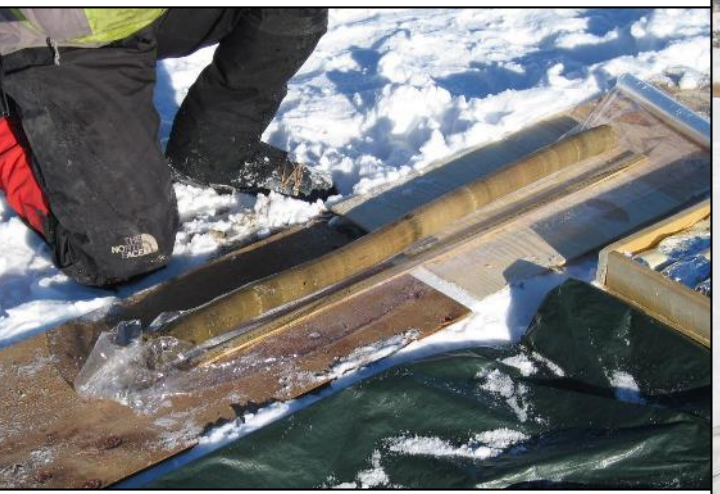
Changing Climate and Water: Montana & the Greater Yellowstone Ecosystem

Cathy Whitlock (MSU)
Steve Hostetler (USGS)

Montana Institute on Ecosystems

PALEOCLIMATE INFO IN GYE



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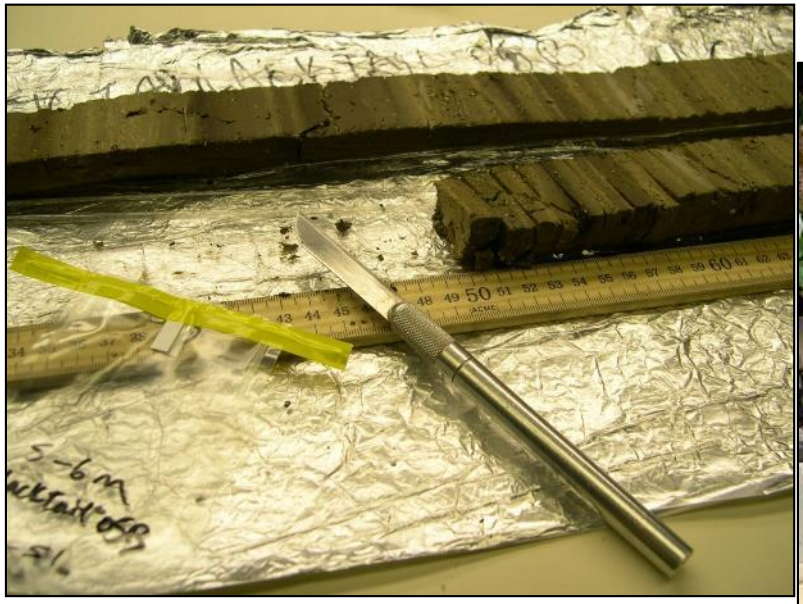

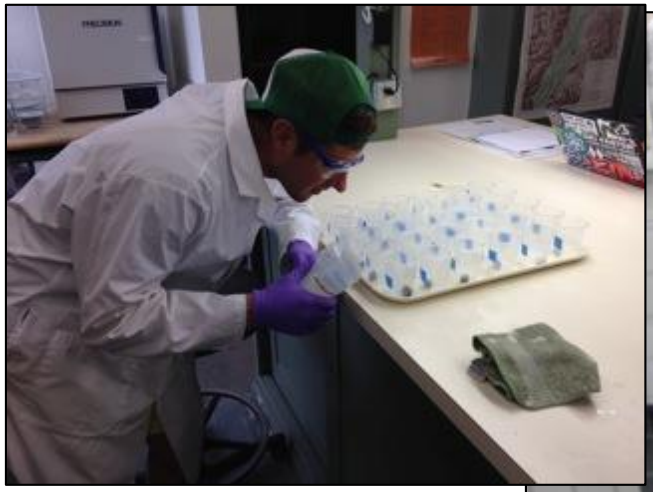

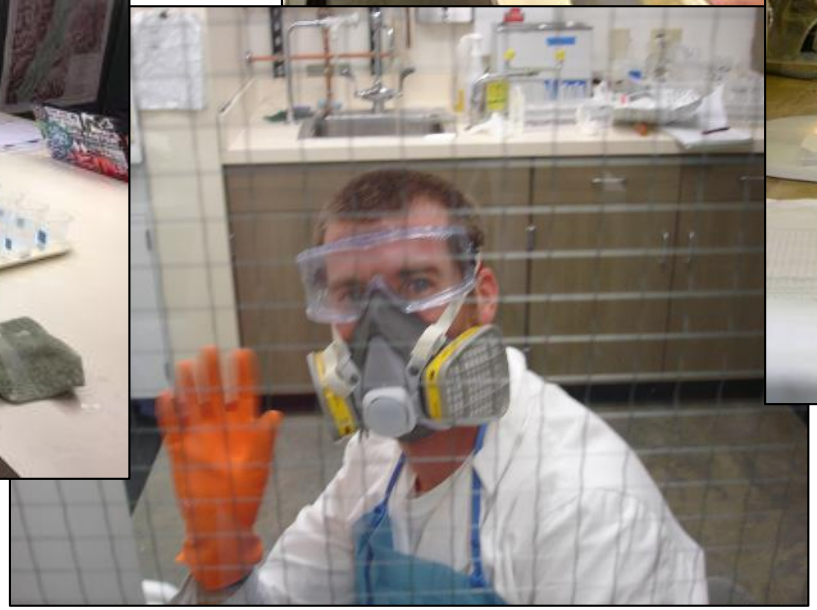

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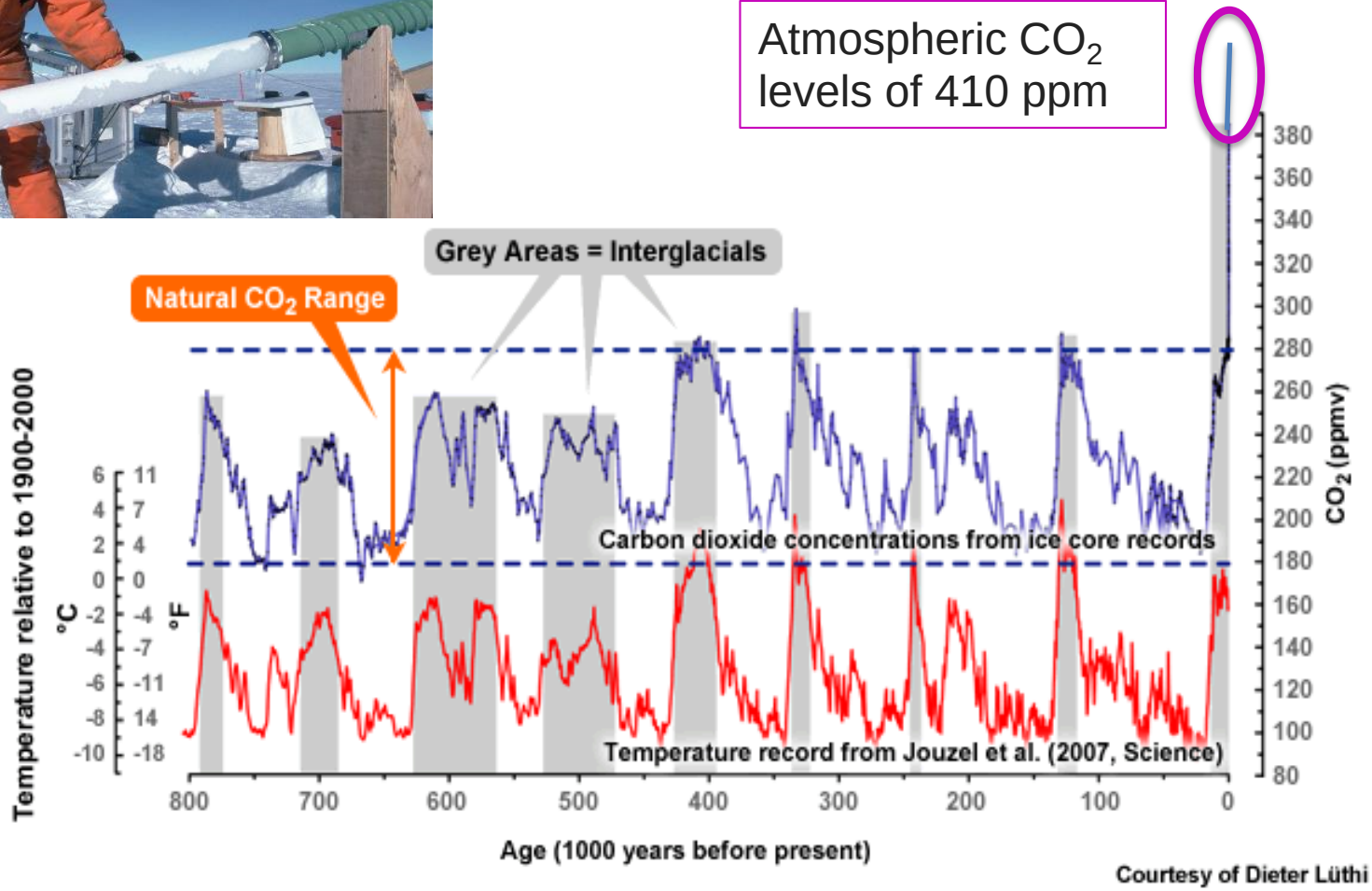
Are Current Climate Trends Unprecedented?

LAST 800,000 YEARS

Atmospheric CO_2 levels of 410 ppm



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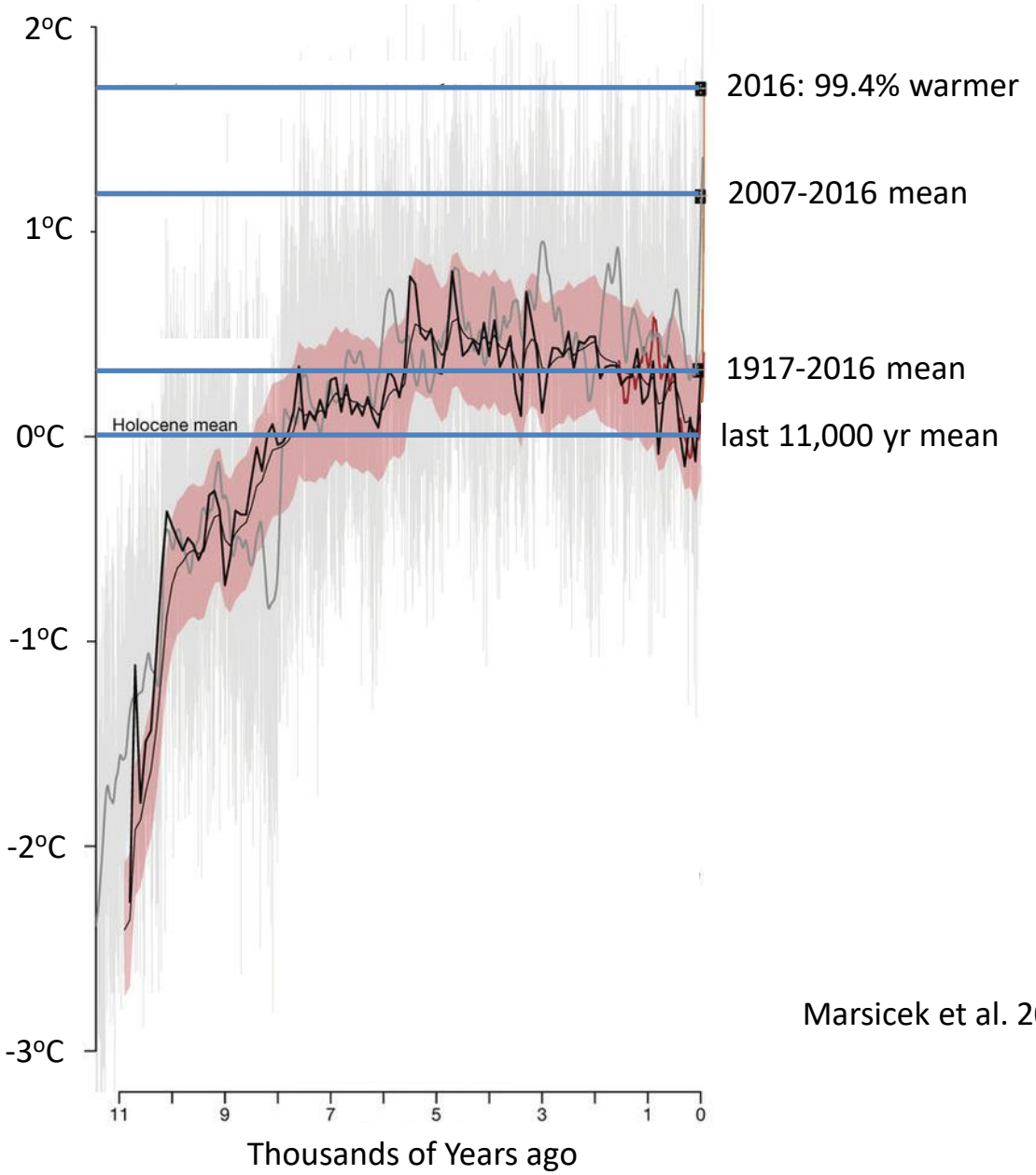
LAST 11,000 YEARS



