Oregon Drought Status and Update Water Year 2021

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Key points:

(1) Although ongoing, the current Oregon drought ranks among the 4 worst in state recorded history alongside 1924, 1931, and 1977

(2) Central Oregon is experiencing its worst drought in recorded history over the last two water years

(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

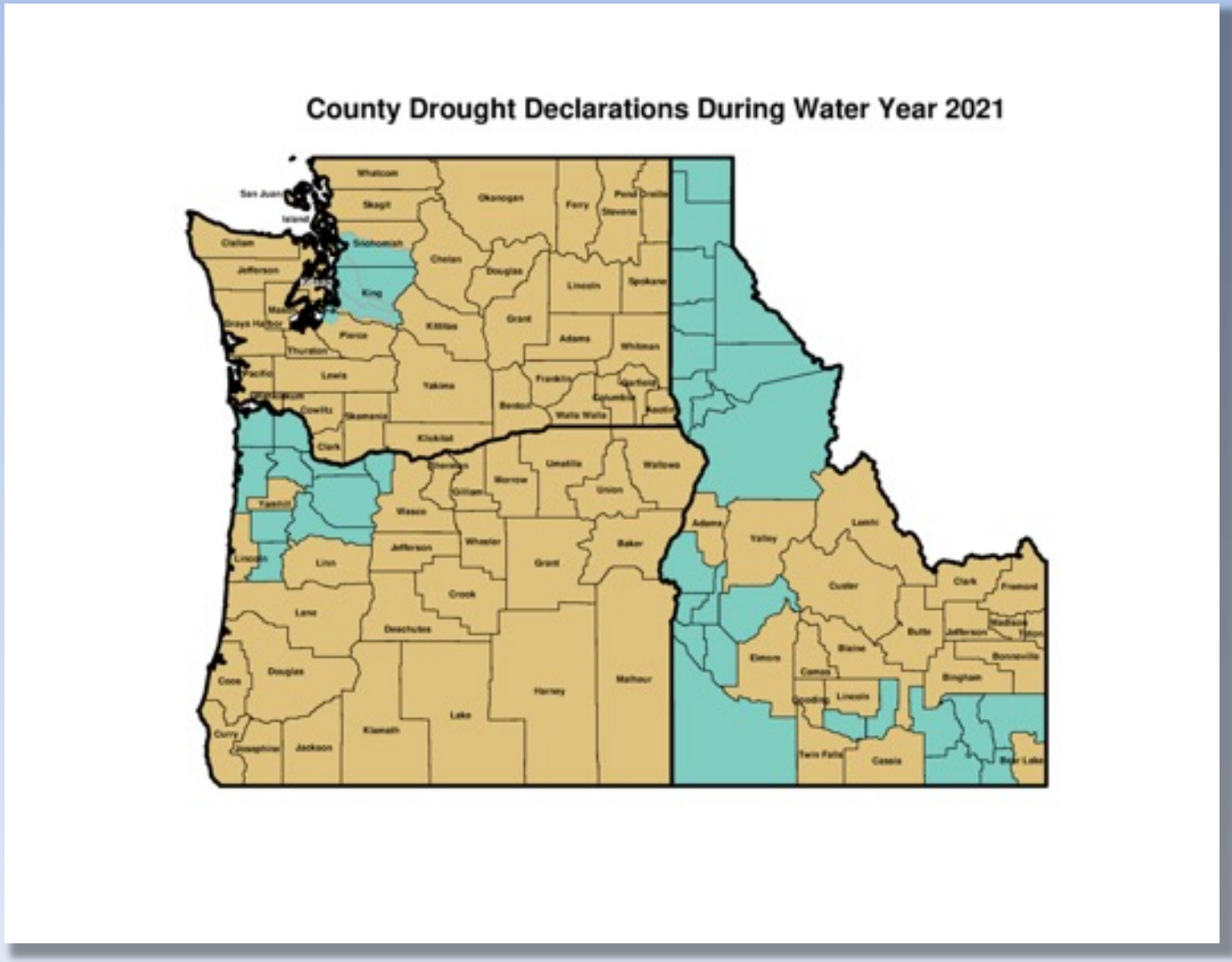
Wickiup Reservoir, August 19, 2021
Image Courtesy of The Bend Bulletin

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

CCCRI

OCS Oregon Climate Service

Pacific Northwest Drought Declarations

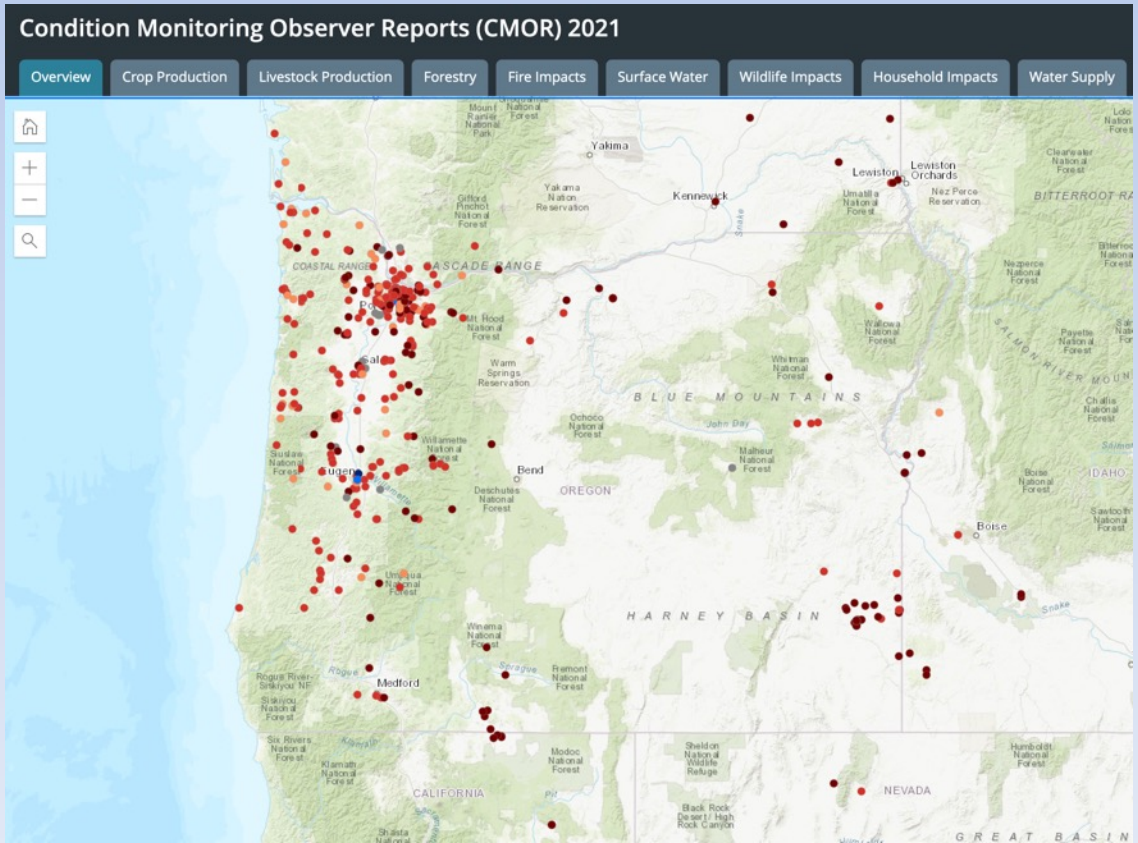


During 2021, 26 out of 36 Oregon counties requested and received state-level emergency drought declarations

Klamath County received the first of the year, with the county declaration occurring on March 9

Condition Monitoring Observer Reports

- Condition observer reports from a variety of sources assist in providing context to the meteorological and hydrological data, and sometimes point to areas where perhaps other objective data have not fully captured drought extent or evolution
- Example below shows the CMOR dashboard service provided by the National Drought Mitigation Center (NDMC)
  - https://go.unl.edu/CMOR_drought



Each dot shows an impact report from this calendar year

Colors represent the reporter's assessment of drought conditions (reds being extreme drought)

156 impact reports received during 2021

Condition Monitoring Observer Reports

July 15, 2021

July 29, 2019

Description and/or caption information:
These photos show the dry ground and grasshopper damage and the difference between 2019 and 2021 on our personal property. All the grass and plants along the dry irrigation canal should be lush and green. The affects of the drought/ grasshoppers is devastating. I caught one little guy posing for the camera😊.

Condition Monitoring Observer Reports

Report Detail - 7/6/2021

Livestock production:
reduced_pasture_forage,feeding_hay,supplemental_feed,purchased_hay,more_invasive_species_plants_,decreased_stock_weights,animal_stress,reduced_grazing_on_public_lands,less_water,hauled_water

Municipal water supply:
hauling_water

Public health impact:
stress

Household impact:
increased_lawn_landscape_wateri,dry_lawn

Fire impact:
more_fire_risk

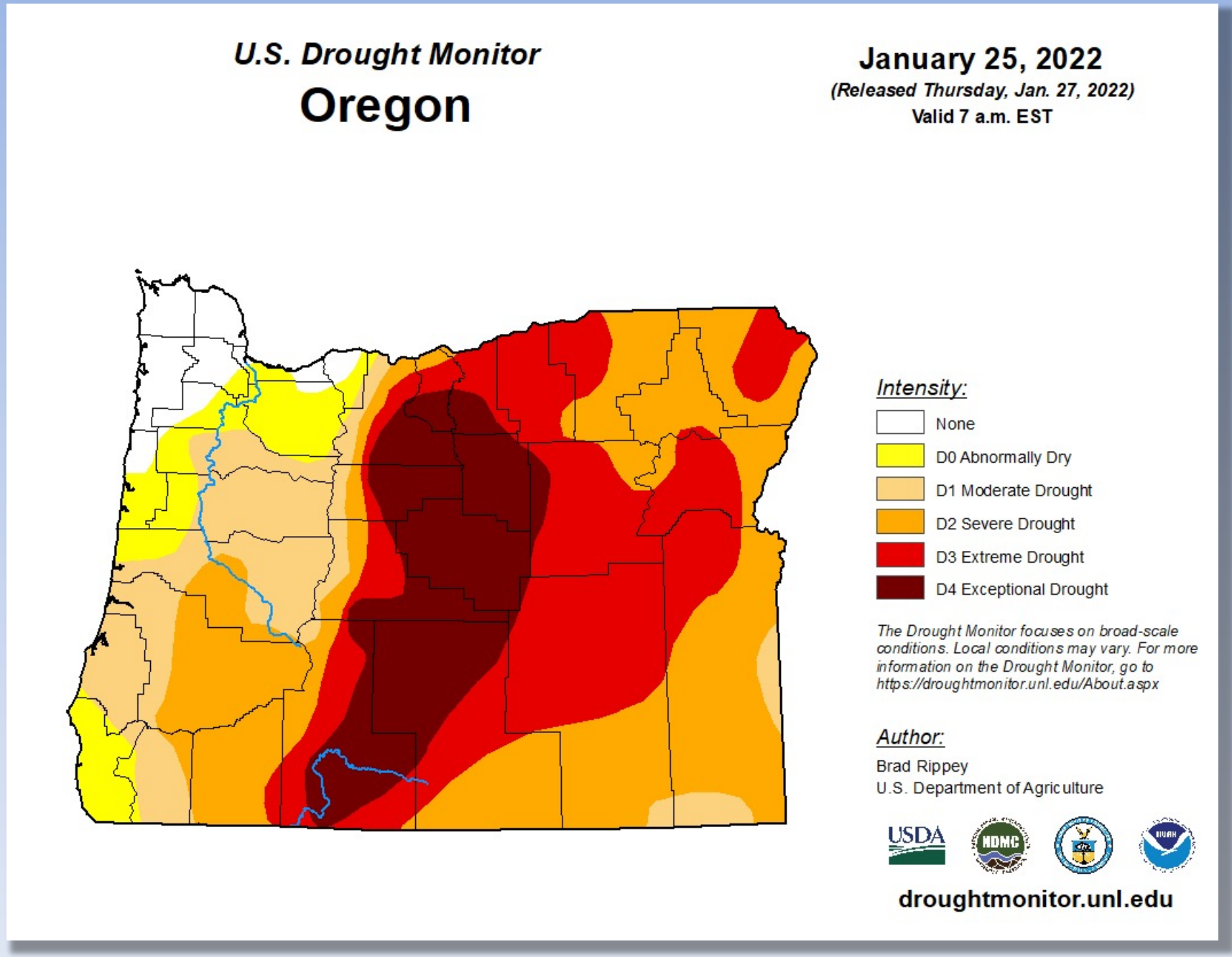
Wildlife habitat impact:
less_food_,less_water_,invasive_plant_or_animal_specie

Description and/or caption information:
This picture was taken out on our BLM range that we are supposed to be using right now but are unable to because of the severe drought and grasshopper invasion. We are also out of irrigation water at home. We are being faced with bringing our cows home 2 months early and feeding them hay that we have to buy. This is total devastation for our ranching communities livelihood.

Current issuance of the weekly U.S. Drought Monitor

It's Thursday, you know what that means…

Any updates to the USDM?



Drought categories

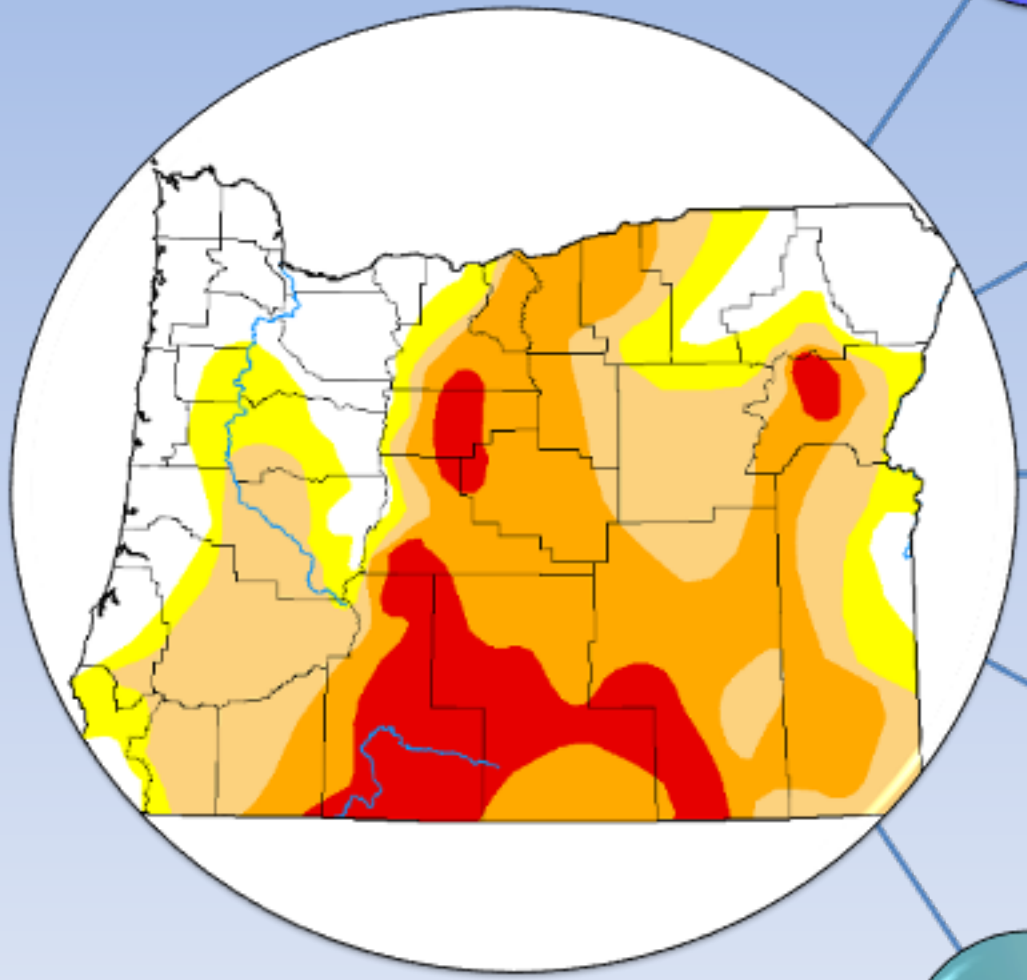
Drought Category	Color	Frequency
• D4, Exceptional Drought:		once per 50 to 100 years
• D3, Extreme Drought:		once per 20 to 50 years
• D2, Severe Drought:		once per 10 to 20 years
• D1, Moderate Drought:		once per 5 to 10 years
• D0, Abnormally Dry:		once per 3 to 5 years

Drought categories are associated with historical occurrences

Objectively characterized by percentile rankings of major drought indicators

It is not anecdotal or subjective, as summarized in this talk

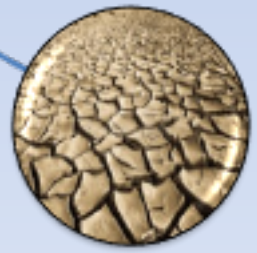
Key objective drought indicators for Oregon



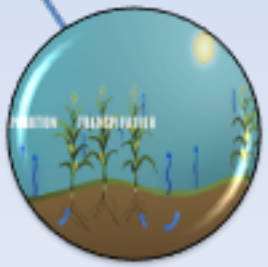
- Streamflow
- Seasonal runoff

- Precipitation
- Standardized Precipitation Index (SPI)

- Snowpack
- Snow Water Equivalent (SWE)



- Soil moisture
- Shallow groundwater



- Evapotranspiration
- Air Temperature
- Standardized Precipitation-Evaporation Index (SPEI)

Time cutoff for observations is Tuesday 12Z each week of issuance

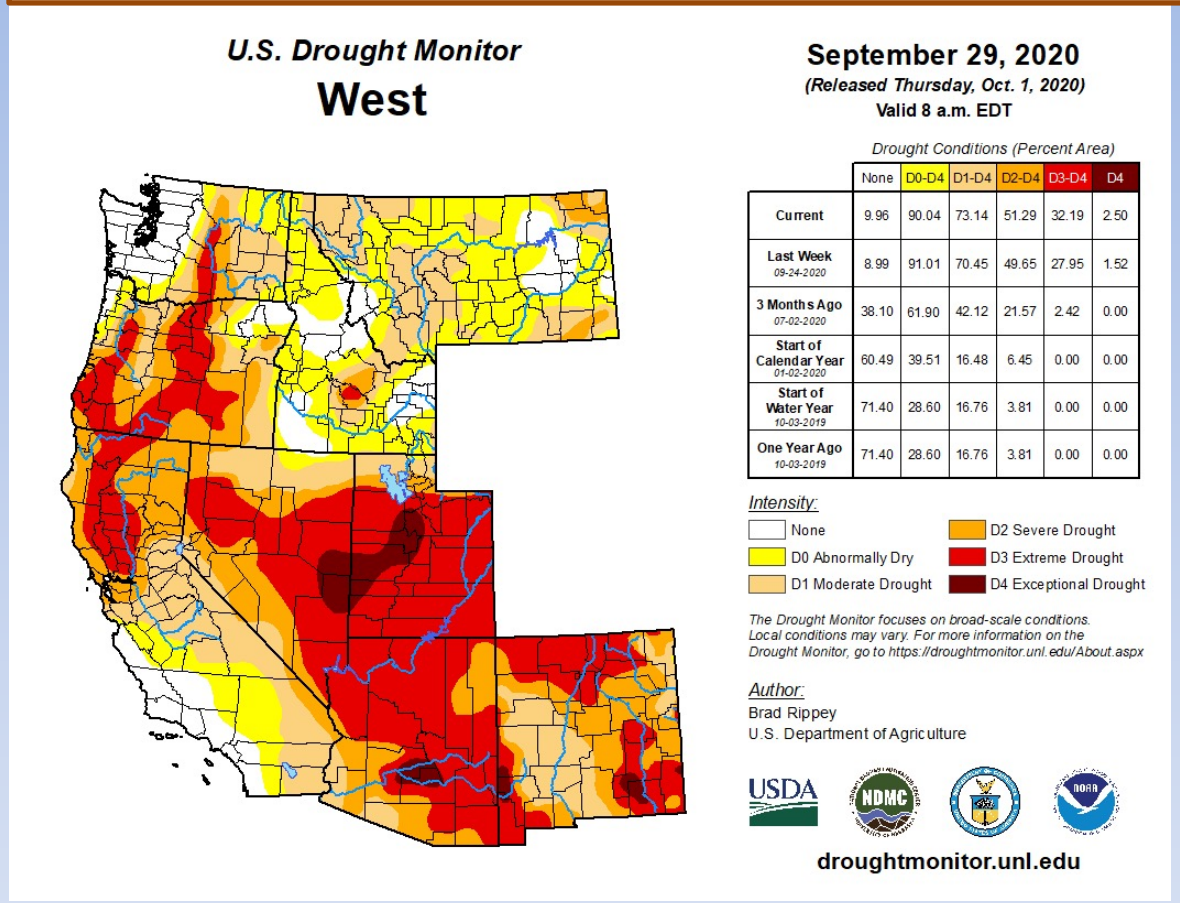
How do we categorize drought?

