



A Climate Context for Adaptive Silviculture in Taylor Park, Colorado

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ASCC, Gunnison & Taylor Park, July 6-9, 2022

Defining Climate

Weather vs. Climate



2008
JANUARY FEBRUARY MARCH APRIL

2007

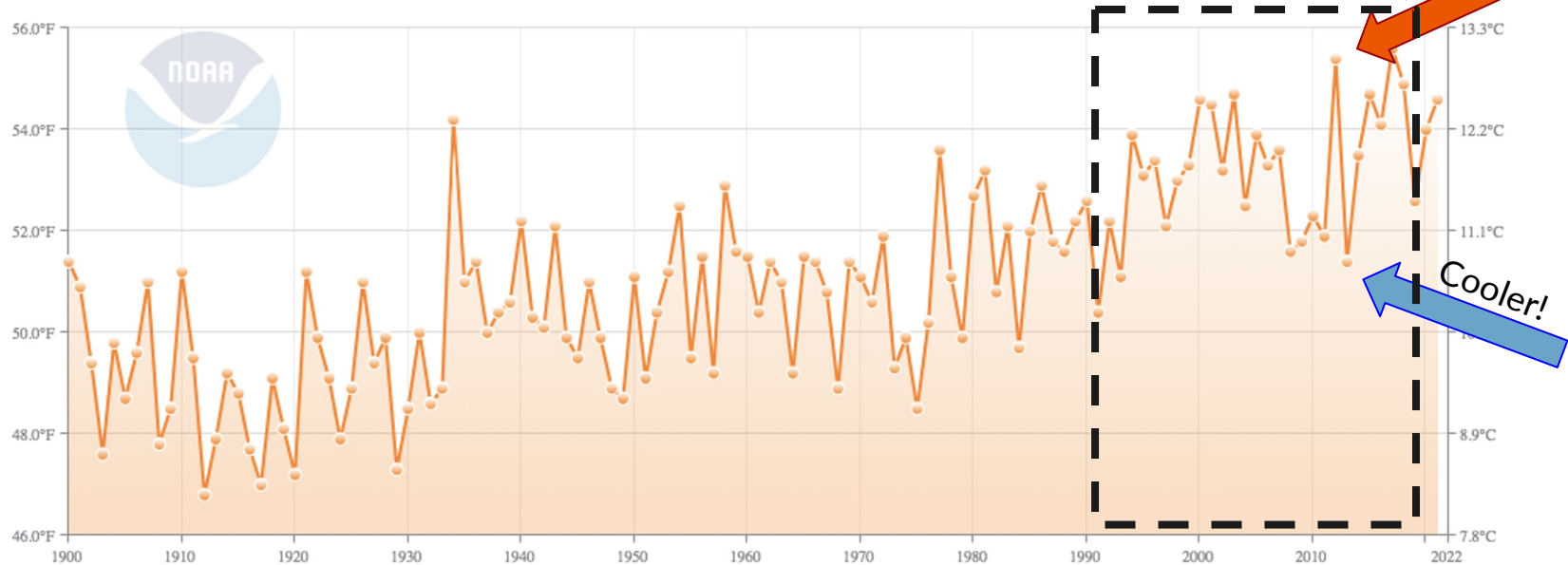
VS

Weather icons: Sun behind cloud, Cloud, Cloud with rain, Cloud with snow

Climatological "Normal" Periods

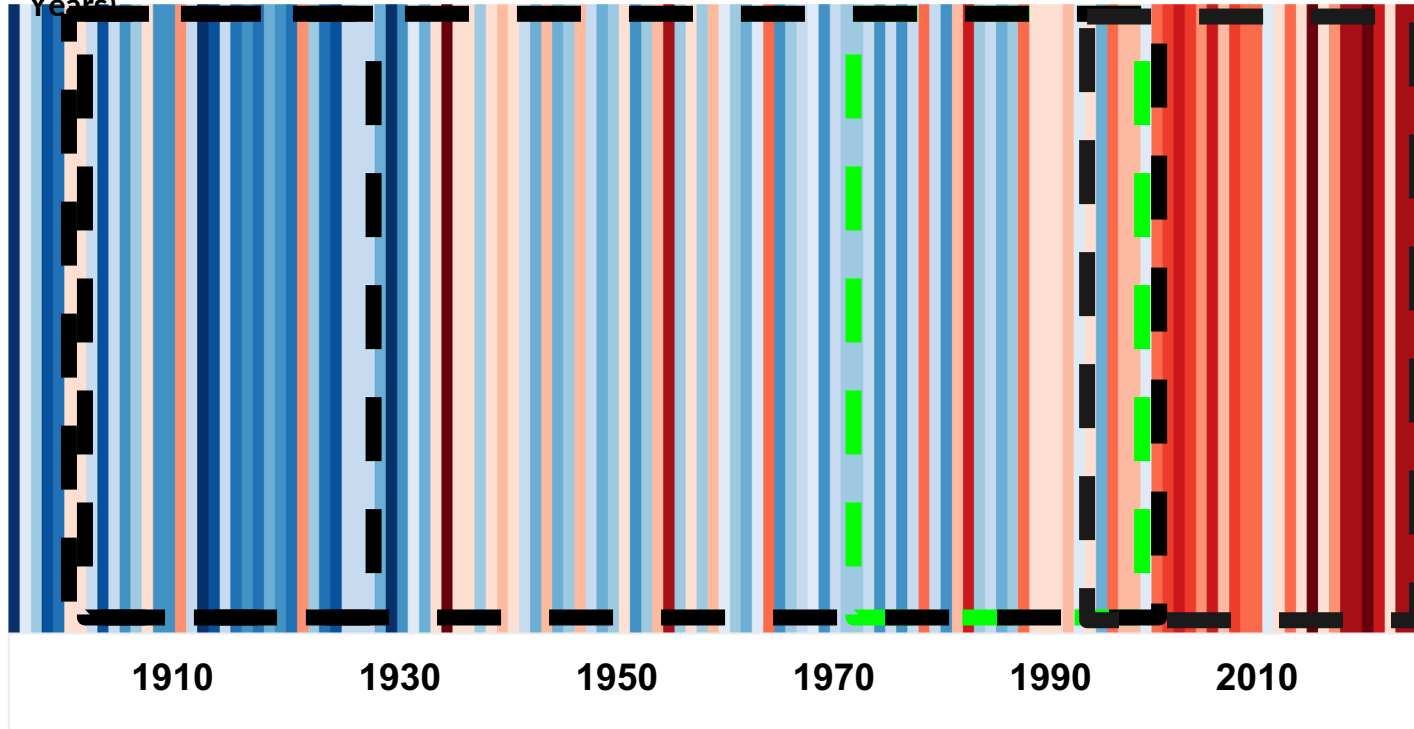


Grand Junction, Colorado Average Temperature
January-December



Understanding Change: Climate Normal Periods as Baselines

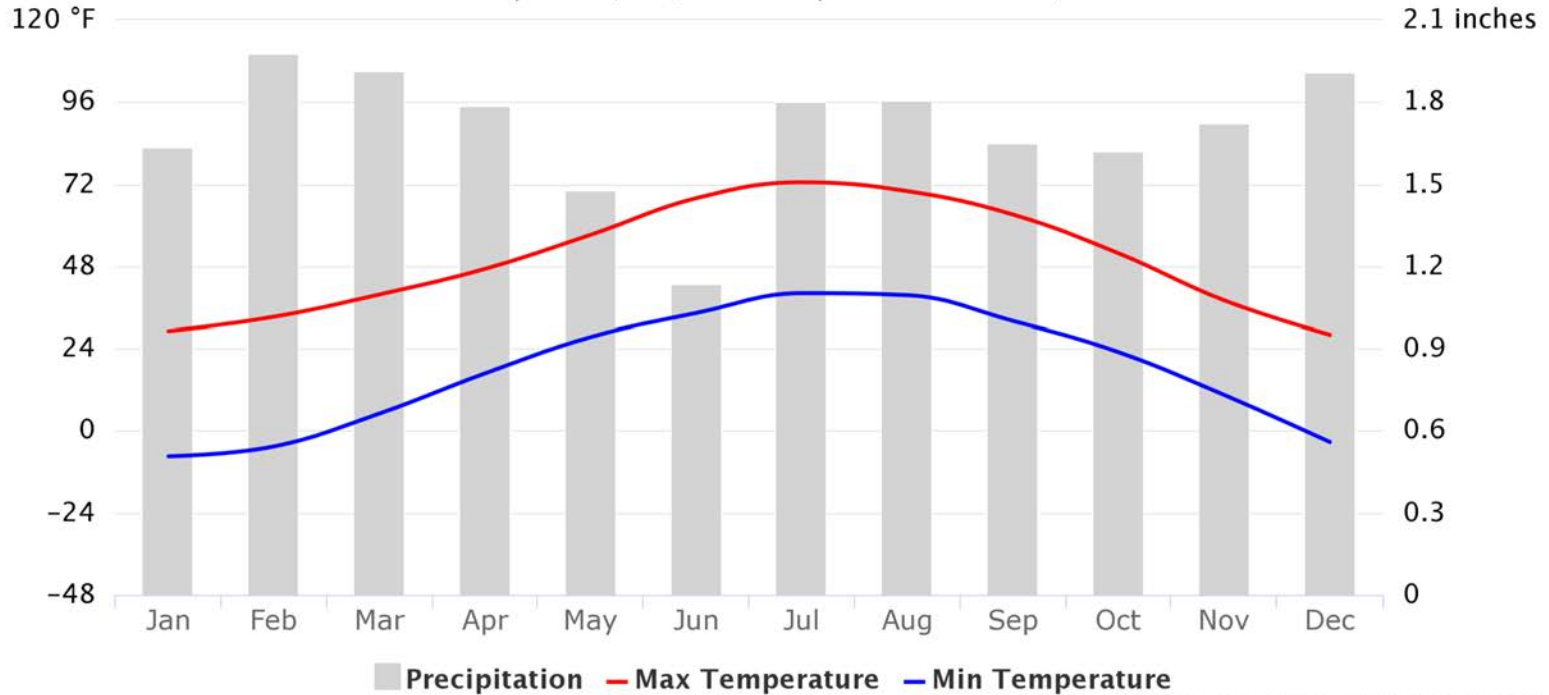
Colorado Annual Temperature (Blue Stripes = Cooler Years; Red Stripes = Warmer Years)