Marsicek et al. 2018, Nature

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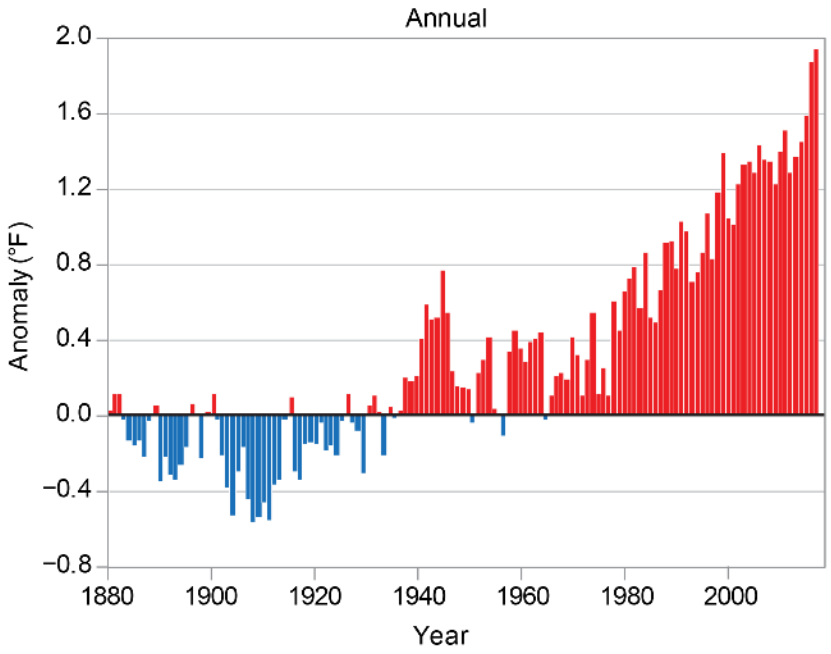
CLIMATE FACTS

Last 115 years are warmest of the last 1700 years, 1.8°F increase in US

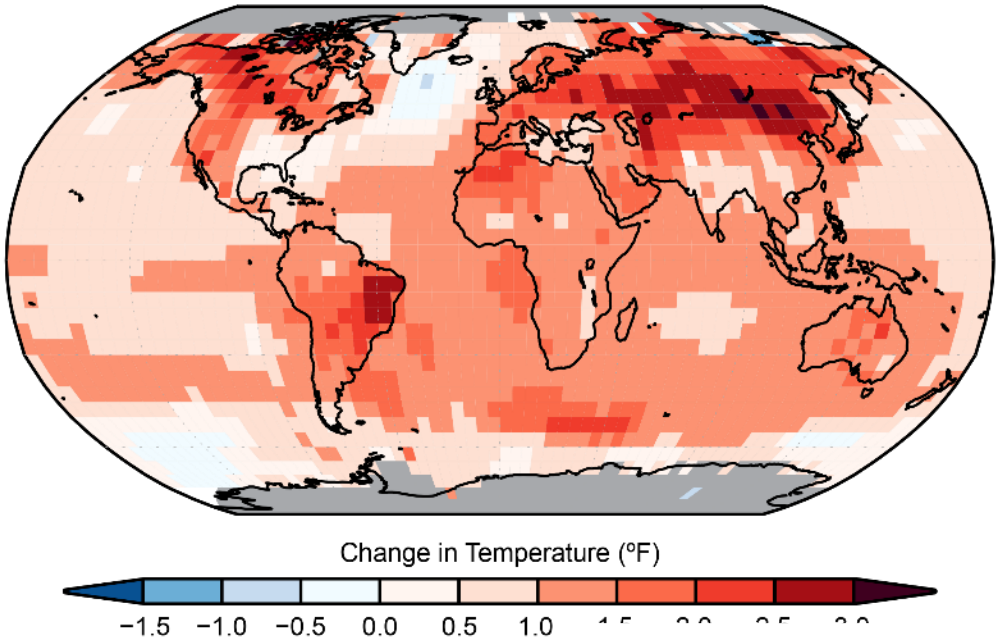
2013-2017: warmest five years on record in US and globally.
May 2018: warmest of last 124 years in U.S. (5.2°F above the average)

2017: 17 weather-climate disasters had losses exceeding $1 billion
(hurricanes, floods, drought, tornados, fires, severe weather (freezes, hail, dust, etc.))

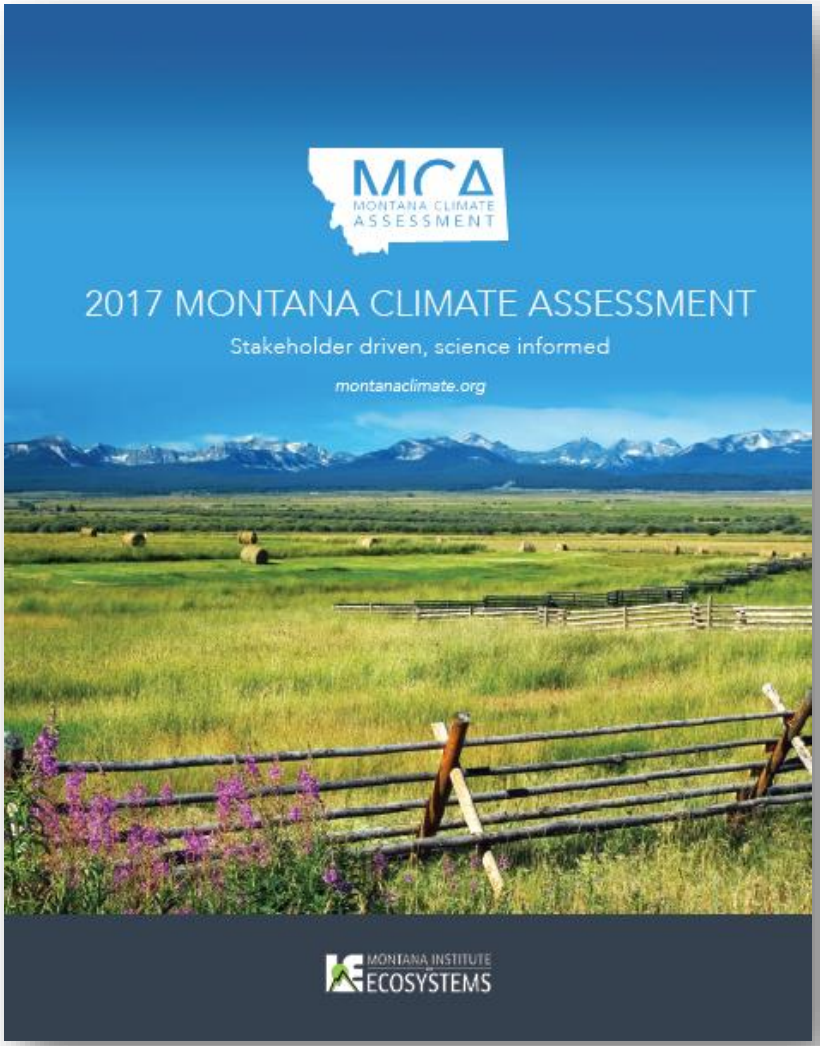
Global Land and Ocean Temperature Anomalies



Surface Temperature Change



MONTANA CLIMATE ASSESSMENT



http://montanaclimate.org

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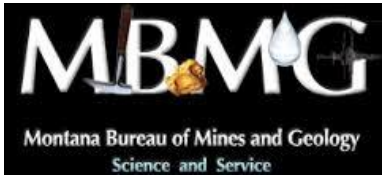
MCA Partners

U.S. National Climate Assessment



Stakeholder Driven

Listening sessions and questionnaires

Stakeholder responses informed the MCA strategy

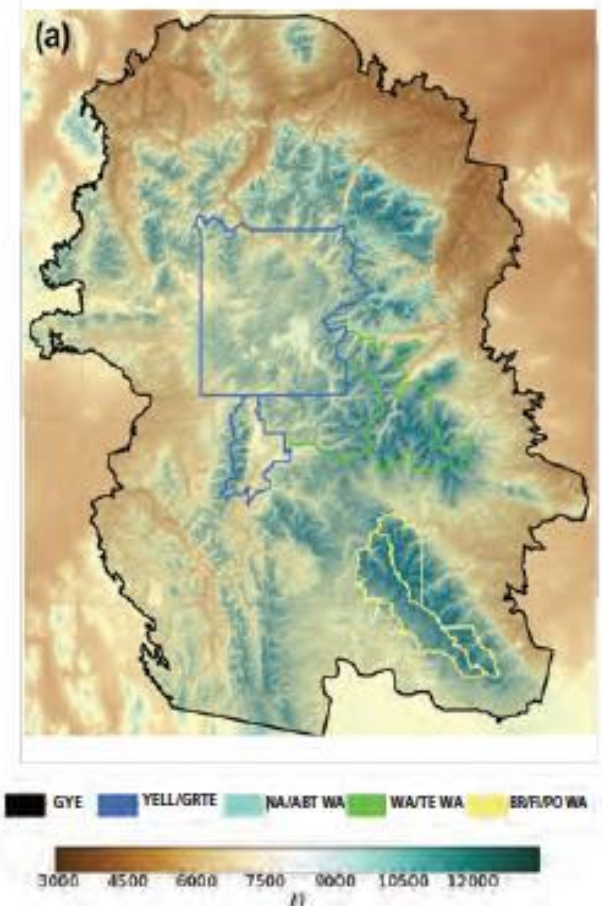
- Critical decisions and issues impacted by climate
- What type of information they need
- How to disseminate useful information

How is Climate Changing in the GYE?

