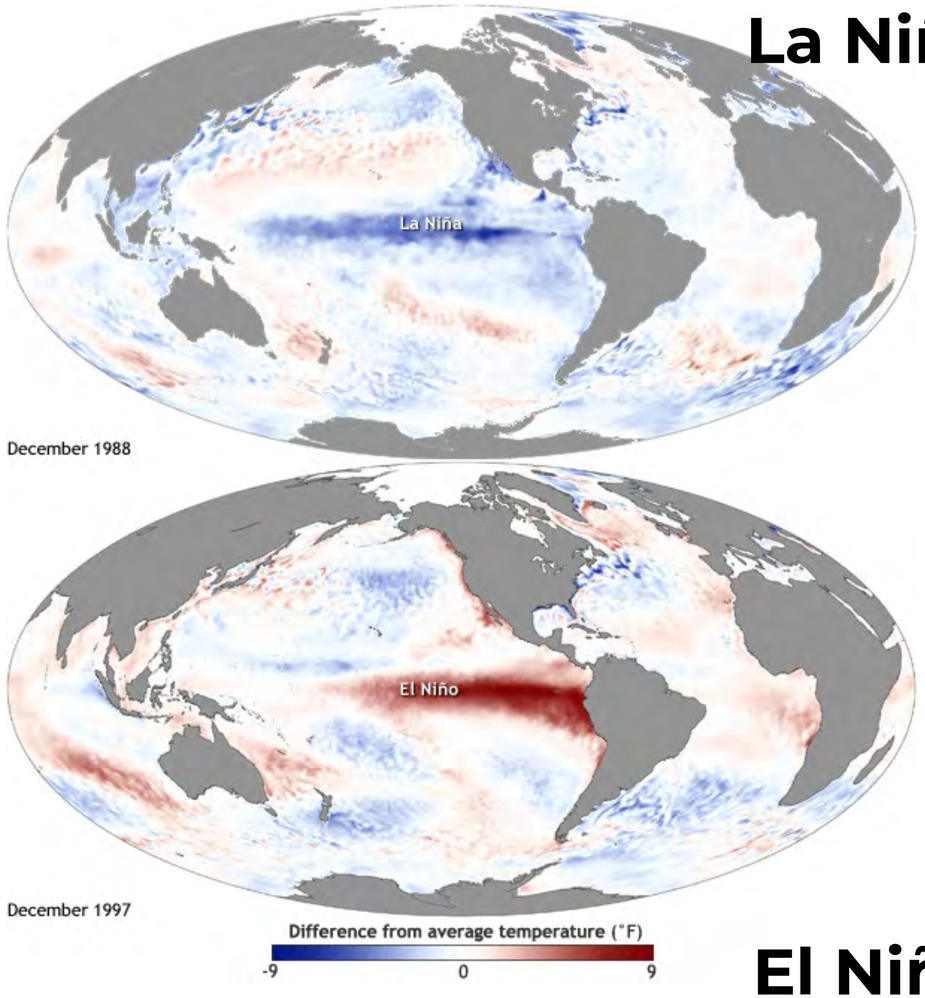
Airflow in Northern Hemisphere high and low pressure systems



EL NIÑO/SOUTHERN OSCILLATION (ENSO)

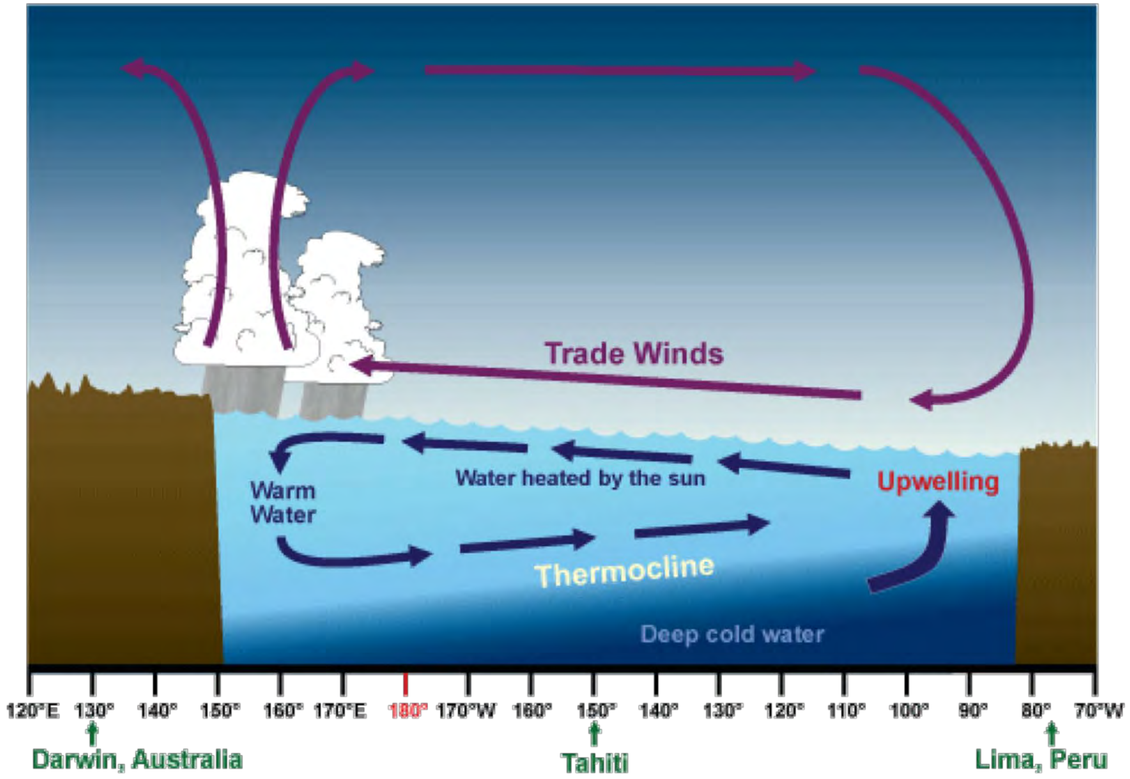
- **ENSO – change in circulation pattern over equatorial Pacific Ocean resulting from warmer or cooler sea-surface temperatures** across that region
- **Southern Oscillation** – surface air pressure differences at Darwin and Tahiti that seesaw over time

