Agriculture Risk in a Changing World

Climate Outlooks for the United States

Kyle Bocinsky

Director of Climate Extension

Montana Climate Office

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- Montana's **official climate data stewards**.
- Provides **high quality, timely, relevant, and scientifically-based climate information** and services to Montanans.
- Operates the **Montana Mesonet** — an extensive and growing network of weather, soil moisture, and snowpack monitoring stations.

Raise your hand if your home community (state, town, reservation, etc.) has **broken a weather record** in the past few years.

In the last 30 days, the CONUS has broken:

🥵 651 daily highest high temperature records

🥶 101 daily lowest low temperature records

☔ 1,845 daily greatest precipitation records

❄️ 487 daily greatest snowfall records

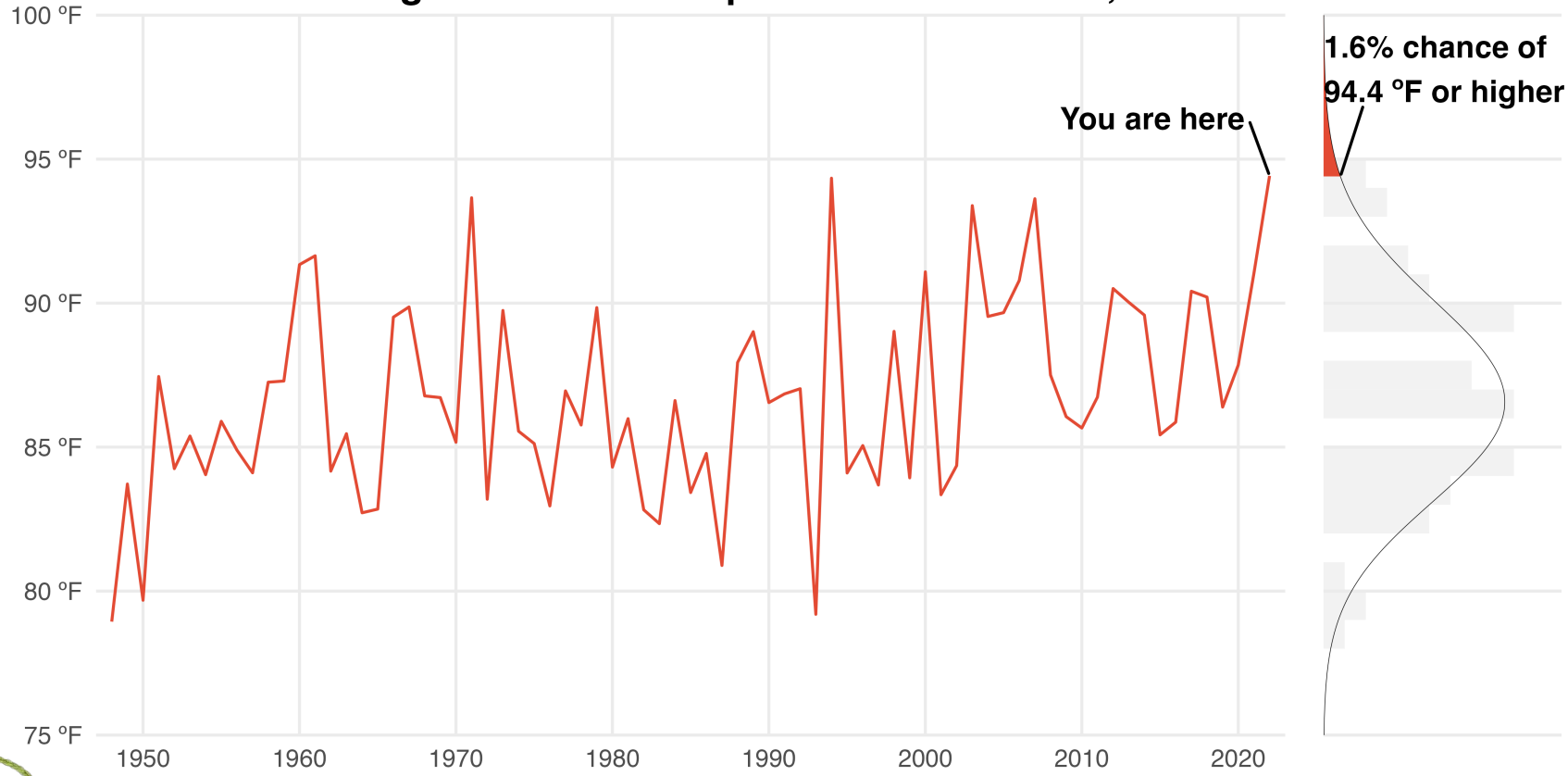
☃️ 135 daily greatest snow depth records

IS THIS NORMAL?

Daily Weather Records
NOAA Climate Data Online
https://www.ncdc.noaa.gov/cdo-web/datatools/records

Montana Climate Office

July 15 to August 15
Average Maximum Temperature in Missoula, MT



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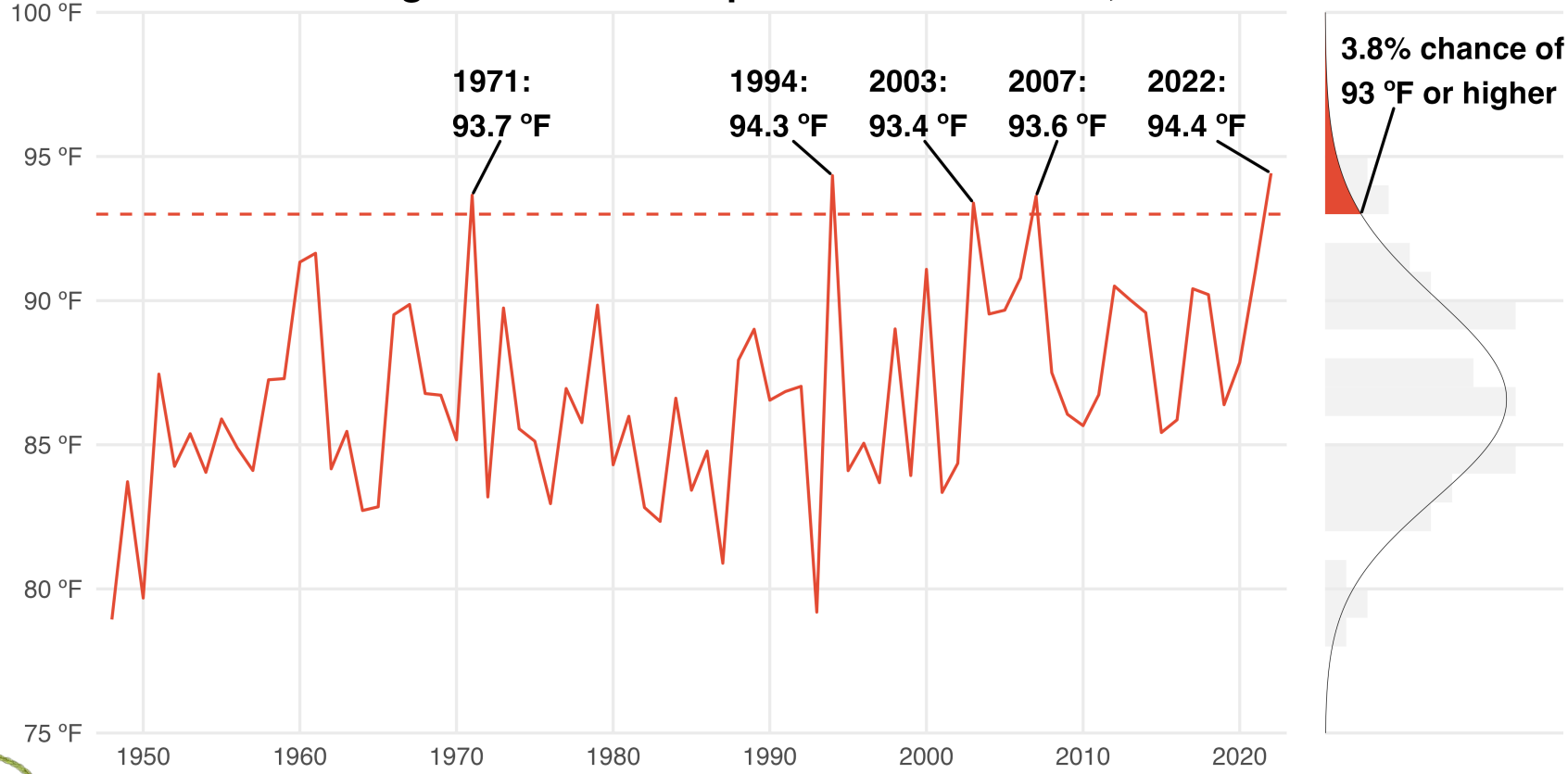

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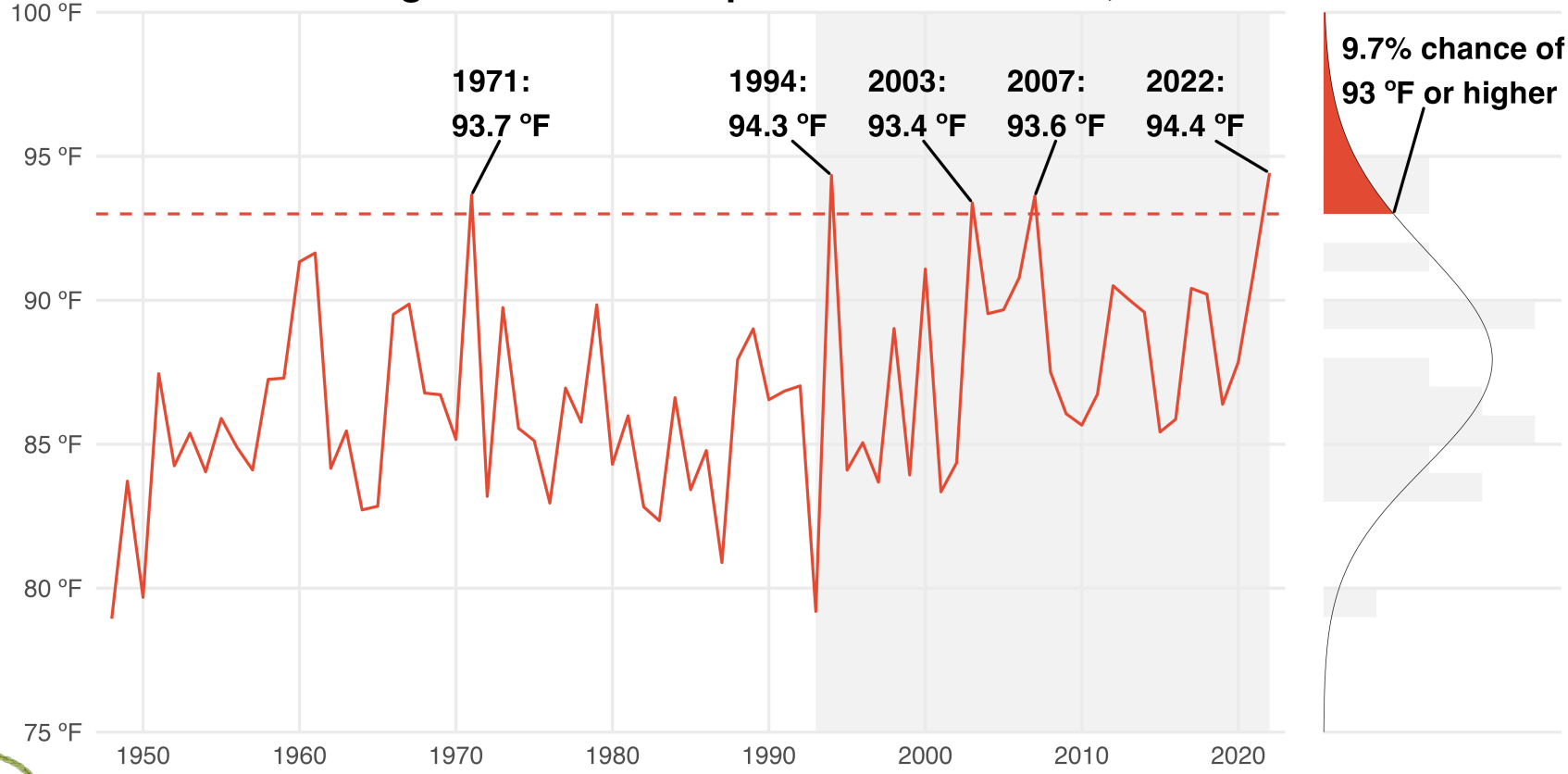

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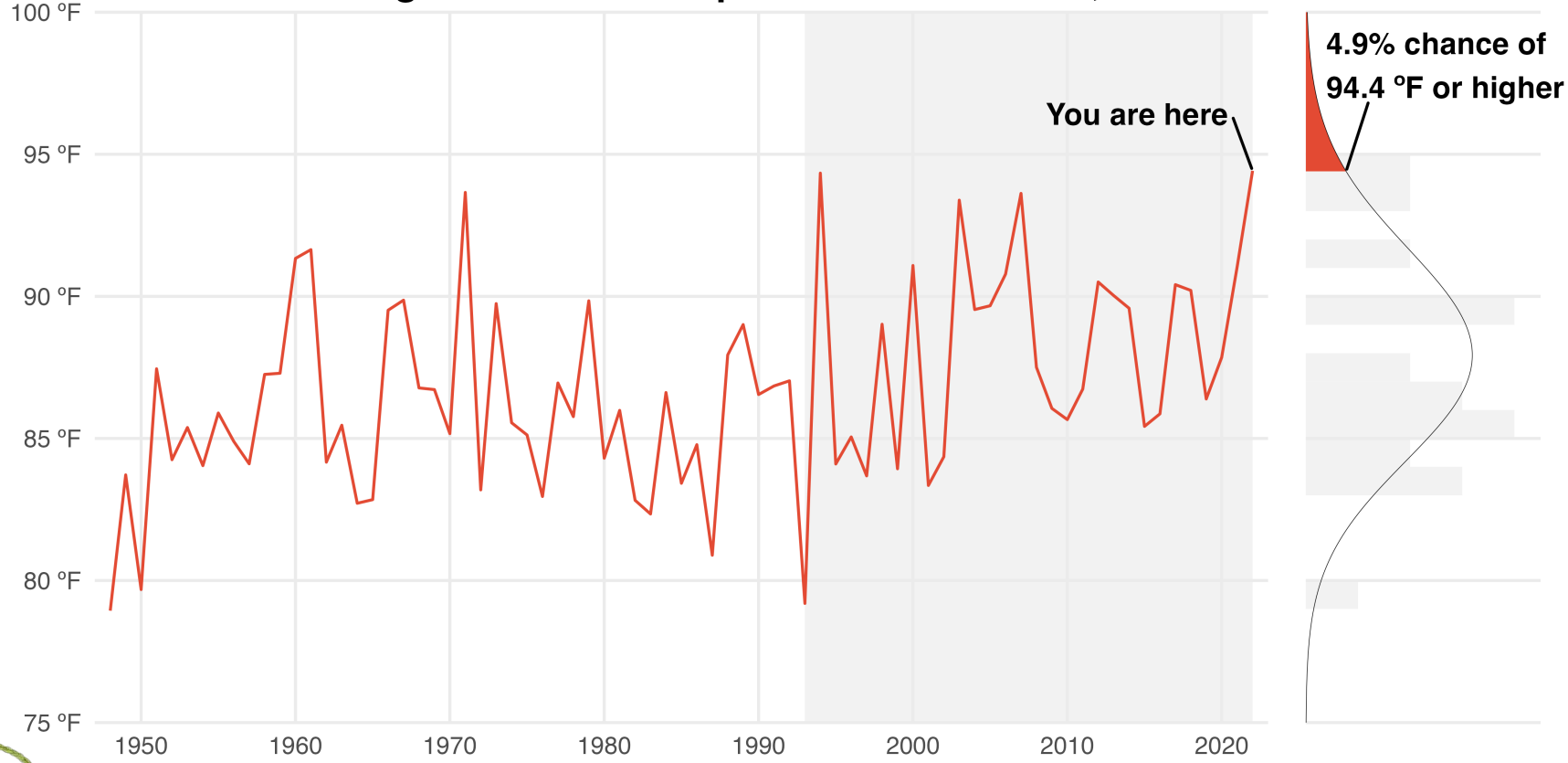
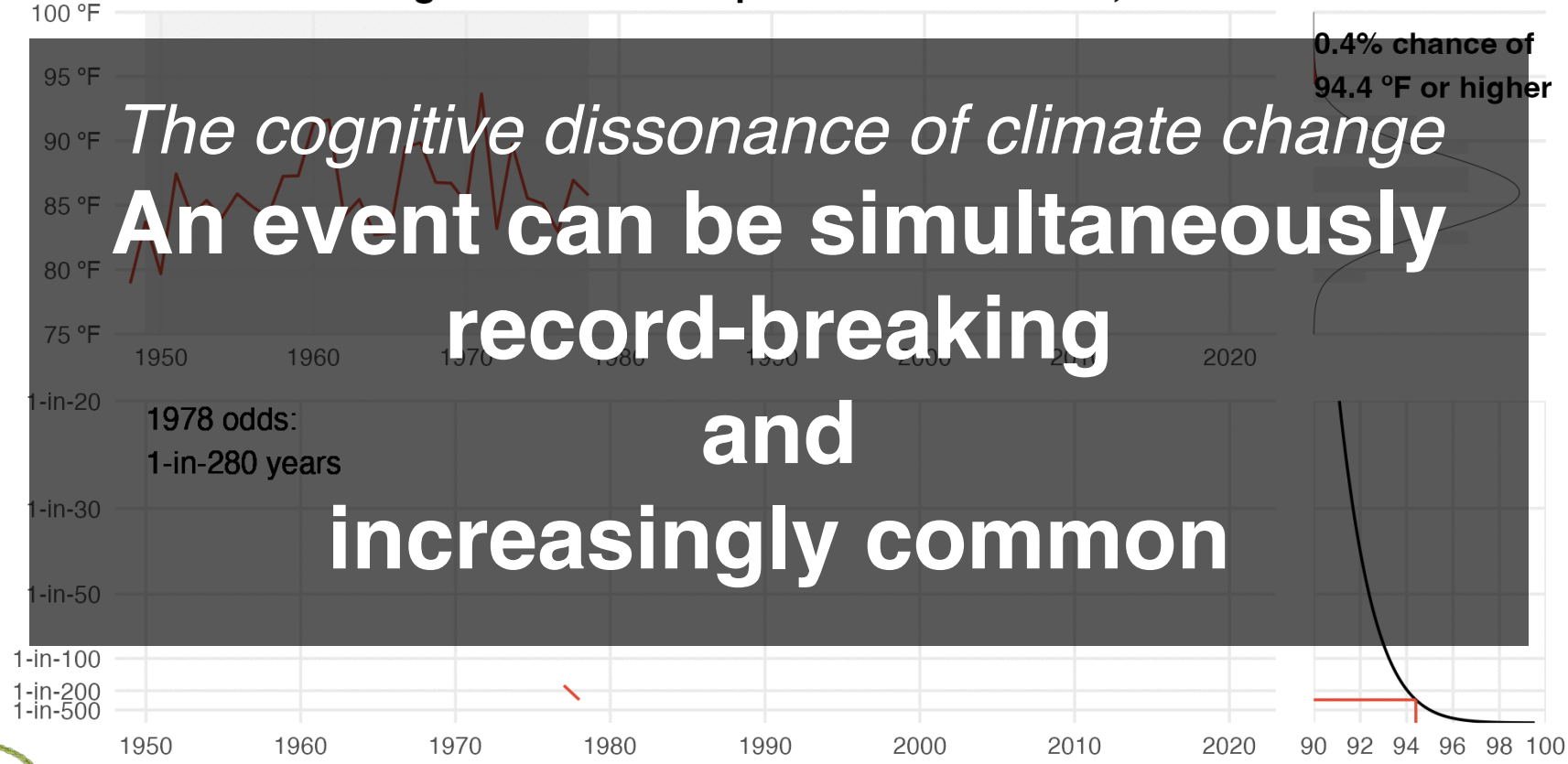


Montana Climate Office

Odds of 2022-like July 15 to August 15 in 1978
Average Maximum Temperature in Missoula, MT



The cognitive dissonance of climate change

An event can be simultaneously record-breaking and increasingly common

Game Plan

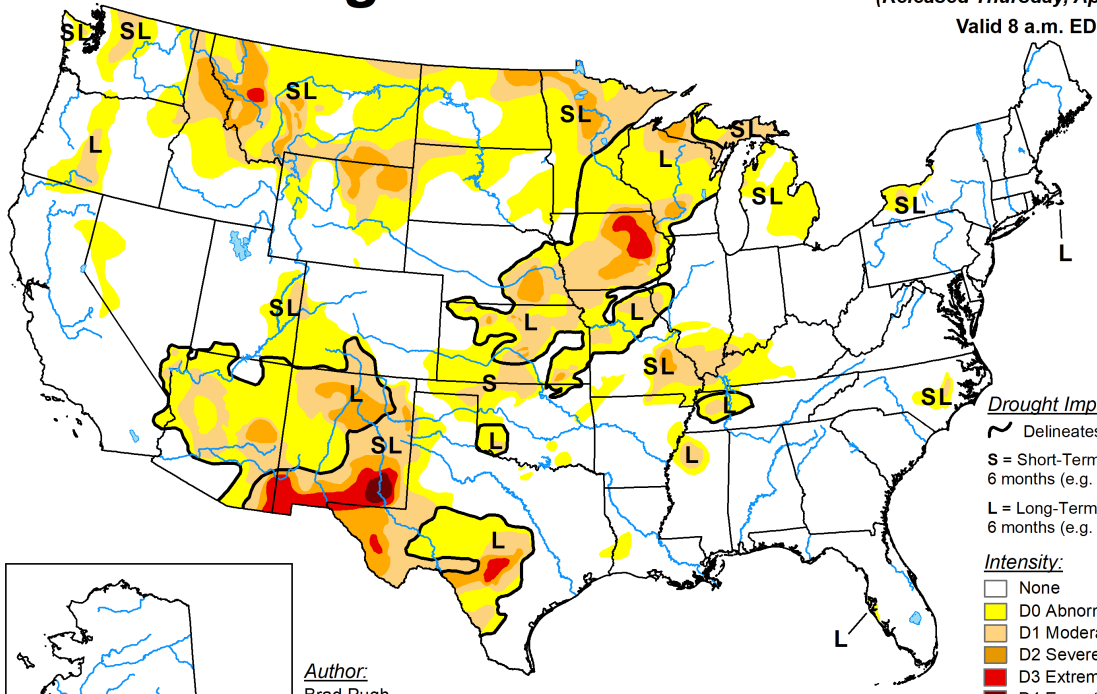
1. Observed trends and climate outlook
2. Risk in a changing climate
3. Tools for Assessing Climate Risk

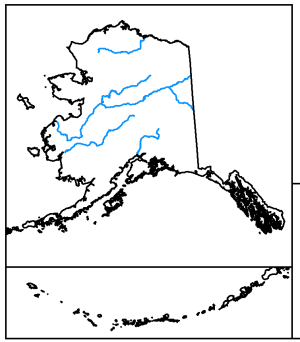
U.S. Drought Monitor

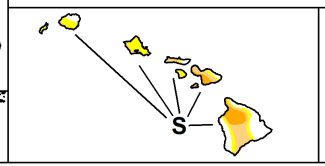
April 2, 2024

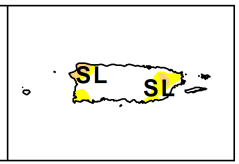
(Released Thursday, Apr. 4, 2024)

Valid 8 a.m. EDT









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:

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

Author:
Brad Pugh
CPC/NOAA

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USDA NDMC NOAA

droughtmonitor.unl.edu

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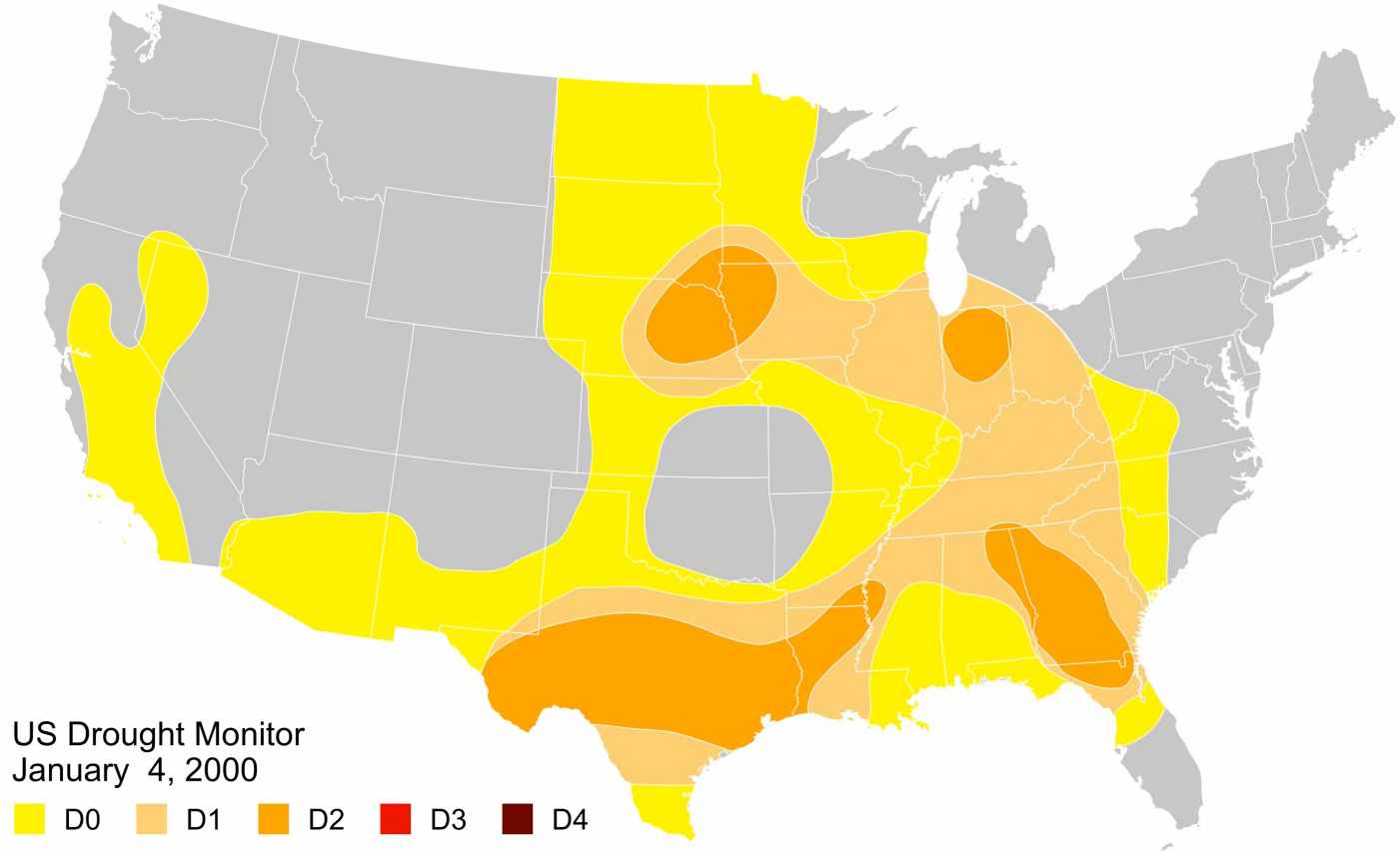
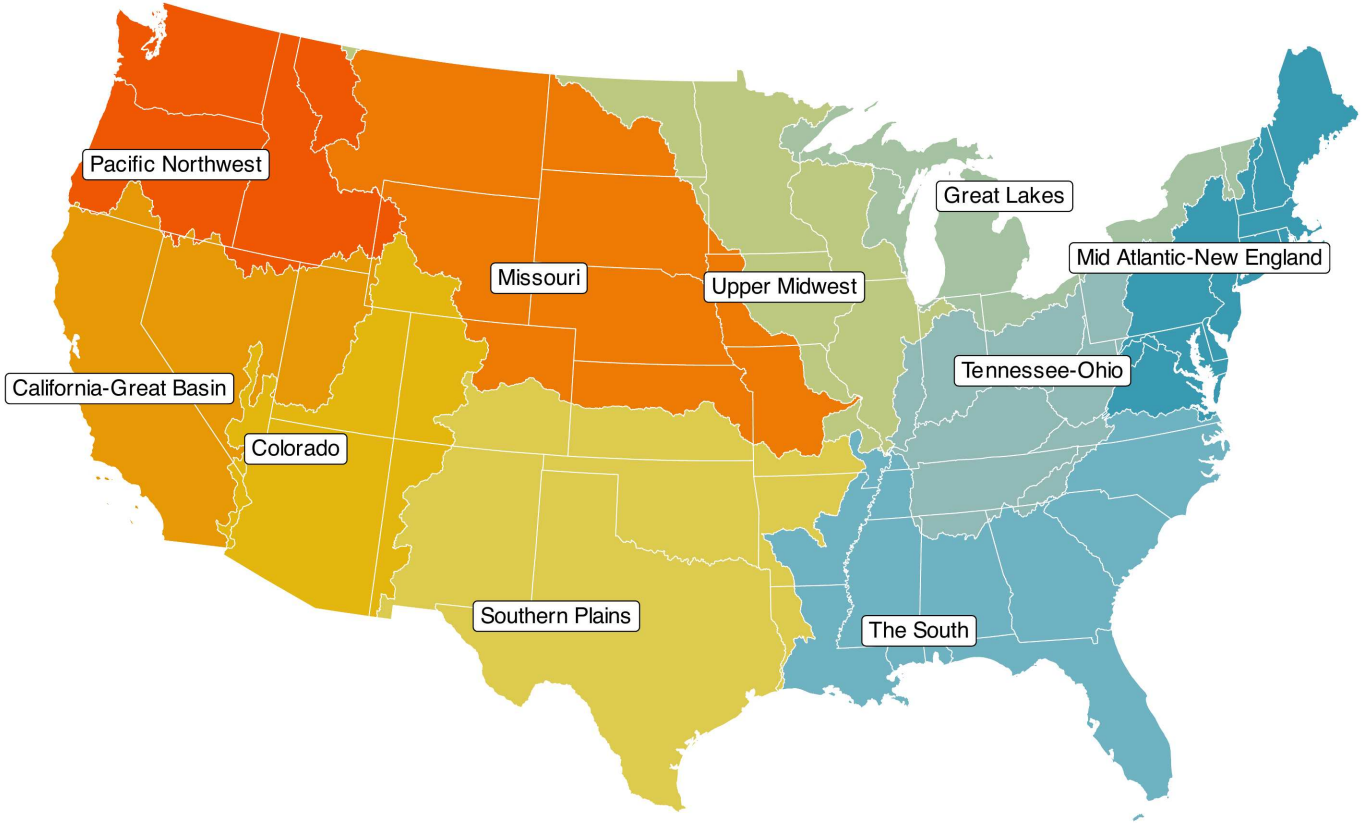
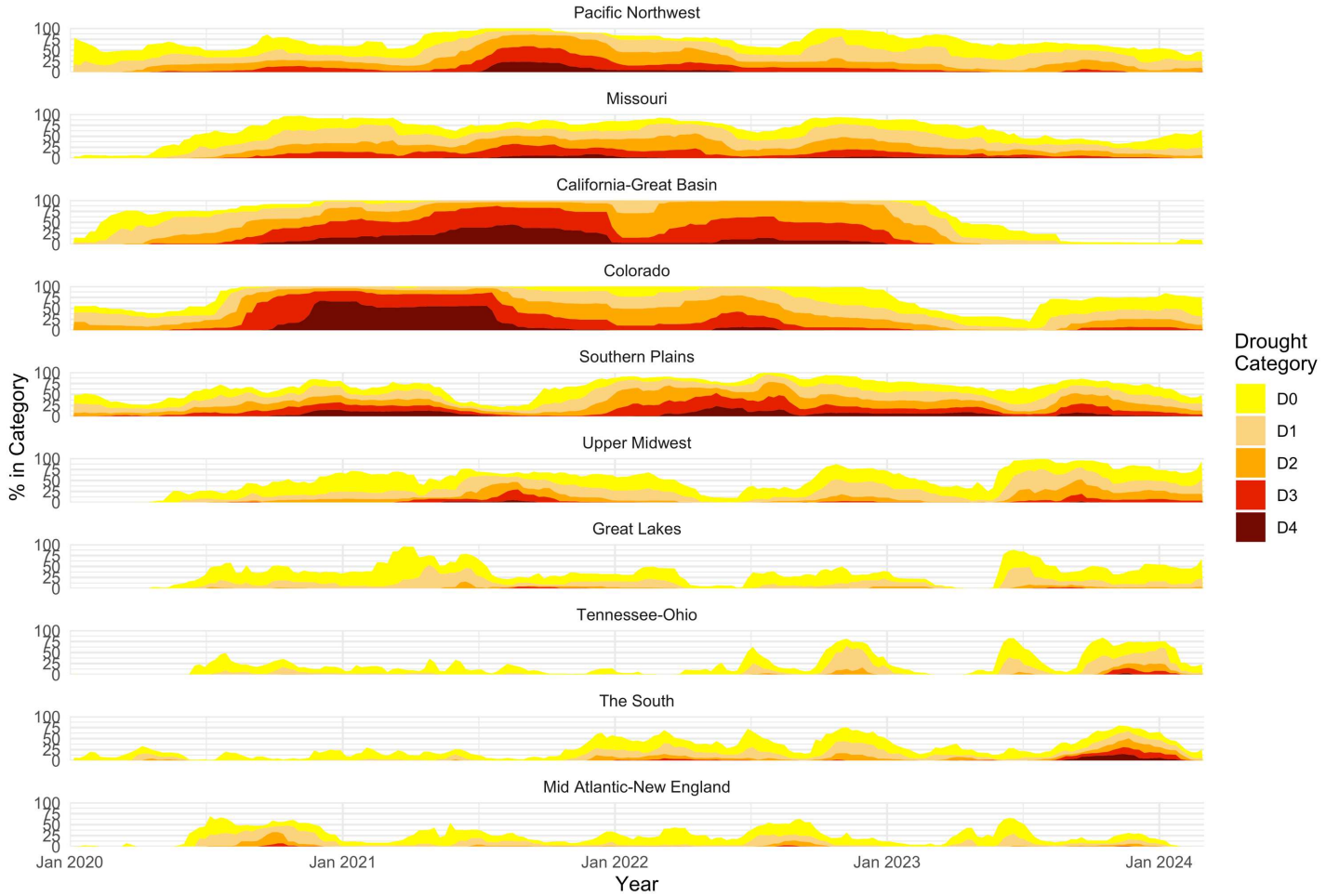

US Drought Monitor
January 4, 2000
D0
D1
D2
D3
D4


Pacific Northwest
Great Lakes
Mid Atlantic-New England
Missouri
Upper Midwest
Tennessee-Ohio
California-Great Basin
Colorado
Southern Plains
The South


Pacific Northwest
Missouri
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Colorado
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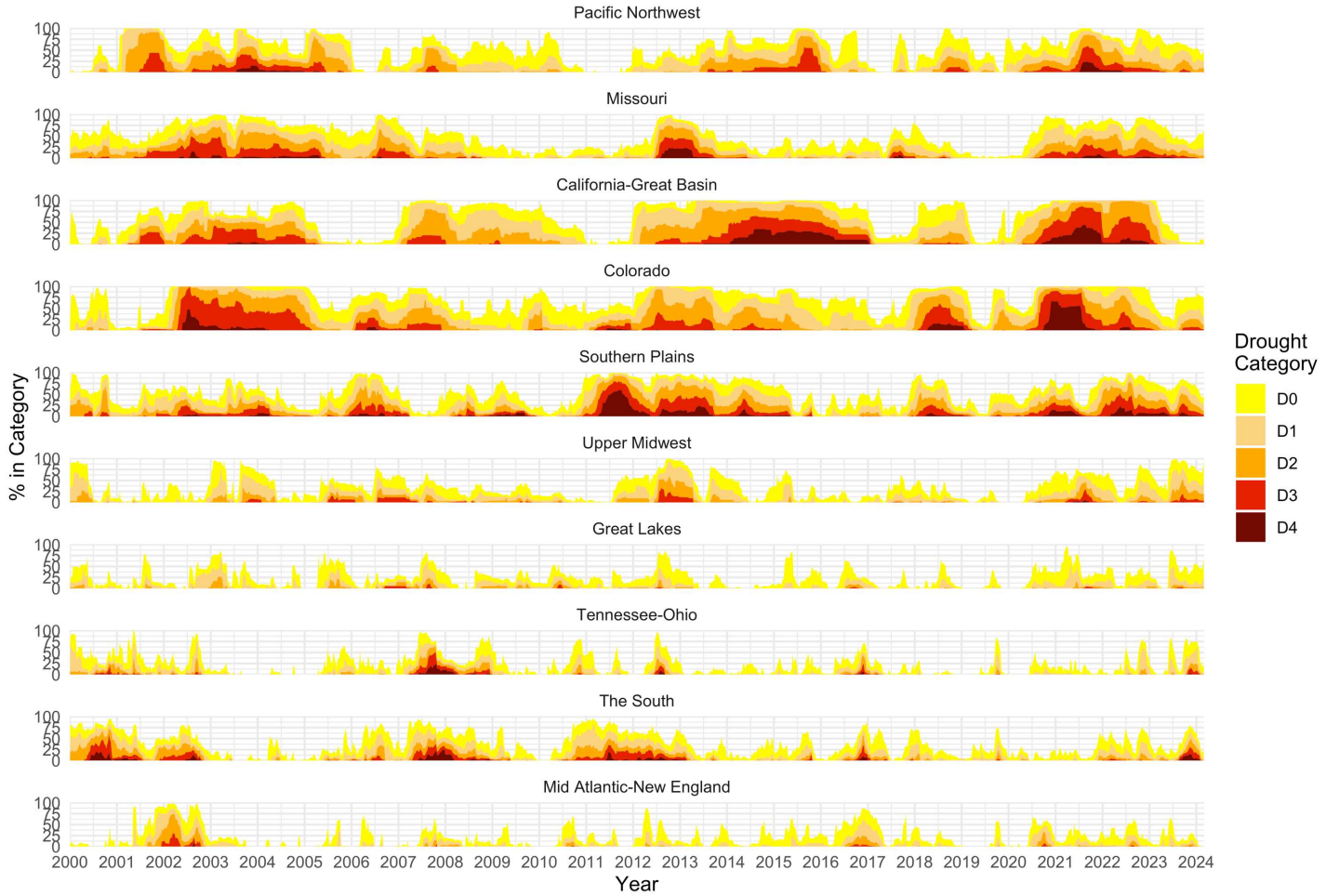
Great Lakes
Tennessee-Ohio
The South
Mid Atlantic-New England
100
75
50
25
0
% in Category
Jan 2020
Jan 2021
Jan 2022
Jan 2023
Jan 2024
Year
Drought Category
D0
D1
D2
D3
D4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2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024
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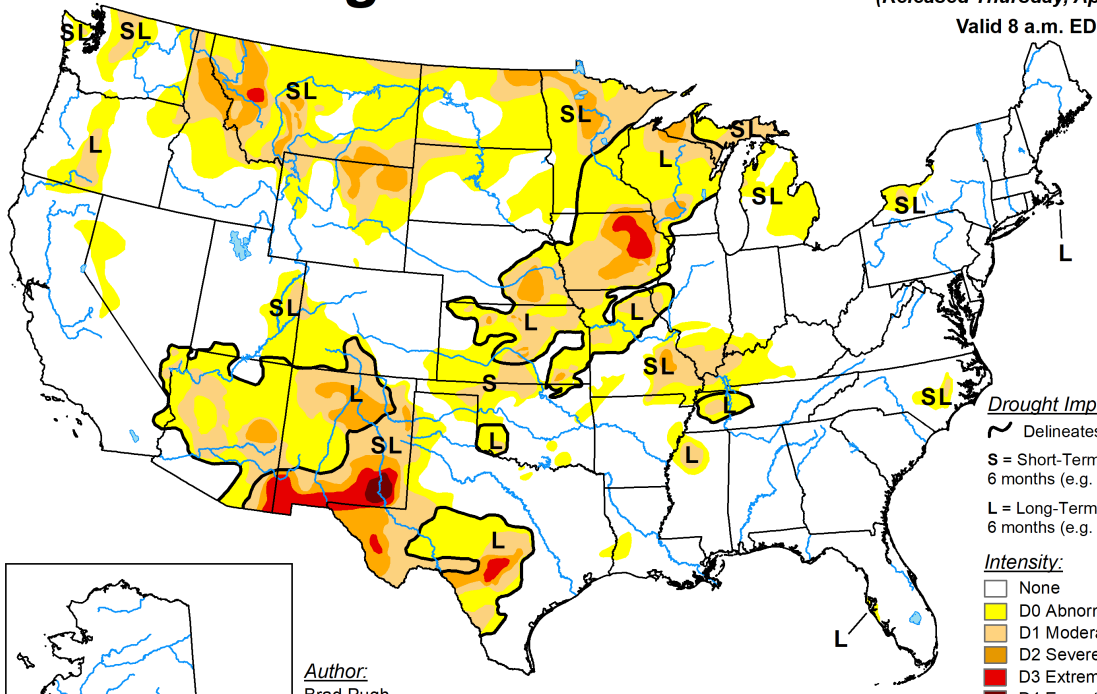

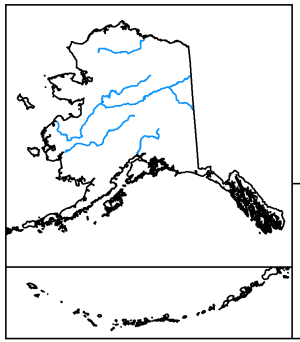

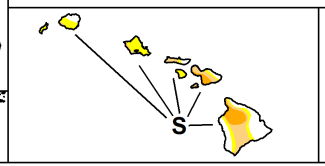

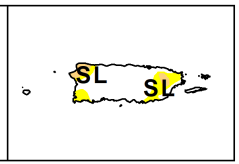

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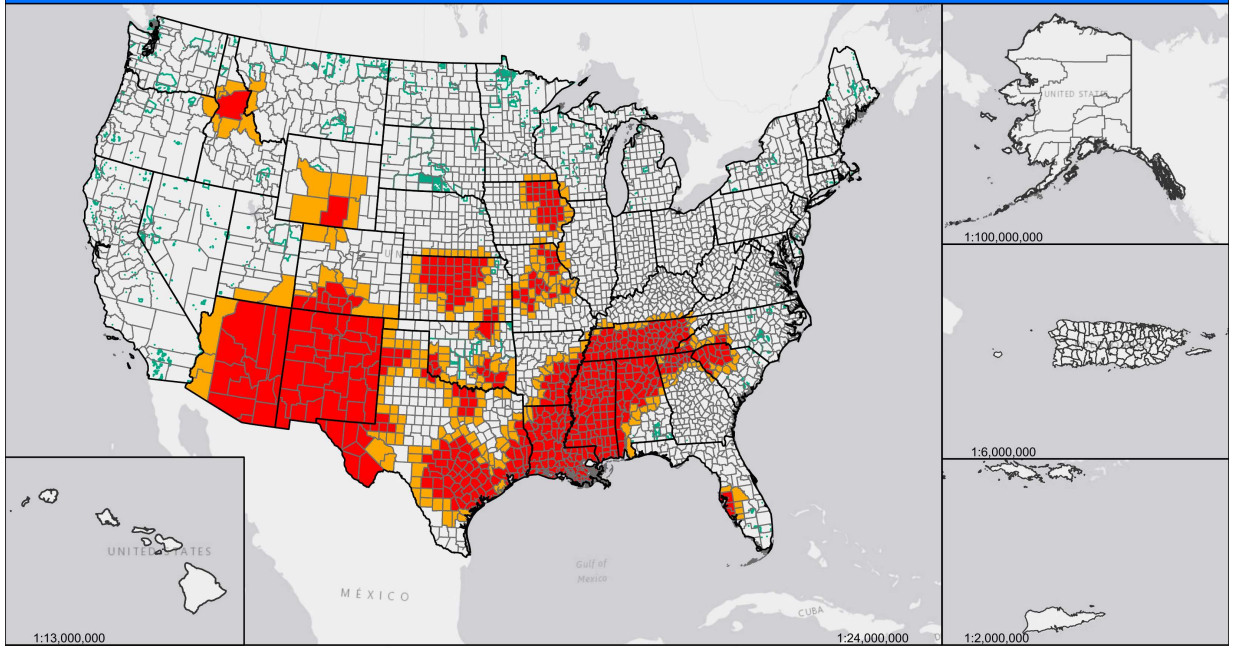
2024 Secretarial Drought Designations - All Drought



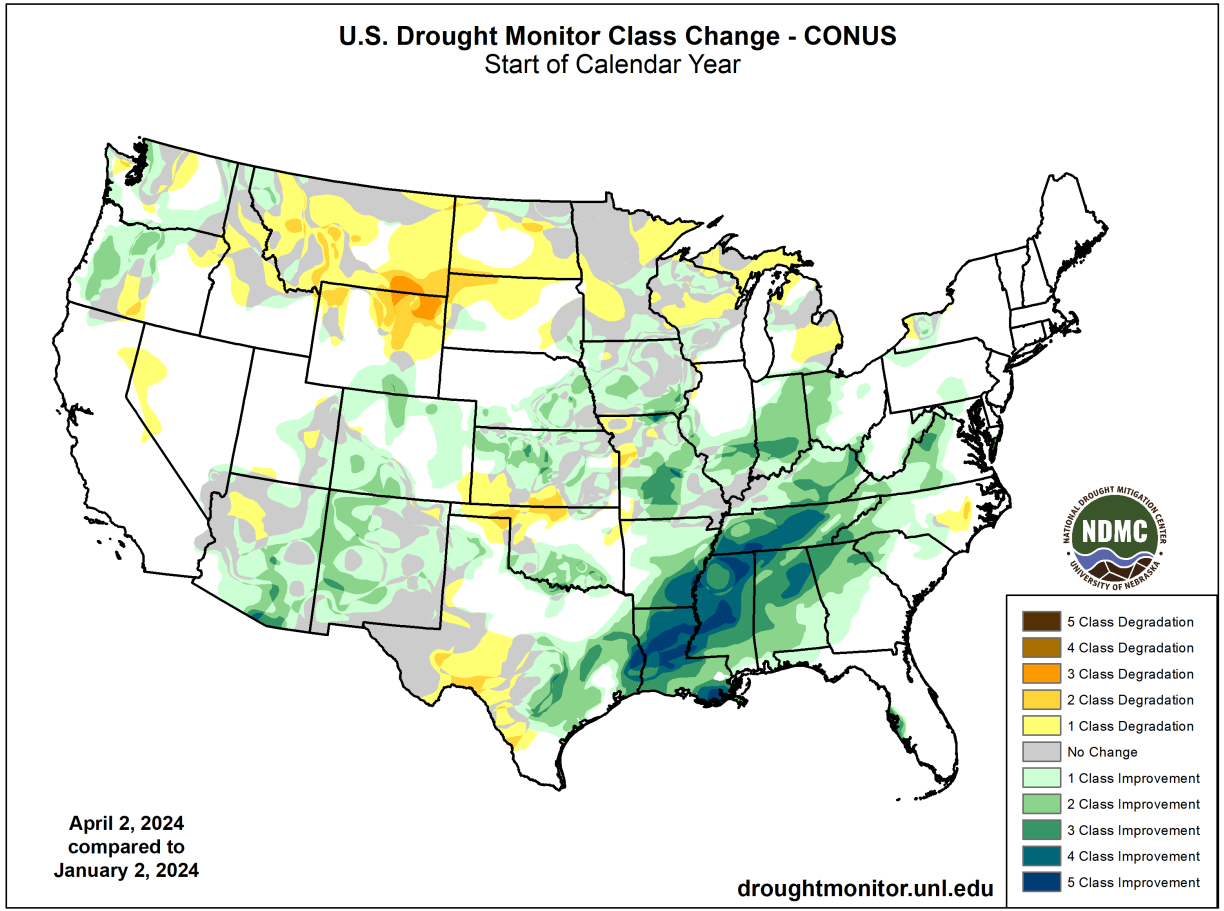
Secretarial Drought Designations for 2024

Disaster Incidences as of April 3, 2024

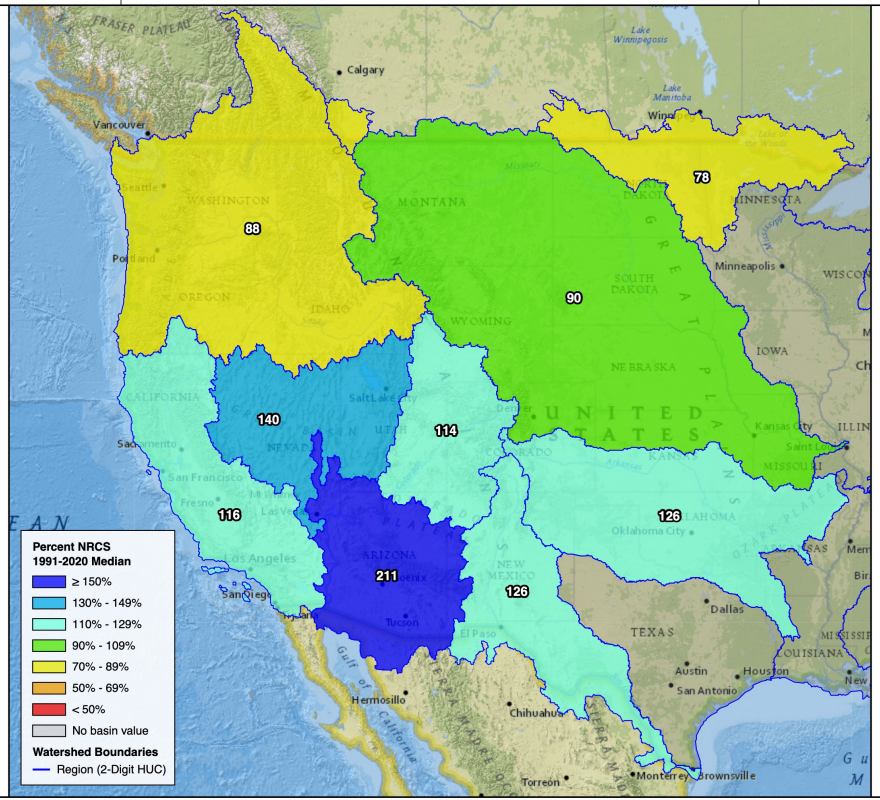
- State Boundary
- County Boundary
- Tribal Lands
- Primary Counties: 566
- Contiguous Counties: 333

USDA

United States Department of Agriculture
Farm Service Agency
Program Delivery/Safety Net Division
April 3, 2024


U.S. Drought Monitor Class Change - CONUS
Start of Calendar Year
April 2, 2024
compared to
January 2, 2024
droughtmonitor.unl.edu
NDMC
NATIONAL DROUGHT MITIGATION CENTER
UNIVERSITY OF NEBRASKA
5 Class Degradation
4 Class Degradation
3 Class Degradation
2 Class Degradation
1 Class Degradation
No Change
1 Class Improvement
2 Class Improvement
3 Class Improvement
4 Class Improvement
5 Class Improvement