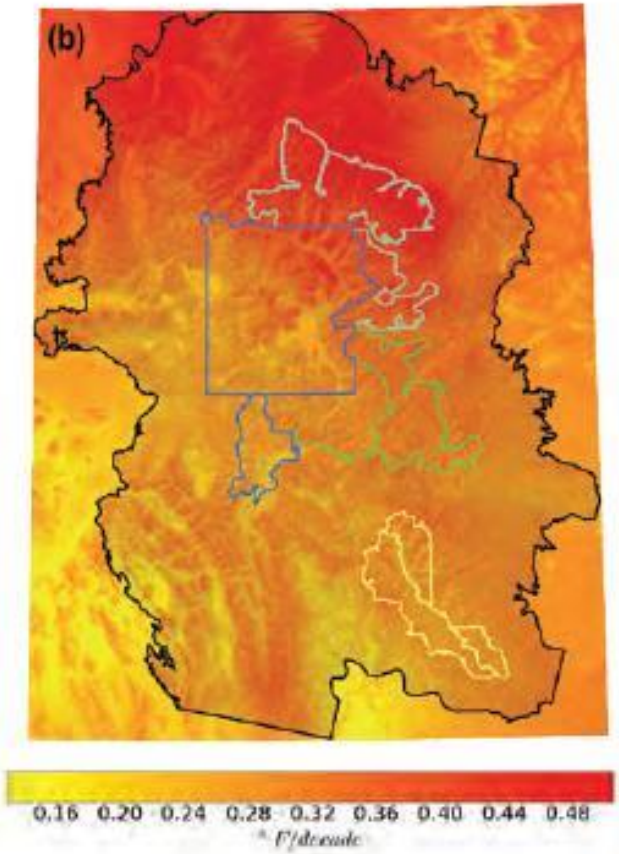
photo credit: Andrew Thomas

RATE OF WARMING (1948-2010)

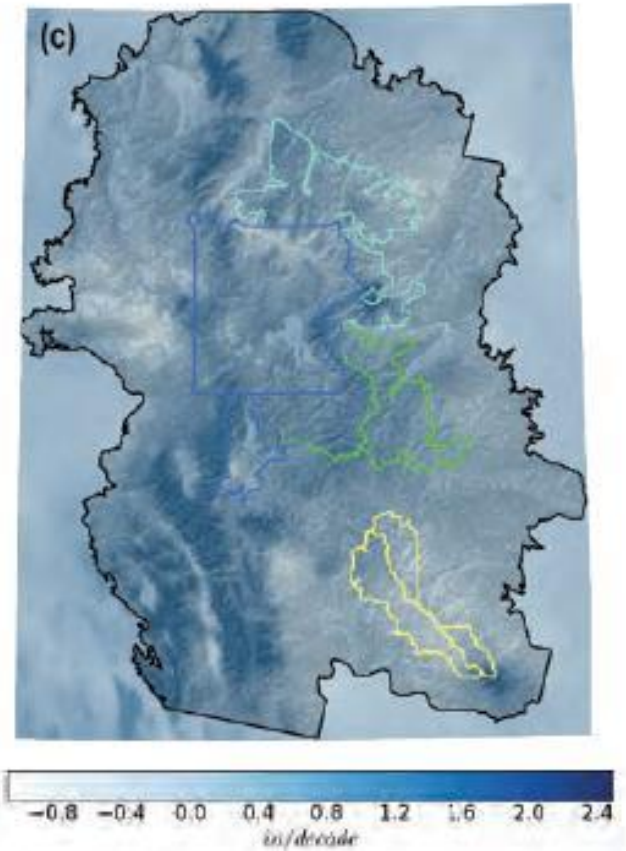
Elevation



Temperature



Precipitation



0.31°F/decade= 2-3°F

0.19 inches/decade

Chang & Hansen, 2015

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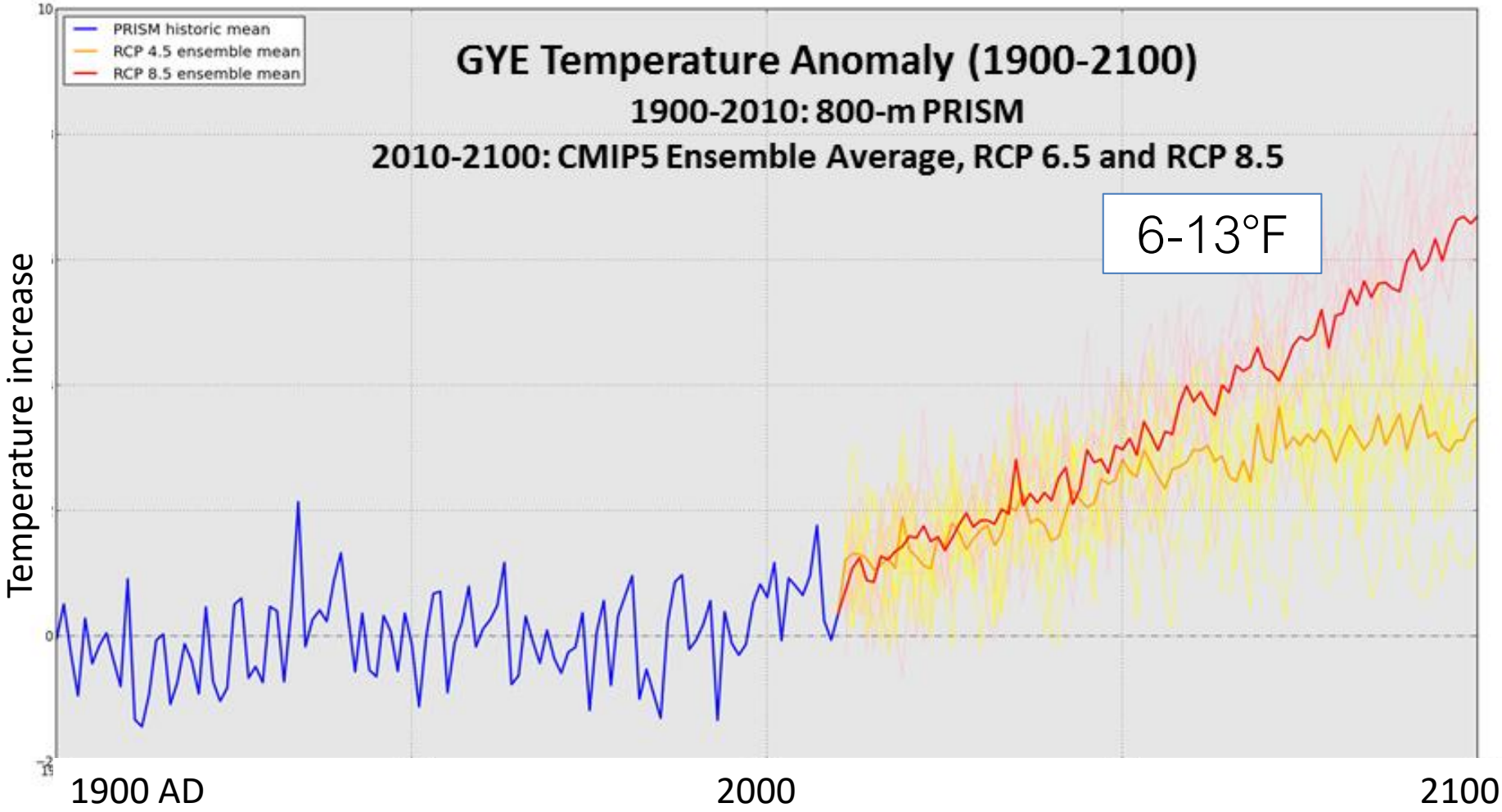
WARMING



Chang & Hansen, 2015

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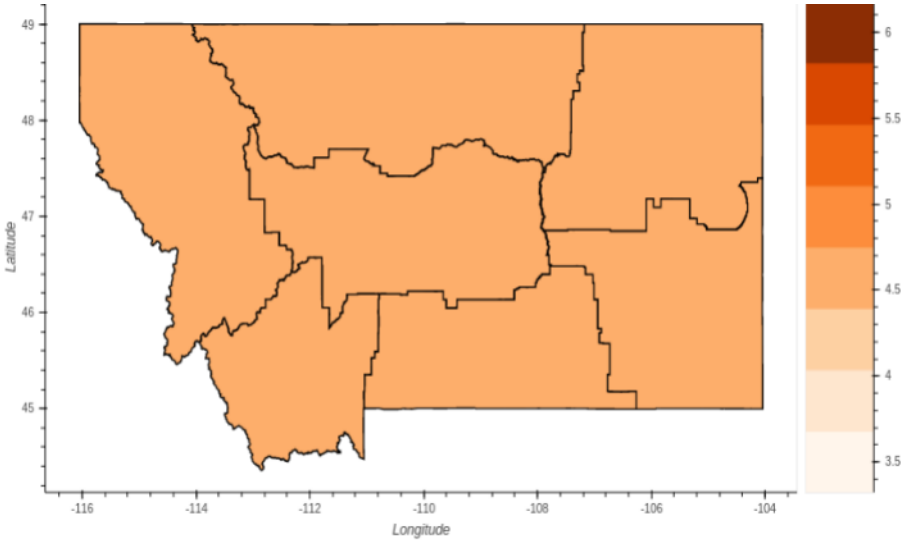
Annual Temperatures by Mid-Century

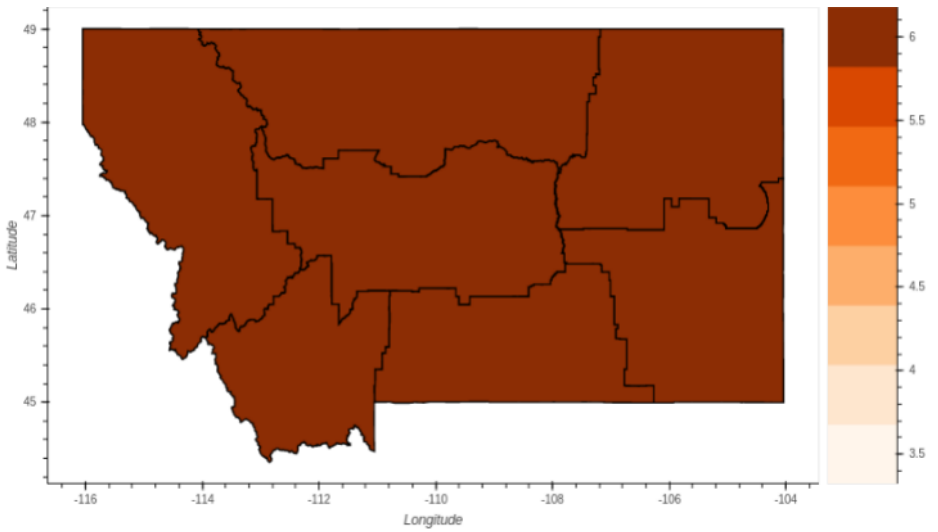
RCP 4.5 (2040-2060)



4.5°F increase

(minimum: 2.7°F, maximum: 6.1°F, model agreement: 100%)

RCP 8.5 (2040-2060)



6°F increase

(minimum: 4.0°F, maximum: 8.2°F, model agreement: 100%)

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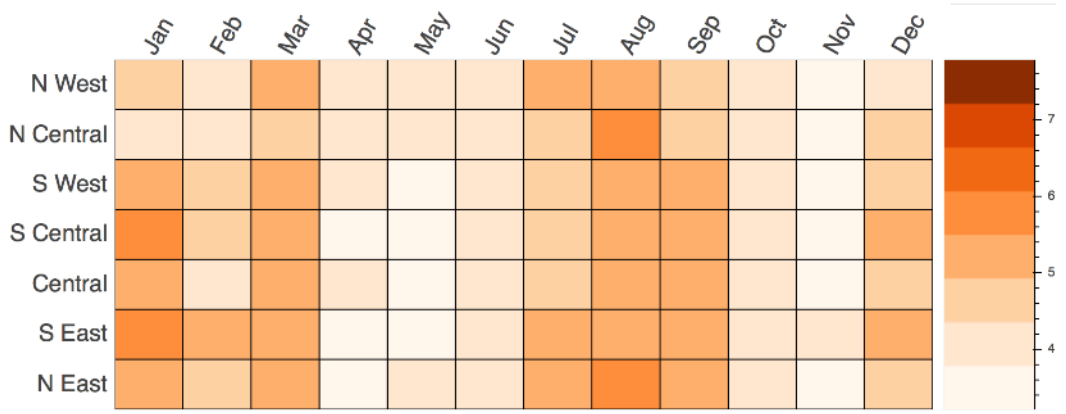
Monthly Temperatures