La Niña



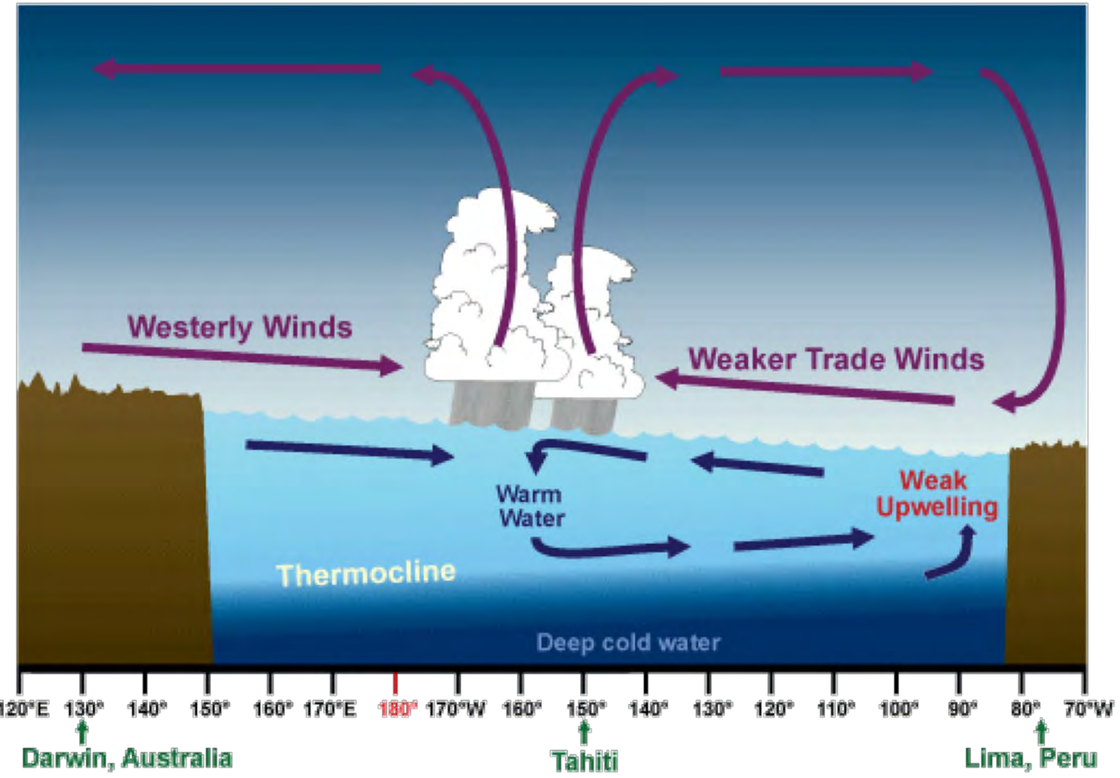
El Niño

NEUTRAL & EL NIÑO PATTERNS

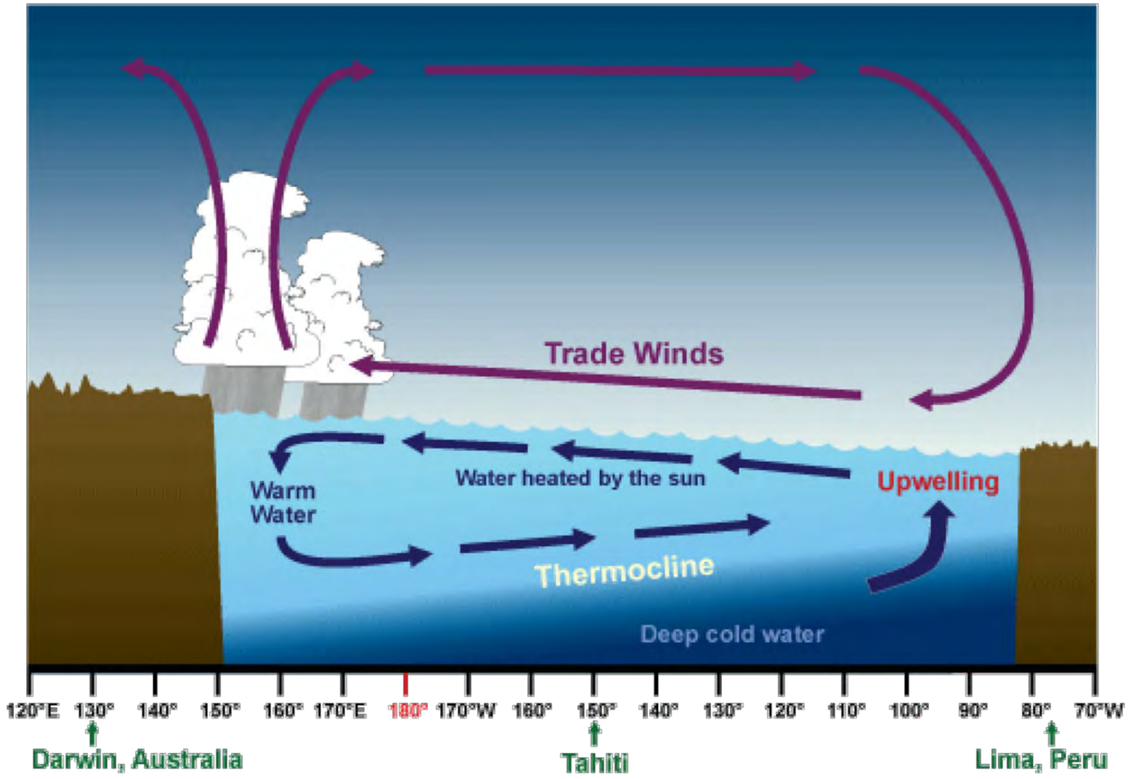


Neutral

El Niño

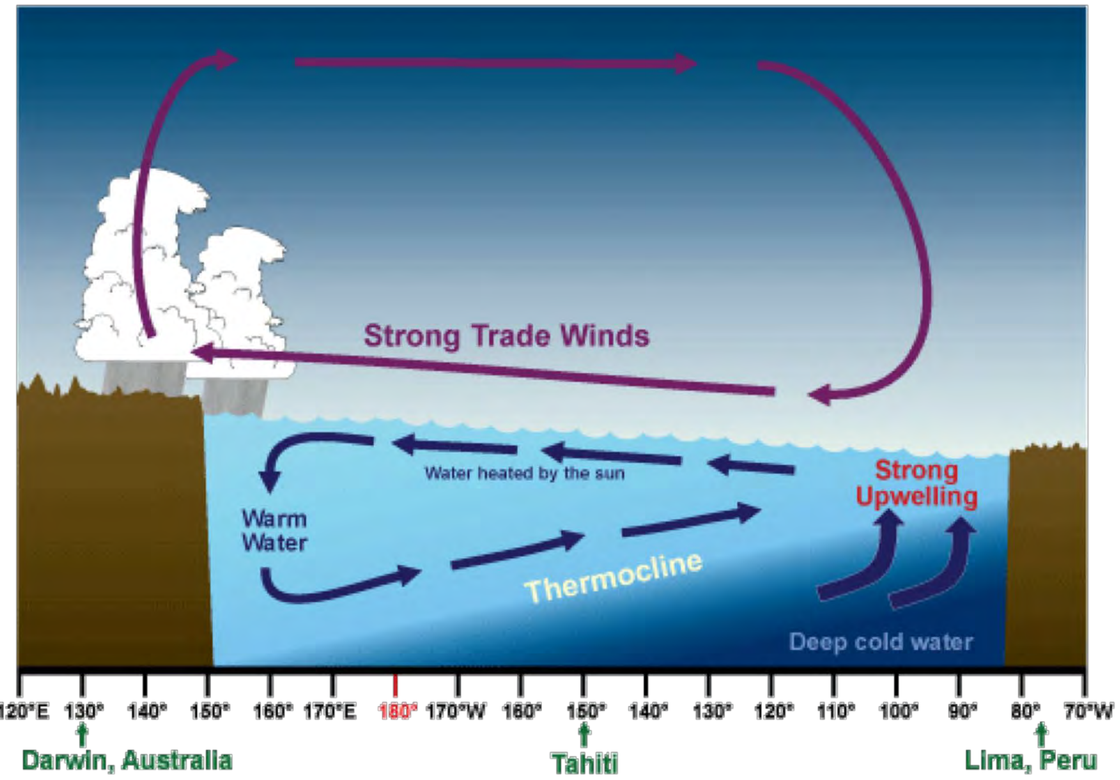


NEUTRAL & LA NIÑA PATTERNS

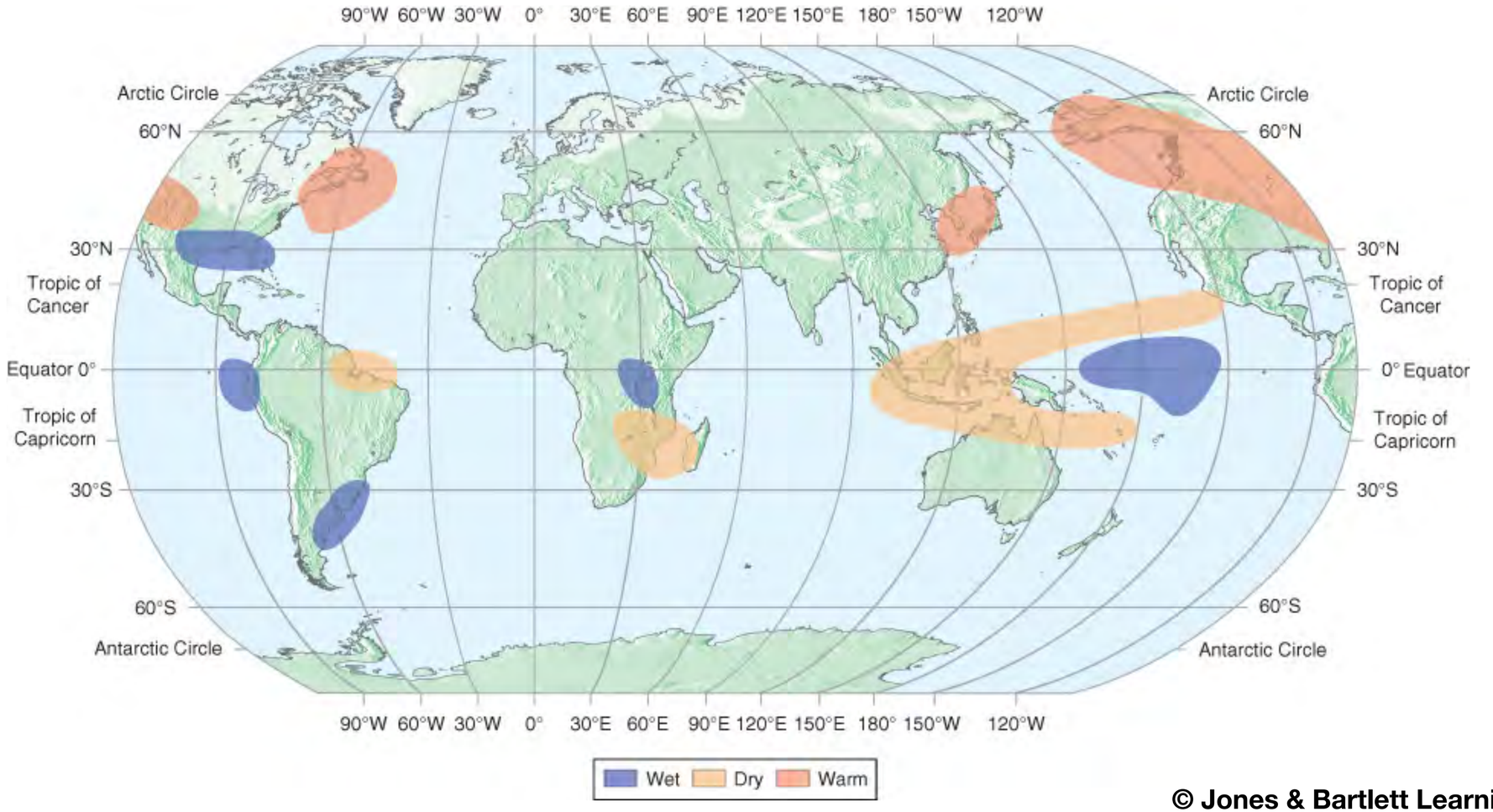