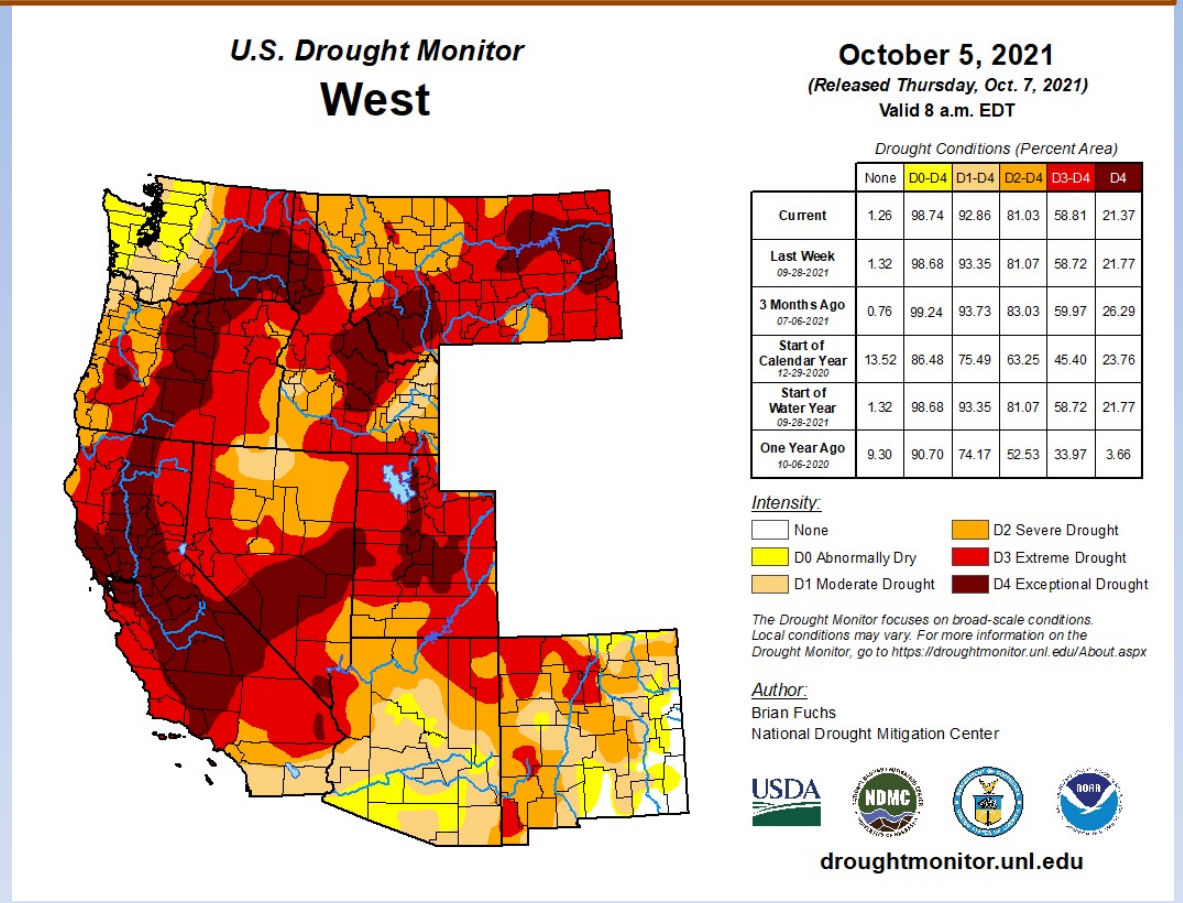
- Drought is measured against historical meteorological and hydrological conditions
- Source of water by precipitation is *NOT* the only factor in drought depiction
  - We also consider loss and storage terms in the total surface water balance:
    - Evaporation (potential evapotranspiration)
    - Runoff (streamflow volume over time)
    - Shallow groundwater storage (near-surface soil moisture, 1-meter soil moisture content)
  - Condition and evolution of the snowpack during winter/spring, which is a key predictor for late spring and summer hydrological drought in snowmelt-dominated basins

U.S. Drought Monitor process for Oregon

- USDM is updated weekly
- National USDM authors solicit feedback from local experts or groups for most states or climate regions
- Oregon has a Drought Monitor Advisory Committee that discusses conditions and contributes suggestions nearly every week
  - I chair this committee
  - Representatives from all local NWS offices (Portland, Medford, Pendleton, and Boise), Oregon USDA/NRCS, Oregon Water Resources Dept (OWRD), and the USGS
  - The Oregon DMAC was formed about 2 years ago to address drought depiction issues specific to Oregon that were not being adequately addressed by national USDM authors
- Approximately monthly drought coordination meetings with NOAA/NIDIS, the state climate offices in Washington and Idaho, WA Dept of Ecology, OCCRI, OWRD, and USDA/NRCS
- Monthly meetings of the Oregon Water Supply Availability Committee and the Drought Readiness Council

Drought progression throughout WY2021





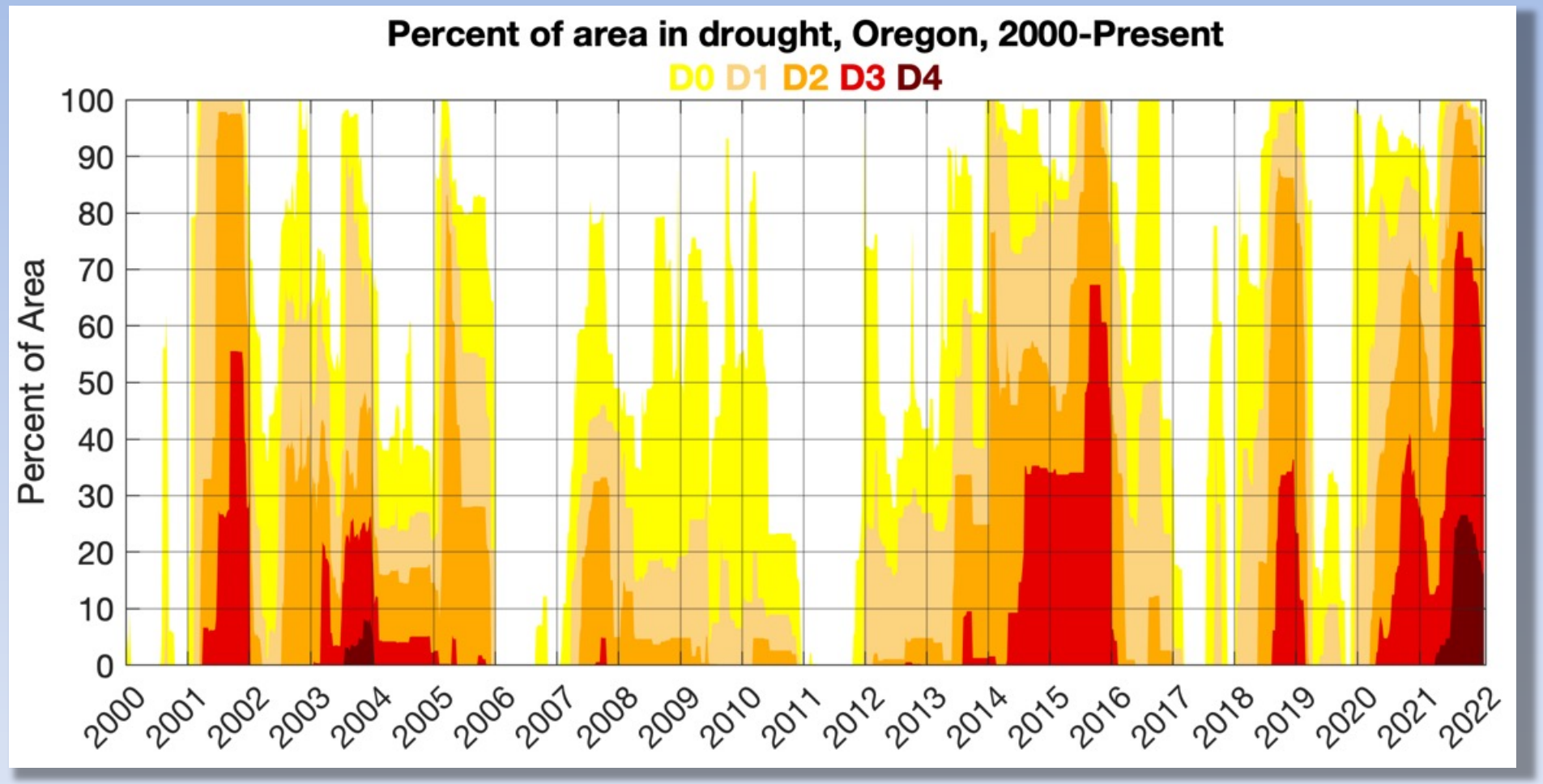
On September 29, 2020:

- Oregon: 15% of area drought-free
  - 34% in D3; 32% in D2; 19% in D1; 9% in D0

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

Oregon drought depiction in the 21st Century

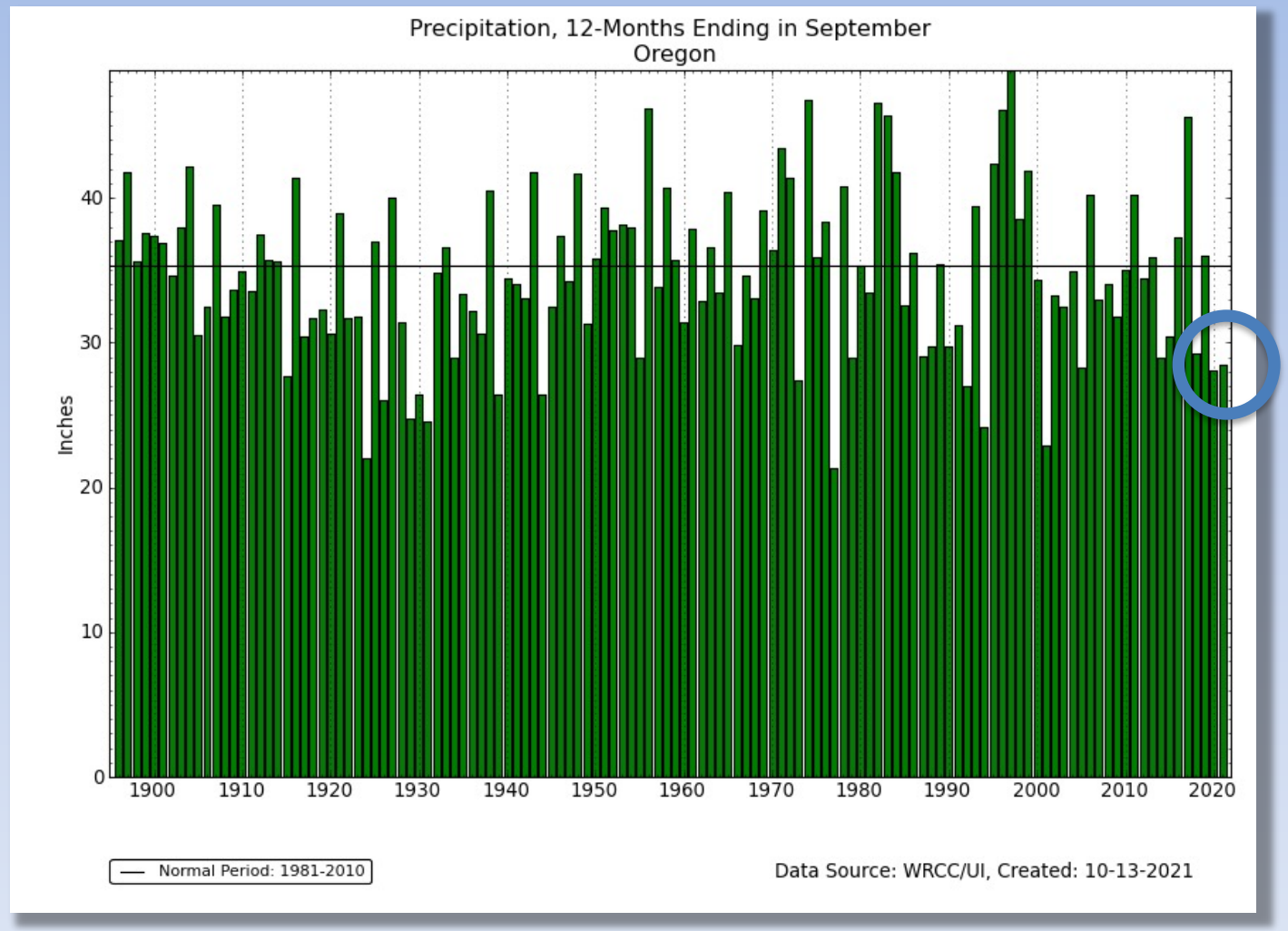


This year, since the USDM began weekly drought classification in early 2000, Oregon:

- Had its most extensive D3+ classification
- Had only its second D4 classification
- At the drought's peak in mid-Sept 2021, D4 covered 27% of Oregon

SUMMARY OF WATER YEAR 2021 METEOROLOGICAL AND HYDROLOGICAL CONDITIONS ASSOCIATED WITH THE DROUGHT

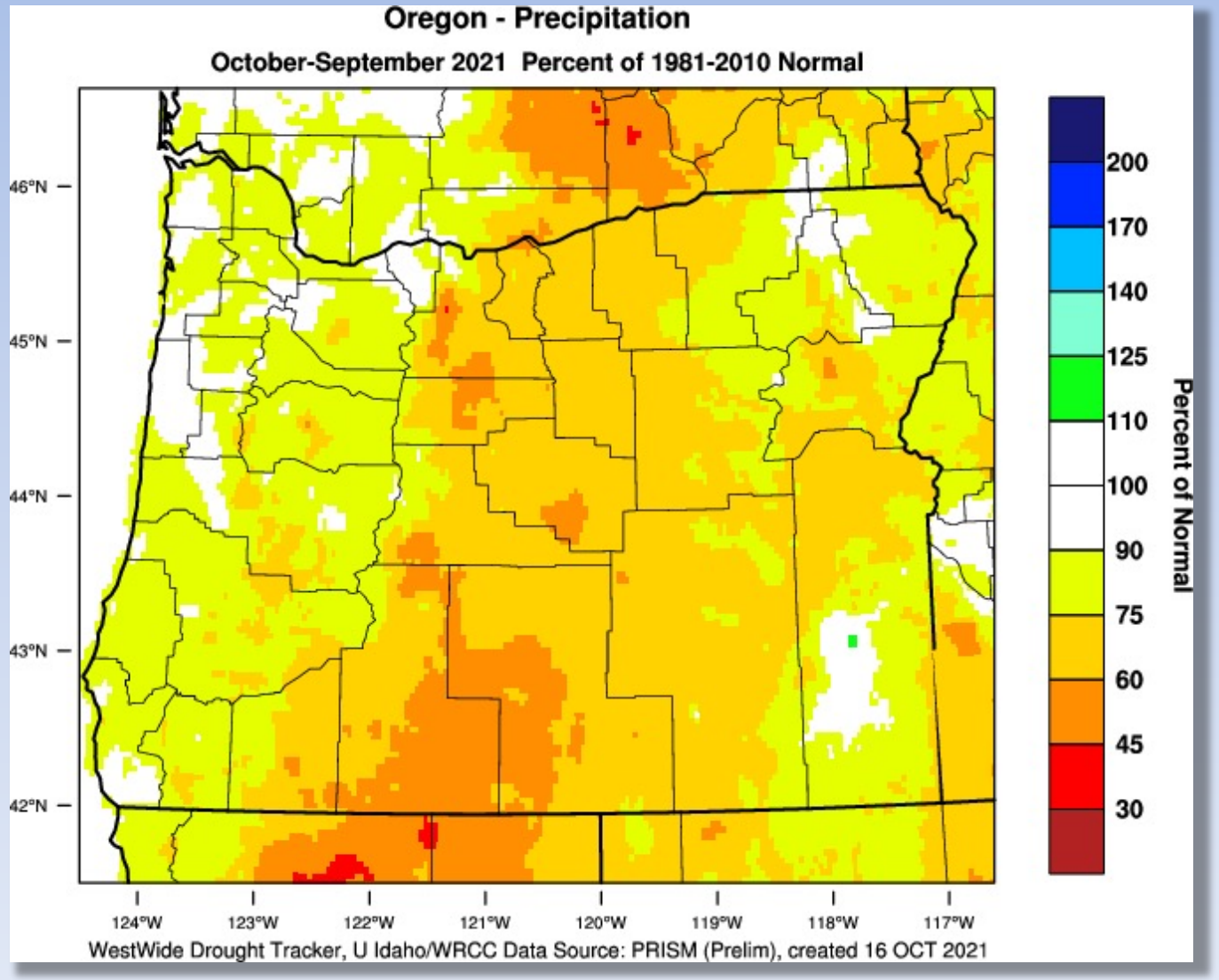
Oregon WY 2021 Total Precipitation



- Water Year 2021 (WY2021) spans Oct 2020-Sept 2021
- Oregon received 80.7% of avg precip
- WY2021 ranks 16th 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 even though both have been La Niña years

Source: Westwide Drought Tracker using the PRISM precipitation analysis
https://wrcc.dri.edu/wwdt/time/

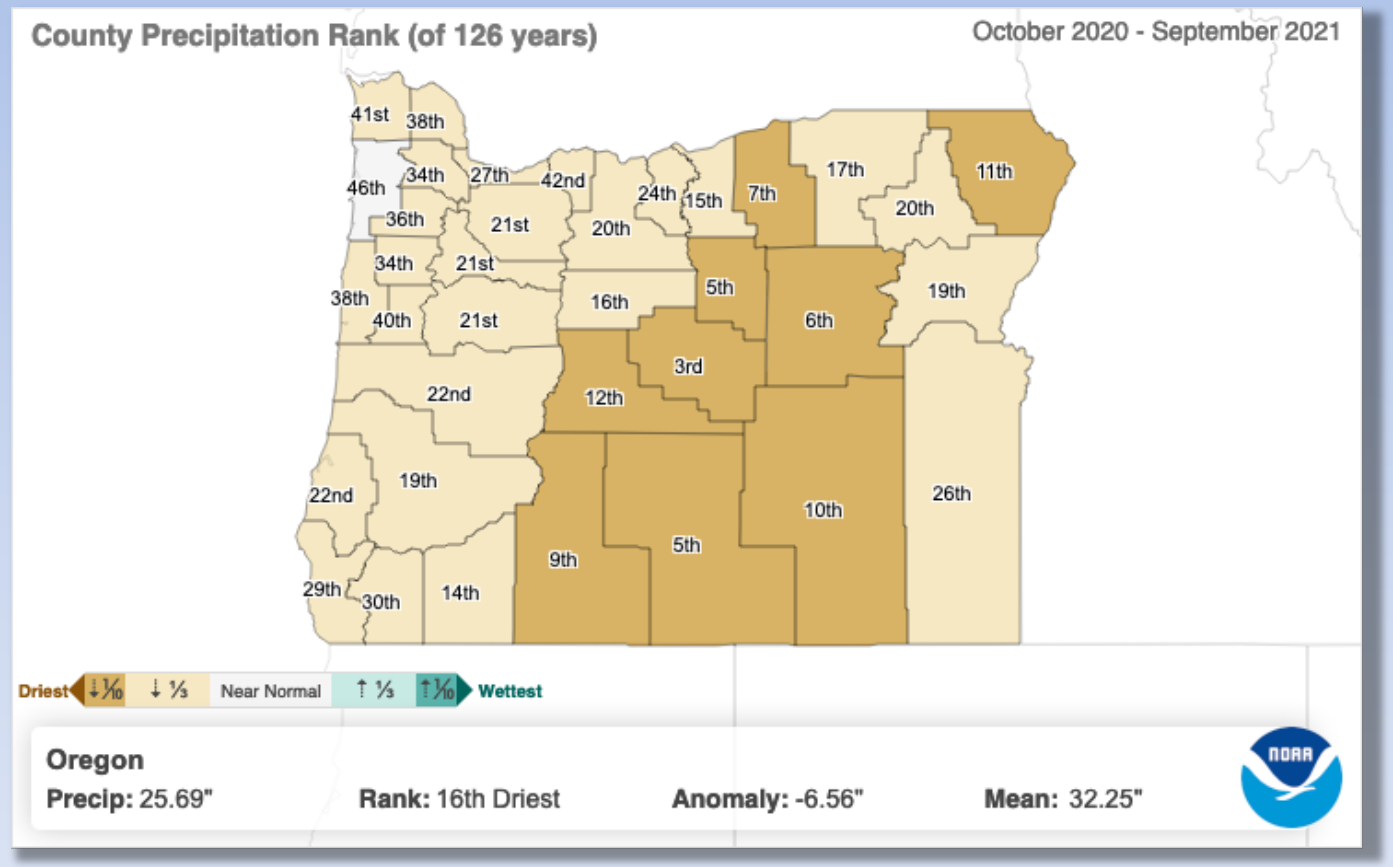
Oregon WY 2021 Total Precipitation



- Dryness unevenly distributed
- Northwest Oregon and the North Oregon Cascades were closer to average
- Most of the state was below 90% of average
- Central and Southern Oregon was really the epicenter of the driest conditions

Source: WestWide drought tracker retrieved Jan 2022
https://wrcc.dri.edu/wwdt/archive.php?region=or

Water Year 2021 accumulated rainfall rankings by county



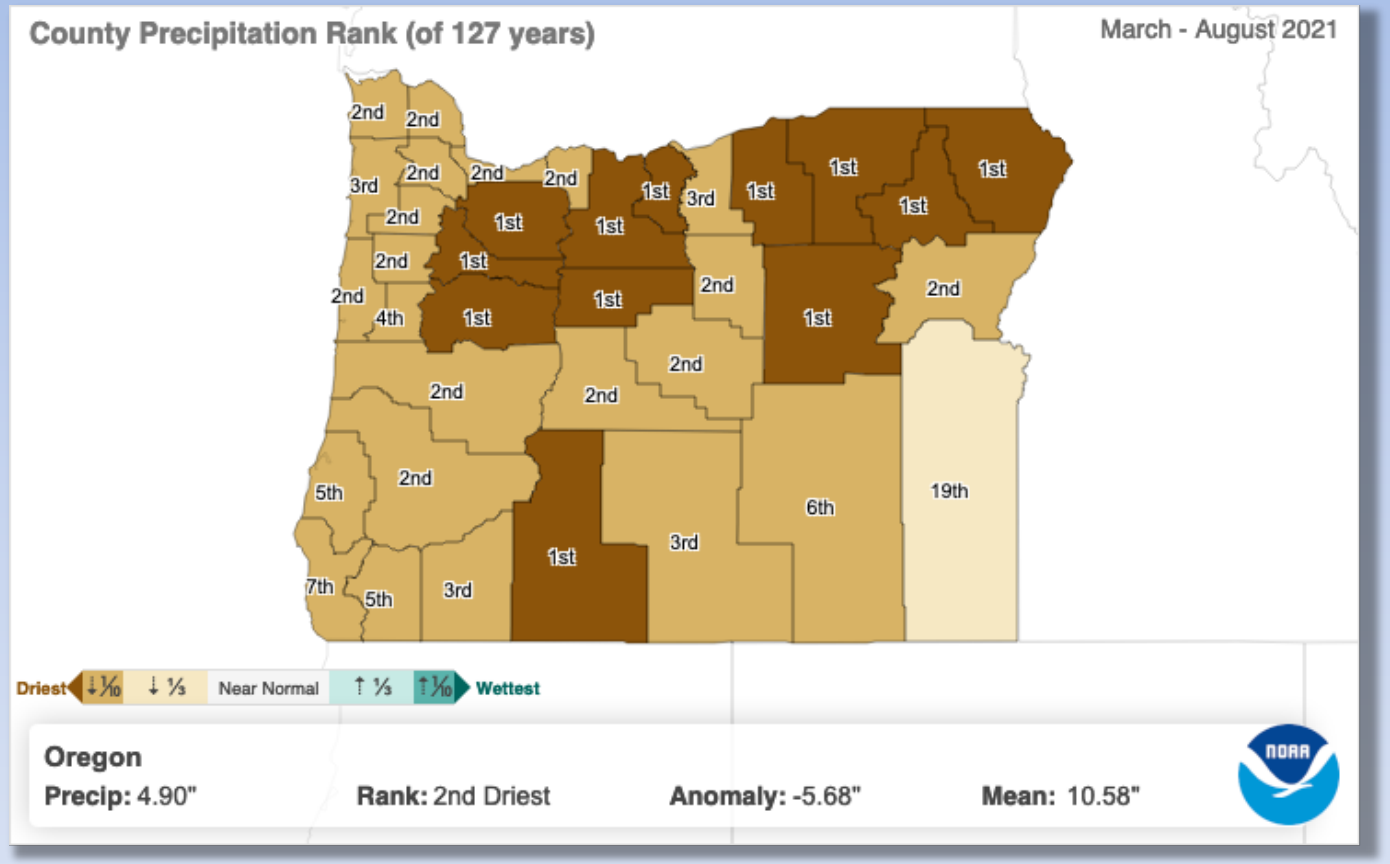
The numbers on the counties represent the rank of WY accumulated precipitation in the 126-year data record (1=driest; 126=wettest)

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.