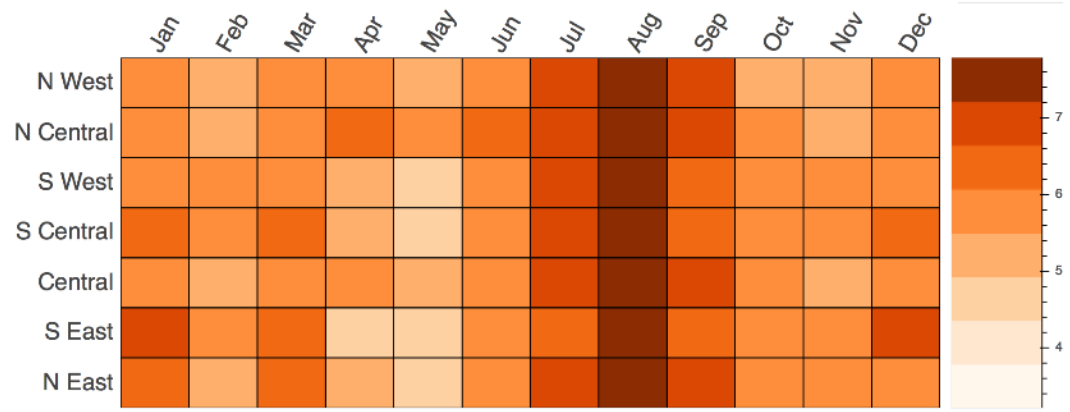
RCP 4.5 (2040-2060)



Greater warming in:

- Winter: 4 to 5°F
- Summer: 5 to 5.5°F

RCP 8.5 (2040-2060)



- Winter: 5 to 7°F
- Summer: 6 to 7.5°F

(100% model agreement)

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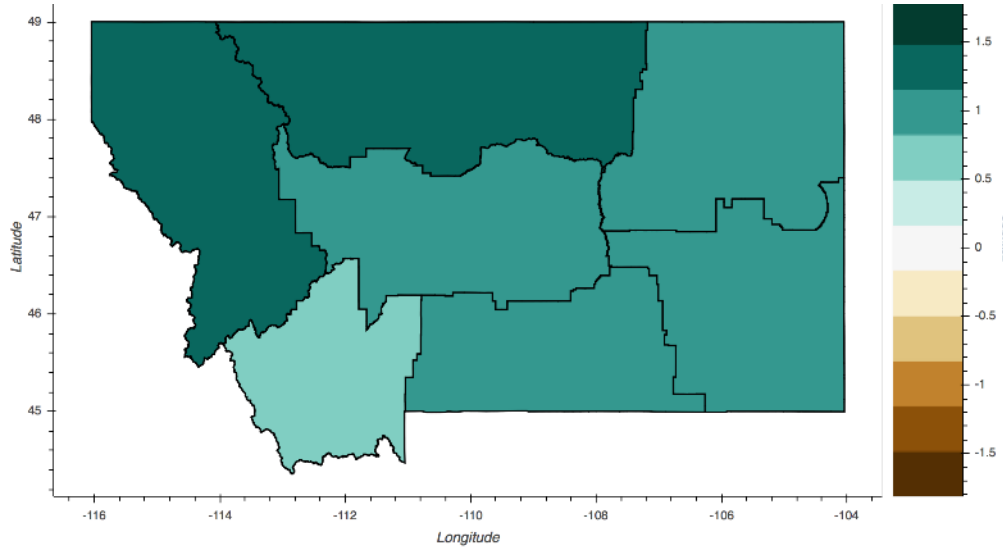
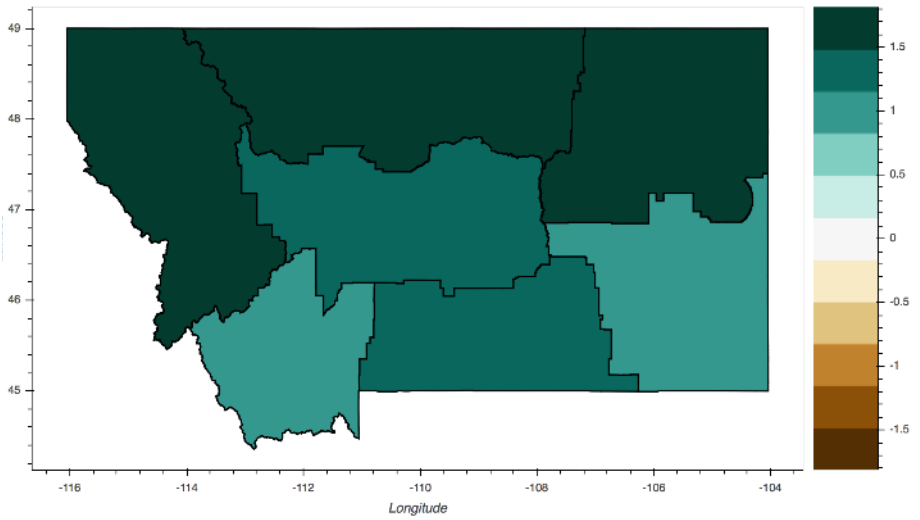
Annual Precipitation

RCP 4.5 (2040-2060)



RCP 8.5 (2040-2060)



Spatially variable
From 1.3 to 0.8 more inches

Spatially variable
From 1.6 to 1.1 more inches

Moderately high model agreement: 85%

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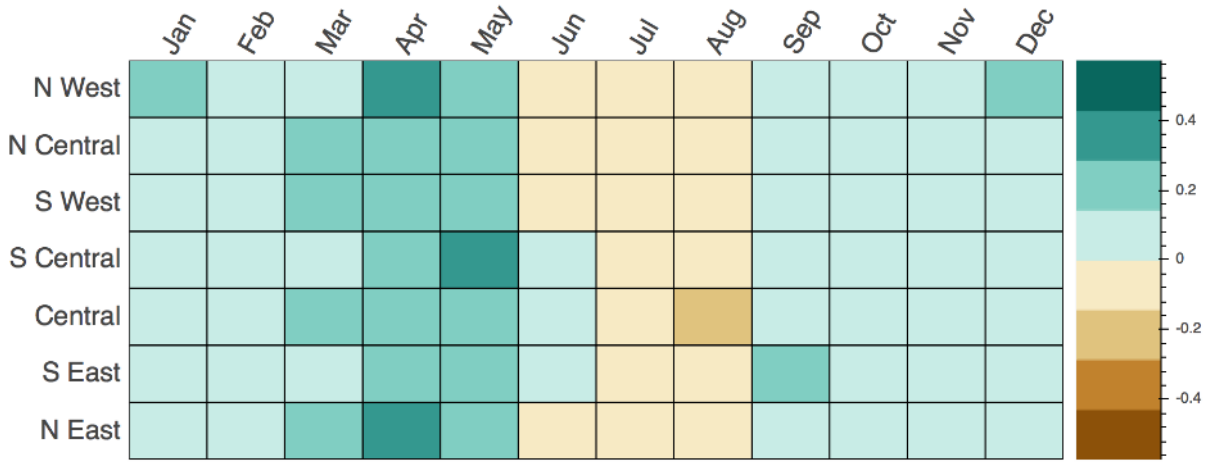
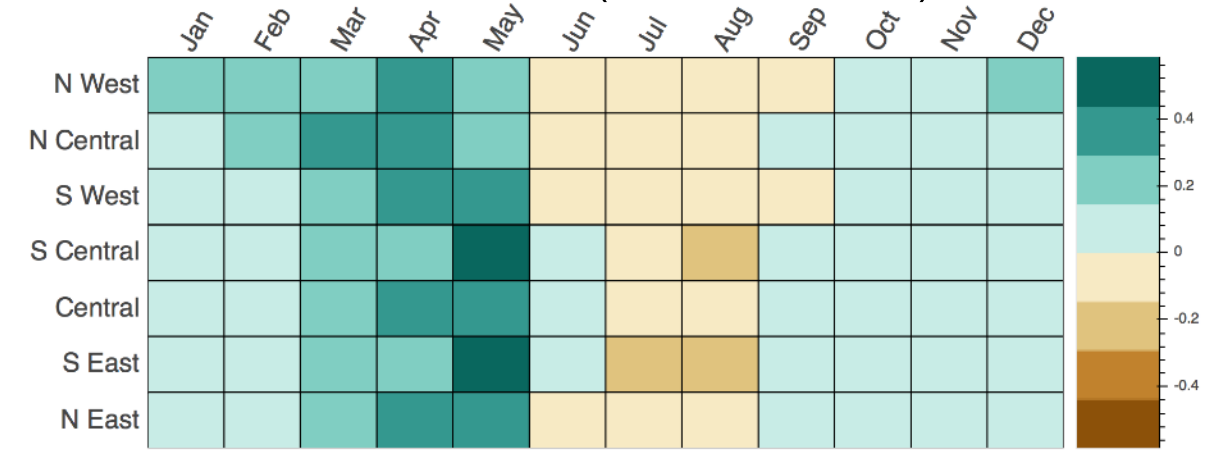
Monthly Precipitation

RCP 4.5 (2040-2060)



Increases in winter, spring, and fall (>85% model agreement)

RCP 8.5 (2040-2060)



Decreases in summer (65% model agreement)

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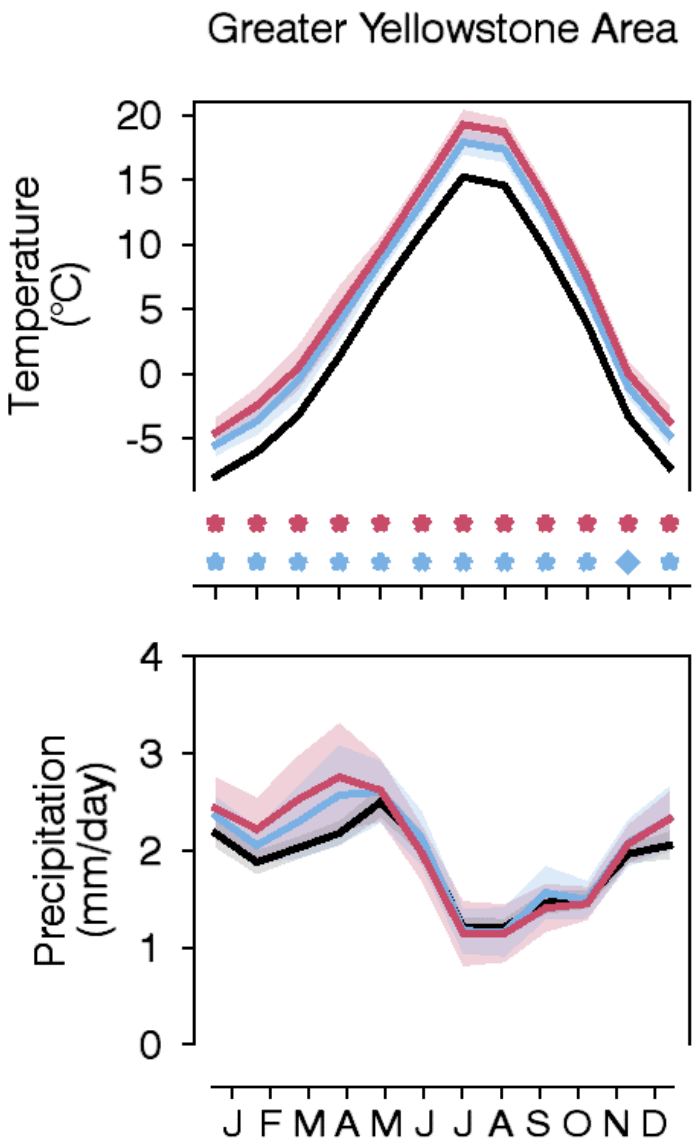
YEAR-ROUND WARMING WETTER WINTER-SPRINGS



Historical (1981-2010)

RCP4.5 (2050-2074) **Stabilization**

RCP8.5 (2050-2074) **Business as usual**

▲ 55-70% of model changes are significant and in agreement

◆ 70-85% of model changes are significant and in agreement

● 85-100% of model changes are significant and in agreement

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How is GYE's Climate Changing?

Between 1950-2015:

- Average temperatures have risen 2-3°F. Winter and springs have warmed the most.
- Growing seasons are 12 days longer.
- Slight changes in annual or seasonal precipitation.

Future:

- Additional warming of 4-6°F by 2050, ~9.5°F by 2100.
- Precipitation will increase slightly in winter, spring and fall, and slightly decrease in summer.