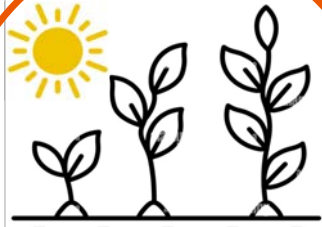
Measuring Climate

Temperature & Precipitation (1981–2010)

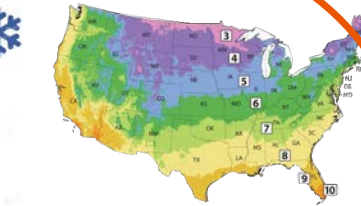
Taylor Park, Co (Annual Precipitation: 20.4 inches)



Forestry-Relevant Climate Indicators



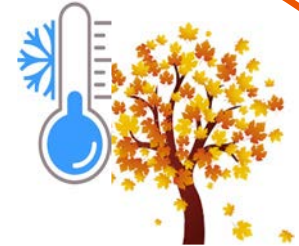
Growing Degree Days (GDD)



Coldest T of the year (TNn) and Plant Hardiness Zone



Last Spring Freeze



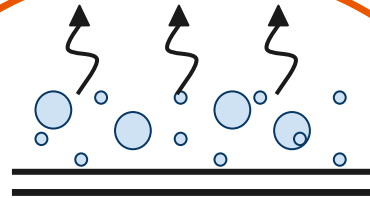
First Fall Freeze



Snowpack



Heat Days



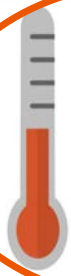
Vapor Pressure Deficit



Fire Danger Days

The Climate of the Taylor Park ASCC Study Site: Historical Data

Historical Climate



Annual
Temp: 35 °F



Annual
Prcp: 21"



TNn: -22 °F
Hardiness
Zone: 4b



GDD(32F):
3124 DD



April 1 SWE:
8.3"



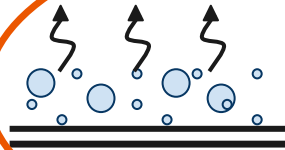
Last Spring
Freeze: June 13th



First Fall Freeze:
August 28th



Heat Days: 0

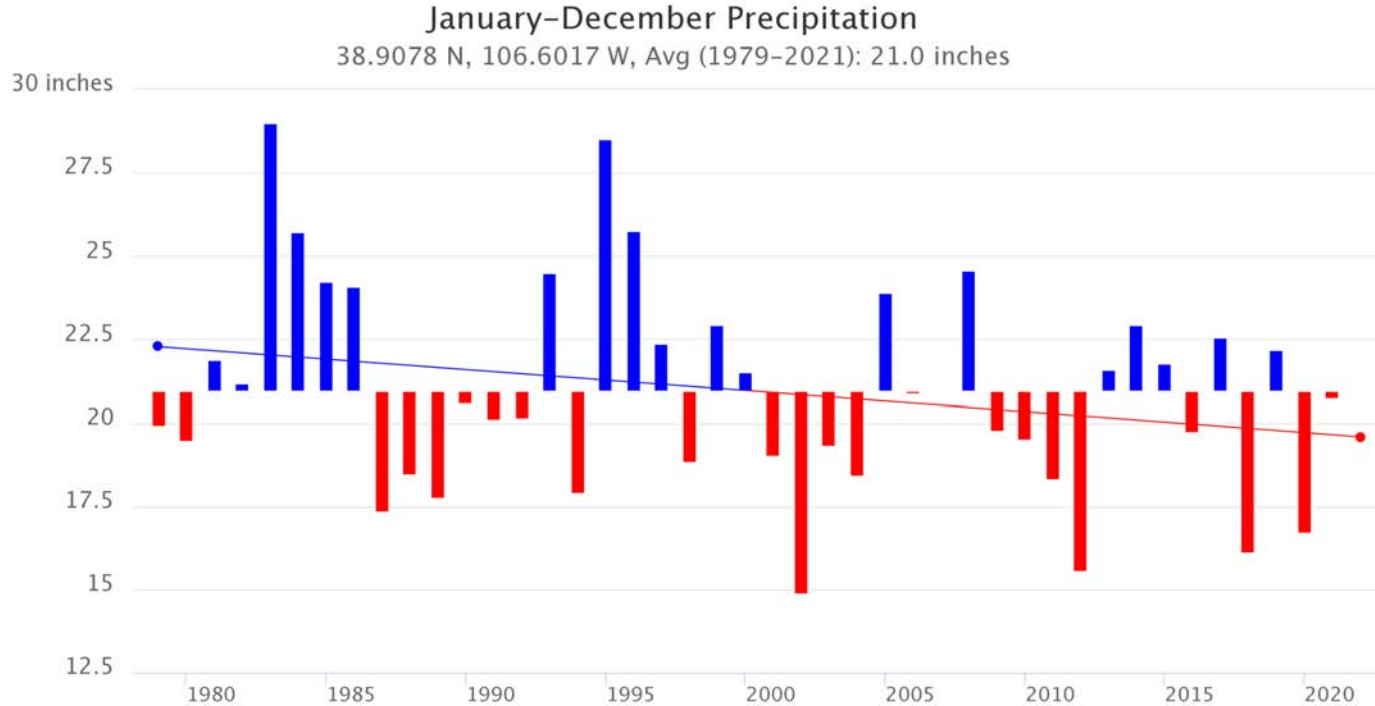


JJA Vapor
Pressure
Deficit: 0.9kPa



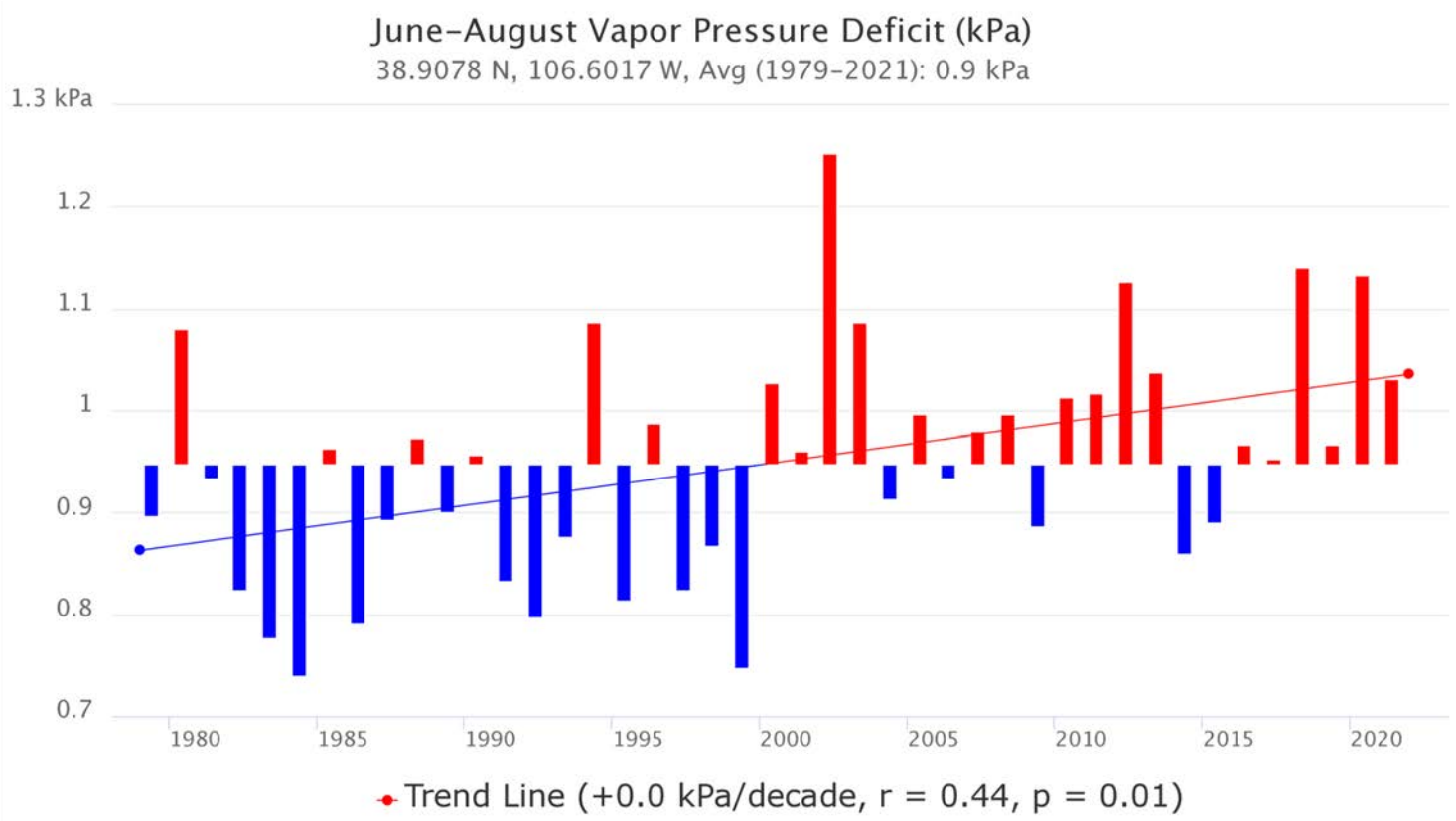
Fire Danger
Days: 11

Historical Climate Trends



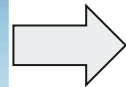
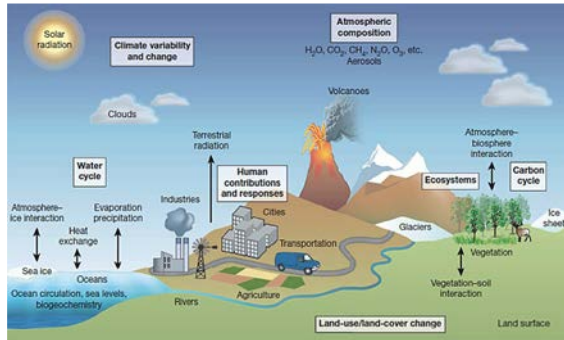
• Trend Line (-0.6 inches/decade, $r = -0.25$, $p = 0.12$)

