

# Oregon-Washington Water Year 2021 Climatological Recap

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## Key points:

- (1) Although ongoing, the WY2021 Oregon drought ranks among the 4 worst in state recorded history alongside 1924, 1931, and 1977**
- (2) Large portions of eastern Washington also experienced a historically significant drought**
- (3) Key drivers of the severity of the drought include record high temperatures which fueled high evaporative demand, record low precipitation during spring and summer, and early meltout of the mountain snowpack**

*Wickiup Reservoir, August 19, 2021  
Image Courtesy of The Bend Bulletin*



**Oregon State University**  
College of Earth, Ocean,  
and Atmospheric Sciences



# Summary of major weather and hydrological events

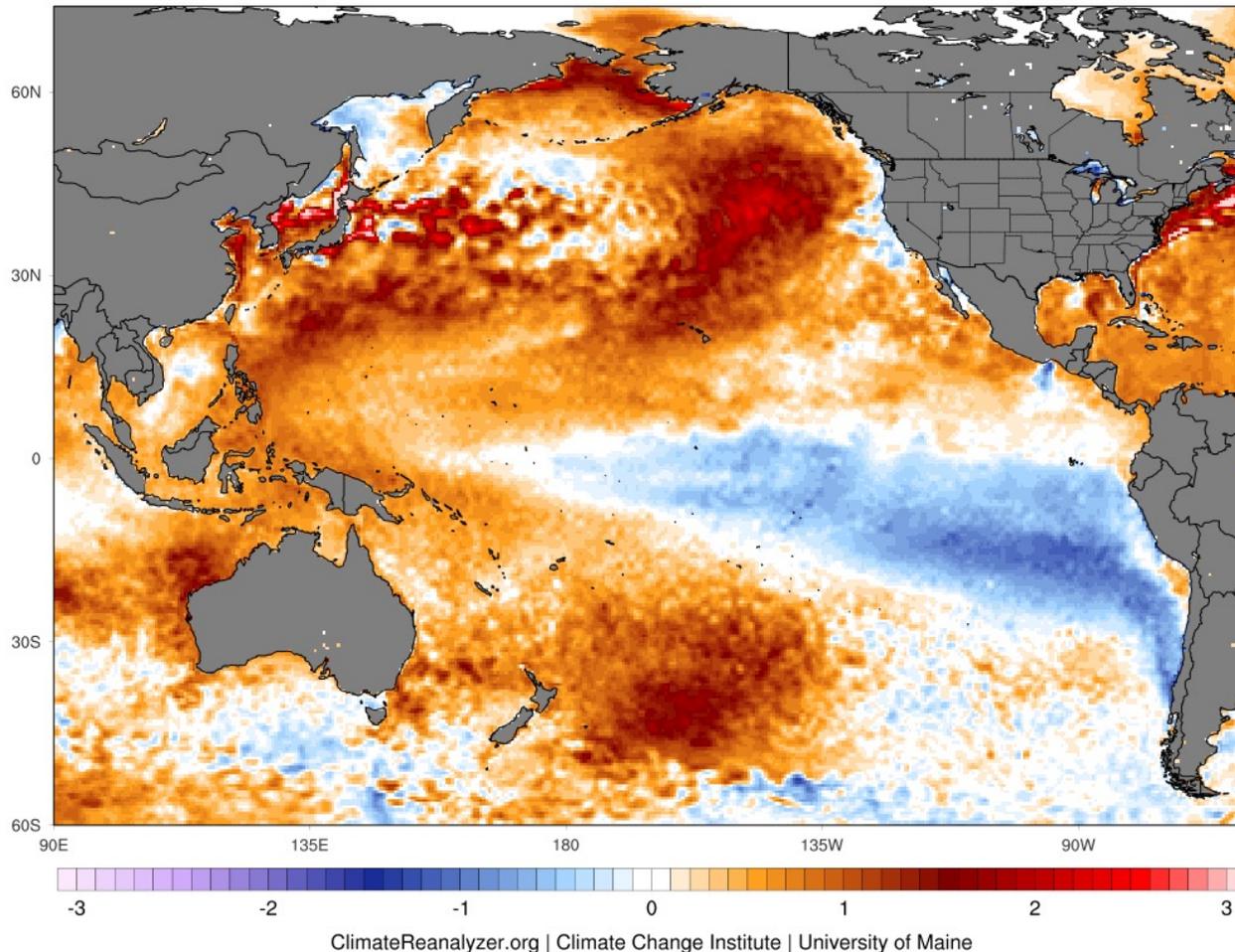
- Moderate La Niña in fall 2020-winter 2021
- Jan/Feb 2021 atmospheric river events
- February 2021 ice storm
- Above average snowpack in WA and north OR Cascades
- Historic late June heat wave
- Another weak summer monsoon season
- Record dry spring/summer
- Historically significant drought in most of Oregon and eastern Washington
- Record warm summer in much of OR and WA fuels record levels of evaporative demand
- Active wildfire season, but no late summer/early fall east wind events
- Late September 2021 atmospheric river event

# Pacific Sea Surface Temperature Anomalies

## Nov-Dec-Jan 2020-2021

Sea Surface Temperature Anomaly (°C)  
NDJ 2020-2021 - 1979-2000

ECMWF ERA5 (0.5x0.5 deg)



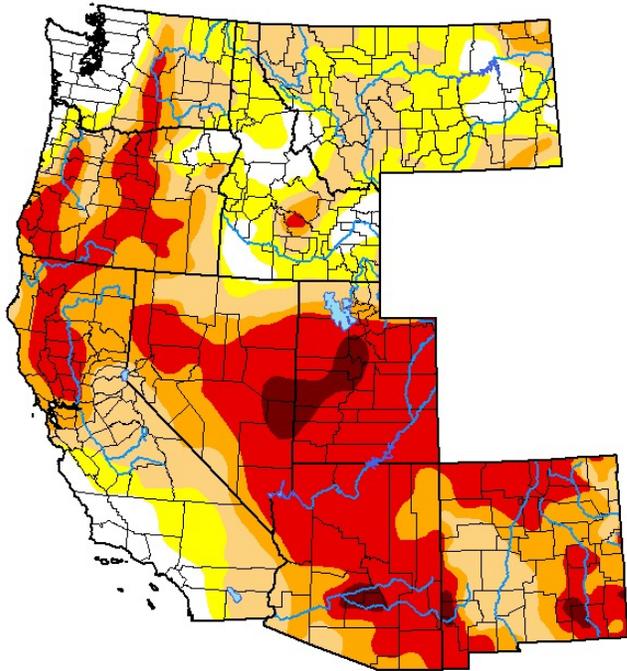
We began WY2021 with moderate La Niña conditions in the eastern equatorial Pacific Ocean

In many parts of the Pacific Northwest, La Niña is historically associated with above average precipitation and mountain snowpack

This bred optimism last fall for drought recovery!

# Drought progression throughout WY2021

## U.S. Drought Monitor West



**September 29, 2020**  
(Released Thursday, Oct. 1, 2020)  
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
<b>Current</b>	9.96	90.04	73.14	51.29	32.19	2.50
<b>Last Week</b> 09-24-2020	8.99	91.01	70.45	49.65	27.95	1.52
<b>3 Months Ago</b> 07-02-2020	38.10	61.90	42.12	21.57	2.42	0.00
<b>Start of Calendar Year</b> 01-02-2020	60.49	39.51	16.48	6.45	0.00	0.00
<b>Start of Water Year</b> 10-03-2019	71.40	28.60	16.76	3.81	0.00	0.00
<b>One Year Ago</b> 10-03-2019	71.40	28.60	16.76	3.81	0.00	0.00

Intensity:



The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:  
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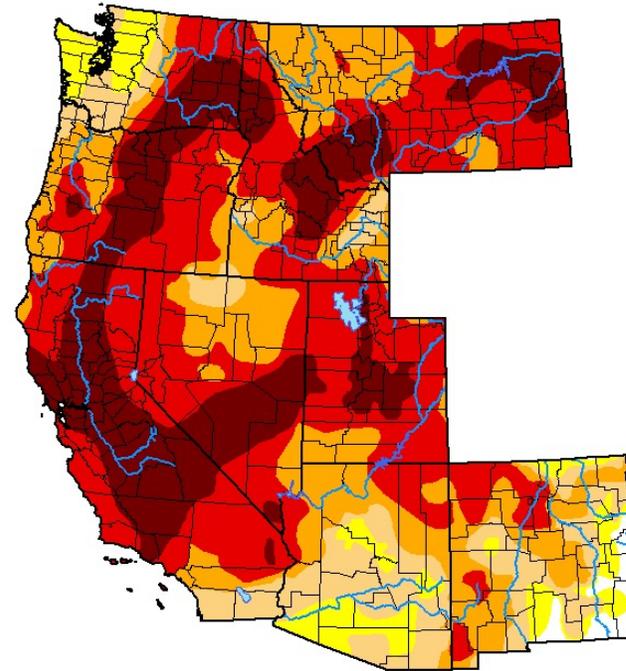


[droughtmonitor.unl.edu](http://droughtmonitor.unl.edu)

### On September 29, 2020:

- Oregon: 6% of area drought-free
  - 34% in D3; 32% in D2; 19% in D1; 9% in D0
- Washington: 37% of area drought-free
  - 6% in D3; 11% in D2; 27% in D1; 19% in D0

## U.S. Drought Monitor West



**October 5, 2021**  
(Released Thursday, Oct. 7, 2021)  
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
<b>Current</b>	1.26	98.74	92.86	81.03	58.81	21.37
<b>Last Week</b> 09-28-2021	1.32	98.68	93.35	81.07	58.72	21.77
<b>3 Months Ago</b> 07-06-2021	0.76	99.24	93.73	83.03	59.97	26.29
<b>Start of Calendar Year</b> 12-29-2020	13.52	86.48	75.49	63.25	45.40	23.76
<b>Start of Water Year</b> 09-28-2021	1.32	98.68	93.35	81.07	58.72	21.77
<b>One Year Ago</b> 10-06-2020	9.30	90.70	74.17	52.53	33.97	3.66

Intensity:



The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:  
Brian Fuchs  
National Drought Mitigation Center



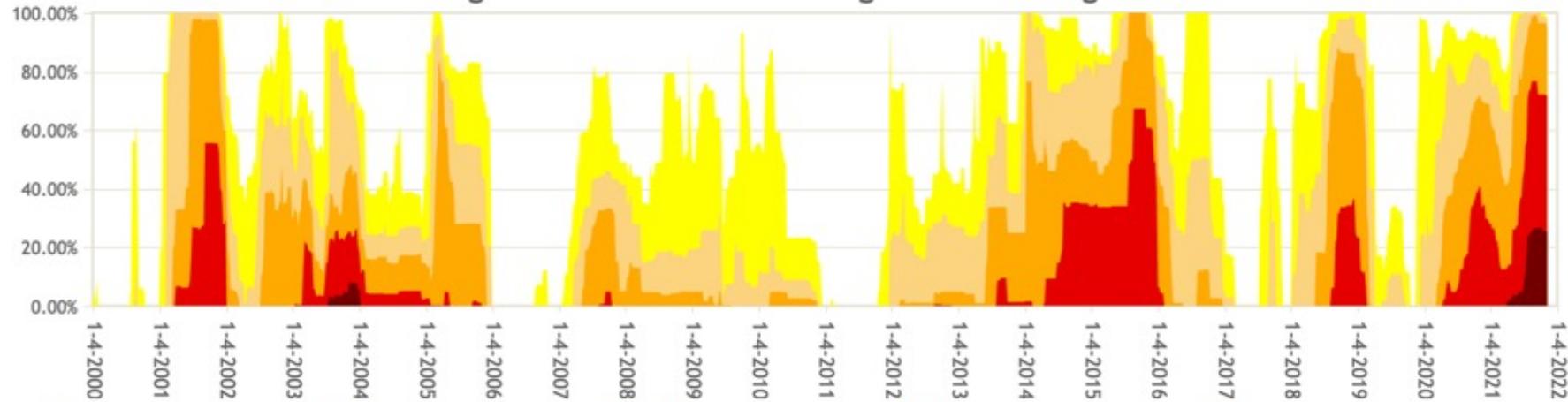
[droughtmonitor.unl.edu](http://droughtmonitor.unl.edu)

### On October 5, 2021:

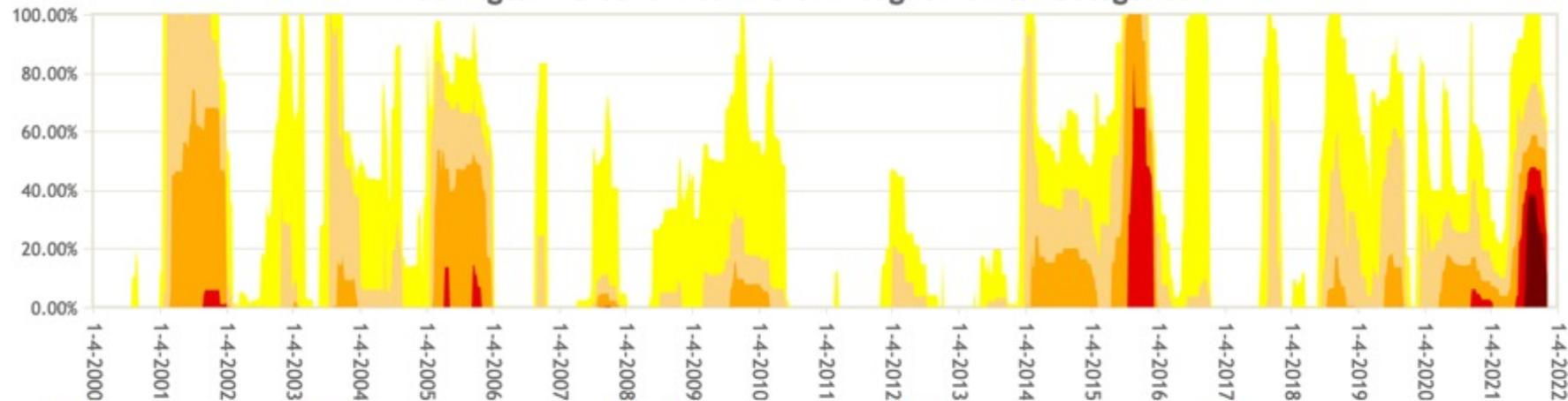
- Oregon: 0% of area drought-free
  - 27% in D4; 46% in D3; 24% in D2; 3% in D1; 0% in D0
- Washington: 0% of area drought-free
  - 25% in D4; 22% in D3; 8% in D2; 18% in D1; 27% in D0

# PacNW drought through the ages

Oregon Percent Area in U.S. Drought Monitor Categories



Washington Percent Area in U.S. Drought Monitor Categories



Legend for U.S. Drought Monitor Categories:

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

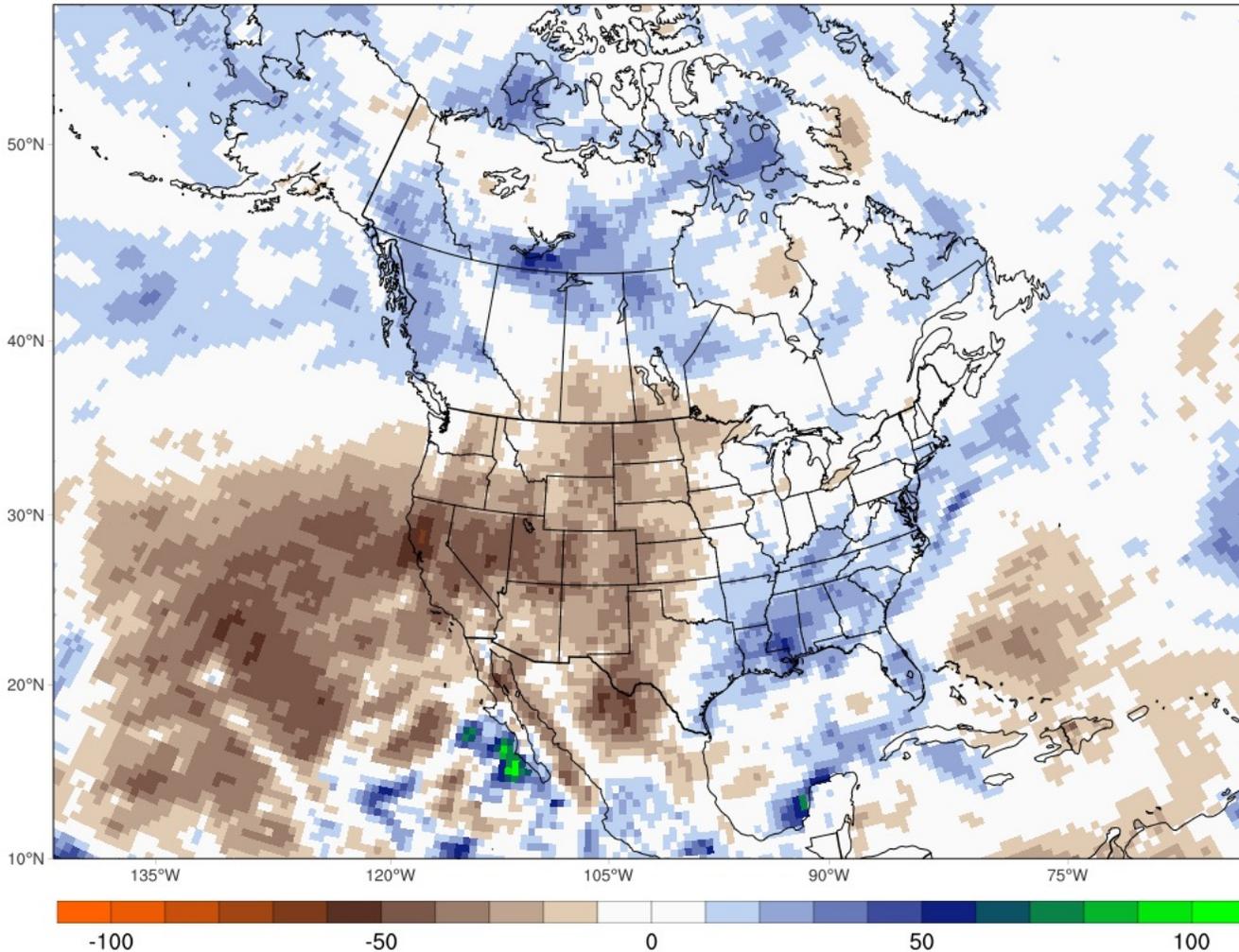
This year, since the USDM began weekly drought classification in early 2000:

- Oregon:
  - Had only its second D4 classification
  - Had its most extensive D3+ classification
- Washington had its first D4 classification
- At the drought's peak in mid-Sept, D4 covered 27% of Oregon and 38% of Washington

# WY2021 Precipitation Anomaly (percentage)

Acc. Precipitation Anomaly (%)  
Water Year (Oct-Sep) 2020-2021 - 1979-2000

ECMWF ERA5 (0.5x0.5 deg)



ClimateReanalyzer.org | Climate Change Institute | University of Maine

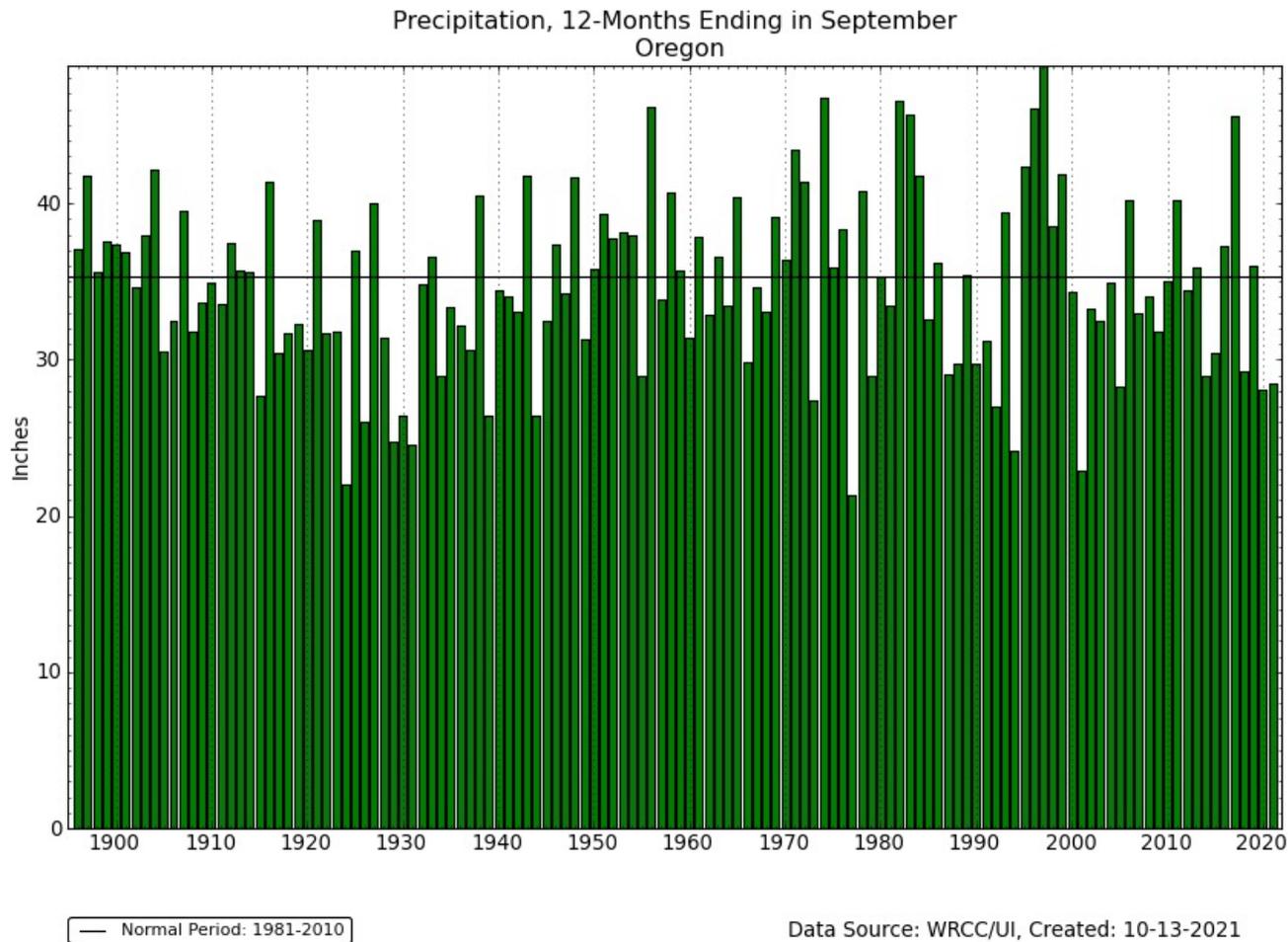
Western half of the continental US was well below average in precipitation for WY2021 while the SE US and Mid-Atlantic regions were well above average

This La Niña event was a bit drier in much of the PacNW than is typically observed during other La Niña events

The pattern of dry conditions in California and wet conditions surrounding the Gulf of Alaska is consistent with many other La Niña events

Western Washington and the north Oregon Cascades received near normal precipitation and above average snowpack

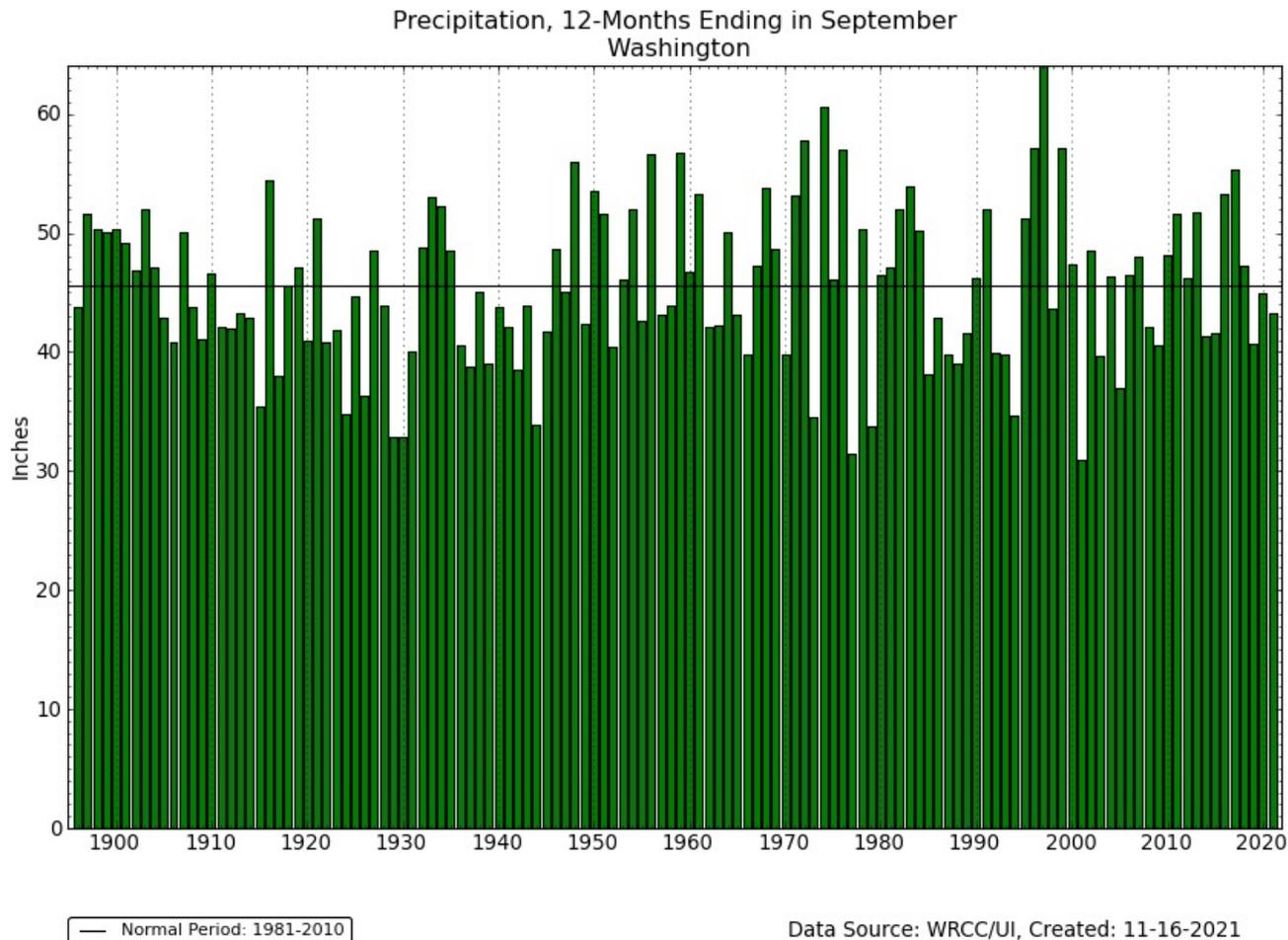
# Oregon WY 2021 Total Precipitation



- Oregon received 80.7% of avg precip for WY2021
- Ranks 16<sup>th</sup> lowest out of 127 years
- In 16 out of the last 22 years, Oregon has received below average precipitation
- The last two years have been well below normal, making this a multi-year drought

Source: Westwide Drought Tracker using the PRISM precipitation analysis (preliminary)

# Washington WY 2021 Total Precipitation



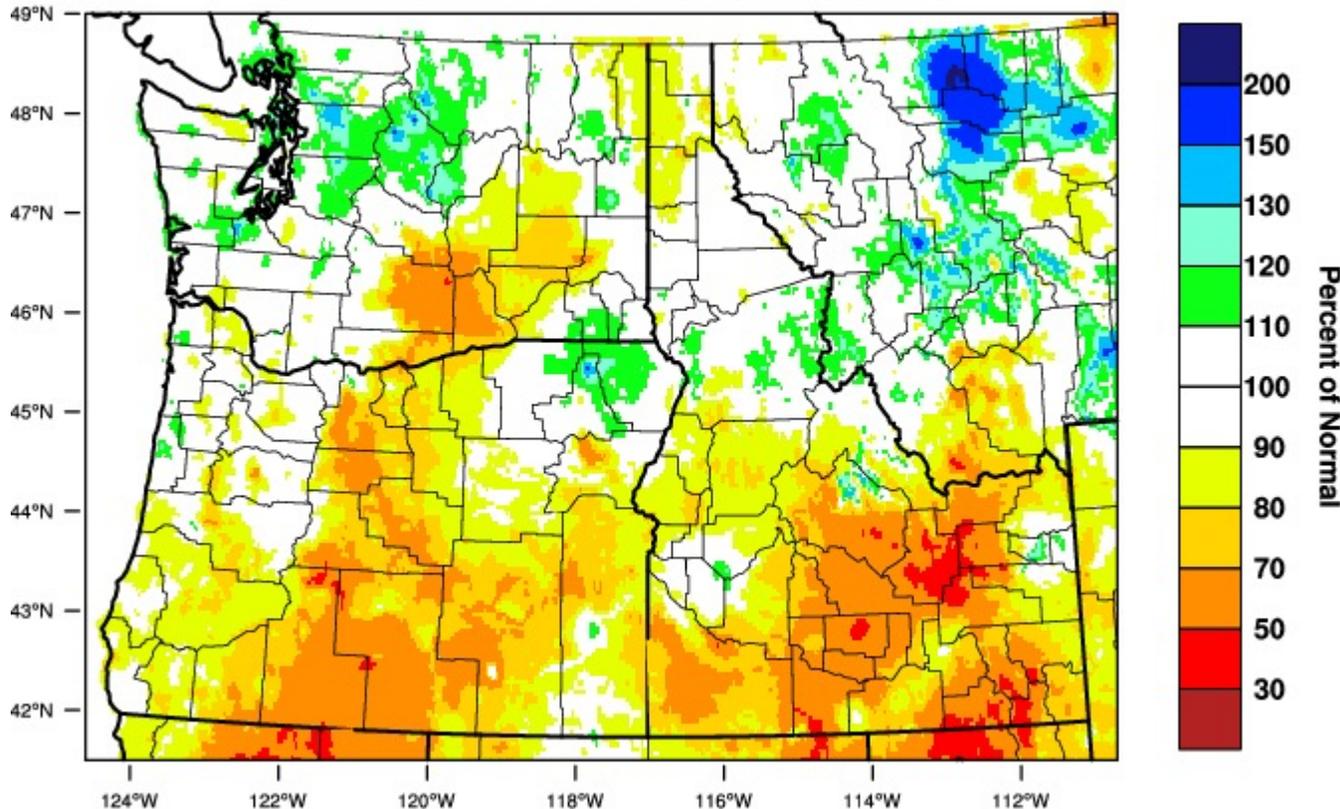
- Washington received 95.1% of avg precip for WY2021
- Ranks 45<sup>th</sup> lowest out of 127 years
- 3 consecutive years of below average precipitation statewide

Source: Westwide Drought Tracker using the PRISM precipitation analysis (preliminary)

# Precipitation Anomaly during the first half of WY2021: a tale of two seasons

## Pacific Northwest - Precipitation

October-March 2021 Percent of 1981-2010 Normal



WestWide Drought Tracker - U Idaho/WRCC Data Source - PRISM (Prelim), created 16 OCT 2021

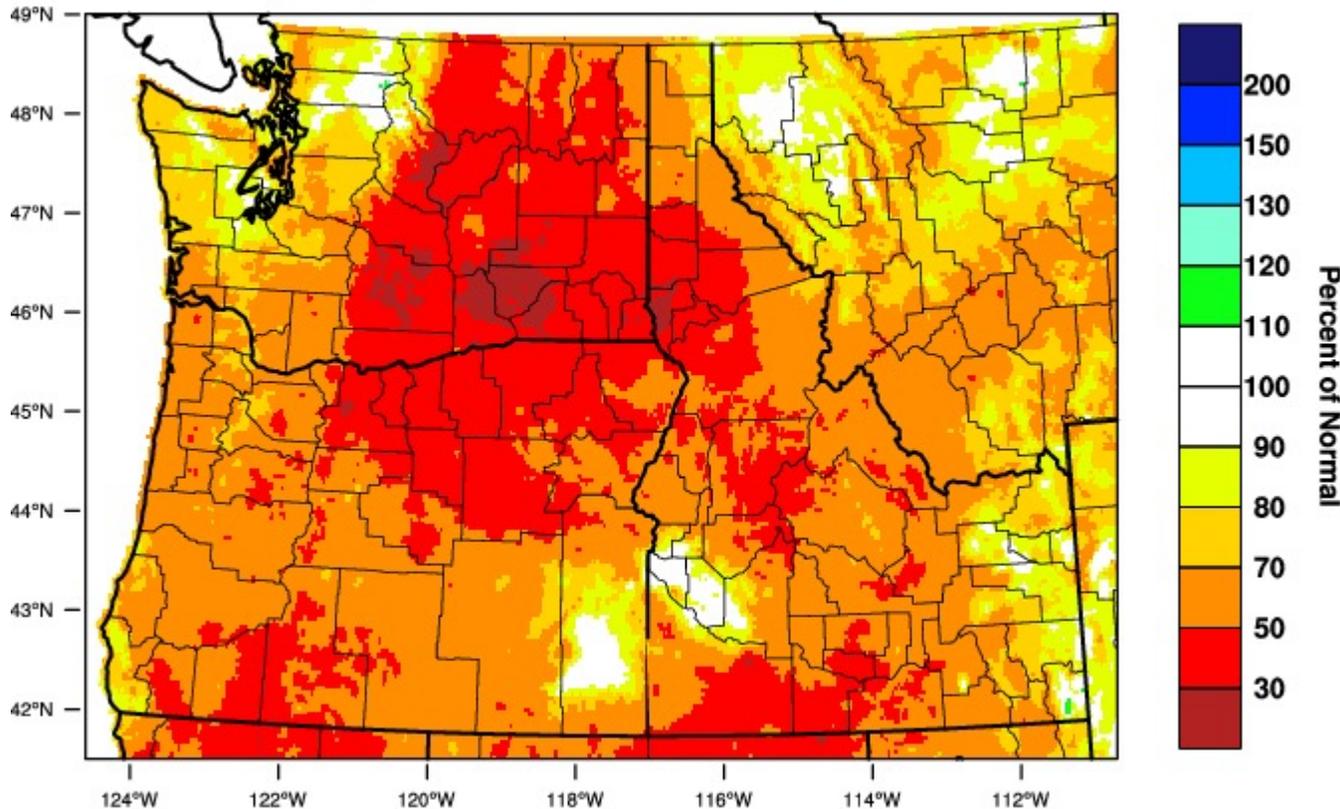
Much of the PacNW was near or above average in precipitation through the first half of the water year