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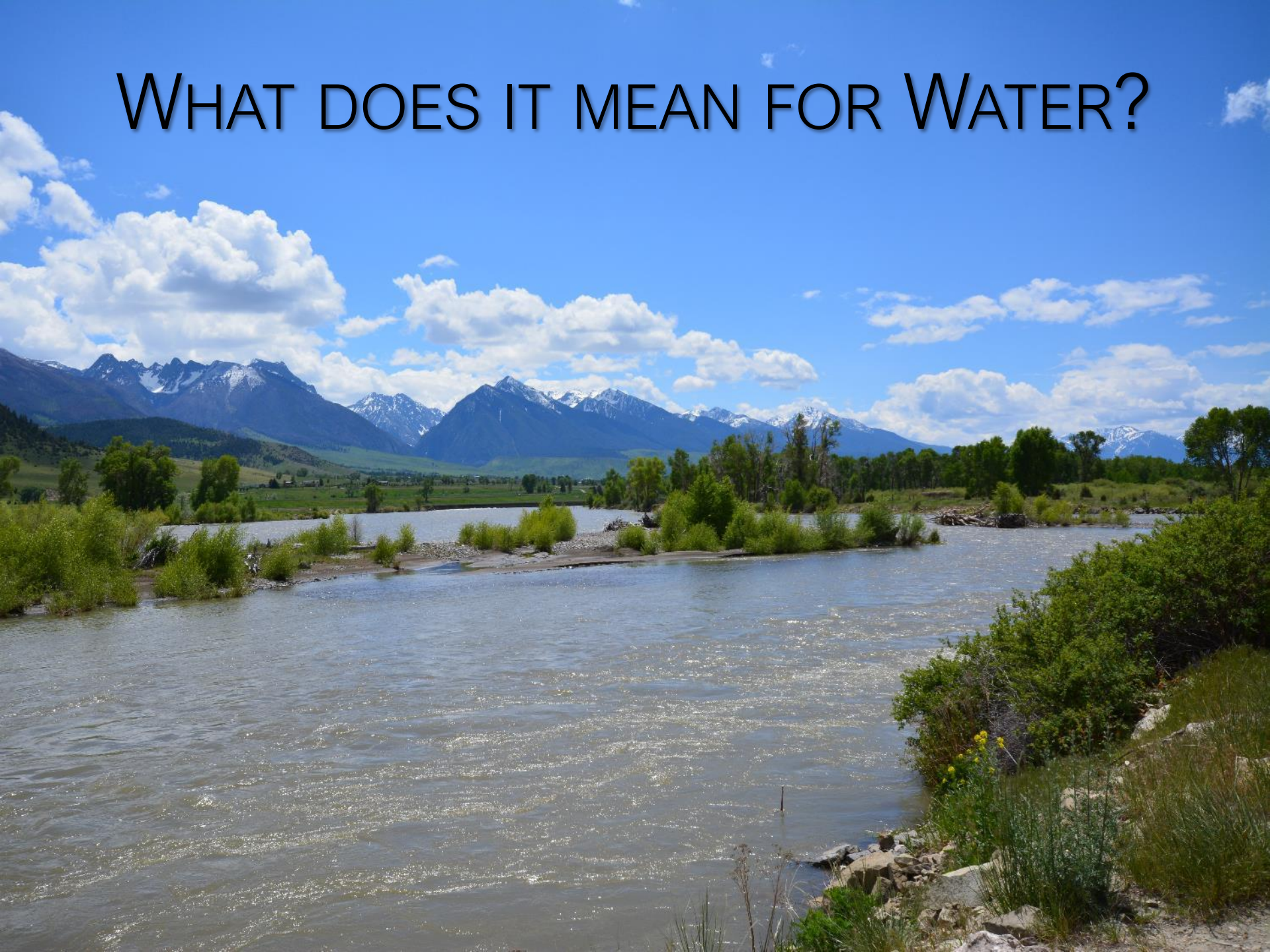
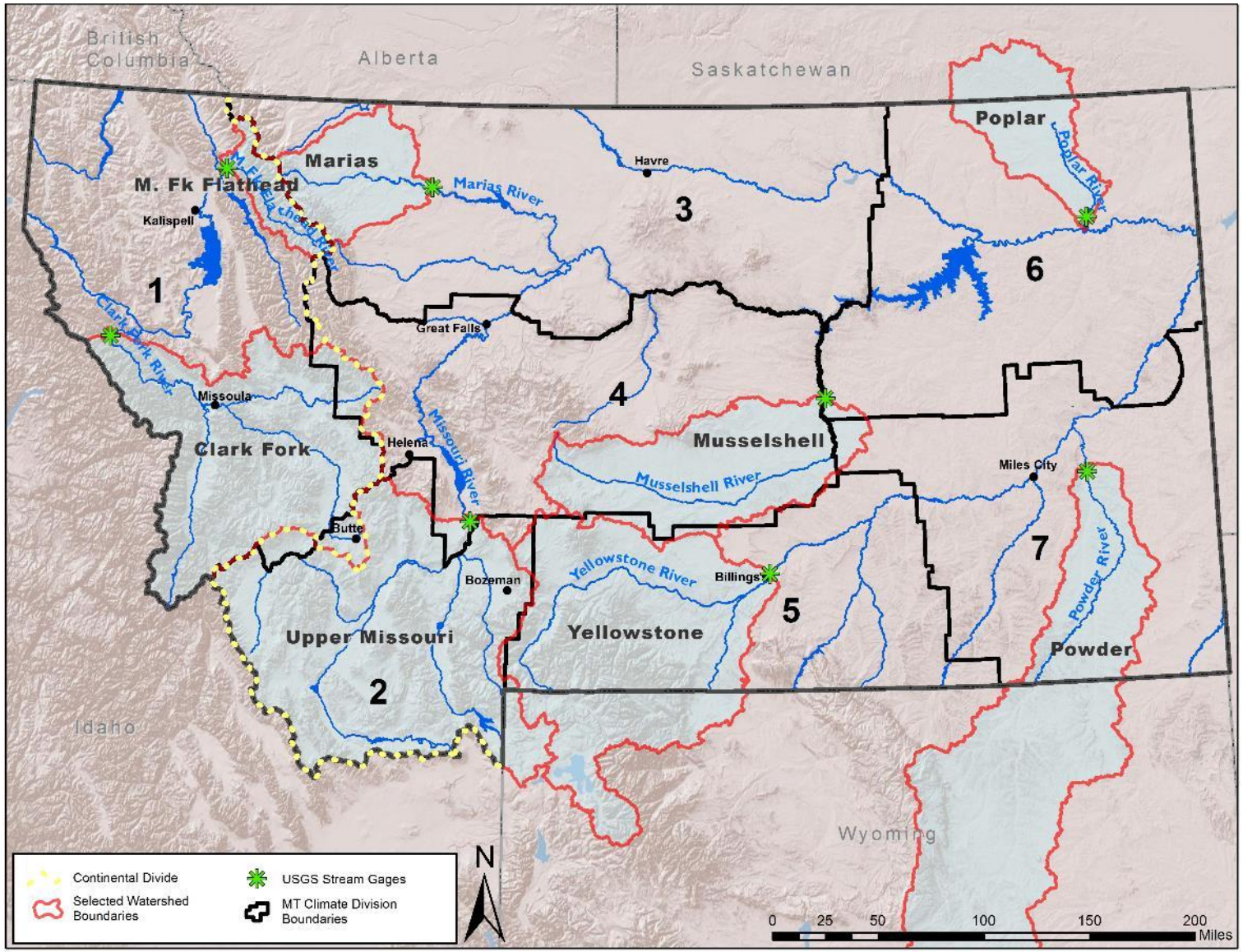
What does it mean for Water?



MONTANA'S FOCAL WATERSHEDS



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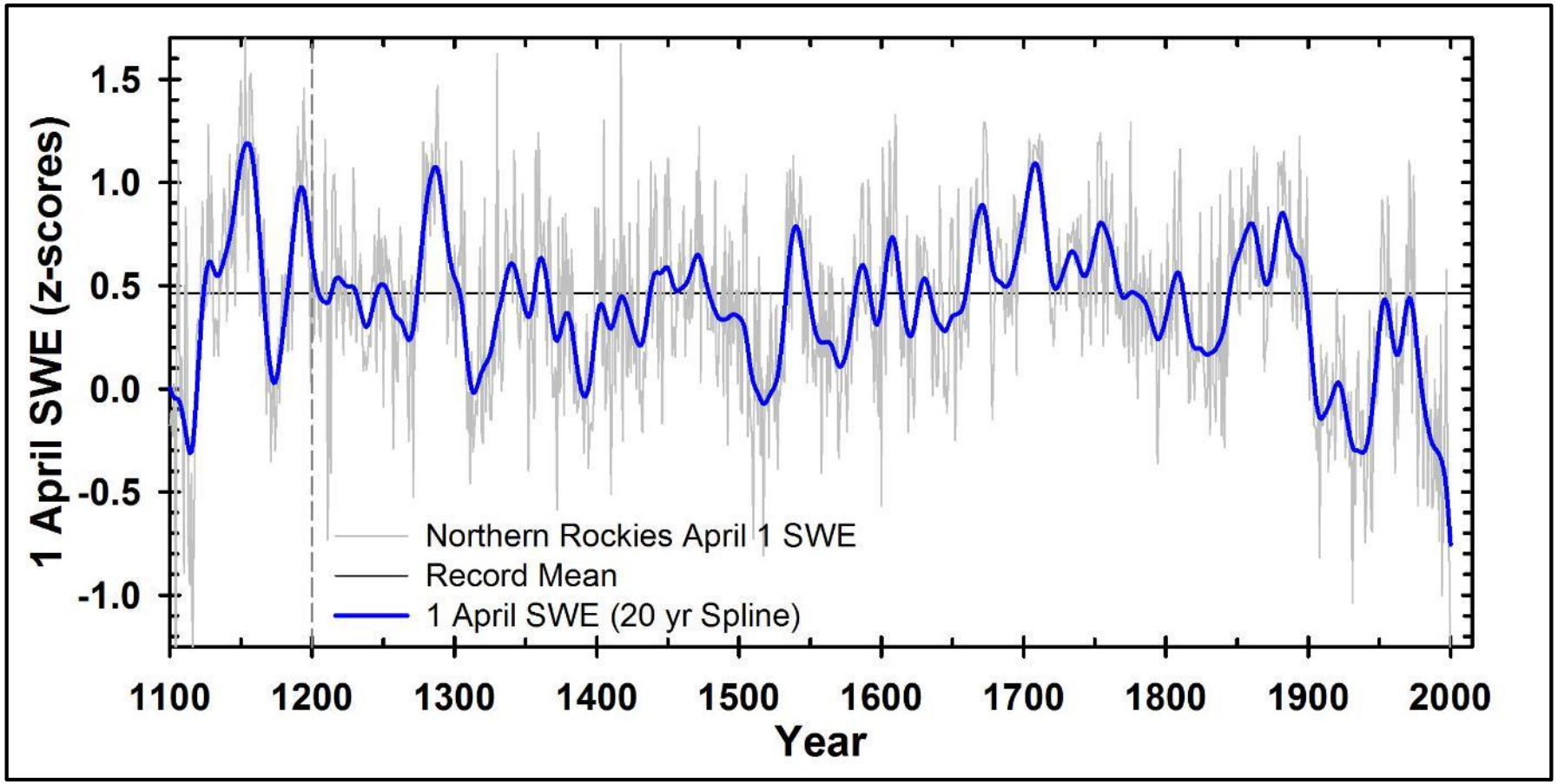
CLIMATE & SNOWPACK

LONG-TERM SWE RECONSTRUCTIONS
(PEDERSON ET AL. 2013)