Historical Climate Trends



The Climate of the Taylor Park ASCC Study Site: Future Projections

Climate Models - How we know what we know



$$f(\omega) = \int f(x) e^{-i\omega x} dx$$

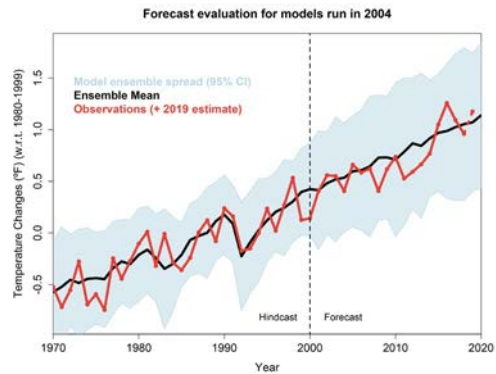
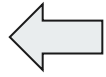
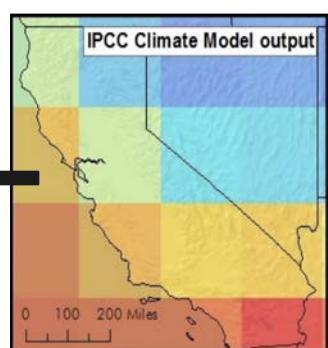
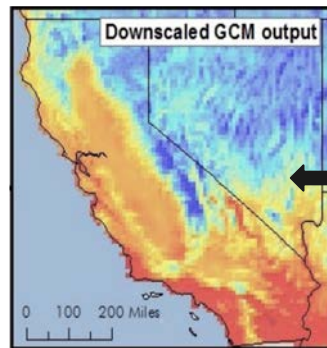
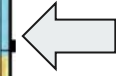
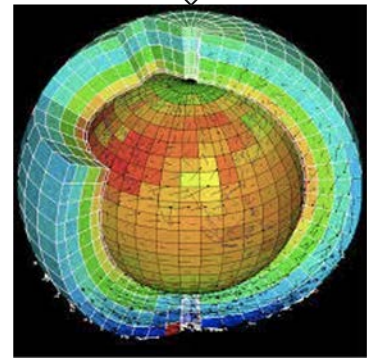
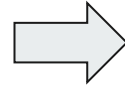
$$\rho \left(\frac{\partial}{\partial t} + v \cdot \nabla \right) = -\nabla p + \nabla \cdot T + f$$

$$H = \sum \rho(x) \log(\rho(x))$$

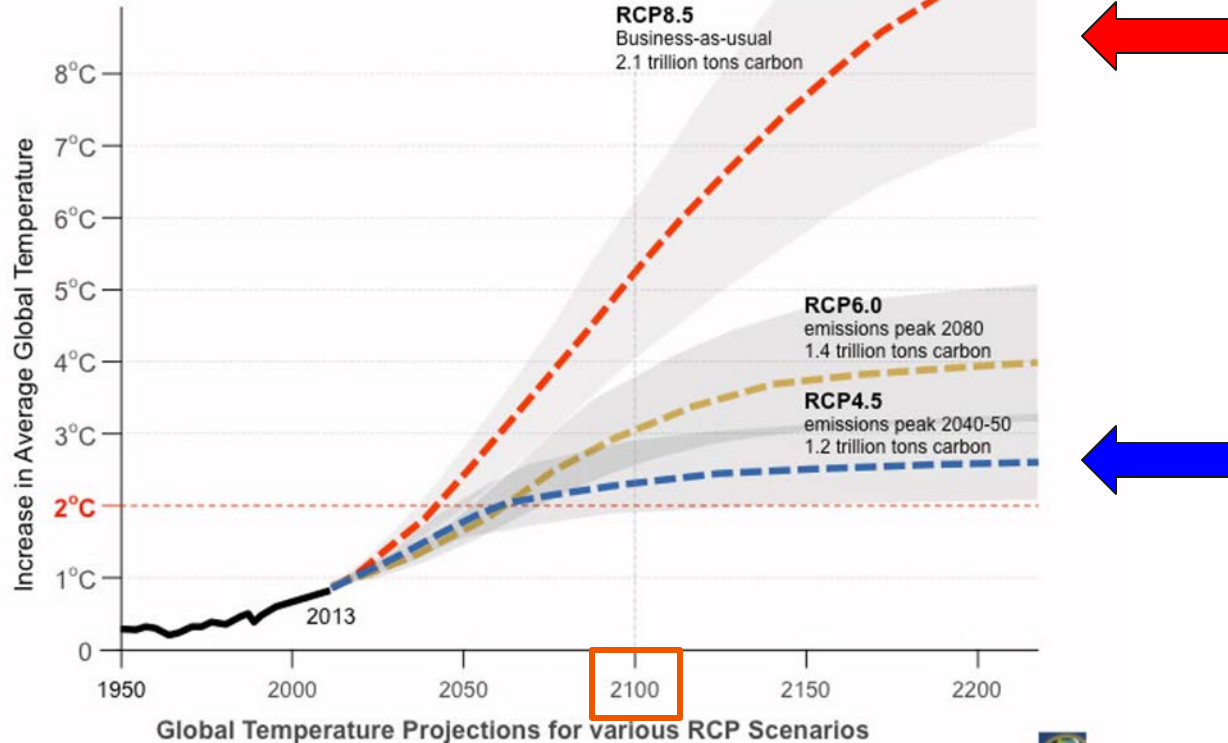
$$TC(Q, q, m) = \sum_{i=1}^n \left[\frac{\partial}{\partial t} S_i + c_i D_i + \frac{q_i H_i}{m} \left(m \left(1 - \frac{D_i}{T_i} \right) - 1 + \frac{\partial D_i}{\partial t} \right) \right]$$

$$\left[\frac{d \Delta p(s, \phi)}{d \phi} \right] = \begin{bmatrix} \beta & -\beta \\ -\beta & 0 \end{bmatrix} \begin{bmatrix} \Delta p(s, \phi) \\ \Delta M(s, \phi) \end{bmatrix}$$

$$\int \log(x) dx = \frac{1}{x} \left(\frac{\pi^2}{12} + \log(x)^2 \right)$$



Future Scenarios



Global Temperature Projections for various RCP Scenarios

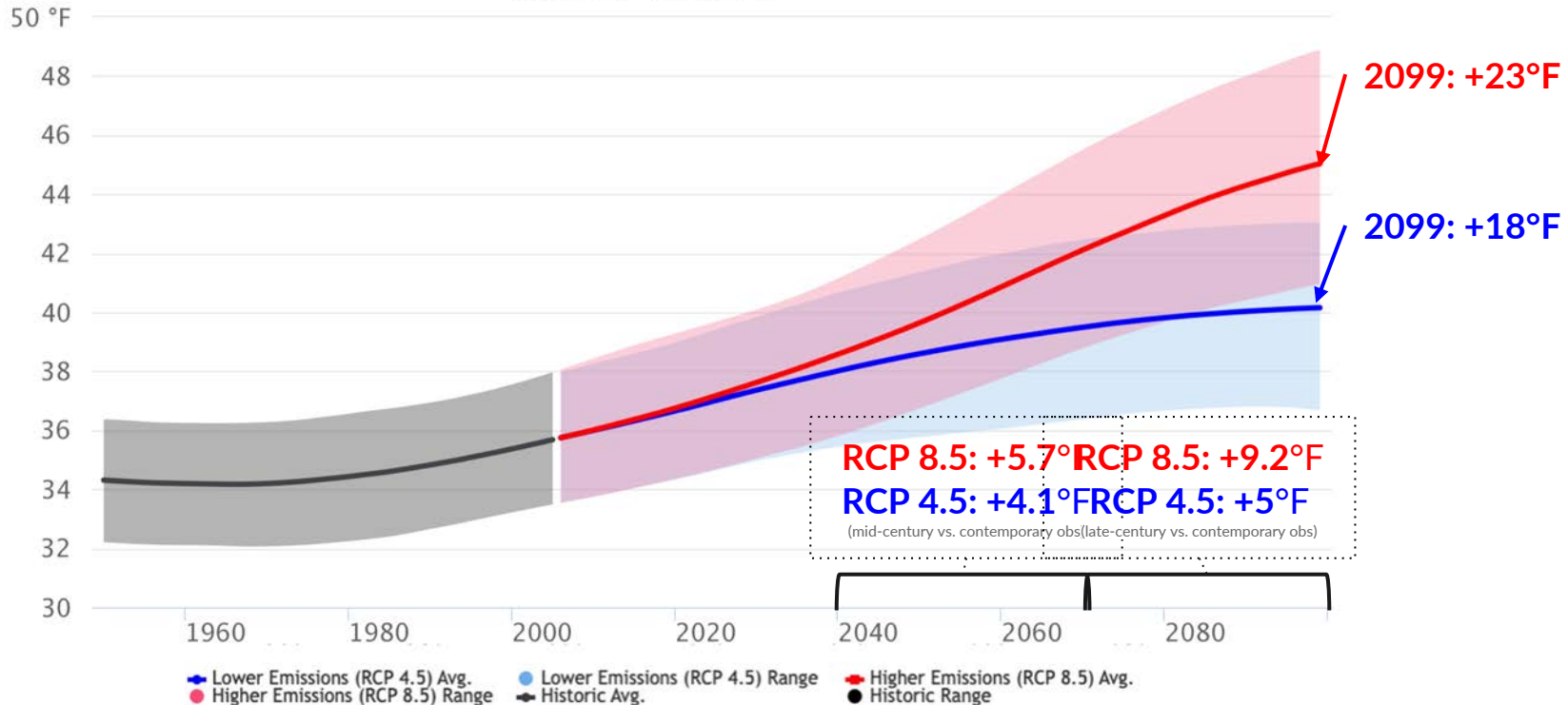
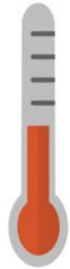
Source: Architecture 2030; Adapted from IPCC Fifth Assessment Report, 2013
Representative Concentration Pathways (RCP), temperature projections for SRES scenarios and the RCPs.



