How Do You Identify Drought in a Desert?

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Arizona Drought & Health Workshop
February 26-27, 2020

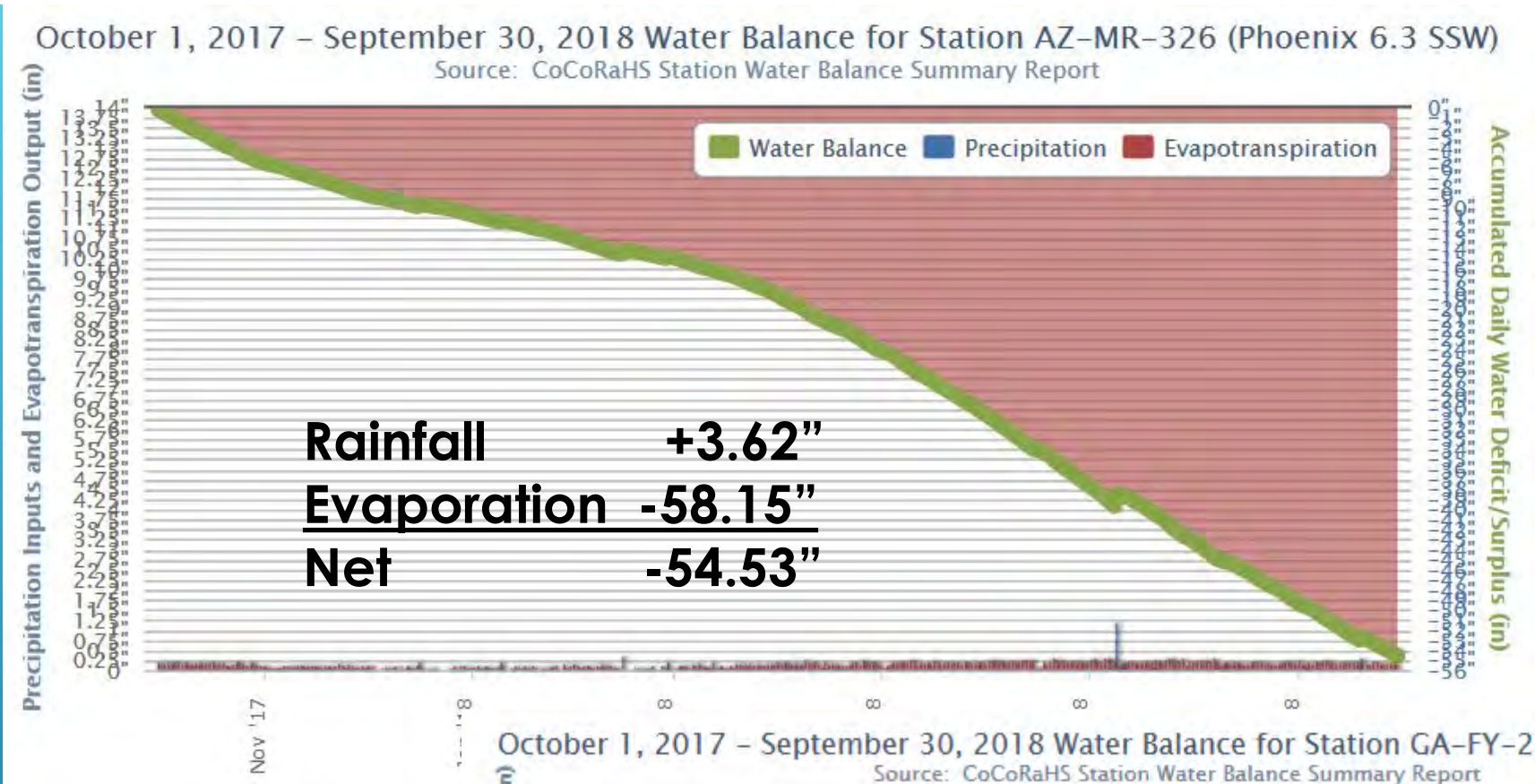
ARIZONA STATE CLIMATE OFFICE

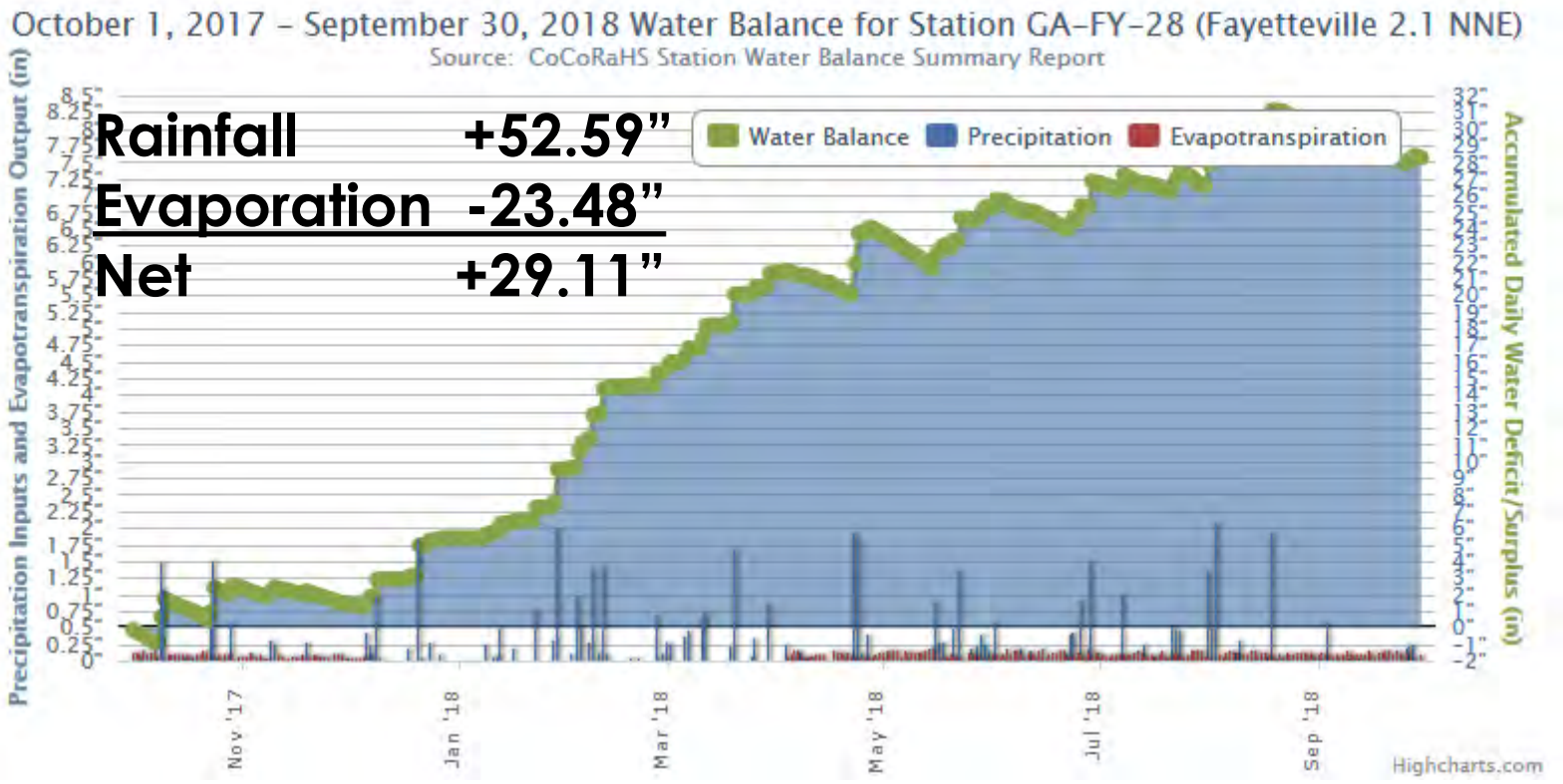
MARICOPA COUNTY
1871
ARIZONA

Desert vs Drought

Desert:

Normal condition is less precipitation than evaporation on an annual basis.


October 1, 2017 – September 30, 2018 Water Balance for Station AZ-MR-326 (Phoenix 6.3 SSW)
Source: CoCoRaHS Station Water Balance Summary Report
Water Balance
Precipitation
Evapotranspiration
Precipitation Inputs and Evapotranspiration Output (in)
Accumulated Daily Water Deficit/Surplus (in)
Rainfall +3.62”
Evaporation -58.15”
Net -54.53”
Nov '17


October 1, 2017 – September 30, 2018 Water Balance for Station GA-FY-28 (Fayetteville 2.1 NNE)
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Rainfall +52.59”
Evaporation -23.48”
Net +29.11”
Nov '17
Jan '18
Mar '18
May '18
Jul '18
Sep '18
Highcharts.com

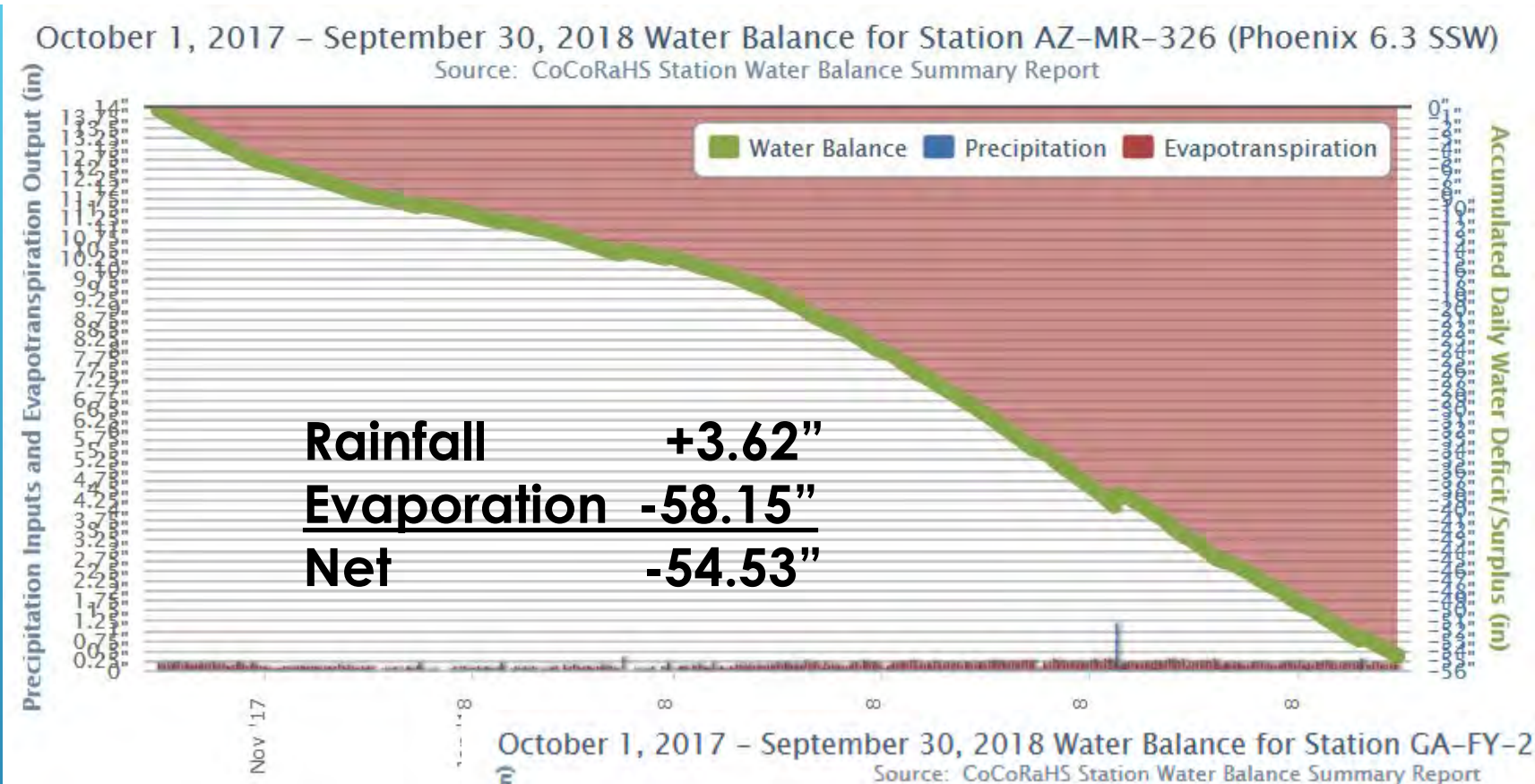
Desert vs Drought

Desert:
Normal condition is less precipitation than evaporation on an annual basis.

Drought:
Drier than normal conditions. Can have Hydrologic impacts, Agricultural impacts, Ecological impacts or Socio-economic impacts

In wet regions, like the East Coast or the Gulf Coast, this could be a week without rain.