Source: NOAA/NCEI Retrieved Jan 2022 from:
https://www.ncdc.noaa.gov/cag/county/mapping/35/pcp/202109/12/rank

March-August 2021 rainfall rankings by county



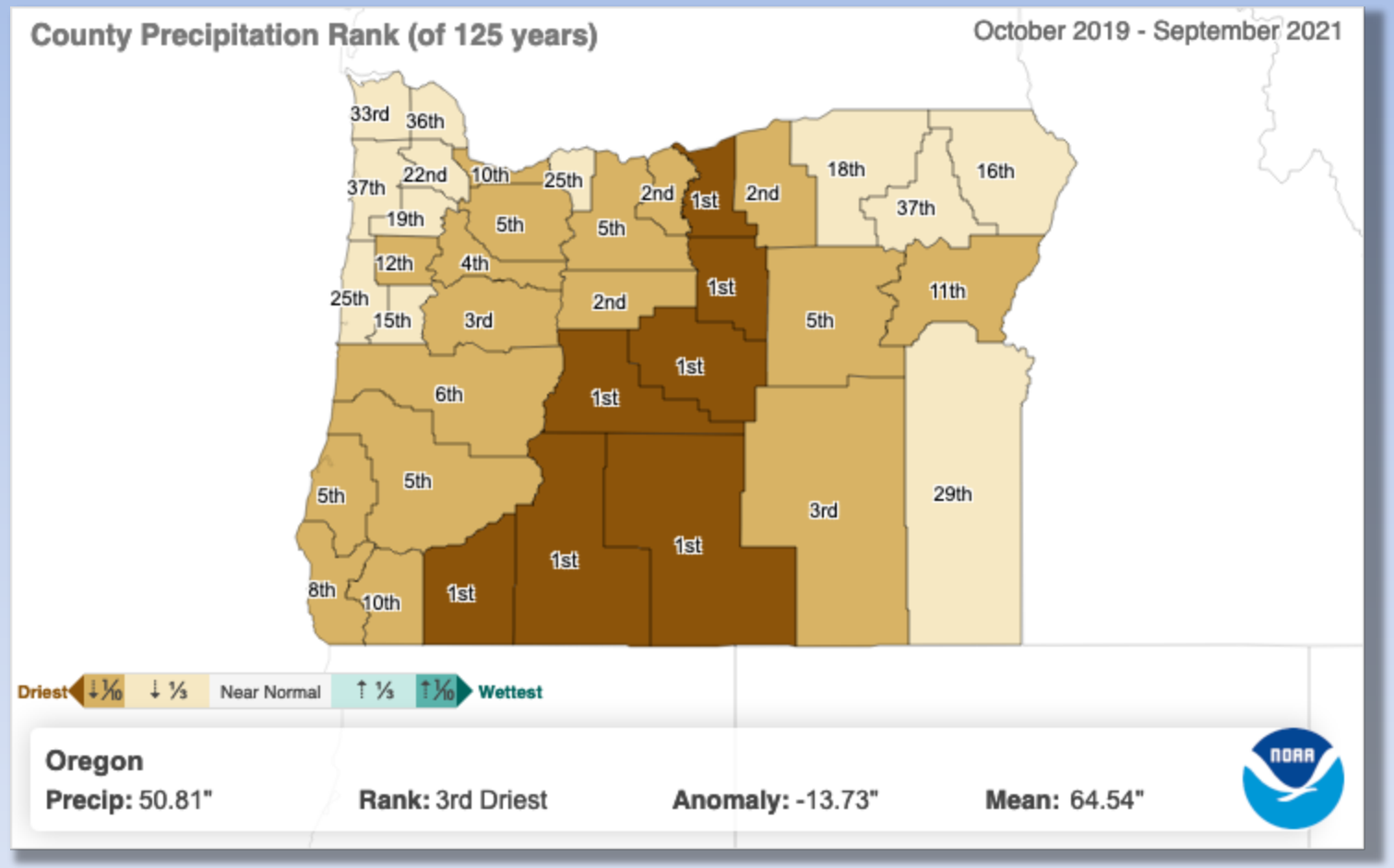
Widespread drought formed and intensified after March 2021 – many counties experienced one of their driest 6-month periods on record

Oregon recorded its second driest Mar-Aug on record

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

Source: NOAA/NCEI Retrieved Jan 2022 from:
https://www.ncdc.noaa.gov/cag/county/mapping/35/pcp/202108/6/rank

WY2020 and WY 2021 rainfall rankings by county



Seven counties in Central Oregon recorded their lowest 2-yr precipitation totals on record (since 1895)

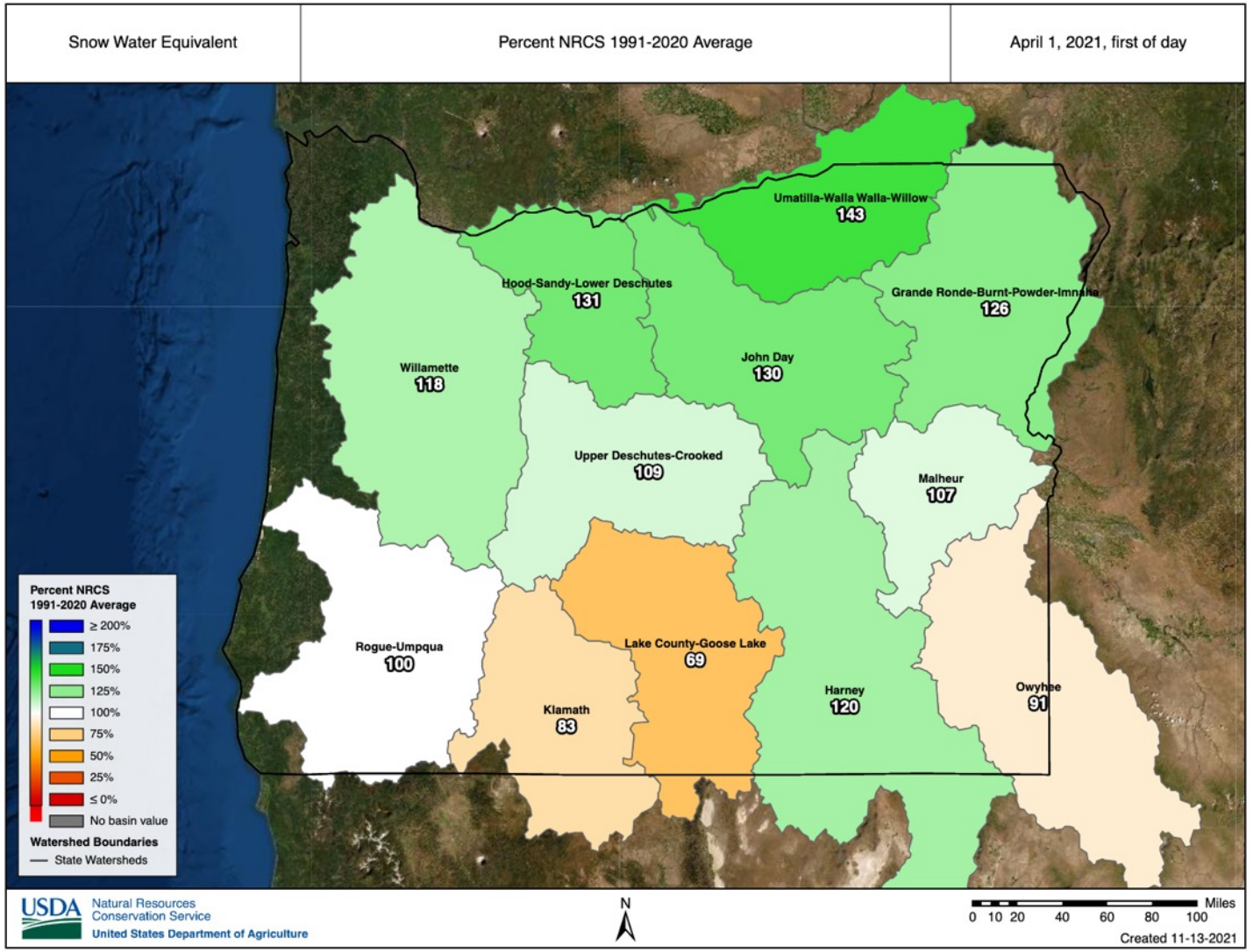
Counties include: Gilliam, Wheeler, Crook, Deschutes, Lake, Klamath, and Jackson

Oregon as a state recorded its third lowest 2-yr precipitation total

Just based on precipitation alone, this multi-year drought qualifies as one of the most severe in state recorded history

Source: NOAA/NCEI Retrieved Jan 2022 from:
https://www.ncdc.noaa.gov/cag/county/mapping/35/pcp/202109/24/rank

April 1, 2021 SWE at SNOTEL stations



Snow water equivalent (SWE) is the amount of water in the snowpack when melted

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

Despite well below average precipitation statewide, the snowpack registered above normal during WY2021

Exceptions include Klamath, Lake, and Owyhee Basins

Statistics courtesy of Scott Oviatt, USDA-NRCS

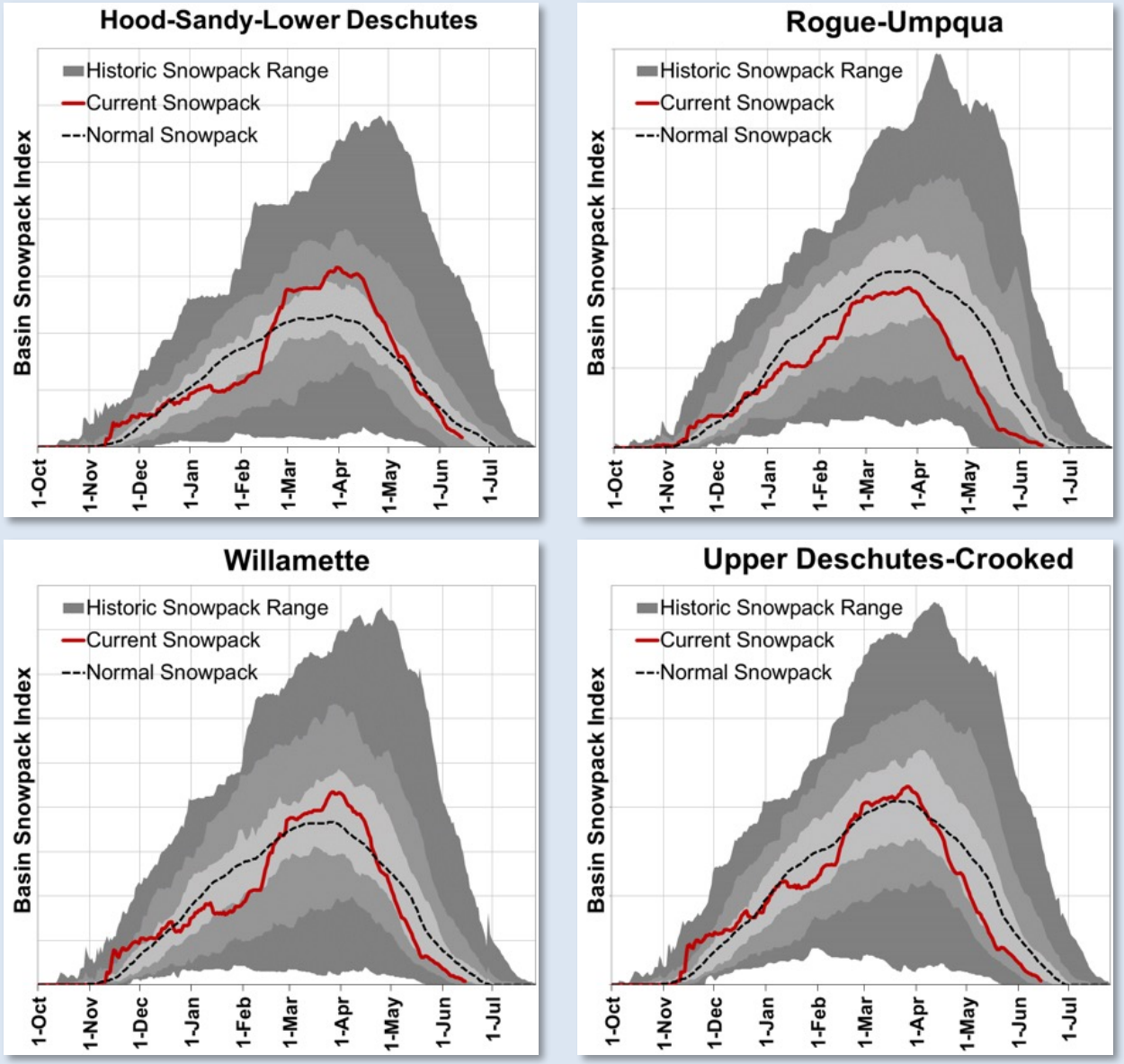
Oregon SNOTEL Basin Snowpack Indices during WY2021

- Indices based on snow-water equivalent at all SNOTEL stations within the basin

- Rogue-Umqua had well below normal snowpack and an early meltout nearly 4 weeks earlier than normal

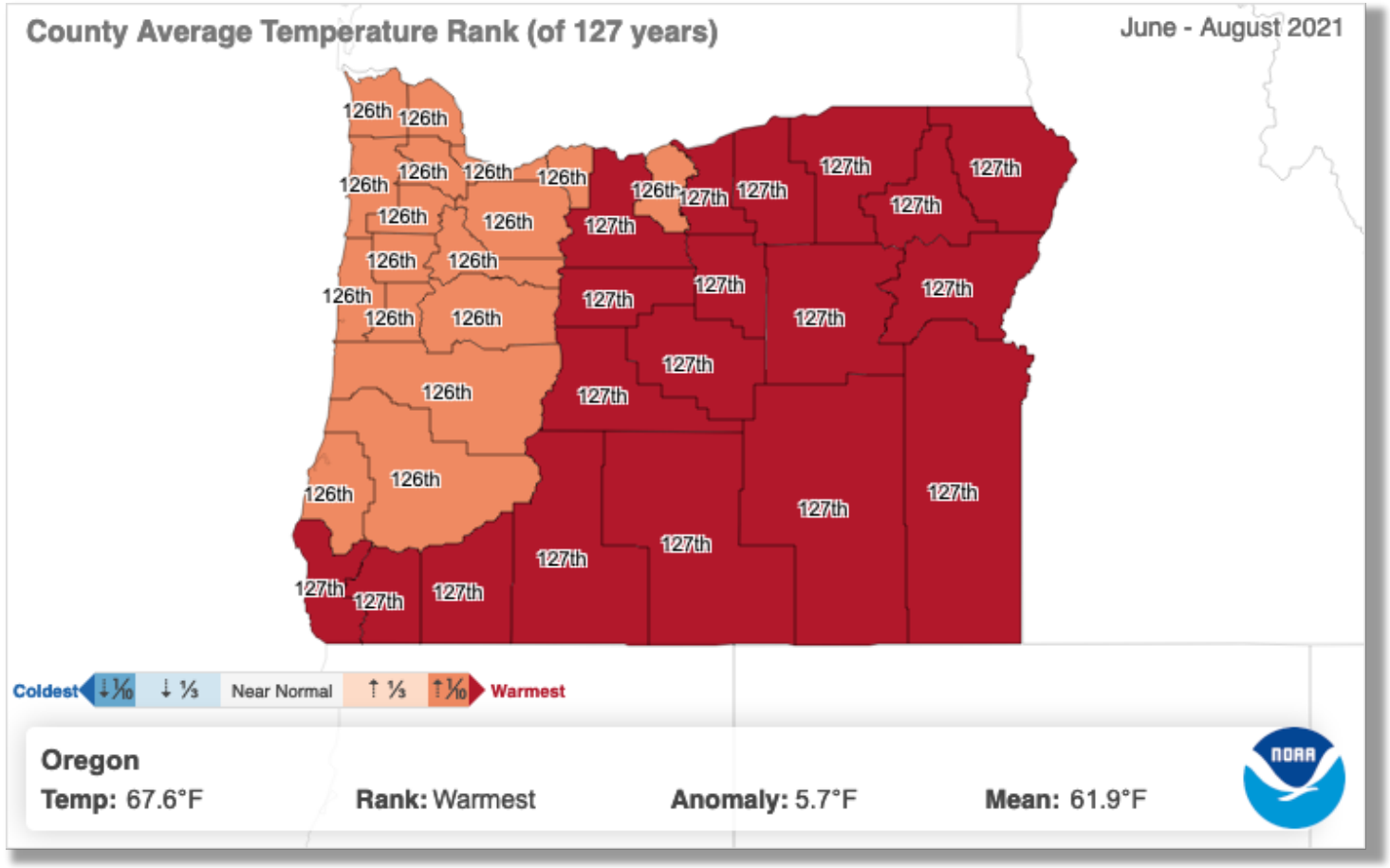
- Other basins had normal to above normal snowpack, but melted out 1-3 weeks early

- 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

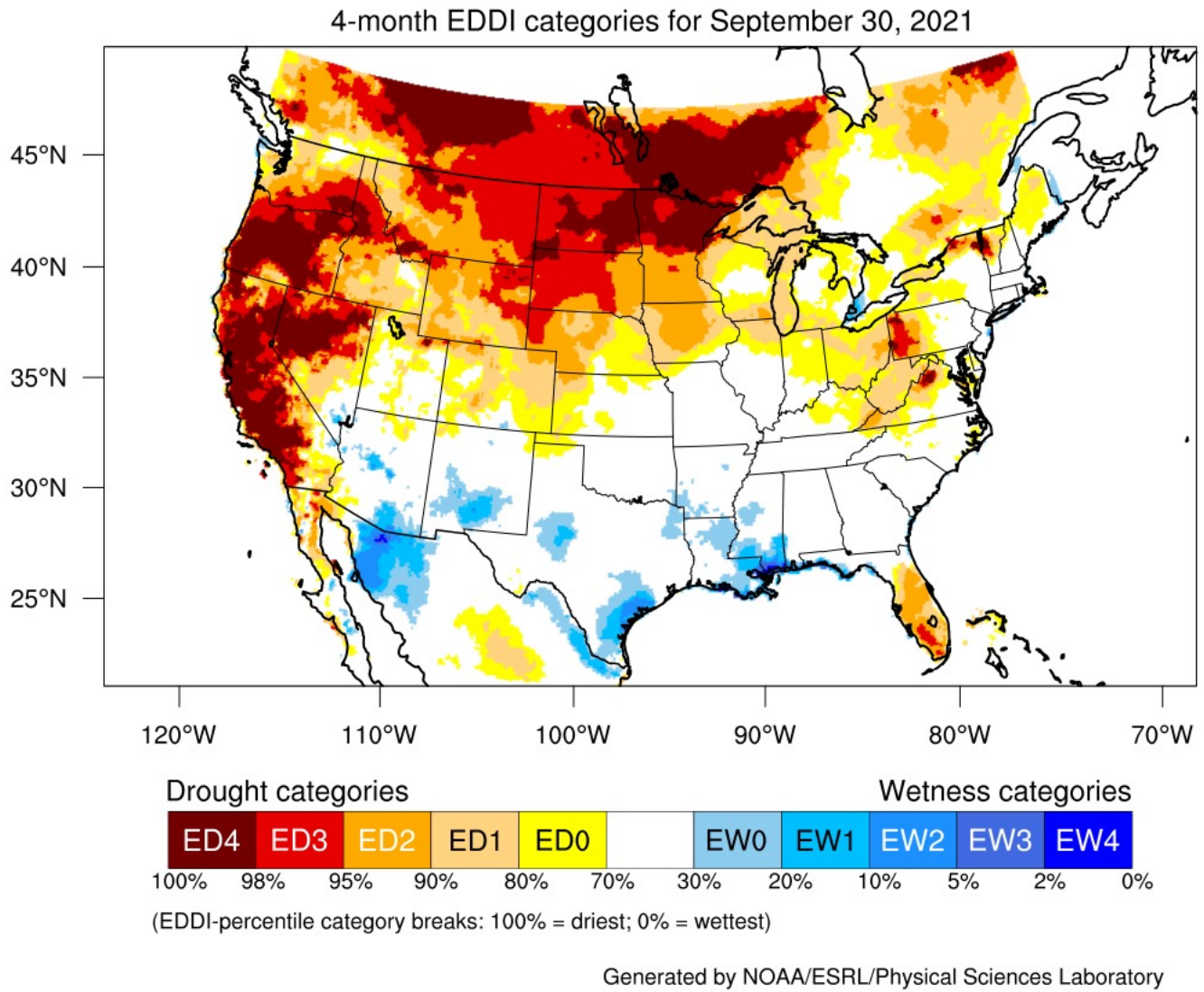
County summer temperature rankings



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

Source: NOAA/NCEI Retrieved Jan 2022 from:
https://www.ncdc.noaa.gov/cag/county/mapping/35/tavg/202108/3/rank