Future Projections

Jan-Dec (Annual) Mean Temperature

38.9078 N, -106.6017 W



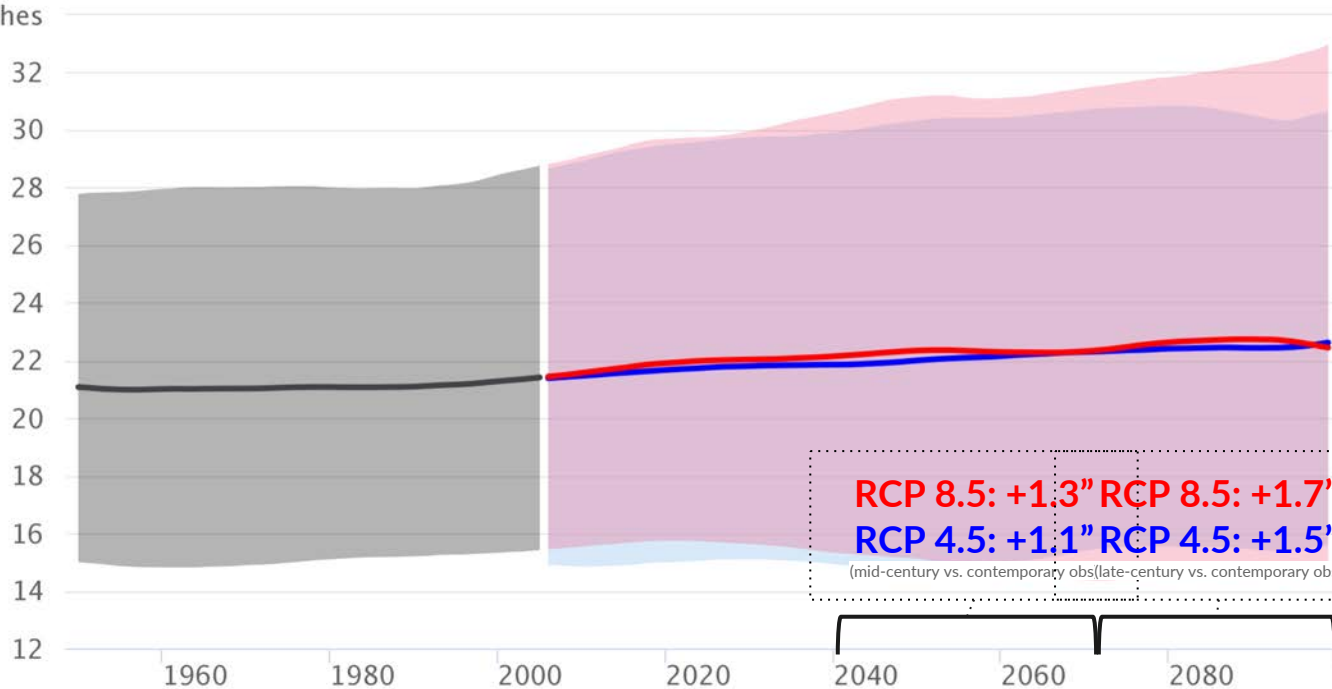
Future Projections



34 inches

Jan-Dec (Annual) Precipitation

38.9078 N, -106.6017 W

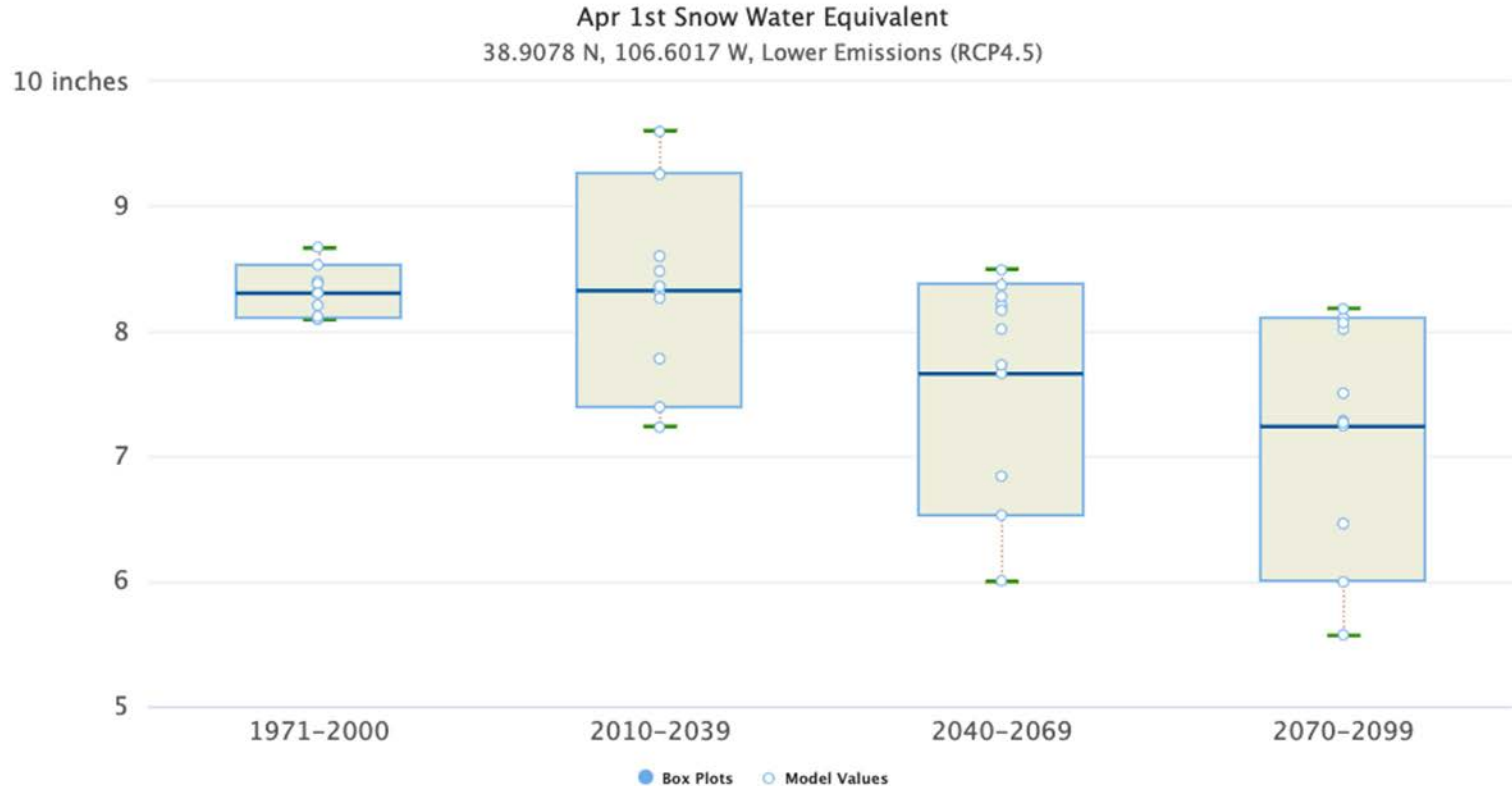


RCP 8.5: +1.3" RCP 8.5: +1.7"
RCP 4.5: +1.1" RCP 4.5: +1.5"