Neutral

La Niña



IMPACTS OF EL NIÑO IN WINTER



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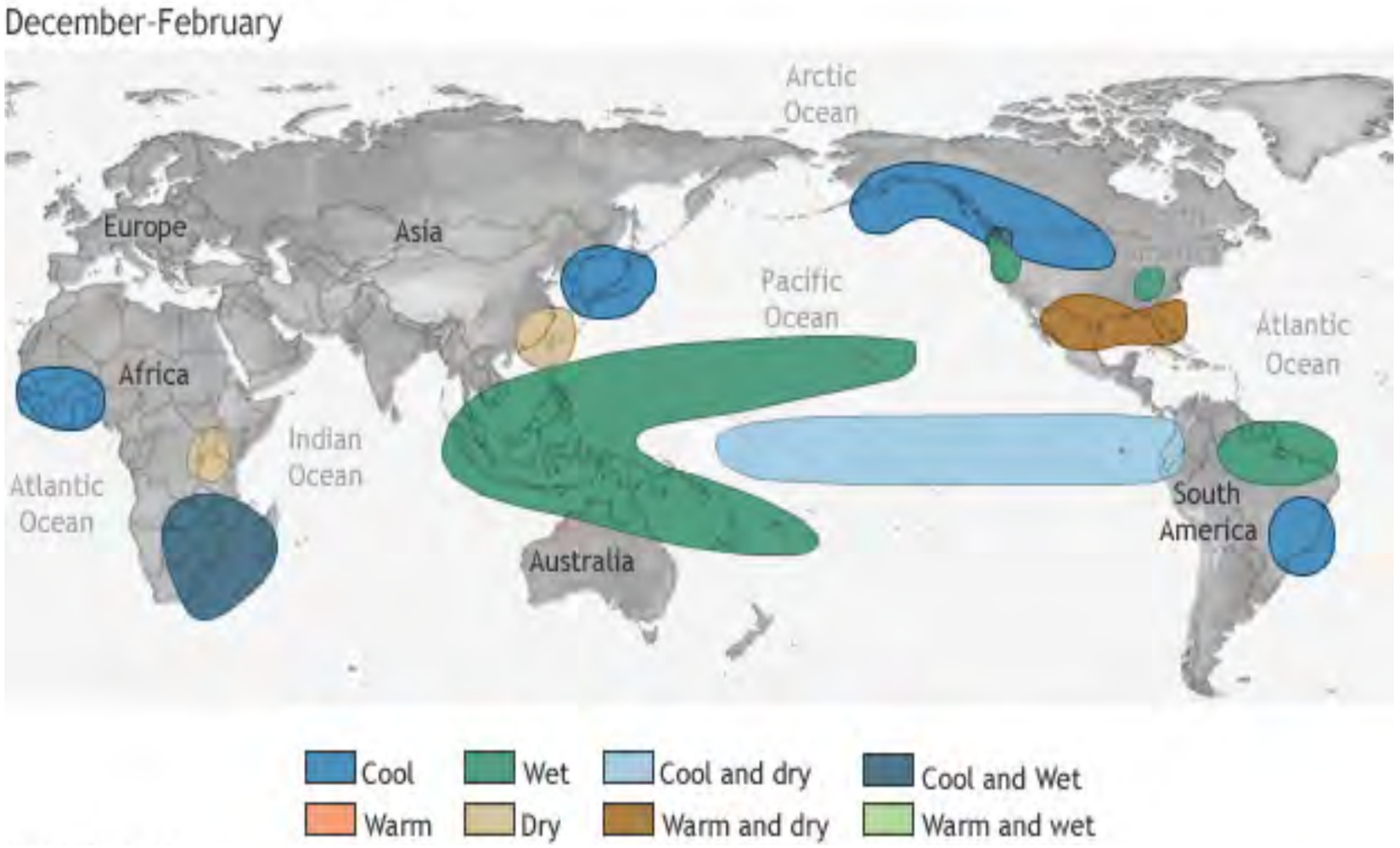
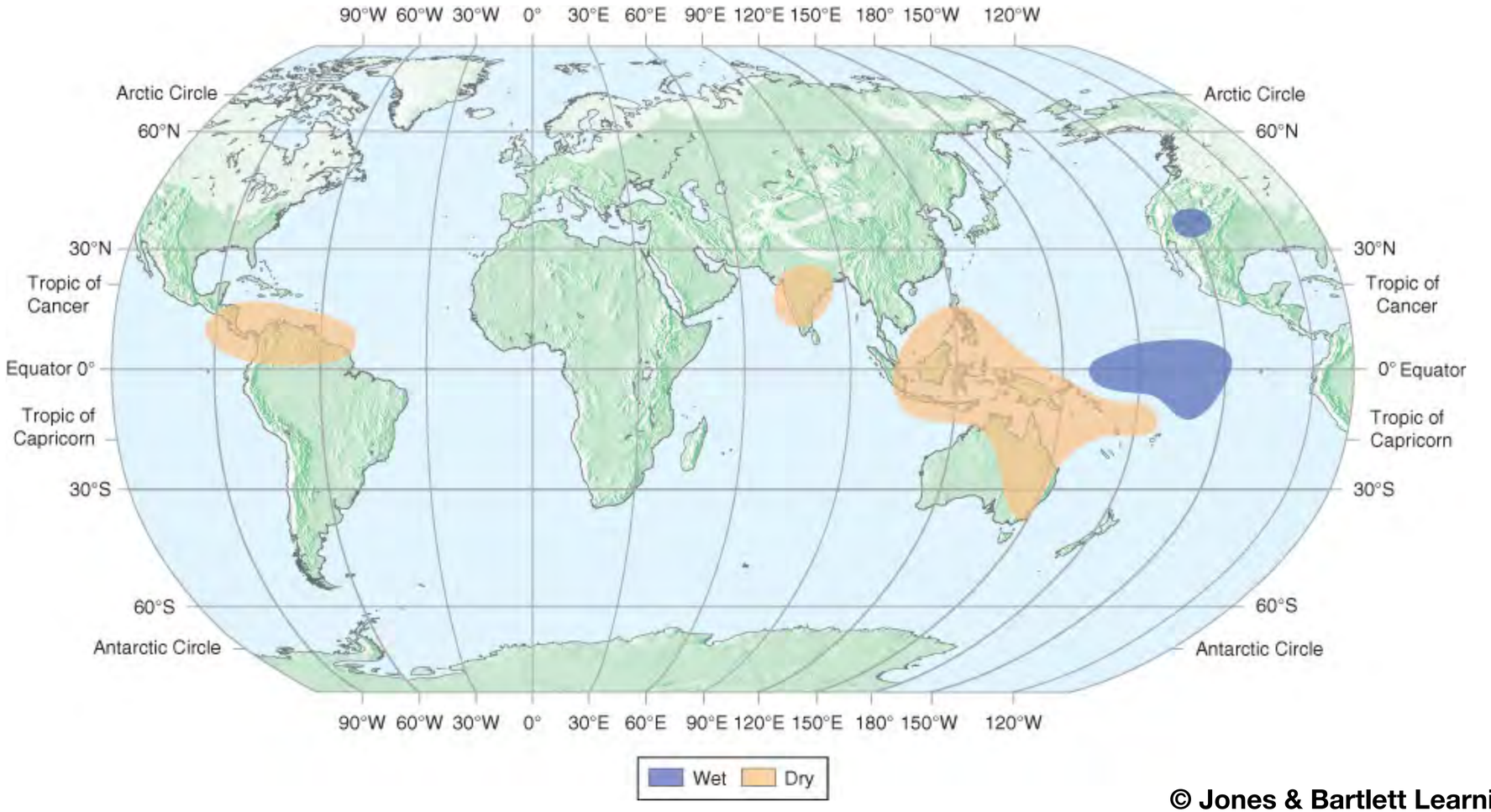
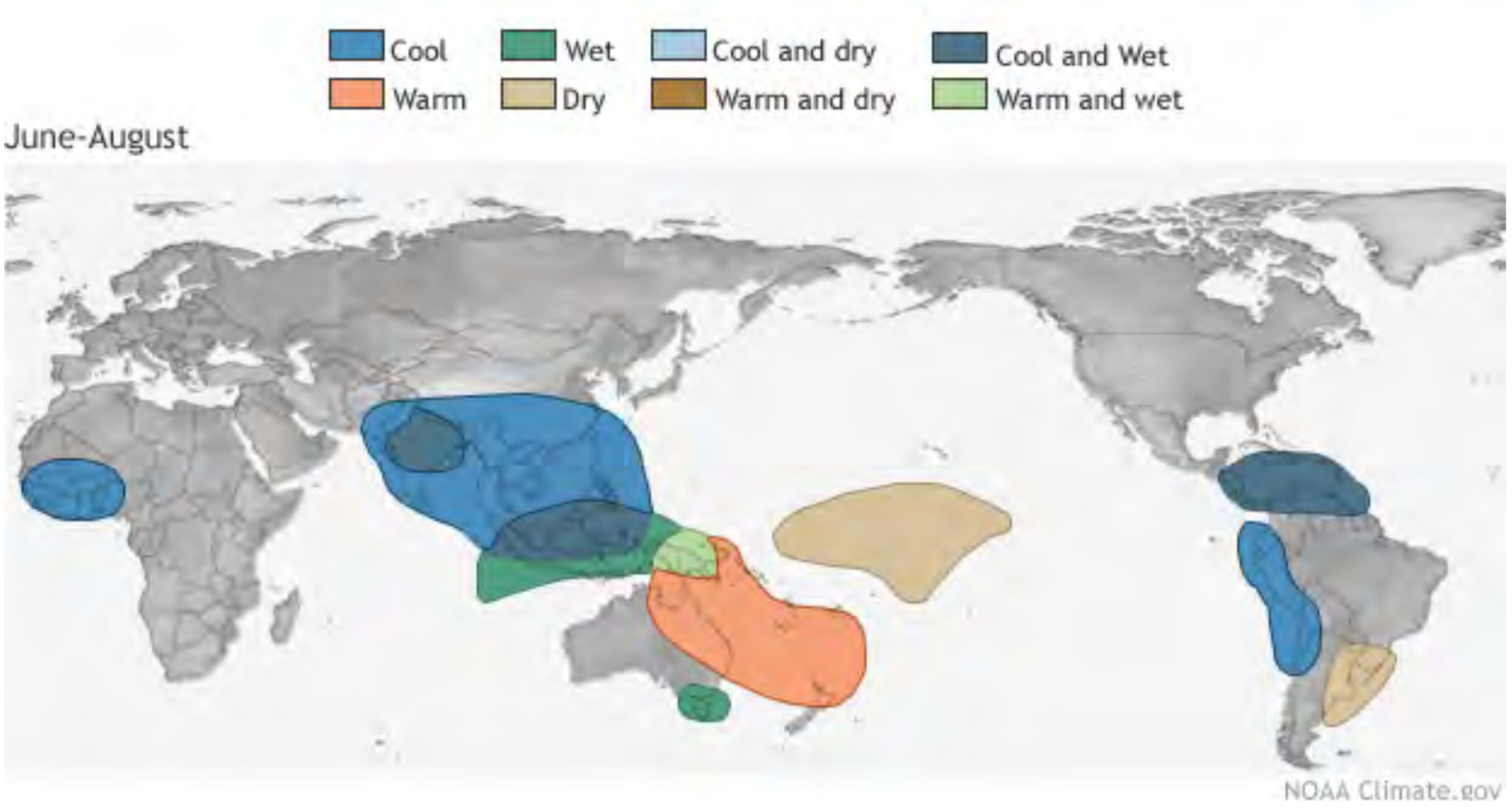