In dry regions, like the Western U.S., this would be consecutive years without rain – a cumulative effect.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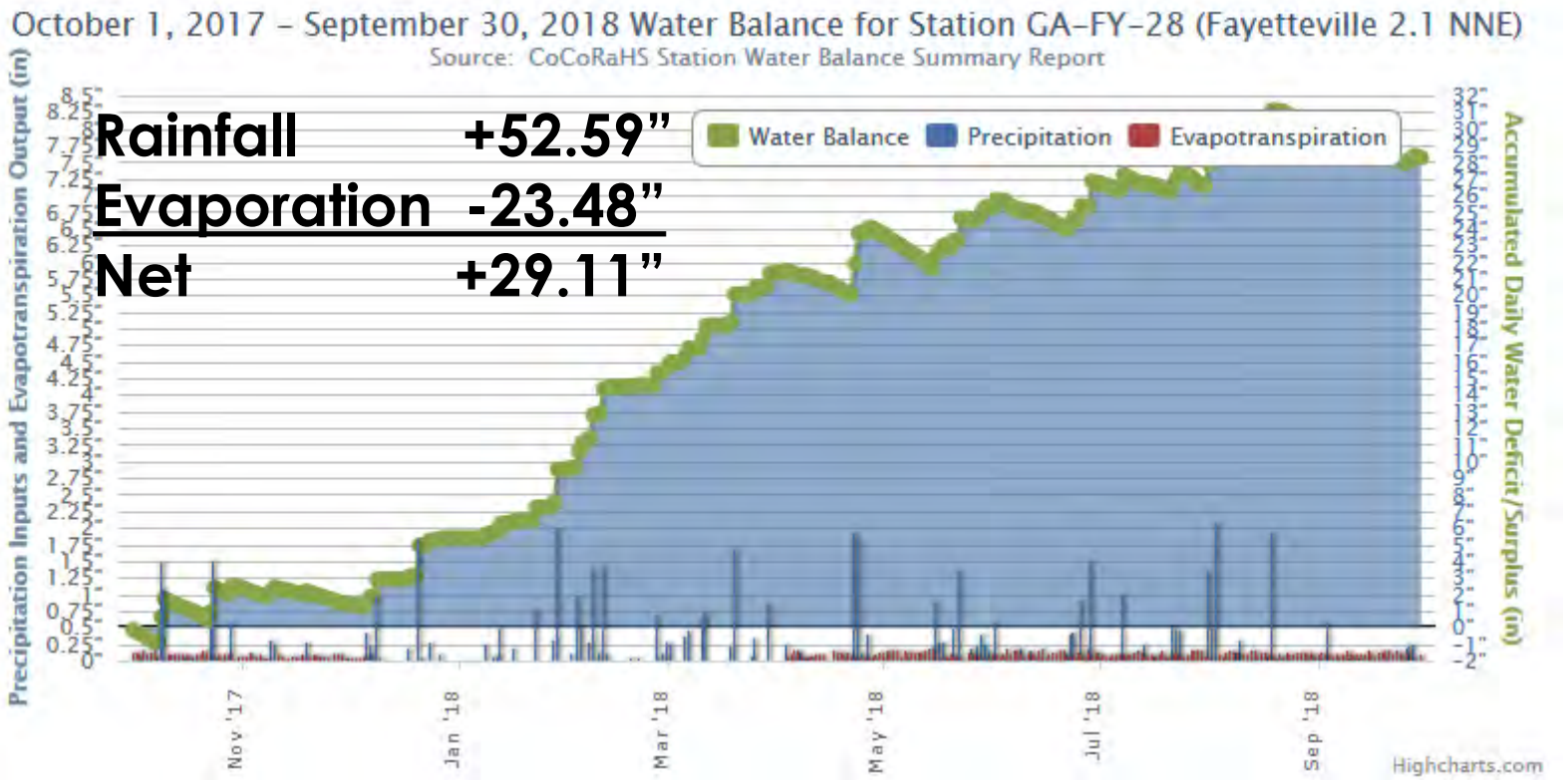
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Short-term Drought vs Long-term Drought

Short-term Drought:

A drier than normal season that results in significantly reduced vegetation growth – rangeland grass, forage, crops.

Or an unusually dry spring or summer that results in dead vegetation and increased brushfire risk.

Long-term Drought:

Consecutive dry years resulting in reduced water resources. Low streamflow, low reservoir levels, stressed forests that can lead to major forest fires.

When does it start and when does it end?

Droughts are slow moving disasters that we rarely recognize until after they have taken hold. We usually have to look back to determine when a drought started.

Droughts have no set length or cycle. The next rainstorm or snowstorm may not signify the end of the drought.

Timing is critical – did the rain come at the right time?

Impacts are everything.

Who is affected and how are they affected?

Rangeland, Wildlife, Livestock, Crops, Streamflow, Riparian Systems, Aquifers, Water Supplies

Droughts have Secondary Impacts

Stressed Forests

Dry Rangeland

Reduced Water Supply

Dry Lakes & Stockponds

Wildfires

Supplemental Feed

Overpumping Groundwater

Hauling Water

Loss of Recreation

Flash Flooding

Poor Air Quality

Land Subsidence/ sinkholes

Wells Running Dry

Poor Water Quality

Dust Storms

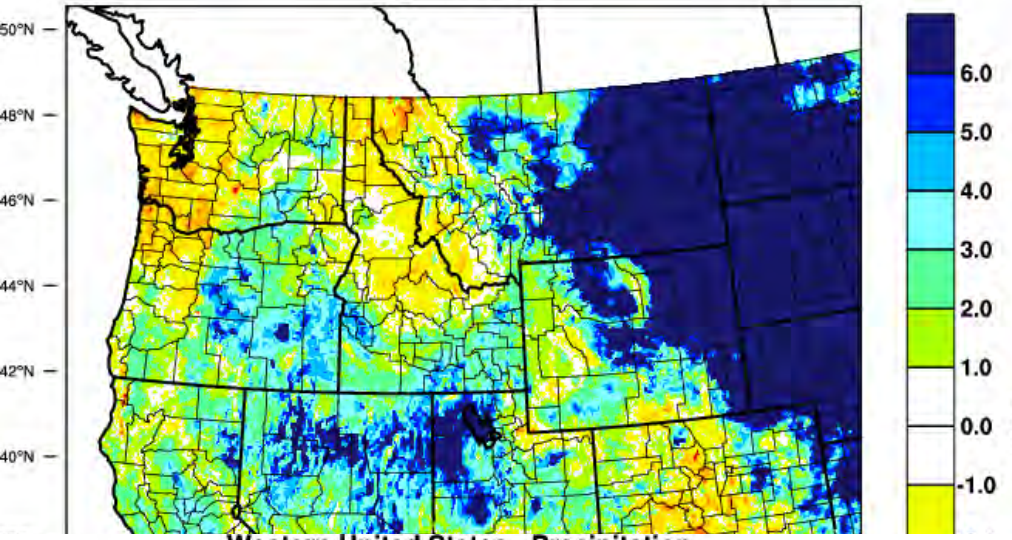
Economic Losses in All Sectors

How Do We Detect a Drought?

- There are many Drought Indices. Here are a few:
- Palmer Drought Severity Index (PDSI), relative dryness based on temperature & precipitation
  - Variations include Palmer Hydrological Drought Index, Palmer Modified Drought Index, Palmer Z-Index – similar but at different time scales.
- Standardized Precipitation Index (SPI) based on precipitation ranking – works at many times scales
- Standardized Precipitation Evaporative Index (SPEI) based on precipitation and evaporation – works better in the western US.
- Evaporative Demand Drought Index (EDDI) a measure of how anomalous the atmospheric evaporative demand is for a location over a time period 1-week to 12-month.
- Crop Moisture Index (CMI) based on weekly temperature & precipitation.
- Surface Water Supply Index (SWSI) based on prediction of available surface water within a watershed.
- Vegetation Drought Response Index (VegDRI) separates drought stress from other vegetation stressors.

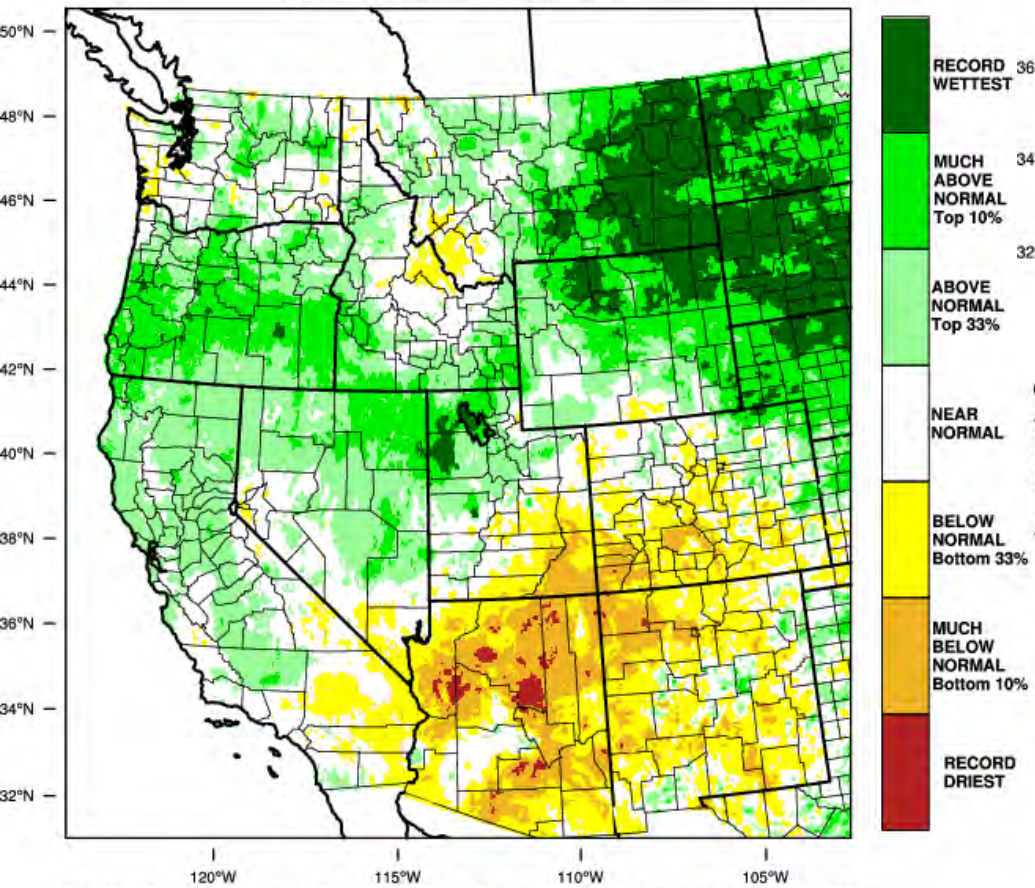
Western United States - PDSI

September 2019



Western United States - Precipitation

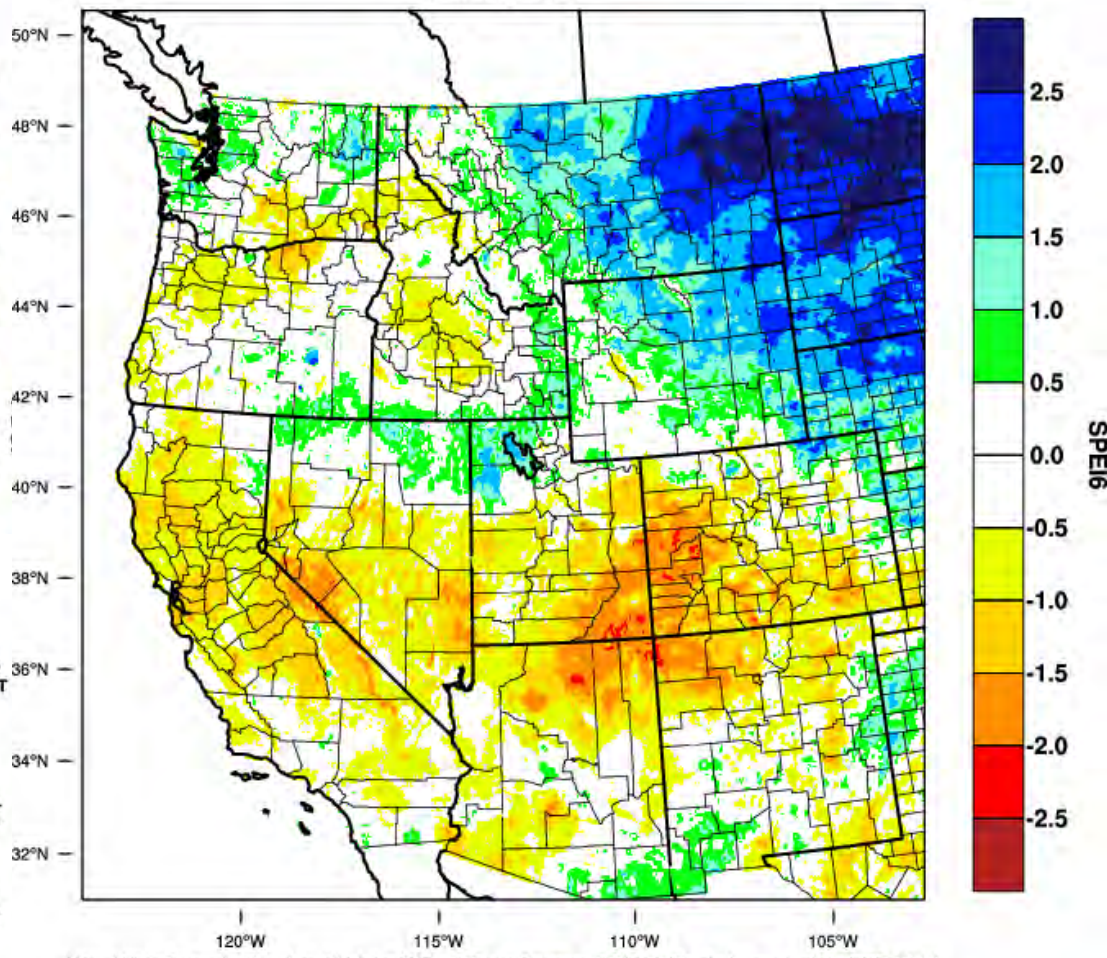
April-September 2019 Percentile



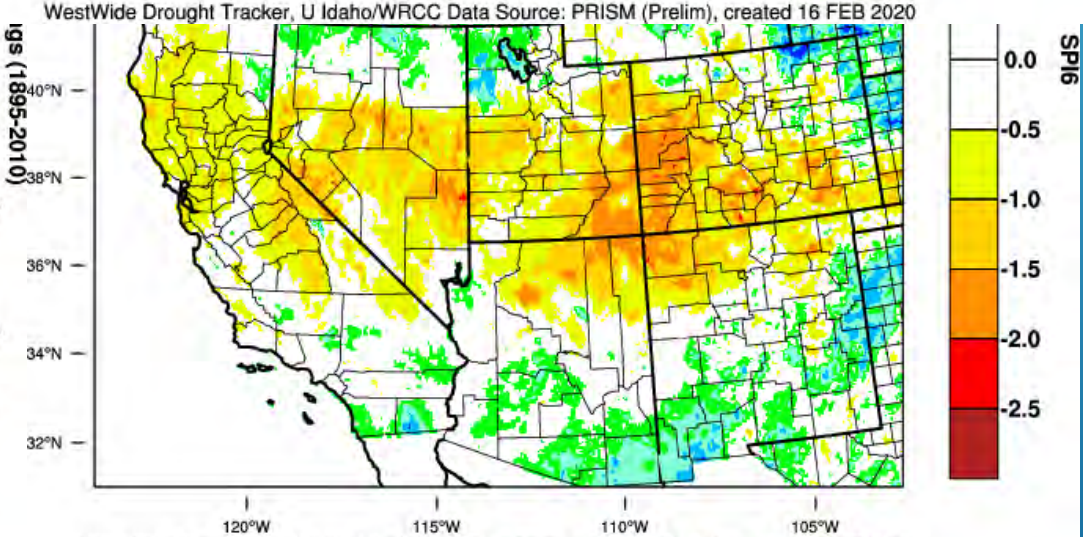
WestWide Drought Tracker, U Idaho/WRCC Data Source: PRISM (Prelim), created 16 OCT 2019