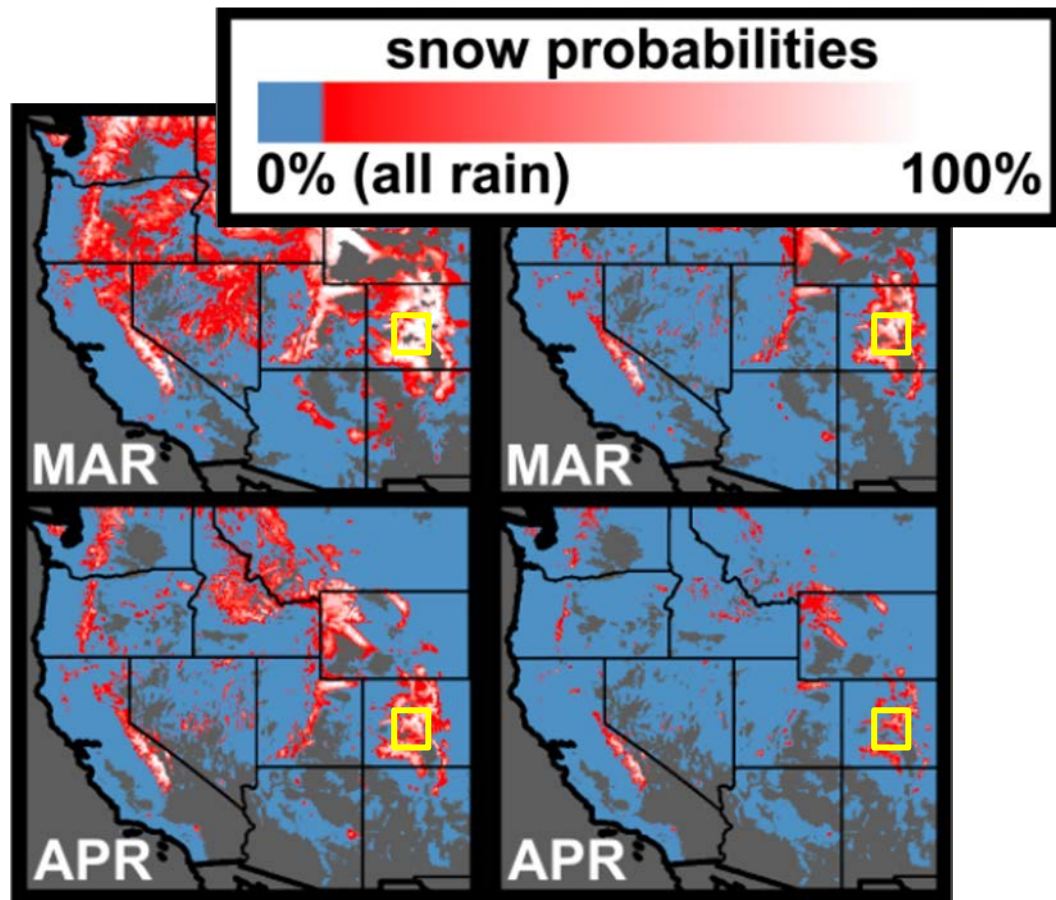
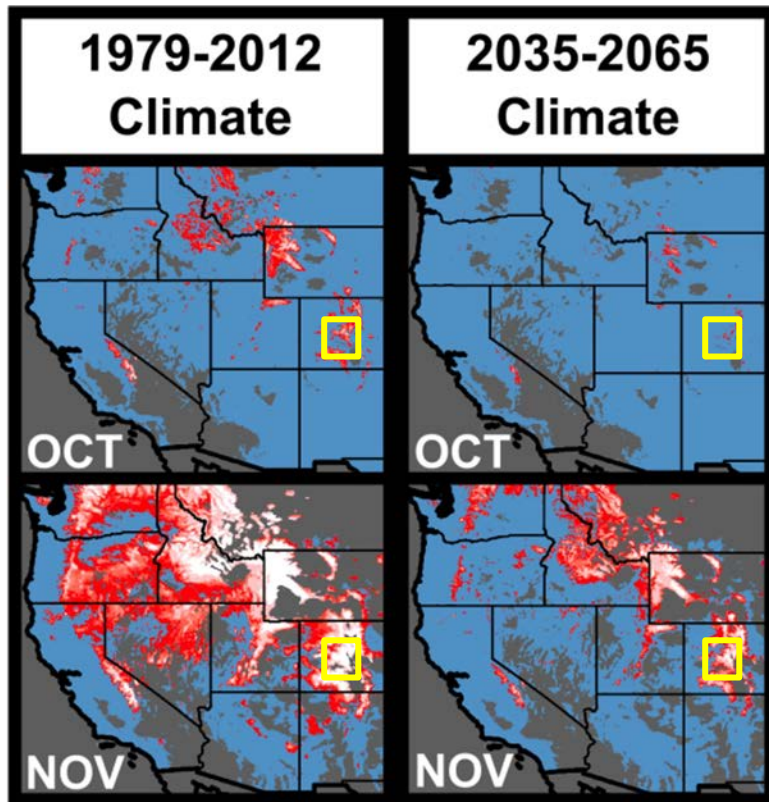
(mid-century vs. contemporary obs)(late-century vs. contemporary obs)

- ◆ Lower Emissions (RCP 4.5) Avg.
- Lower Emissions (RCP 4.5) Range
- ◆ Higher Emissions (RCP 8.5) Avg.
- Higher Emissions (RCP 8.5) Range
- ◆ Historic Avg.
- Historic Range

Future Projections



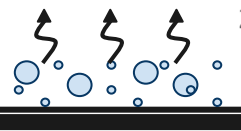
Future Projections



Future Projections

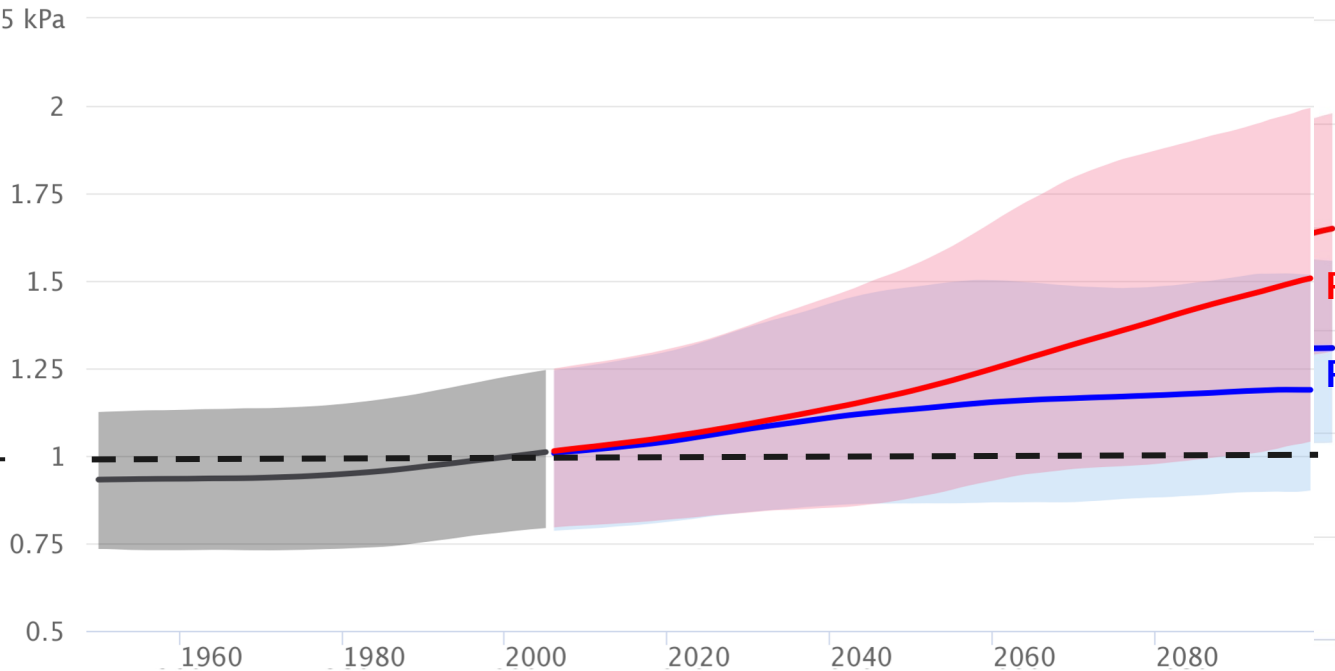
Jun-Jul-Aug Vapor Pressure Deficit

38.9078 N, -106.6017 W



2.25 kPa

High VPD Threshold



RCP 8.5:
RCP 8.5: +0.6 kPa
RCP 4.5: +0.3 kPa

- Lower Emissions (RCP 4.5) Avg.
- Higher Emissions (RCP 8.5) Range
- Lower Emissions (RCP 4.5) Range
- Historic Avg.
- Higher Emissions (RCP 8.5) Avg.
- Historic Range

Climate Toolbox, Data Source: MACAv2-METDATA CMIP5 (UC Merced)

Future Projections

2040-2069 Multi-Model Mean Climatology vs. Contemporary (1979-2021) Observed Climatology



TNn: **↑ 6 to ↑ 8 °F**
Hardiness Zone:
5b to 5b



GDD(32F):
+695 DD to +1290 DD



Last Spring Freeze:
6 to 9 days earlier



First Fall Freeze:
3 to 3.5 weeks later



Hottest Day: **↑ 5 to ↑ 7 °F**
Heat Days: **< 1 to 1**



Fire Danger Days (2040-2069):
18 - 22
(+7 to +11)

Future Projections

2070-2099 Multi-Model Mean Climatology vs. Contemporary (1979-2021) Observed Climatology