IMPACTS OF EL NIÑO IN SUMMER



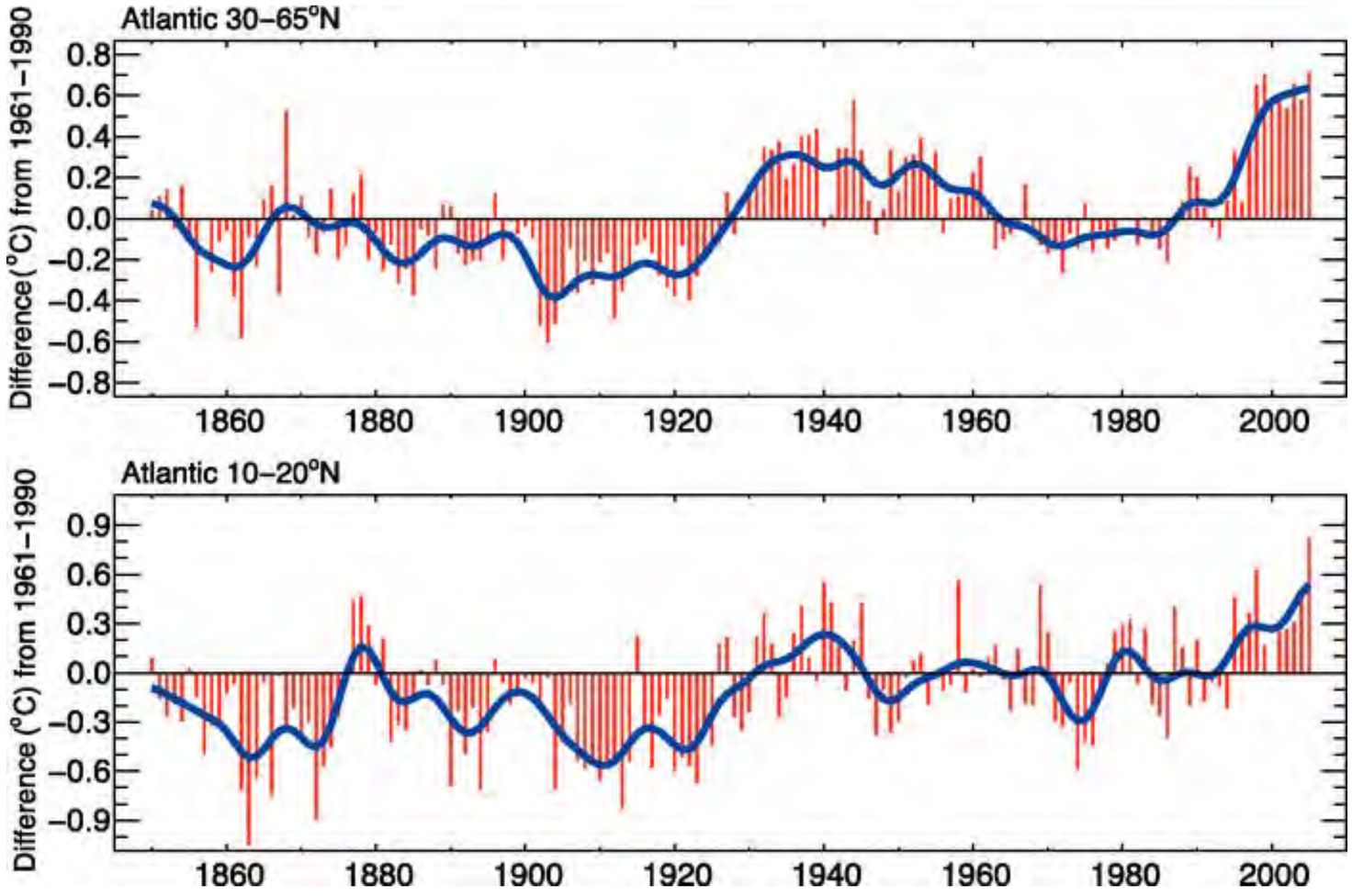
IMPACTS OF LA NIÑA IN SUMMER



ATLANTIC MULTIDECADAL OSCILLATION (AMO)

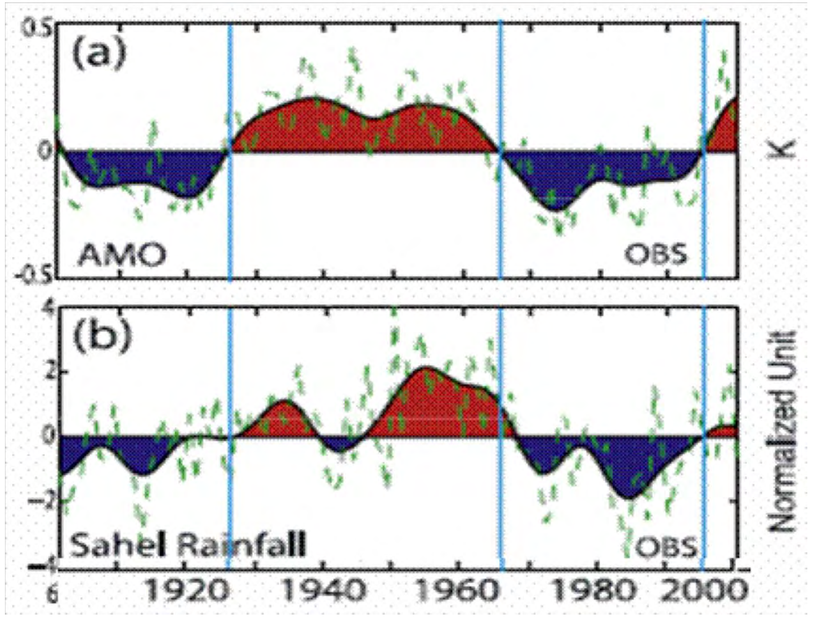
- **Pattern of natural variability of sea-surface temperatures in the North Atlantic Ocean**
- **Period of 60-80 years**; know less about it than other ocean-atmosphere modes because have few observations of full cycles
- May be caused by small changes in Atlantic portion of thermohaline circulation
- **Appears to modulate ENSO teleconnections**

ATLANTIC MULTIDECADAL OSCILLATION (AMO)



IMPACTS OF THE AMO

- **Positive (warm) phase of AMO** – twice as many major hurricanes during warm phase than cool phase; **possible relationship with major droughts in the U.S. Midwest/Great Plains & Southwest** (e.g., Dust Bowl & 1950s drought)



Zhang and Delworth (2006)

- Negative (cool) phase of AMO – enhanced drought over Sahel; increased sea ice concentration in Barents & Greenland Seas

THE SUMMER OF 2011

- Dry Fall/Winter/Spring preceding, driven by La Niña conditions and larger ocean patterns
- Stationary high pressure over the region
- Enlargement of drought area and intensity
- Widespread drought impacts observed in numerous ecological and economic sectors

Drought Monitoring

DROUGHT INDICES

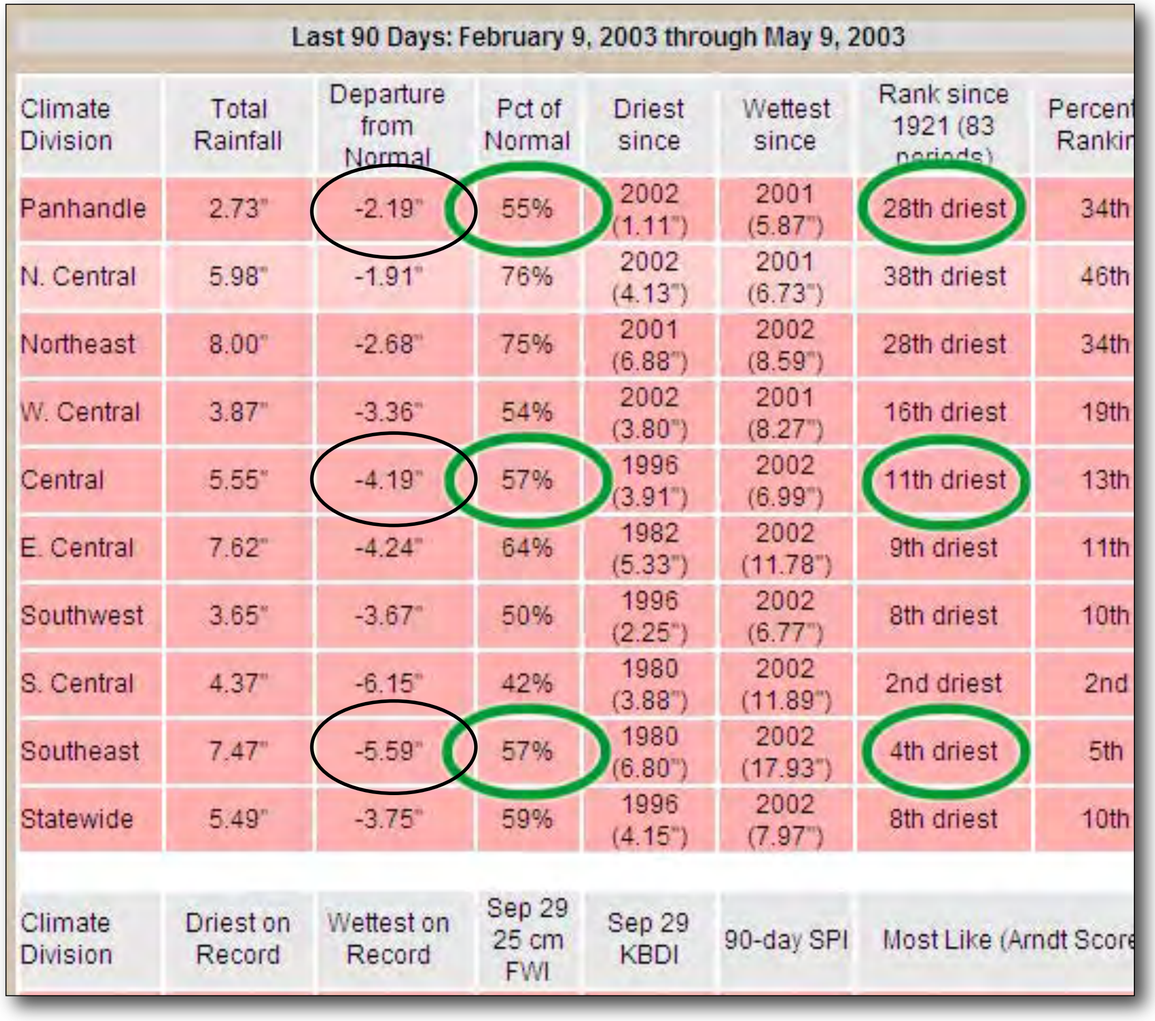
- Drought indices used to monitor drought and its severity
- Examples:
  - Precipitation departure
  - Palmer Drought Severity Index (PDSI)
  - Crop Moisture Index (CMI)
  - Standardized Precipitation Indices (SPI)
  - Keetch-Byram Drought Index (KBDI)

PRECIPITATION DEPARTURES

- **Precipitation departure – usually, the difference between a measured value & its associated climate normal**; an anomaly
- Precipitation is a key indicator for vegetation growth, water resources; temperature effects also important, but precipitation dominates
- Measured virtually everywhere & easy to calculate
- May not reveal complete picture of drought situation (see next slide for example)