Notable exceptions were central Oregon (especially in and around the Klamath Basin), and south-central Washington on Lower Columbia River basin

# Precipitation Anomaly during the second half of WY2021: a tale of two seasons

## Pacific Northwest - Precipitation

April-September 2021 Percent of 1981-2010 Normal

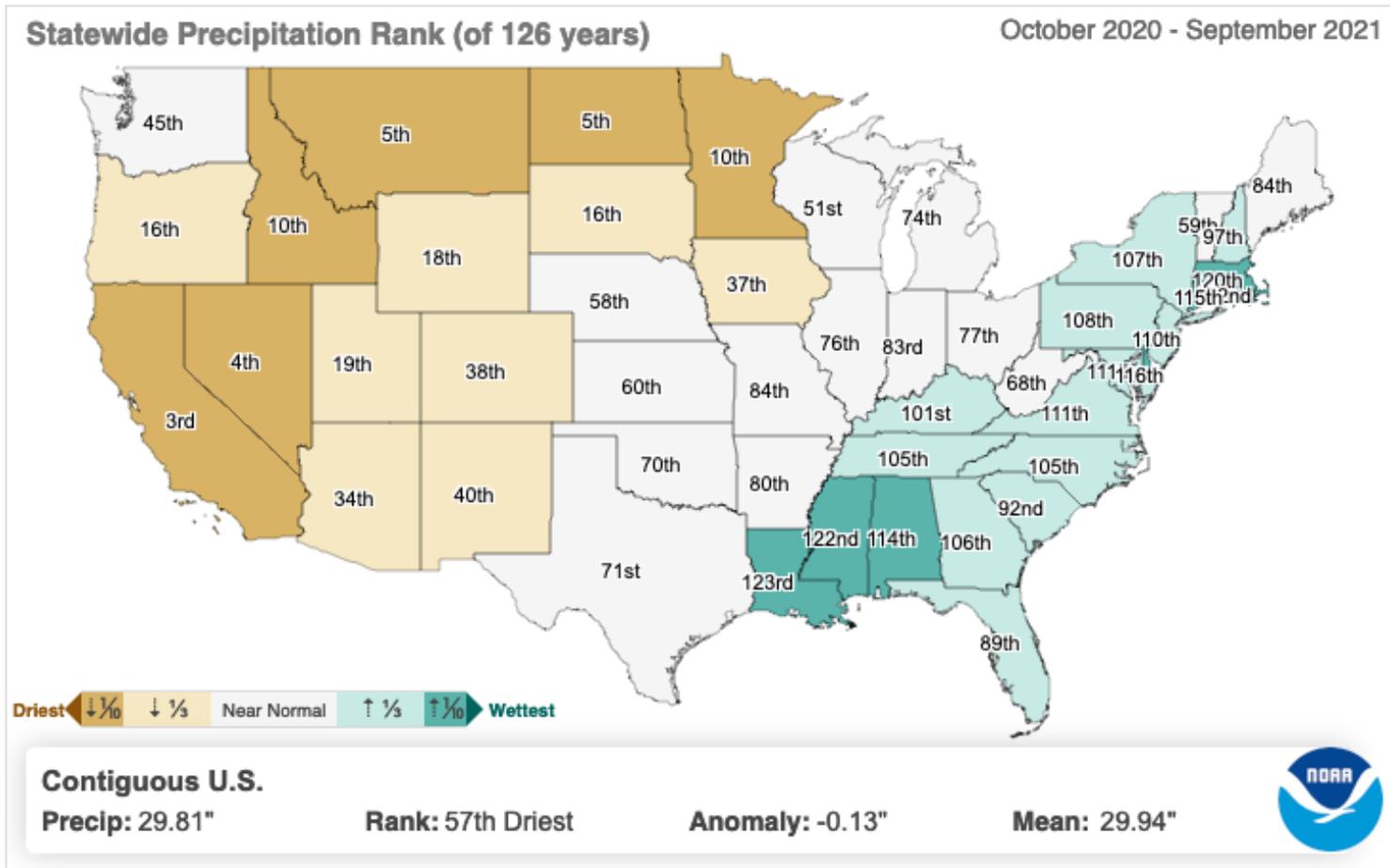


WestWide Drought Tracker - U Idaho/WRCC Data Source - PRISM (Prelim), created 16 OCT 2021

Nearly all the PacNW was well below normal in spring and summer precipitation

Particularly hard hit were Washington and northern Oregon east of the Cascade crest

# Water Year 2021 Precipitation Ranking



The US West and Upper Plains suffered through an extremely dry WY2021

How dry was it?

**Oregon:** 16<sup>th</sup> driest out of 126 years

**Washington:** 45<sup>th</sup> driest out of 126 years

# WY 2021 Seasonal Precipitation Rankings

Numbers shown are the dryness rankings since 1895  
1=driest, 127=wettest

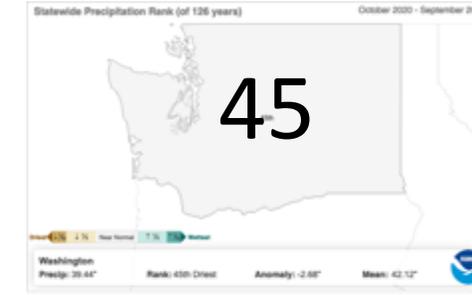
Oct-Nov-Dec 2020

Jan-Feb-Mar 2021

Apr-May-Jun 2021

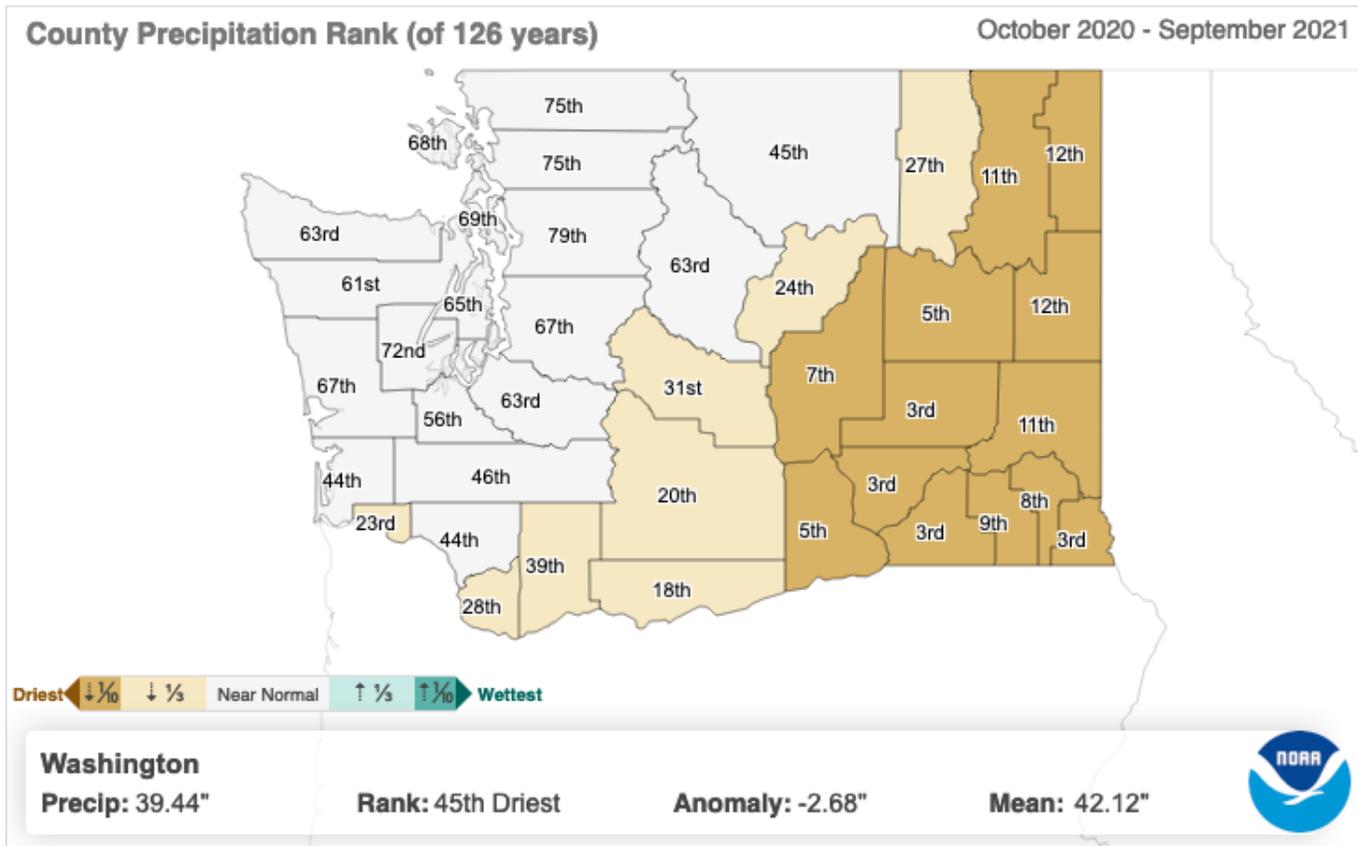
Jul-Aug-Sep 2021

Oct 2020-Sep 2021



- Washington overall had a slighter wetter than normal winter
- Oregon started with a moderately dry fall and winter
- Both WA and OR had a historically dry springtime
- September rainstorm boosted what was otherwise a dry late summer with relative lack of monsoonal moisture

# Water Year accumulated rainfall rankings by county -- Washington

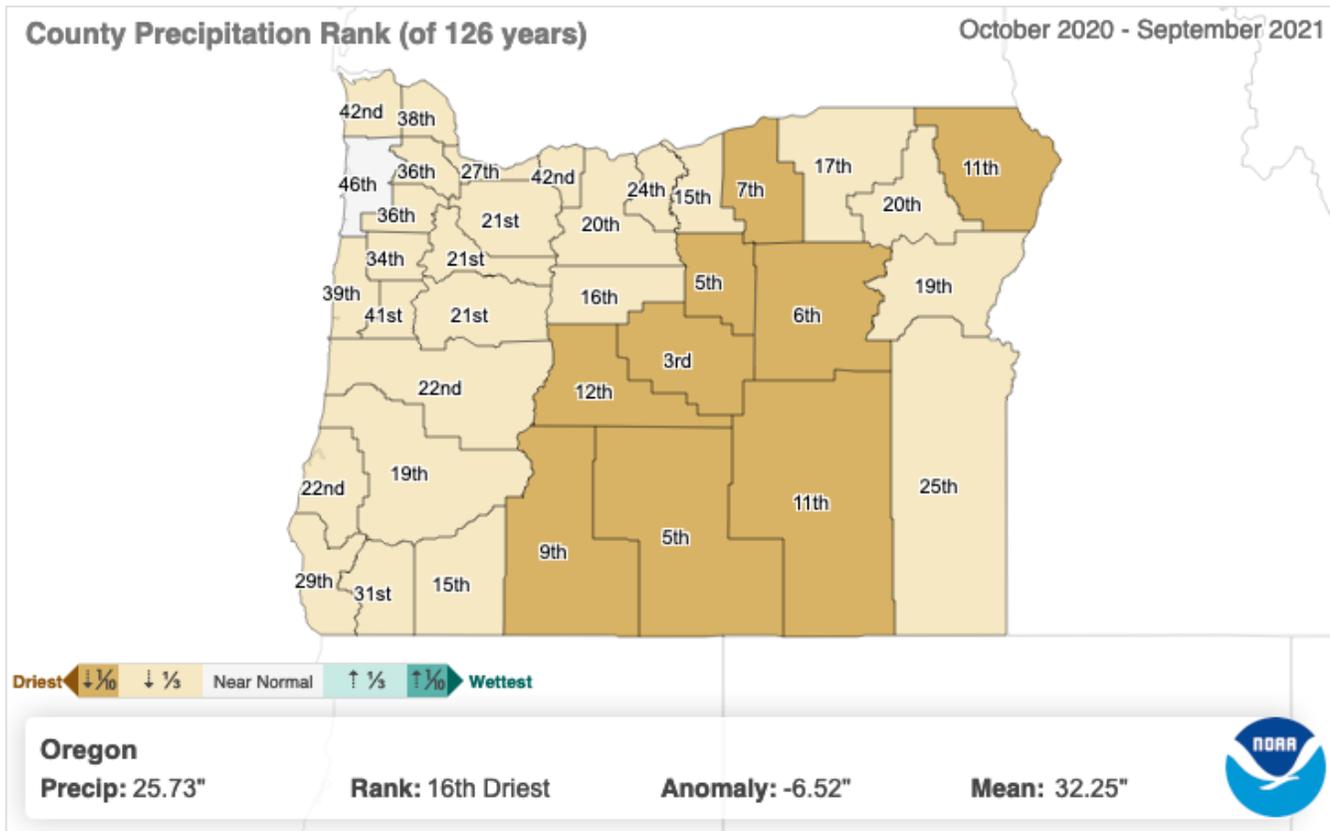


The numbers on the counties represent the rank of WY accumulated precipitation in the 126-year data record (1=driest; 126=wettest)

Shading represents the percentile rank (brown = within driest 10 percent of all years; tan = within driest 33%)

Counties in eastern and south-central Washington fared significantly worse than other parts of the state

# Water Year accumulated rainfall rankings by county -- Oregon



The numbers on the counties represent the rank of WY accumulated precipitation in the 126-year data record (1=driest; 126=wettest)

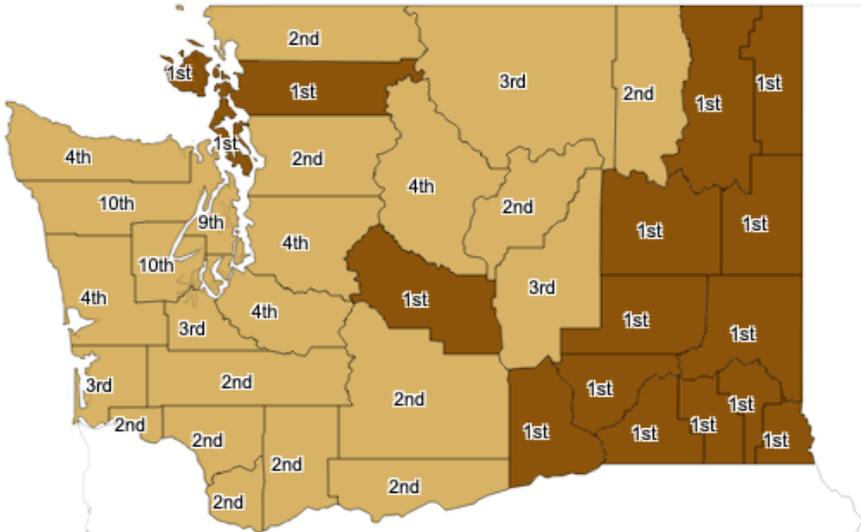
Shading represents the percentile rank (brown = within driest 10 percent; tan = within driest 33%)

Counties in Southern and Central Oregon fared significantly worse than other parts of the state with WY precipitation totals in the driest 10 percent of record.