Summer Evaporative Demand



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 experienced record or near record amounts of evaporation

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

Number of days above 90°F during 2021

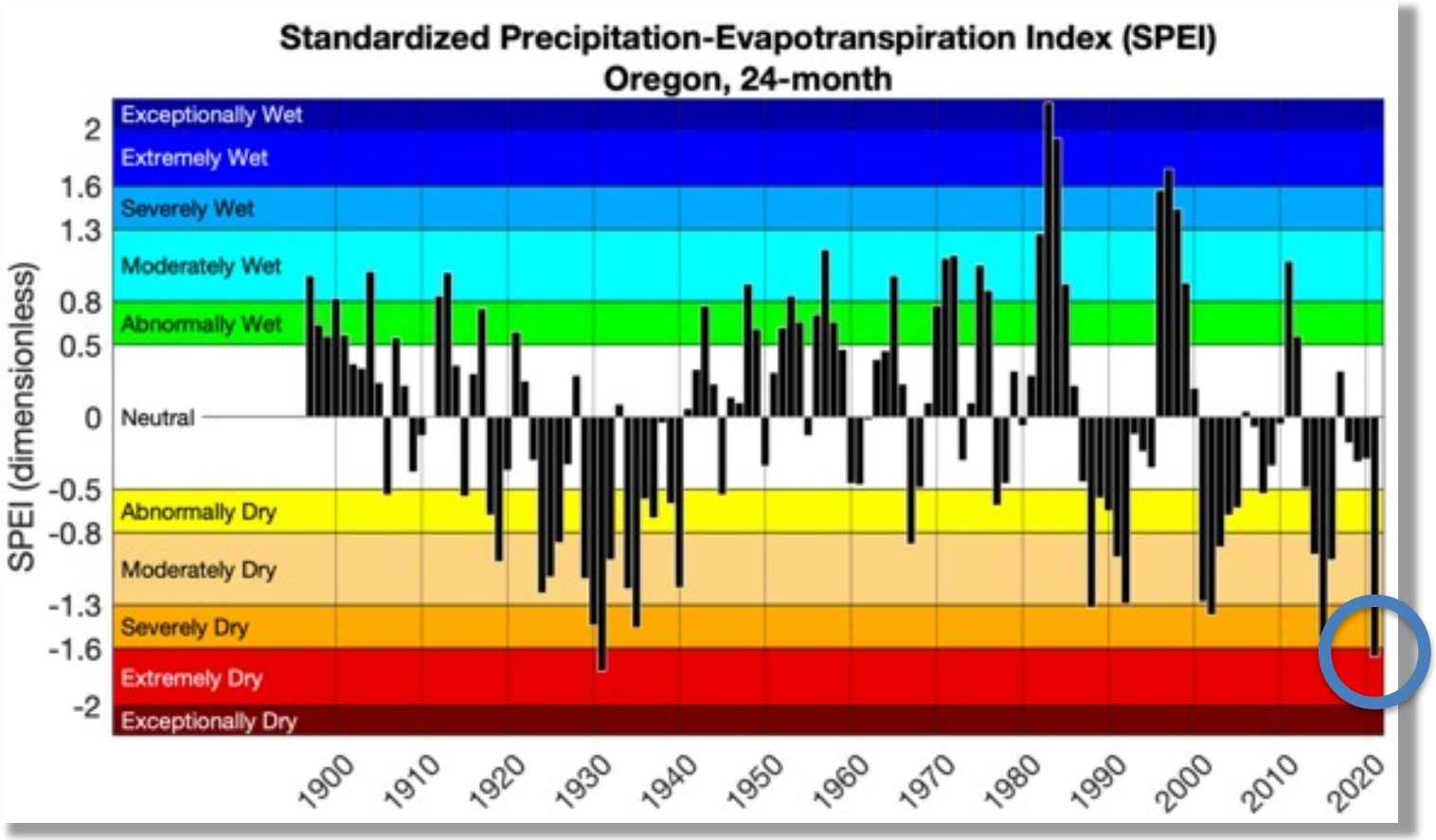
- The record warm summer was not just a product of the June heatwave, but also of prolonged stretches of well above average temperatures
- This fueled the historically high levels of evaporation

Table of select stations in Oregon with POR>50 years

	# 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

Data courtesy of NOAA-NCEI from the GHCN-D station dataset

Assessing Oregon's drought severity: 24-month SPEI

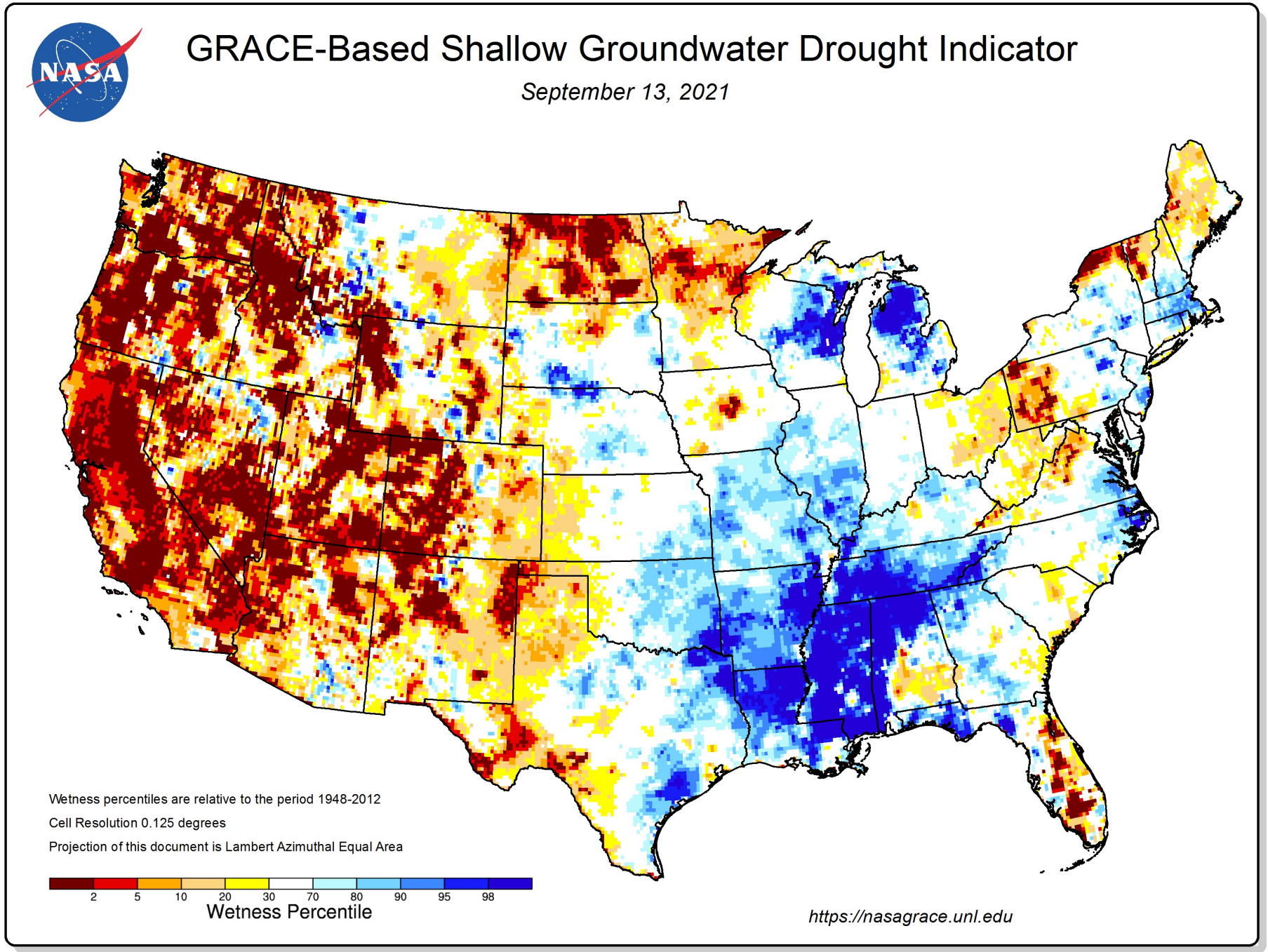


The Standardized Precipitation-Evapotranspiration Index (SPEI) is another drought indicator commonly used in the US West to categorize drought severity and extent

It accounts for variability in both precipitation and evaporation in categorizing drought

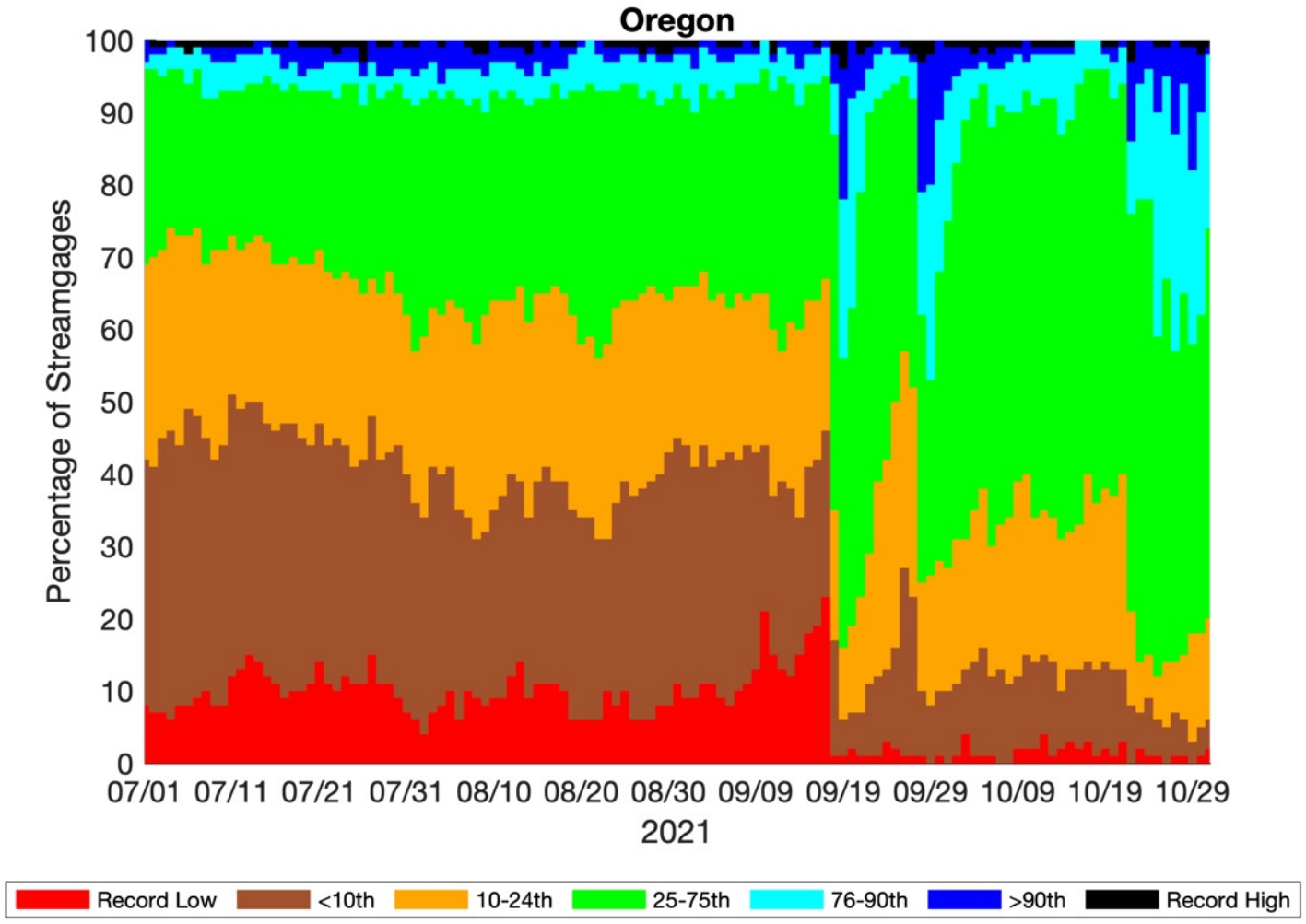
Going out to the last 2 water years (WY2020 and WY2021), the SPEI is the second lowest on record just behind the WY1930 and WY1931

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



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

USGS daily streamflow percentiles during summer/fall 2021

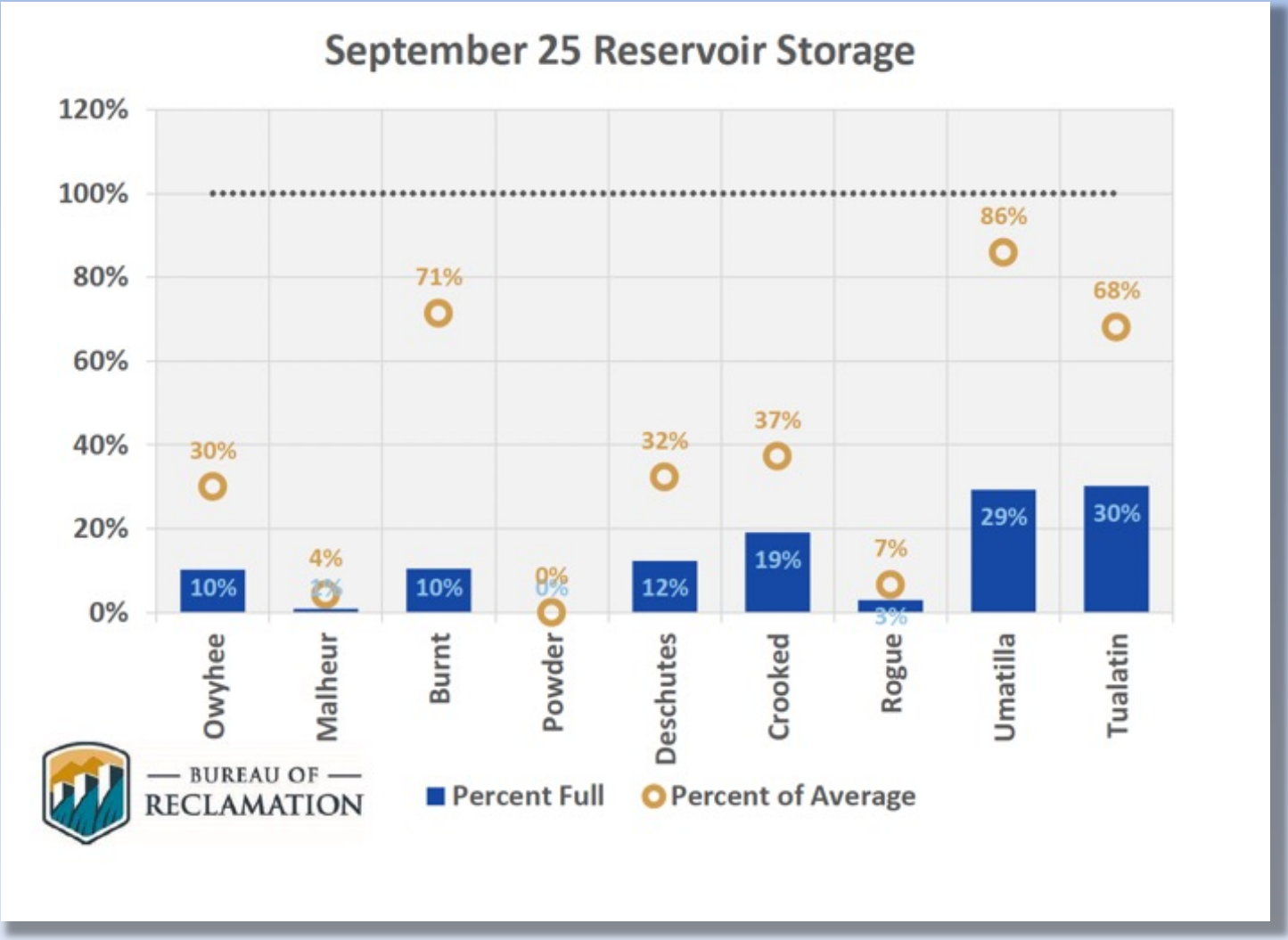


Time series of the percentage of USGS streamflow gages within each percentile class in all of Oregon

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

Reservoir storage conditions near end of WY2021



Many reservoir projects had little to no carryover into WY2022 and were at or near historic lows

Examples: Wickiup, Prineville, Applegate, Phillips

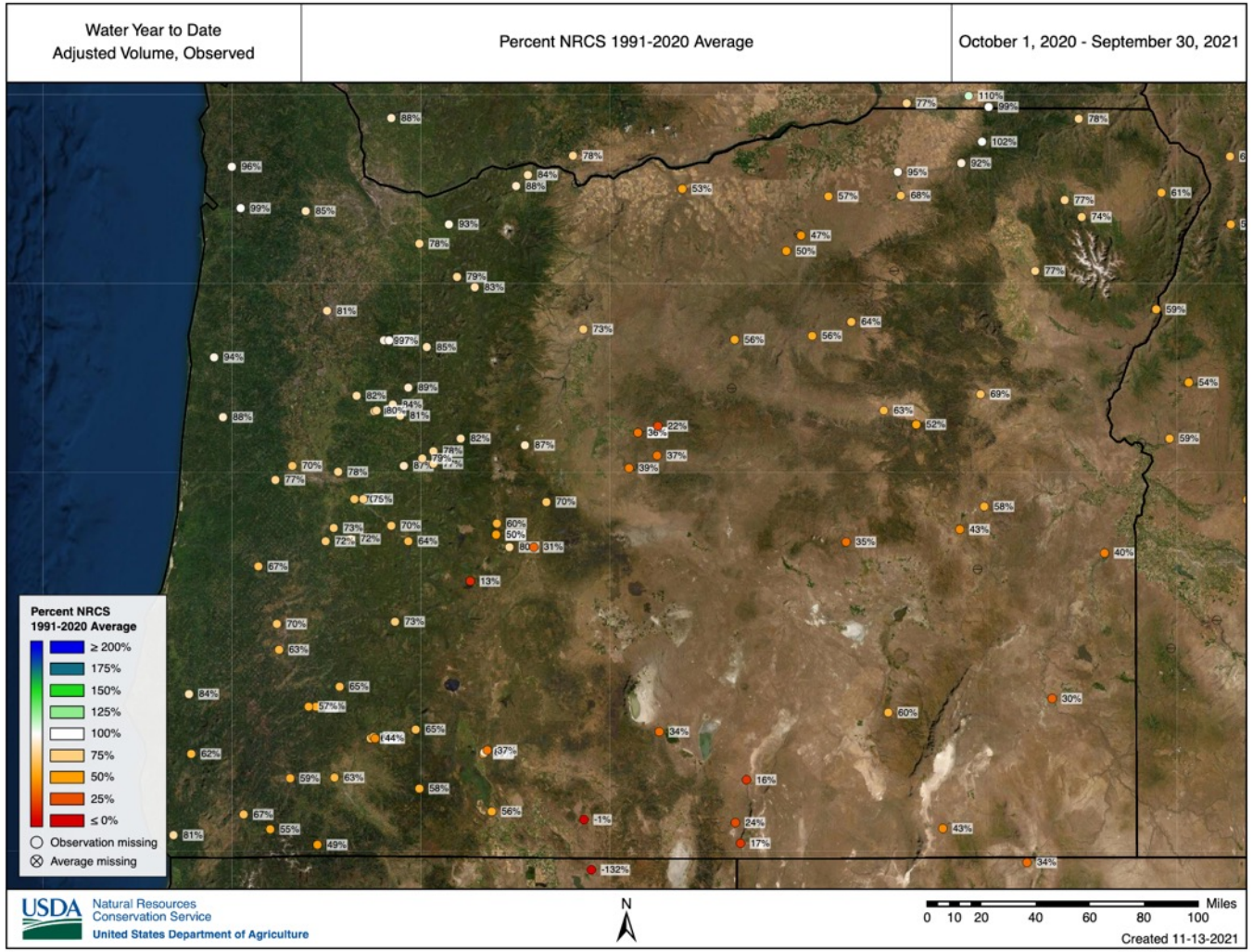
Listed are USBR basins, which are groupings of reservoirs

Summary

- WY2021 was the second year of a multiyear drought for Oregon
- 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

Extra slides

Water Year 2021 runoff percentiles – Oregon



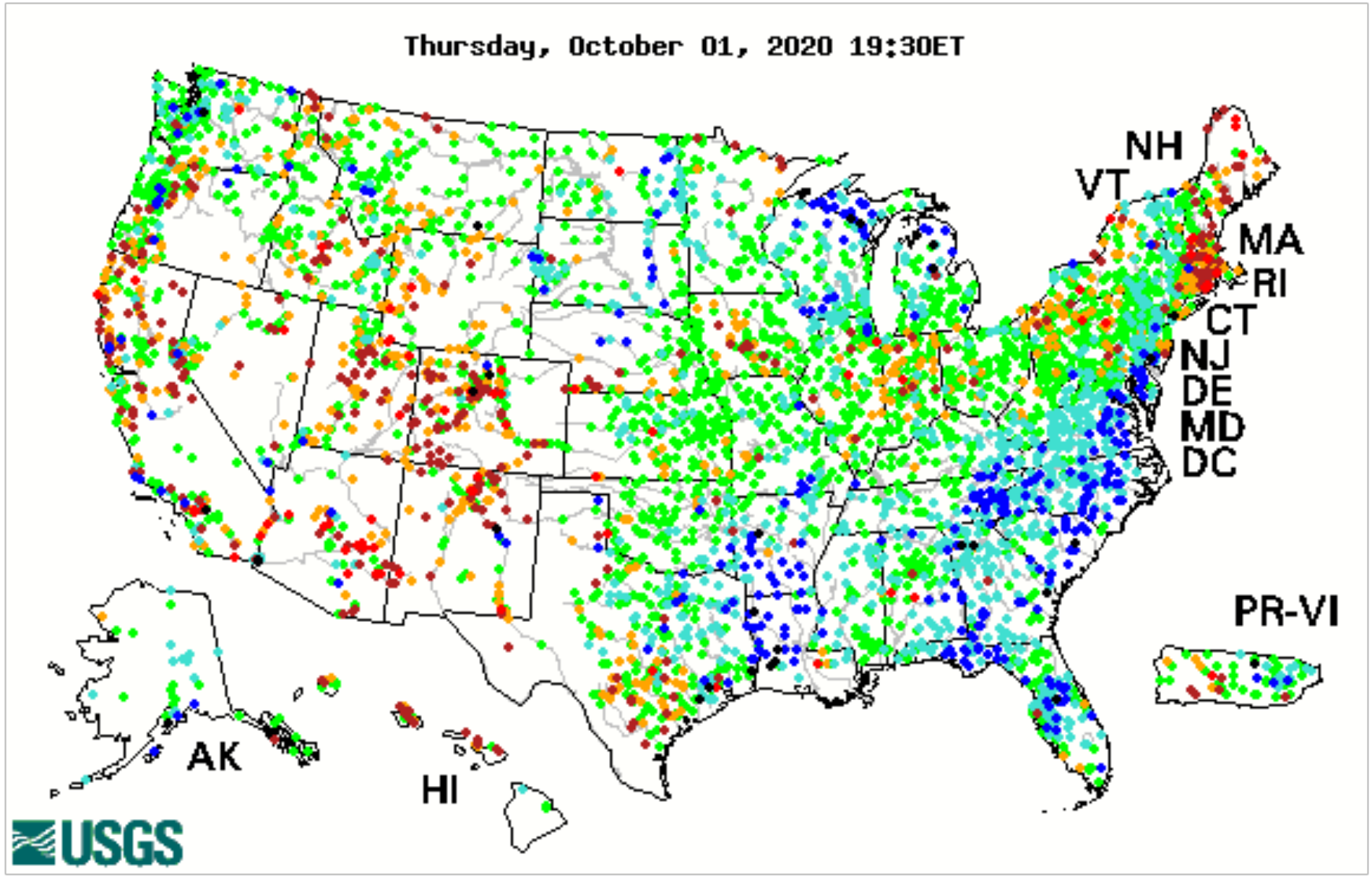
WY runoff largely follows pattern of WY precipitation in Oregon:

Below 20th percentile in western Oregon, High Cascades, and most of central Oregon

A number of locations below the 10th percentile

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

Notable extremes:
- All-time low at Ochoco Creek blw Prineville
- Umatilla River abv Meacham (94th percentile)
- South Fork Rogue nr Prospect (5th percentile)
- Deschutes River at Benham Falls (3rd percentile)
- Upper Williamson River (6th percentile)
- S Fork Coquille River (7th percentile)
- Warm Springs River (6th percentile)
- Wickiup Res inflow (4th percentile)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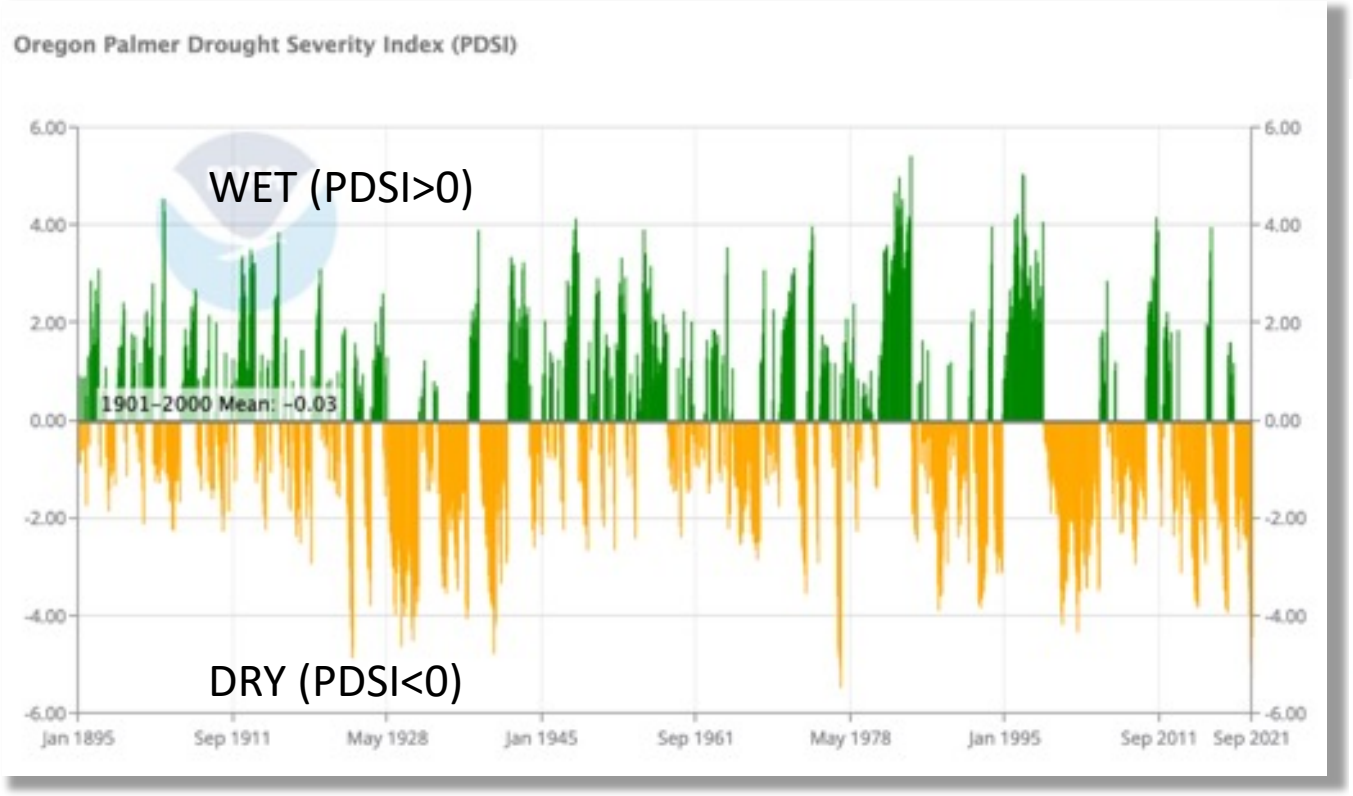
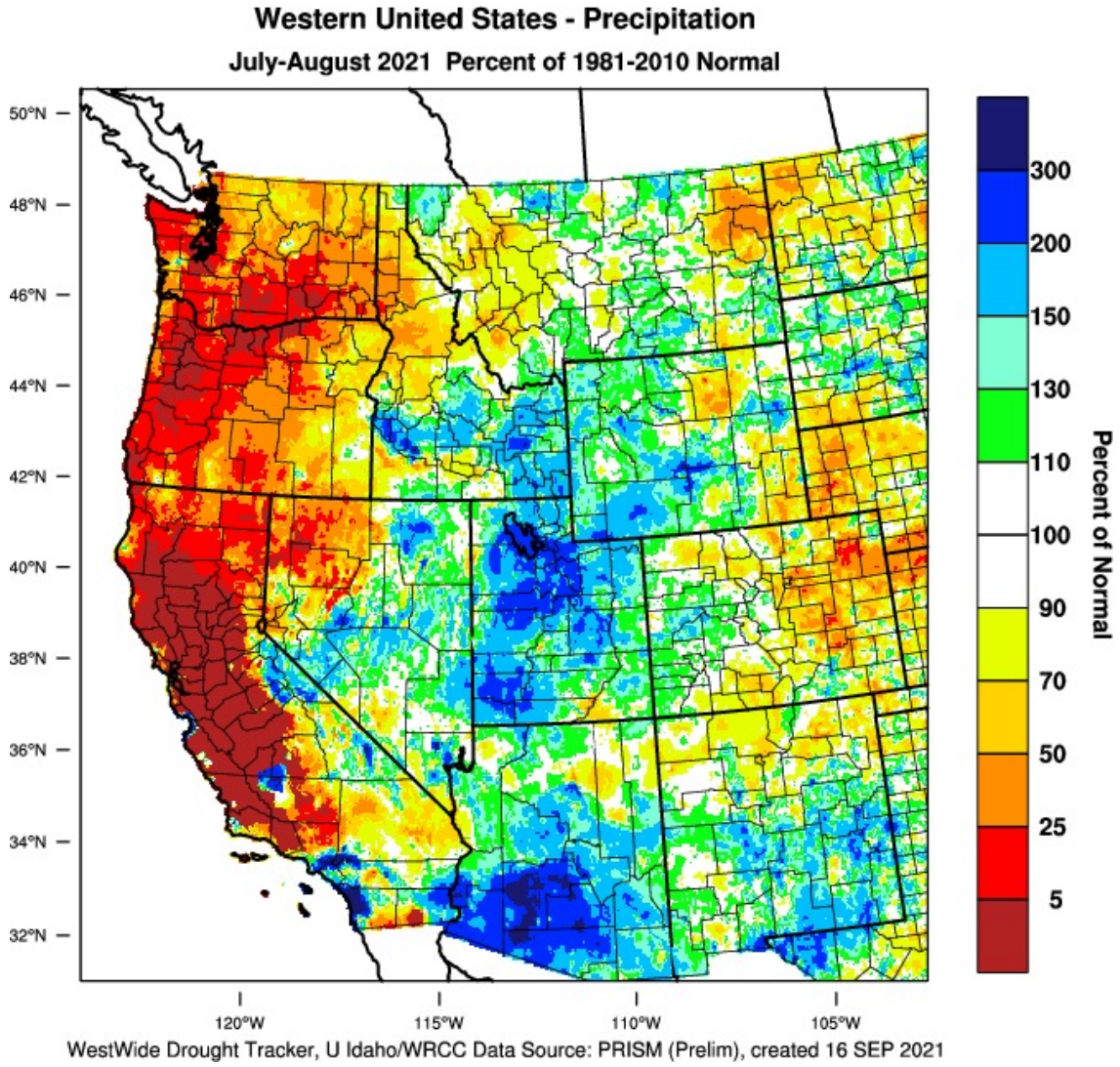
Assessing Oregon's drought severity



			Ranges				
Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Objective Drou Indicator Blen (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

- 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 (12th lowest monthly ranking on record)
- July 2021 PDSI: -4.93 (4th lowest monthly ranking on record)

2021 Monsoon Season was a bust for the PacNW

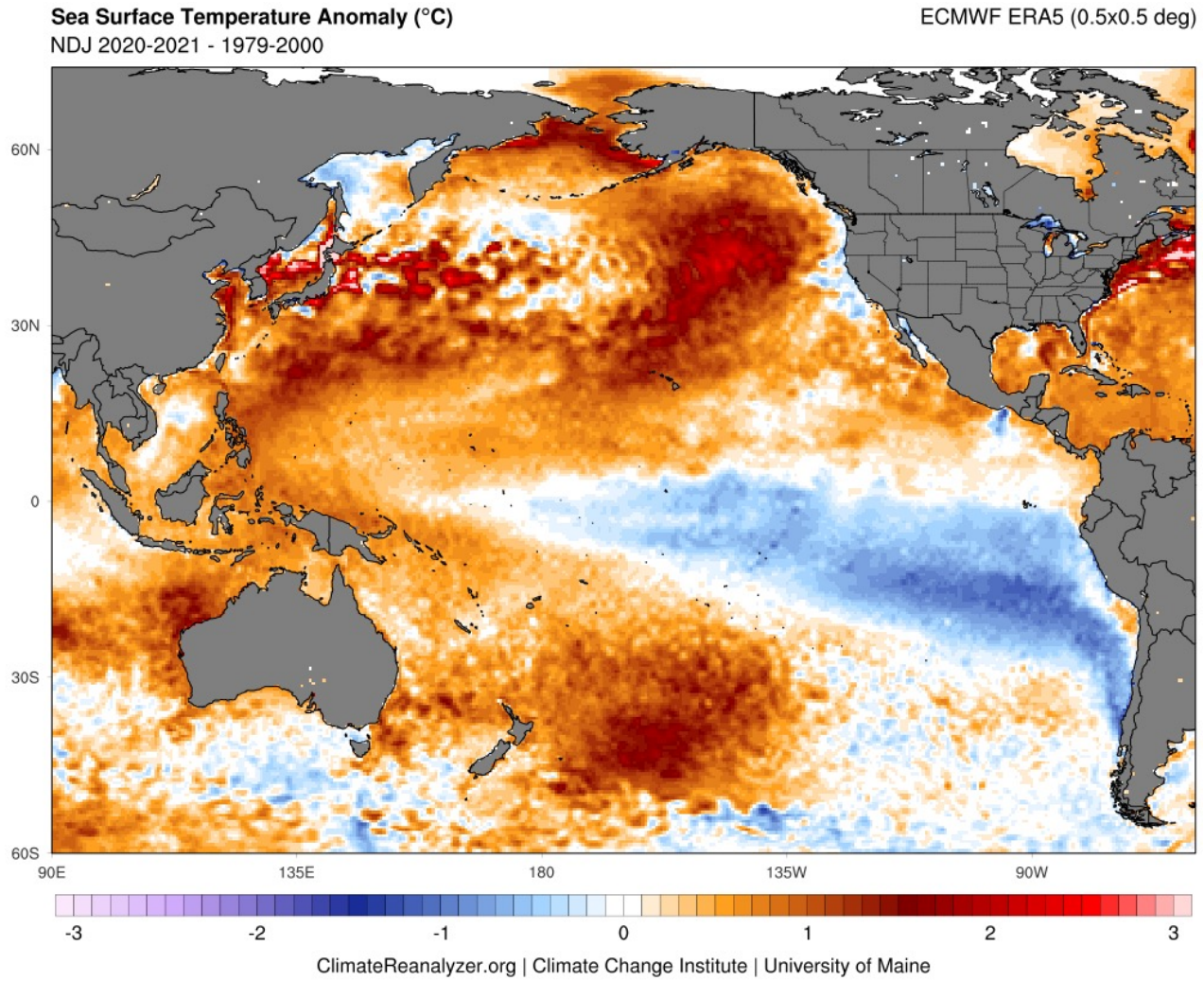


The monsoon brings critical summer moisture in July and August to eastern Oregon and Washington via thunderstorms and convective showers

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

Pacific Sea Surface Temperature Anomalies Nov-Dec-Jan 2020-2021

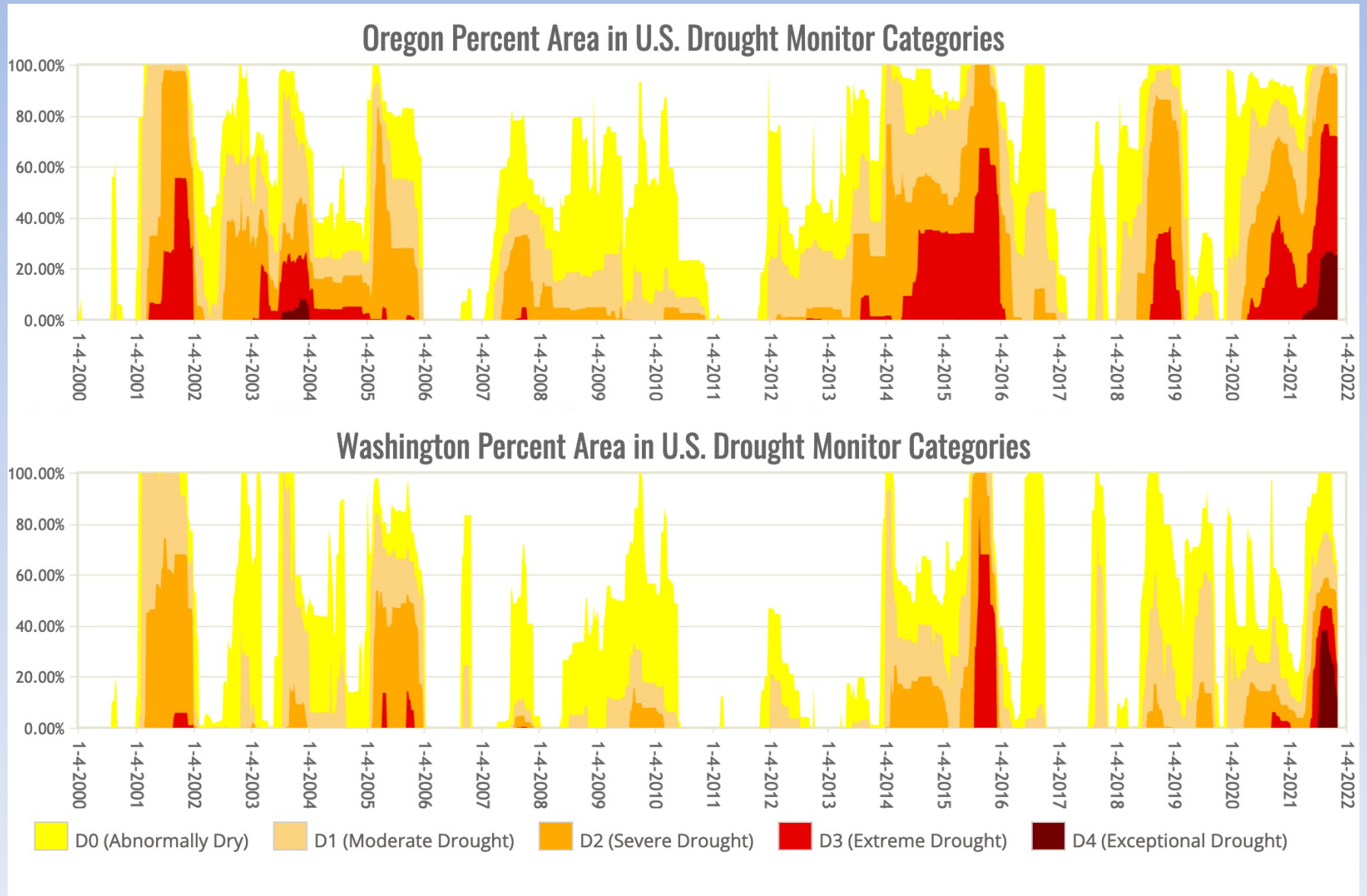


We began WY2021 with moderate La Niña conditions in the eastern equatorial Pacific Ocean

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!

PacNW drought through the ages

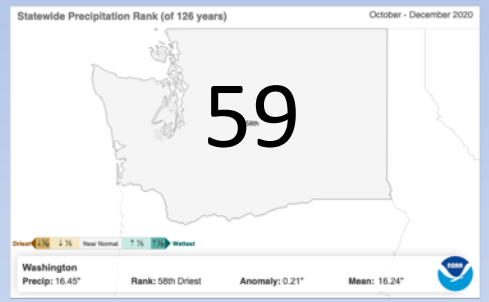


This year, since the USDM began weekly drought classification in early 2000:

- 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

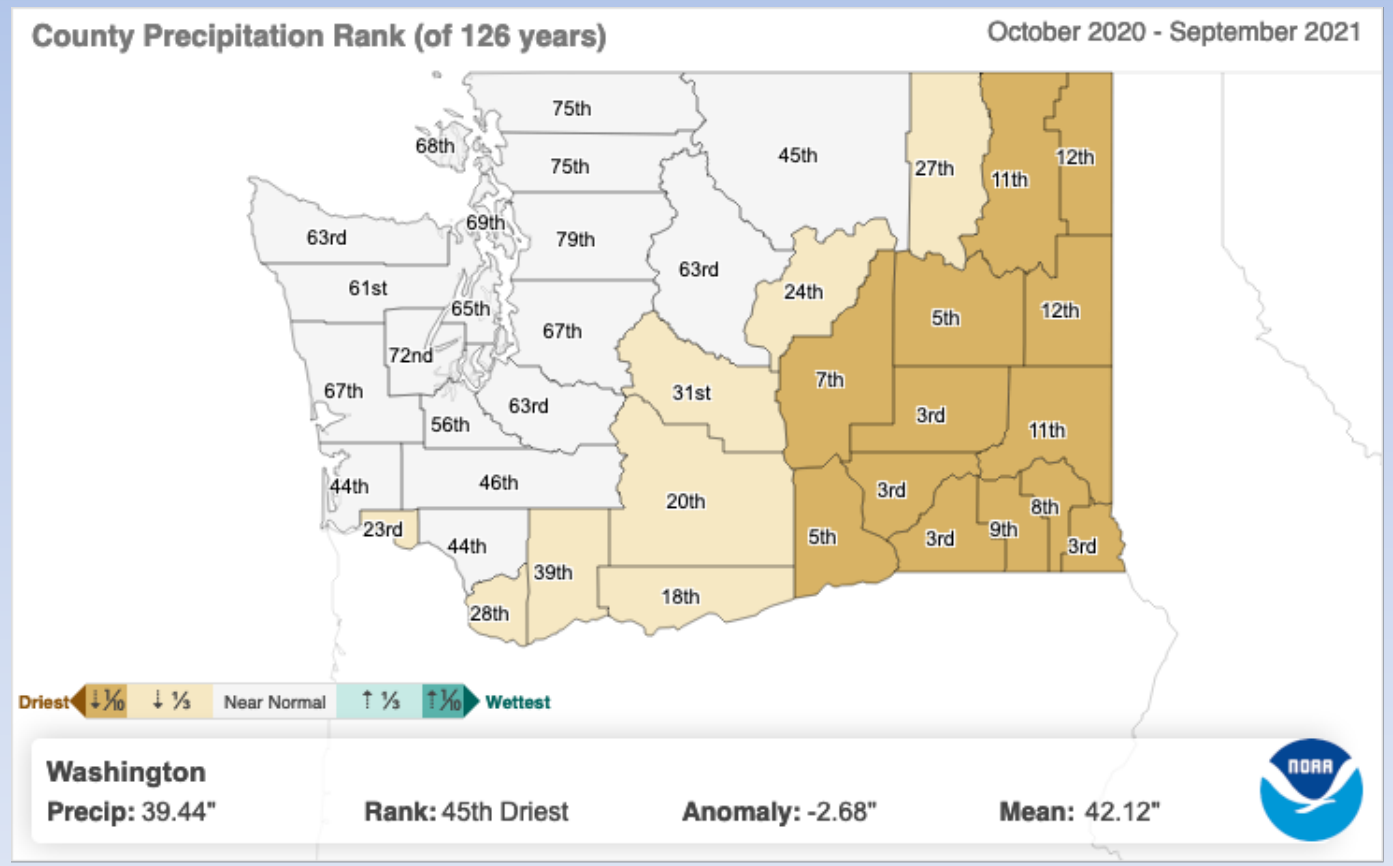
WY 2021 Seasonal Precipitation Rankings

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

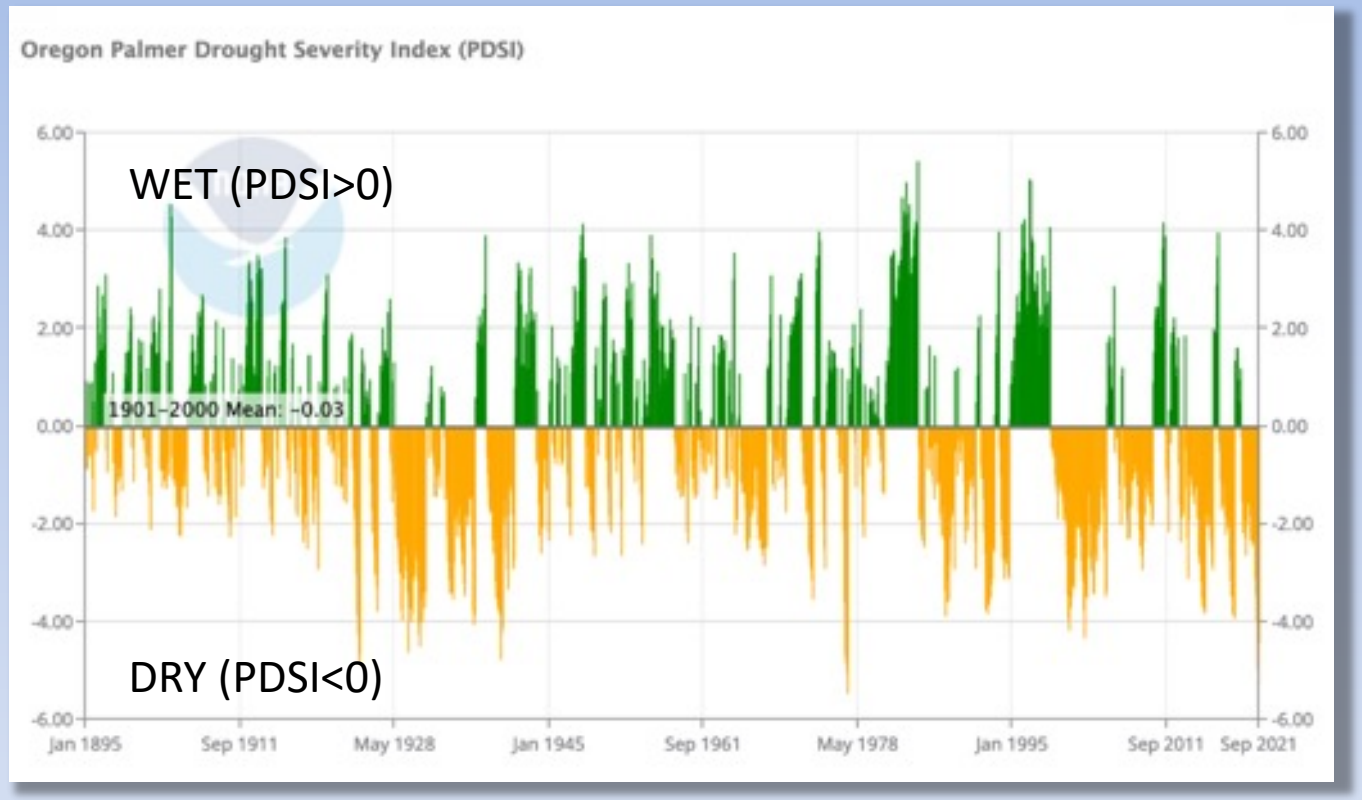


The numbers on the counties represent the rank of WY accumulated precipitation in the 126-year data record (1=driest; 126=wettest)

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

Assessing Oregon's drought severity



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

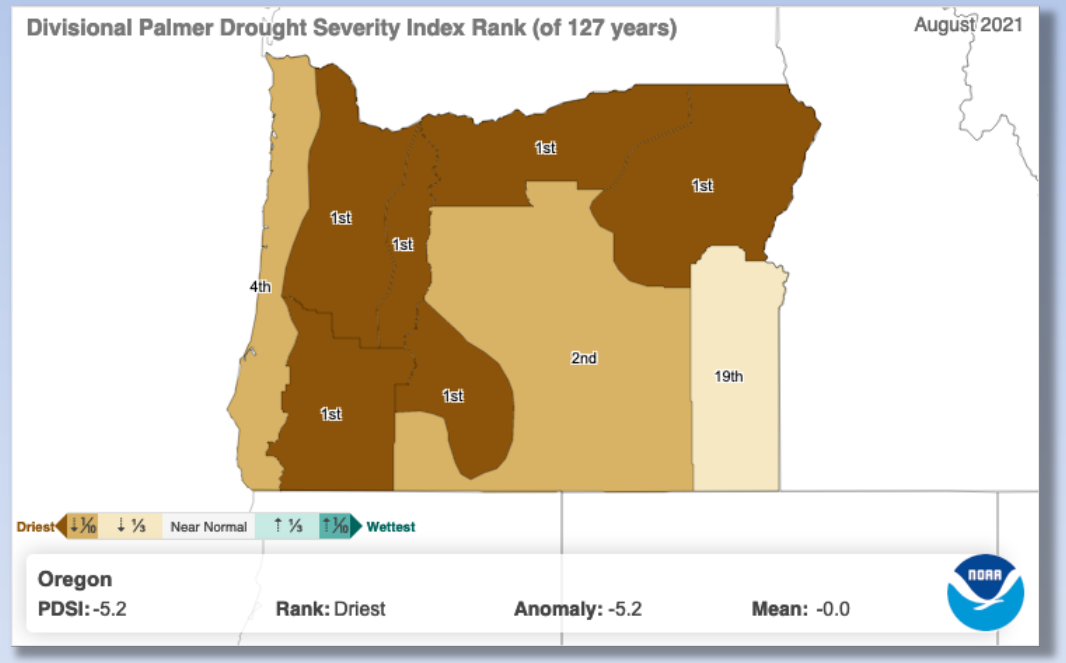
The PDSI is derived from a moisture balance model, using historic records of precipitation, temperature, and the local available water capacity of the soil

The PDSI does not incorporate the condition of the snowpack

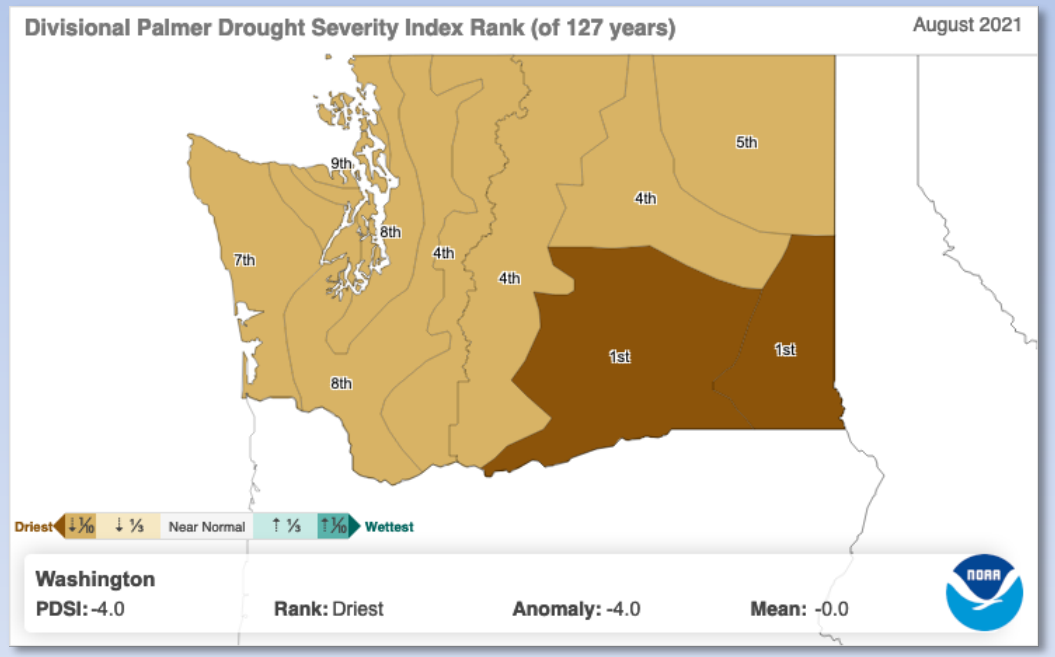
- Oregon statewide PDSI for August 2021: -5.24 (second lowest monthly ranking in the 127-year record)
- The lowest occurred during April 1977
- Sept 2021 PDSI: -4.42 (12th lowest monthly ranking on record)
- July 2021 PDSI: -4.93 (4th lowest monthly ranking on record)

Assessing the drought's severity

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

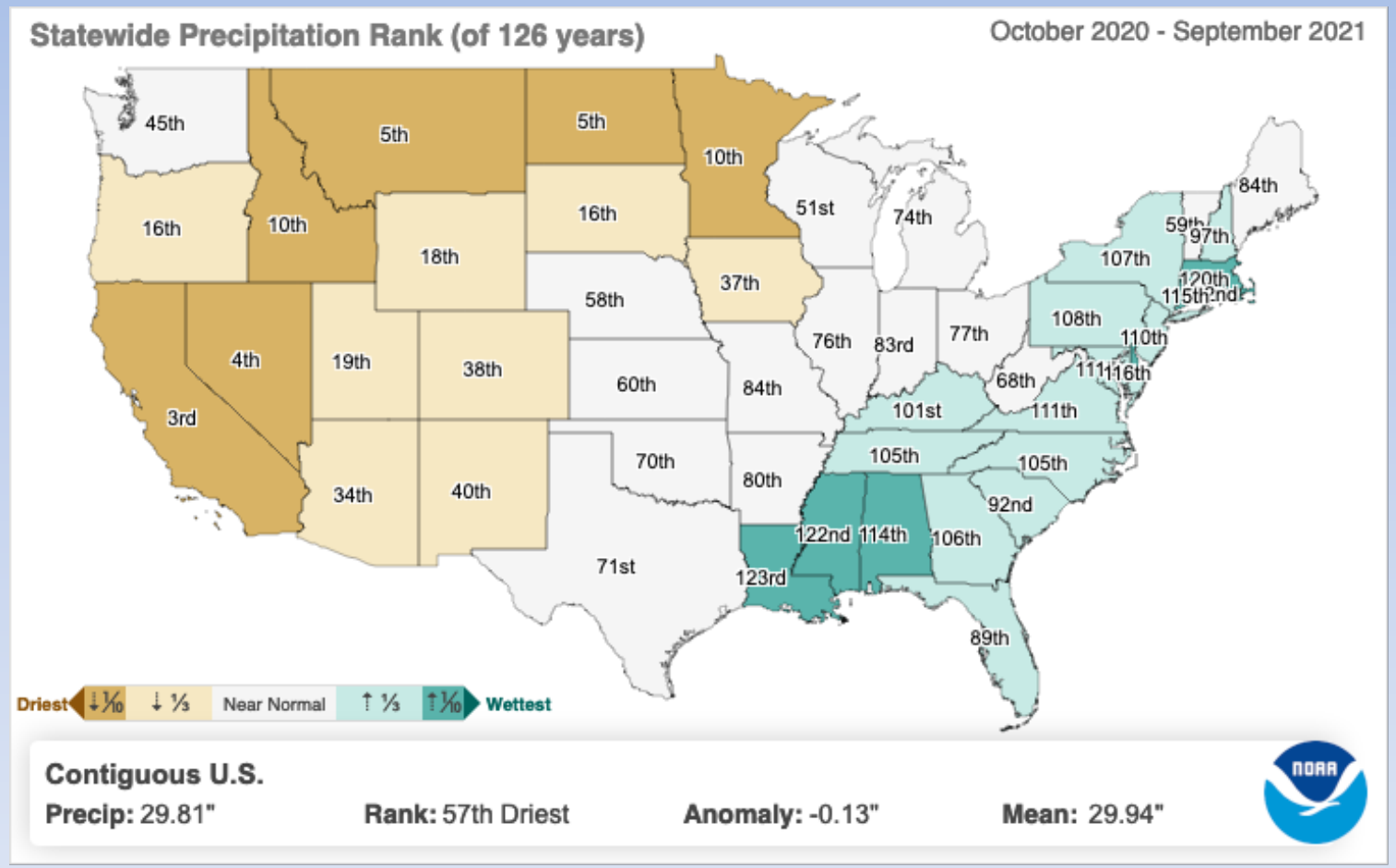


2 out 10 Washington climate divisions recorded their lowest monthly PDSI on record:



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

Water Year 2021 Precipitation Ranking



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

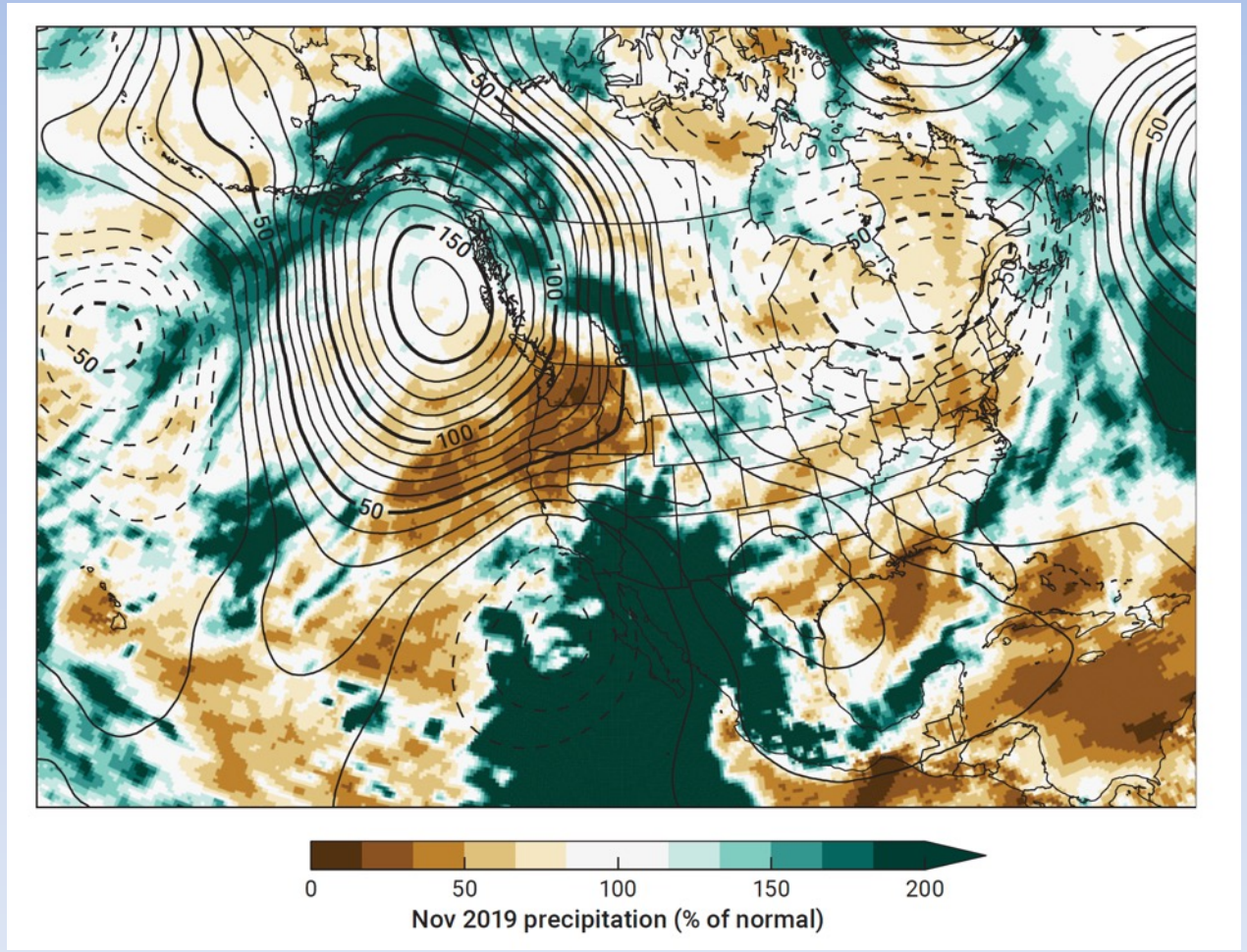
How dry was it?

Oregon: 16th driest out of 126 years

Washington: 45th driest out of 126 years

https://www.ncdc.noaa.gov/cag/statewide/mapping/110/pcp/202009/12/rank

November 2019
and the
Ridiculously Resilient Ridge

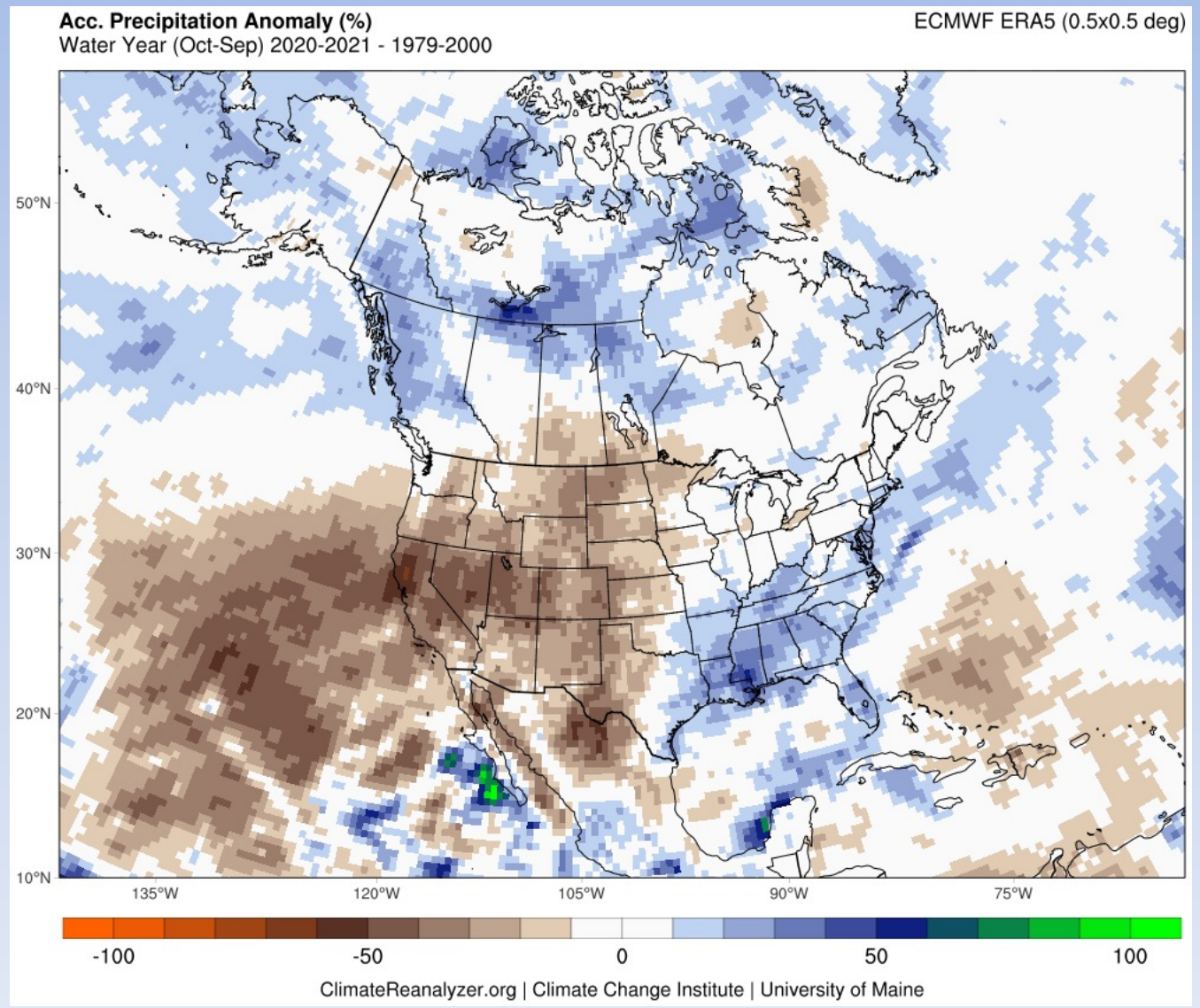


A strong and persistent ridge of high pressure formed in the Gulf of Alaska and diverted storms around the PacNW

Most of the PacNW received less than 30% of normal precipitation

Contours show 500mb height anomalies during Nov 2019; colors are precipitation anomalies

WY2021 Precipitation Anomaly (percentage)



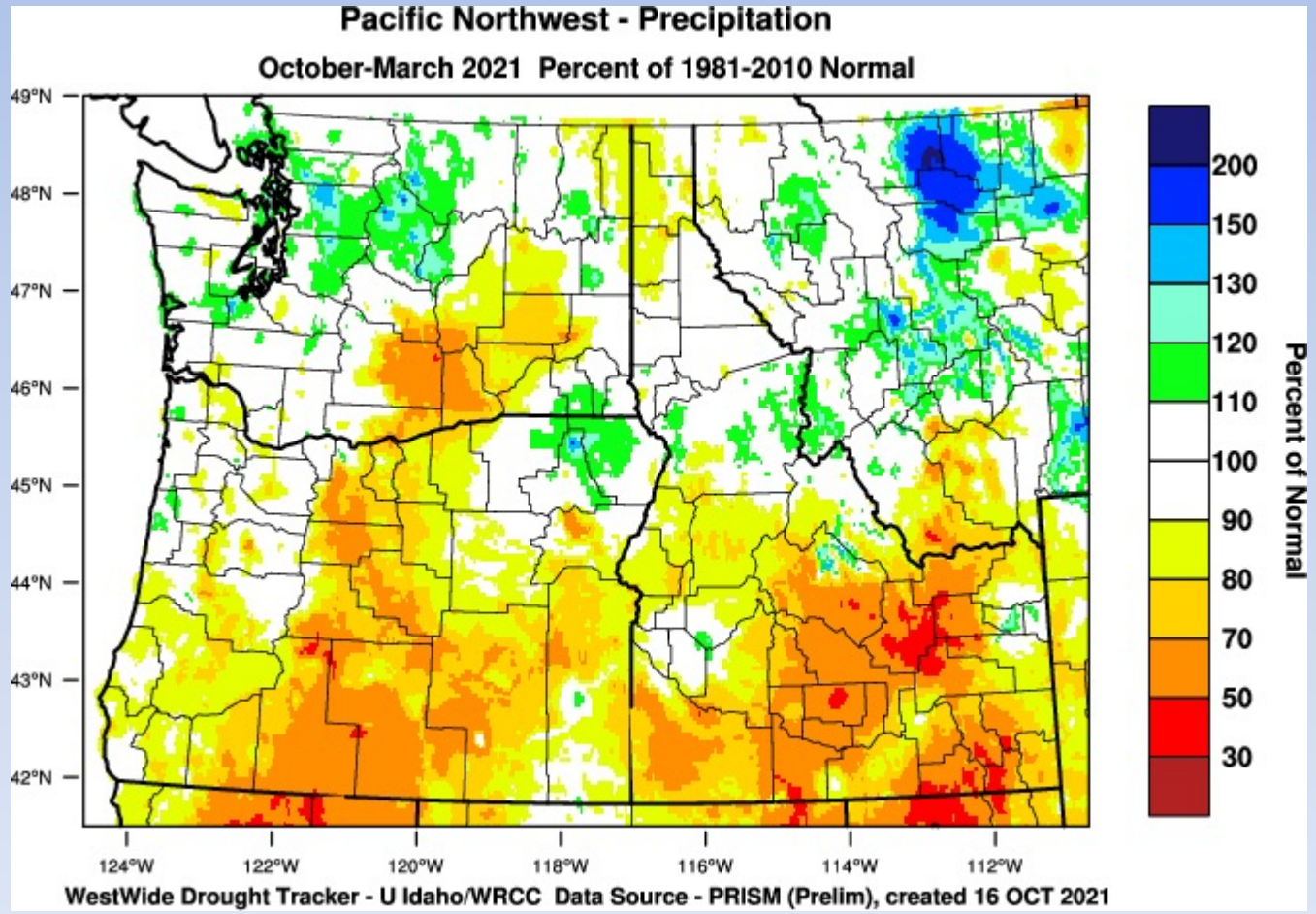
Western half of the continental US was well below average in precipitation for WY2021 while the SE US and Mid-Atlantic regions were well above average