TNn: **↑7** to **↑13** °F
Hardiness Zone:
5b to **6a**



GDD(32F):
+910 DD to **2190 DD**



Last Spring Freeze:
1 to **3** weeks earlier



First Fall Freeze:
2 to **4** weeks later



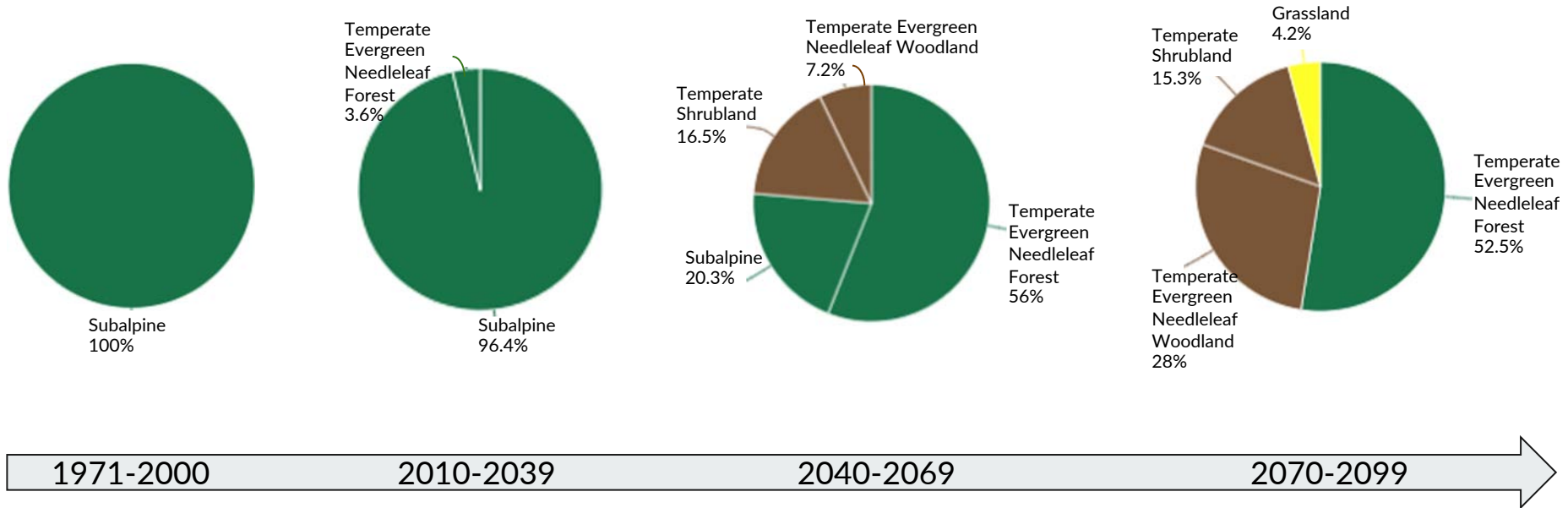
Hottest Day: **↑6** to **↑11** °F
Heat Days: **1** to **10**



Unavailable for end of century

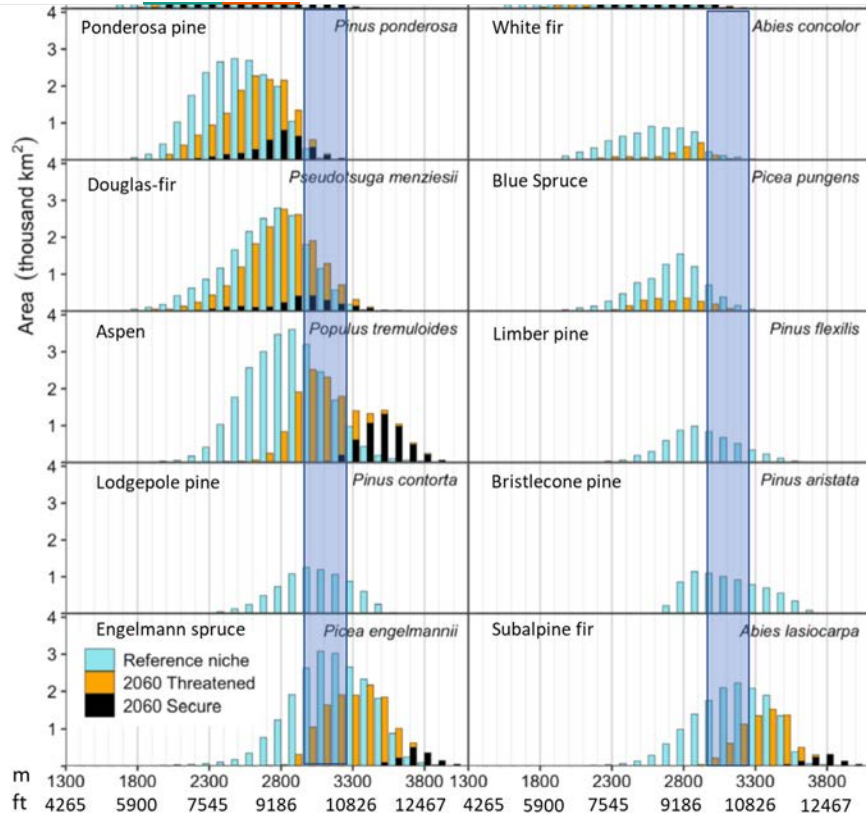
Vegetation Class Niche Shifts

Climate-driven shifts in vegetation cover



Shifts in modeled vegetation class under RCP 8.5, with fire suppression

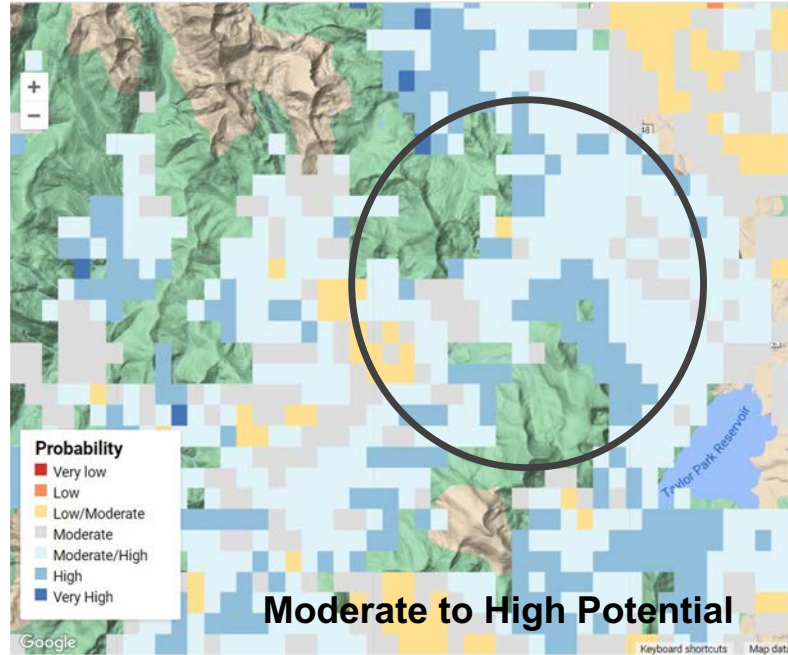
Climatic Niche Models – 2060



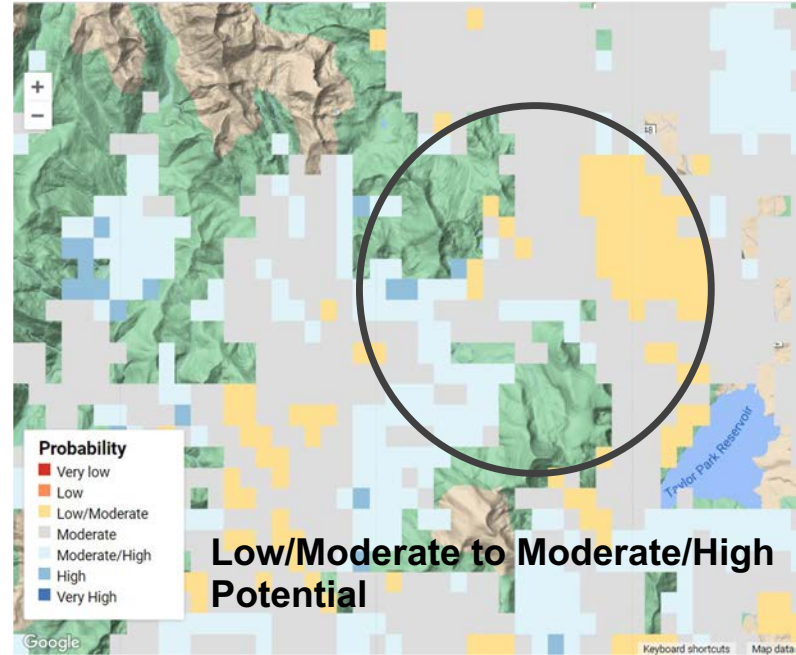
- Blue shaded box represents study site elevation range
- **Potential loss** of lodgepole pine, limber pine, bristlecone pine, white fir
- **Threatened**: Aspen, Blue spruce, Engelmann spruce, and subalpine fir
- **Secure**: Ponderosa pine, Douglas-fir

Regeneration potential after high severity fire

Lodgepole Pine, Current Climate (2001-2020)