Snow Water Equivalent	Percent NRCS 1991-2020 Median	April 8, 2024, end of day



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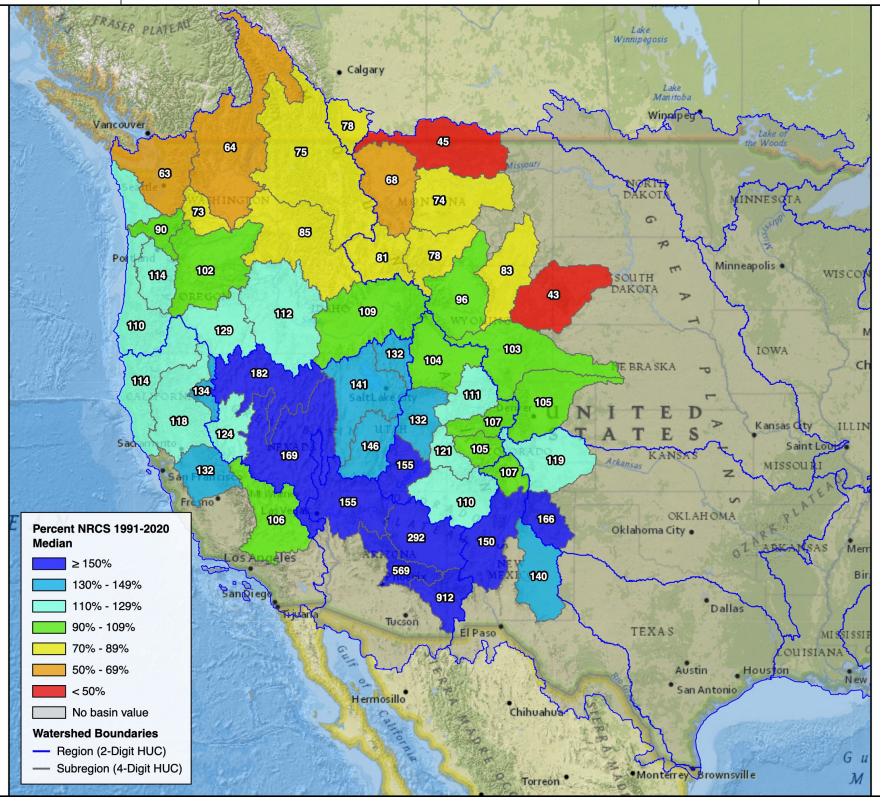

USDA Natural Resources Conservation Service
United States Department of Agriculture

N

0 50 100 200 300 400 500 Miles

Created 4-09-2024

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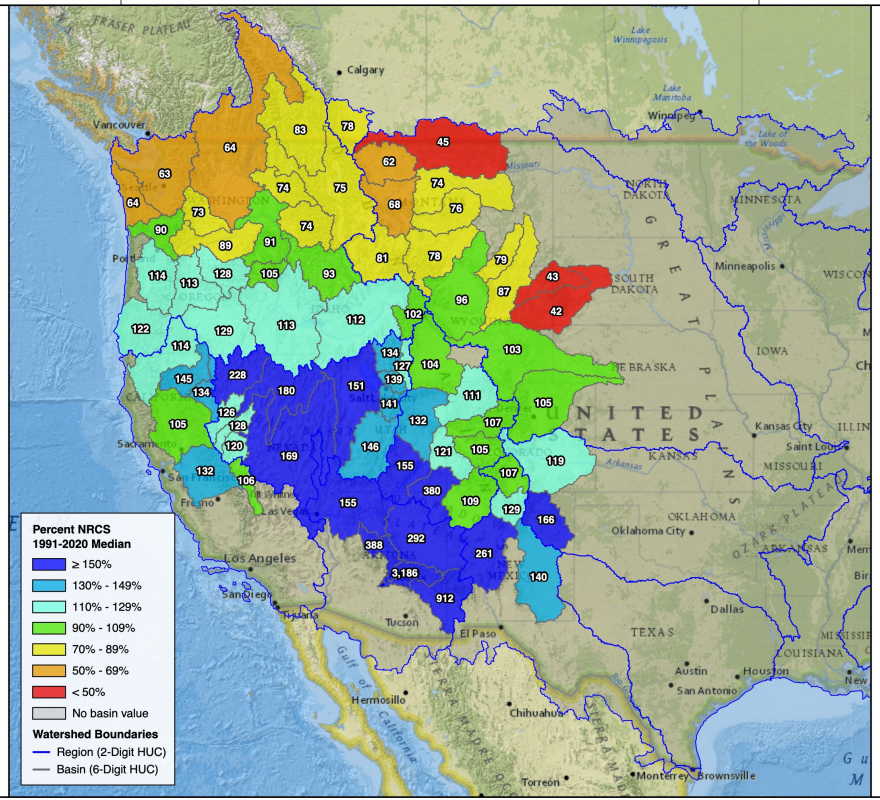

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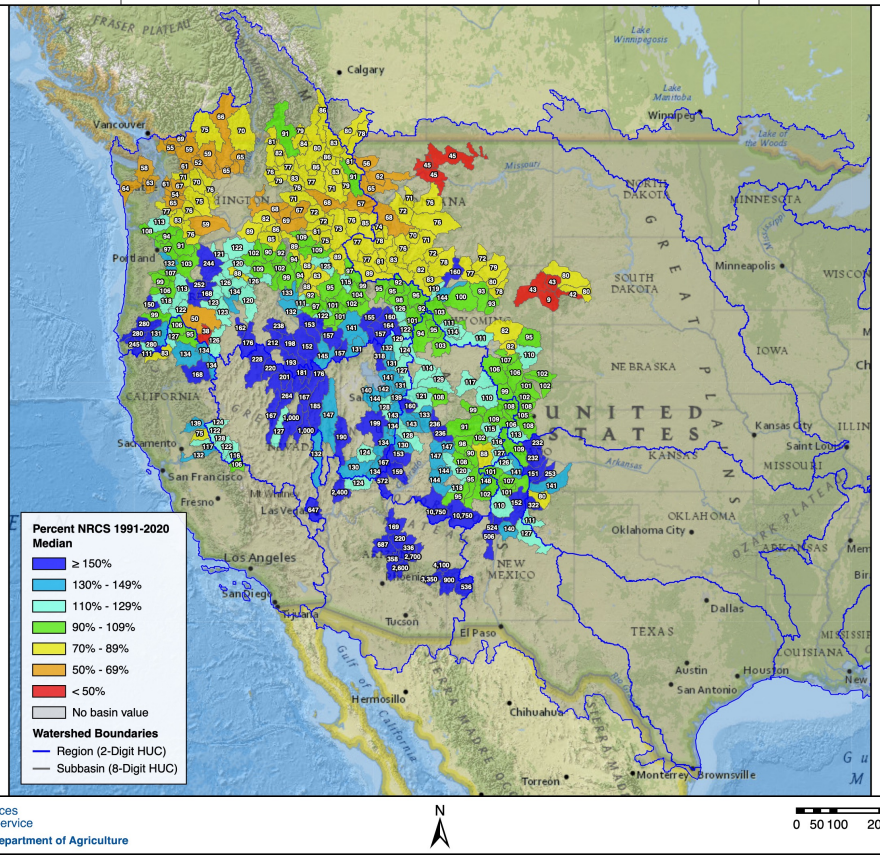
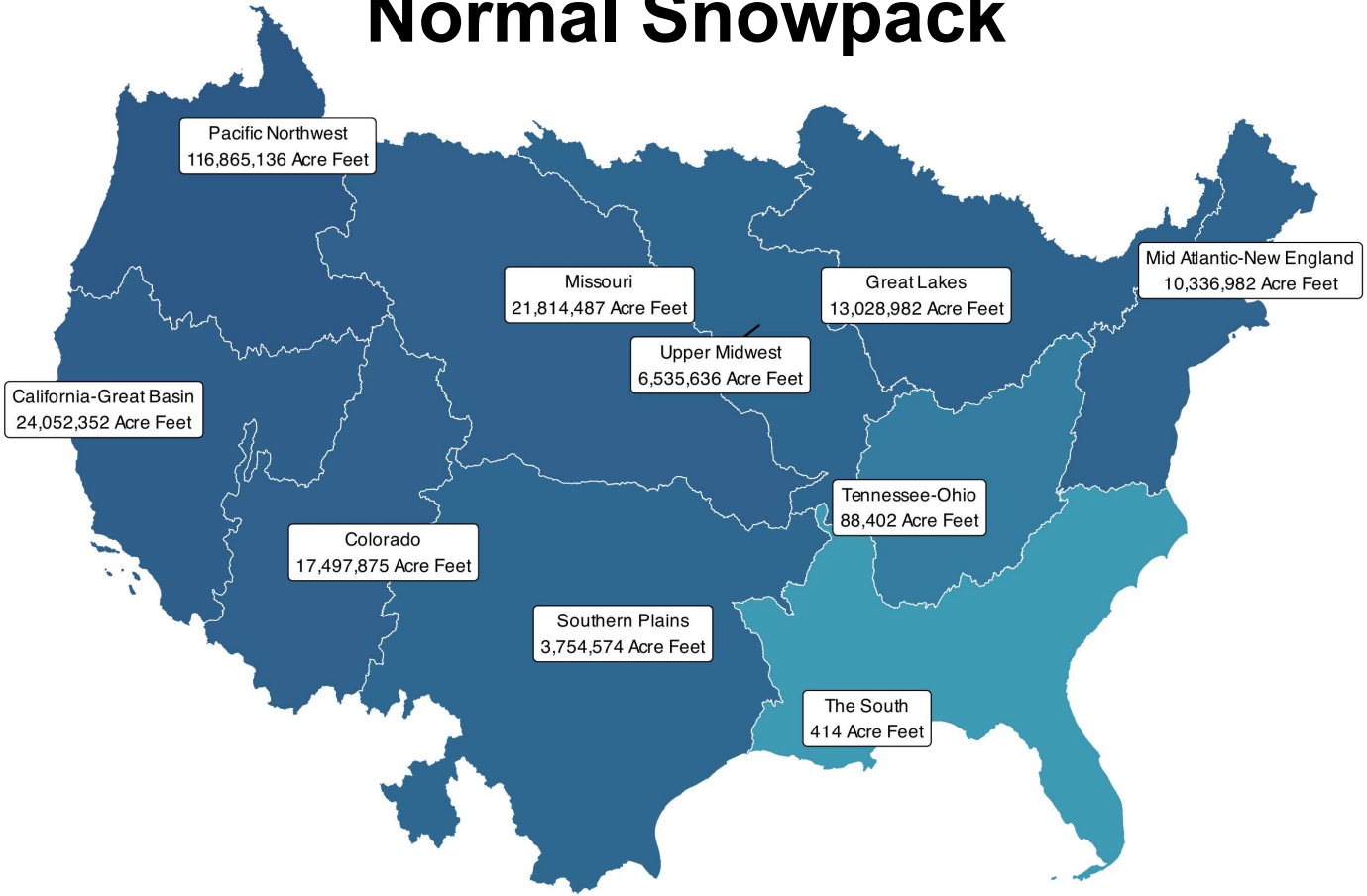
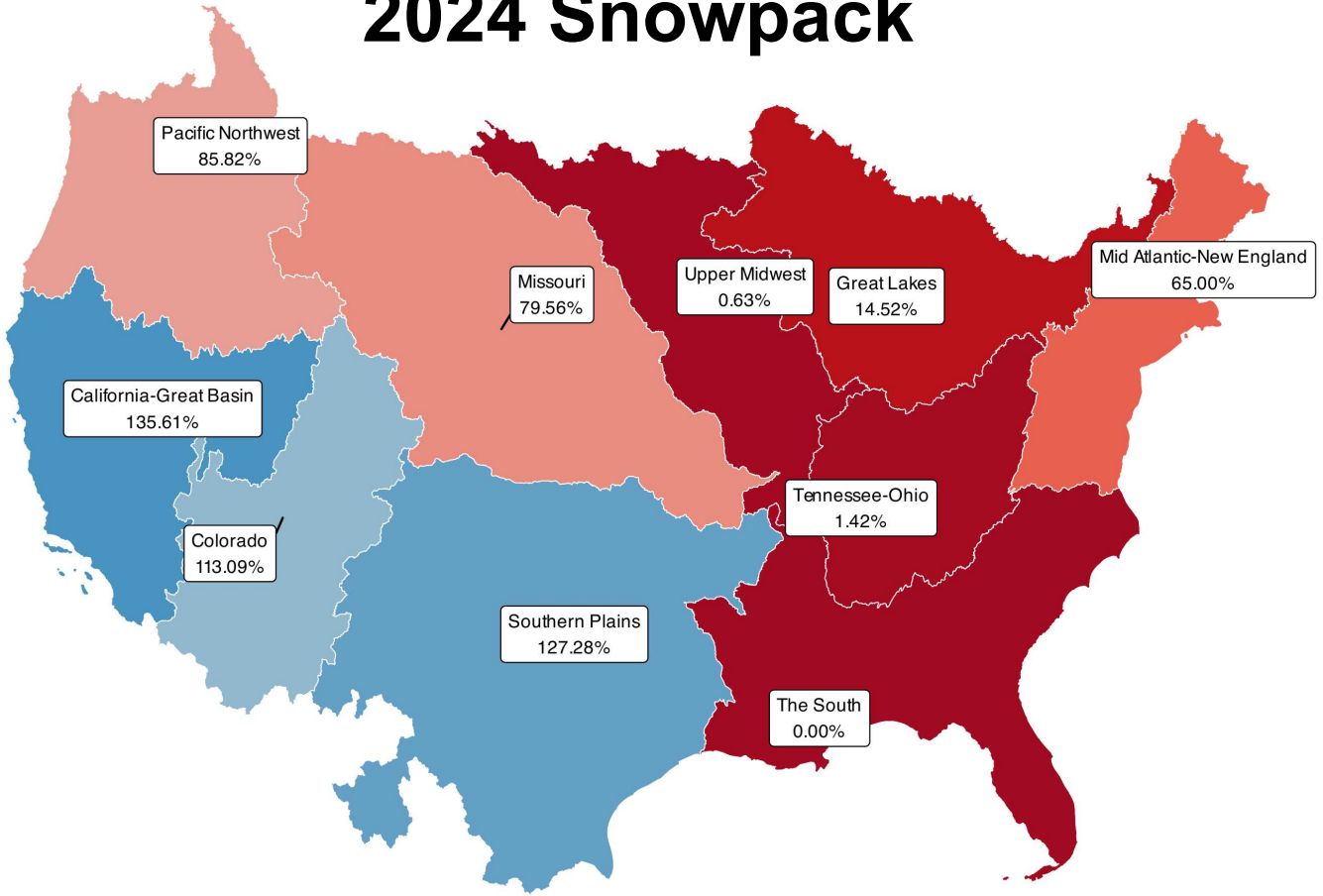


Normal Snowpack



2024 Snowpack

2024 Snowpack



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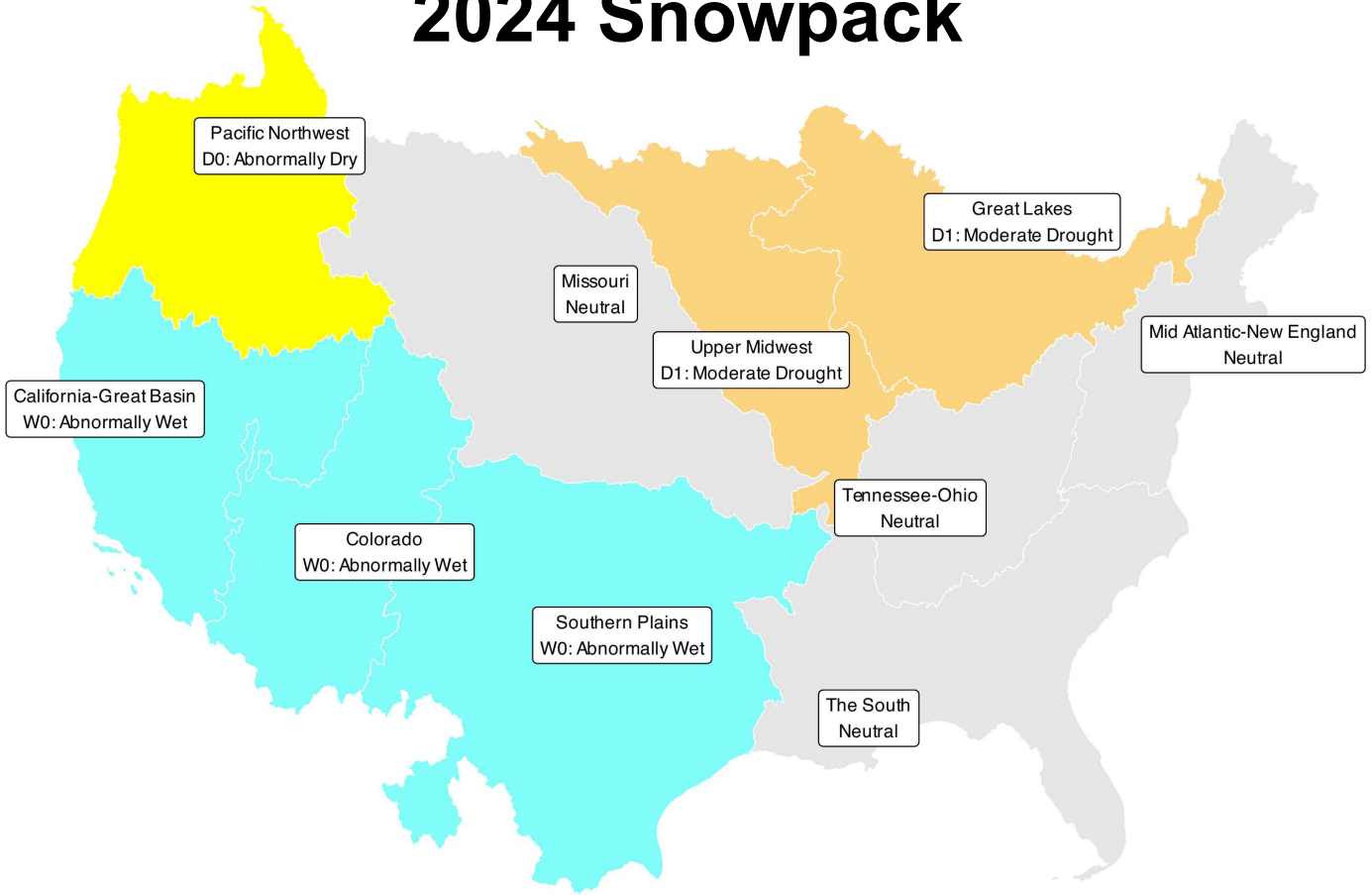

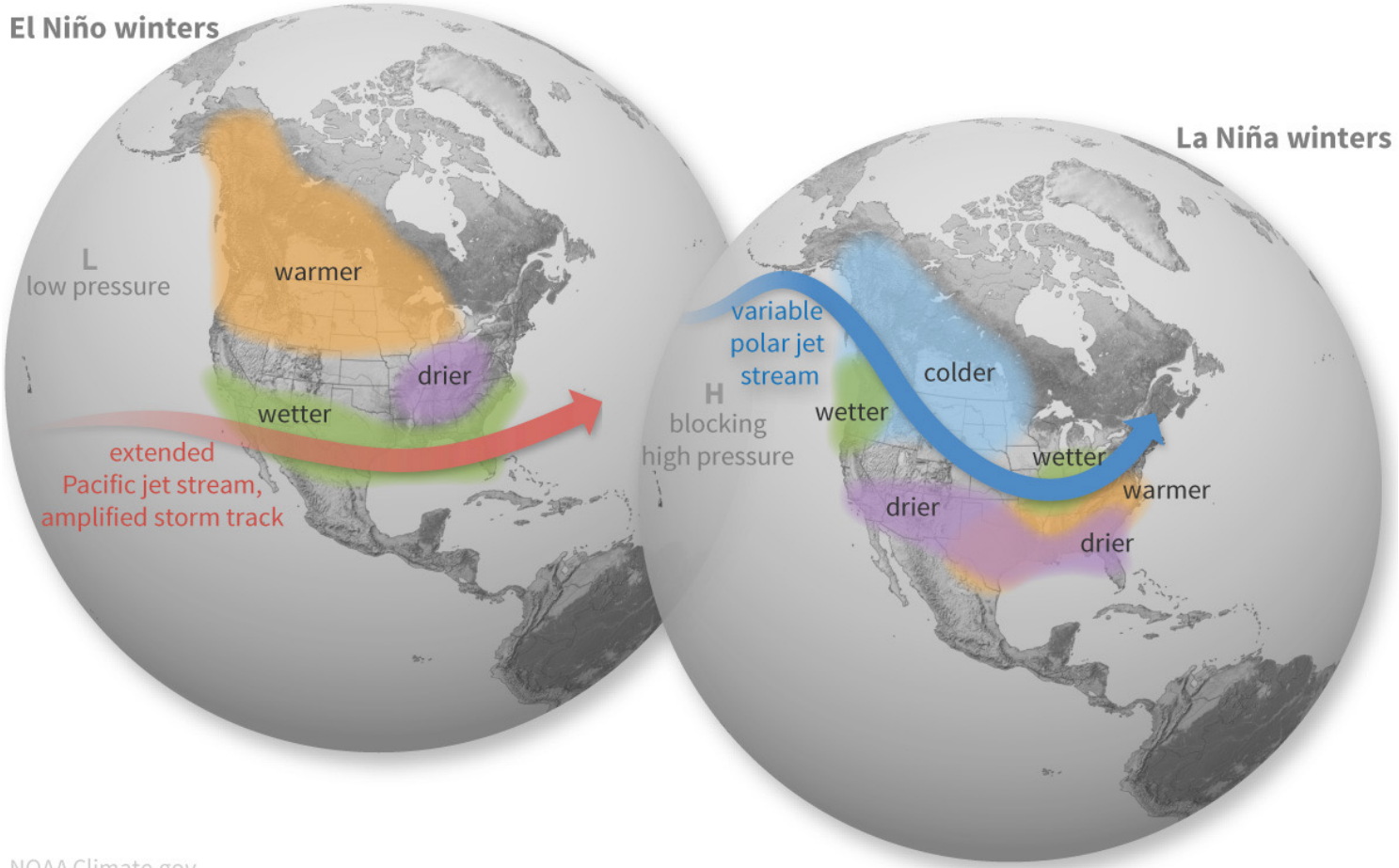

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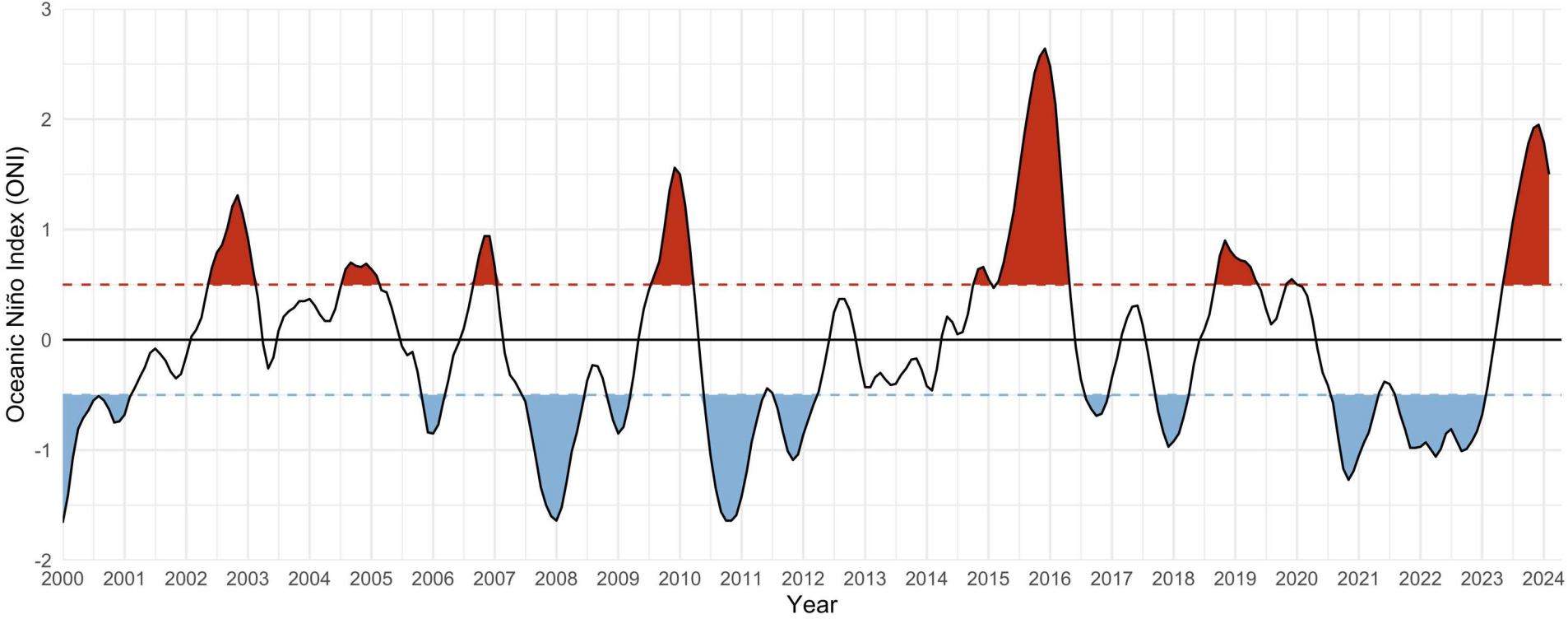
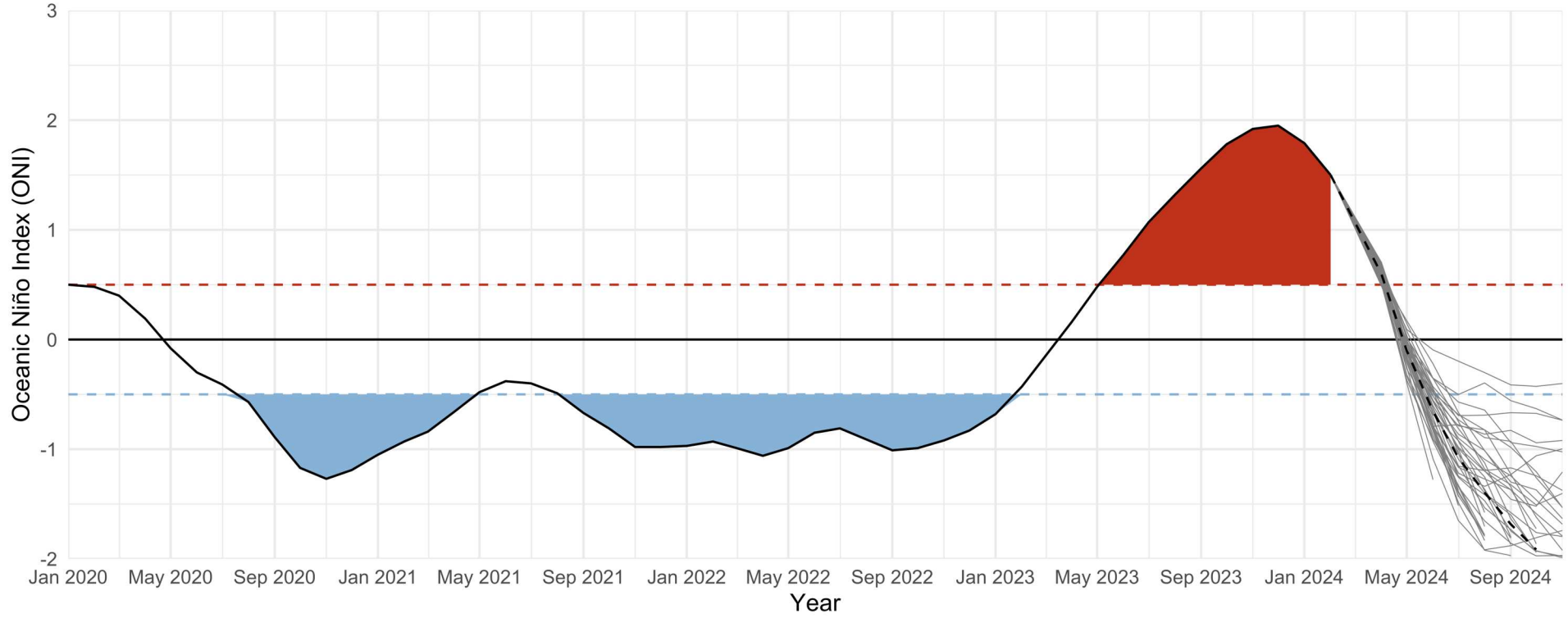
ENSO Since 2000