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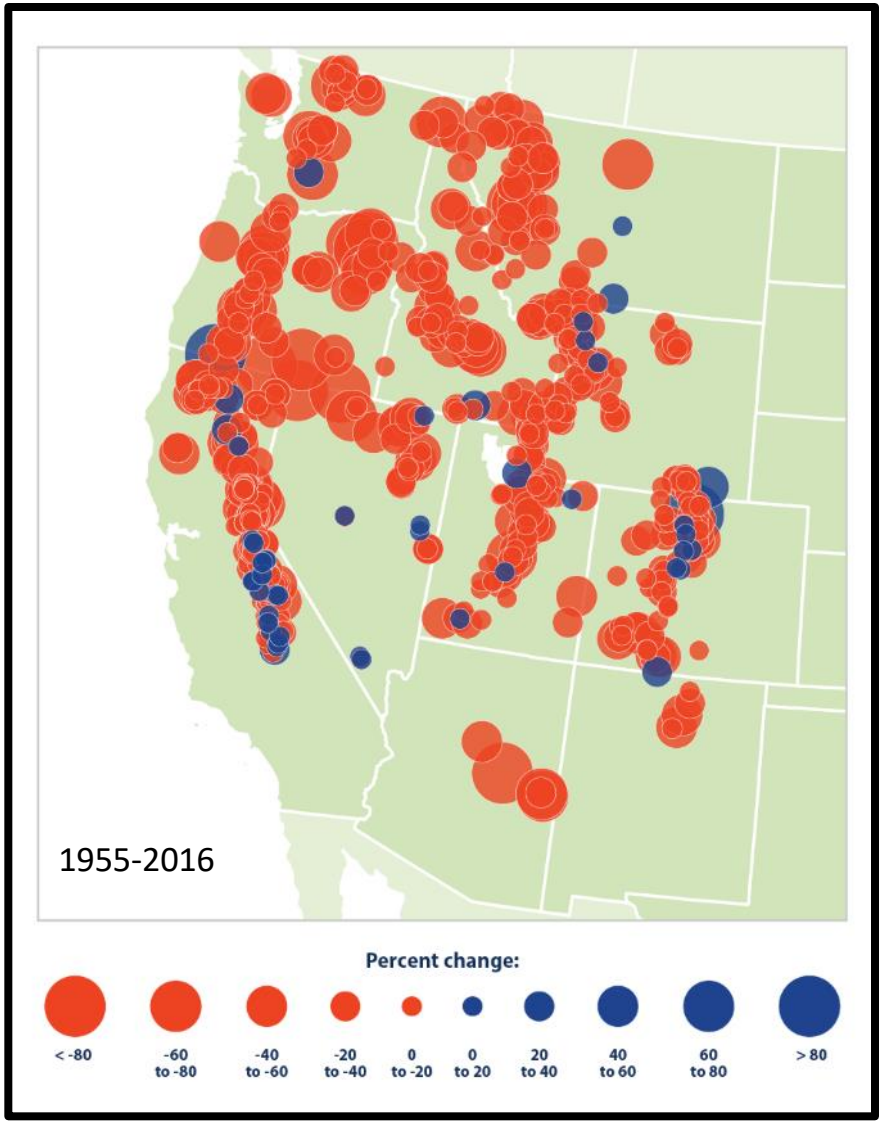
SNOWPACK TRENDS

Red = declining snowpack

Blue = increasing snowpack

20-80% decline in GYE



Mote and Sharp 2016

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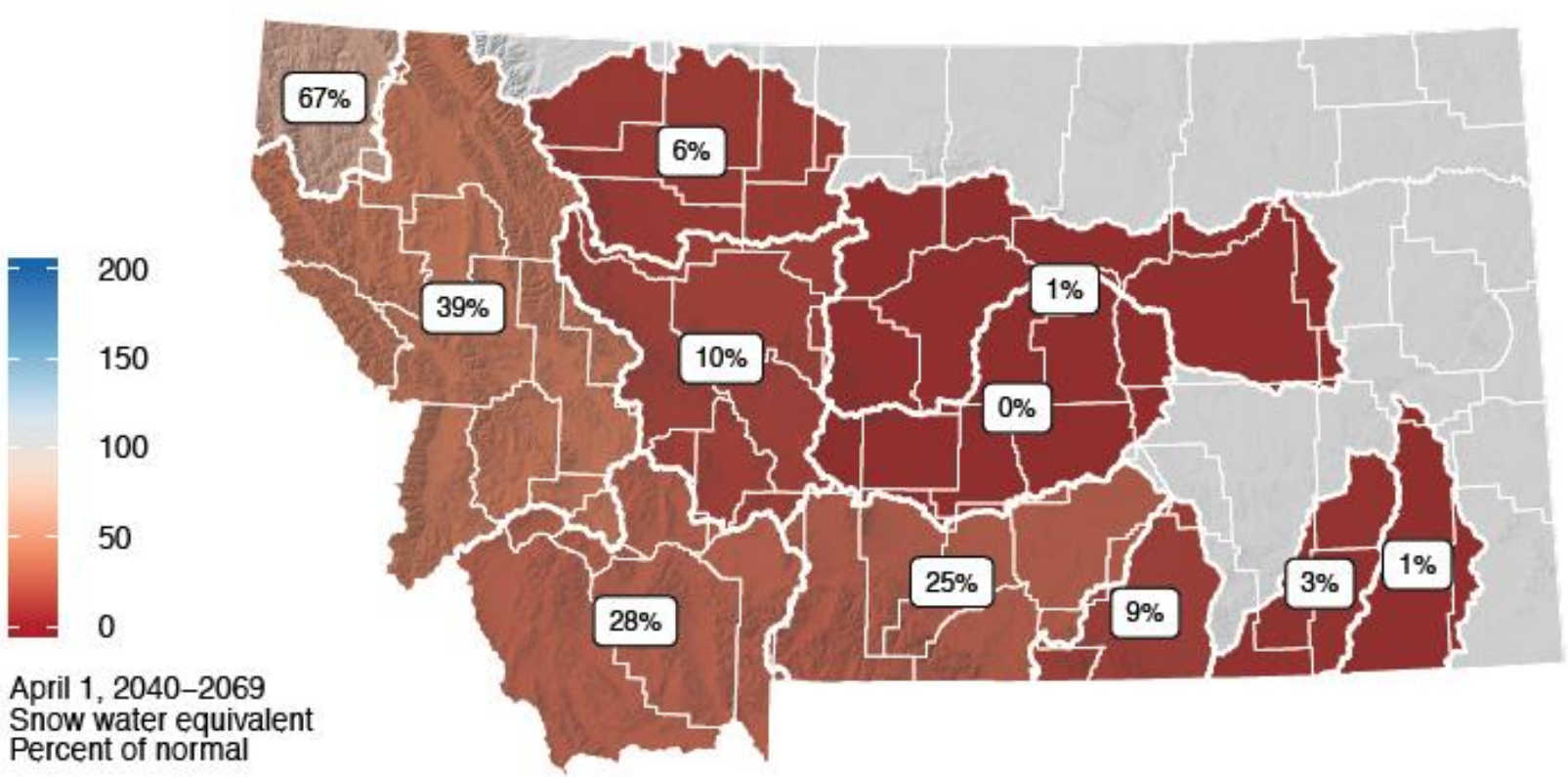
SNOWPACK PROJECTIONS: 2040-2069



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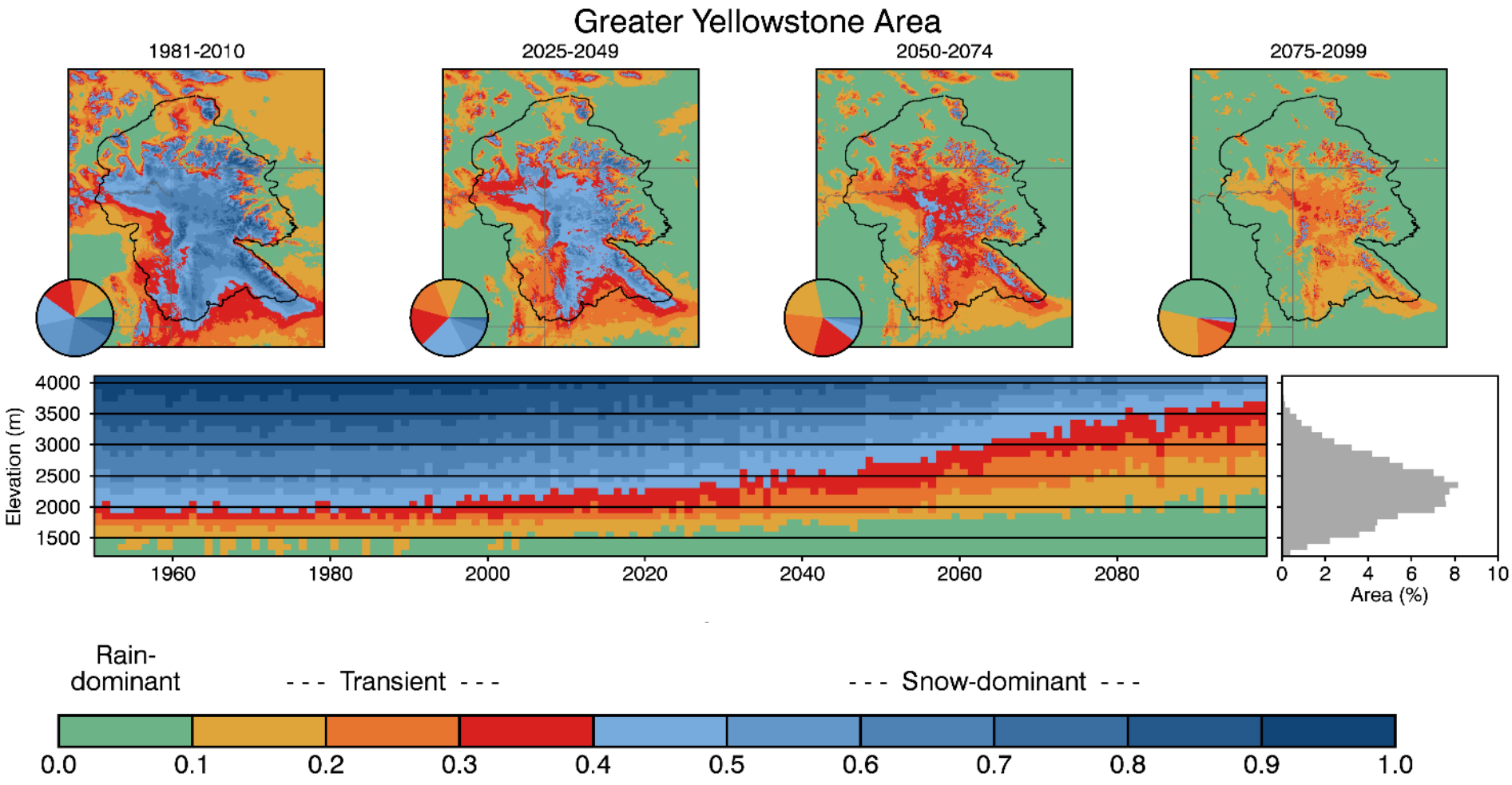
Snow to Rain