# March-August rainfall rankings by county

County Precipitation Rank (of 127 years)

March - August 2021



Driest  $\downarrow 1/2$   $\downarrow 1/3$  Near Normal  $\uparrow 1/3$   $\uparrow 1/2$  Wettest

**Washington**  
Precip: 6.81"

Rank: 2nd Driest

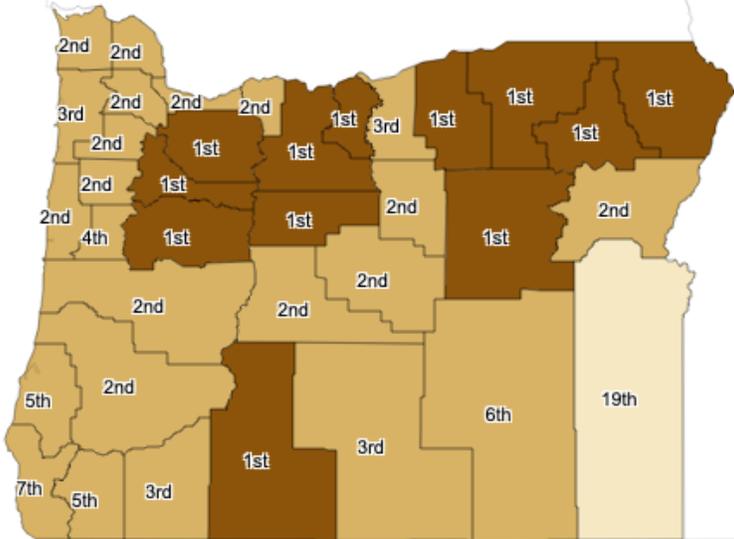
Anomaly: -6.22"

Mean: 13.03"



County Precipitation Rank (of 127 years)

March - August 2021



Driest  $\downarrow 1/2$   $\downarrow 1/3$  Near Normal  $\uparrow 1/3$   $\uparrow 1/2$  Wettest

**Oregon**  
Precip: 4.91"

Rank: 2nd Driest

Anomaly: -5.67"

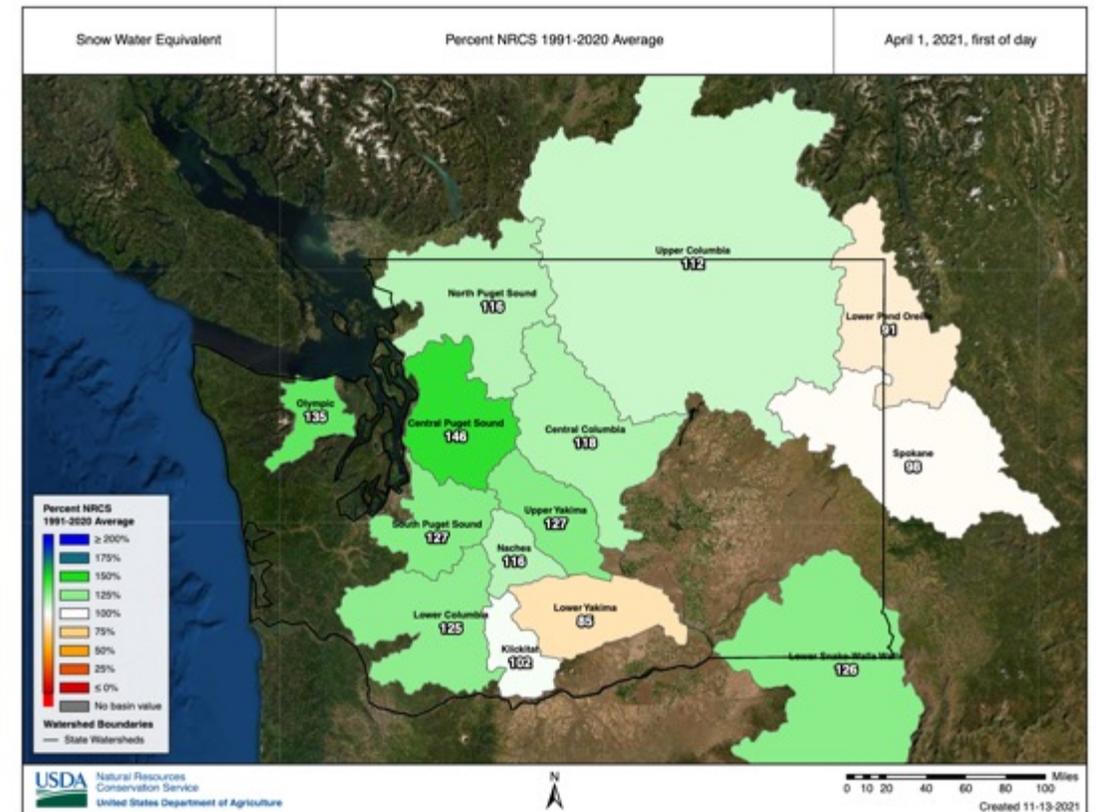
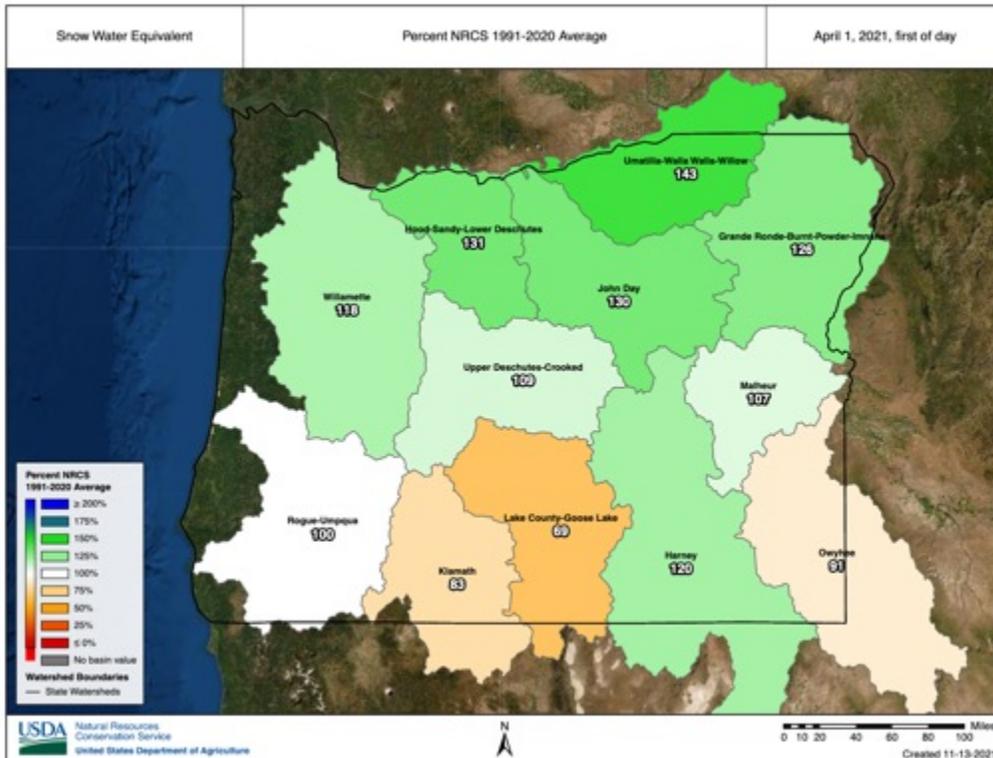
Mean: 10.58"



Widespread drought accelerated after March 2021 – many counties experienced one of their driest 5-month periods on record

Many counties east of the Cascades receive 30-50% of their annual WY precipitation during these months

# Date of peak SWE at SNOTEL stations

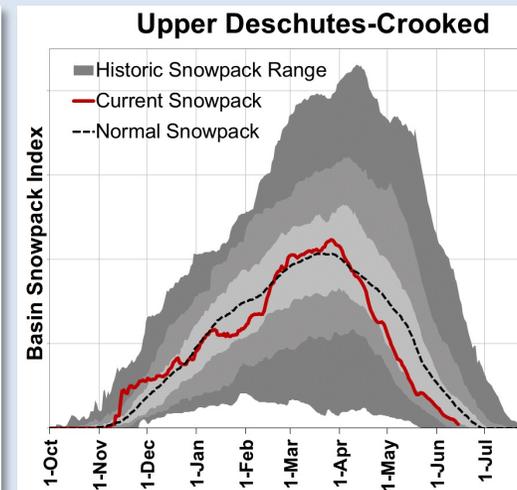
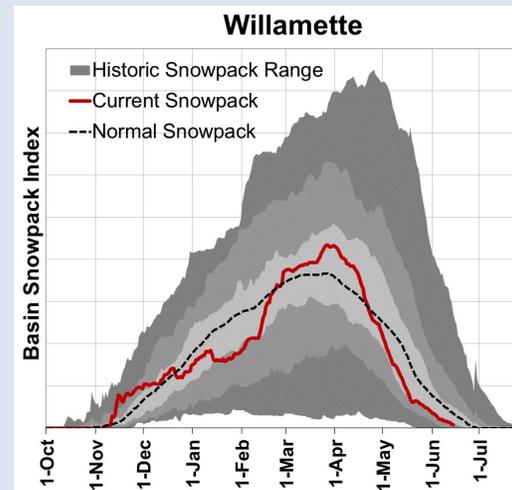
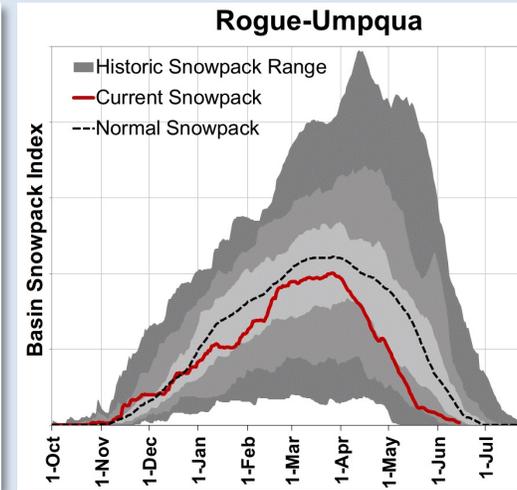
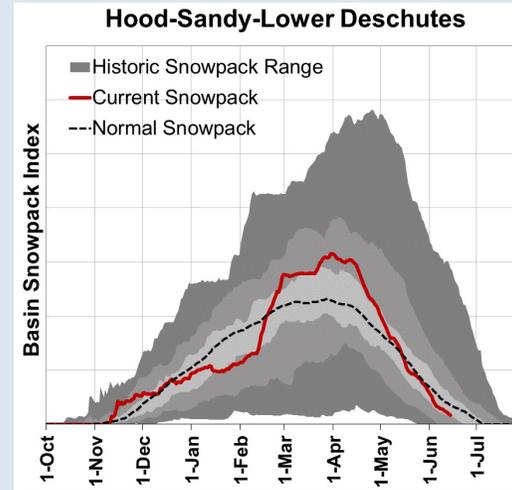


SWE peaked on March 25, 2021 in Oregon at 122% of median

SWE peaked on March 25, 2021 in Washington at 123% of median

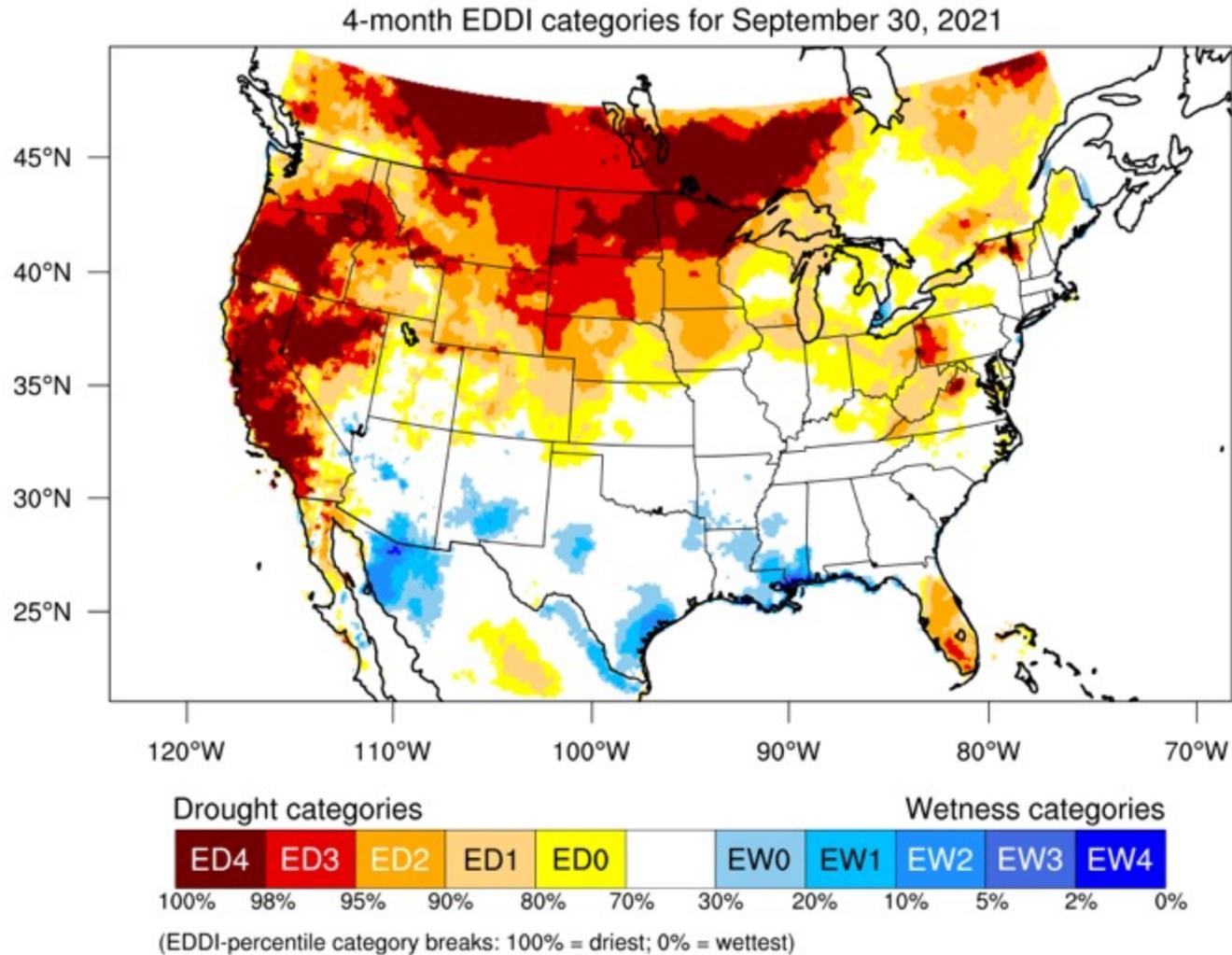
# Oregon SNOTEL Basin Snowpack Indices

- Indices based on snow-water equivalent at all SNOTEL stations within the basin
- Rogue-Umpqua had well below normal snowpack and an early meltout
- Other basins had normal to above normal snowpack, but melted out 1-3 weeks early
- Early meltout contributed to:
  - Below average late summer naturalized streamflows
  - Drier shallow groundwater systems
  - Longer high-elevation fire season



*Images courtesy of Scott Oviatt, USDA-NRCS*

# Evaporative Demand



Generated by NOAA/ESRL/Physical Sciences Laboratory

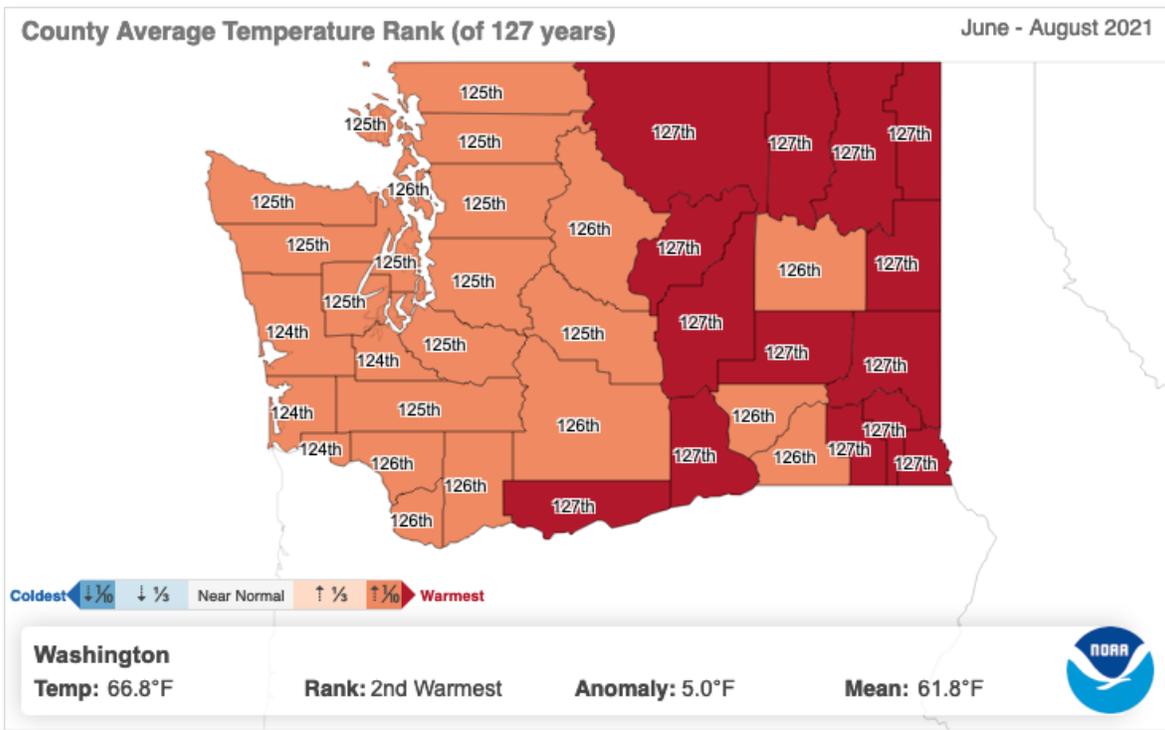
Very high evaporative demand fueled increasing drought severity in the US west this water year due mainly to the record warm summer