PRECIPITATION DEPARTURES

- Often, the raw statistics do not reveal the complete picture
- 55% vs. 57% vs. 57% doesn't necessarily mean they're all in the same situation



Last 90 Days: February 9, 2003 through May 9, 2003

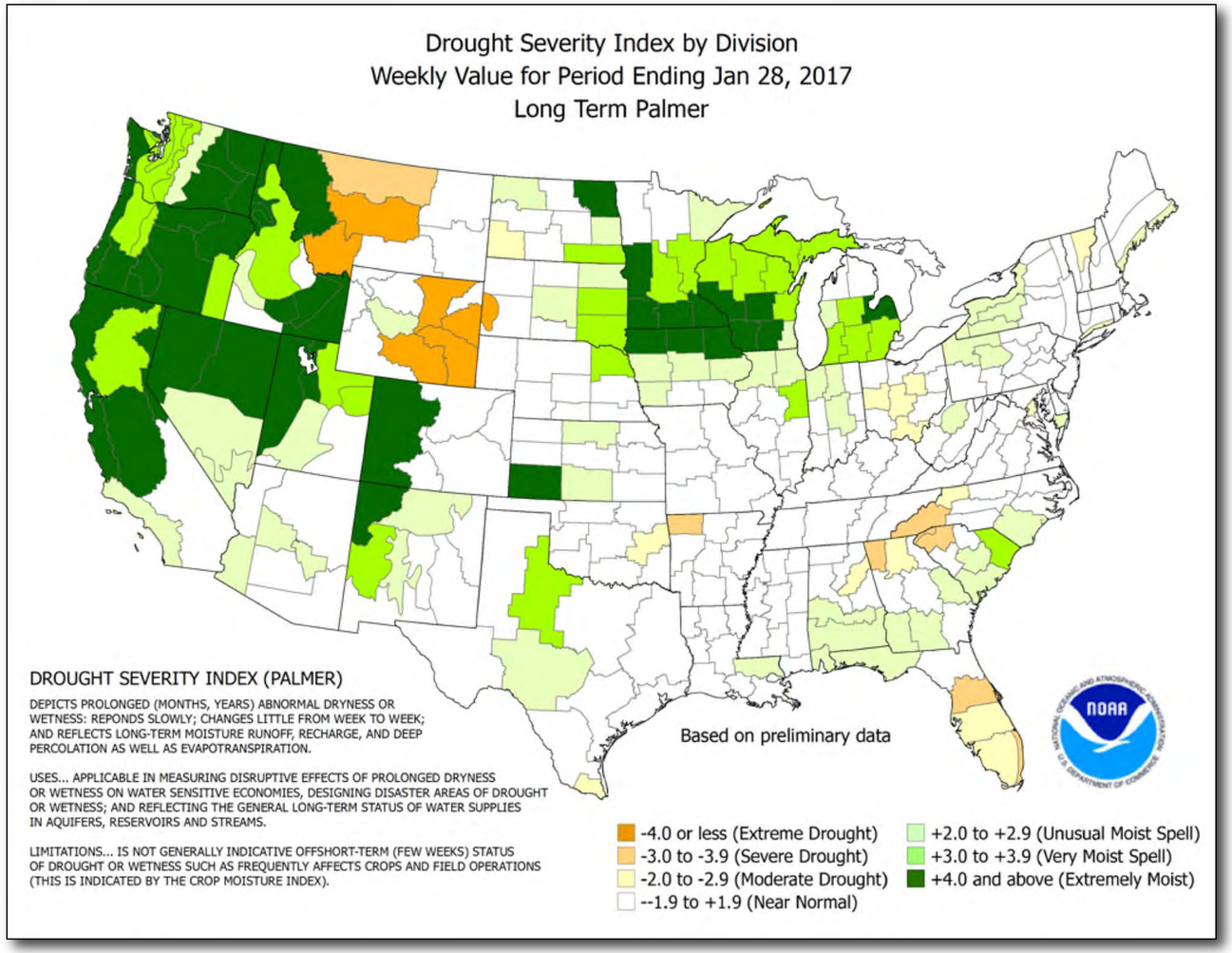
Climate Division	Total Rainfall	Departure from Normal	Pct of Normal	Driest since	Wettest since	Rank since 1921 (83 periods)	Percent Rankin
Panhandle	2.73"	-2.19"	55%	2002 (1.11")	2001 (5.87")	28th driest	34th
N. Central	5.98"	-1.91"	76%	2002 (4.13")	2001 (6.73")	38th driest	46th
Northeast	8.00"	-2.68"	75%	2001 (6.88")	2002 (8.59")	28th driest	34th
W. Central	3.87"	-3.36"	54%	2002 (3.80")	2001 (8.27")	16th driest	19th
Central	5.55"	-4.19"	57%	1996 (3.91")	2002 (6.99")	11th driest	13th
E. Central	7.62"	-4.24"	64%	1982 (5.33")	2002 (11.78")	9th driest	11th
Southwest	3.65"	-3.67"	50%	1996 (2.25")	2002 (6.77")	8th driest	10th
S. Central	4.37"	-6.15"	42%	1980 (3.88")	2002 (11.89")	2nd driest	2nd
Southeast	7.47"	-5.59"	57%	1980 (6.80")	2002 (17.93")	4th driest	5th
Statewide	5.49"	-3.75"	59%	1996 (4.15")	2002 (7.97")	8th driest	10th

Climate Division	Driest on Record	Wettest on Record	Sep 29 25 cm FWI	Sep 29 KBDI	90-day SPI	Most Like (Arndt Score

PALMER DROUGHT SEVERITY INDEX (PDSI)

- Developed in 1965; **uses temperature & 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 flat regions
- **May lag emerging drought conditions** by several months

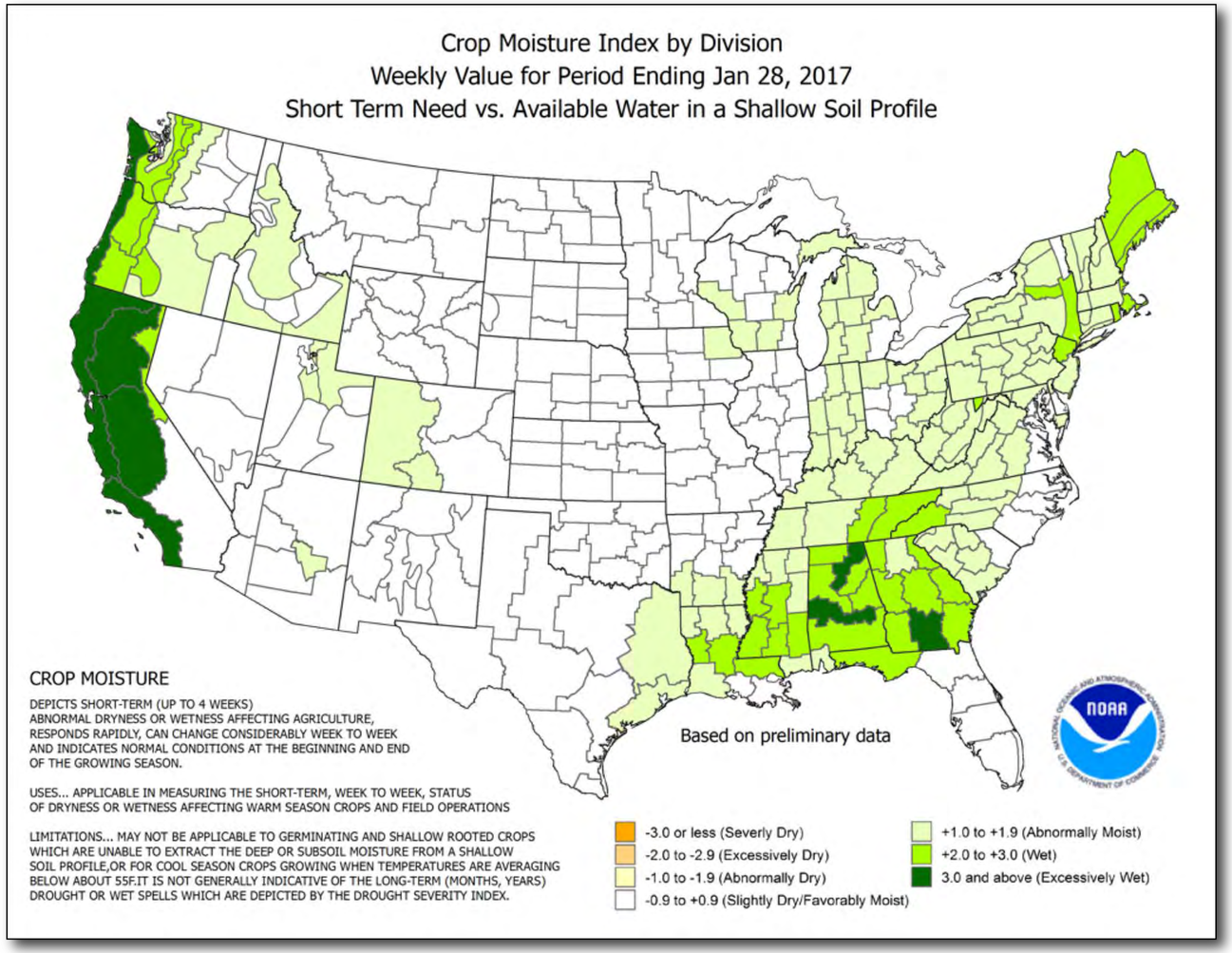
PALMER DROUGHT SEVERITY INDEX MAP



CROP MOISTURE INDEX (CMI)

- Developed in 1968; **geared for agricultural drought**
- Uses same categories as PDSI, but **CMI responds more rapidly than PDSI** (good for short-term dryness or wetness)
- Starts and ends growing season at near zero (not good for long-term assessments)
- **May overestimate recovery** resulting from short-term rainfall