Alder & Hostetler, USGS

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SNOWPACK & WATER SUPPLY

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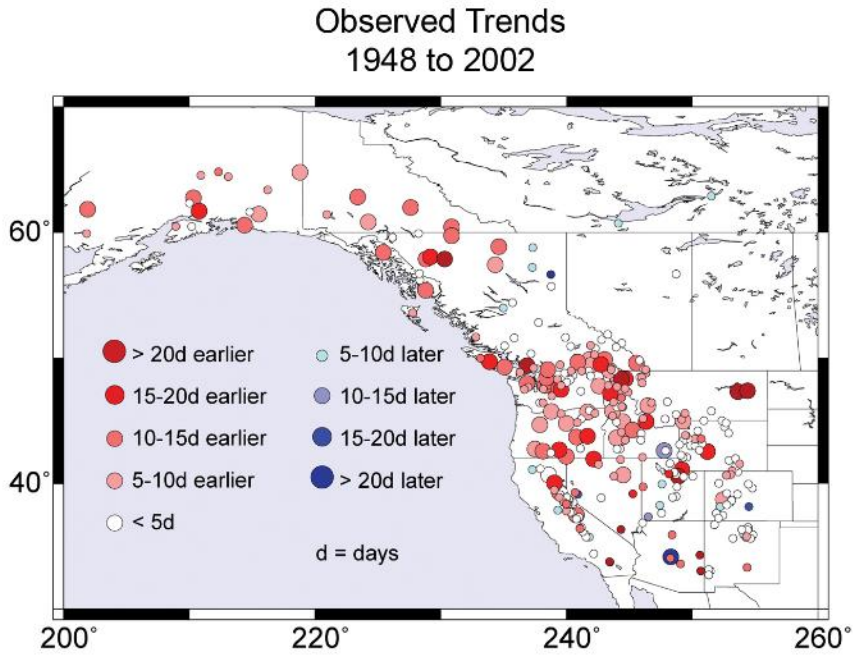
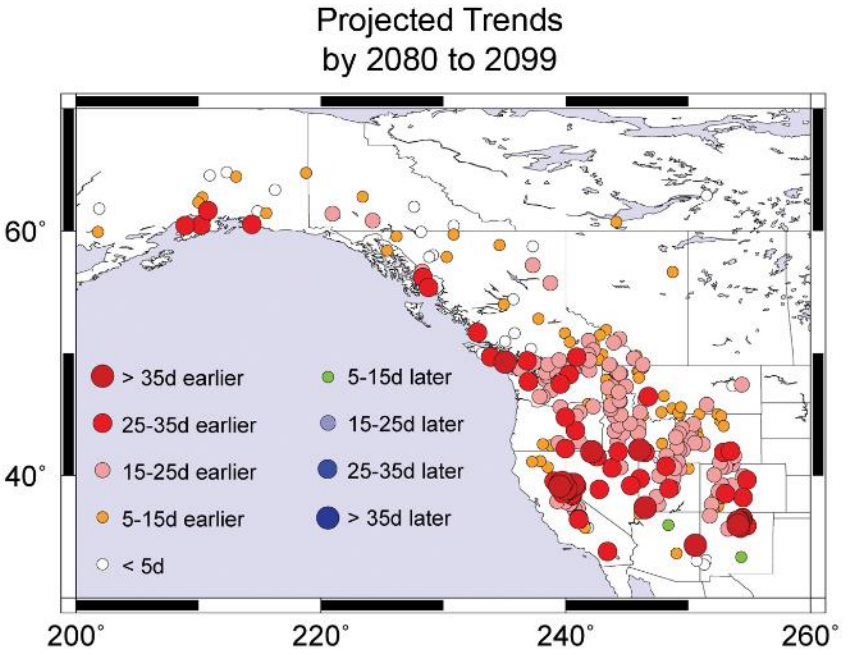
Observed and projected changes in runoff timing across the West

Increased springtime temperatures

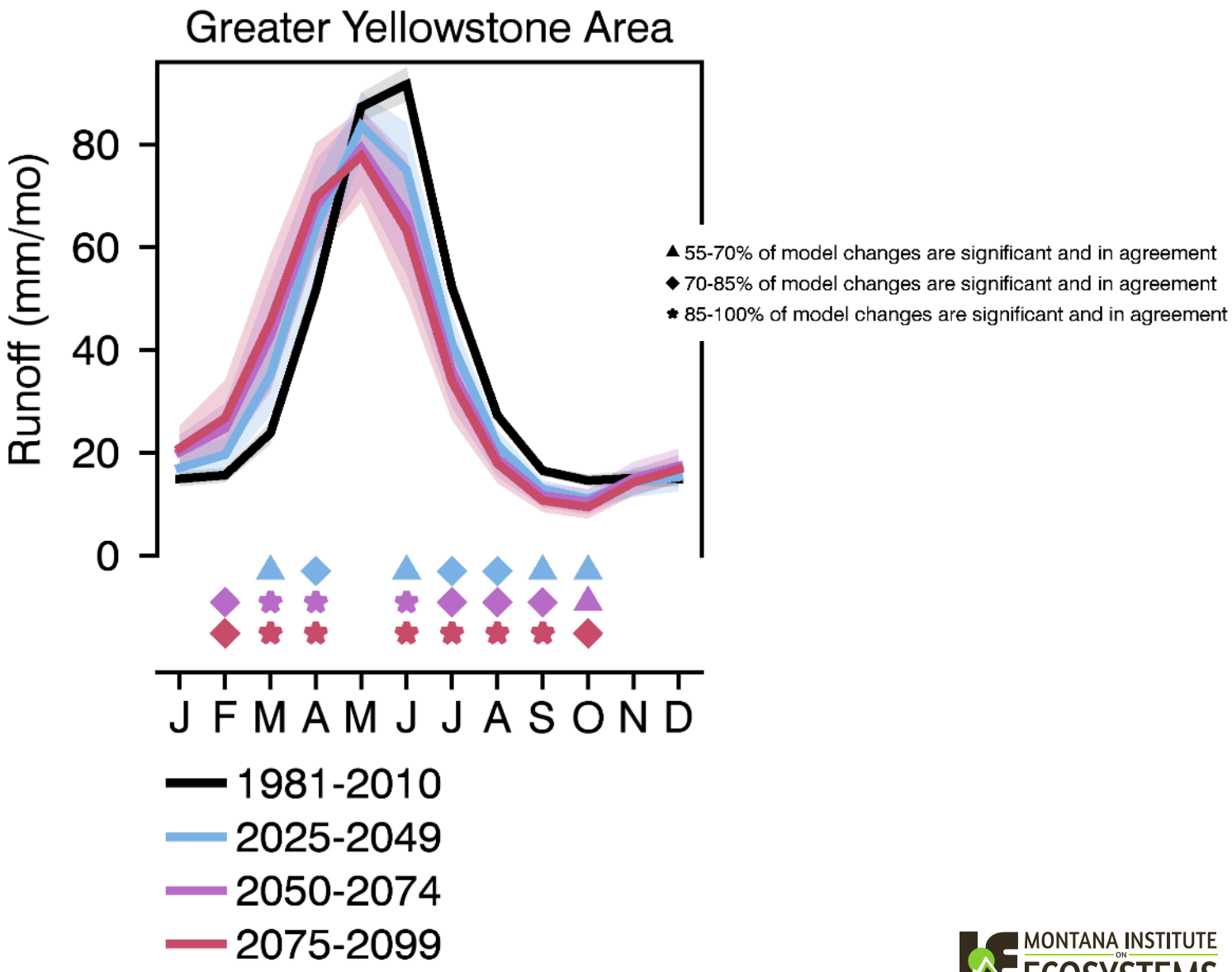
10-15 days earlier since 1948
15-25 days earlier in 2090





Stewart et al. 2004

Earlier Peak Run-off



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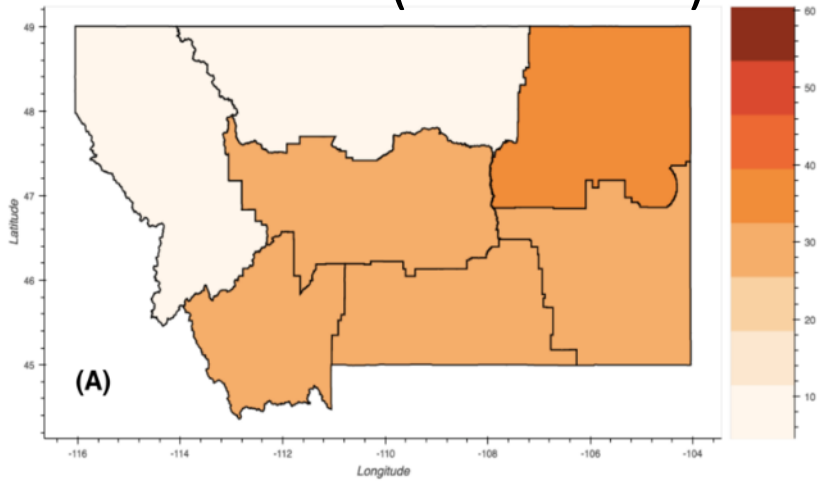
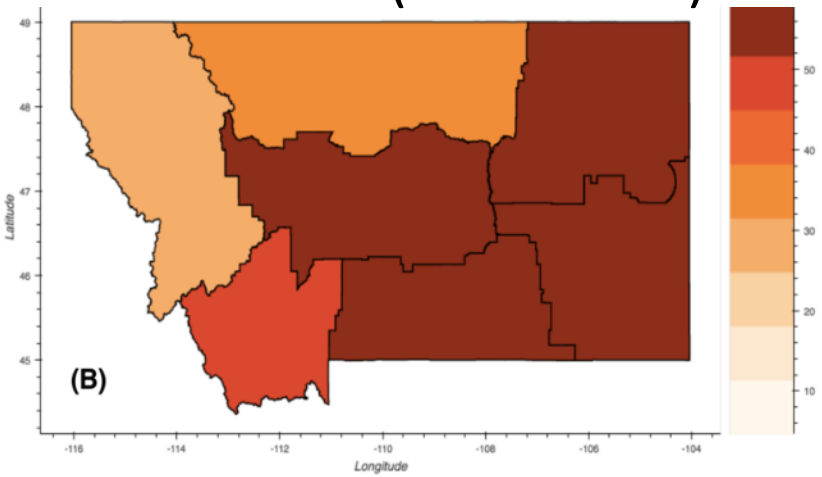
Drought

Rising Temperatures exacerbate Drought

RCP 4.5 (2040-2060)



RCP 8.5 (2040-2060)



Increased days >90°F
(up to 35 additional days)

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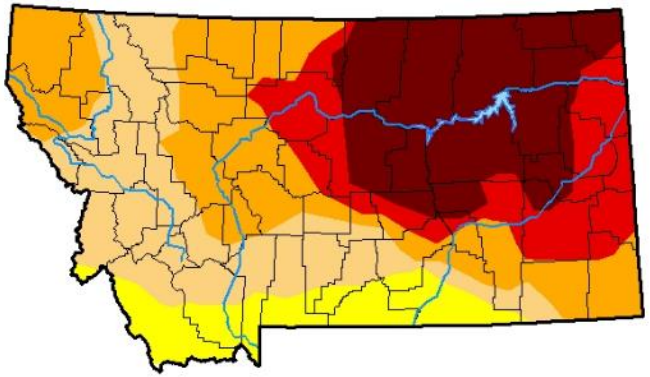
2017 DROUGHT

U.S. Drought Monitor

Montana



August 29, 2017

(Released Thursday, Aug. 31, 2017)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.03	99.97	90.20	66.01	39.42	24.55
Last Week 08-22-2017	2.77	97.23	90.20	59.55	34.34	11.87
3 Months Ago 05-30-2017	67.50	32.50	0.00	0.00	0.00	0.00
Start of Calendar Year 01-03-2017	74.25	25.75	4.87	0.00	0.00	0.00
Start of Water Year 09-27-2016	55.14	44.86	25.49	5.86	0.33	0.00
One Year Ago 08-30-2016	43.00	57.00	24.93	7.60	0.35	0.00

Intensity:

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

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

Author:

Chris Fenimore

NCEI/NESDIS/NOAA

USDA NDMC

http://droughtmonitor.unl.edu/

MT: $378 million in federal & state funds

1.26 million acres burned

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What does it mean for Agriculture?

MONTANA AGRICULTURE PROJECTIONS

- Decreasing snowpack will reduce late-season irrigation capacity (affect hay, sugar beet, malt barley, garden/potato production).
- Longer growing season could enable crop diversity but with greater vulnerability.
- Increase number of days >90^{o}F will impact wheat & stress livestock.
- Winter annual weeds will increase.