Summer 2024 Projections



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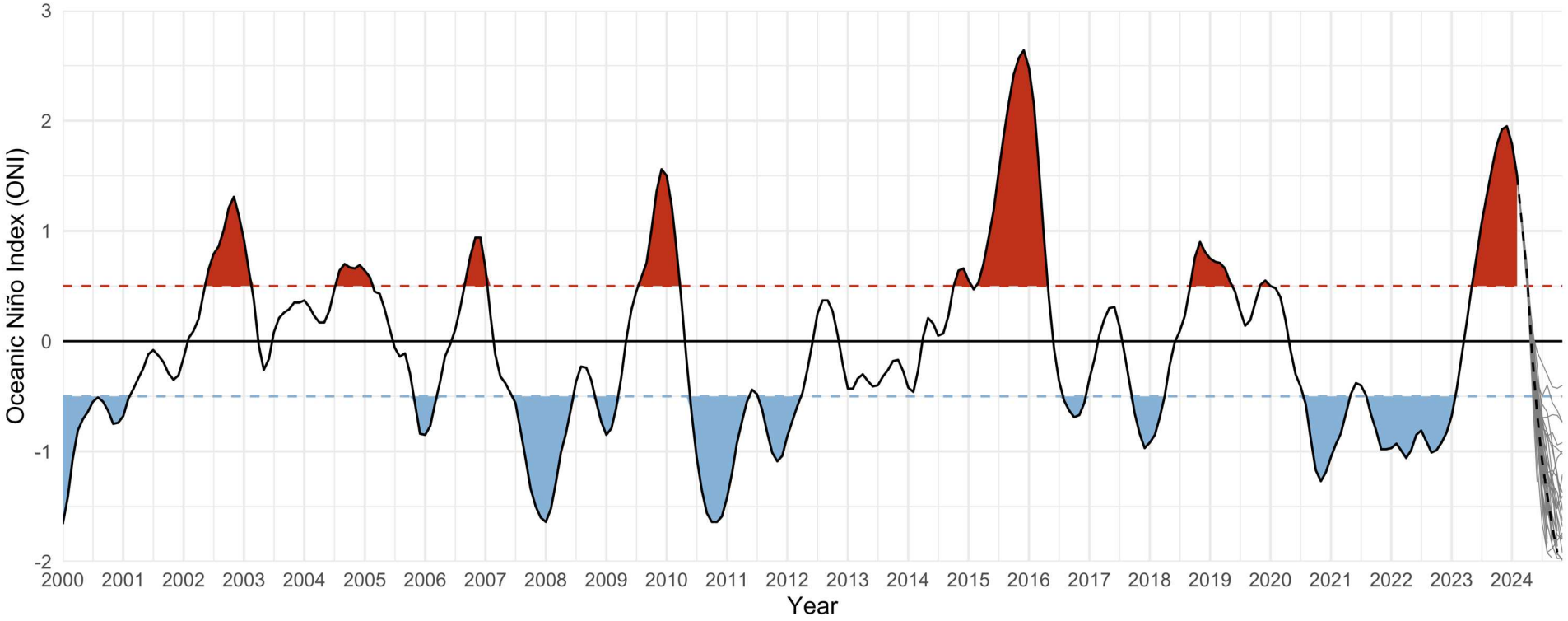
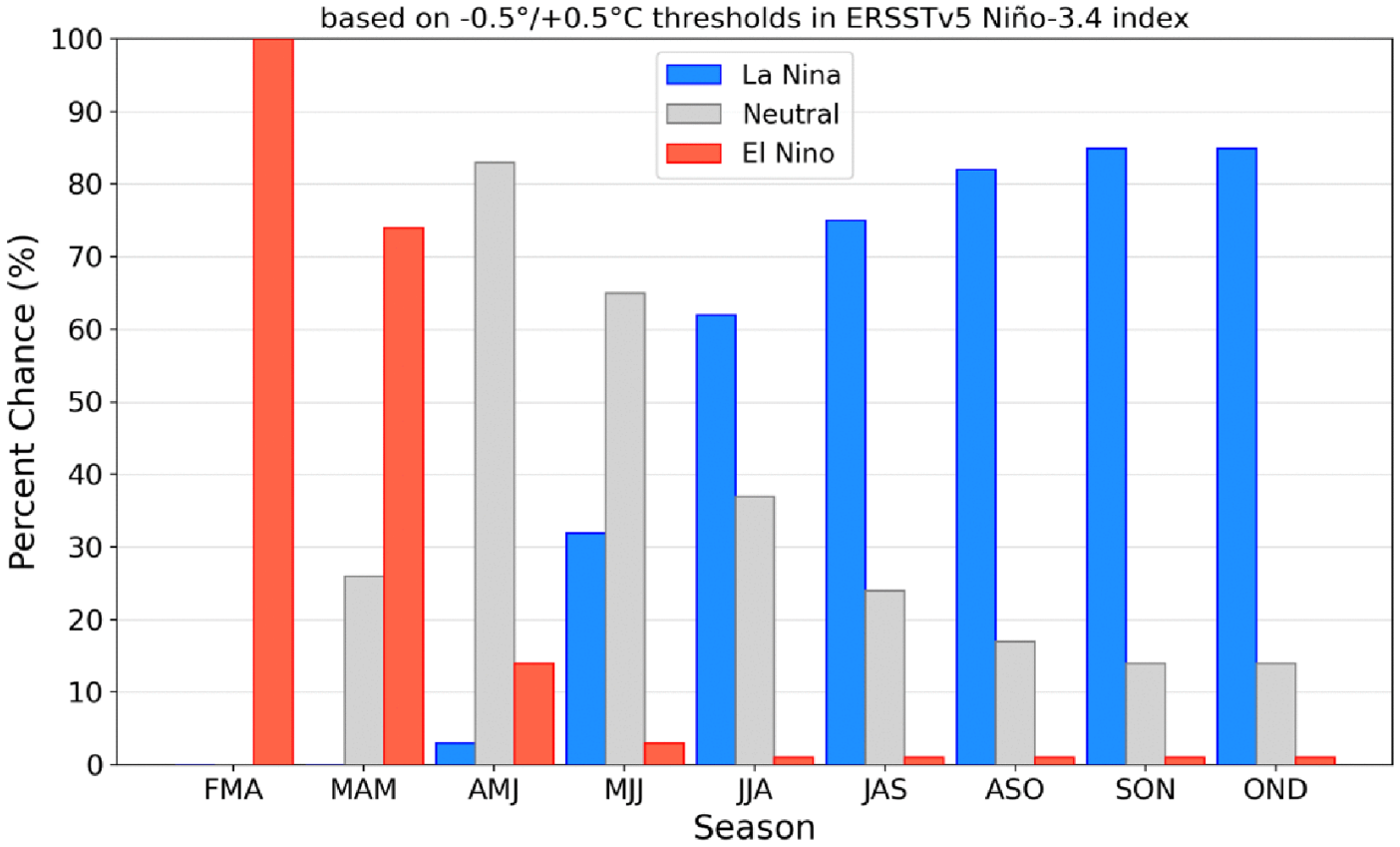
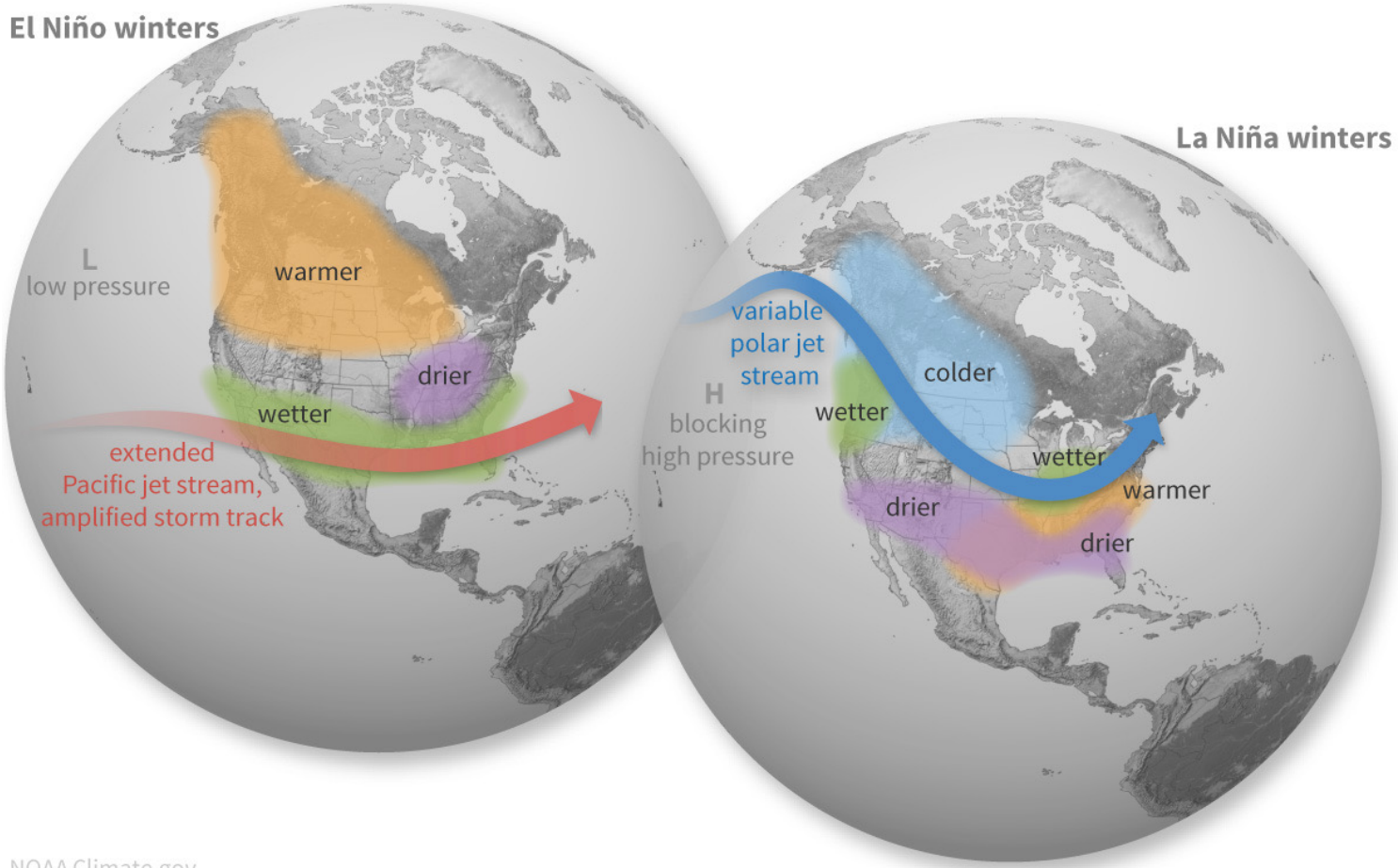


Official NOAA CPC ENSO Probabilities (issued Mar. 2024)





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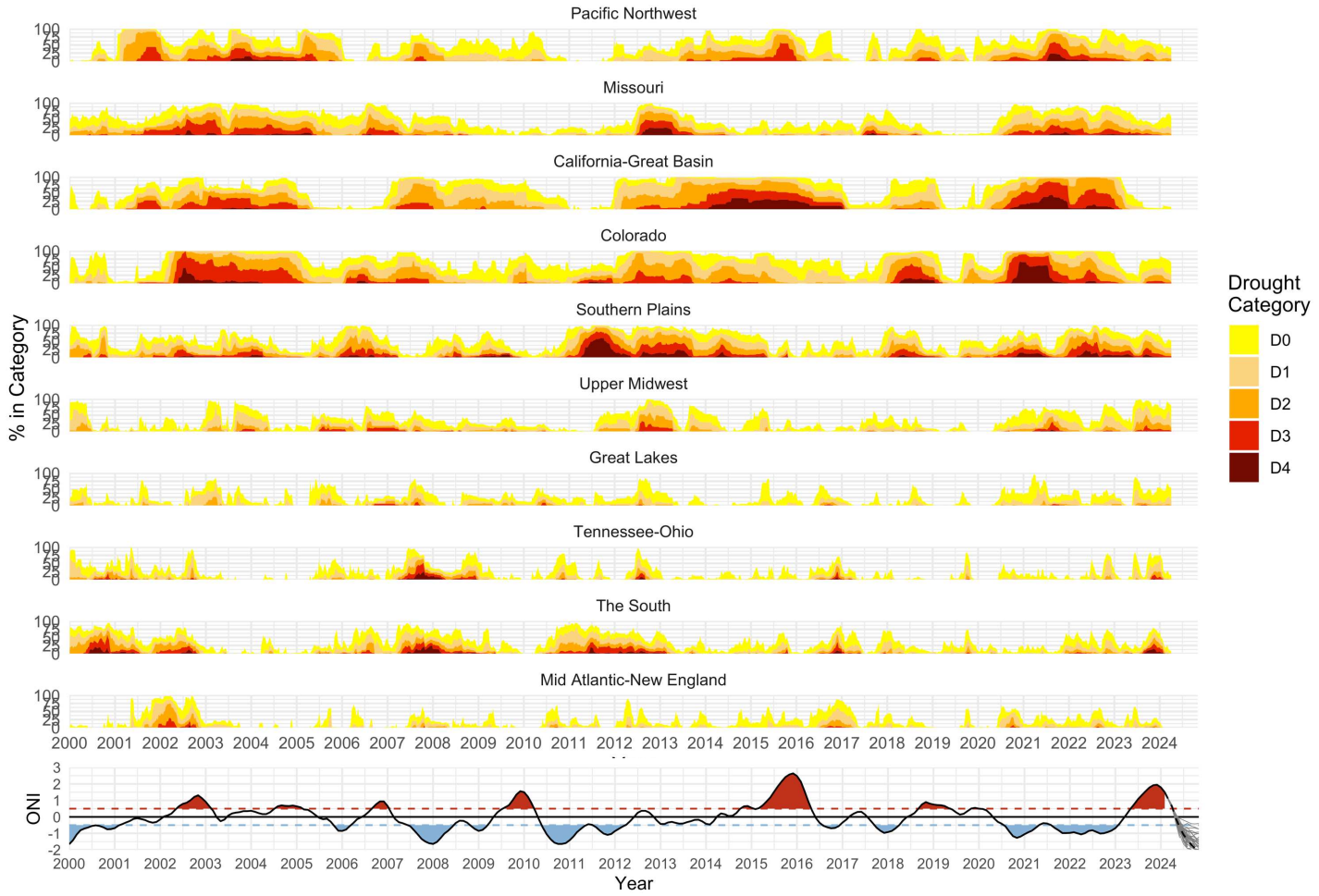

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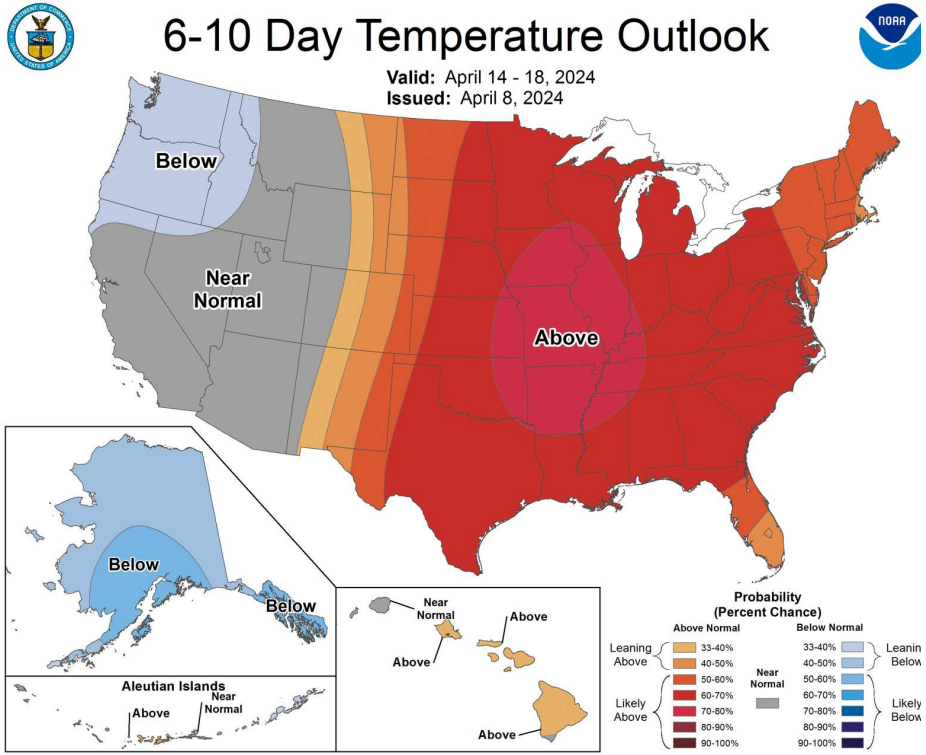
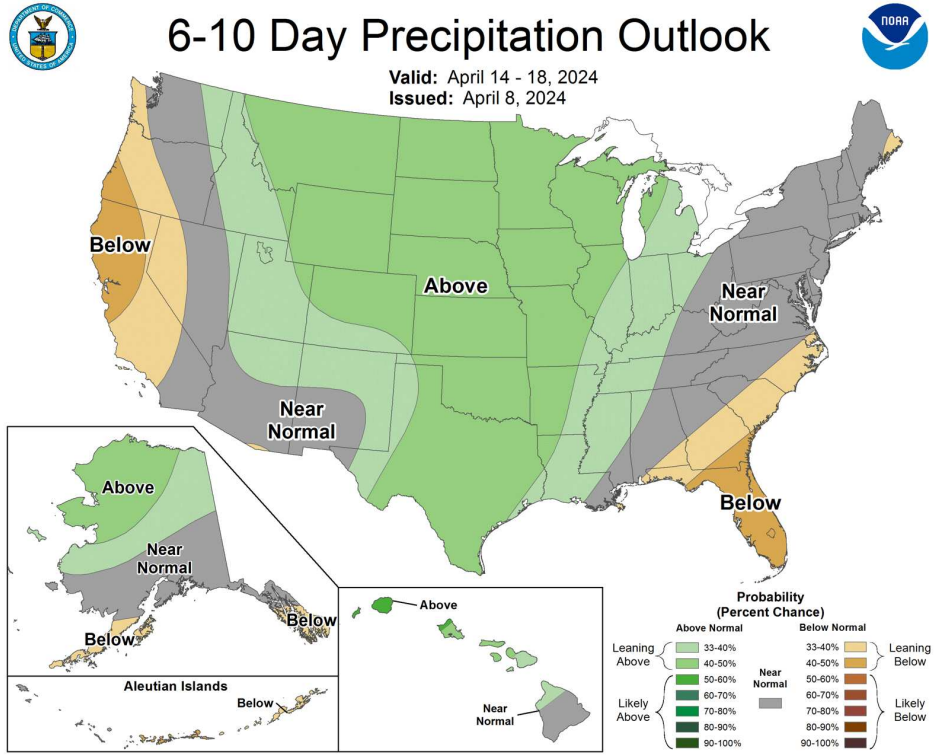

6-10 Day Temperature Outlook
Valid: April 14 - 18, 2024
Issued: April 8, 2024
Below
Near Normal
Above
Below
Below
Aleutian Islands
Above
Near Normal
Near Normal
Above
Above
Above
Probability (Percent Chance)
Above Normal
Below Normal
Leaning Above
Likely Above
Near Normal
Leanin Below
Likely Below
33-40%
40-50%
50-60%
60-70%
70-80%
80-90%
90-100%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Below
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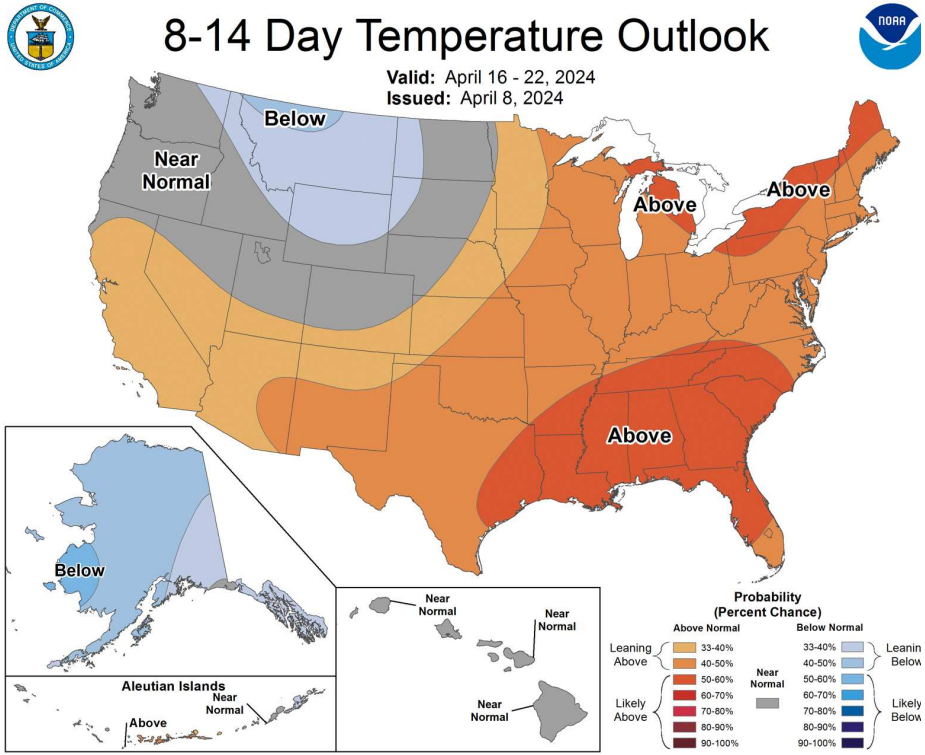

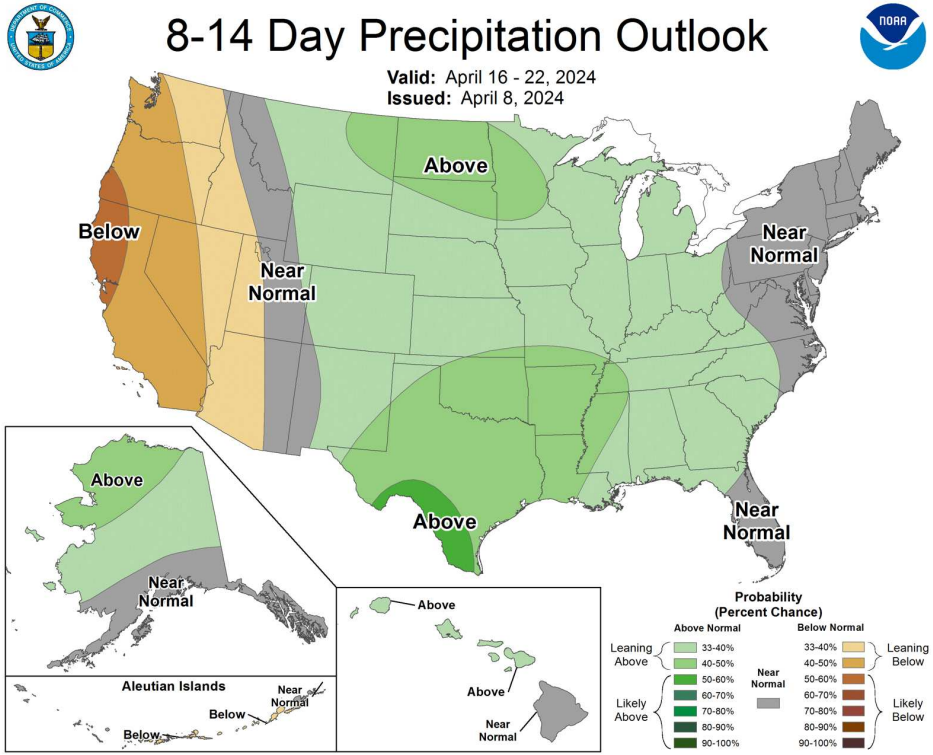

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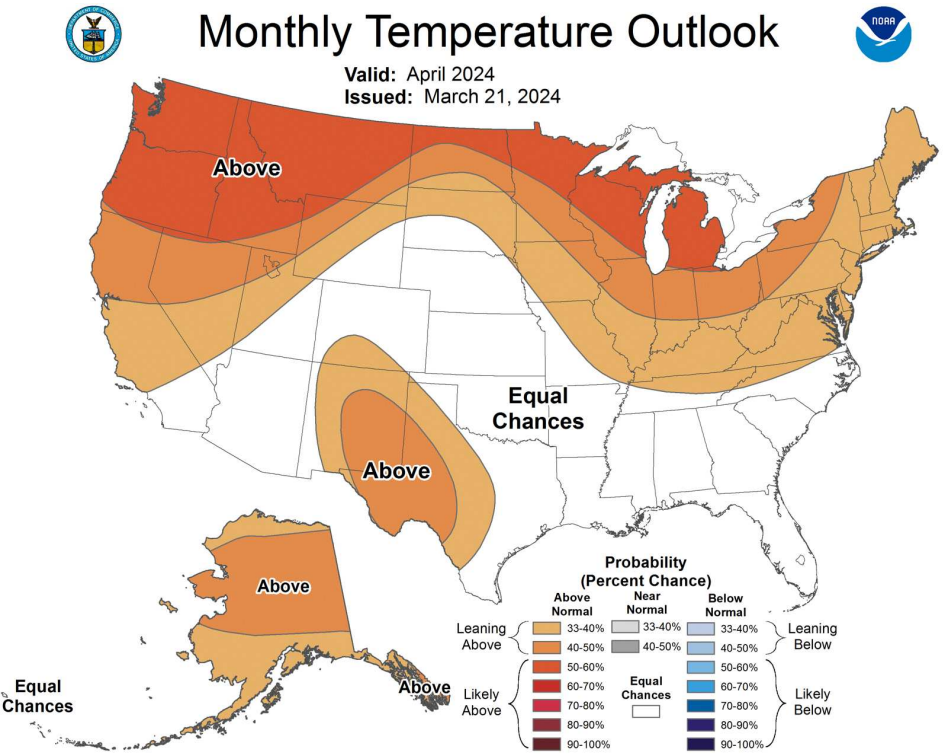