CROP MOISTURE INDEX MAP

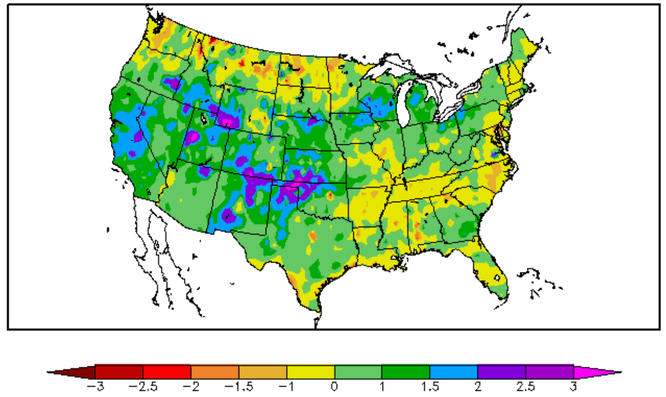


STANDARDIZED PRECIPITATION INDEX (SPI)

- Developed 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
  - Estimates evaporation based on temperature
- **Values of –2 or less are extremely dry; +2 and greater are extremely wet**

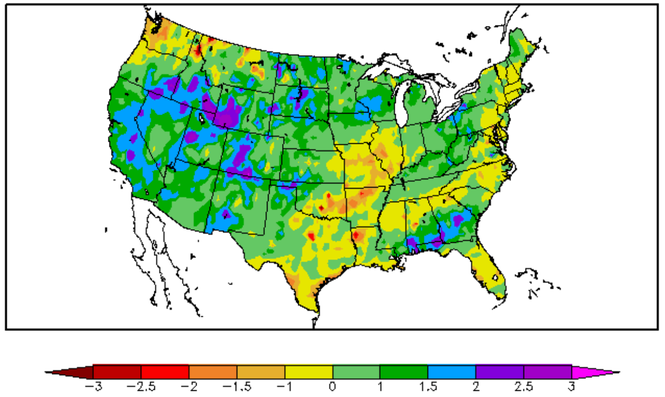
STANDARDIZED PRECIPITATION INDEX MAPS

30 Day SPI
1/6/2017 – 2/4/2017



Generated 2/5/2017 at HPRCC using provisional data. Regional Climate Centers

60 Day SPI
12/7/2016 – 2/4/2017



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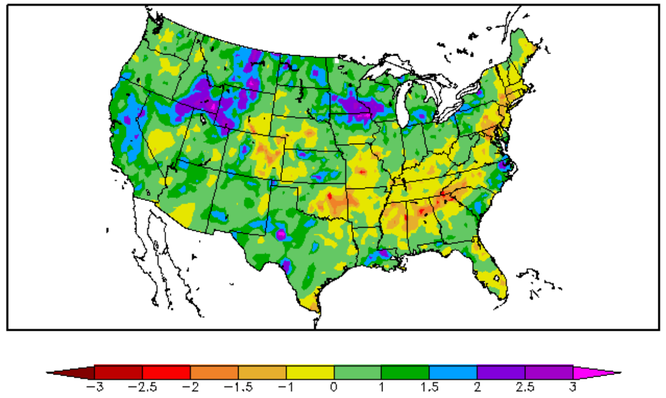
6 Month SPI
8/5/2016 – 2/4/2017



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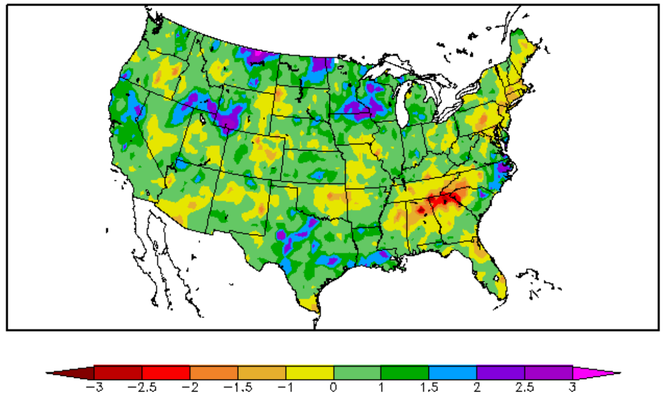
12 Month SPI
2/5/2016 – 2/4/2017

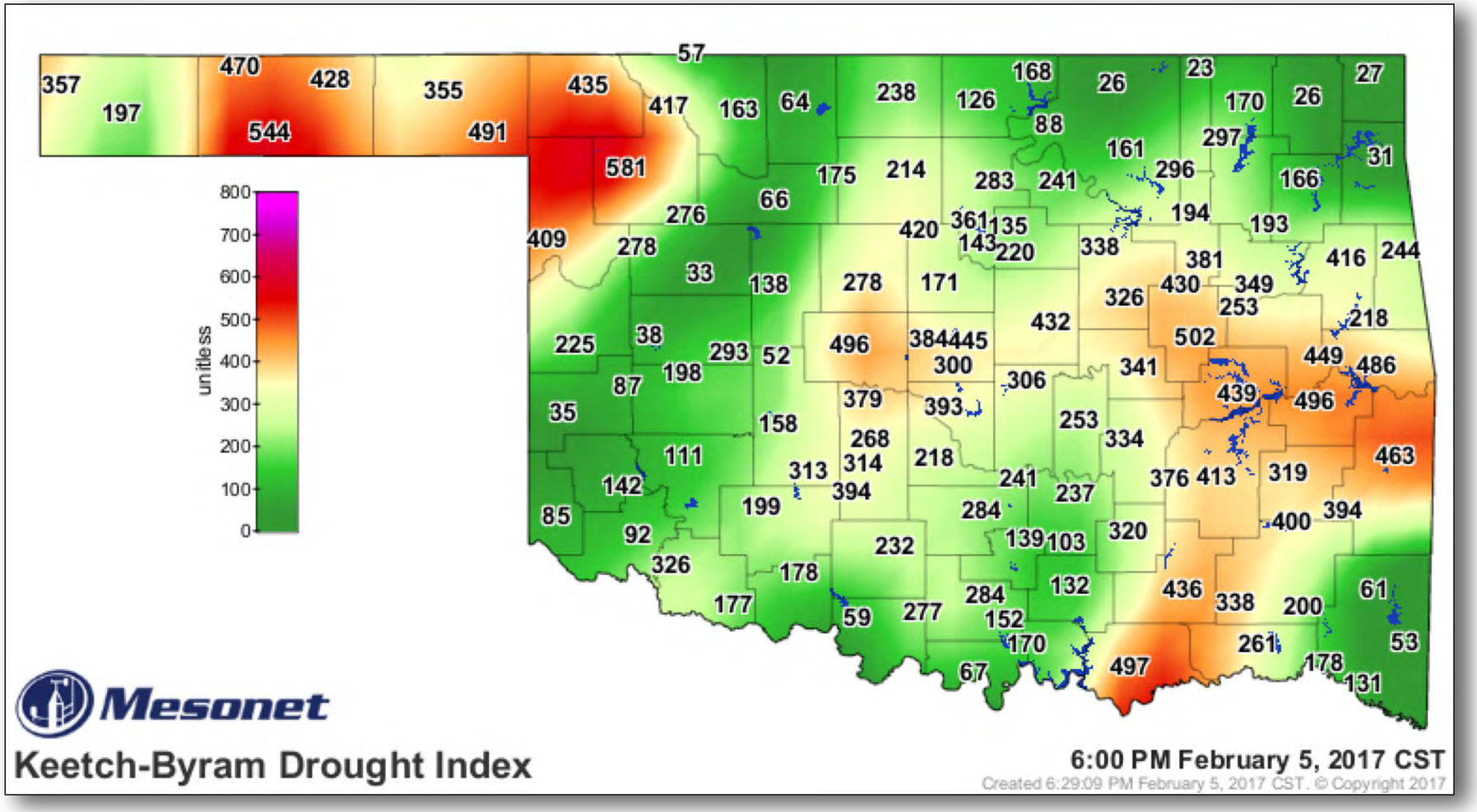


Generated 2/5/2017 at HPRCC using provisional data. Regional Climate Centers

KEETCH-BYRAM DROUGHT INDEX (KBDI)

- **Estimates dryness of soil and dead vegetation**
- **Ranges from 0 (saturated soil) to 800 (dry soil)**
- Based on combination of recent precipitation and estimated evaporation
  - Soil may dry because of extended periods without precipitation or by high temperatures / strong winds
- **Developed for fire management purposes, but also a good short-term drought indicator**