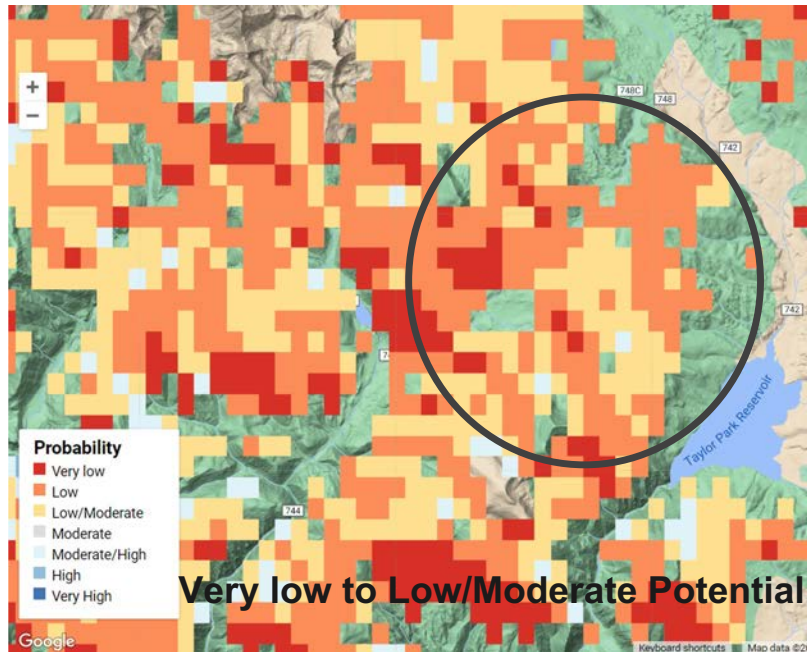
Lodgepole Pine, RCP 4.5, (2031-2050)



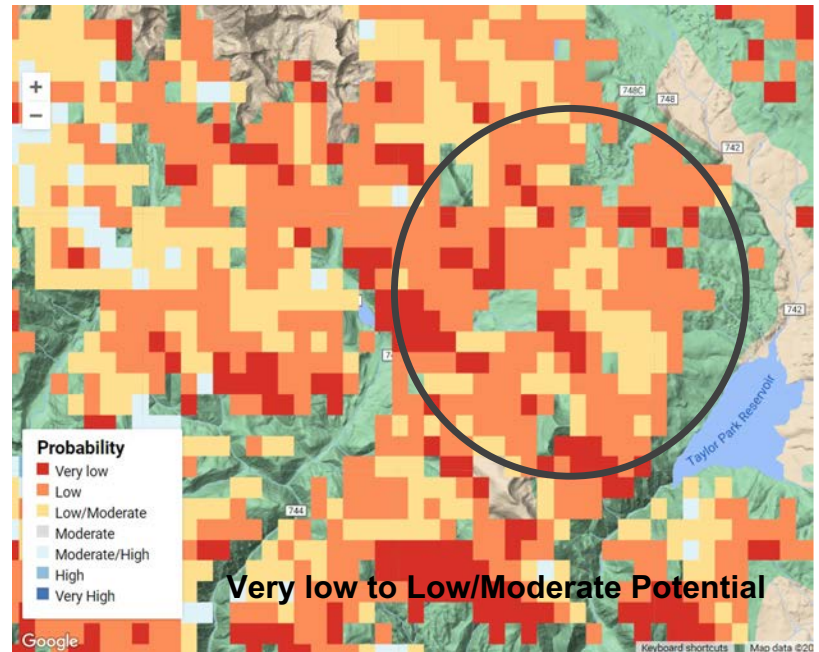
Regeneration potential after high severity fire



Engelmann Spruce, Current Climate, (2001-2020)



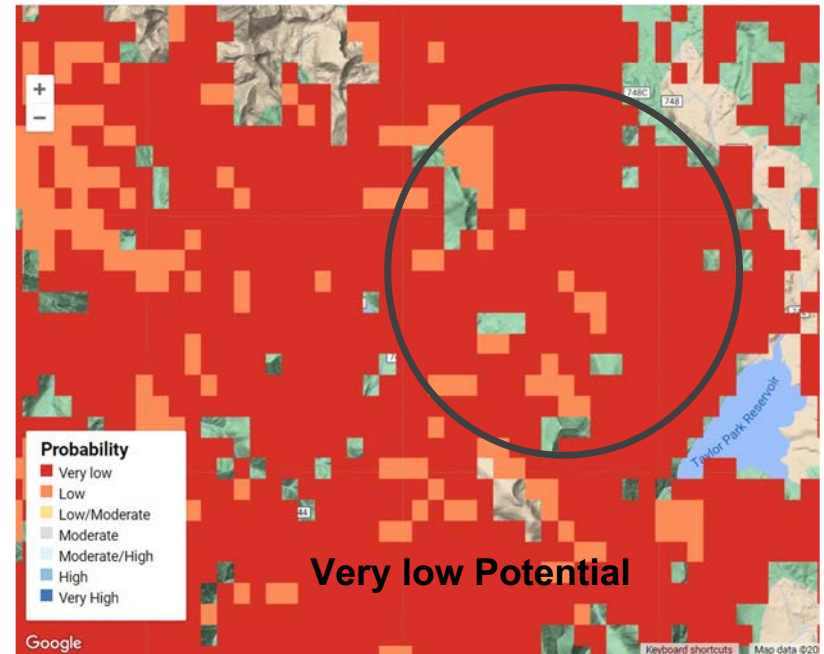
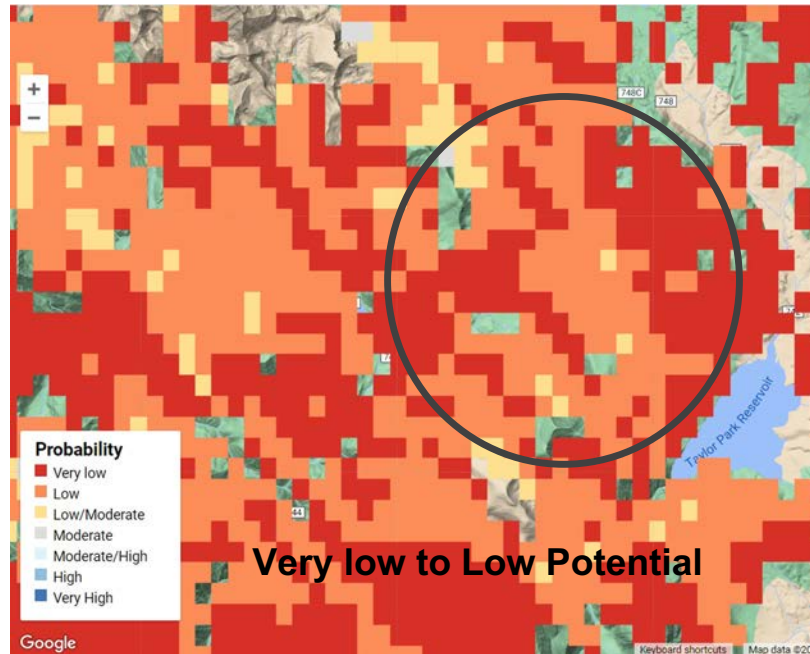
Engelmann Spruce, RCP 4.5, (2031-2050)



Regeneration potential after high severity fire

Subalpine fir, Current Climate (2001-2020)


Subalpine Fir, RCP 4.5 (2031-2050)



Questions or Comments

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Online Climate Tools & Resources

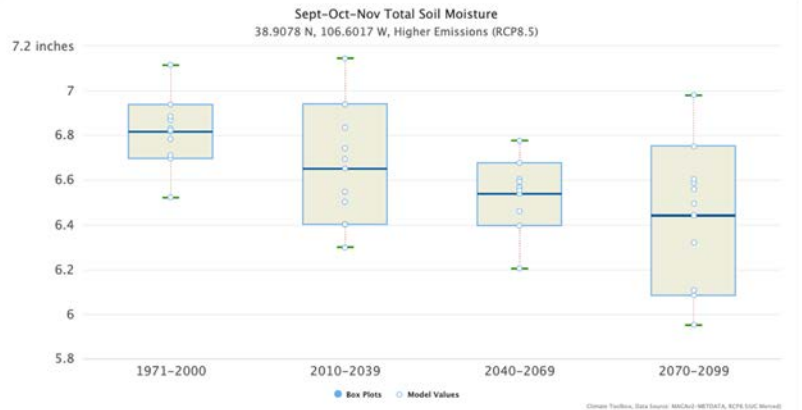
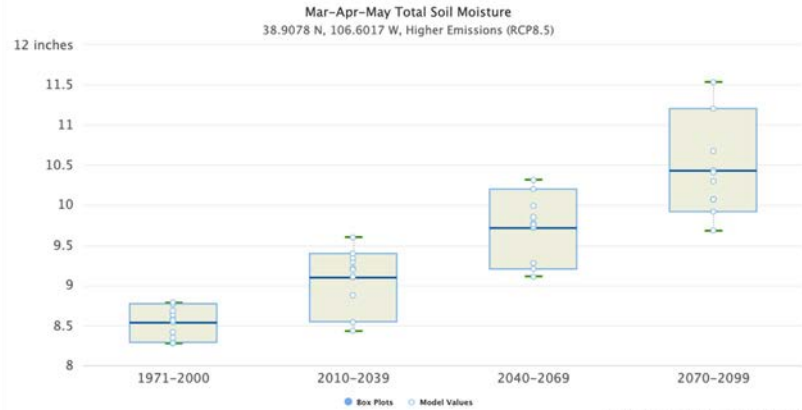
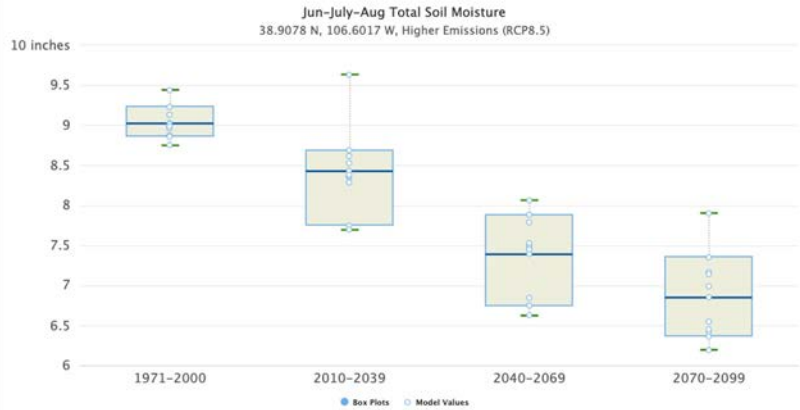
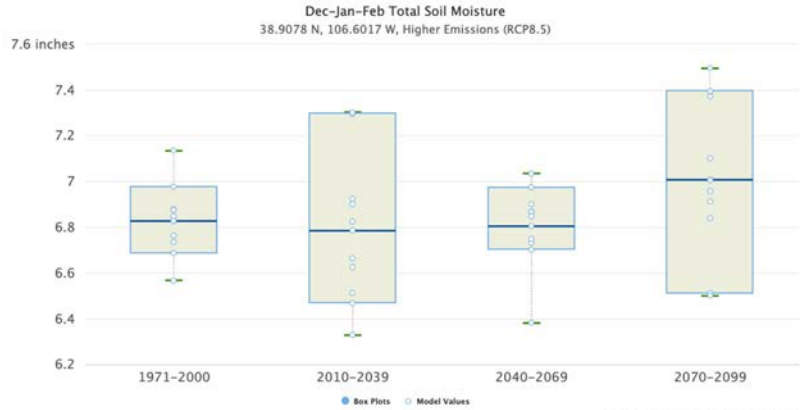