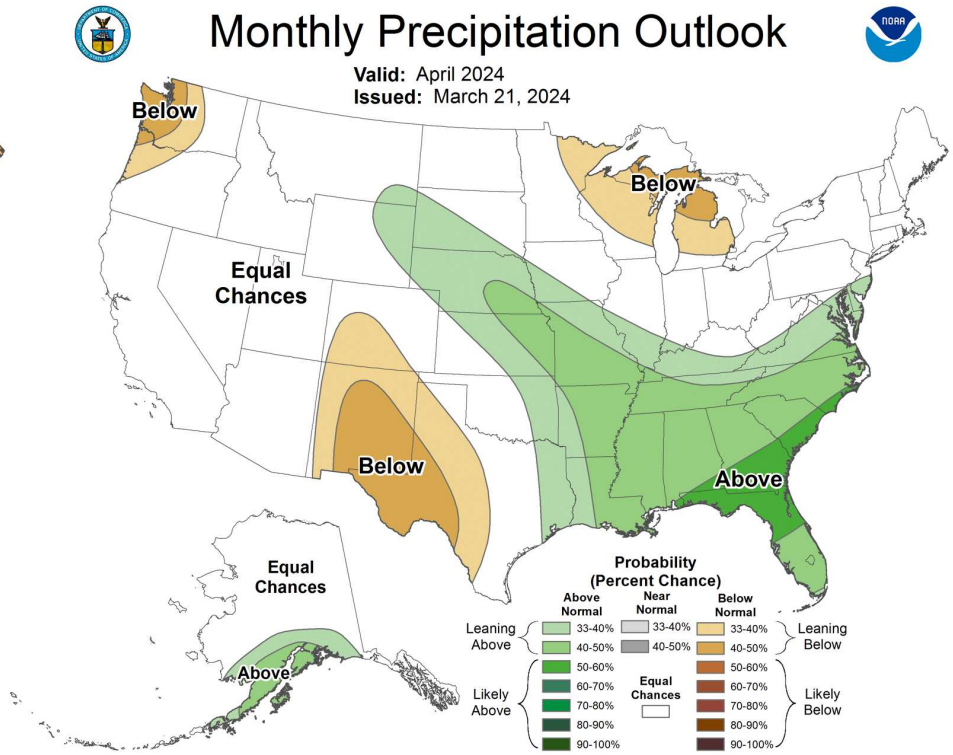

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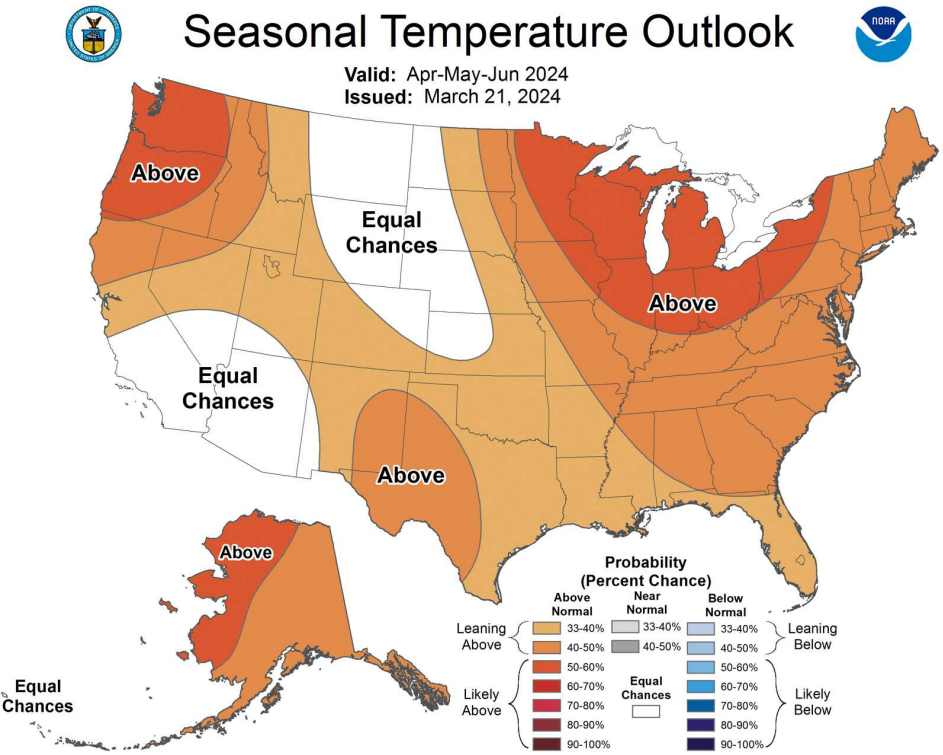

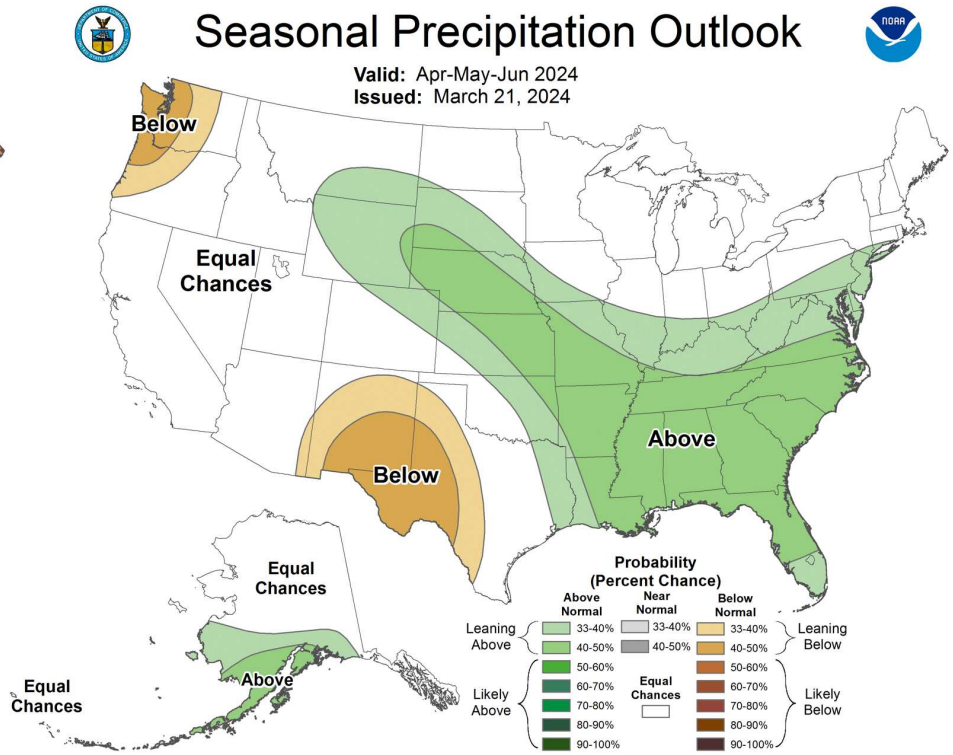

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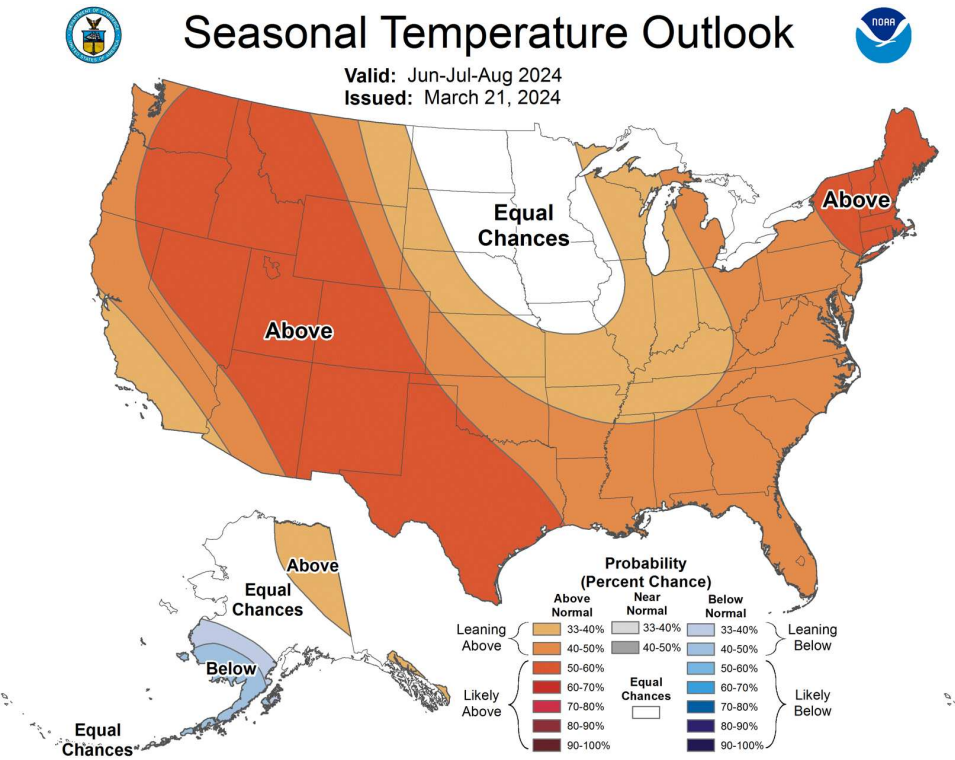

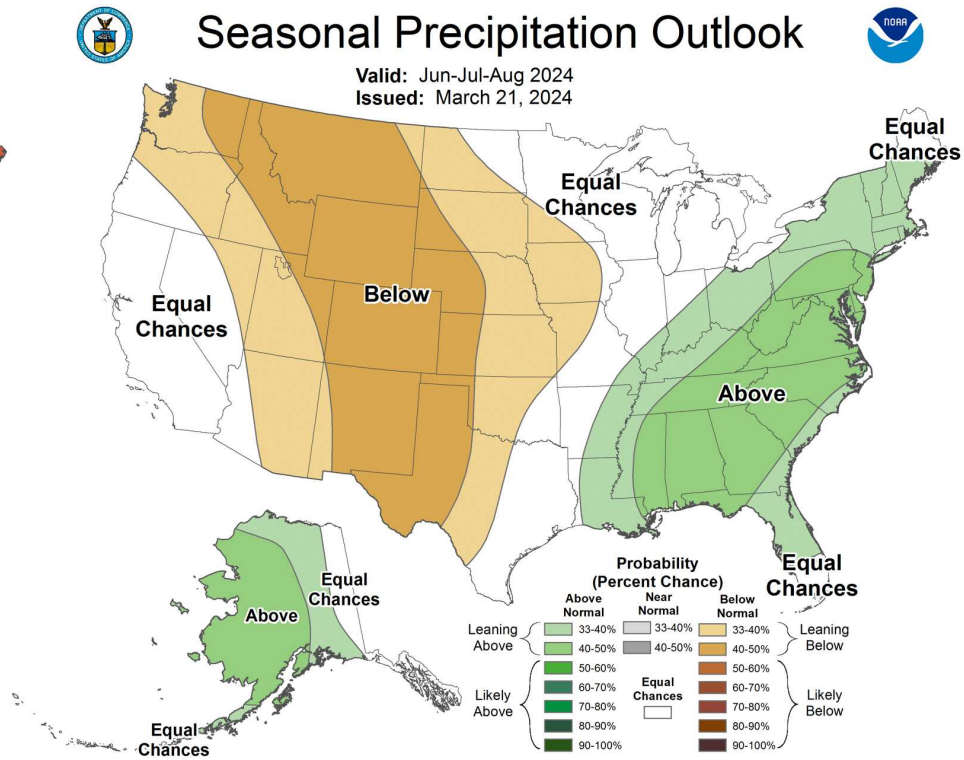

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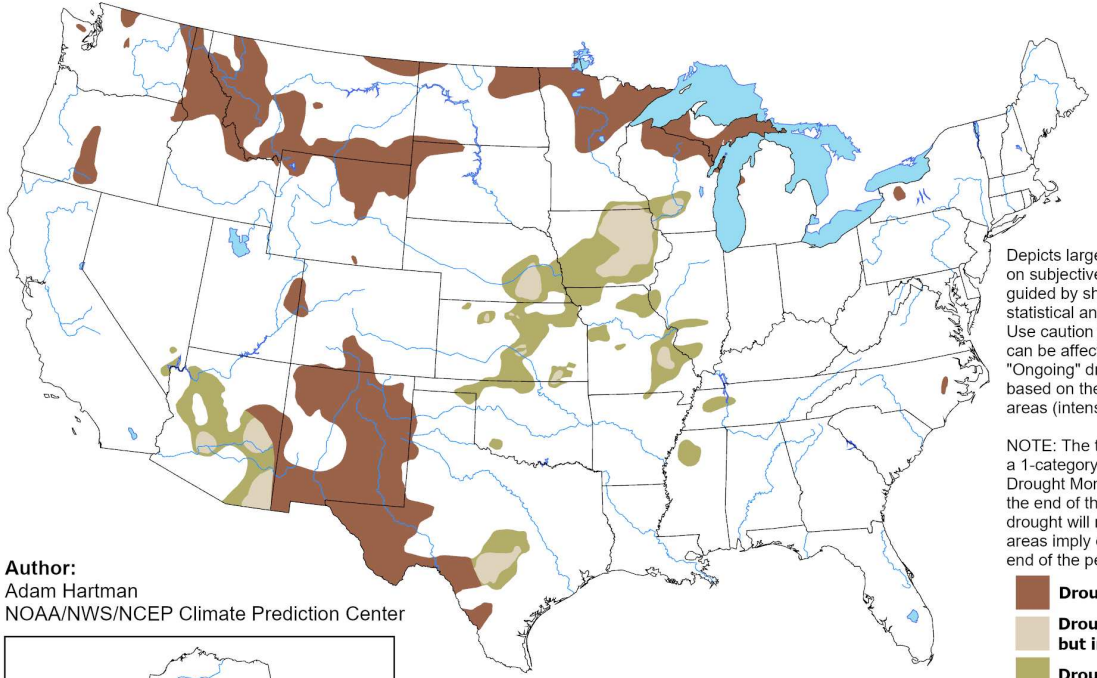
U.S. Monthly Drought Outlook

Drought Tendency During the Valid Period

Valid for April 2024
Released March 31, 2024

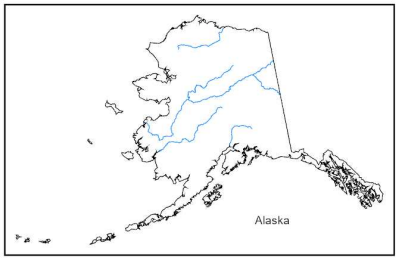


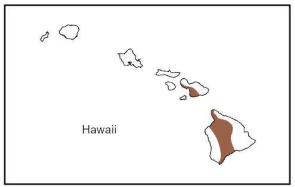
Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that can be affected by short lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor areas (intensities of D1 to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

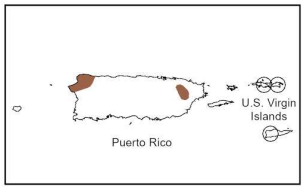
NOTE: The tan areas imply at least a 1-category improvement in the Drought Monitor intensity levels by the end of the period, although drought will remain. The green areas imply drought removal by the end of the period (D0 or none).

- **Drought persists**
- **Drought remains, but improves**
- **Drought removal likely**
- **Drought development likely**
- **No drought**

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





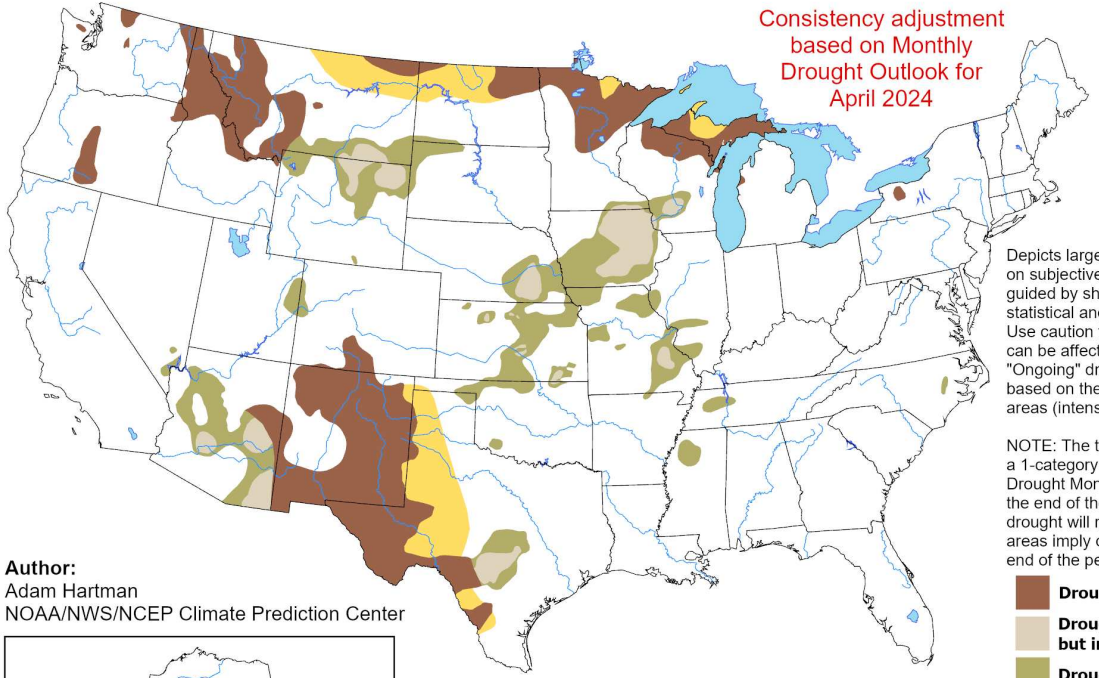


https://go.usa.gov/3eZGd

U.S. Seasonal Drought Outlook

Drought Tendency During the Valid Period

Valid for April 1 - June 30, 2024
Released March 31, 2024



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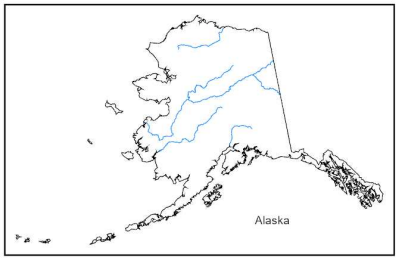
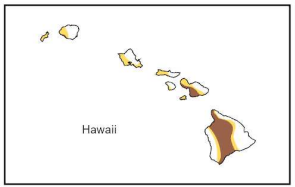
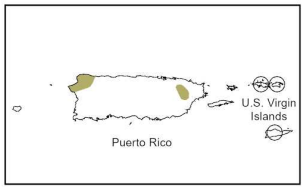






https://go.usa.gov/3eZ73

Game Plan

1. Observed trends and climate outlook
2. Risk in a changing climate
3. Tools for Assessing Climate Risk

nature COMMUNICATIONS

ARTICLE

https://doi.org/10.1038/s41467-022-30316-5 OPEN

Check for updates

Drought assessment has been outpaced by climate change: empirical arguments for a paradigm shift

Zachary H. Hoylman[1,2✉], R. Kyle Bocinsky[1,3] & Kelsey G. Jencso[1,2]

Despite the acceleration of climate change, erroneous assumptions of climate stationarity are still inculcated in the management of water resources in the United States (US). The US system for drought detection, which triggers billions of dollars in emergency resources, adheres to this assumption with preference towards 60-year (or longer) record lengths for drought characterization. Using observed data from 1,934 Global Historical Climate Network (GHCN) sites across the US, we show that conclusions based on long climate records can substantially bias assessment of drought severity. Bias emerges by assuming that conditions from the early and mid 20th century are as likely to occur in today's climate. Numerical simulations reveal that drought assessment error is relatively low with limited climatology lengths (~30 year) and that error increases with longer record lengths where climate is changing rapidly. We assert that non-stationarity in climate must be accounted for in contemporary assessments to more accurately portray present drought risk.

Under stationary assumptions, drought severity is exaggerated in locations that are experiencing aridification and underrepresented in locations that are getting wetter.

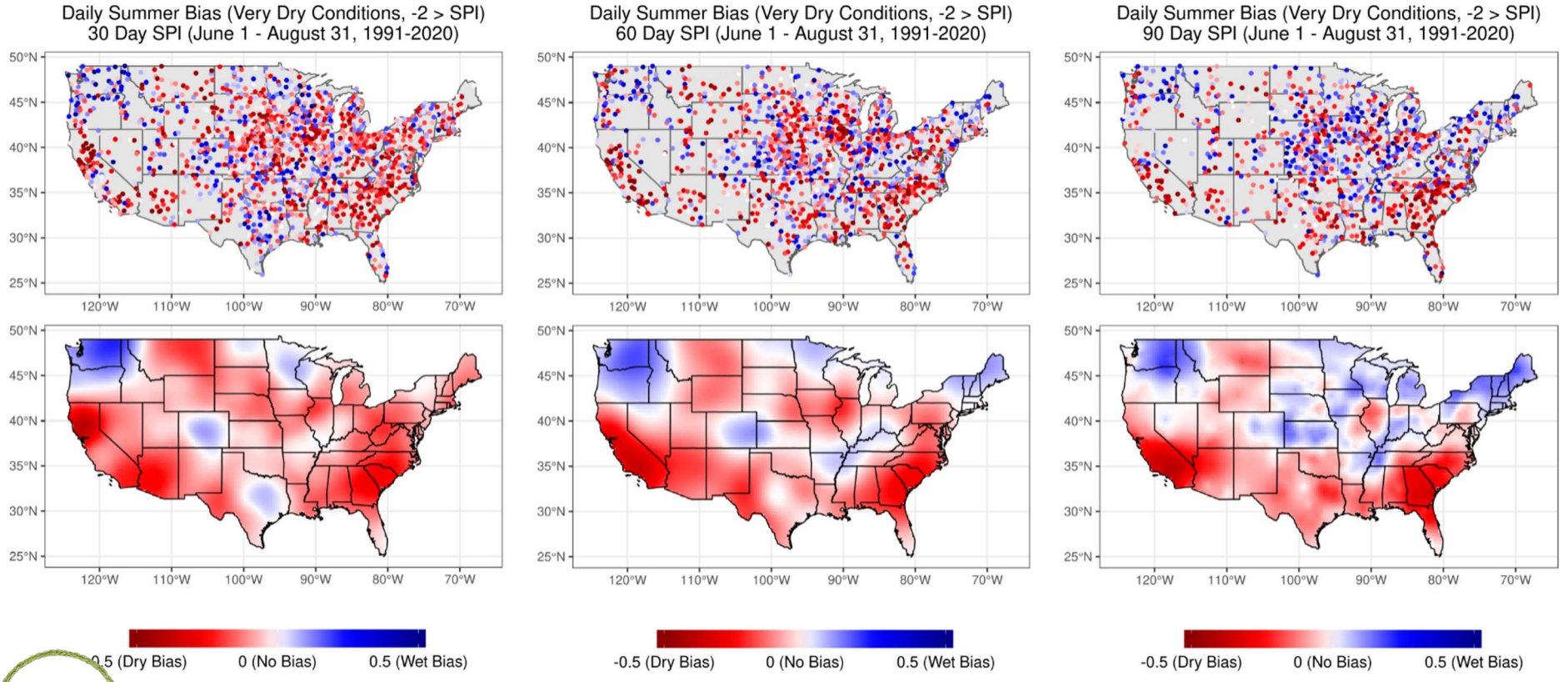
This concept applies to other metrics commonly used in drought assessment.

Shifting to 30-year drought climatologies achieves the following goals:

- Drought assessment better reflects present drought risk to affected communities;
- Greater standardization across datasets with differing periods of record;
- Better accounting for climate change into the future.