Western United States - 6 month SPEI

January 2020



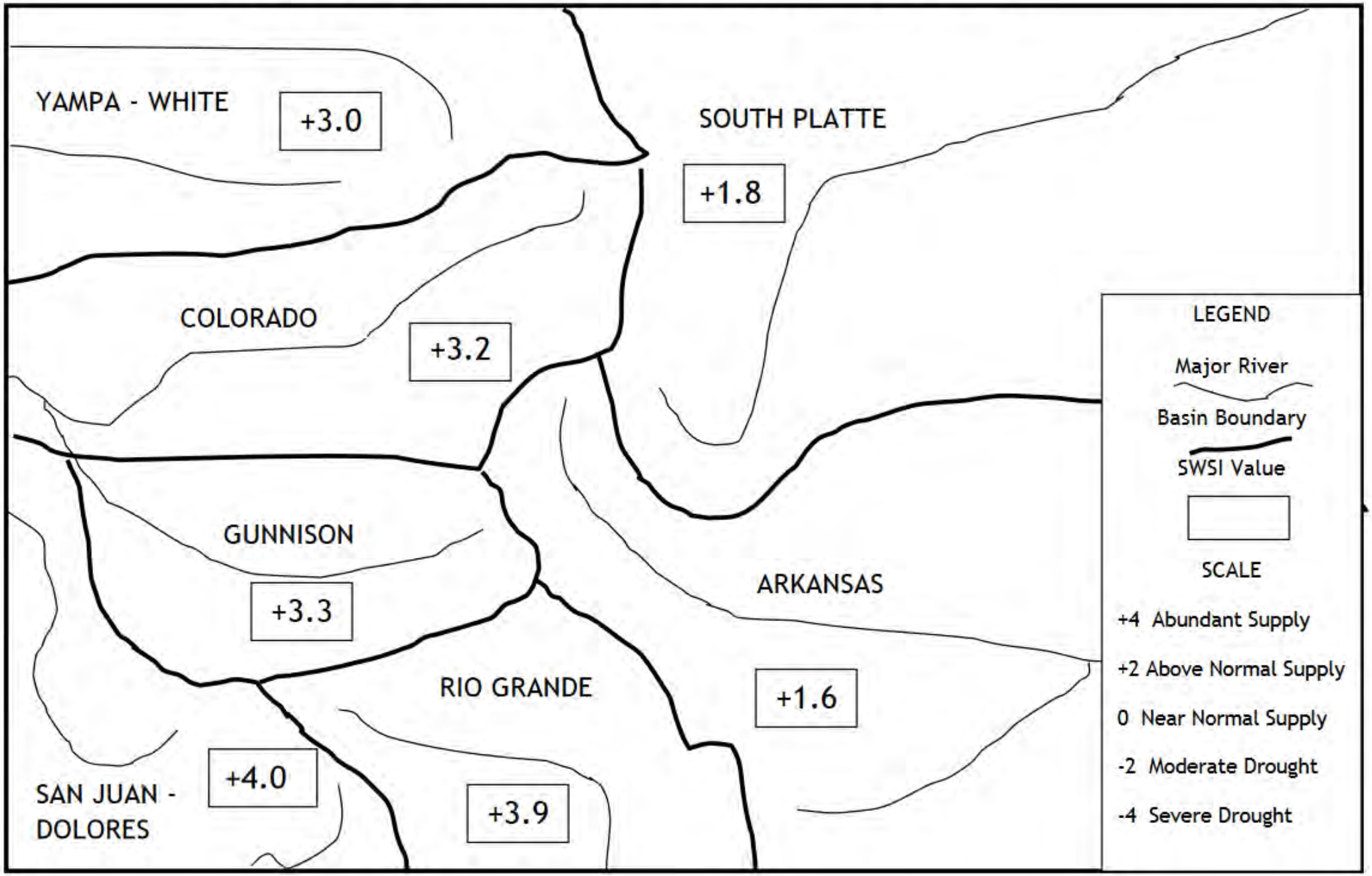
WestWide Drought Tracker, U Idaho/WRCC Data Source: PRISM (Prelim), created 16 FEB 2020



WestWide Drought Tracker, U Idaho/WRCC Data Source: PRISM (Prelim), created 16 FEB 2020

Western United States - 6 month SPEI

SURFACE WATER SUPPLY INDEX FOR COLORADO BY MAJOR RIVER BASIN



July 1, 2019

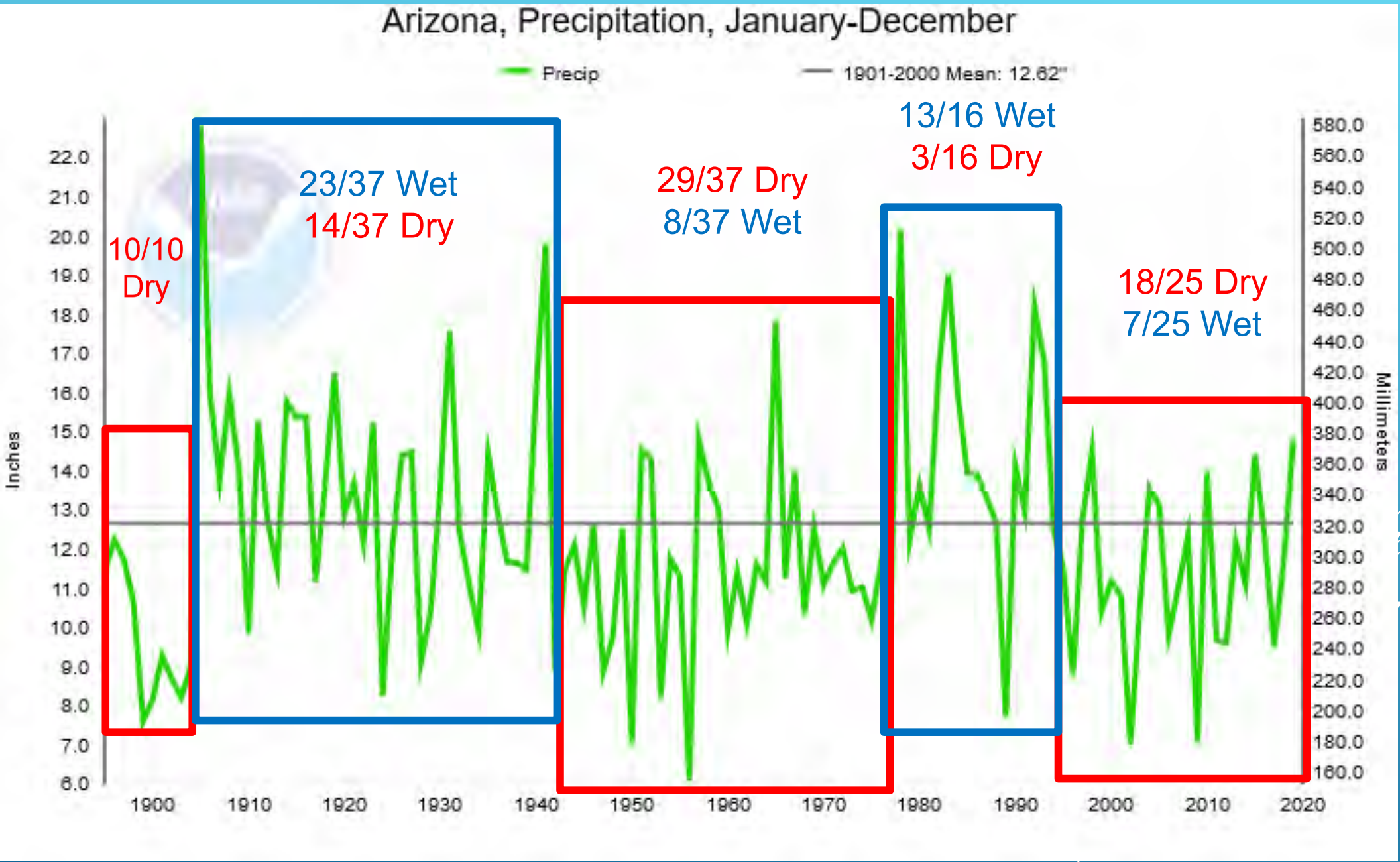
			Ranges				
Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Objective Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: ▪ short-term dryness slowing planting, growth of crops or pastures Coming out of drought: ▪ some lingering water deficits ▪ pastures or crops not fully recovered	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	▪ Some damage to crops, pastures ▪ Streams, reservoirs, or wells low, some water shortages developing or imminent ▪ Voluntary water-use restrictions requested	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	▪ Crop or pasture losses likely ▪ Water shortages common ▪ Water restrictions imposed	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	▪ Major crop/pasture losses ▪ Widespread water shortages or restrictions	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5
D4	Exceptional Drought	▪ Exceptional and widespread crop/pasture losses ▪ Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2

Impacts Vary by State

Drought Classification | Impacts by State

https://droughtmonitor.unl.edu/About/WhatistheUSDM.aspx

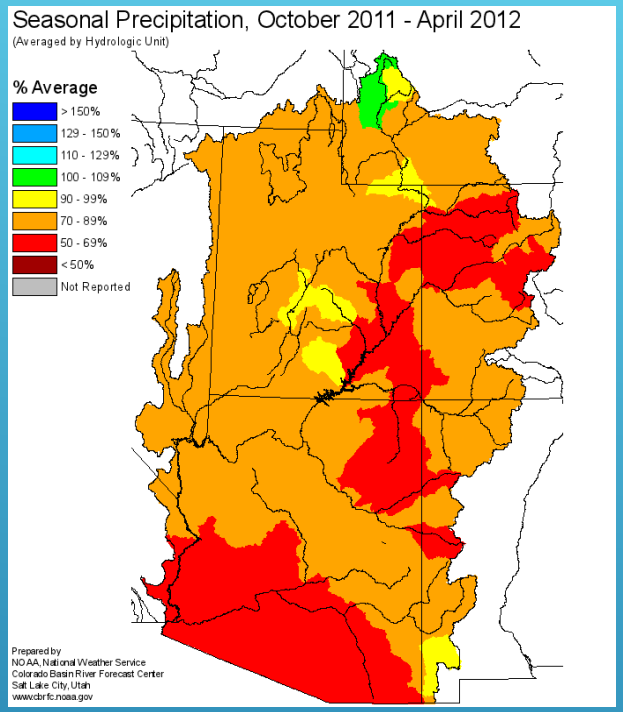
Historical Precipitation – Statewide Averages