KBDI FOR OKLAHOMA



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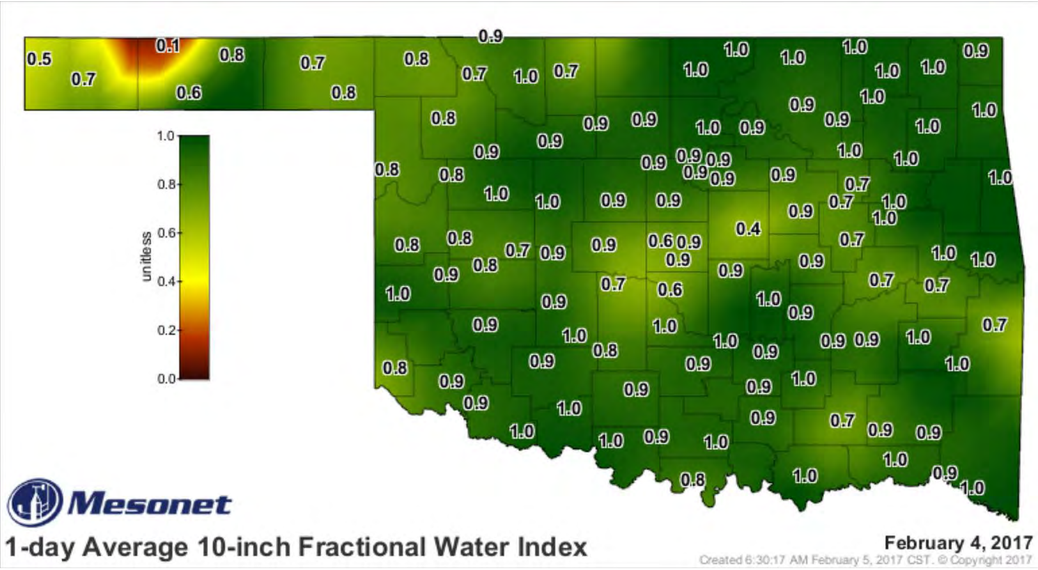
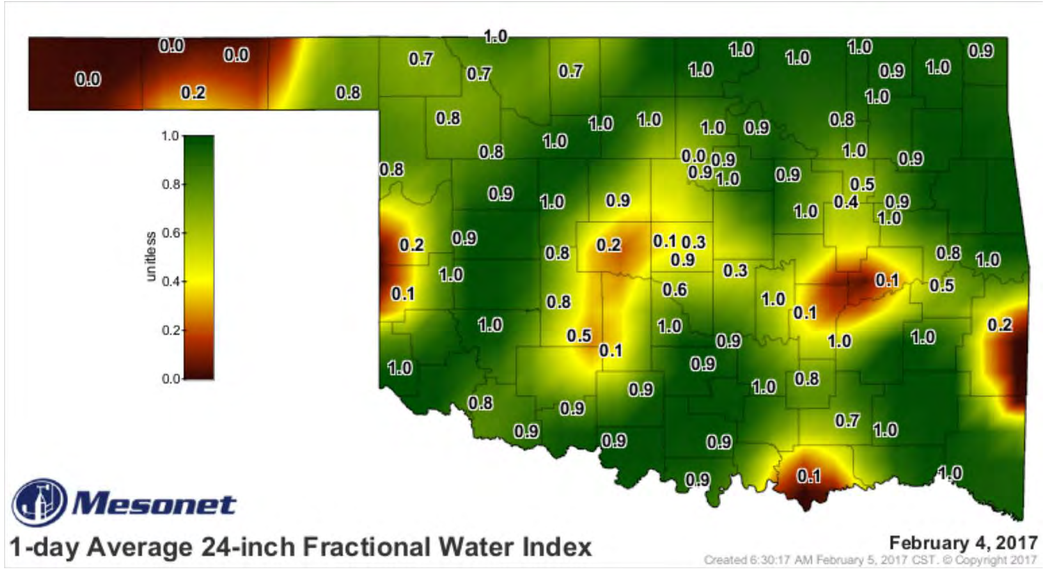
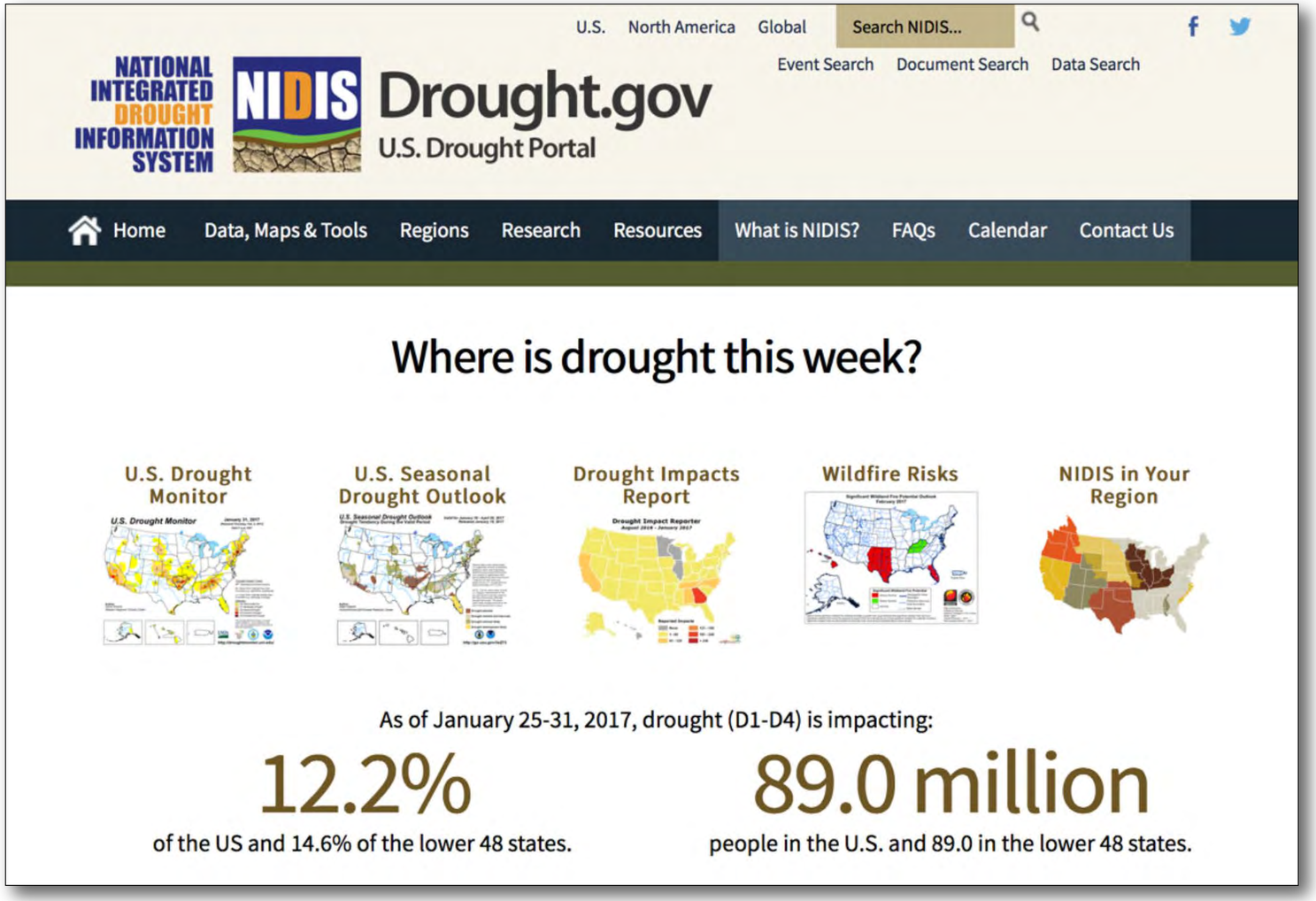
SOIL MOISTURE

- Integrates precipitation deficits over time
- Lagging indicator but strongly related to impacts
- Valuable for assessing recovery





NIDIS DROUGHT PORTAL (DROUGHT.GOV)



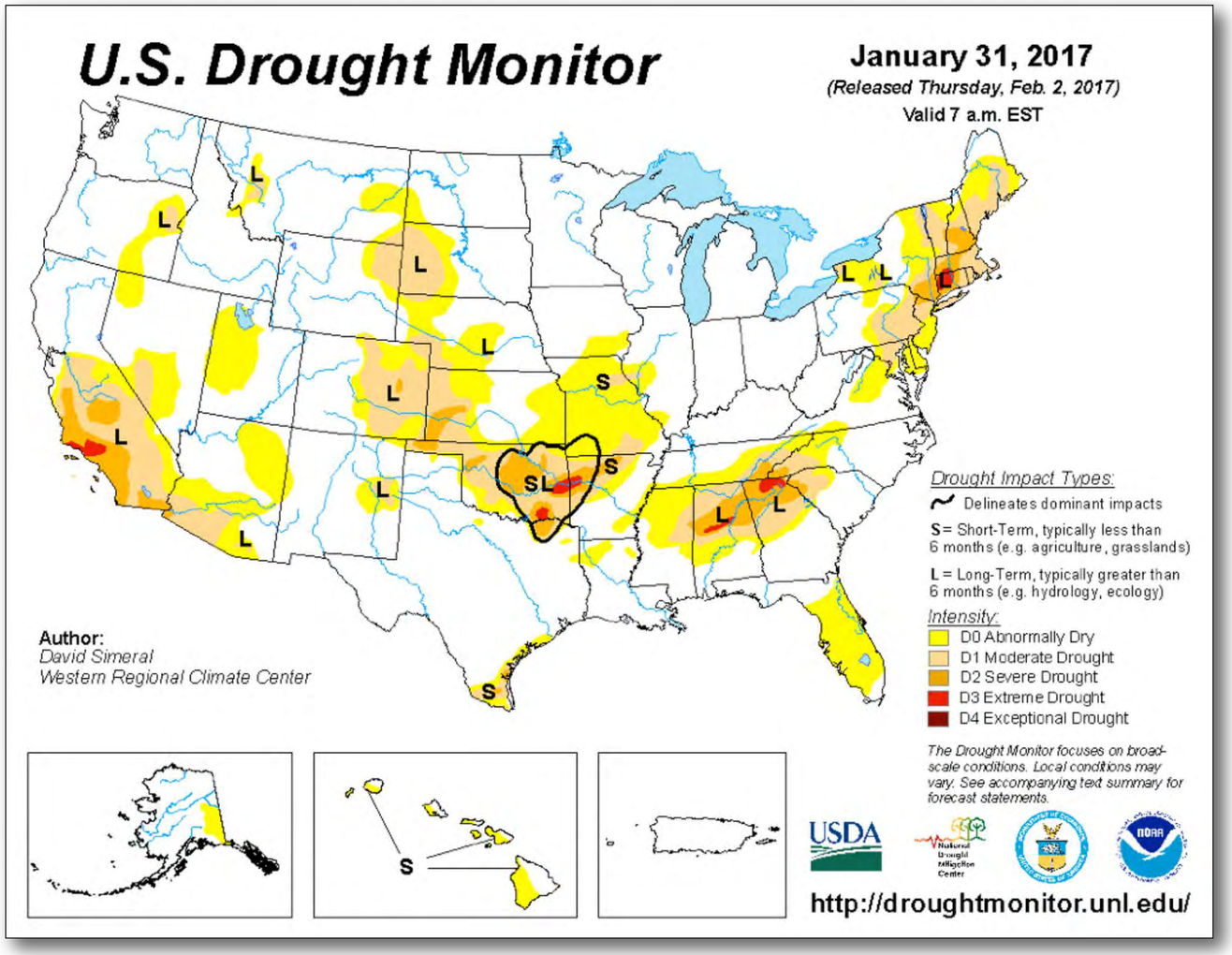
U.S. DROUGHT MONITOR

- National Drought Mitigation Center, Climate Prediction Center, & National Center for Environmental Information
- **Consolidation of indicators into one comprehensive national drought map**
- Trying to capture these characteristics: **drought magnitude** (duration + intensity); **spatial extent** (how widespread); **how often** similar conditions occur; **impacts**
- An assessment – **not a forecast, not a declaration**

U.S. DROUGHT MONITOR

- **Rates drought intensity by percentile ranks**
- **Incorporates relevant information** & products from all entities dealing with drought (federal/state agencies, etc.)
- **Updated weekly** for 50 states, Puerto Rico, and the U.S. Pacific possessions
- Key variables: climate data; soil moisture; stream flow; ground water; reservoir and lake levels; snow pack; short- to long-range forecasts; vegetation health/stress; fire danger

U.S. DROUGHT MONITOR



D0 Abnormally Dry (30% – 1 in 3 years)