Patrick T. Fallon/Agence France-Presse — Getty Images

POR bias exceeds +/-1 class during severe drought



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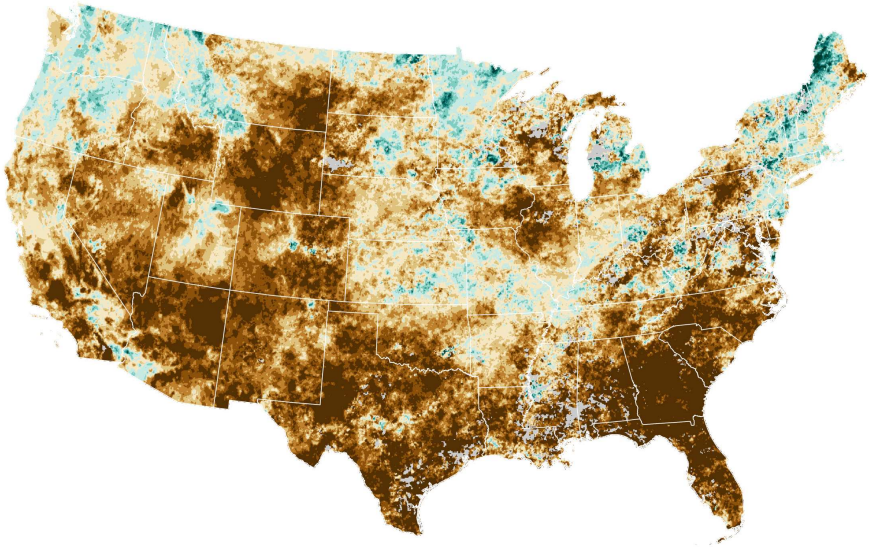
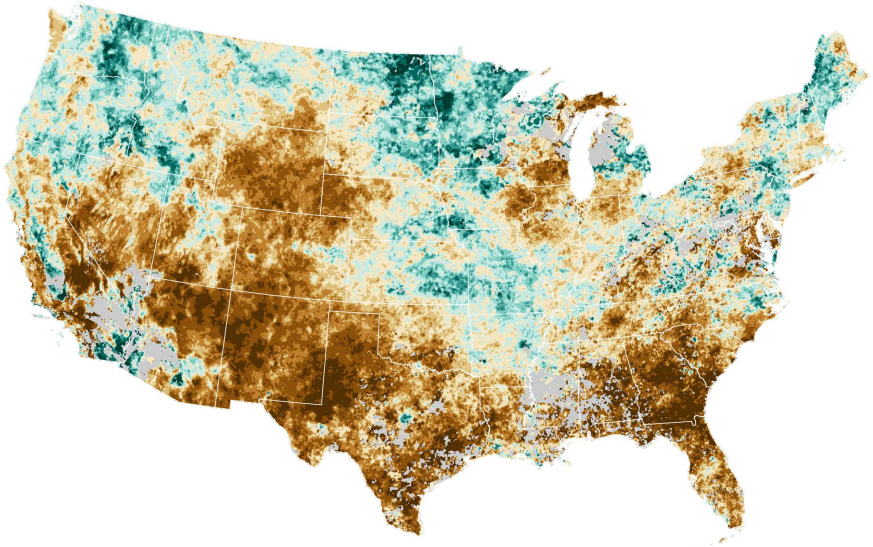
POR bias exceeds +/-1 class during severe drought

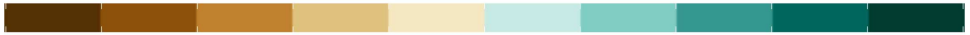
Precipitation only (SPI)



Precipitation and evaporation (SPEI)



Period-of-record bias during severe drought (>= D2), summer 2012–2021



1. **USDM declarations for severe drought (>= D2) align with century-scale climatologies**

Demonstrable bias against declaring drought in places that are getting wetter

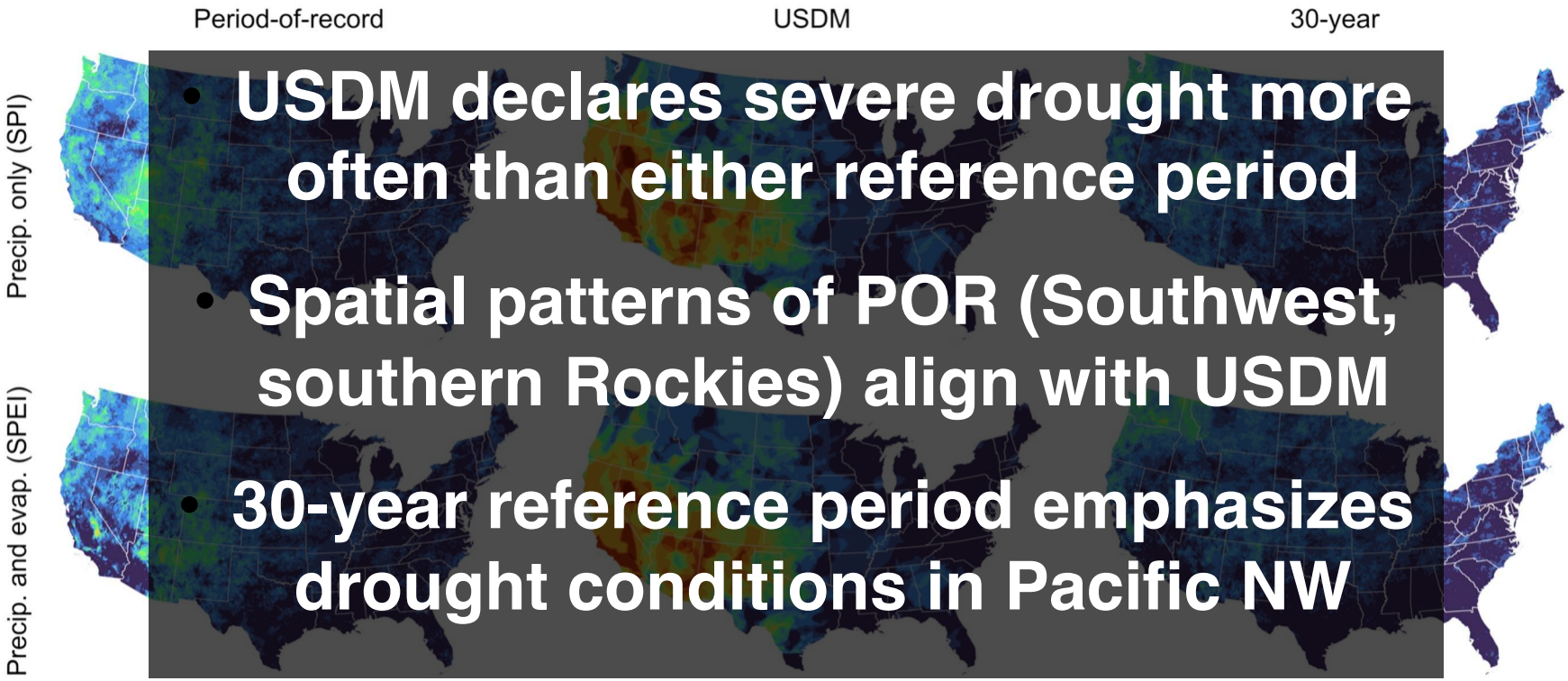
2. **“Nearly automatic” disaster relief triggered by the USDM primarily benefits aridifying regions**

Excess payments may be undermining adaptation

3. **Climate change scenarios suggest amplifying inequities in assistance**

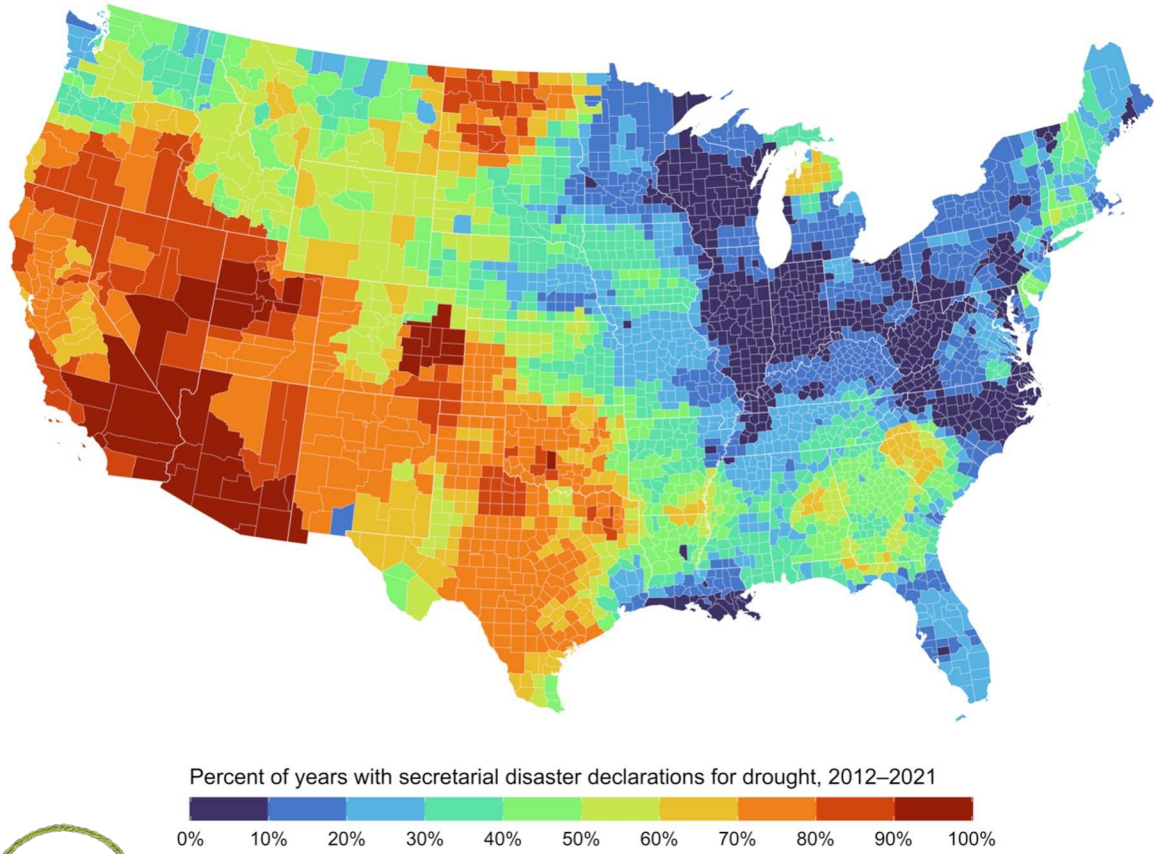
If the money is there to begin with…

Summertime severe drought declarations



- USDM declares severe drought more often than either reference period
- Spatial patterns of POR (Southwest, southern Rockies) align with USDM
- 30-year reference period emphasizes drought conditions in Pacific NW

USDM triggers disaster declarations and relief

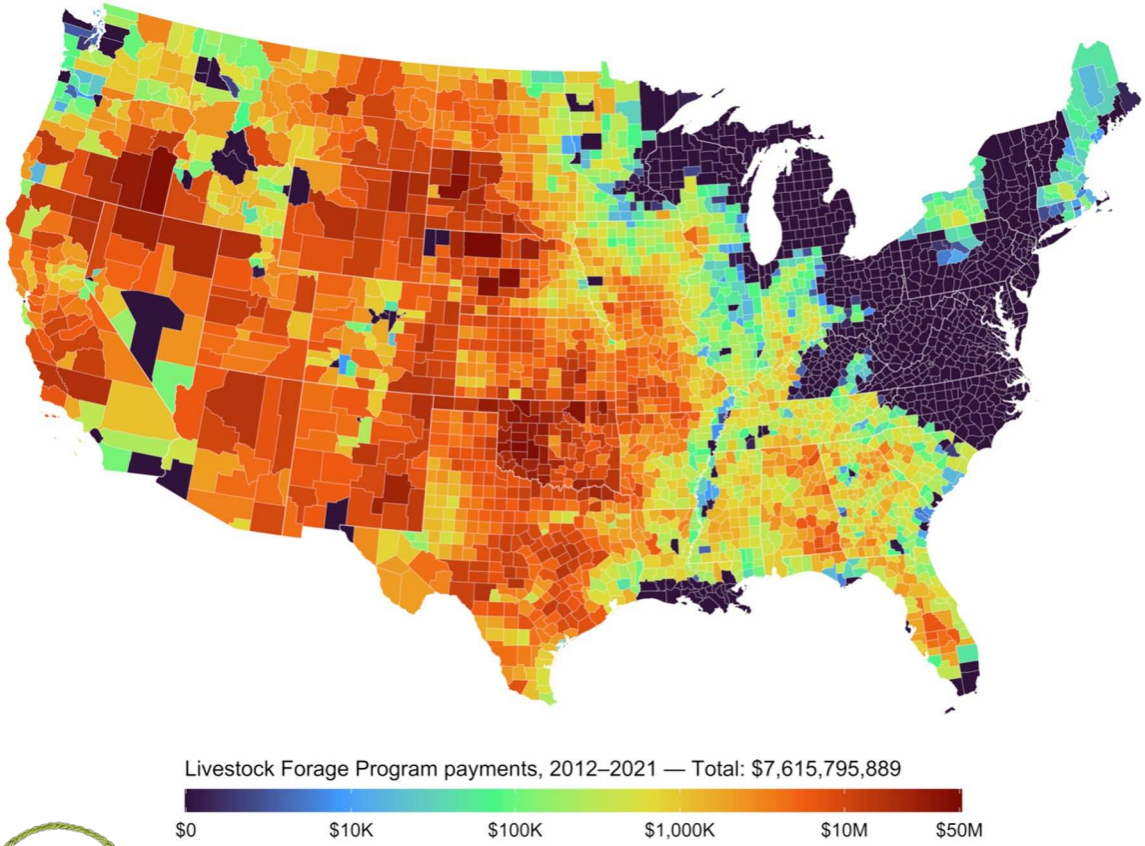


USDA Secretarial Drought Disasters

"Fast Track" Secretarial disaster designations for severe drought provide for a **nearly automatic designation** when, during the growing season, any portion of a county meets the D2 (Severe Drought) drought intensity value for eight consecutive weeks or a higher drought intensity value for any length of time as reported in the U.S. Drought Monitor.

7 CFR § 759.5 - Secretarial disaster area determination and notification process

USDM triggers disaster declarations and relief



Livestock Forage Program Eligibility Criteria

1 monthly payment:
D2 (severe drought) for at least eight consecutive weeks

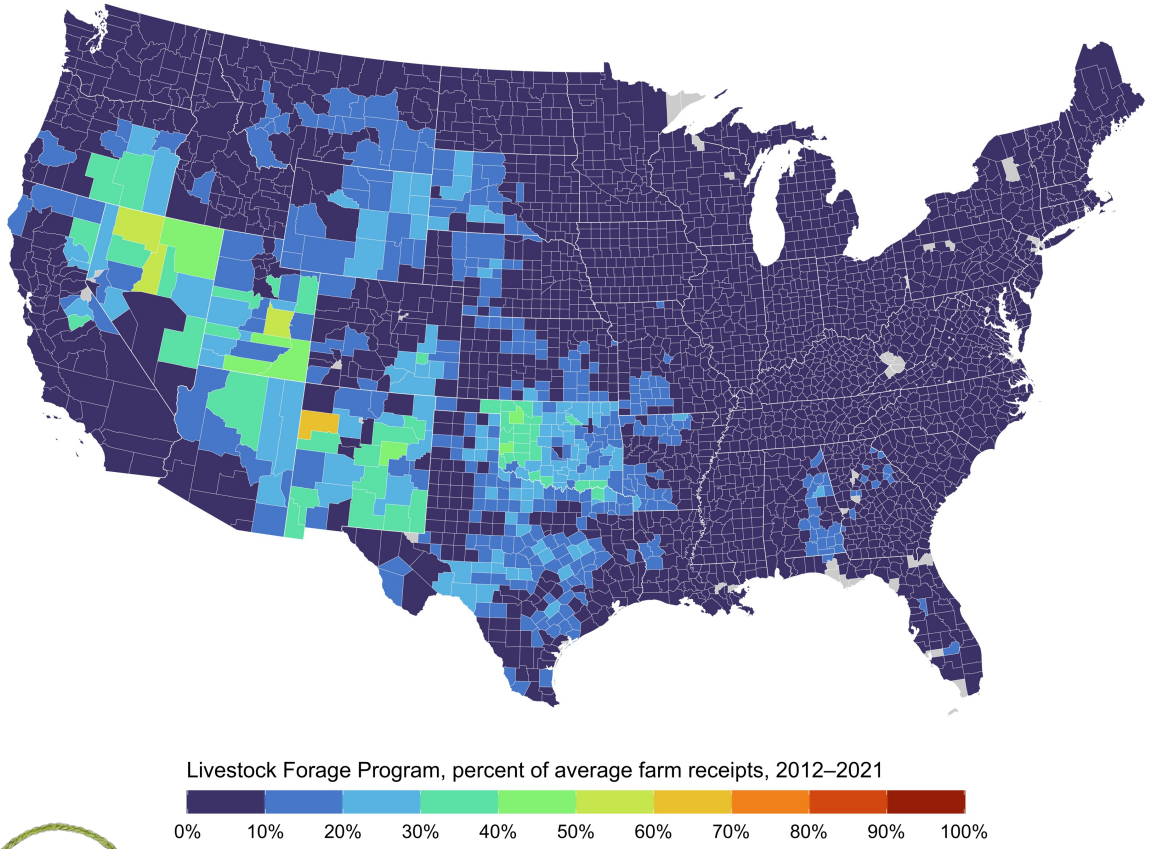
3 monthly payments:
D3 (extreme drought) at any time

4 monthly payments:
D3 (extreme drought) for at least four consecutive weeks or D4 (exceptional drought) intensity at any time

5 monthly payments:
D4 (exceptional drought) for any four weeks

7 CFR § 1416.205 - Eligible grazing losses

USDM triggers disaster declarations and relief



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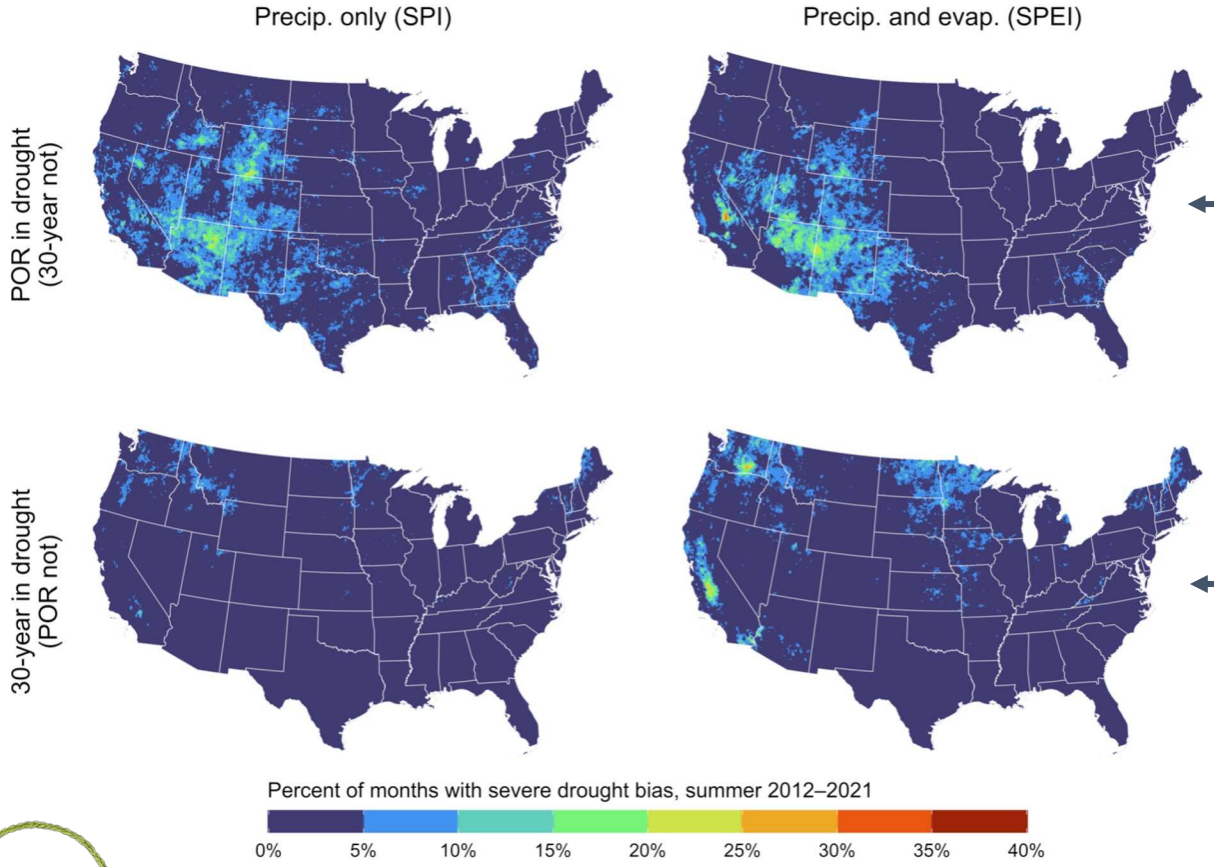
Drought bias affects disaster declarations and relief

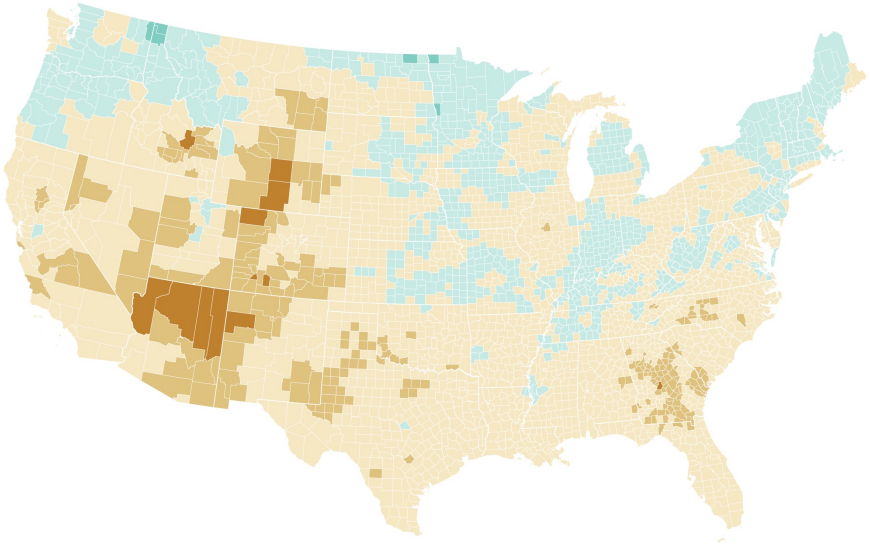


Regions where aridification is occurring and climate adaptation needed most.

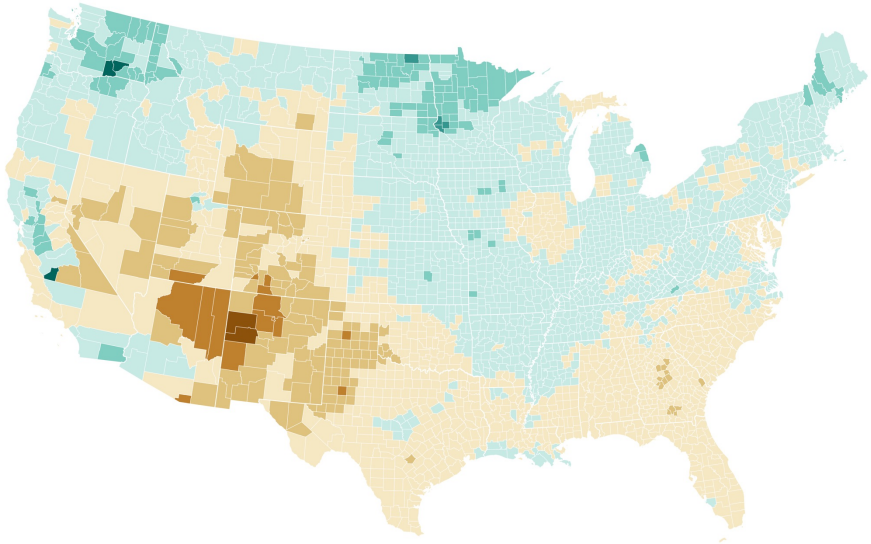
Climate patterns are shifting here too, leading to an under-assessment of drought conditions.