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

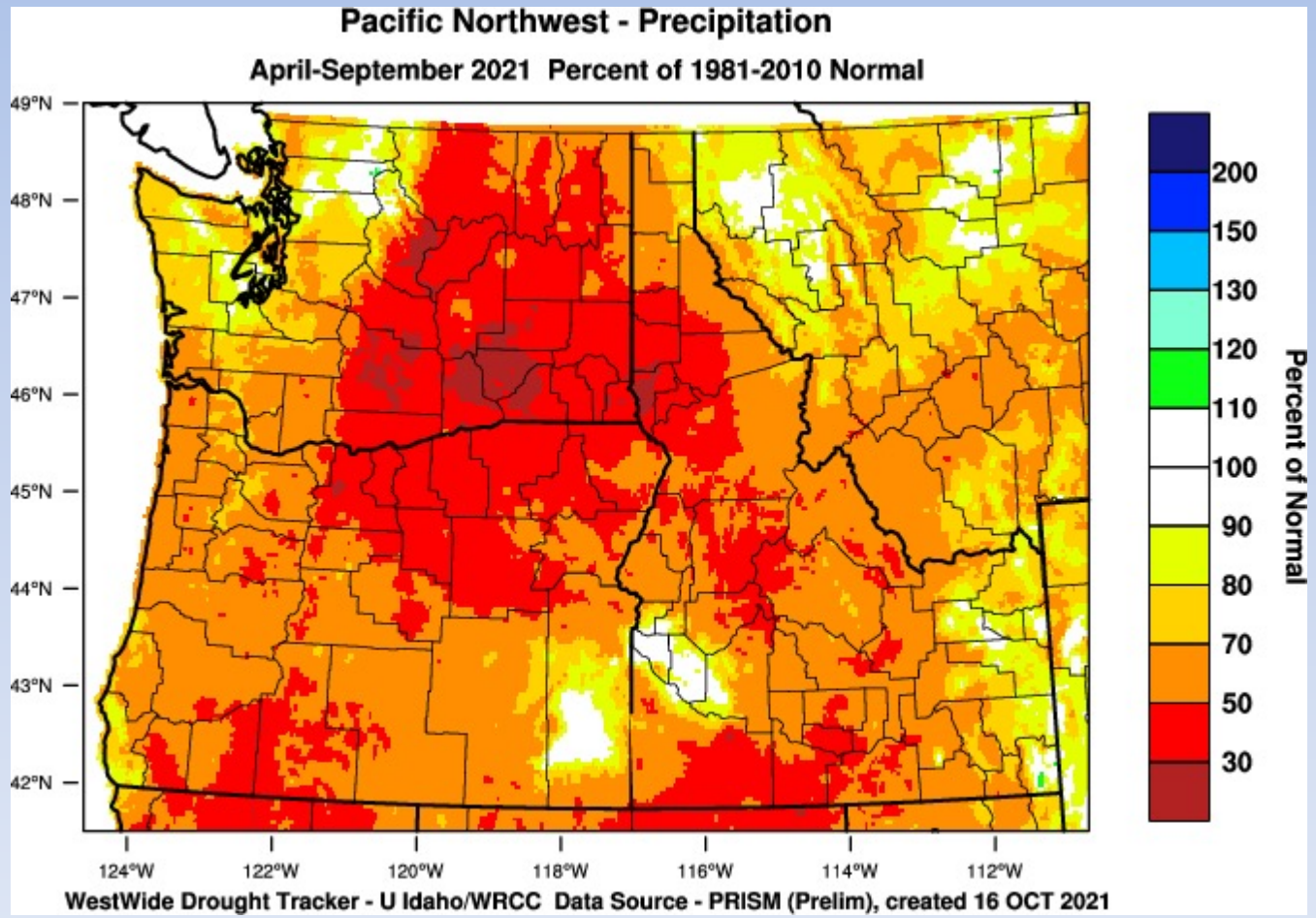
Precipitation Anomaly during the first half of WY2021: a tale of two seasons



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

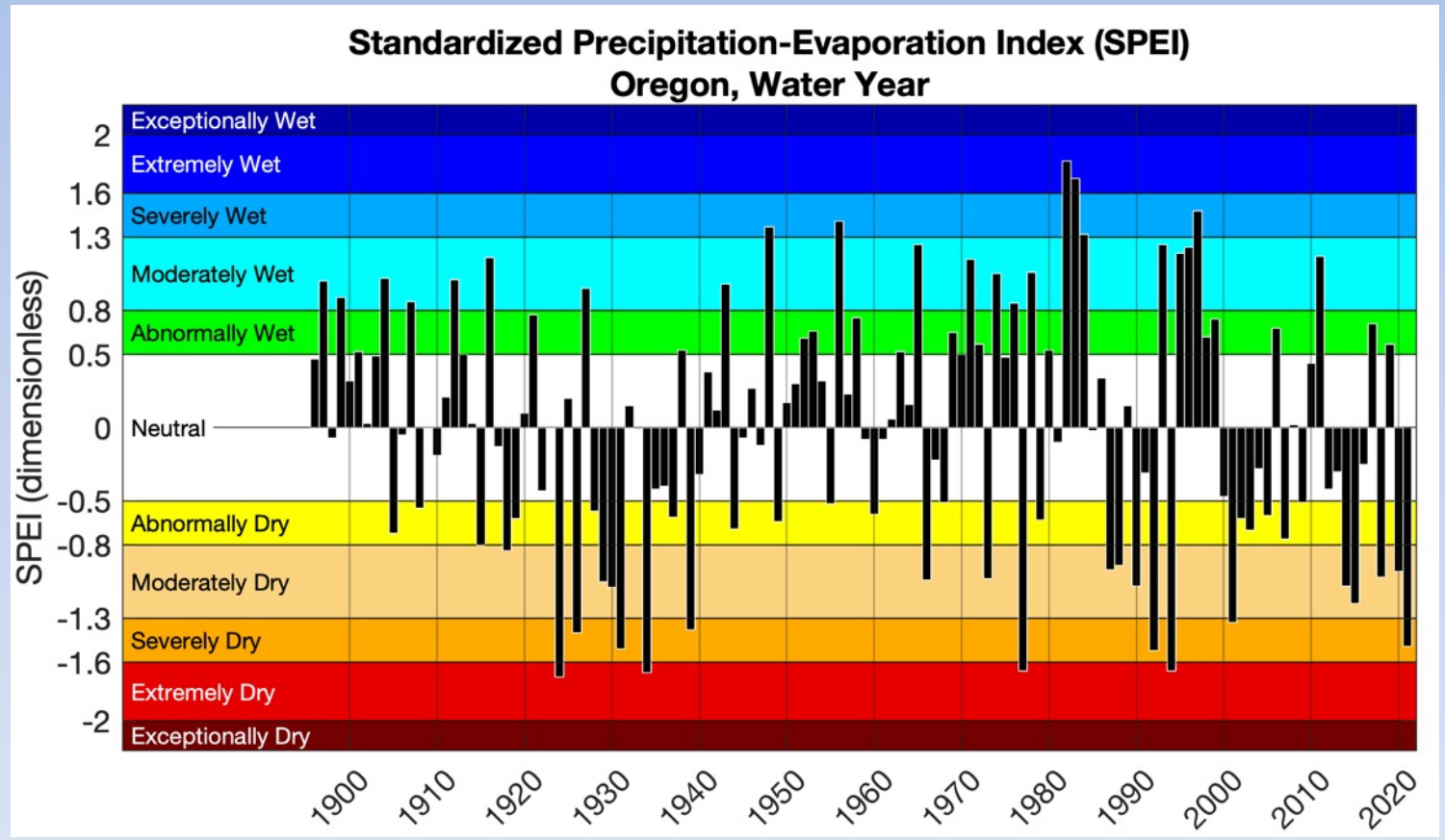
Precipitation Anomaly during the second half of WY2021: a tale of two seasons



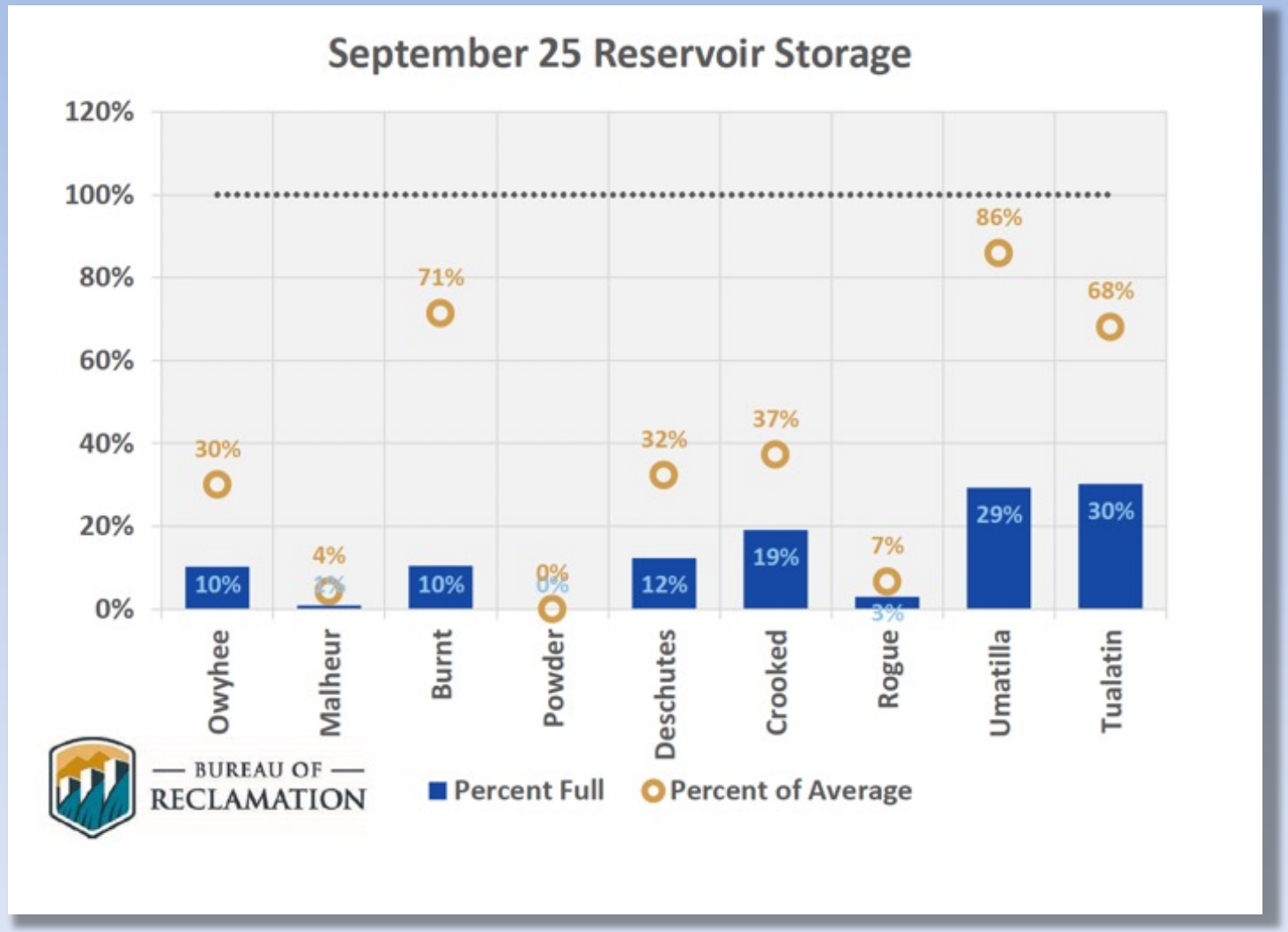
Nearly all the PacNW was well below normal in spring and summer precipitation

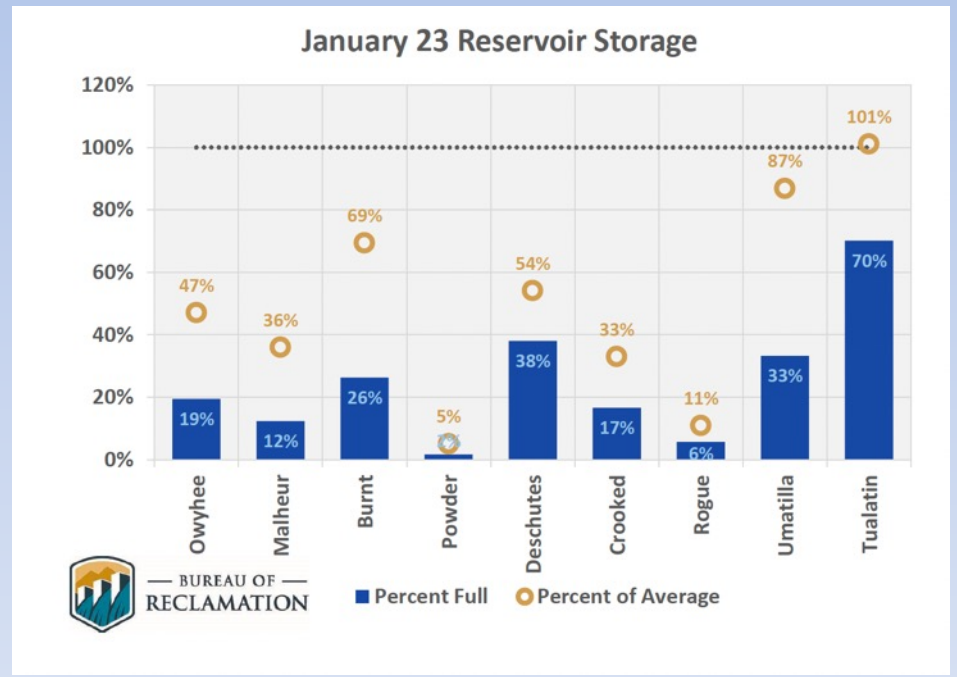
Particularly hard hit were Washington and northern Oregon east of the Cascade crest

Assessing Oregon's drought severity: 12-month SPEI

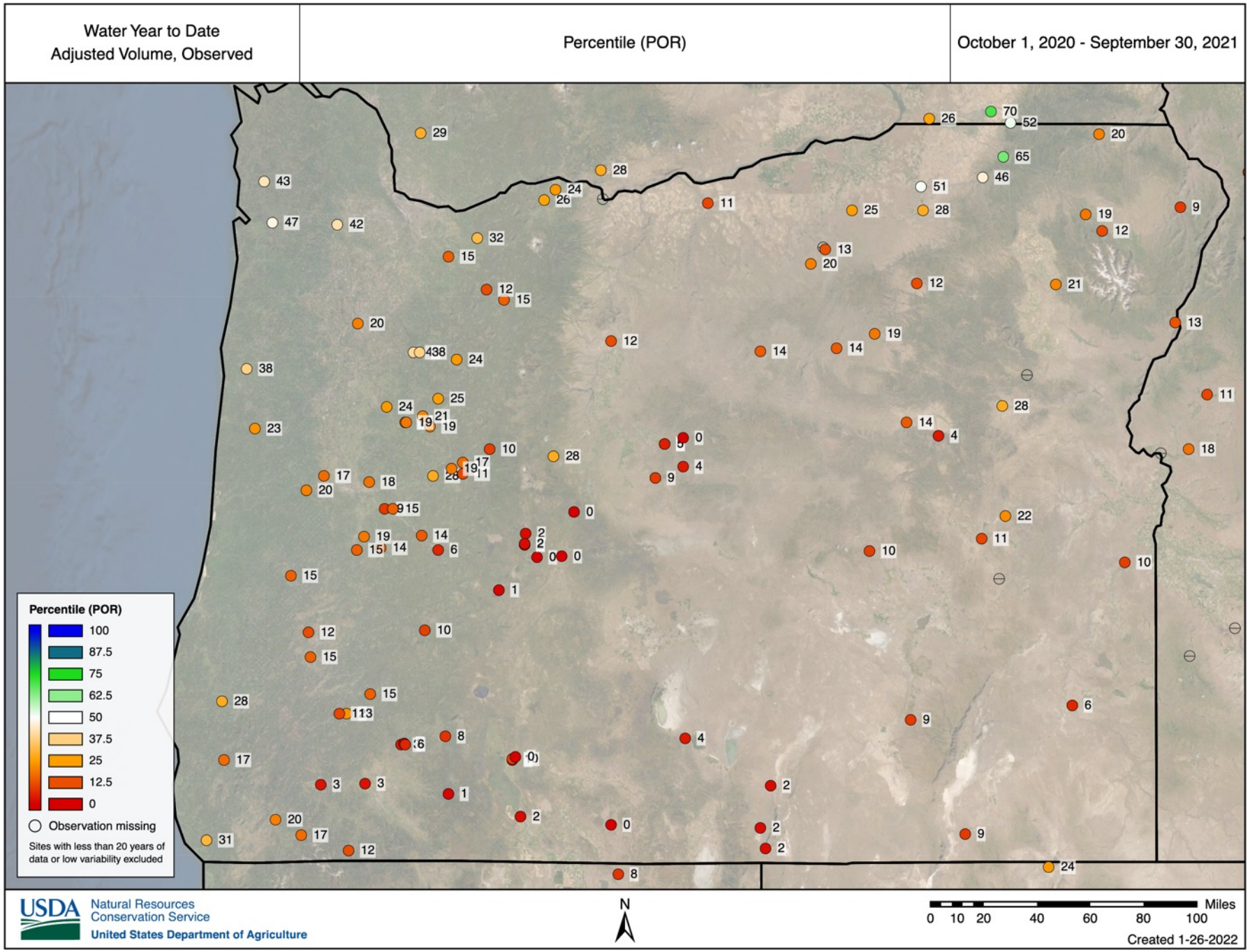


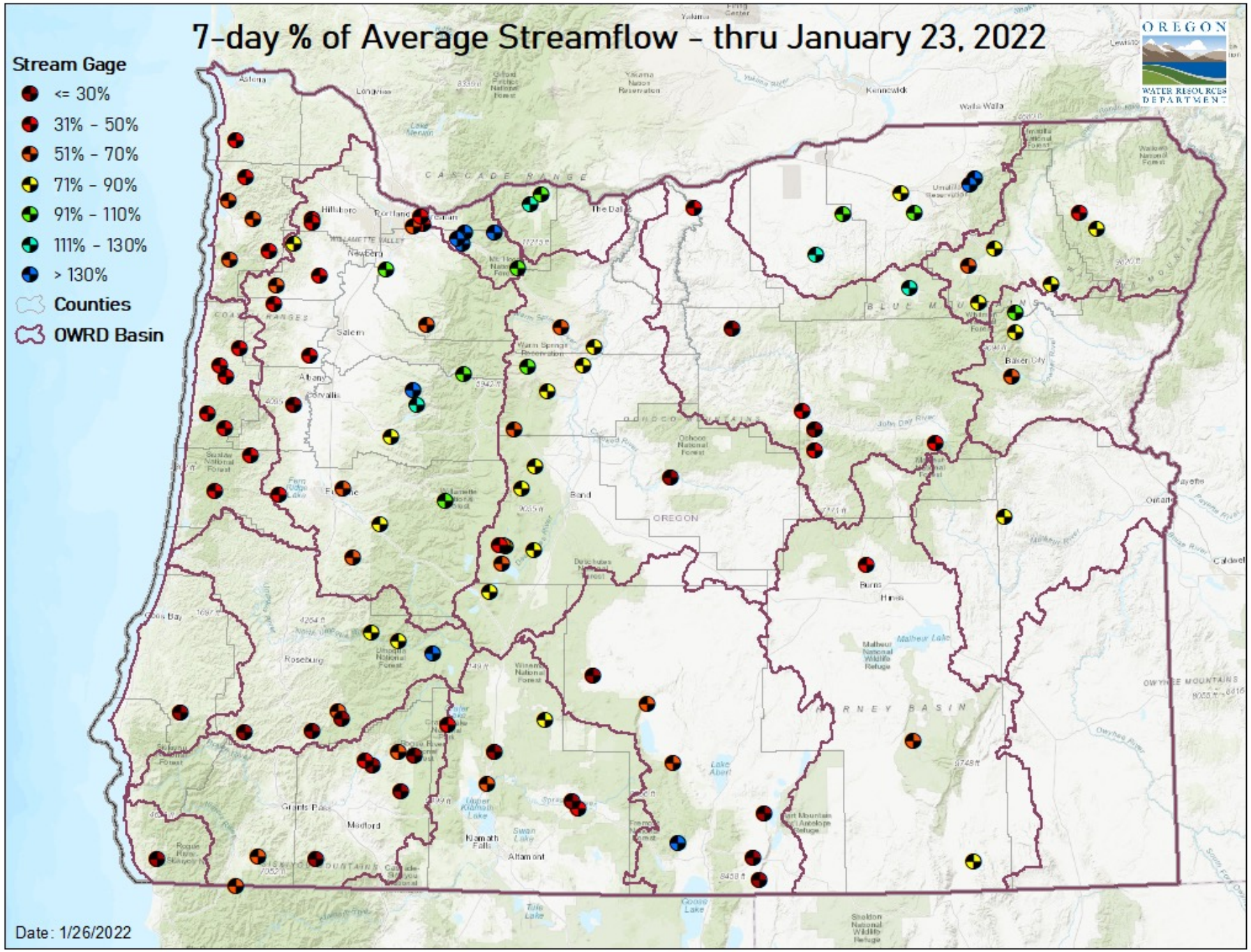
Reservoir storage conditions near end of WY2021