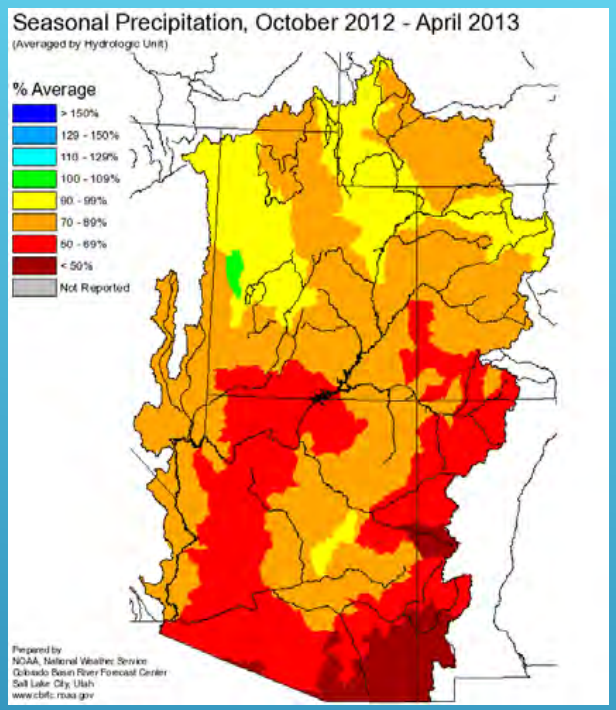
Dry and Wet Periods 1895-2019

Winter Precipitation % Average Colorado River Basin

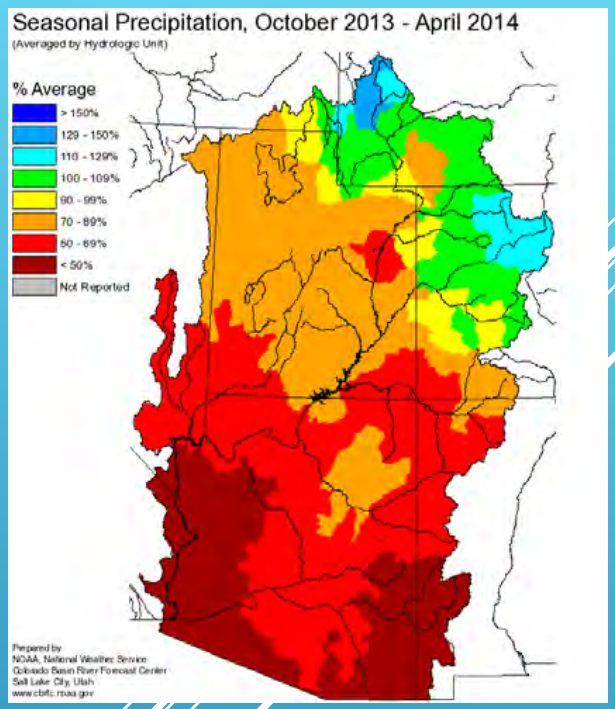
WY 2012



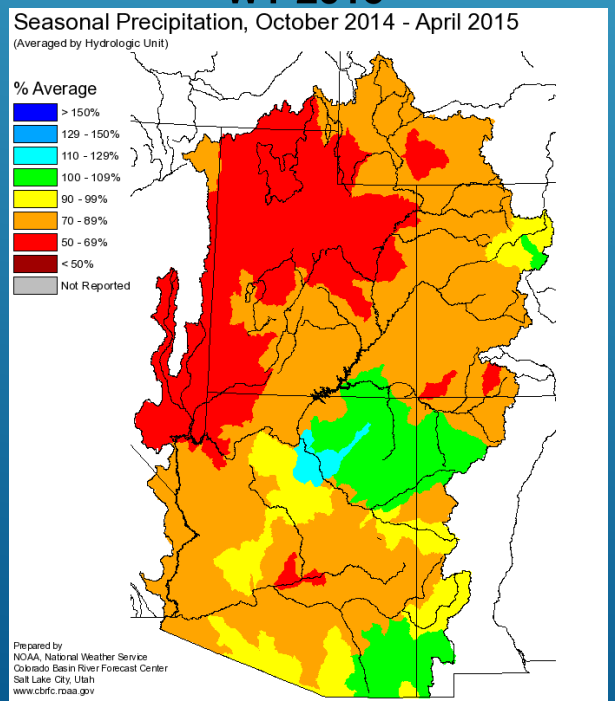
WY 2013



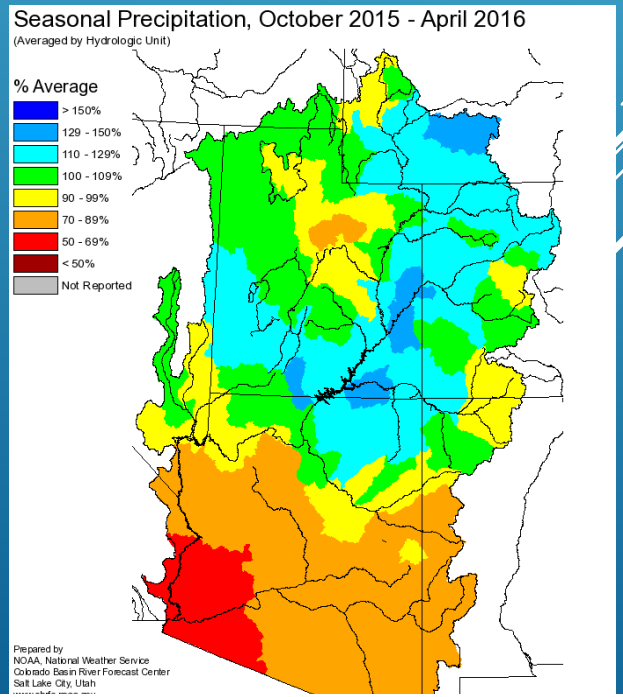
WY 2014



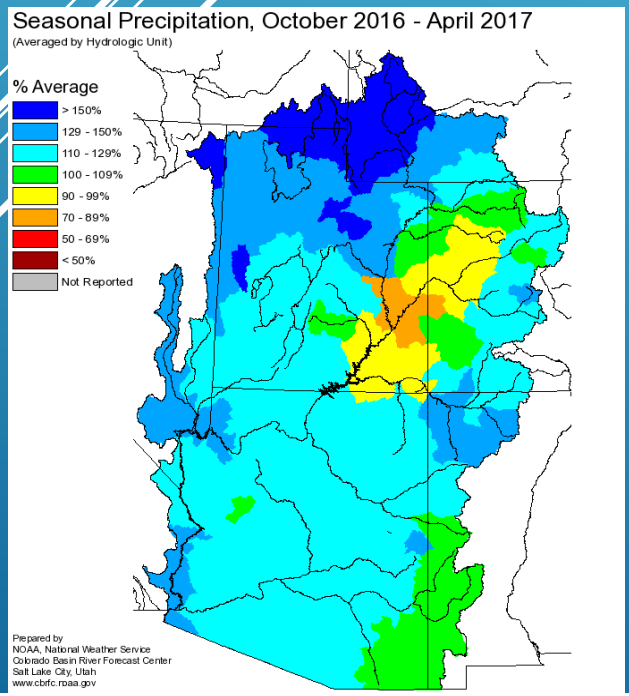
WY 2015



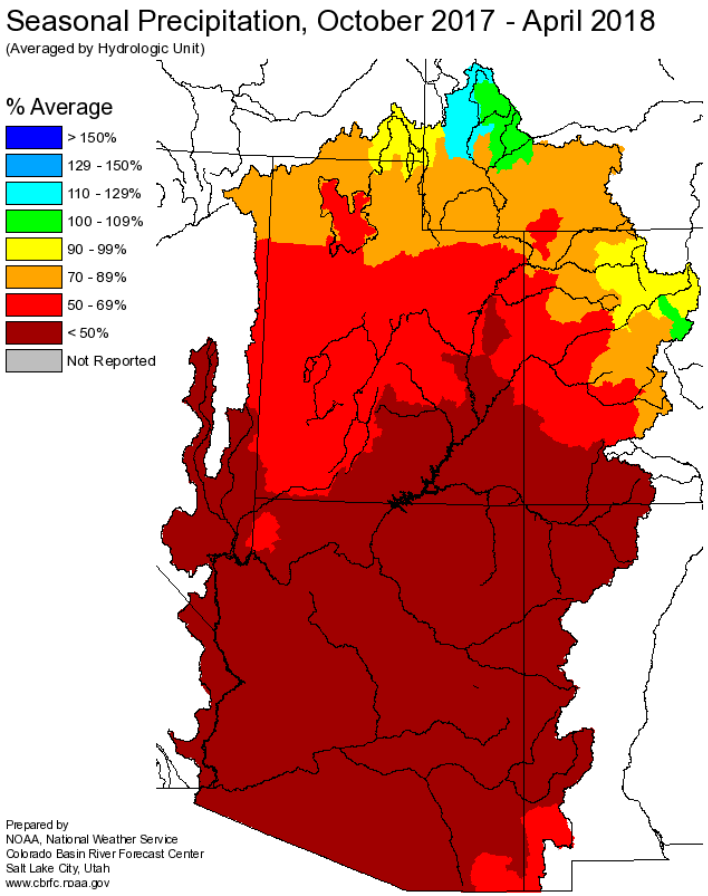
WY 2016

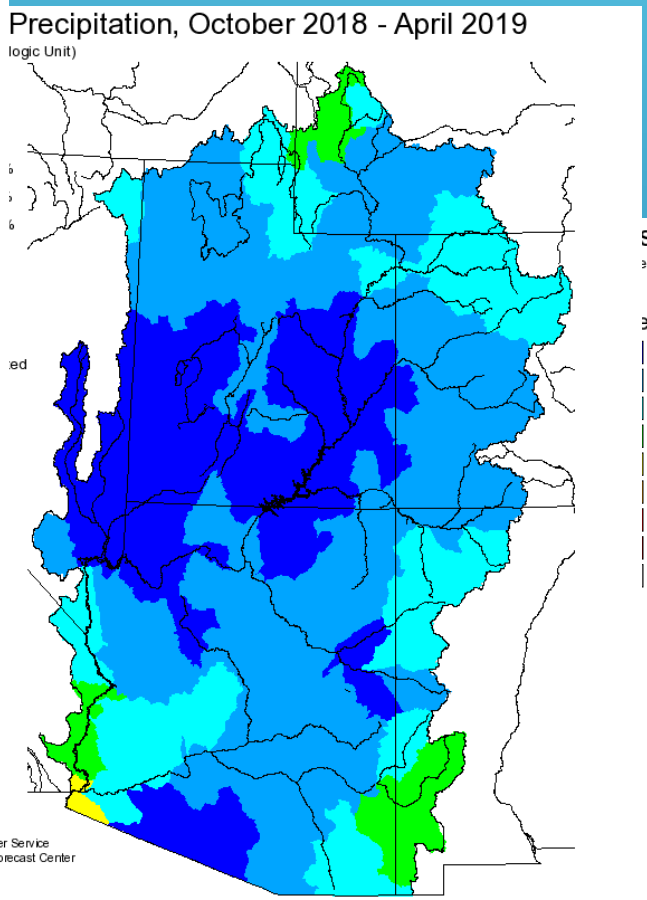


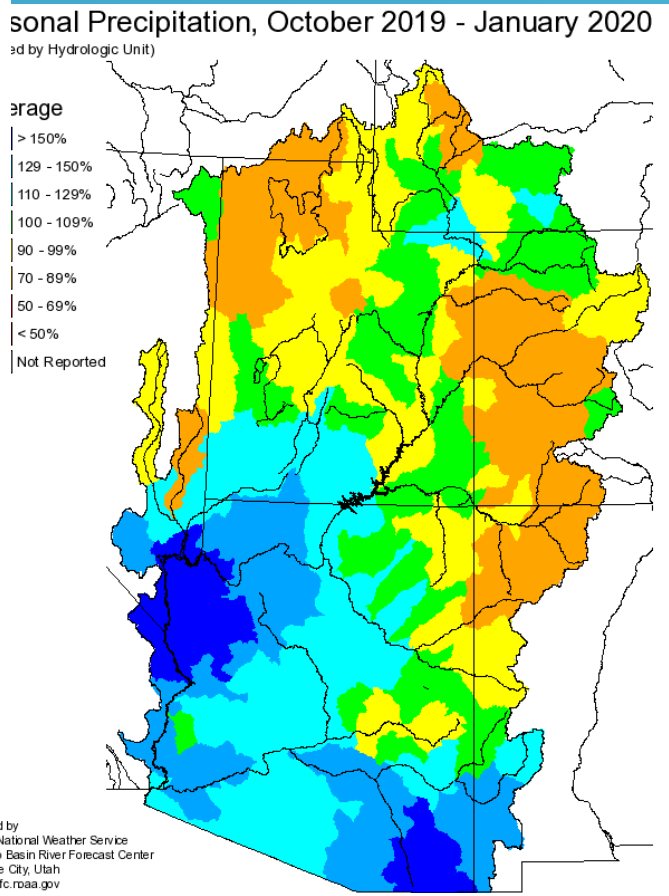
WY 2017



Precipitation % of Average
Winter 2018, 2019, 2020 (so far)





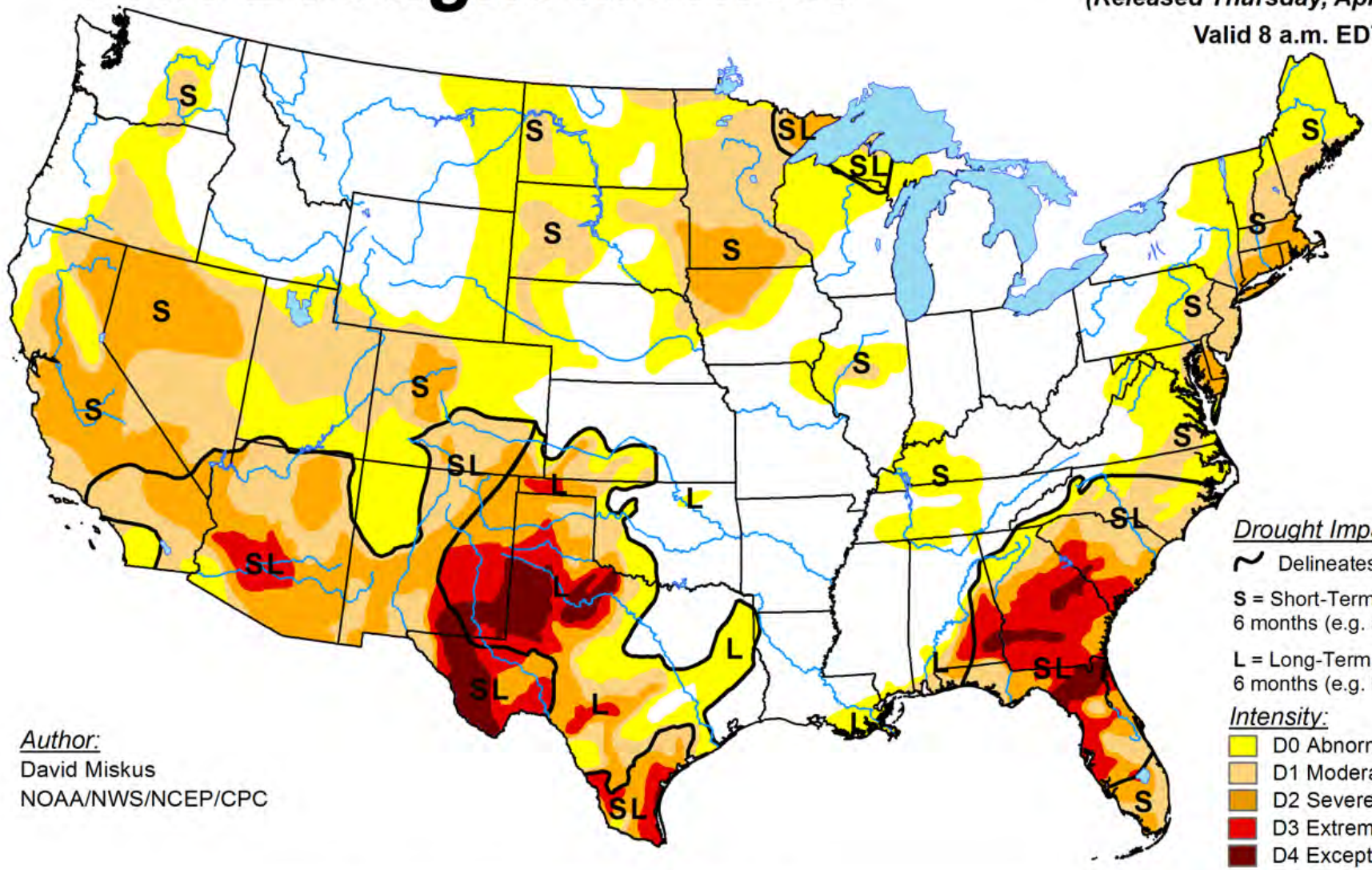


U.S. Drought Monitor

April 10, 2012

(Released Thursday, Apr. 12, 2012)