Drought bias affects disaster declarations and relief

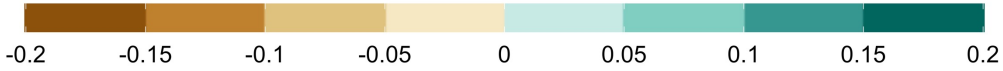
Precipitation only (SPI)



Precipitation and evaporation (SPEI)



Drought non-stationarity correction, summer 2012–2021

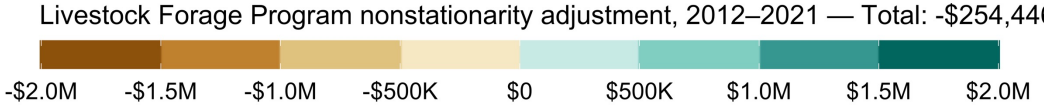


Drought bias affects disaster declarations and relief

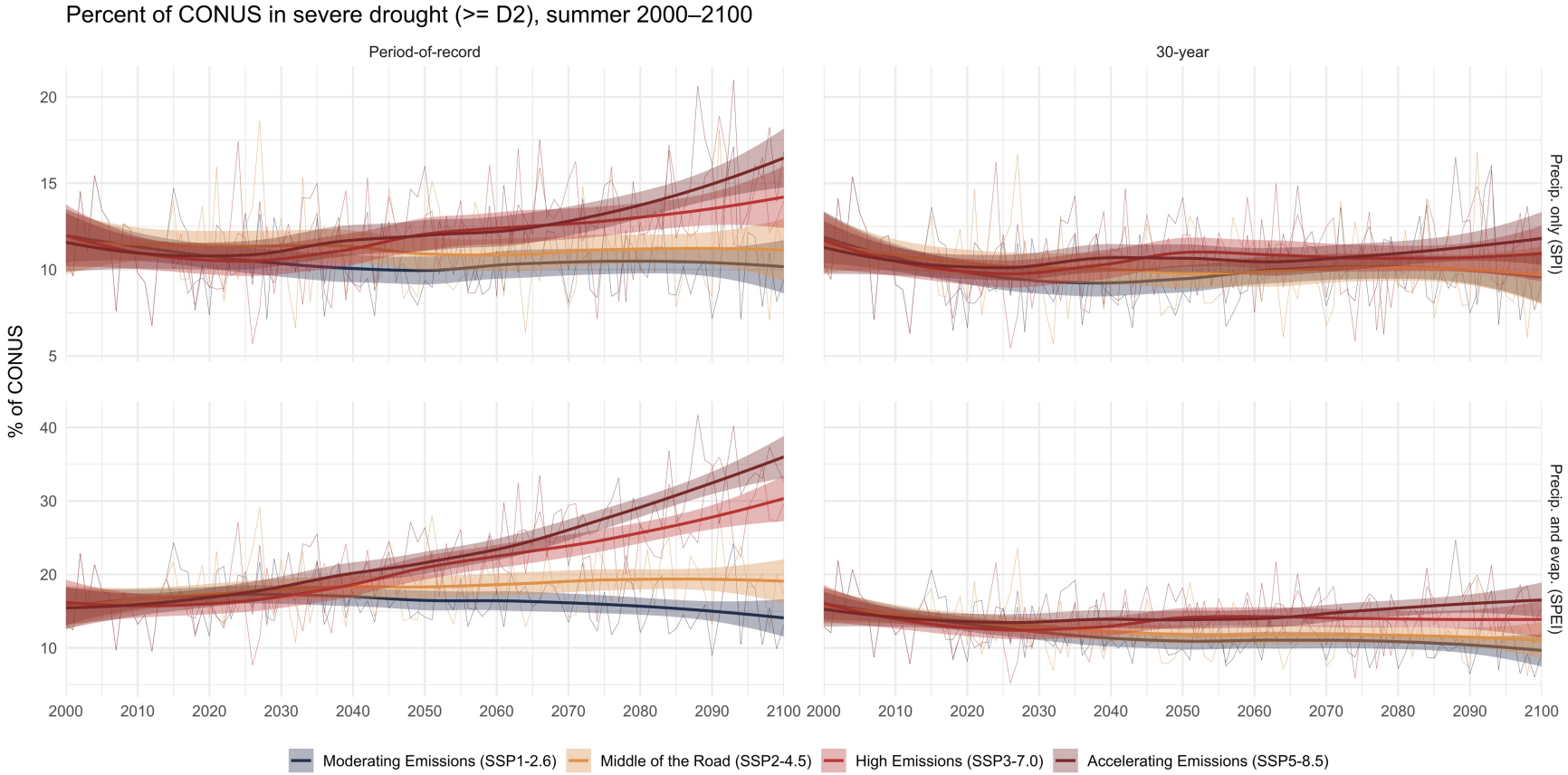
Precipitation only (SPI)

Precipitation and evaporation (SPEI)

Under a 30-year reference period, drought relief would have been distributed differently, and would have been substantially less costly.



POR-based drought relief



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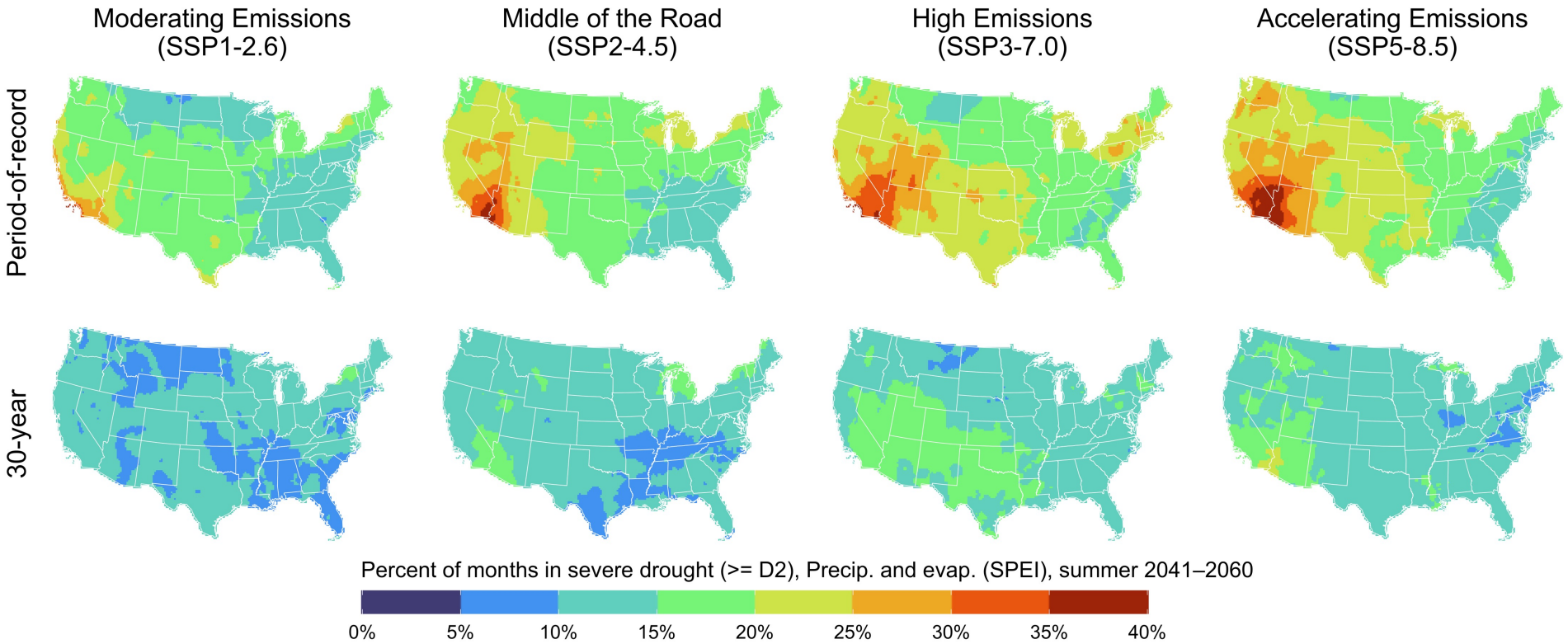
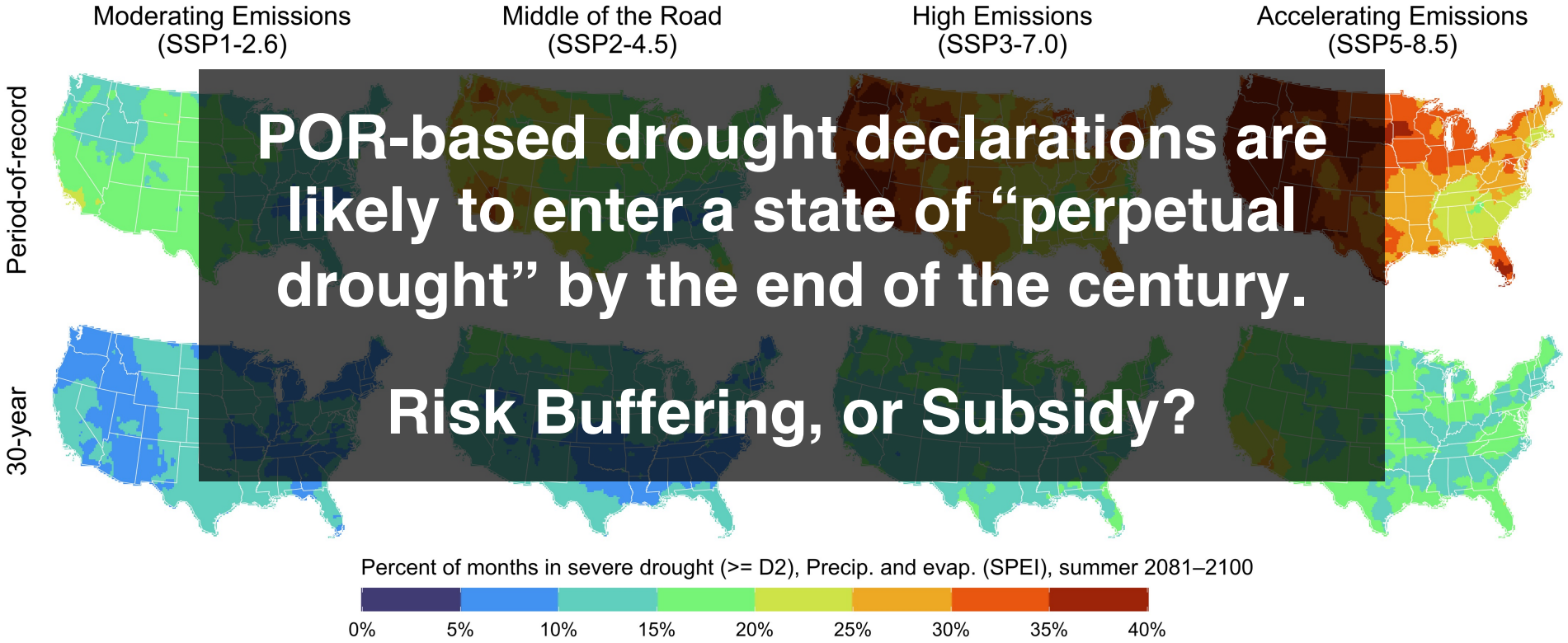


POR-based drought relief



Recommendations for drought monitoring

1. Begin the transition to standard, regularly updated reference periods (climatologies).

2. Develop sector-specific drought assessments that align with adaptive capacity.

3. Engage more fully with climate projections in order to inform drought adaptation efforts.

Recommendations for policymakers

1. **Ensure that [drought] relief programs are responding to contemporary risk.**

2. **Support drought monitoring as a tool for both risk assessment and climate adaptation.**

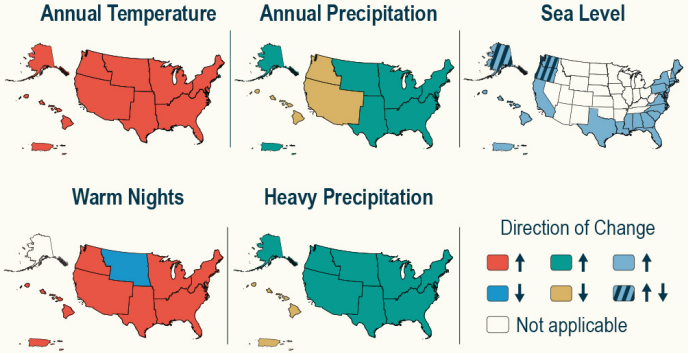
3. **Target adaptation in those places and sectors that are experiencing the greatest change.**

Game Plan

1. Observed trends and climate outlook
2. Risk in a changing climate
3. Tools for Assessing Climate Risk

Climate Change Risks and Opportunities in the US

Climate change is happening now in all regions of the US

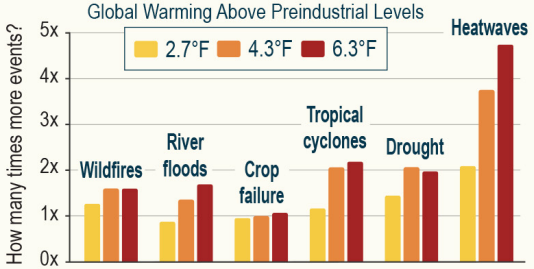


Each additional increment of warming leads to greater risks

- Water supply
- Food security
- Infrastructure
- Health and well-being
- Ecosystems
- Economy
- Livelihoods and heritage

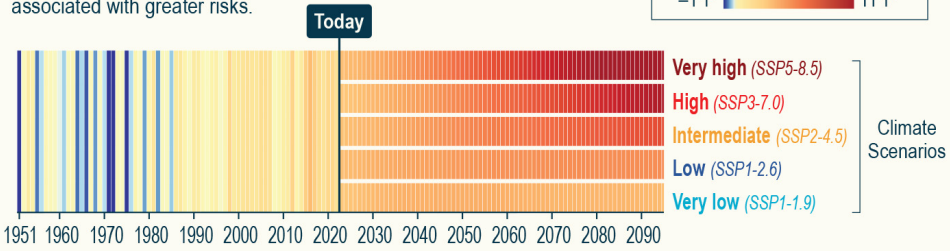
Without deeper cuts in global net emissions, climate risks to the US will continue to grow

- A person born in North America in 2020 will experience more climate hazards during their lifetime, on average, than a person born in 1965.



How much more the US warms depends on choices made today

- Future global greenhouse gas emissions from human activities determine whether and how quickly the US reaches warming levels associated with greater risks.



Action to limit future warming and reduce risks can have near-term benefits and opportunities

- Low-carbon energy jobs
- Improved air quality
- Health benefits
- Economic benefits
- Reduced risks to ecosystems
- Reduced risks to biodiversity
- More options for adaptation
- Social benefits

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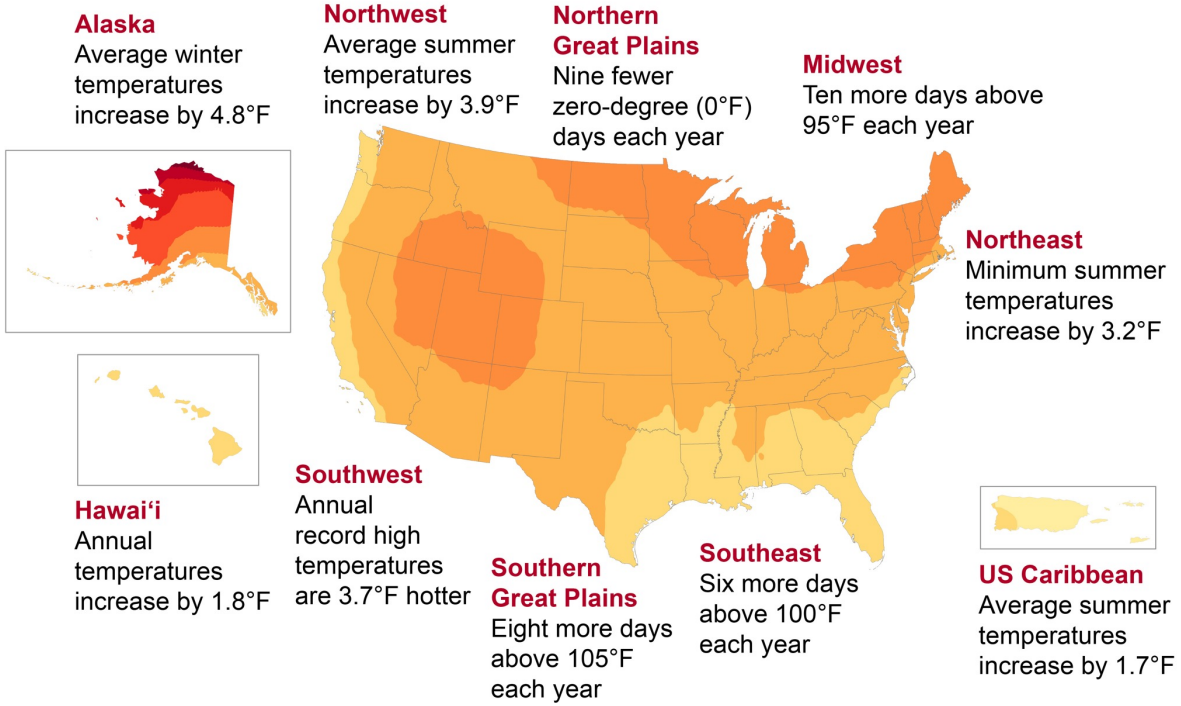
Agriculture Risk in a Changing World

Kyle Bocinsky, Montana Climate Office

2024 ERME National Conference, Salt Lake City, UT — April 9, 2024

Projected Changes at 3.6°F (2.0°C) of Global Warming



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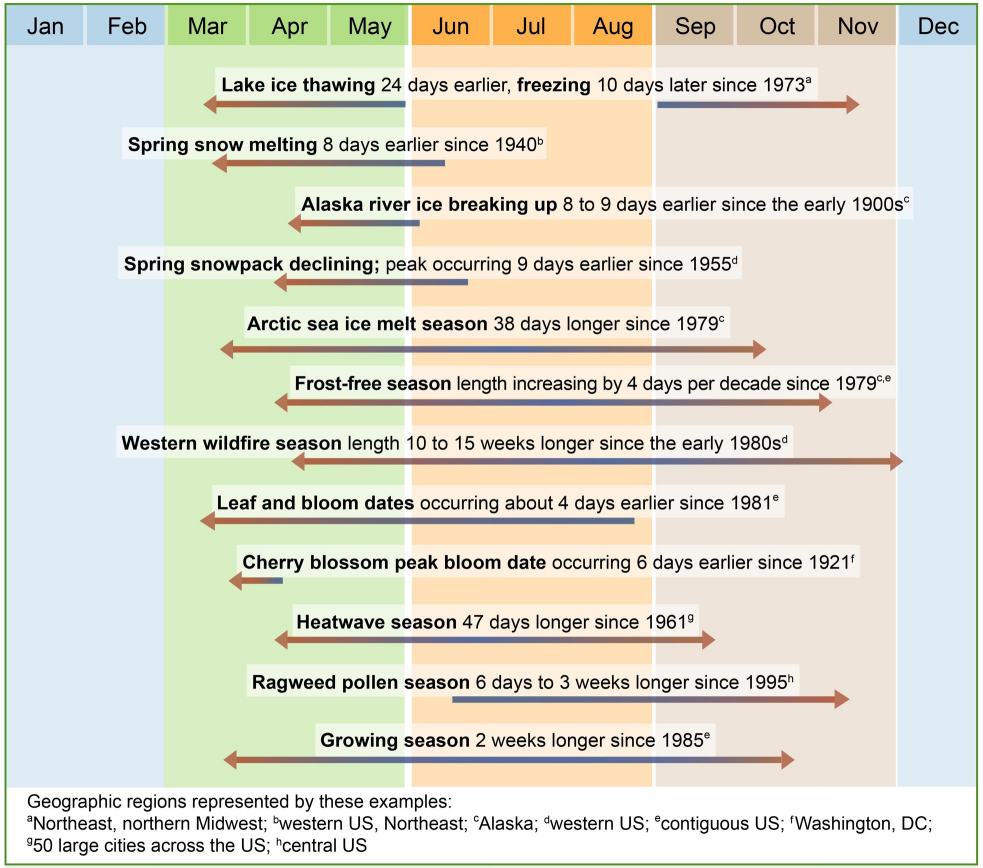
Changes in Seasonality



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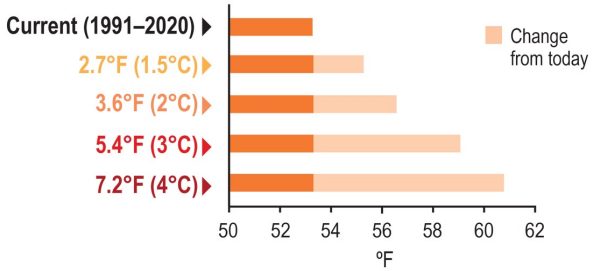
Consequences are Greater at Higher Global Warming Levels

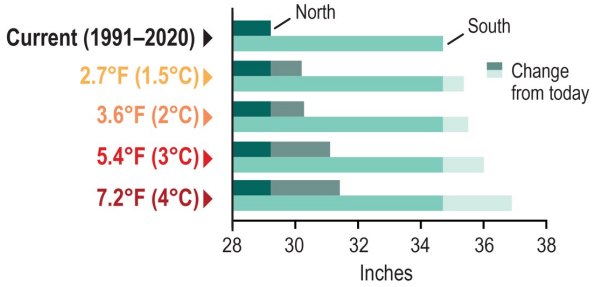
US average temperature

The US warms more than the global average compared to the preindustrial period



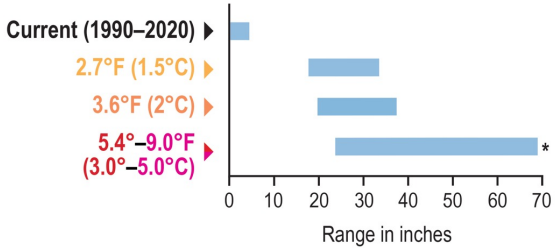
Annual average rainfall

Annual average rainfall totals increase rapidly in the North, more slowly in the South.



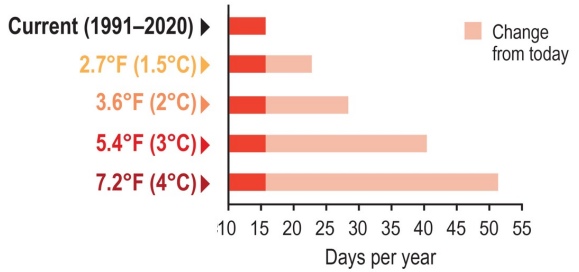
US average sea level rise

Sea level rise (by 2100 compared to 2020) is higher for higher warming levels.



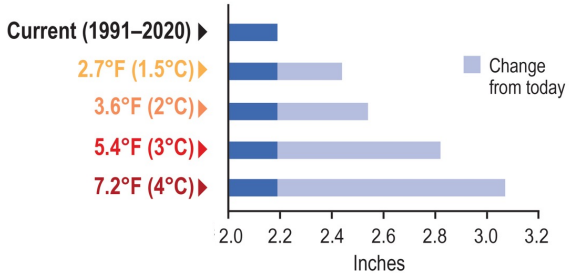
Number of days ≥ 95°F

The number of very hot days (95°F or hotter) increases.



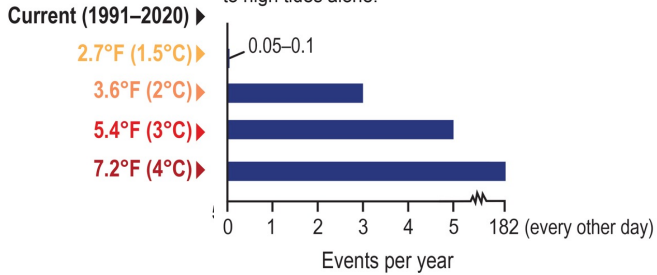
Extreme precipitation events

More rain falls during the most extreme precipitation events.



Coastal flooding events

Sea level rise drives an increase in the number of major coastal flooding events per year due to high tides alone.



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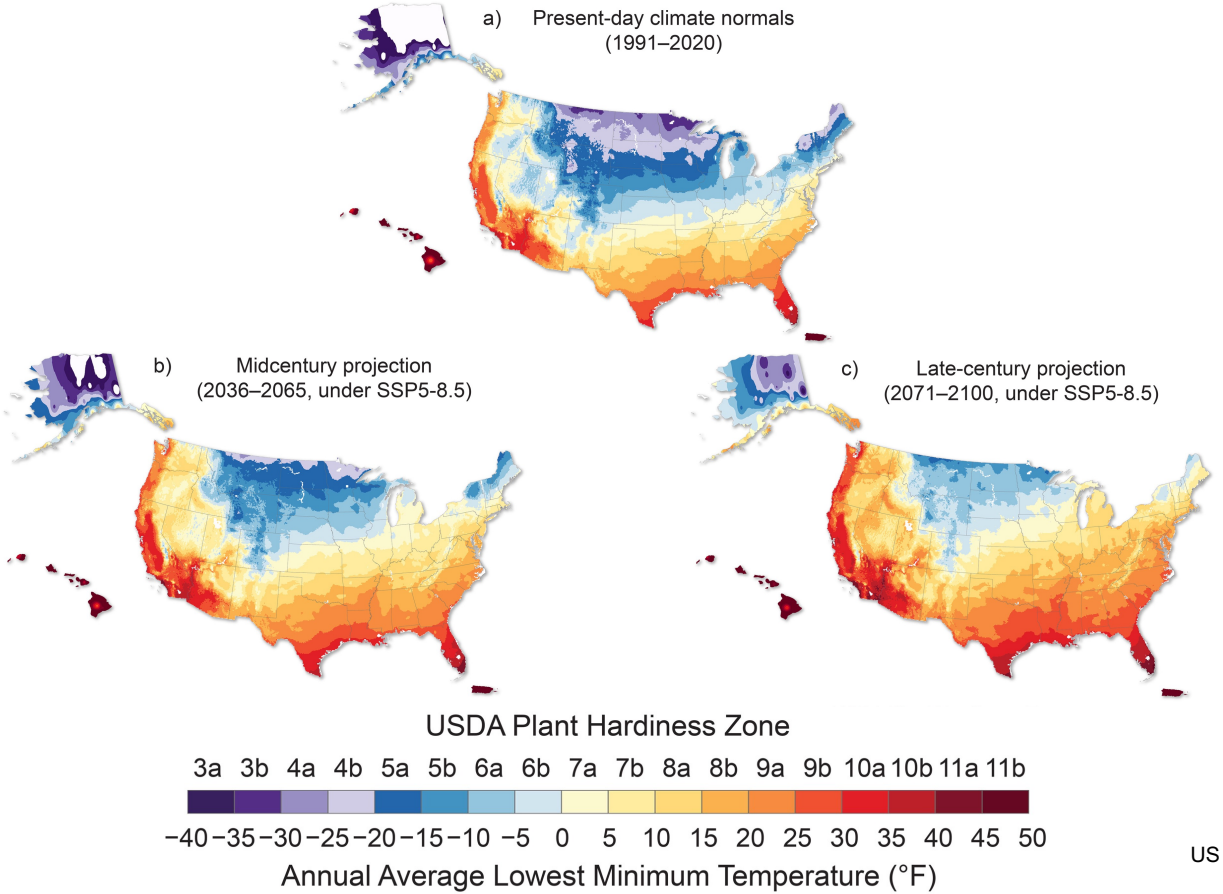
Projected Changes in Plant Hardiness Zones