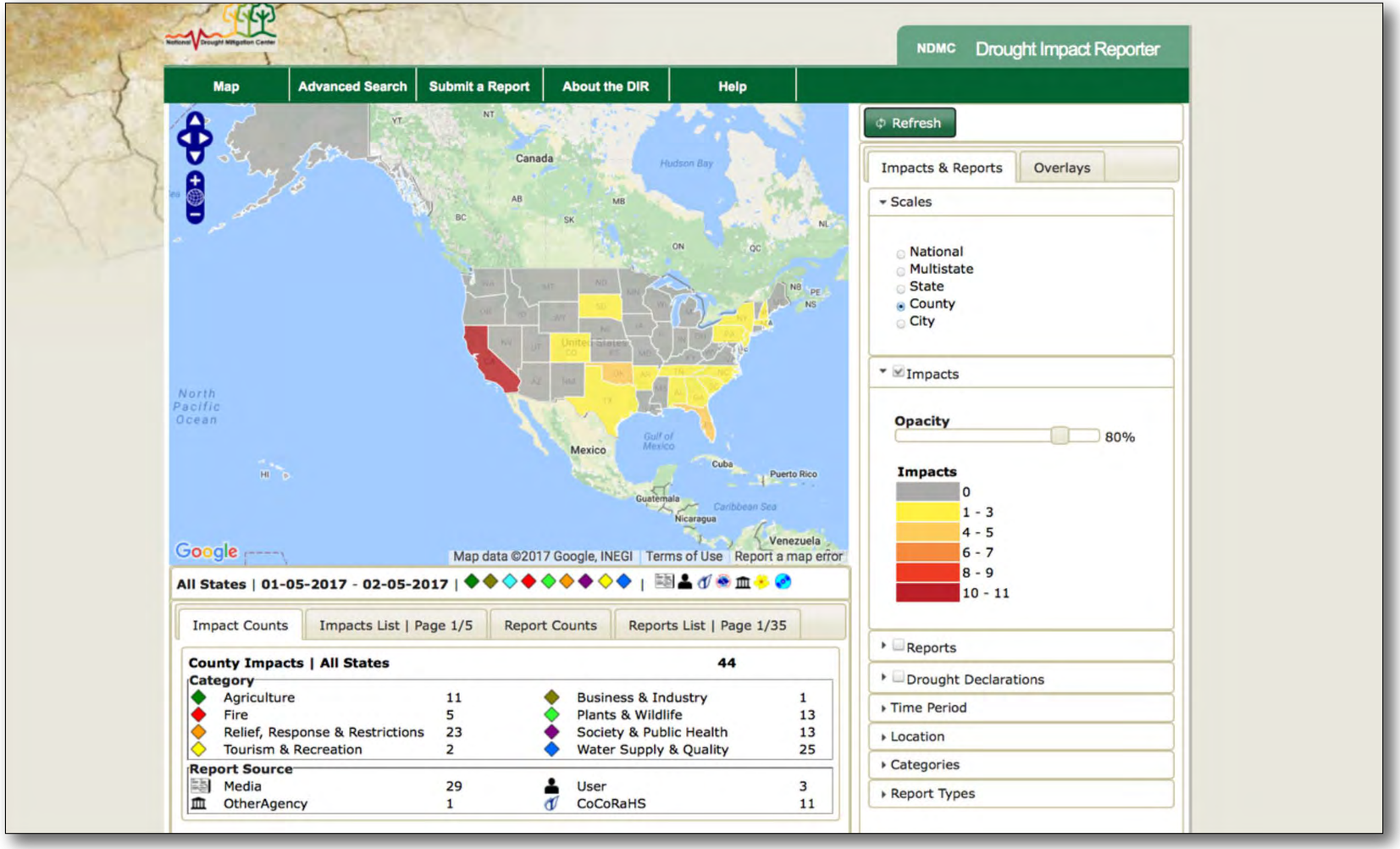
D1 Drought Moderate (20% – 1 in 5 years)

D2 Drought Severe (10% – 1 in 10 years)

D3 Drought Extreme (5% – 1 in 20 years)

D4 Drought Exceptional (2% – 1 in 50 years)

DROUGHT IMPACT REPORTER (DROUGHTREPORTER.UNL.EDU)



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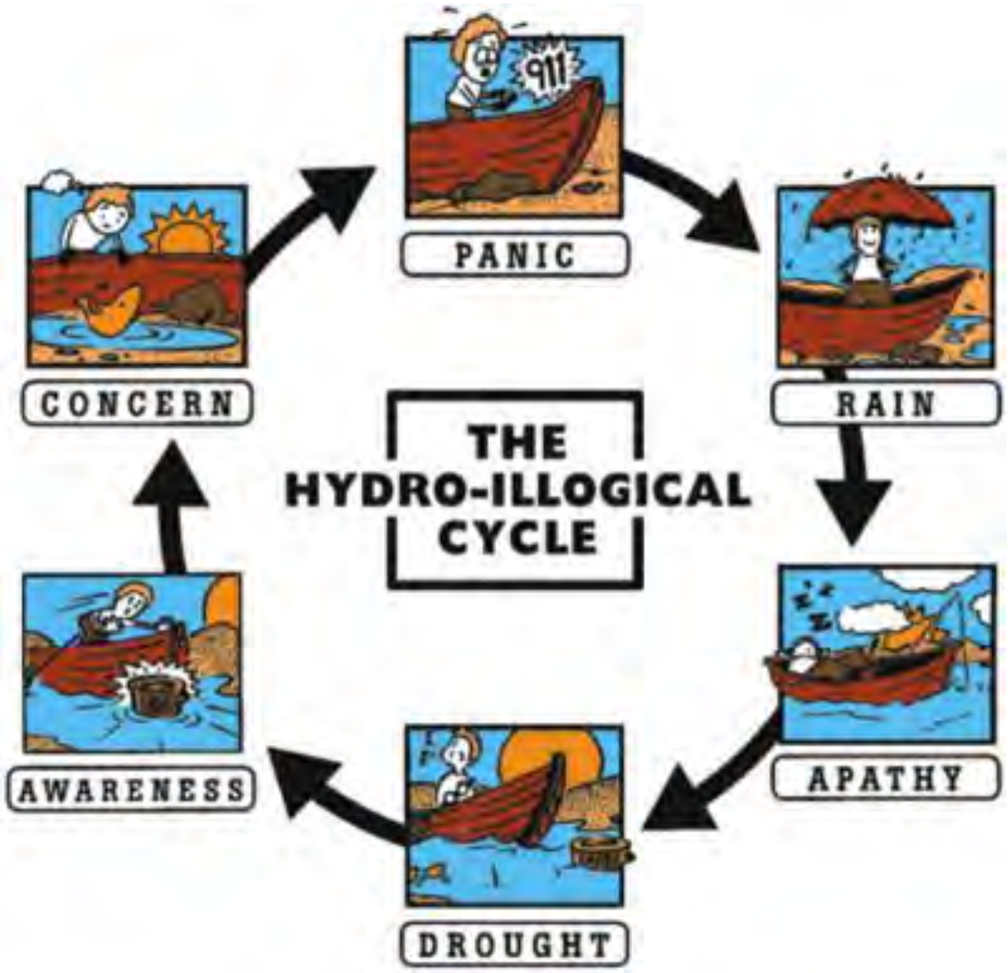
Drought Planning

REACTIVE PLANNING...



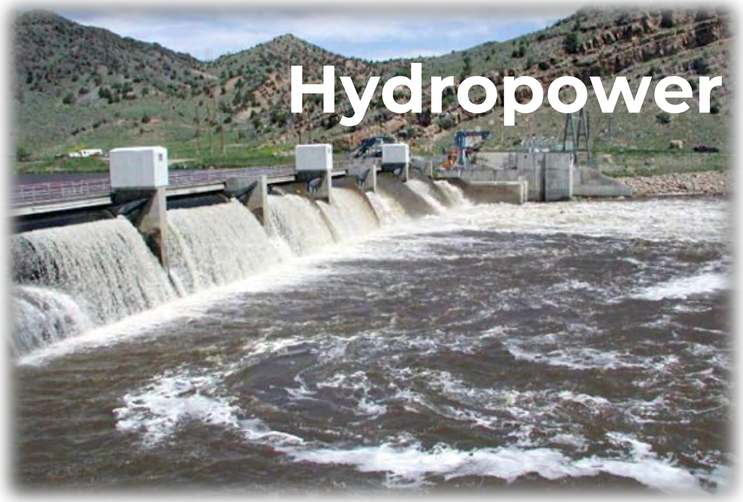
WHY PLAN?

- Drought is inevitable
- Pre-drought action increases flexibility and minimizes loss during drought
- Early responses are effective responses
- Drought creeps up on you! Don’t be surprised!

THE ABCs OF DROUGHT PLANNING

- Assess Conditions
  - Rainfall patterns and departures from normal
  - Drought indicators
  - Water resources
  - Impacts
- Be Prepared
  - Develop a good drought plan
  - Identify at-risk businesses and users
- Communicate!
  - Who needs to know and when? How will you let them know?

COMPETING VALUES FOR WATER



Flood Control

WHAT IS IN A DROUGHT PLAN?

- Vulnerability analysis
- Response capacities
- Roles and responsibilities
- Monitoring indices
- Communication
- Triggers

PLANNING RESOURCES

- Drought-Ready Communities (next slide)
- Managing Drought Risk on the Ranch
  - https://drought.unl.edu/ranchplan/Overview.aspx
- National Drought Mitigation Center
  - https://drought.unl.edu/
- NIDIS
  - https://www.drought.g ov/drought/

DROUGHT-READY COMMUNITIES

https://drought.unl.edu/droughtplanning/AboutPlanning/PlanningProcesses/Drought-ReadyCommunities.aspx

- Resource materials assembled into a “Drought Ready Communities Kit” to help guide communities in their assessment of drought risk and mitigation actions
- Elements include:
  - Developing a leadership team
  - Data sources and drought indicators
  - Sample documents for communicating about drought to the public
  - Example plans from other communities

MITIGATION AND RESPONSE PROGRAMS

- Drought planning
- Improved monitoring/early warning
- Water supply augmentation
- Demand reduction/water conservation
- Soil erosion control (vegetative cover, wind breaks)
- Drought-tolerant landscaping
- Public awareness/education programs
- Water use conflict resolution
- Legislation/policy changes
- Technical assistance on water management

QUESTIONS?