Valid 8 a.m. EDT



Author:
David Miskus
NOAA/NWS/NCEP/CPC

Drought Impact Types:

Delineates dominant impacts

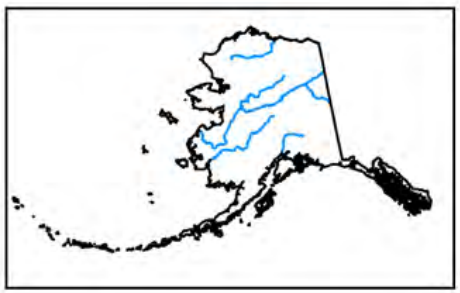
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)

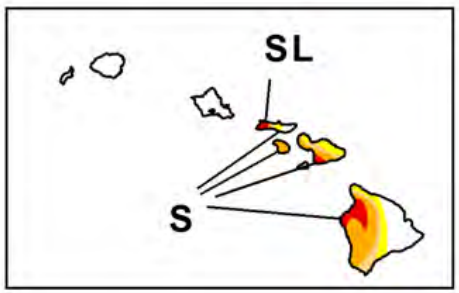
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

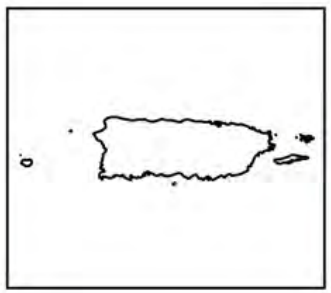
Intensity:

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

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





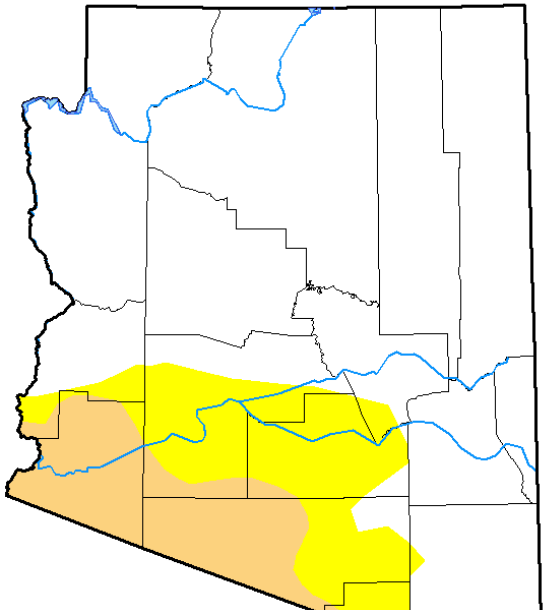


USDA

National Drought Mitigation Center

http://droughtmonitor.unl.edu/

U.S. Drought Monitor
Arizona



September 5, 2017
(Released Thursday, Sep. 7, 2017)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	75.16	24.84	10.69	0.00	0.00	0.00
Last Week 09-29-2017	75.16	24.84	10.69	0.00	0.00	0.00
3 Months Ago 06-06-2017	52.14	47.86	27.83	0.23	0.00	0.00
Start of Calendar Year 01-03-2017	38.68	61.32	24.76	3.65	0.00	0.00
Start of Water Year 09-27-2016	6.23	93.77	44.76	4.17	0.00	0.00
One Year Ago 09-06-2016	0.07	99.93	71.85	2.84	0.00	0.00

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

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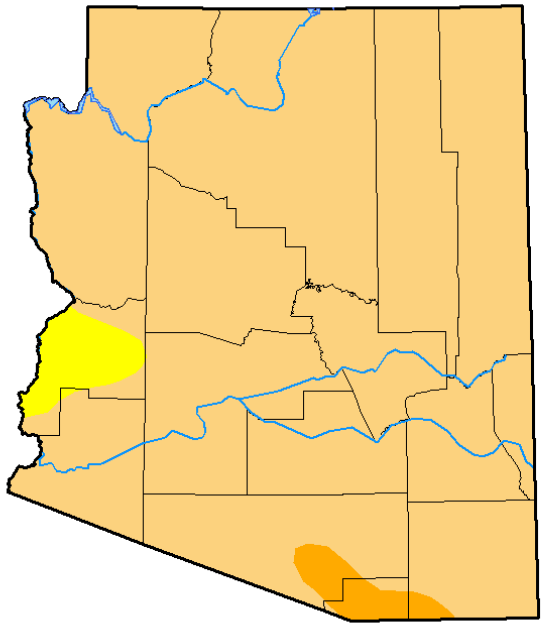
Author:
Deborah Bathke
National Drought Mitigation Center

U.S. Drought Monitor
Arizona



December 5, 2017
(Released Thursday, Dec. 7, 2017)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	97.28	2.05	0.00	0.00
Last Week 11-28-2017	0.00	100.00	73.10	2.05	0.00	0.00
3 Months Ago 09-05-2017	75.16	24.84	10.69	0.00	0.00	0.00
Start of Calendar Year 01-03-2017	38.68	61.32	24.76	3.65	0.00	0.00
Start of Water Year 09-26-2017	45.38	54.62	10.69	0.00	0.00	0.00
One Year Ago 12-06-2016	22.61	77.39	44.76	4.17	0.00	0.00

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

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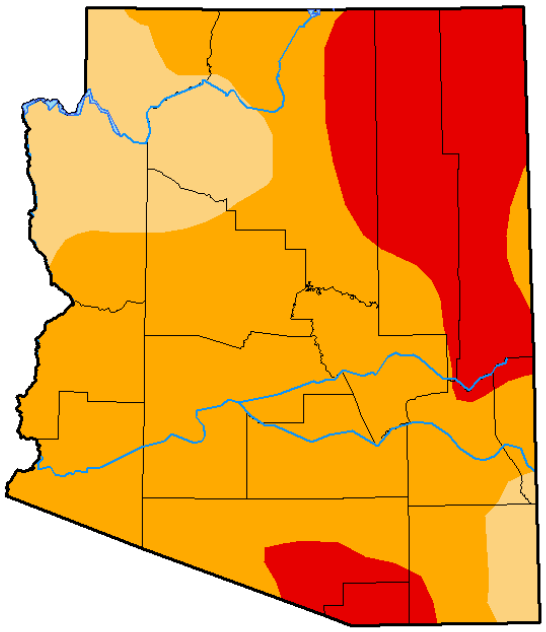
Author:
David Simeral
Western Regional Climate Center

U.S. Drought Monitor
Arizona



March 6, 2018
(Released Thursday, Mar. 8, 2018)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	84.09	23.77	0.00
Last Week 02-27-2018	0.00	100.00	100.00	73.22	9.27	0.00
3 Months Ago 12-05-2017	0.00	100.00	97.28	2.05	0.00	0.00
Start of Calendar Year 01-02-2018	0.00	100.00	100.00	28.66	0.00	0.00
Start of Water Year 09-26-2017	45.38	54.62	10.69	0.00	0.00	0.00
One Year Ago 03-07-2017	71.87	28.13	13.51	0.23	0.00	0.00

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

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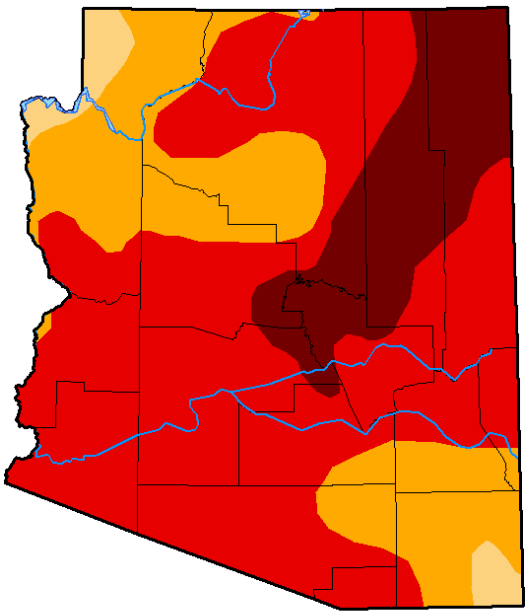
Author:
Richard Tinker
CPC/NOAA/NWS/NCEP

U.S. Drought Monitor
Arizona



June 5, 2018
(Released Thursday, Jun. 7, 2018)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	97.05	73.61	15.71
Last Week 05-29-2018	0.00	100.00	100.00	97.05	73.61	15.71
3 Months Ago 03-06-2018	0.00	100.00	100.00	84.09	23.77	0.00
Start of Calendar Year 01-02-2018	0.00	100.00	100.00	28.66	0.00	0.00
Start of Water Year 09-26-2017	45.38	54.62	10.69	0.00	0.00	0.00
One Year Ago 06-06-2017	52.14	47.86	27.83	0.23	0.00	0.00

Intensity:
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Author:
Anthony Artusa
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http://droughtmonitor.unl.edu/

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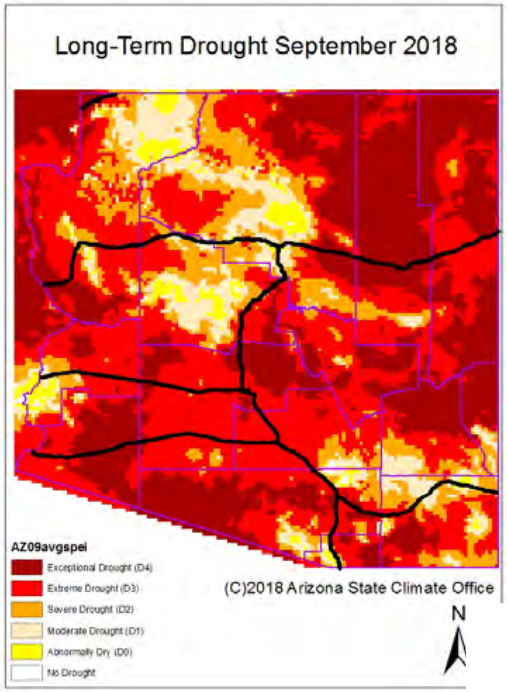
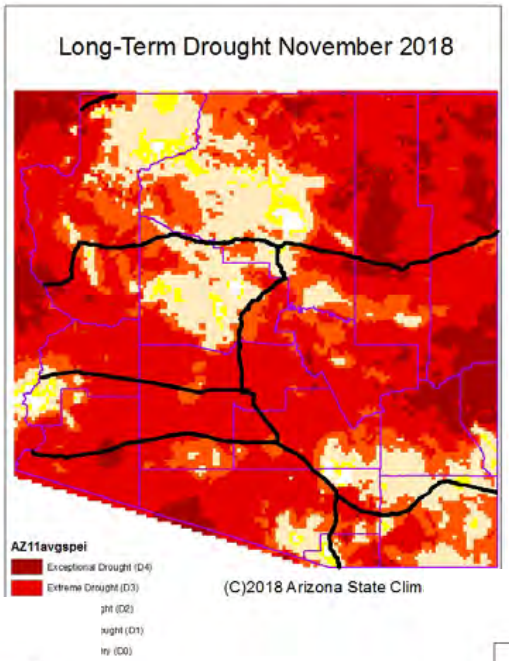
Arizona Long-Term Drought Status