One measure of evaporation is the Evaporative Demand Drought Index (EDDI), which ranks evaporation against the historical data record

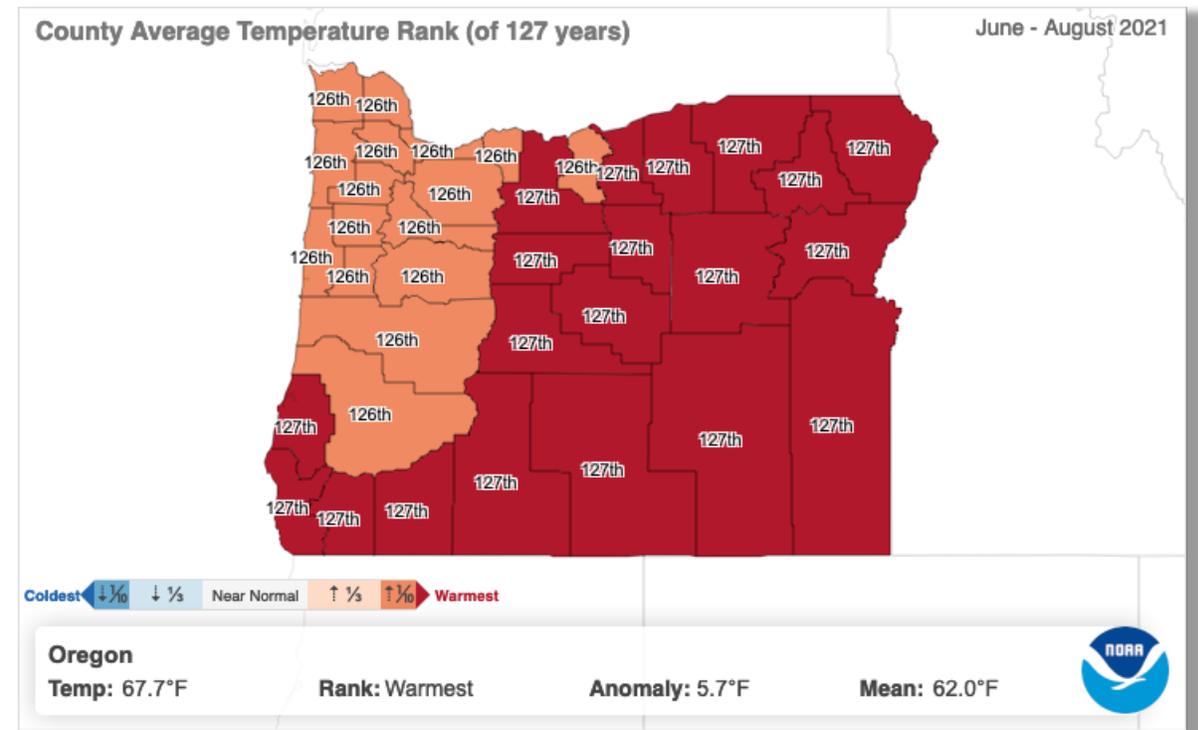
Most of Oregon and southeastern Washington were in the two most intense drought categories by this metric

Excessive evaporation means precipitation does not go as far in meeting our water supply demands

# County summer temperature rankings



All Washington counties experienced either their warmest or top-3 warmest summer on record



All Oregon counties experienced either their warmest or second warmest summer on record

# Days above 90°F

- The record warm summer was not just a product of the June heatwave, but also of prolonged stretches of well above average temperatures

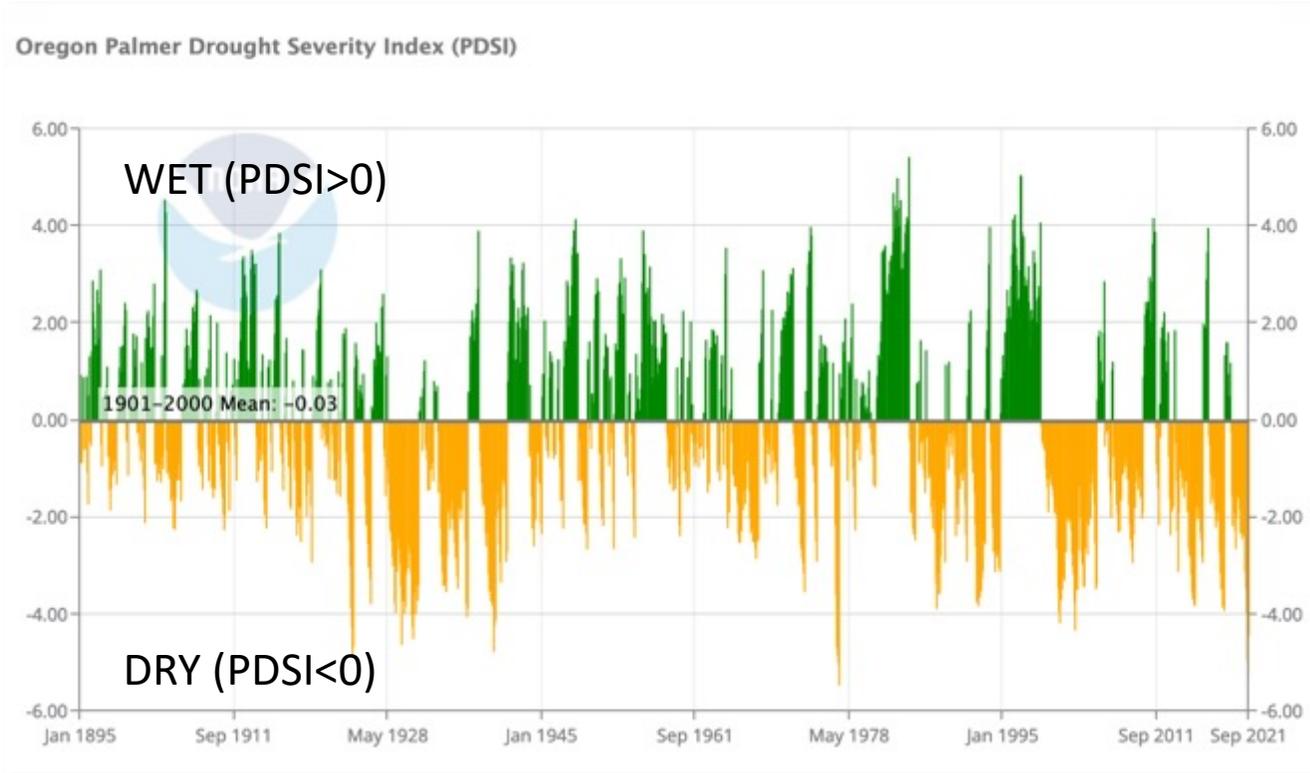
## Oregon

	# of days >=90°F	Rank
Portland	24	Tied-3
Salem	41	1
Eugene	42	1
Roseburg (Riddle)	65	Tied-1
Medford	74	Tied-5
Klamath Falls	53	1
Redmond	57	2
Bend	38	2
Burns	61	1

## Washington

	# of days >=90°F	Rank
Kennewick	64	Tied-14
LaCrosse	56	5
Spokane	42	1
Pullman	42	1
Walla Walla	53	Tied-6
Yakima	60	5
Seattle (SeaTac)	8	Tied-4
Olympia	10	Tied-12

# Assessing Oregon's drought severity



The Palmer Drought Severity Index (PDSI) incorporates precipitation and evaporation on net surface water supply

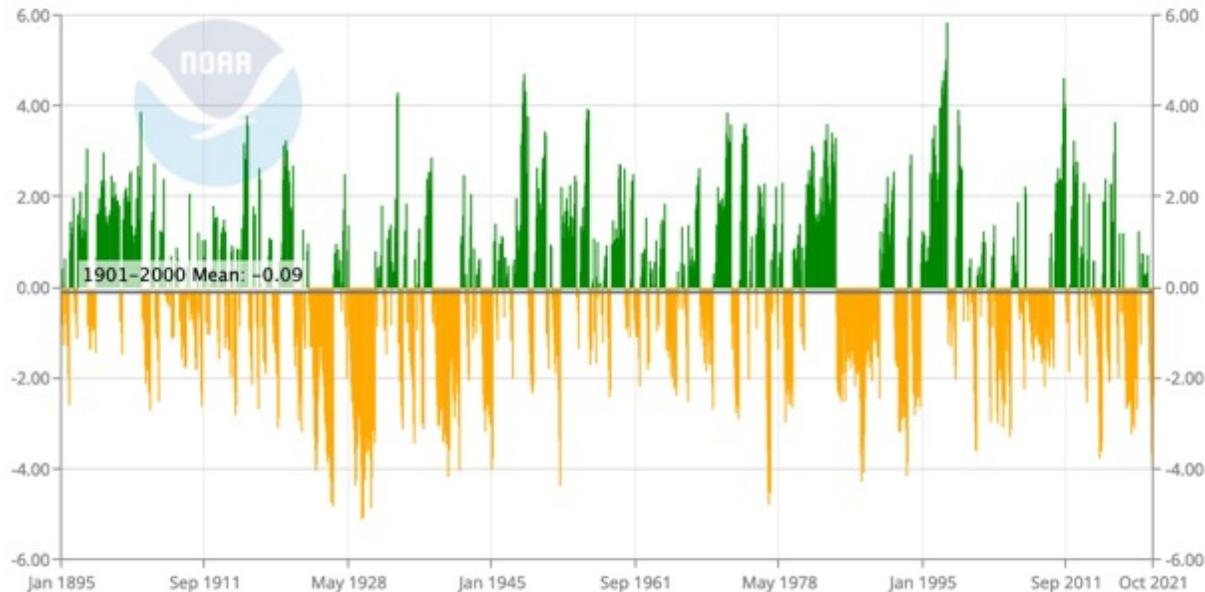
The PDSI is derived from a moisture balance model, using historic records of precipitation, temperature, and the local available water capacity of the soil

The PDSI does not incorporate the condition of the snowpack

- Oregon statewide PDSI for August 2021: -5.24 (second lowest monthly ranking in the 127-year record)
- The lowest occurred during April 1977
- Sept 2021 PDSI: -4.42 (12<sup>th</sup> lowest monthly ranking on record)
- July 2021 PDSI: -4.93 (4<sup>th</sup> lowest monthly ranking on record)

# Assessing Washington's drought severity

Washington Palmer Drought Severity Index (PDSI)



Despite the great snowpack, Washington ended with a PDSI consistent with severe drought

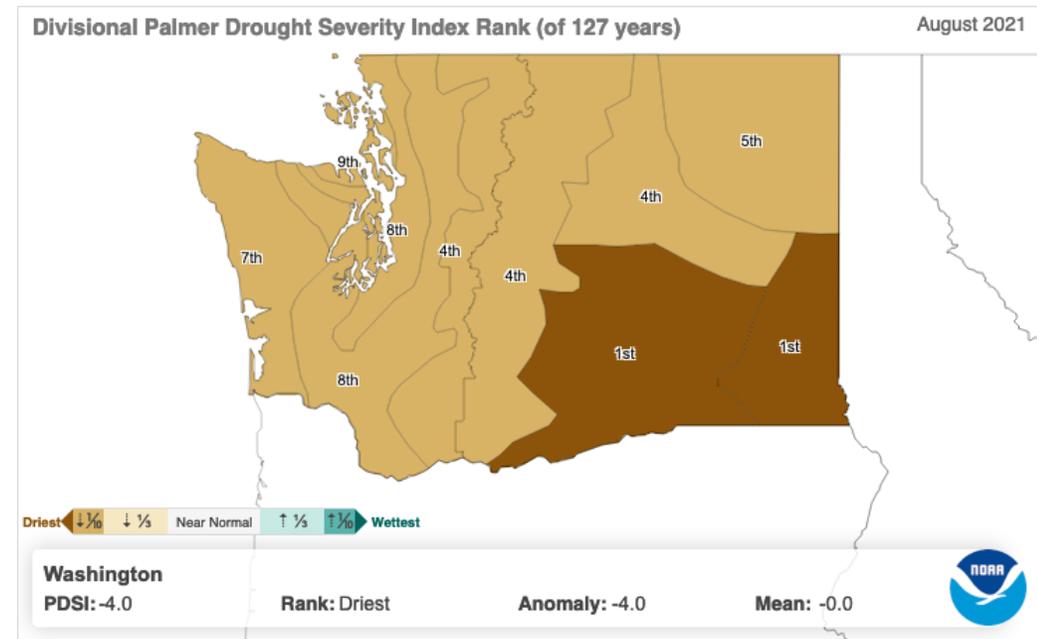
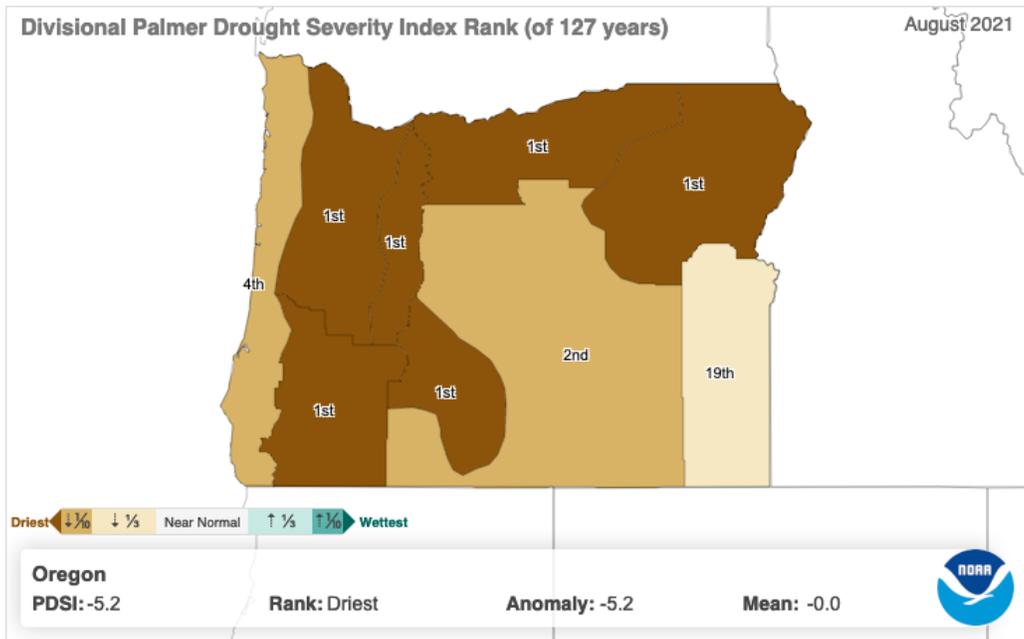
The spring drought in WA was primarily based on precipitation deficits so PDSI is a relevant indicator of drought severity and extent

In August 2021, the monthly PDSI in Washington state ranked as the 29<sup>th</sup> lowest since 1895 (PDSI = -4.00) and the lowest since February 1993.