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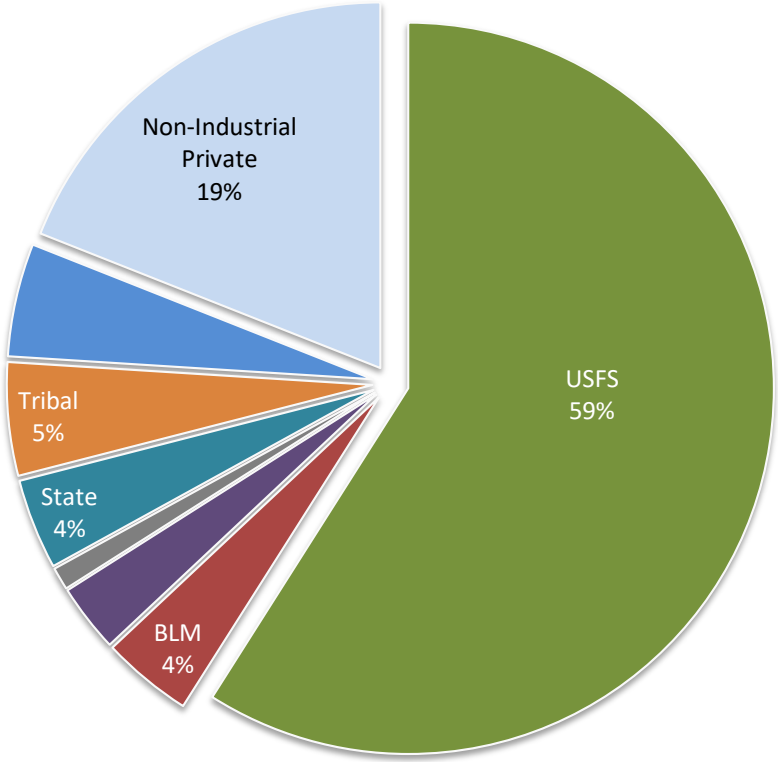
What does it mean for Forests?

photo credit: Philip Higuera, Univ MT

CONTEXT

- 23 million acres of forests
- Majority on public lands
- Existing forest conditions vary



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Framework for Forest Impacts

- Direct impacts of climate
  - Establishment & regeneration
  - Growth and productivity
  - Mortality
  - Range shifts and forest distribution
- Indirect impacts of climate
  - Fire
  - Pathogens and insects

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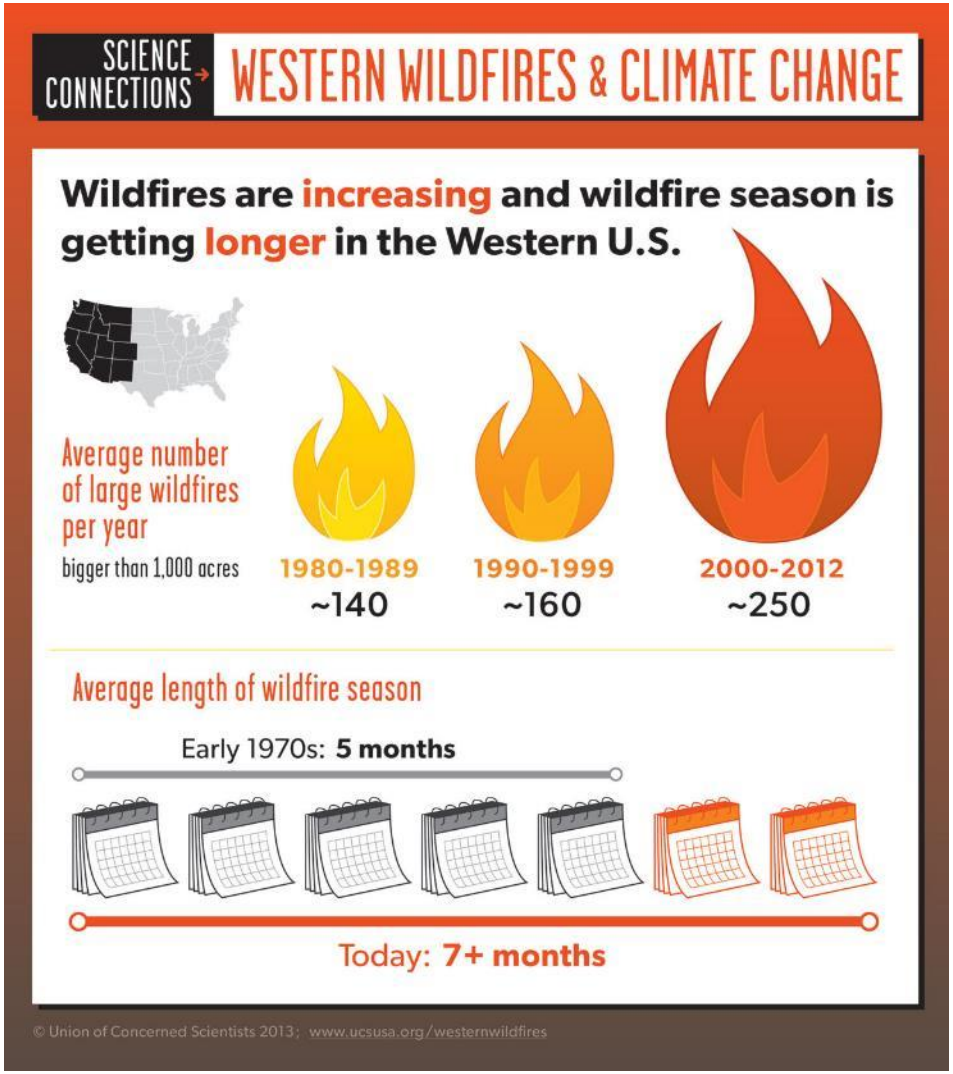
Indirect Effects: Fire

- Large fires have increased.
- Fire season is longer.
- Forest recovery is changing.
- Fires will increase (warmer weather & past management policies in some areas)



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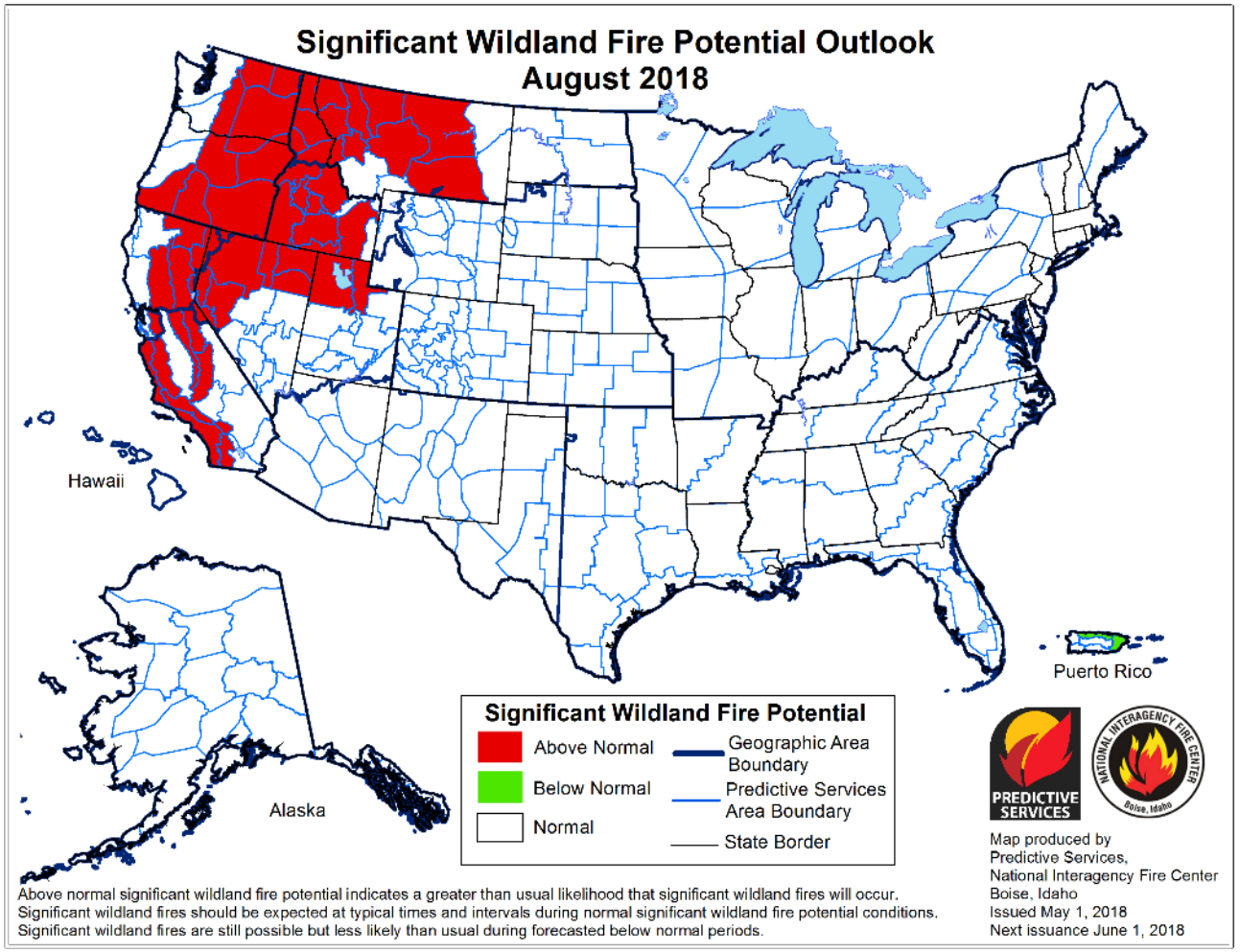
FIRE OUTLOOK 2018



Based on expected warmer drier conditions than normal in late summer.

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Ecological Change in the GYE

Impacts on Winter Recreation

- Shortened season
  - Less stable snow conditions, more rain-on-snow events
  - Greater chance of flooding
  - Shoulder seasons are uncertain

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Impacts on Summer Recreation

- Lengthened season
  - More visitors and infrastructure use
  - More wildlife-human interactions
  - More focus on aquatic activities

Impacts on Summer Recreation

- High water temperatures & low flows
  - Yellowstone cutthroat vs non-natives
  - Fish diseases (e.g., whitefish kill on YSR)
  - Angling and boating restrictions
- More wildfires (health & safety issues)

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MCA: WHERE ARE WE NOW?

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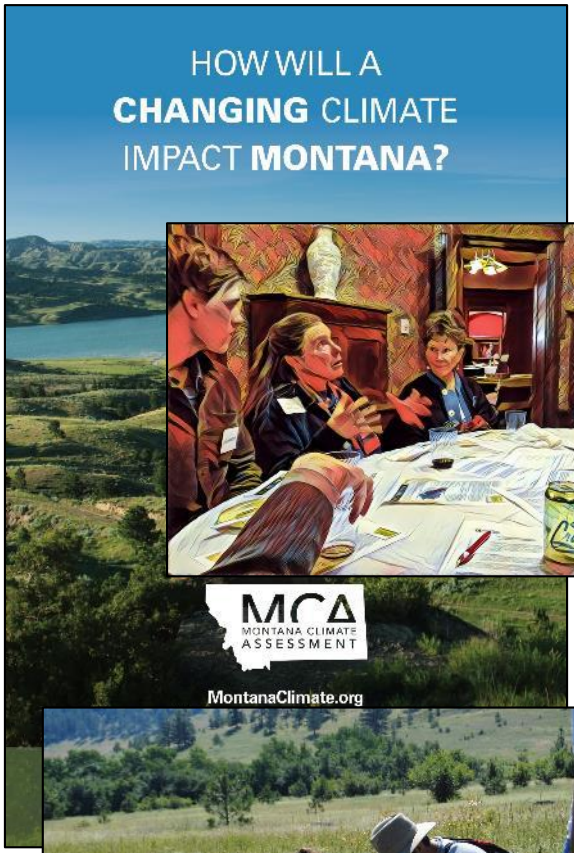
MCA "Road Show"



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Public Conversations

- Water & water storage
- Floods & droughts
- Wildfire response, before & after
- Livestock & crop decisions
- Economic implications
- Health considerations

GYE Climate Assessment

- Public-private partnership, driven by stakeholder needs in different jurisdictions
- High-resolution climate information for GYE
- Updatable & sustained
- Possible topics
  - Tourism & recreation
  - Fish & wildlife
  - Water supply and demand
  - Fires and forest management

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