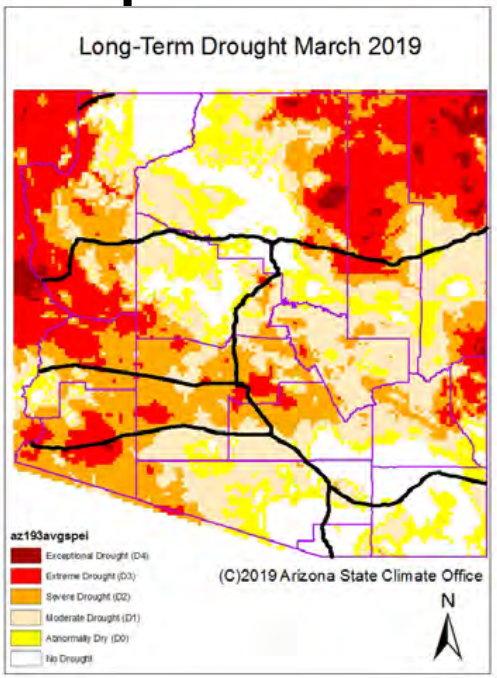
October 2018



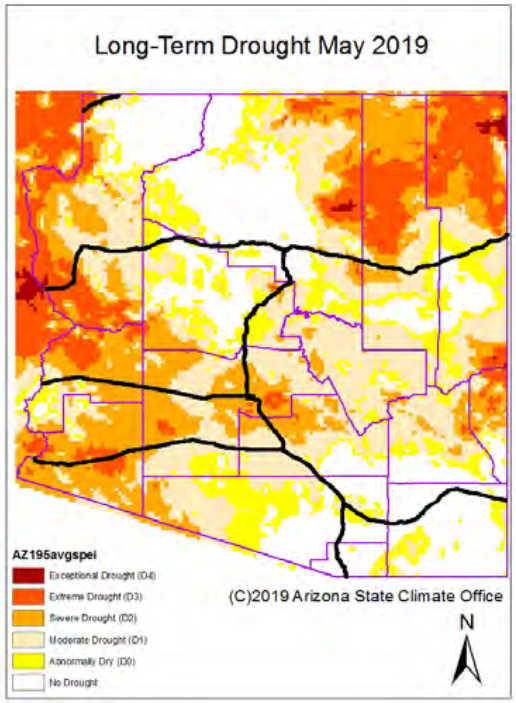
December 2018



April 2019

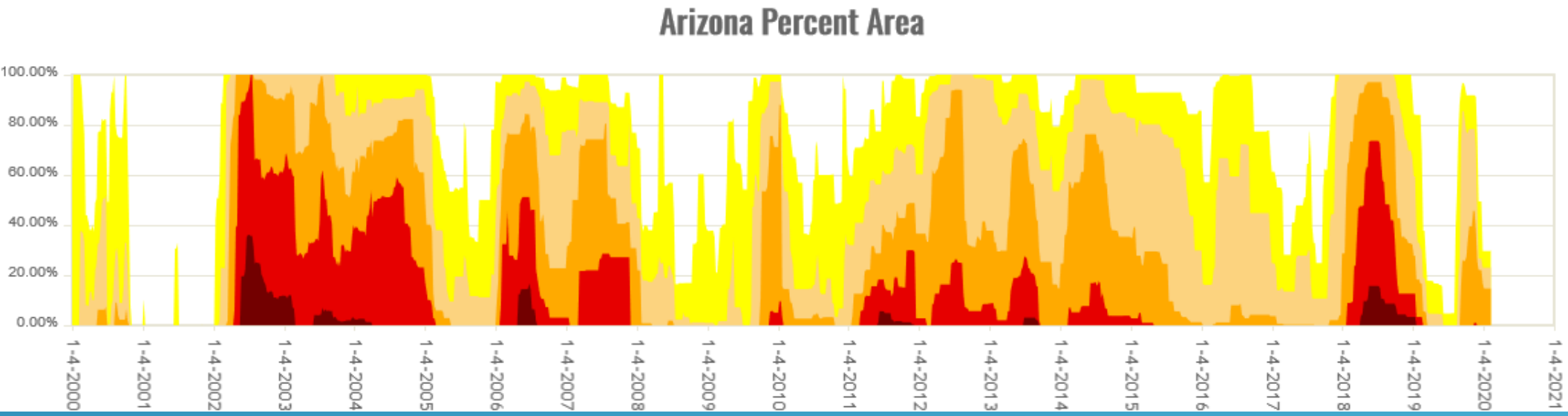


June 2019

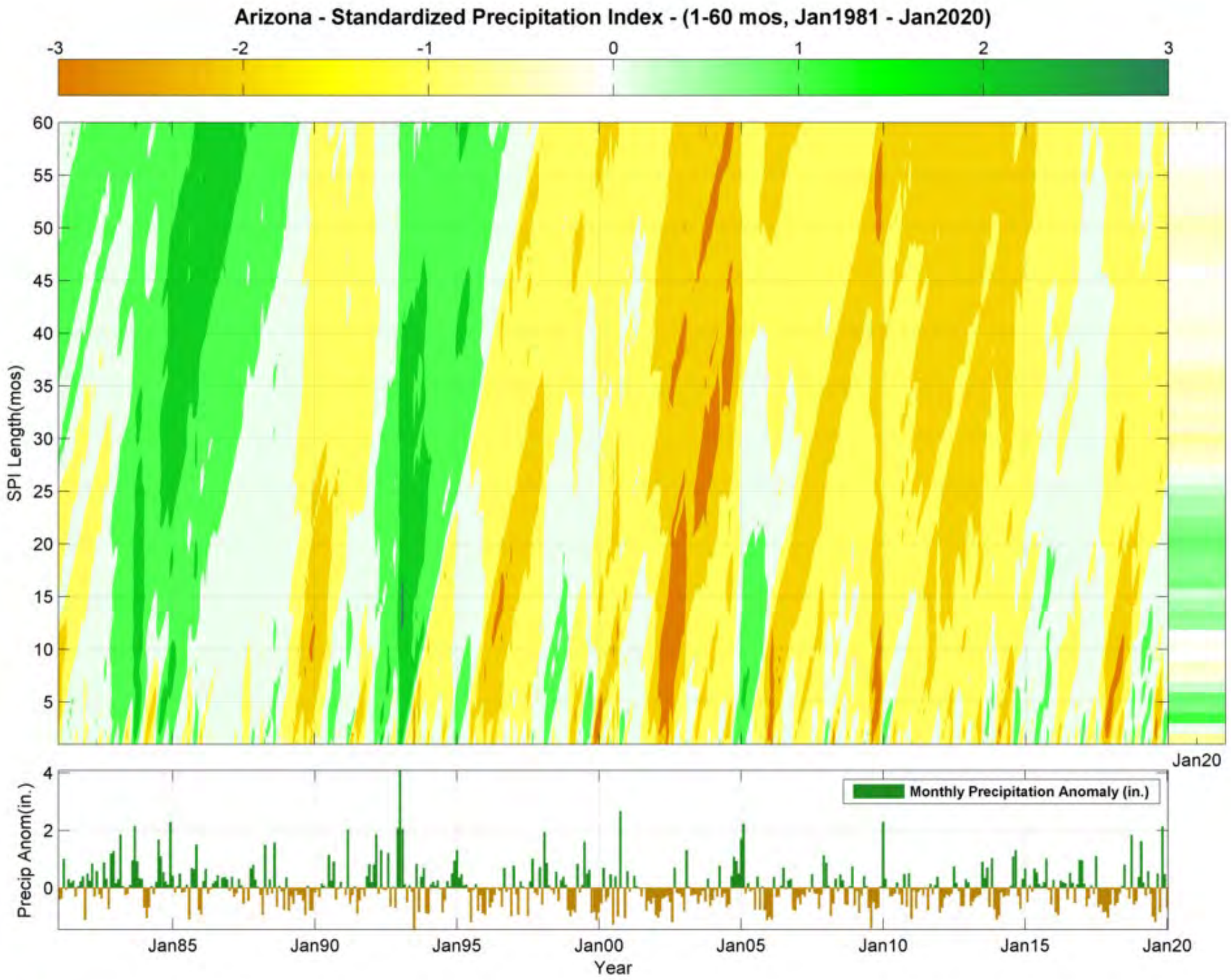


Based on average of 24-, 36-, and 48-month SPI & SPEI

Drought in Arizona since 2000



Drought Monitor map produced weekly by the National Drought Mitigation Center is used by USDA to identify counties that need drought relief in the form of agricultural assistance – including Livestock Forage Program, and economic relief from crop failure.



Climate Science Applications Program
University of Arizona Cooperative Extension
http://cals.arizona.edu/climate

Data source: NOAA National Climatic Data Center
ftp://ftp.ncdc.noaa.gov/pub/data/cirs/climdiv
Base Period= 1900-2020 Date created: 19-Feb-2020

WILLIAMS DECLARES WATER CRISIS

ARIZONA DAILY SUN
MARCH 5, 2014

Arizona Town Literally Running Out Of Water

Written by: Tara Dodrill Current Events May 17, 2014 1 Comment Print This Article

A northern Arizona town near the Grand Canyon is running out of water.

The water reserves are so low, in fact, that the residents of the city of Williams can be fined for washing their cars and watering their lawns. When they go out for date night, they no longer automatically get a glass of water with their meal.

The city is under a "level 4" water crisis — the highest level.

OffTheGridNews May 17, 2014

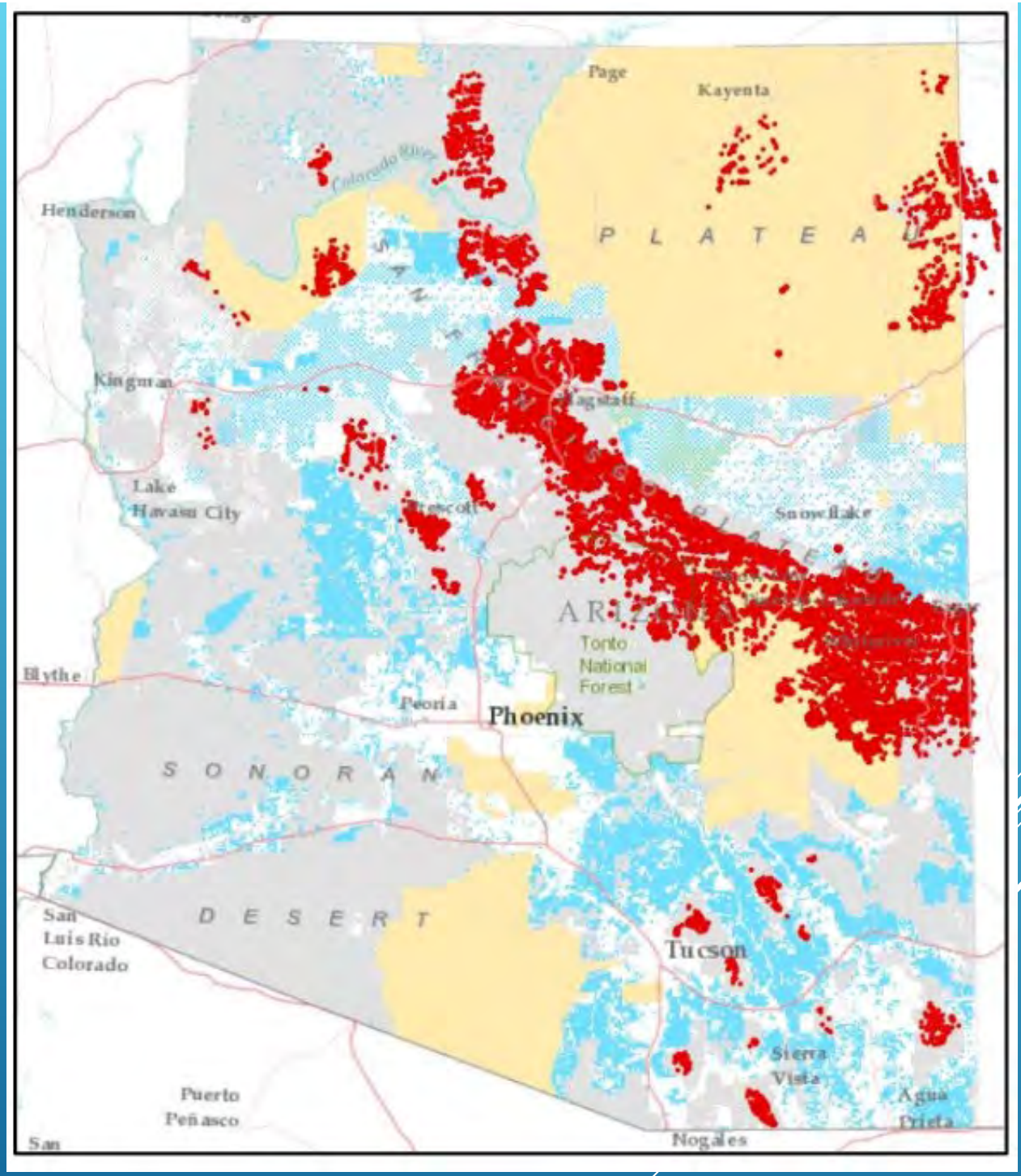
Bark Beetle Infestation - 2018

Figure 3. Ponderosa pine mortality in the transition zone. Photo Credit: Daniel DePinte

Source: Arizona Forest Health Conditions 2018, AZ. Dept of Forestry and Fire Management

2018 – Bark Beetle infestation map.