# Assessing the drought's severity

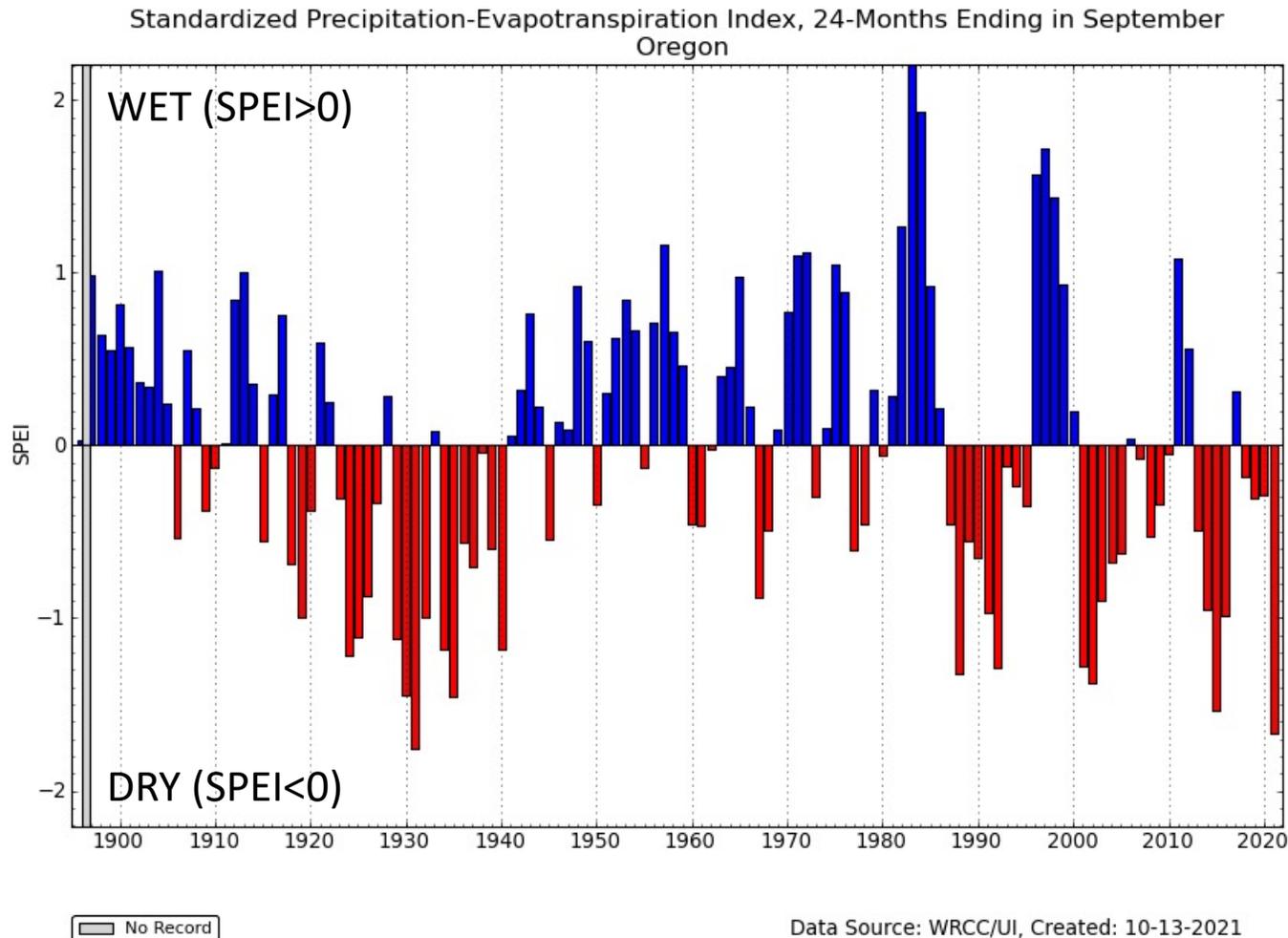
*For 6 out of 9 Oregon climate divisions, August 2021 ranked as the lowest monthly PDSI on record*

*2 out of 10 Washington climate divisions recorded their lowest monthly PDSI on record:*



Central Basin (PDSI = -6.6) and Palouse Blue Mountains (PDSI = -5.9)

# Assessing Oregon's drought severity: 24-month SPEI



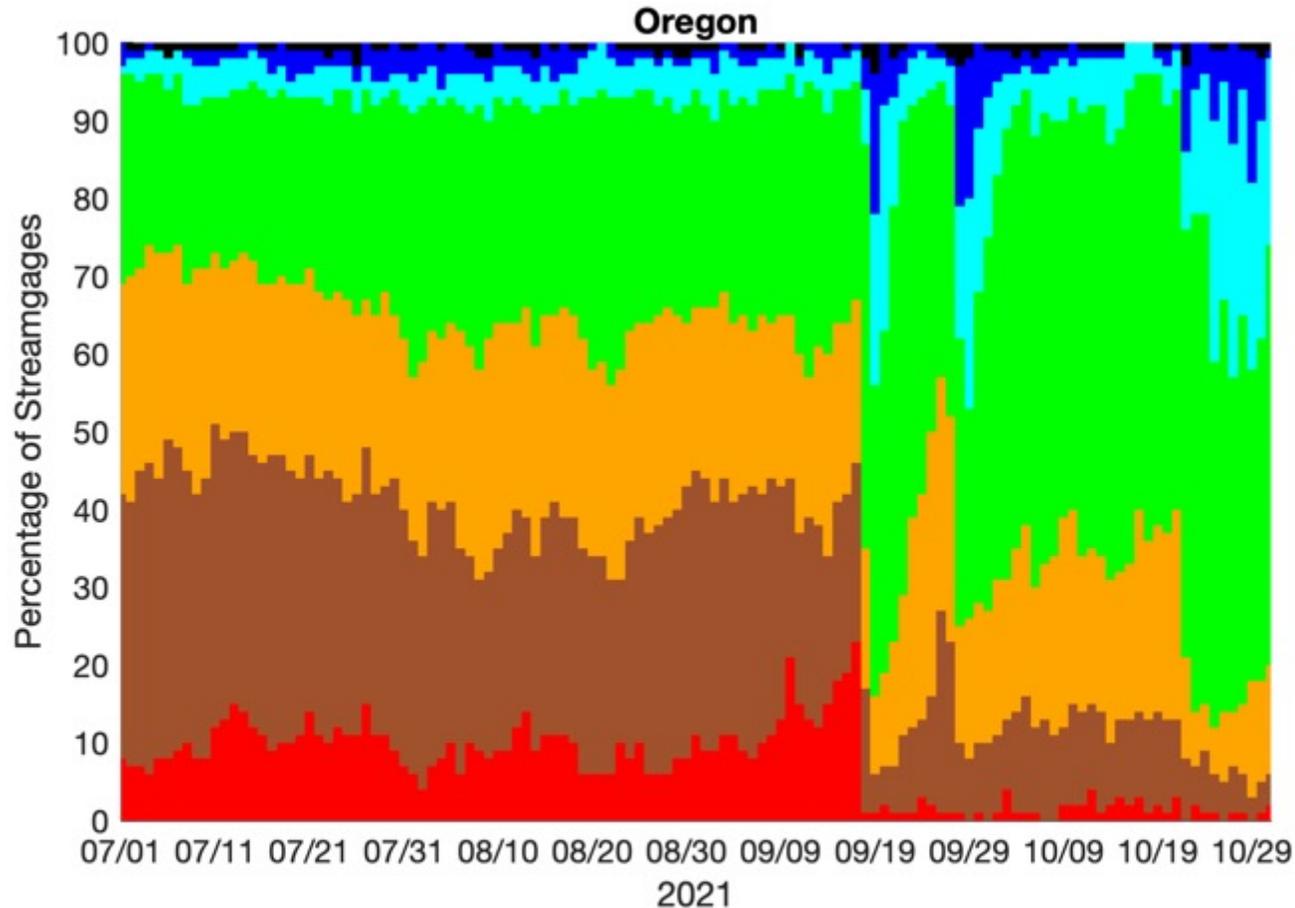
The Standardized Precipitation-Evapotranspiration Index (SPEI) is another drought indicator commonly used in the US West to assess drought severity and extent

Like the PDSI, it also incorporates potential evapotranspiration in deriving a surface water balance

Going out to the last 2 water years (WY2020 and WY2021), the SPEI is the second lowest on record just behind the WY1930-1931

*The multi-year aspect to the drought also contributed to the severity of adverse impacts felt during WY2021*

# USGS daily streamflow percentiles



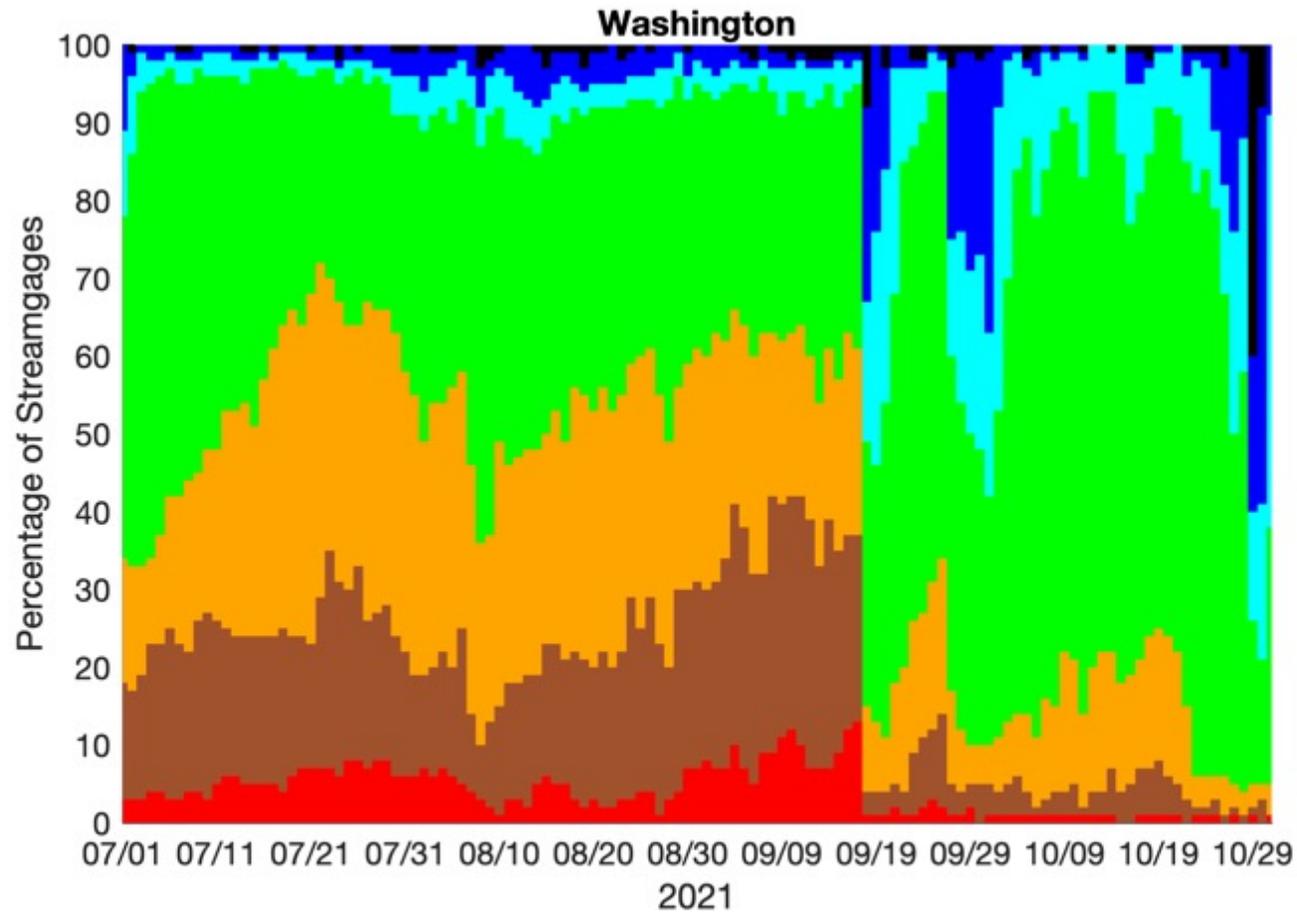
Record Low <10th 10-24th 25-75th 76-90th >90th Record High

Time series of the percentage of USGS streamflow gages within each percentile class in all of Oregon

Until the mid-Sept wet period, about 25% of stream gages were recording record low flows and about 70% were recording well below average streamflows

The hydrological drought severity peaked in mid-September

# USGS daily streamflow percentiles



Time series of the percentage of USGS streamflow gages within each percentile class in all of Oregon

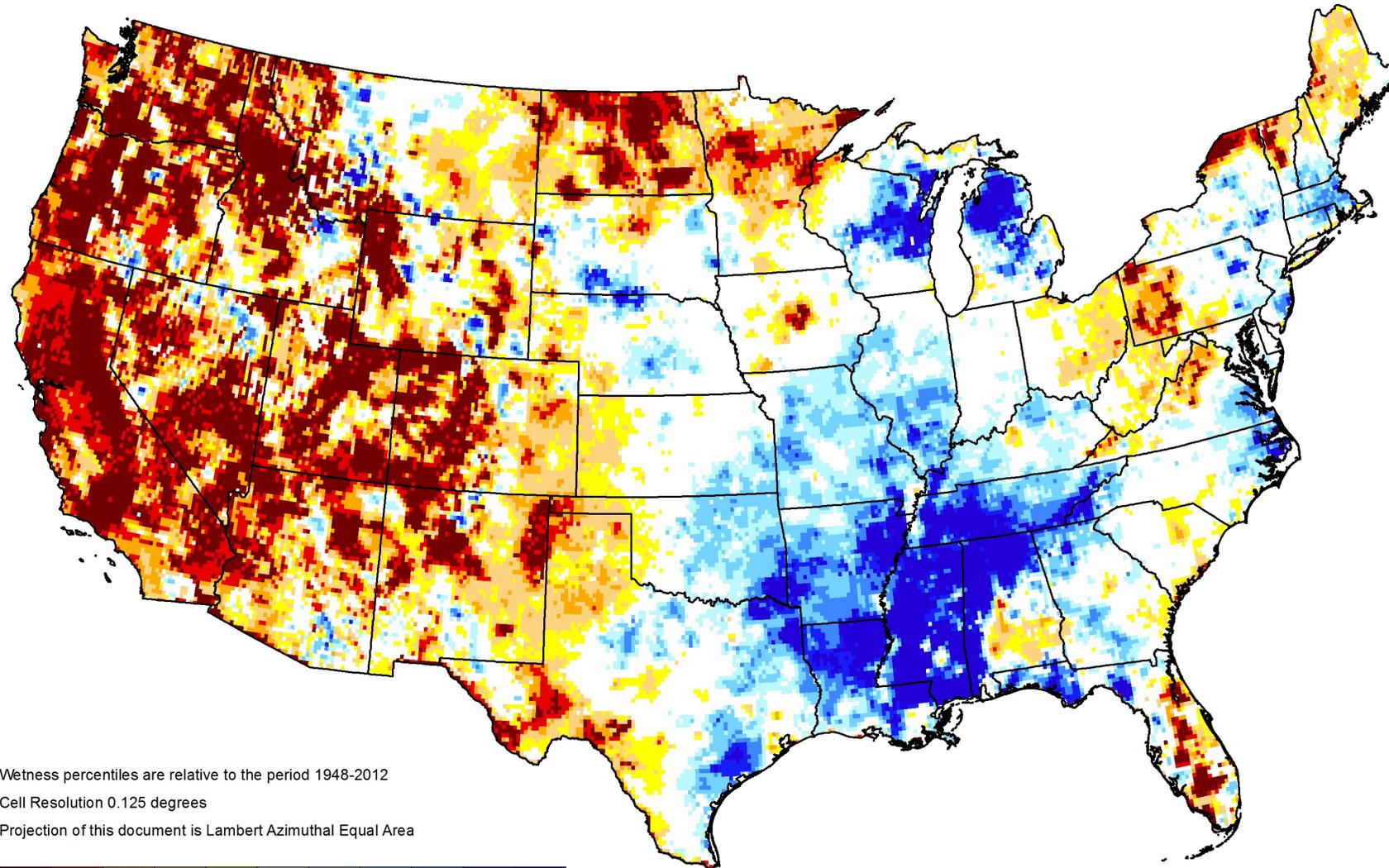
Until the mid-Sept wet period, about 10% of stream gages were recording record low flows and about 60% were recording well below average streamflows





# GRACE-Based Shallow Groundwater Drought Indicator

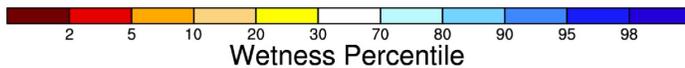
September 13, 2021



Wetness percentiles are relative to the period 1948-2012

Cell Resolution 0.125 degrees

Projection of this document is Lambert Azimuthal Equal Area



<https://nasagrace.unl.edu>

Most of the PacNW had historically low soil moisture in the upper 1 meter of the surface which persisted throughout the summer

# Summary

WY2021 was the second year of a multiyear drought for Oregon and much of Washington