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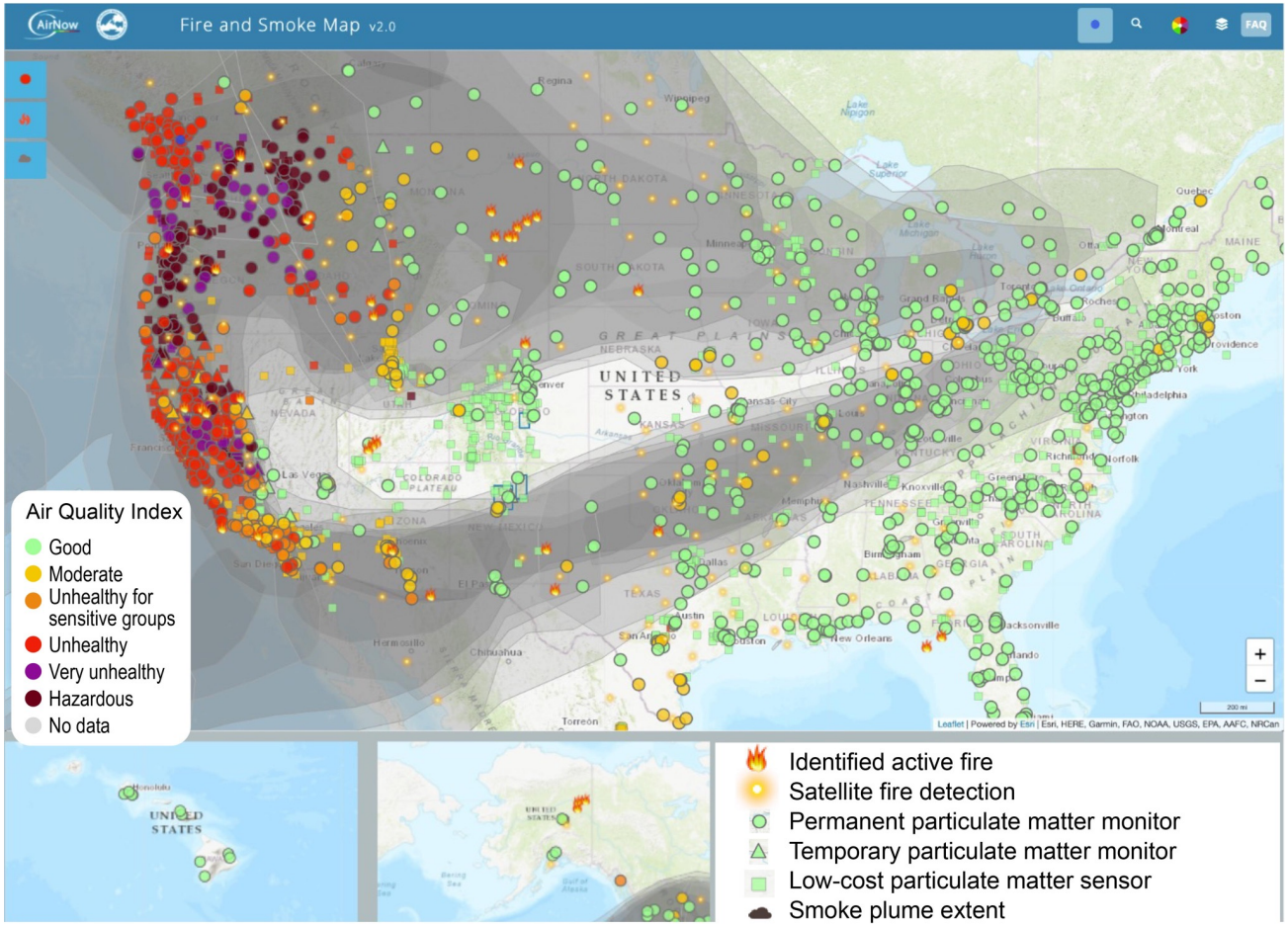
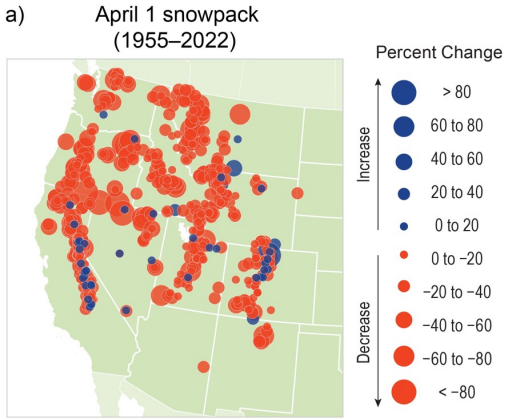
Impacts of Wildfire Smoke on Air Quality



Snowpack Changes in the West



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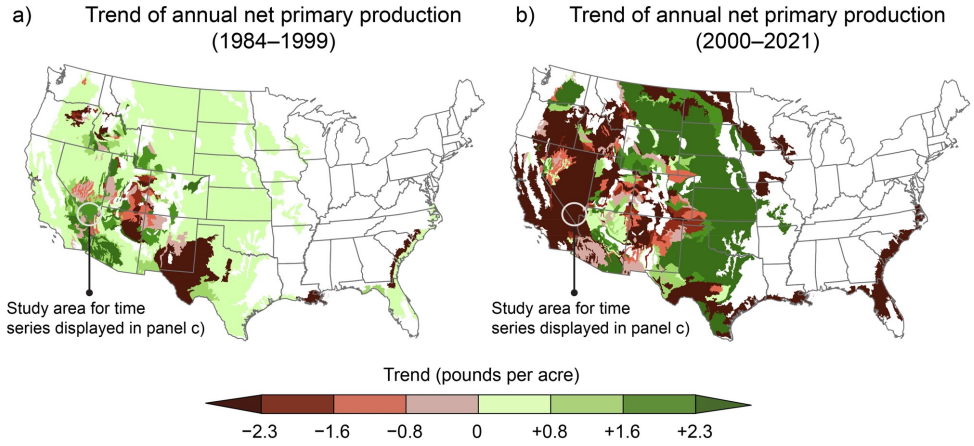
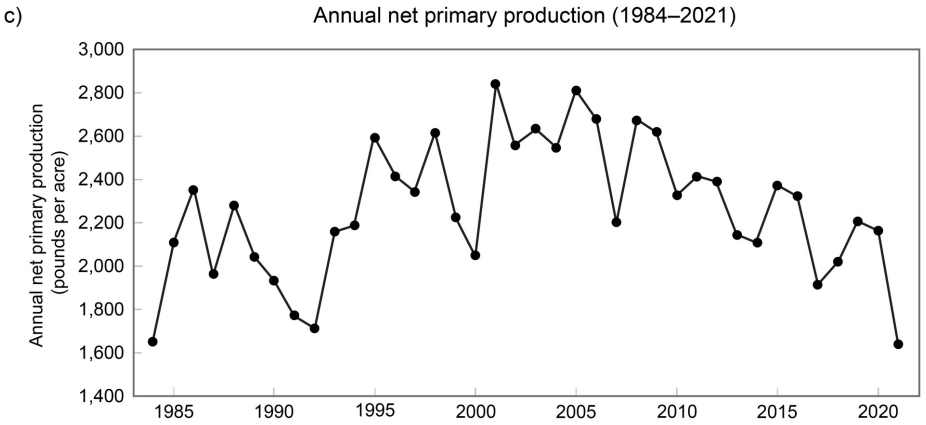
Rangeland Production





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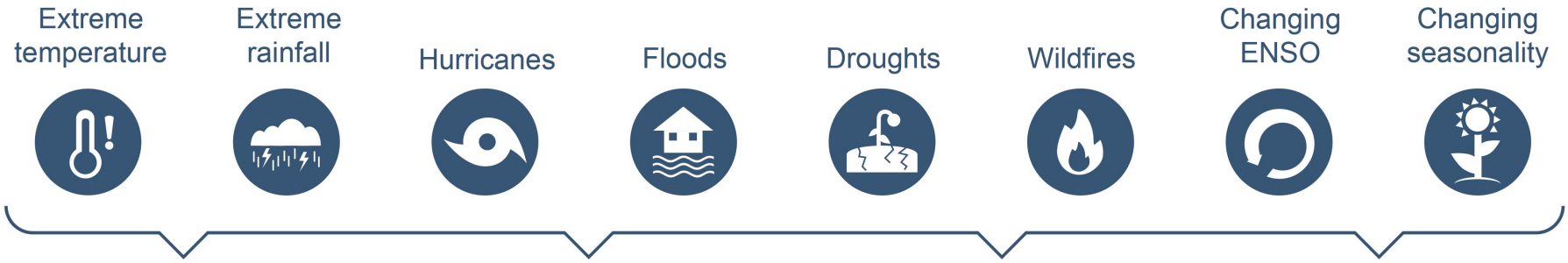
Example Effects of Climate Change on the Food Supply Chain



Production	Storage, processing, and distribution	Retail and markets	Consumption
Irrigation	Electricity access	Infrastructure	Seasonal food availability
Crop health and selection	Storage capacity, quality, and safety	Market and supplier access	Food accessibility, cost, and usability
Water quality	Import/export restrictions	Product supply and demand	Nutritional content
Worker health and safety	Labor supply	Product cost	Consumer preferences, choices, and means
Input supplies and prices	Transport networks and fuel prices	Product waste	
Output yields and quality			

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Compound Events

a) Temporal compounding of events in 2020 and 2021

b) Spatially compounding climate-related disasters: September 15, 2020

Large wildfires across Oregon, Washington, and California damage homes and infrastructure. Wildfire smoke in western states causes weeks of bad air quality across the West.

Hurricane Sally, the 18th-named Atlantic storm of 2020, is about to make landfall. It brings widespread flooding, infrastructure damage, and power outages to Louisiana, Alabama, and Florida.

Drought · Wildfire · Extreme heat · Extreme thunderstorms · Wind · Marine life

Hot sea surface temperature · Atmospheric river · Hurricane · COVID-19

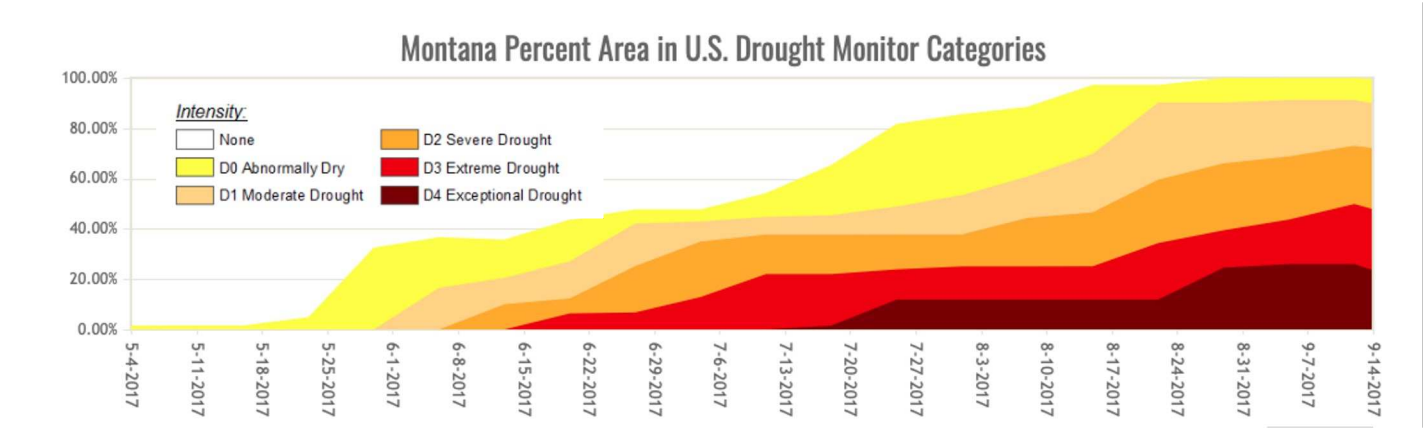
Nationwide

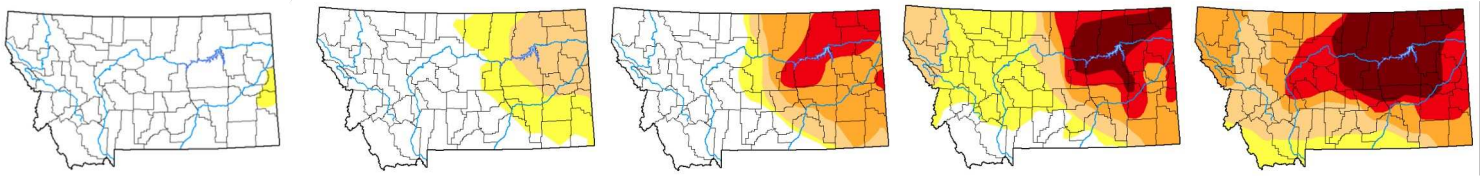
The COVID-19 pandemic limits access to, and the response capacity of, hospitals, cooling centers, and evacuation centers.

2020 Aug Sep Oct Nov Dec 2021 Jun Jul Aug Sep Oct Nov Dec

Fifth National Climate Assessment
US Global Change Research Program
nca2023.globalchange.gov

Recent Extremes: Flash Drought

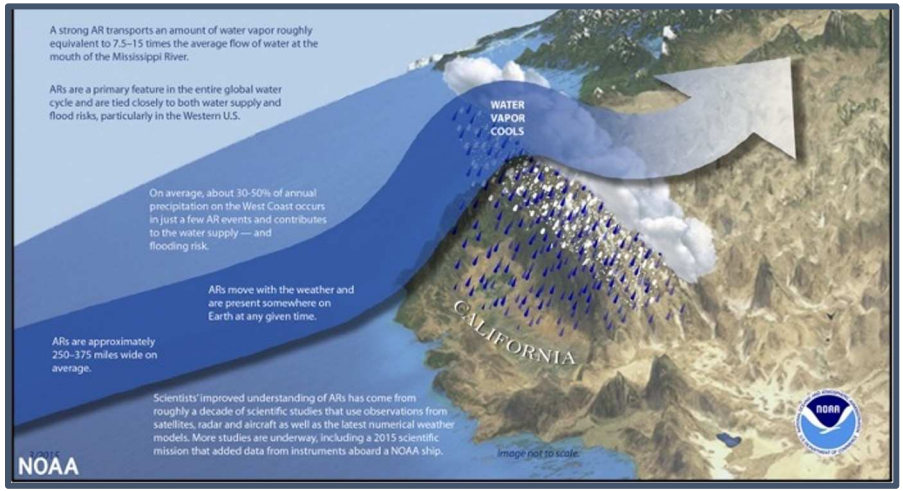




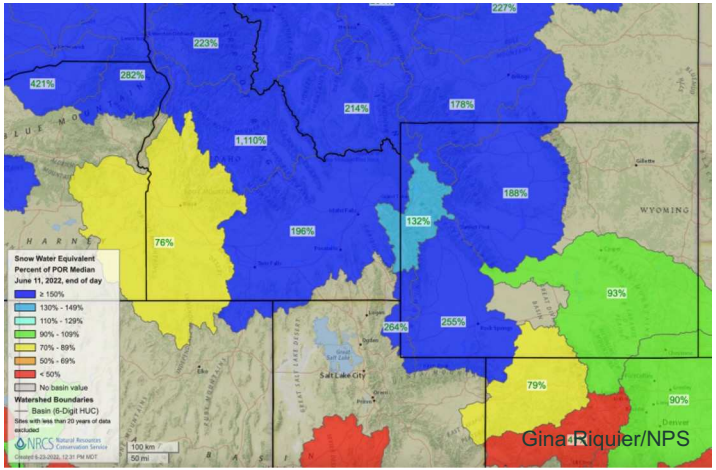
- Warm May and June temperatures and record low rainfall contributed to a **rapid dry-down across the state**
- **Impacts:** 1.4 million acres burned, poor air quality, loss of crops and livestock, decreases in tourism and recreation, **$2.6B in ag. losses across US N. Plains**

Recent Extremes: Atmospheric Rivers, Snowpack and Flooding

Atmospheric Rivers



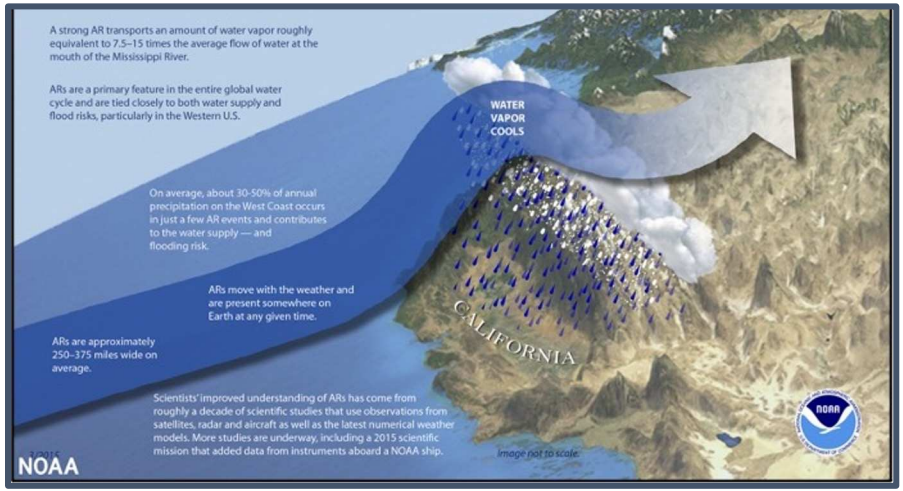
Atmospheric River + Delayed Snowmelt



- Storm system of warm and extremely wet air that originates from the tropical pacific.
- One atmospheric river can transport as much water as 7–15x the Mississippi!

Recent Extremes: Atmospheric Rivers, Snowpack and Flooding

Atmospheric Rivers



- Storm system of warm and extremely wet air that originates from the tropical pacific.
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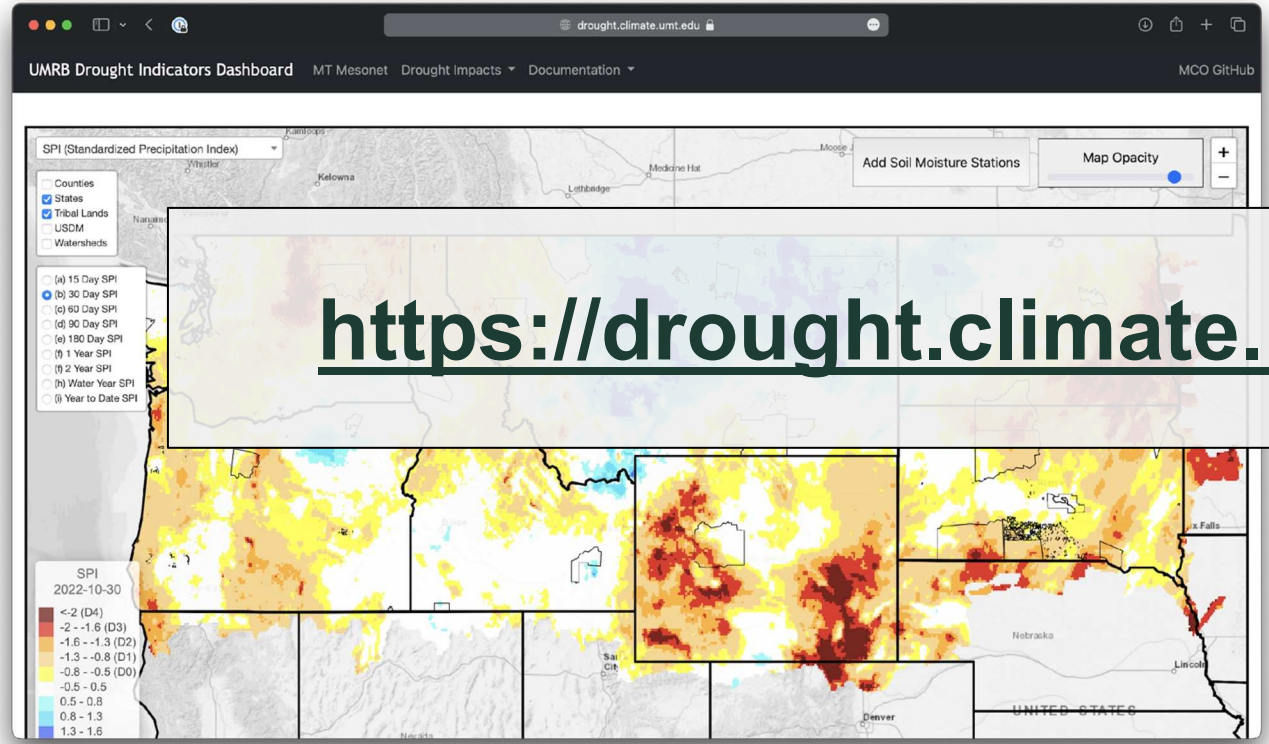
Atmospheric River + Delayed Snowmelt

- Yellowstone: On June 10–13th a category 5 atmospheric river dropped 2–4 inches of rain on melting snowpack.
- 1 in 500-year flood event!

Drought Monitoring & Indicators Dashboard



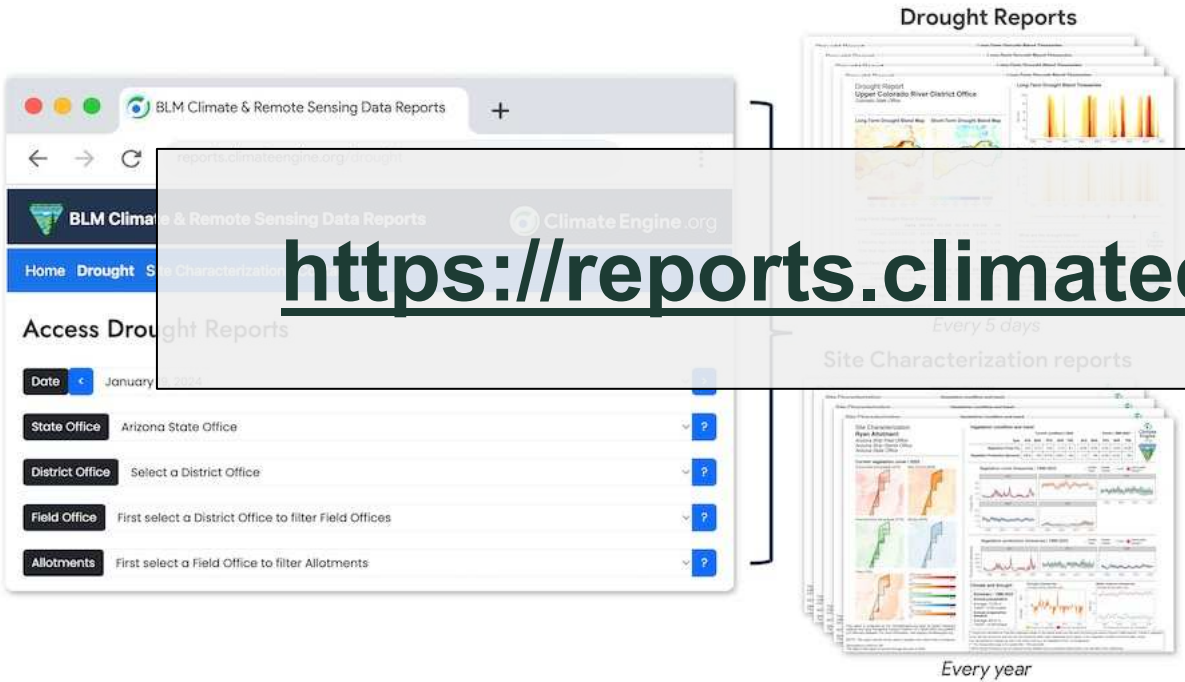
https://drought.climate.umt.edu

Operational drought models

- Daily to weekly
- 30m – 1km resolution
- Local validation via MT Mesonet

These data form the basis for objective assessment by the monitoring committee and making our case to the USDM

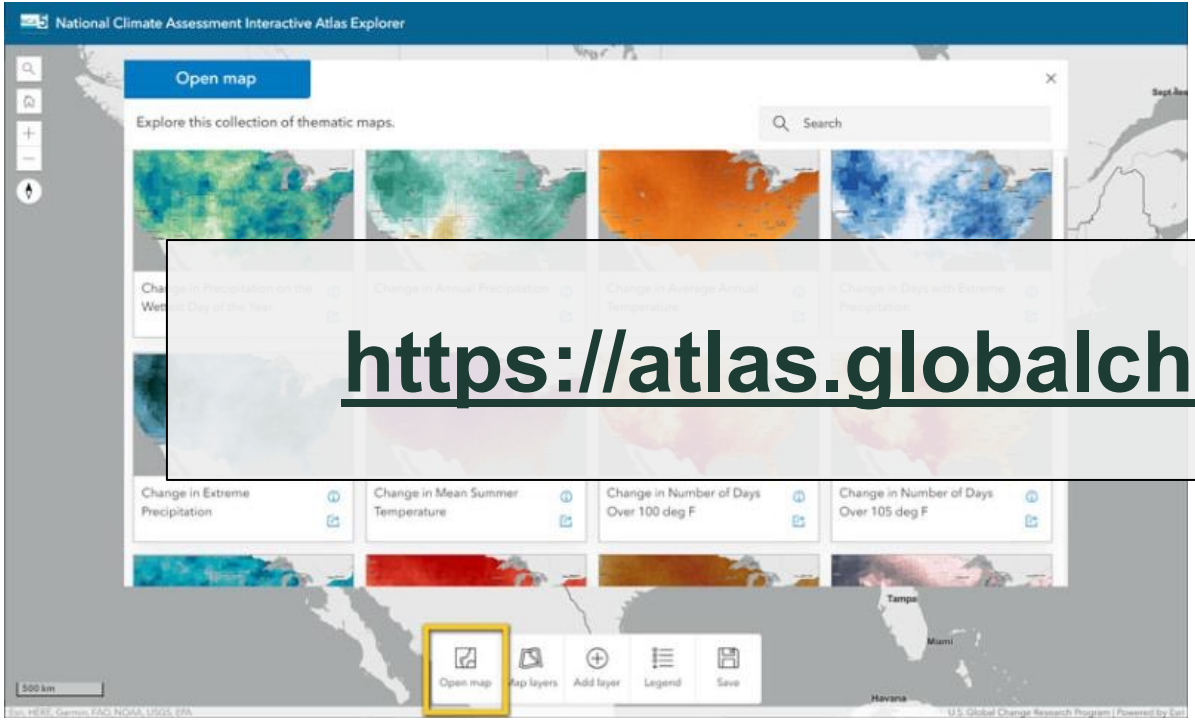
BLM Climate and Remote Sensing Data



- Scalable drought summaries
- Near real-time vegetation conditions
- Weekly drought reports
- Annual Site Characterization

https://reports.climateengine.org

5th National Climate Assessment Atlas



- Climate trends and impacts
- Explore Climate Maps from the Assessment
- StoryMap about Climate Impacts
- Download data from NCA5

https://atlas.globalchange.gov

Questions?

kyle.bocinsky@umontana.edu

EMRE Climate Workshop Survey 2

What weather/climate resources are most useful and trusted by Extension educators and your communities and what else do you need?

URL: https://tinyurl.com/kmyye4v5