Increase in acres affected by Bark Beetles from 2017 to 2018 was 3,141%



Source: Arizona Forest Health Conditions 2018, AZ. Dept of Forestry and Fire Management

Mt. Bigelow

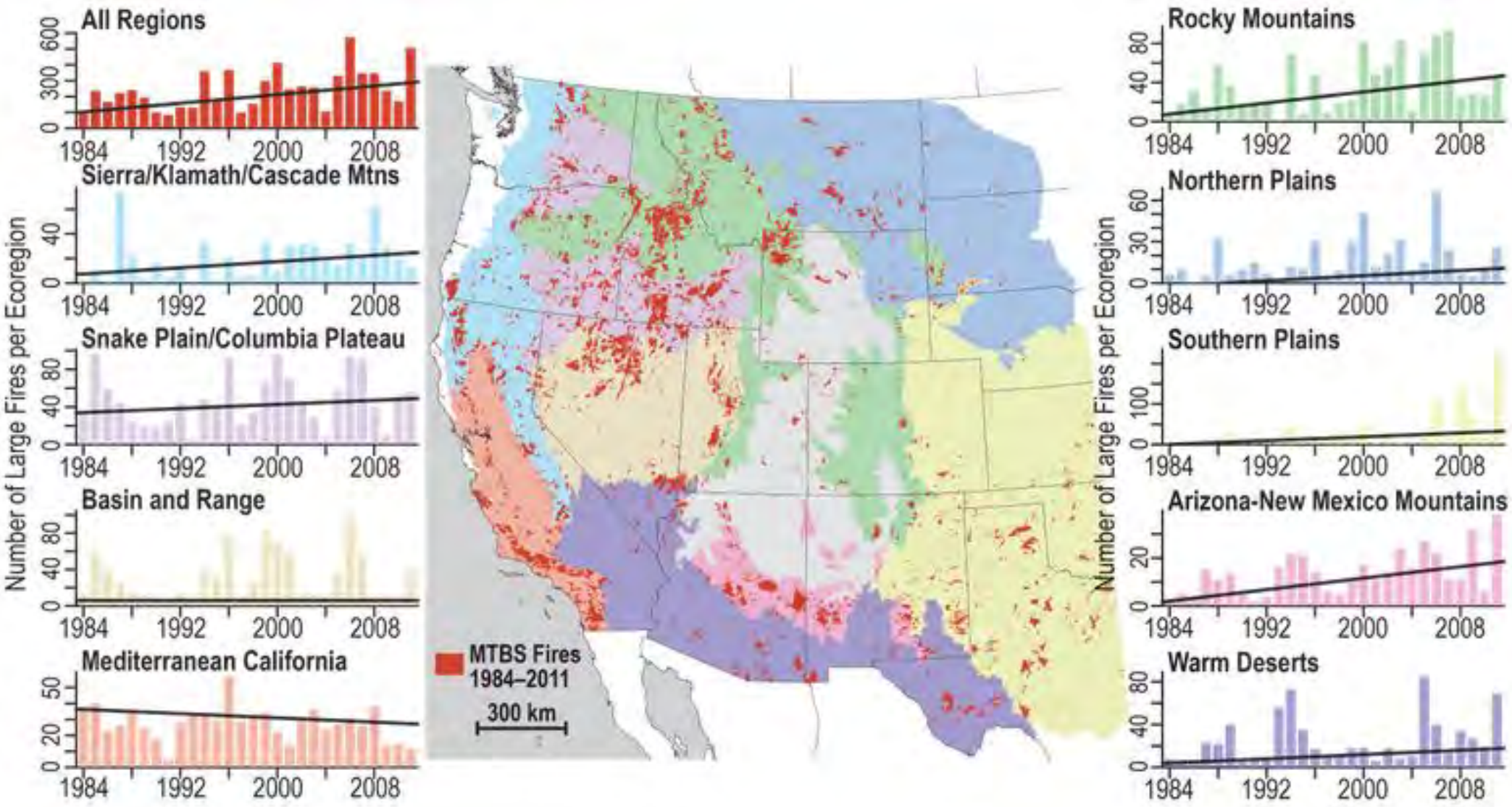
Rodeo-Chediski
2002
468,638 acres
burned

The Rodeo-Chediski Fire burns across the Mogollon Rim. The massive 2002 blaze burned 468,638 acres. *USDA, Apache-Sitgreaves NF*

http://www.srpnet.com/water/forest/involvement.aspx

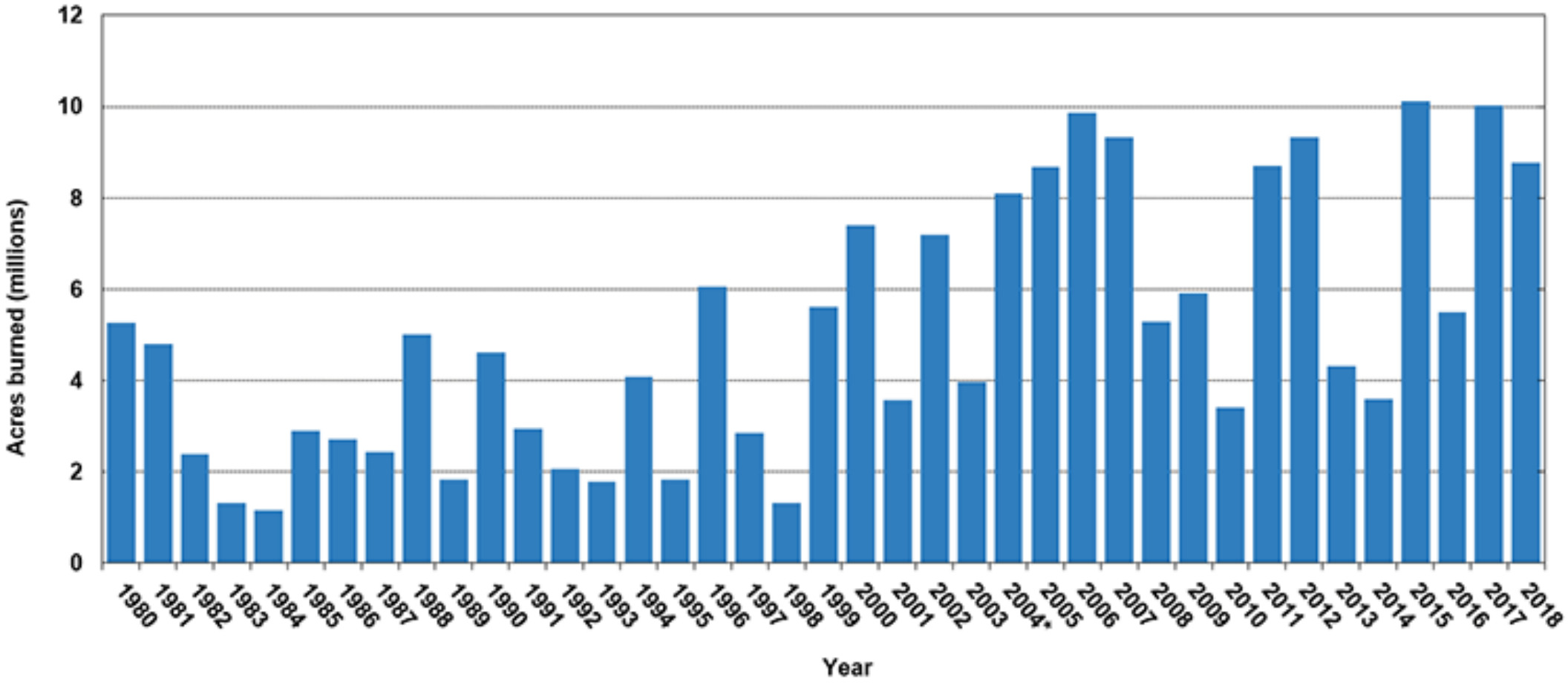

Wallow Fire - 2011
~538,049 acres, 841 sq. mi.
Kari Greer/U.S. Forest Service

Number of Large Wildfires in Western Regions from 1984-2011



Climate Science Special Report: Fourth National Climate Assessment

Annual Number of Acres Burned in Wildland Fires, 1980-2018



Top 10 States At High To Extreme Wildfire Risk, 2019 (1)

Rank	State	Estimated number of properties at risk	Rank	State	Percent of properties at risk
1	California	2,019,800	1	Montana	29%
2	Texas	717,800	2	Idaho	26
3	Colorado	371,100	3	Colorado	17
4	Arizona	237,900	4	California	15
5	Idaho	175,000	5	New Mexico	15
6	Washington	160,500	6	Utah	14
7	Oklahoma	153,400	7	Wyoming	14
8	Oregon	151,400	8	Oklahoma	9
9	Montana	137,800	9	Oregon	9
10	Utah	136,000	10	Arizona	8

(1) As of September 2019.

Source: Verisk Wildfire Risk Analytics used data from FireLine®, Verisk's wildfire risk management tool.

Chemistry of Wildfires

- **Primary air pollutants**
  - Particulate Matter (PM)
  - CO
  - NO_2
  - Polycyclic aromatic hydrocarbons (PAHs)
  - Volatile organic compounds (VOCs)

- **Secondary air pollutants**
  - Particulate Matter (PM)
  - Ozone

- **When vehicles and buildings burn:**
  - Structural fire smoke contains other toxic air contaminants
    - HCN, HCl, phosgene, metals
    - toluene, styrene, dioxins

Presentation Wildfires & Health
Kari Nadeau, Ph.D. M.D. Stanford Medicine
http://med.stanford.edu/wildfire-and-health-Presentation-Kari-2.17.19rev.pptx

Floodwaters gather at the Schultz Fire site. Estimates put the damage caused by the fire and subsequent flooding at $147 million. *Ecological Restoration Institute, NAU*

http://www.srpnet.com/water/forest/involvement.aspx

Post-Fire Burn Scar Health Effects:

High fire temperatures force hydrophobic substances into the soil essentially sealing it from absorbing water.
Run-off after rainfall becomes overland flow, causing significant flooding downstream of the fire.

Debris from the burn is also washed downstream into the washes, streams, and reservoirs, leading to water quality issues.

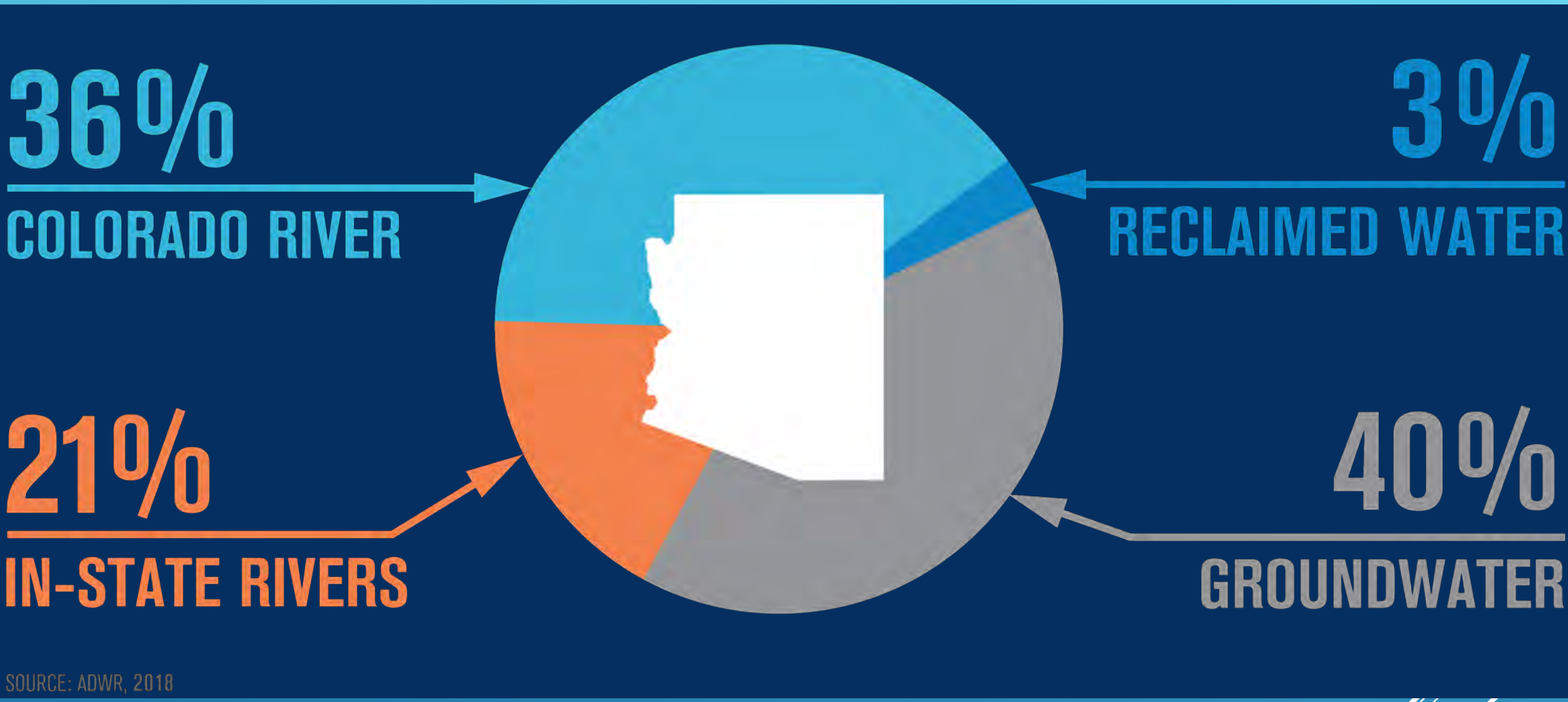
Ponding of water that does not infiltrate leads to increased populations of potentially disease carrying mosquitos.