ClimateToolbox – Historic and future climate data for the contiguous US with variables for applications including water, agriculture, and fire. Source of many of the graphics and data in this presentation. Modeled climate data are available at a 4-km resolution at a daily time step for 20 climate models from 1971-2099 under 2 RCP scenarios (4.5 and 8.5). Daily observed data are available on a 4-km grid from 1979 to yesterday.

<https://climatetoolbox.org/>

Climate-By-Forest – Climate projections for every national forest in the US, with information at the ecoregion scale (e.g. Elk Mountains region in the GMUG). Underlying data are from the MACA and GridMET datasets, which are also the underlying data provided by ClimateToolbox. <https://climate-by-forest.nemac.org/>

Soil Moisture

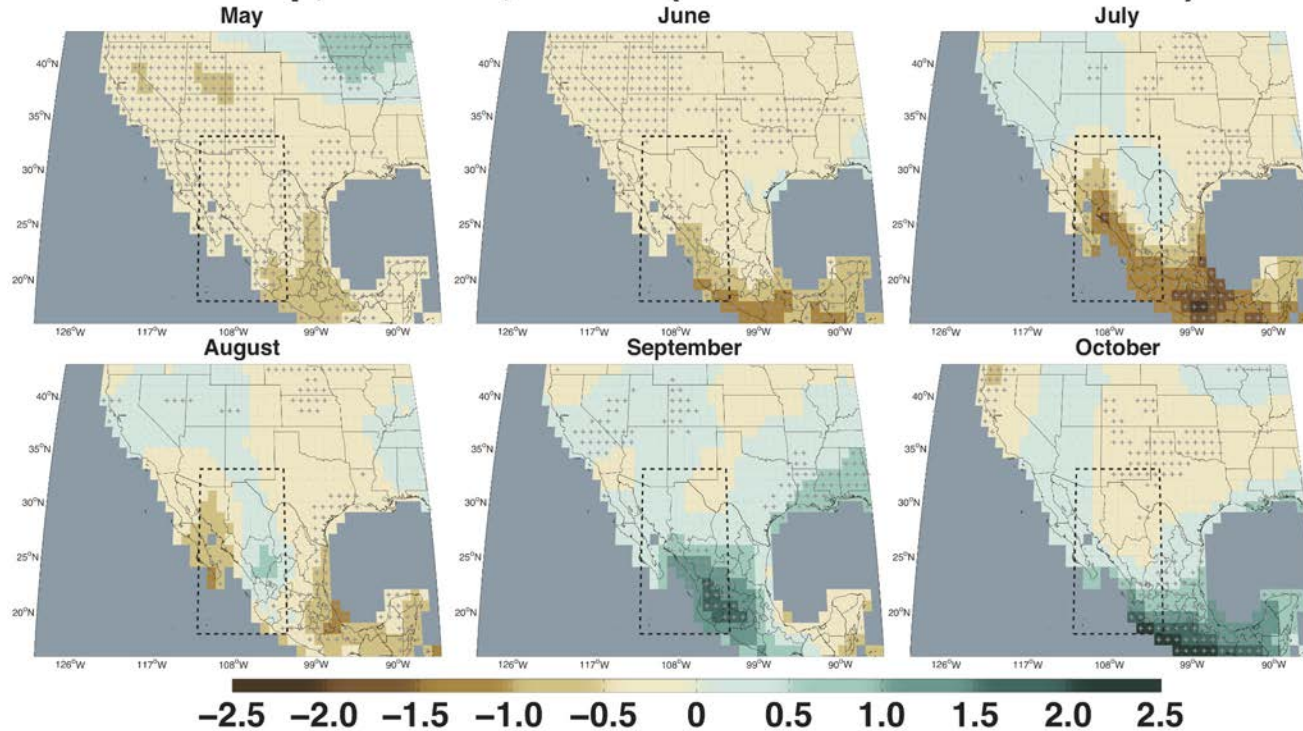


Climate Toolbox, Data Source: MRCAD2-METADATA, RCP8.5C-Monset

Climate Toolbox, Data Source: MRCAD2-METADATA, RCP8.5C-Monset

North American Monsoon

Δ Precip, RCP 8.5, mm d^{-1} (2080–2099 vs 1980–1999)



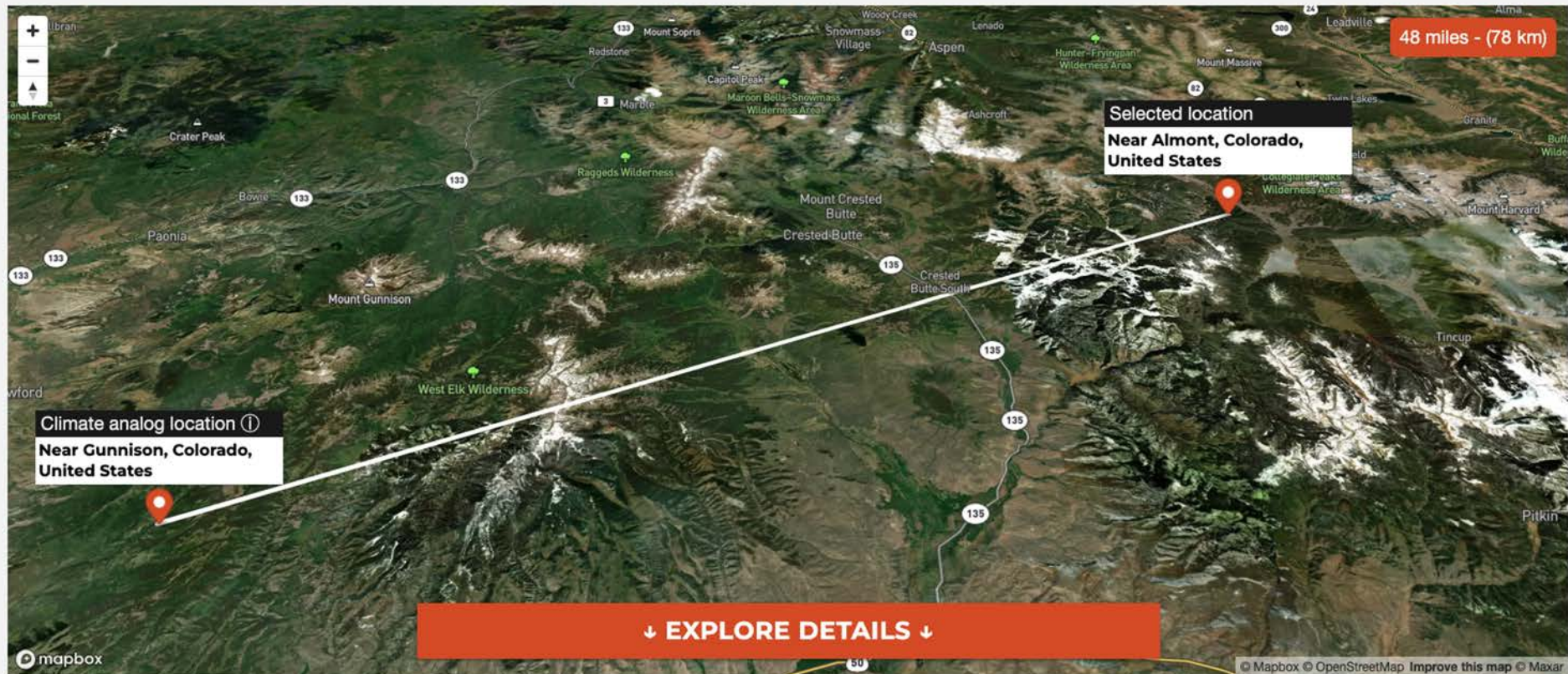
Climate Analogs

ANALOG ATLAS

TRY ANOTHER LOCATION

SELECT YOUR FUTURE CLIMATE CONDITIONS

2c 4c 



↓ EXPLORE DETAILS ↓