Drought metrics show extreme drought development during Spring 2021

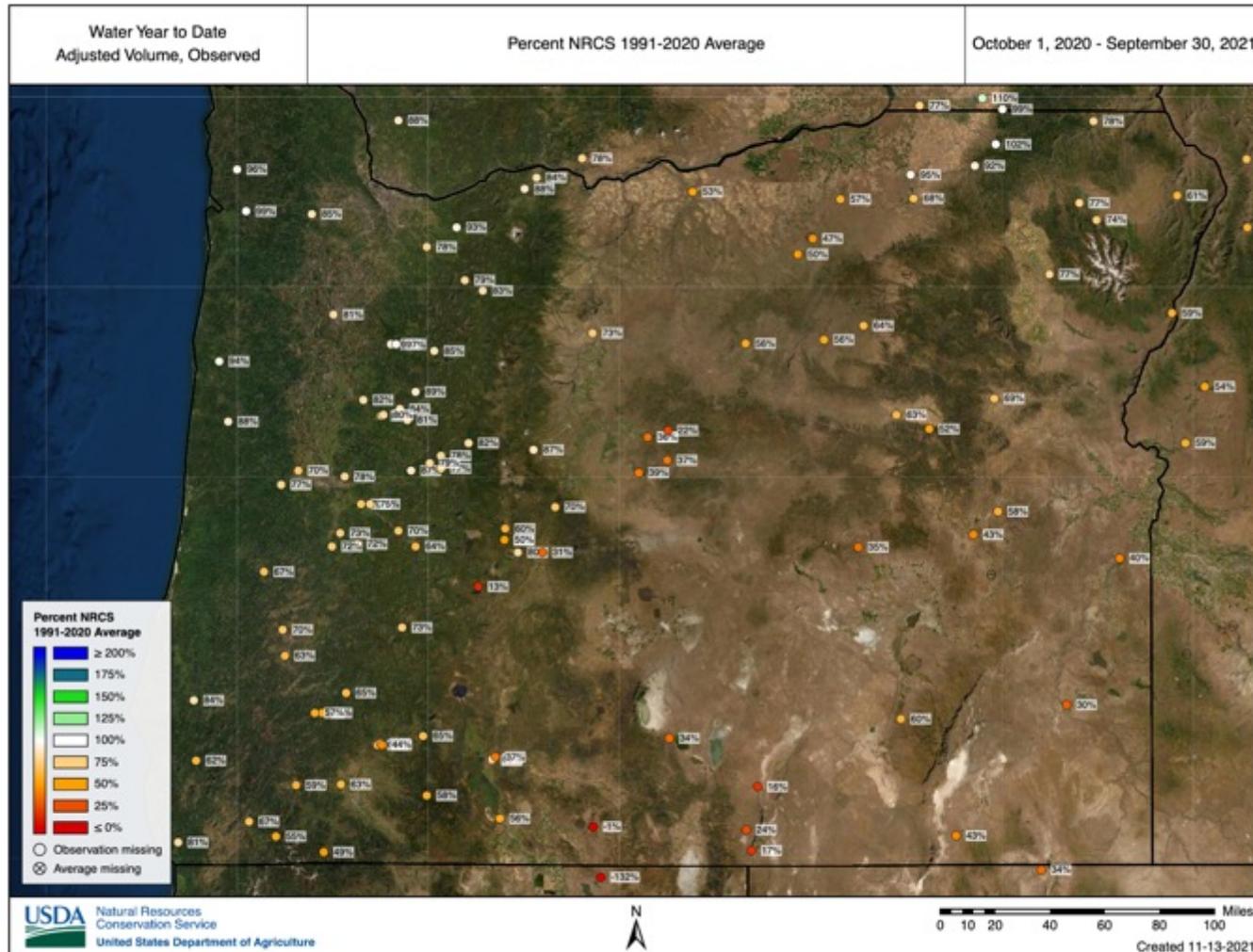
Character of the drought affected by early snow meltout, particularly in Oregon

Streamflows and soil moisture set record lows for much of the summer

Impacts were more severe this year compared with last year

Precipitation did not do as far as it usually does due to record high temperatures and evaporation during summer

# Water Year 2021 runoff percentiles – Oregon



WY runoff largely follows pattern of WY precipitation in Oregon:

Below 20<sup>th</sup> percentile in western Oregon, High Cascades, and most of central Oregon

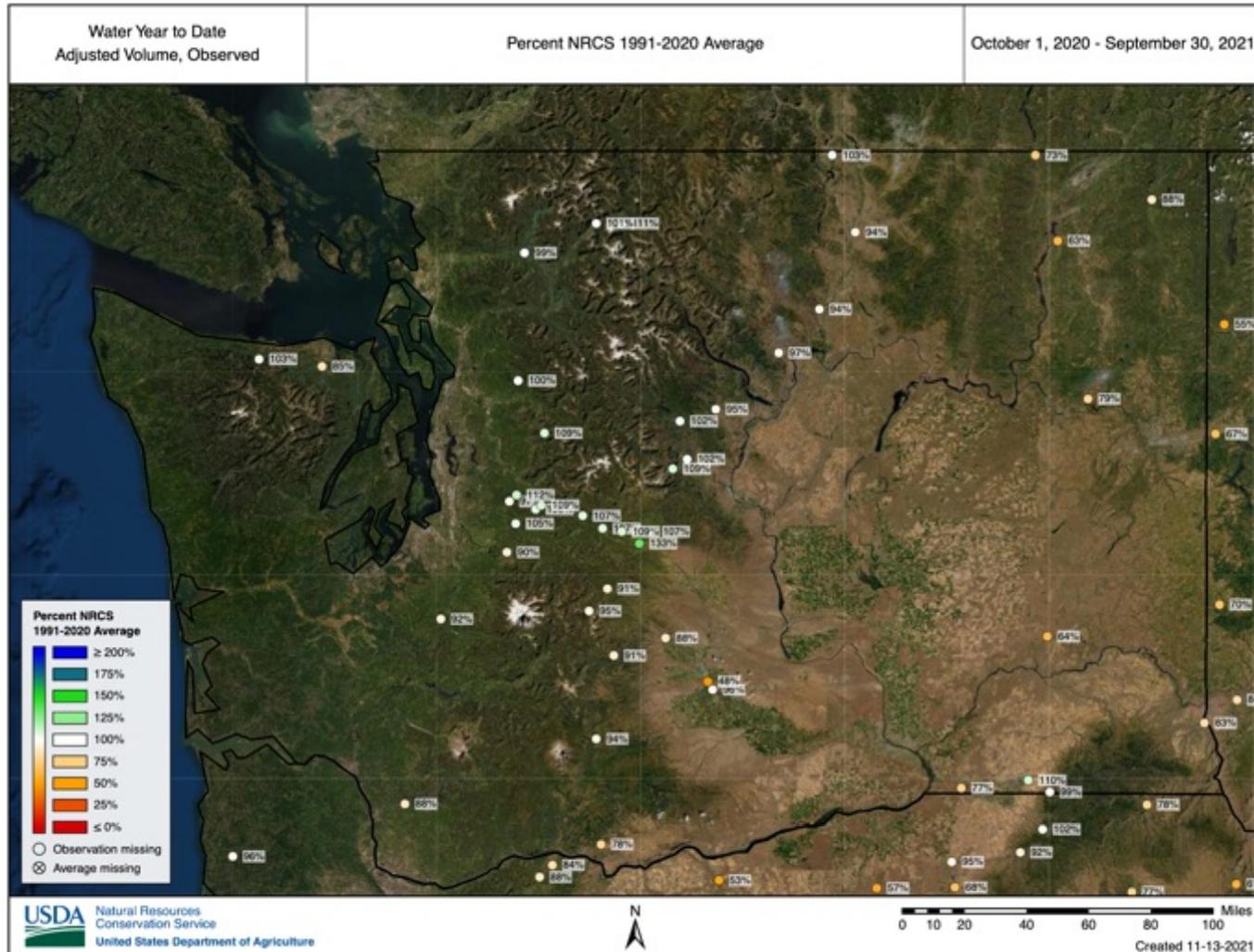
A number of locations below the 10<sup>th</sup> percentile

Northeast Oregon generally above normal runoff, while SE Oregon mostly between the 25<sup>th</sup> and 35<sup>th</sup> percentiles

Notable extremes:

- All-time low at Ochoco Creek blw Prineville
- Umatilla River abv Meacham (94<sup>th</sup> percentile)
- South Fork Rogue nr Prospect (5<sup>th</sup> percentile)
- Deschutes River at Benham Falls (3<sup>rd</sup> percentile)
- Upper Williamson River (6<sup>th</sup> percentile)
- S Fork Coquille River (7<sup>th</sup> percentile)
- Warm Springs River (6<sup>th</sup> percentile)
- Wickiup Res inflow (4<sup>th</sup> percentile)

# Water Year 2021 runoff percentiles – Washington



Washington WY runoff pattern also generally follows the pattern of precipitation and snowpack

Washington Cascades above median

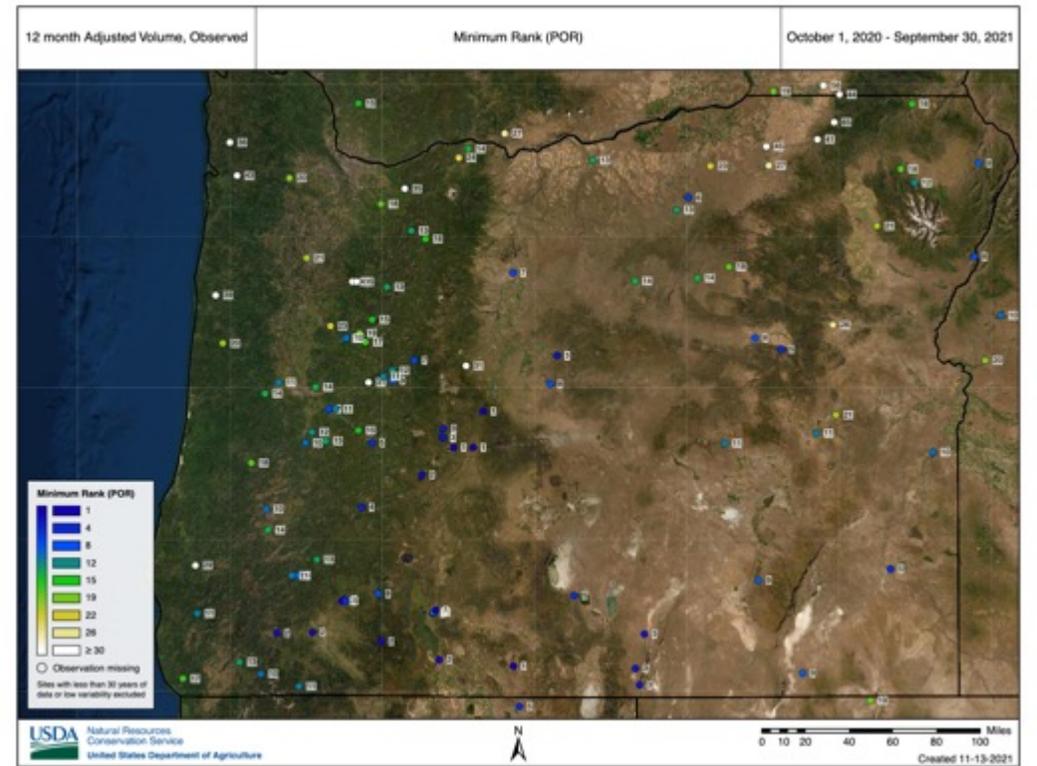
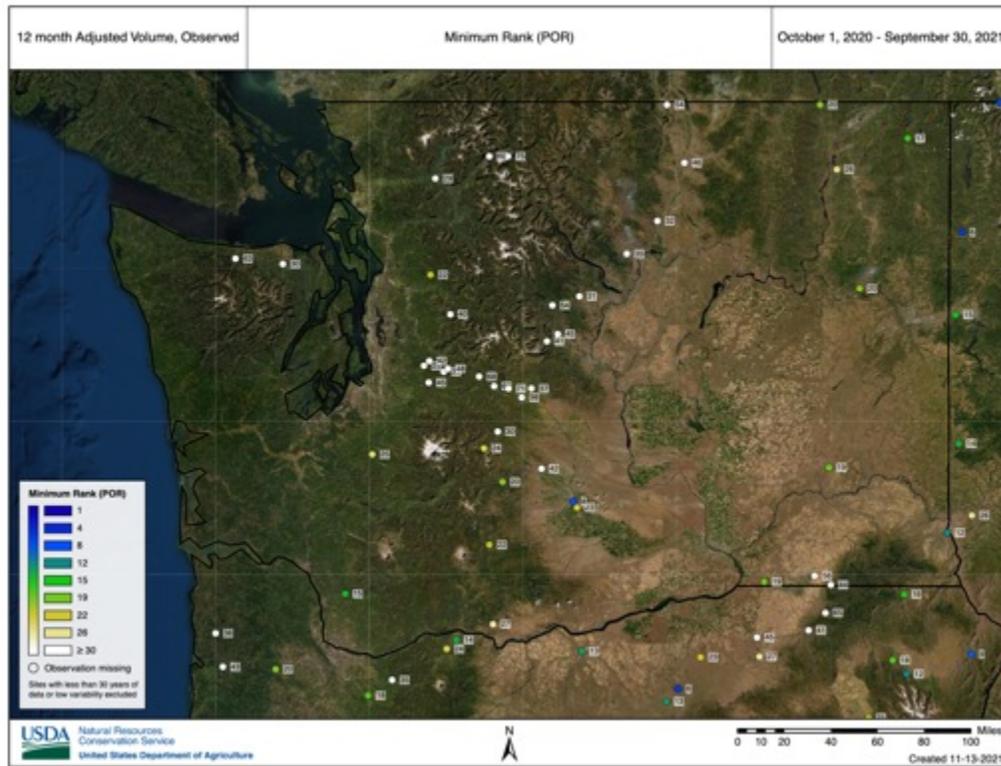
Olympic peninsula somewhat below median

South-central and SE Washington with a few well below normal runoff stations

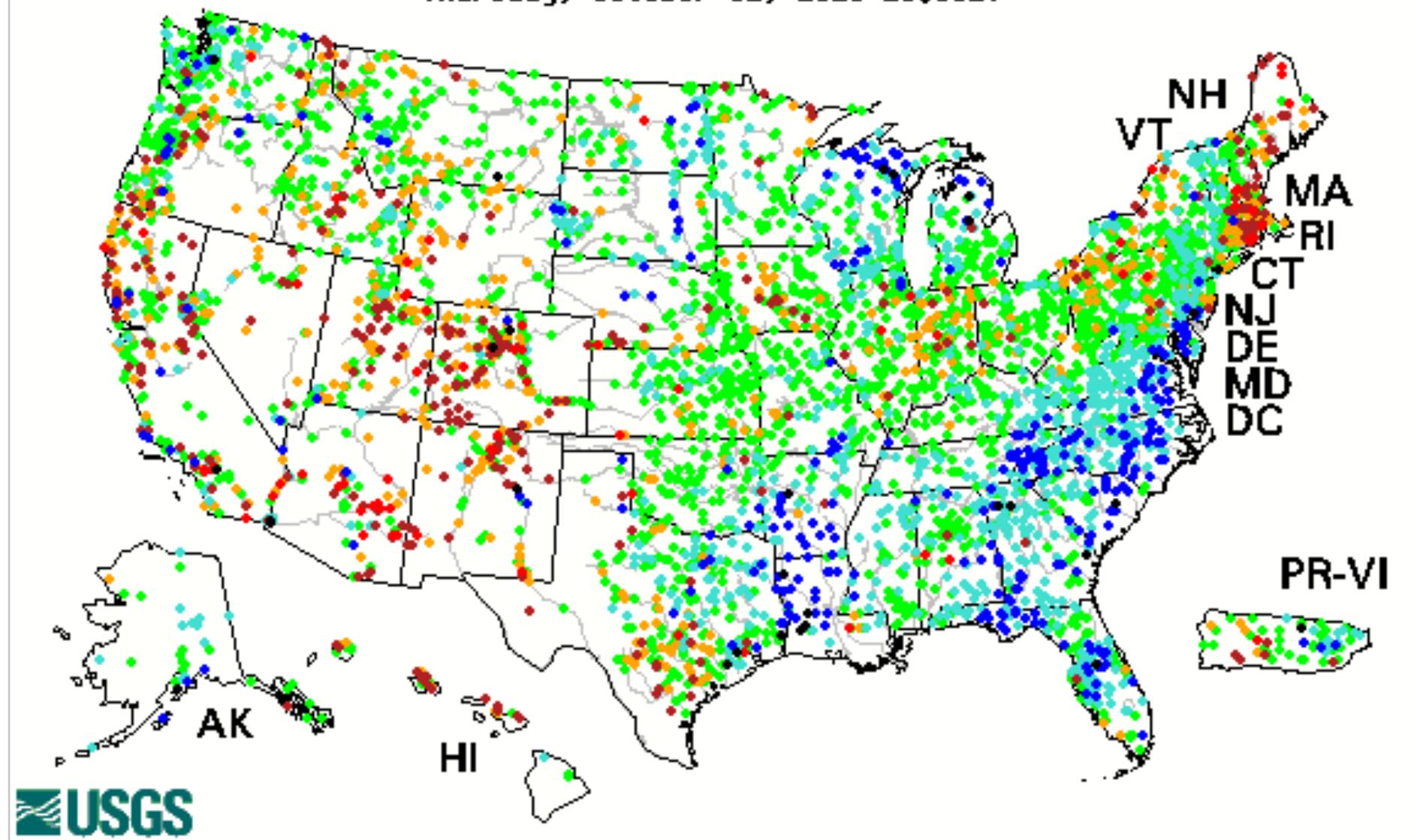
Notable extremes:

- S Fork Tolt River (12147600) sets record high runoff (out of 55 year POR)
- Yakima River at Cle Elum (95<sup>th</sup> percentile)

# Water Year 2021 runoff rankings



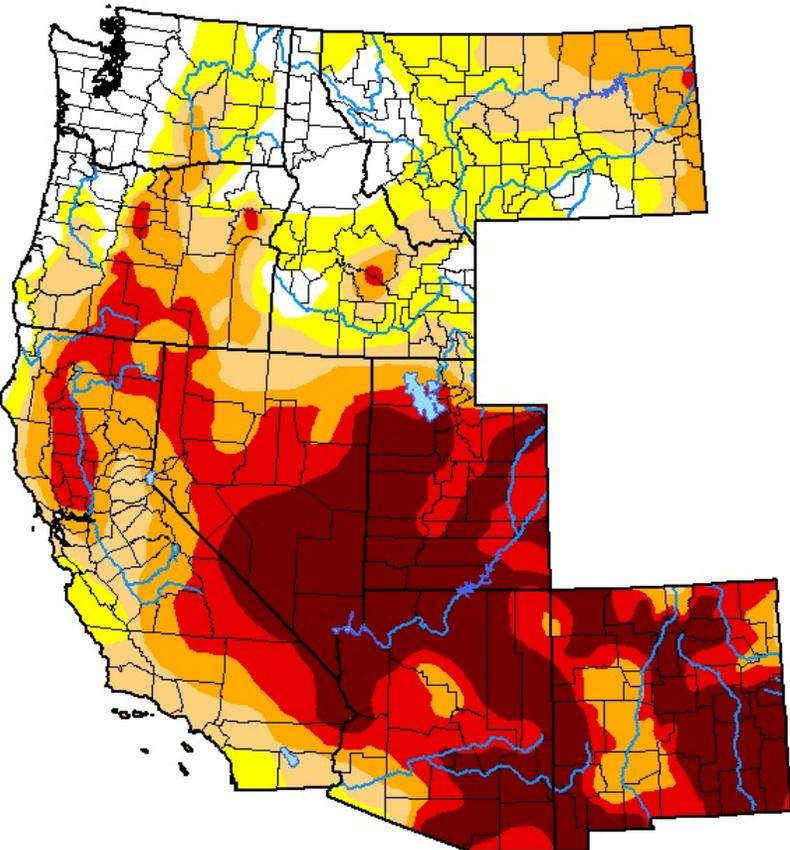
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# US Drought Monitor Progression through WY2021

## U.S. Drought Monitor West

**March 30, 2021**  
(Released Thursday, Apr. 1, 2021)  
Valid 8 a.m. EDT



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
<b>Current</b>	-	-	-	-	-	-
<b>Last Week</b> <i>03-23-2021</i>	-	-	-	-	-	-
<b>3 Months Ago</b> <i>12-29-2020</i>	13.52	86.48	75.49	63.25	45.40	23.76
<b>Start of Calendar Year</b> <i>12-29-2020</i>	13.52	86.48	75.49	63.25	45.40	23.76
<b>Start of Water Year</b> <i>09-29-2020</i>	9.96	90.04	73.14	51.29	32.19	2.50
<b>One Year Ago</b> <i>03-31-2020</i>	49.34	50.66	28.52	4.72	0.00	0.00

- Intensity:**
- None
  - D2 Severe Drought
  - D0 Abnormally Dry
  - D3 Extreme Drought
  - D1 Moderate Drought
  - D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

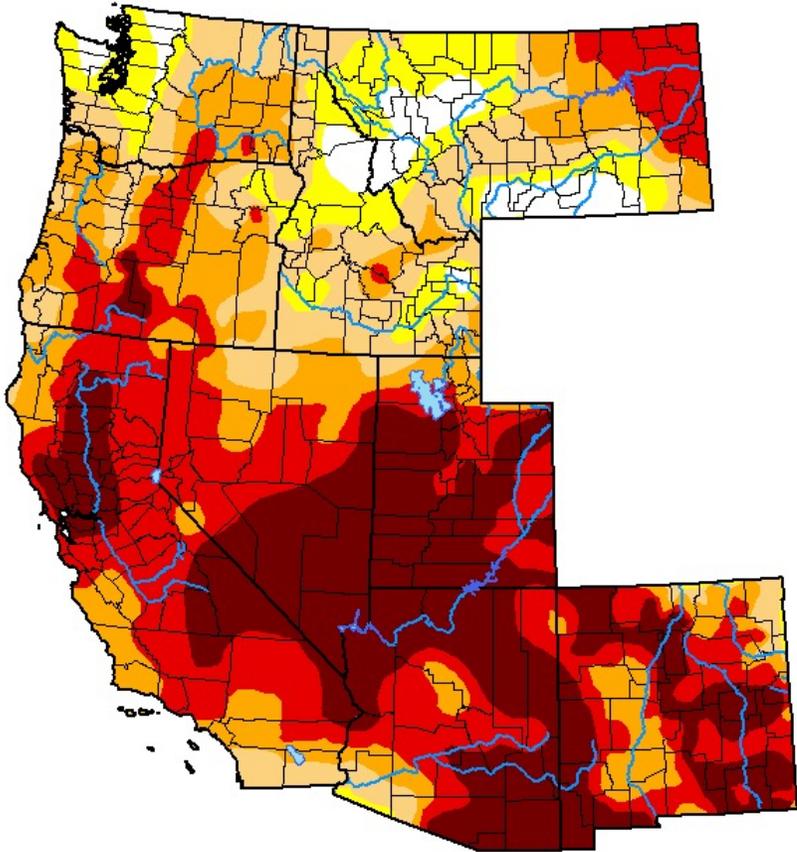
**Author:**  
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# US Drought Monitor Progression through WY2021

## U.S. Drought Monitor West

**June 1, 2021**  
(Released Thursday, Jun. 3, 2021)  
Valid 8 a.m. EDT



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
<b>Current</b>	3.99	96.01	87.24	71.98	52.79	26.18
<b>Last Week</b> <i>05-25-2021</i>	3.79	96.21	87.12	71.34	52.88	26.92
<b>3 Months Ago</b> <i>03-02-2021</i>	12.93	87.07	76.82	57.96	42.34	22.93
<b>Start of Calendar Year</b> <i>12-29-2020</i>	13.52	86.48	75.49	63.25	45.40	23.76
<b>Start of Water Year</b> <i>09-29-2020</i>	9.96	90.04	73.14	51.29	32.19	2.50
<b>One Year Ago</b> <i>06-02-2020</i>	39.53	60.47	41.41	16.52	1.52	0.00

Intensity:

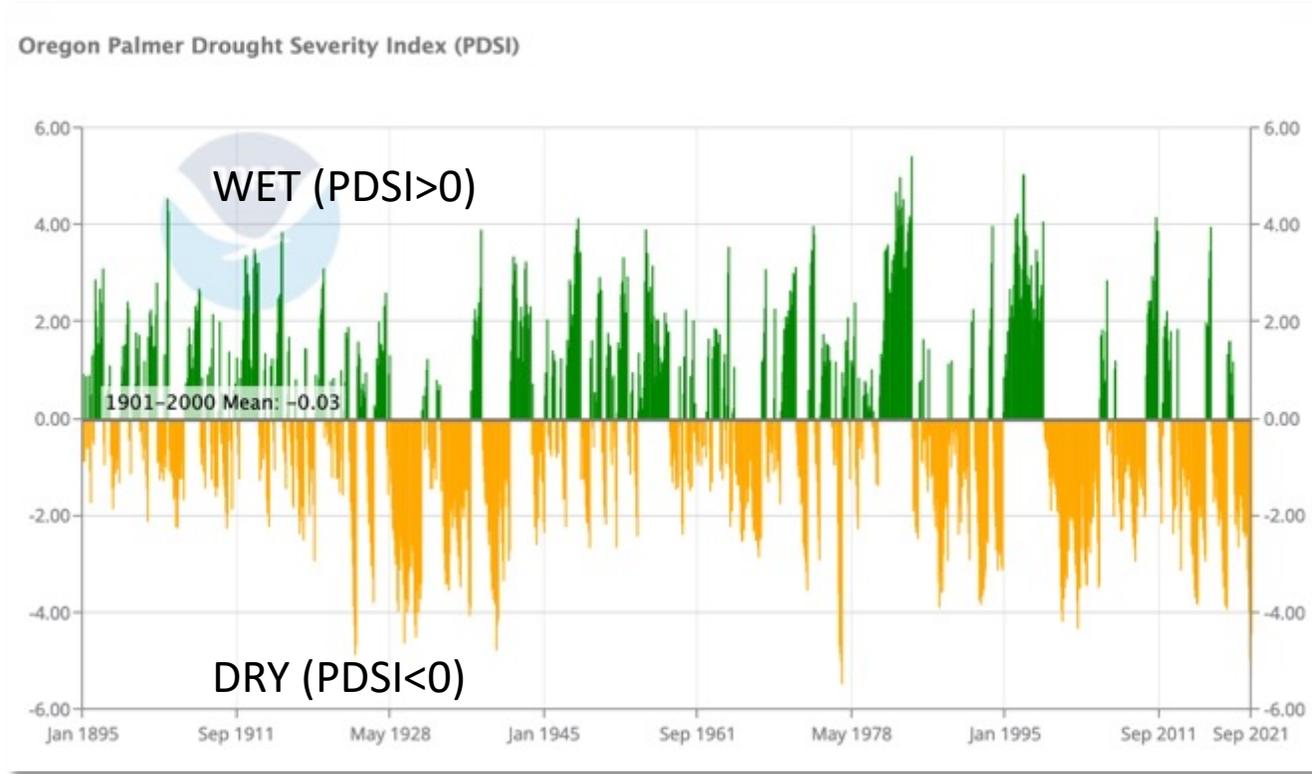
- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

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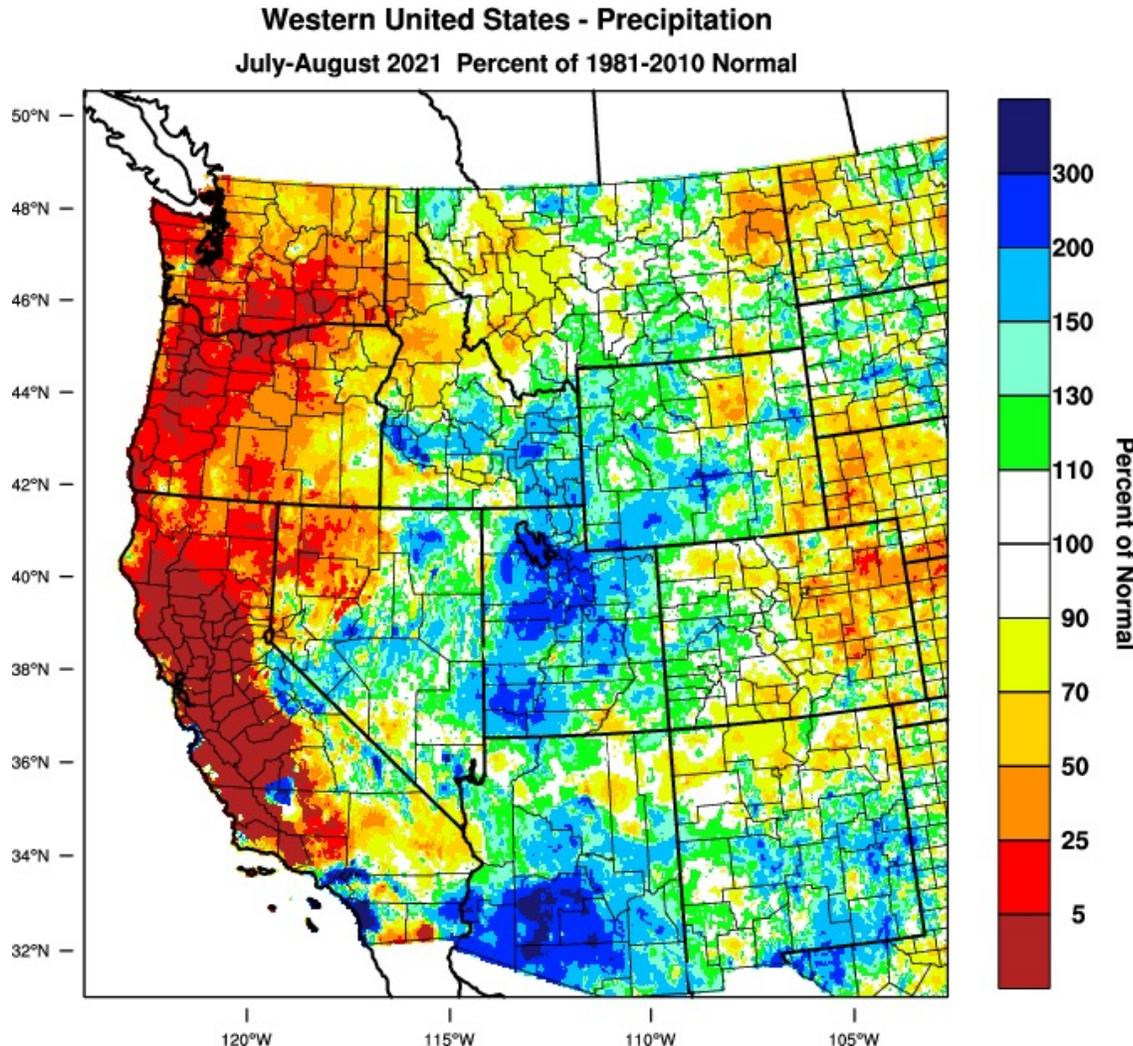
# Assessing Oregon's drought severity



Category	Description	Possible Impacts	Ranges				
			Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Objective Drought Indicator Blend (Percentiles)
D0	Abnormally Dry	<ul style="list-style-type: none"> <li>Going into drought:                             <ul style="list-style-type: none"> <li>short-term dryness slowing planting, growth of crops or pastures</li> </ul> </li> <li>Coming out of drought:                             <ul style="list-style-type: none"> <li>some lingering water deficits</li> <li>pastures or crops not fully recovered</li> </ul> </li> </ul>	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	<ul style="list-style-type: none"> <li>Some damage to crops, pastures</li> <li>Streams, reservoirs, or wells low, some water shortages developing or imminent</li> <li>Voluntary water-use restrictions requested</li> </ul>	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	<ul style="list-style-type: none"> <li>Crop or pasture losses likely</li> <li>Water shortages common</li> <li>Water restrictions imposed</li> </ul>	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	<ul style="list-style-type: none"> <li>Major crop/pasture losses</li> <li>Widespread water shortages or restrictions</li> </ul>	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5
D4	Exceptional Drought	<ul style="list-style-type: none"> <li>Exceptional and widespread crop/pasture losses</li> <li>Shortages of water in reservoirs, streams, and wells creating water emergencies</li> </ul>	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2

- Oregon statewide PDSI for August 2021: -5.24 (second lowest monthly ranking in the 127-year record)
- The lowest occurred during April 1977
- Sept 2021 PDSI: -4.42 (12<sup>th</sup> lowest monthly ranking on record)
- July 2021 PDSI: -4.93 (4<sup>th</sup> lowest monthly ranking on record)

# 2021 Monsoon Season was a bust for the PacNW



WestWide Drought Tracker, U Idaho/WRCC Data Source: PRISM (Prelim), created 16 SEP 2021

The monsoon brings critical summer moisture in July and August to eastern Oregon and Washington via thunderstorms and convective showers

Like last water year, the North American monsoon season was mostly dry in Washington, Oregon, and California

Large parts of the desert southwest received well above normal monsoonal moisture