July 5, 2011 Major Dust Storm 50 mph winds, ~100 miles wide, 5000-6000 feet high, traveled 150 miles from Tucson past Wickenburg

http://www.wrh.noaa.gov/psr/pns/2011/July/DustStorm.php

Highway Dust Storms

Arizona Water Sources



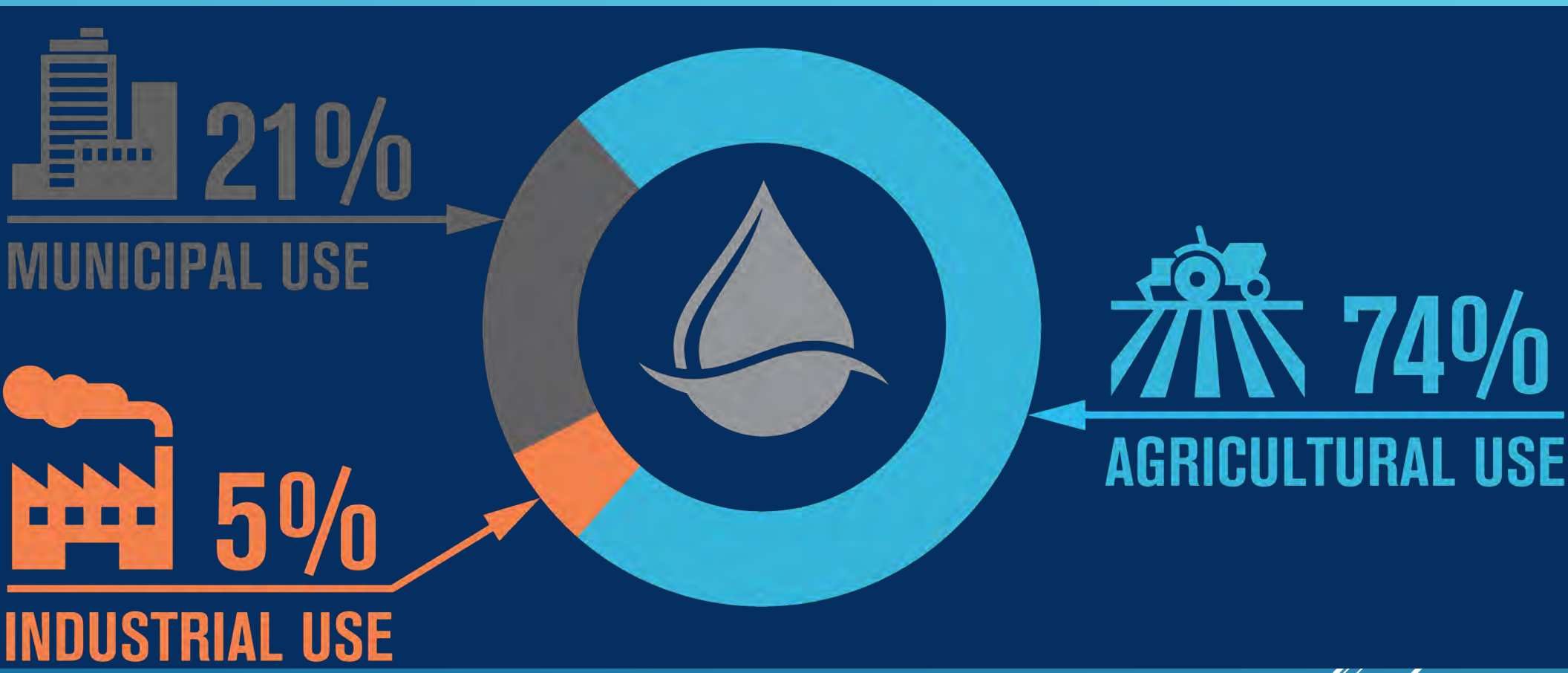
FISSURING SUBSIDENCE

1957

18.2’ Drop

1991

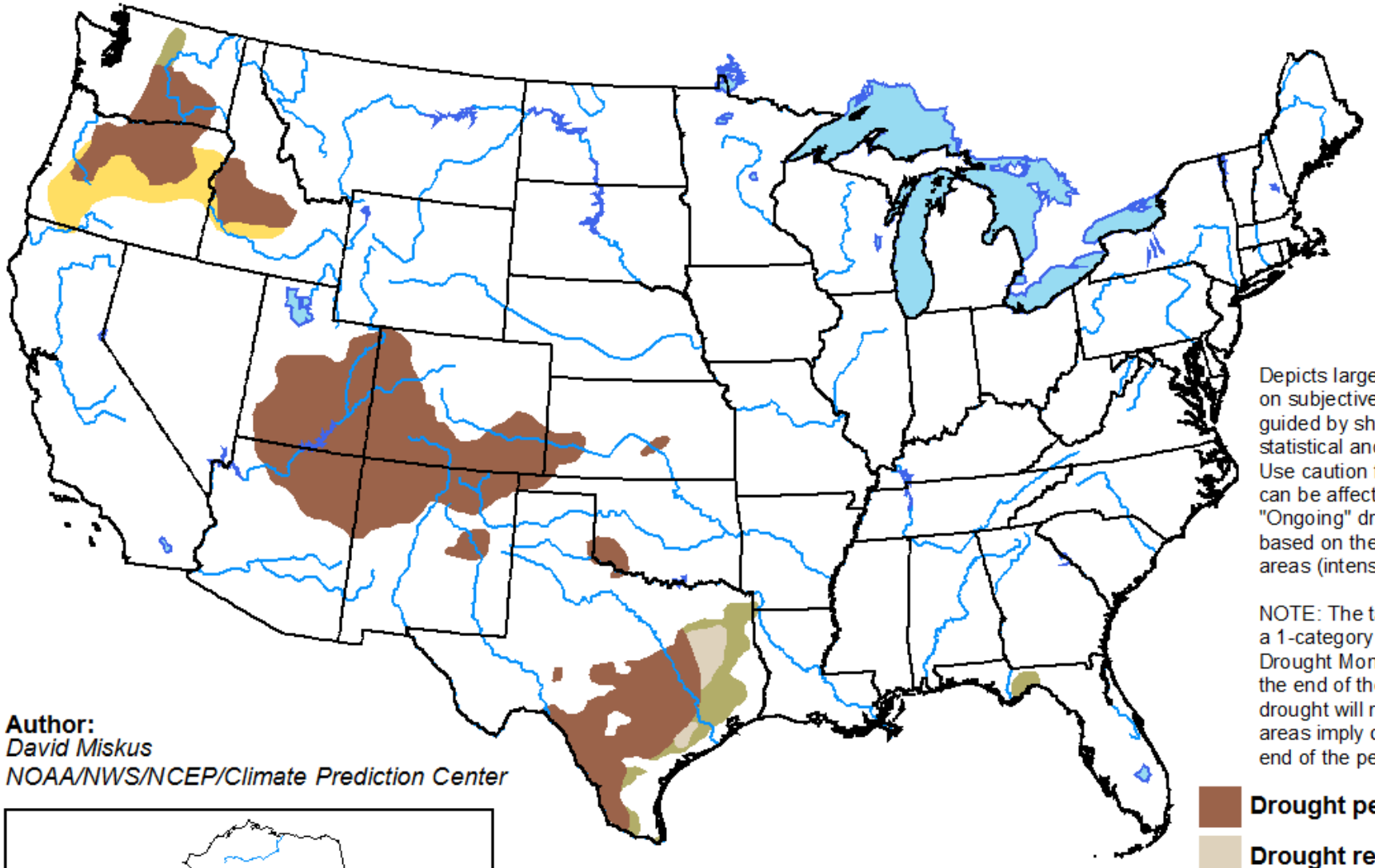
Overpumping Groundwater – prevalent in East Valley


21%
MUNICIPAL USE
74%
AGRICULTURAL USE
5%
INDUSTRIAL USE

U.S. Monthly Drought Outlook

Drought Tendency During the Valid Period

Valid for February 2020
Released January 31, 2020



Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that can be affected by short lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor areas (intensities of D1 to D4).

NOTE: The tan areas imply at least a 1-category improvement in the Drought Monitor intensity levels by the end of the period, although drought will remain. The green areas imply drought removal by the end of the period (D0 or none).

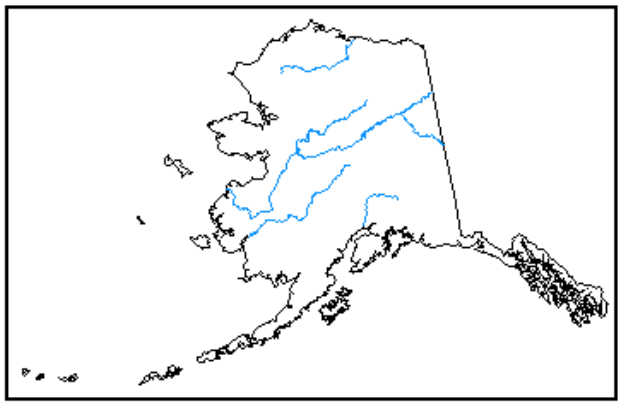
Drought persists

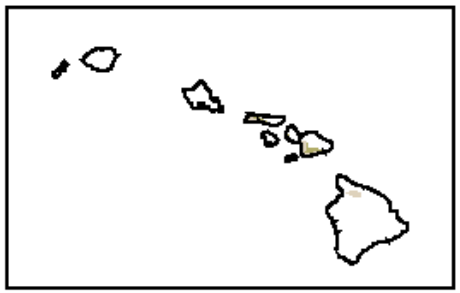
Drought remains but improves

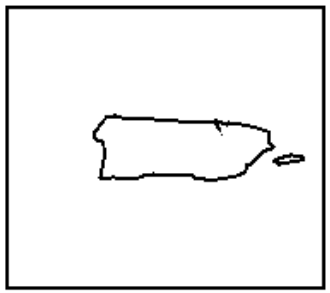
Drought removal likely

Drought development likely

Author:
David Miskus
NOAA/NWS/NCEP/Climate Prediction Center





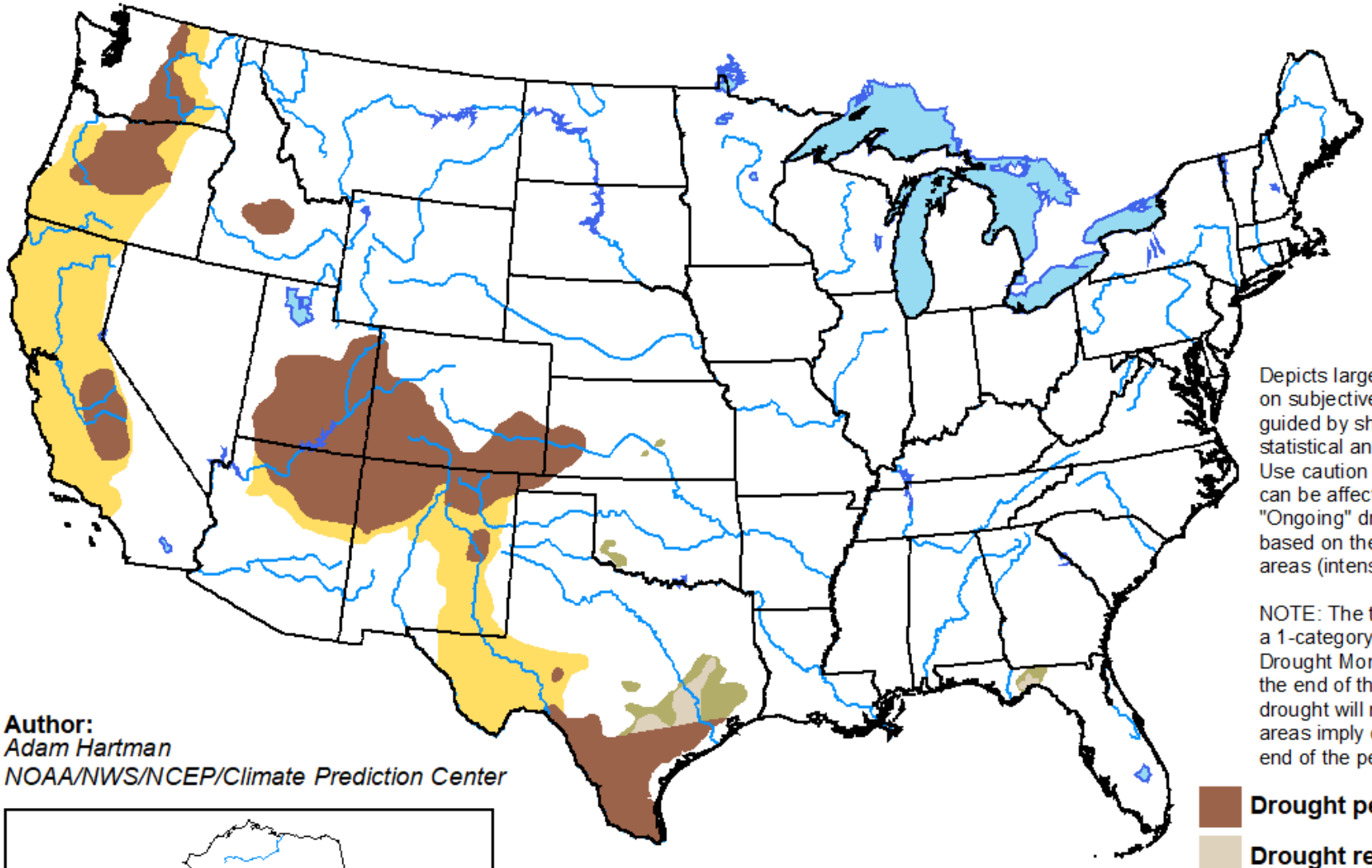


http://go.usa.gov/3eZGd

U.S. Seasonal Drought Outlook

Drought Tendency During the Valid Period

Valid for February 20 - May 31, 2020
Released February 20



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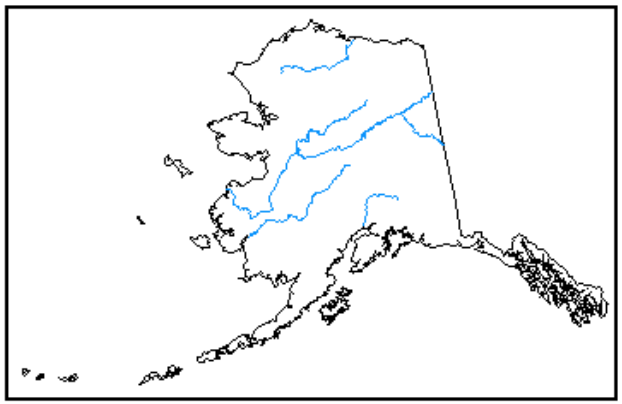
Drought persists

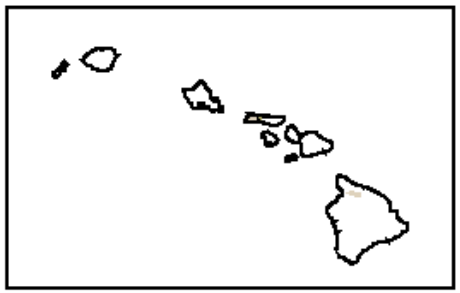
Drought remains but improves

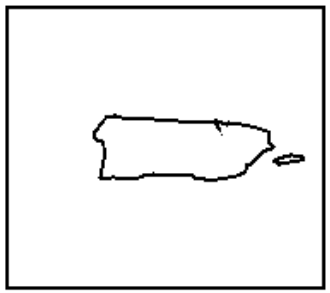
Drought removal likely

Drought development likely

Author:
Adam Hartman
NOAA/NWS/NCEP/Climate Prediction Center







http://go.usa.gov/3eZ73

QUESTIONS?

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480-965-0580

ARIZONA STATE CLIMATE OFFICE