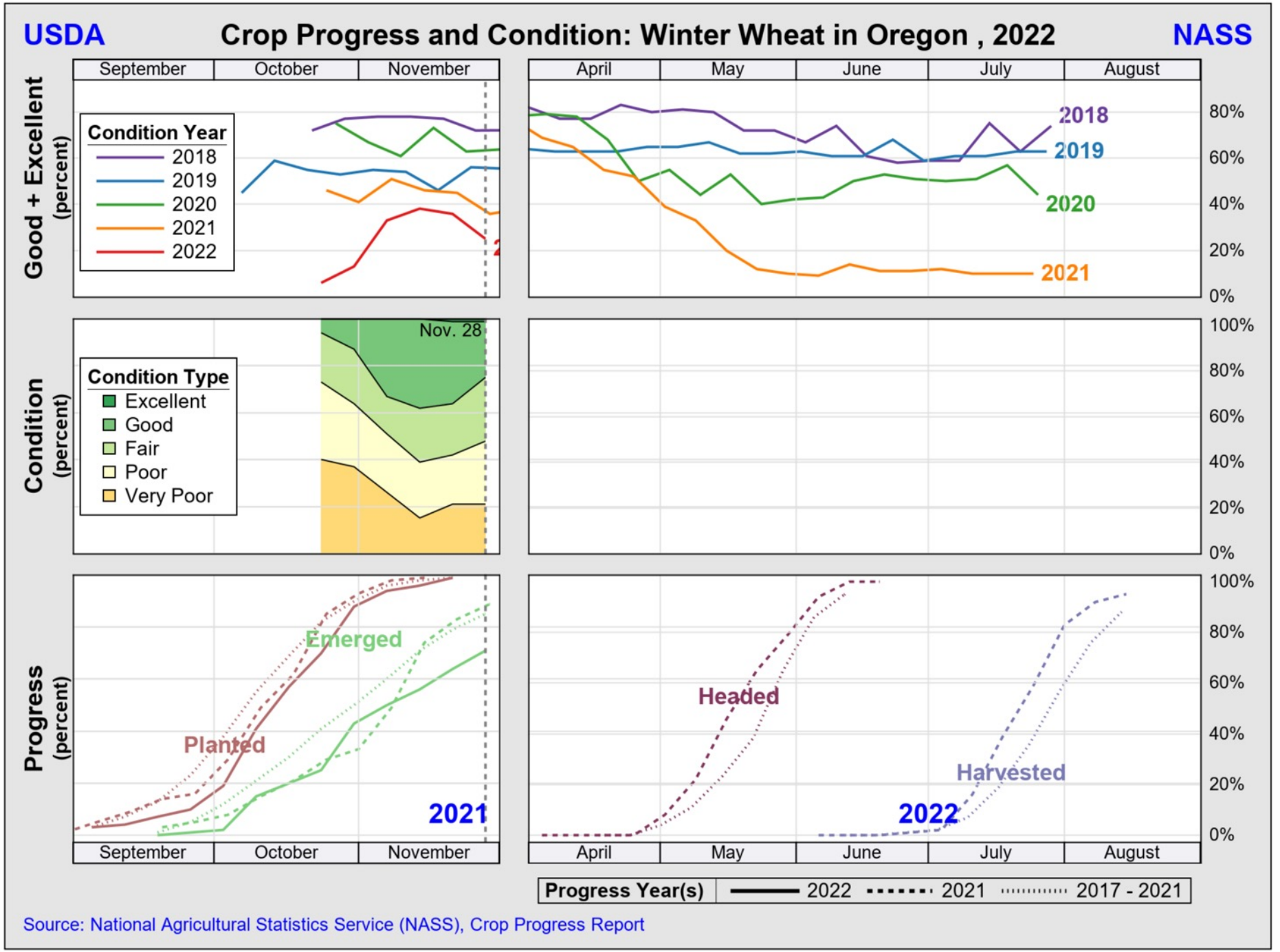
Listed are USBR basins, which are groupings of reservoirs

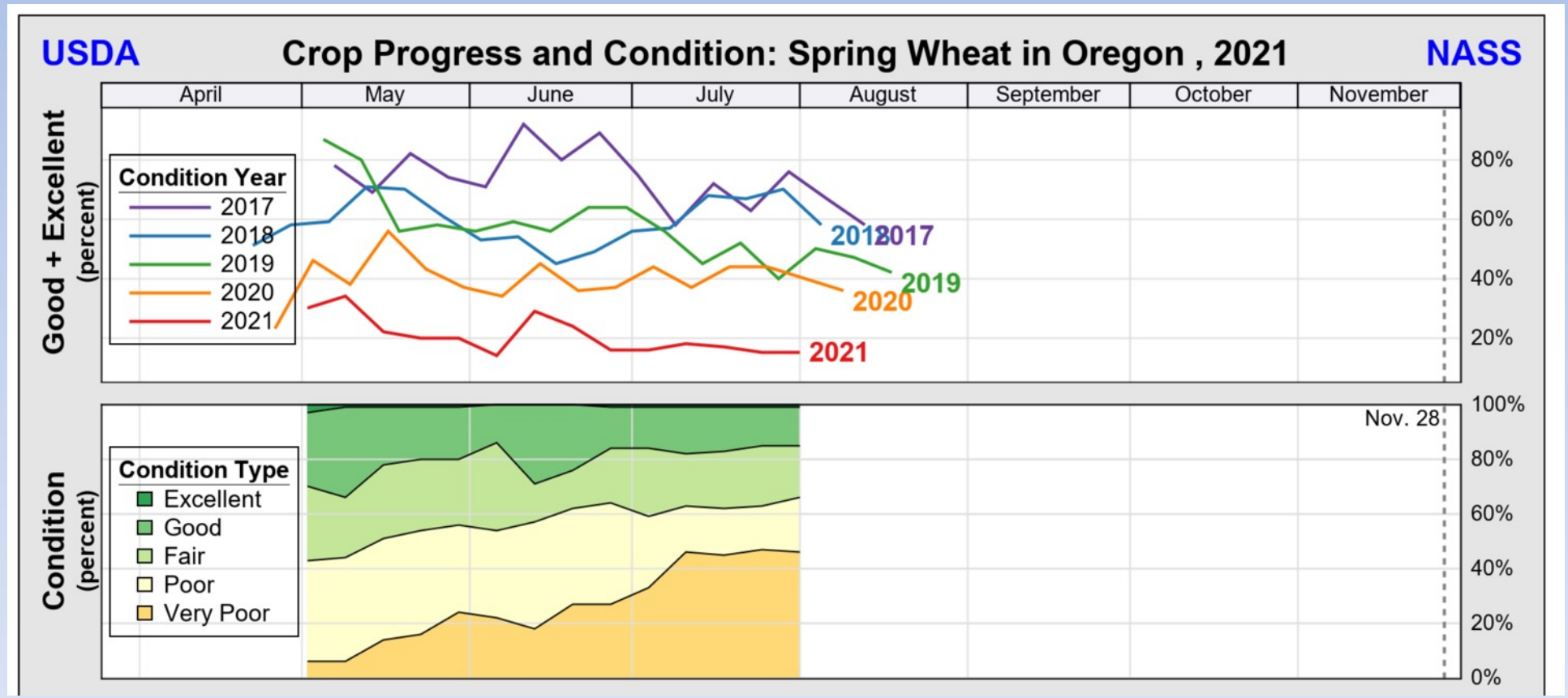

Water Year to Date
Adjusted Volume, Observed
Percentile (POR)
October 1, 2020 - September 30, 2021
Percentile (POR)
100
87.5
75
62.5
50
37.5
25
12.5
0
Observation missing
Sites with less than 20 years of data or low variability excluded
USDA
Natural Resources Conservation Service
United States Department of Agriculture
N
Miles
0 10 20 40 60 80 100
Created 1-26-2022


7-day % of Average Streamflow - thru January 23, 2022
Stream Gage
<= 30%
31% - 50%
51% - 70%
71% - 90%
91% - 110%
111% - 130%
> 130%
Counties
OWRD Basin
OREGON
WATER RESOURCES DEPARTMENT
Date: 1/26/2022

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

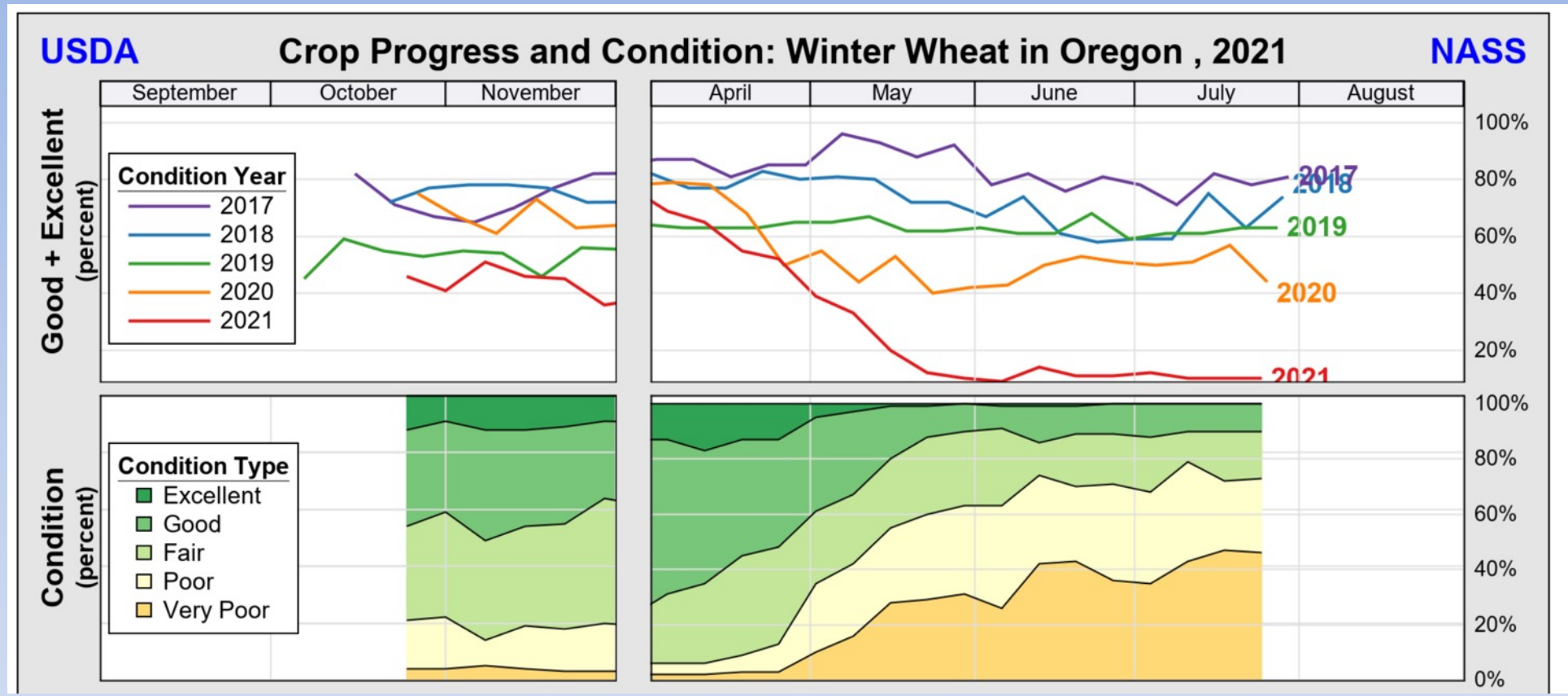

USDA
Crop Progress and Condition: Winter Wheat in Oregon , 2022
NASS
Good + Excellent (percent)
September
October
November
April
May
June
July
August
Condition Year
2018
2019
2020
2021
2022
2018
2019
2020
2021
80%
60%
40%
20%
0%
Condition (percent)
Condition Type
Excellent
Good
Fair
Poor
Very Poor
Nov. 28
100%
80%
60%
40%
20%
0%
Progress (percent)
Emerged
Planted
2021
Headed
Harvested
2022
100%
80%
60%
40%
20%
0%
Progress Year(s)
2022
2021
2017 - 2021
Source: National Agricultural Statistics Service (NASS), Crop Progress Report


USDA
Crop Progress and Condition: Spring Wheat in Oregon , 2021
NASS
April
May
June
July
August
September
October
November
Good + Excellent
(percent)
Condition Year
2017
2018
2019
2020
2021
2017
2018
2019
2020
2021
80%
60%
40%
20%
Condition
(percent)
Condition Type
Excellent
Good
Fair
Poor
Very Poor
Nov. 28
100%
80%
60%
40%
20%
0%

USDA Crop progress report for 2021

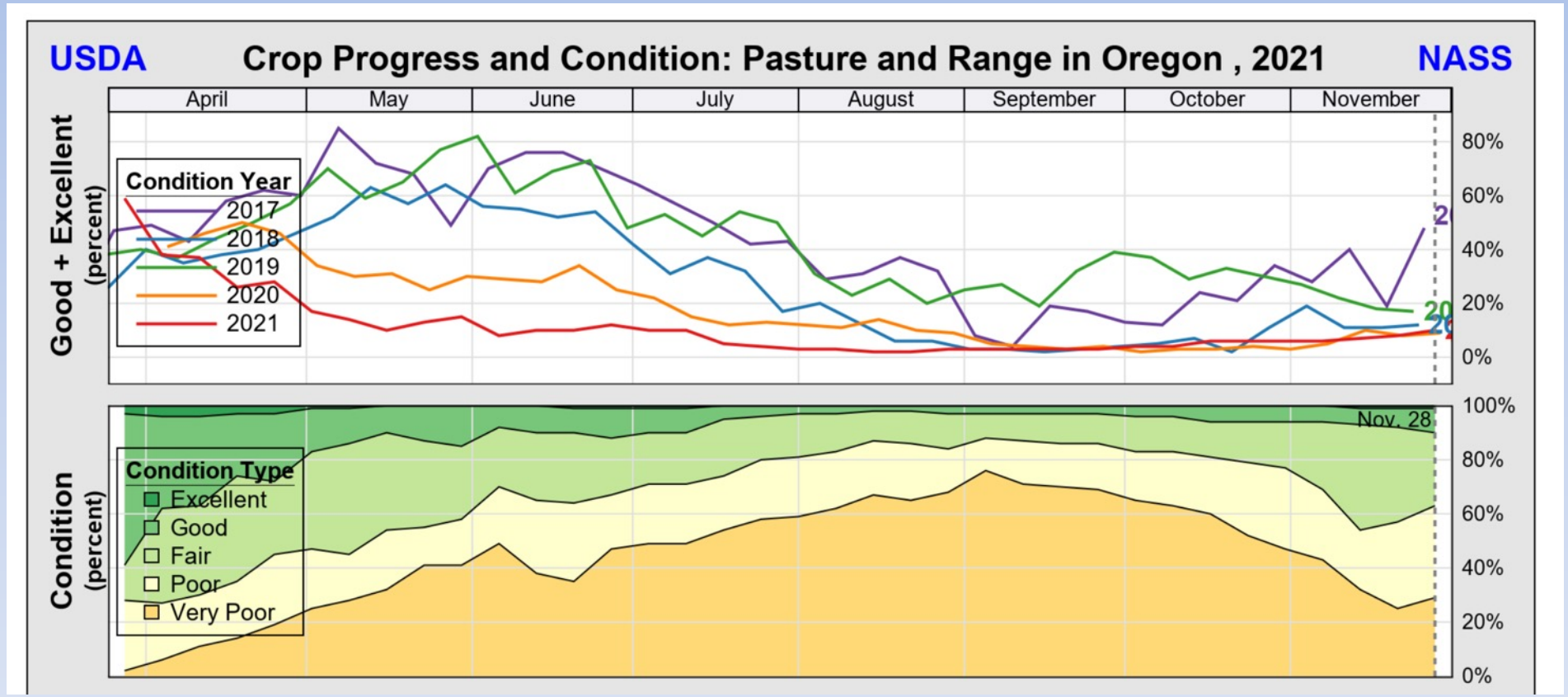
2021 winter wheat crop in poor condition relative to the past 5 years

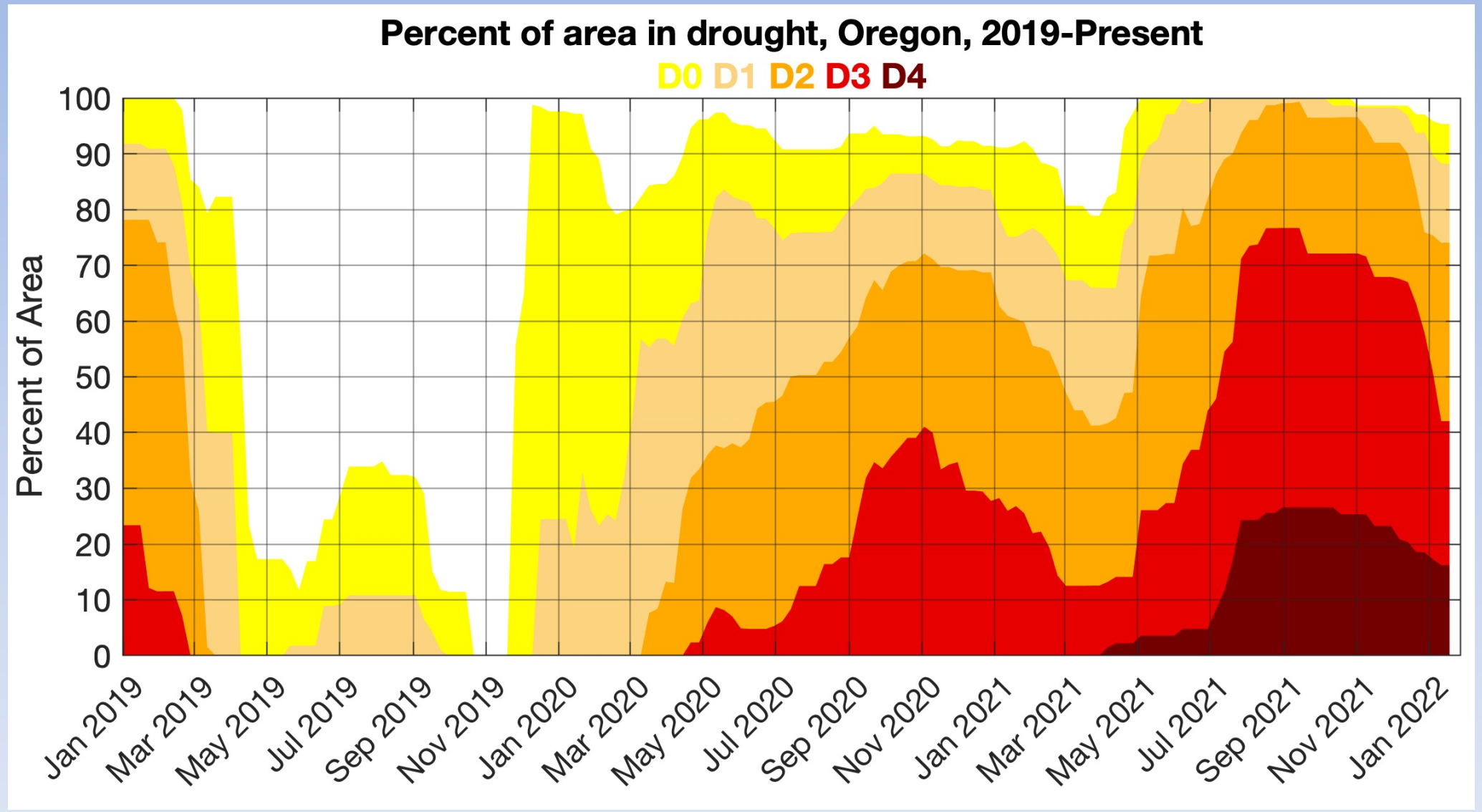
~70% of the crop rated in poor or very poor condition during June-July 2021



Source: USDA Monthly Crop and Progress Report for Oregon
https://www.nass.usda.gov/Charts_and_Maps/Crop_Progress_&_Condition/2021/index.php

By August and September 2021, ~80% of pasture and rangeland conditions were rated poor or very poor




Percent of area in drought, Oregon, 2019-Present
D0 D1 D2 D3 D4
Percent of Area
100
90
80
70
60
50
40
30
20
10
0
Jan 2019
Mar 2019
May 2019
Jul 2019
Sep 2019
Nov 2019
Jan 2020
Mar 2020
May 2020
Jul 2020
Sep 2020
Nov 2020
Jan 2021
Mar 2021
May 2021
Jul 2021
Sep 2021
Nov 2021
Jan 2022

Drought categories + possible impacts

These are the drought categories (and color scale) used in the U.S. Drought Monitor

Impacts are typically separated into short term (lasting <6 months and primarily associated with meteorological drought) and long term (>6 months and associated with hydrological, agricultural, and ecological drought)

Category	Description	Possible Impacts
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
D1	Moderate Drought	■ Some damage to crops, pastures ■ Streams, reservoirs, or wells low, some water shortages developing or imminent ■ Voluntary water-use restrictions requested
D2	Severe Drought	■ Crop or pasture losses likely ■ Water shortages common ■ Water restrictions imposed
D3	Extreme Drought	■ Major crop/pasture losses ■ Widespread water shortages or restrictions
D4	Exceptional Drought	■ Exceptional and widespread crop/pasture losses ■ Shortages of water in reservoirs, streams, and wells creating water emergencies