

# Sagebrush, perennial grasses & soil moisture: what should we expect?

John Bradford



Northwest CASC

SW Biological Science Center



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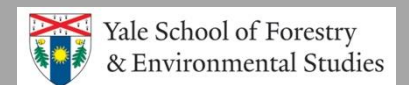
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# Sagebrush, perennial grasses & soil moisture: what should we expect?

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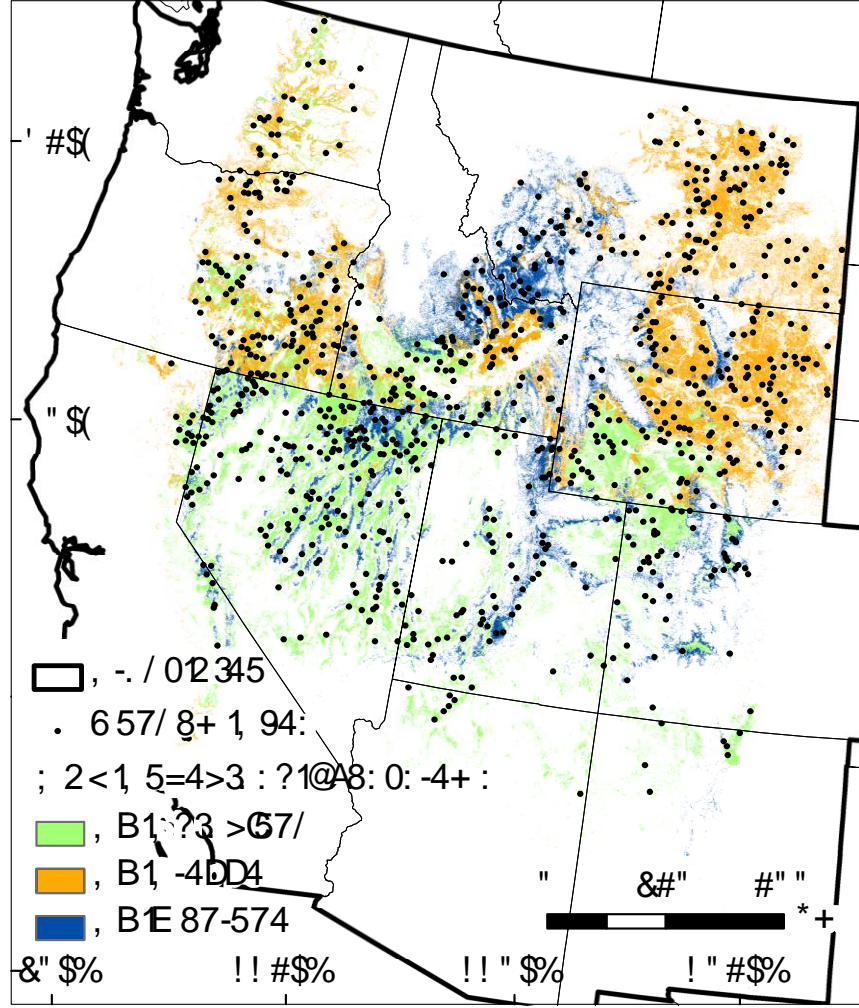
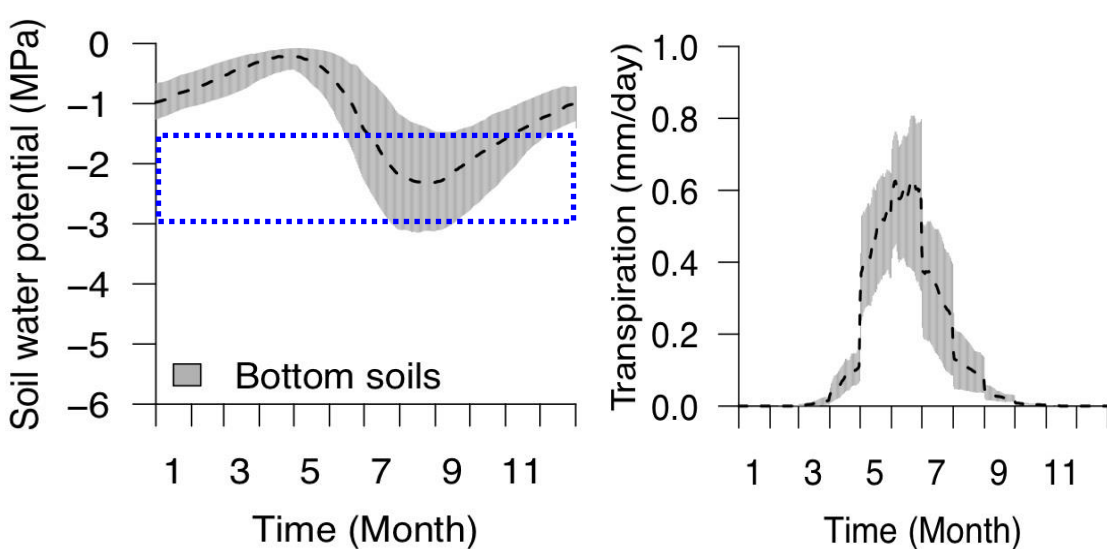
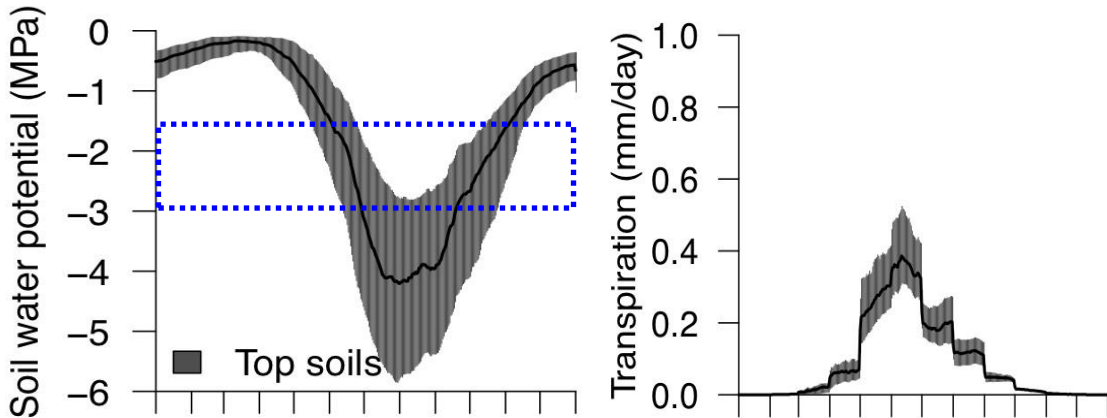
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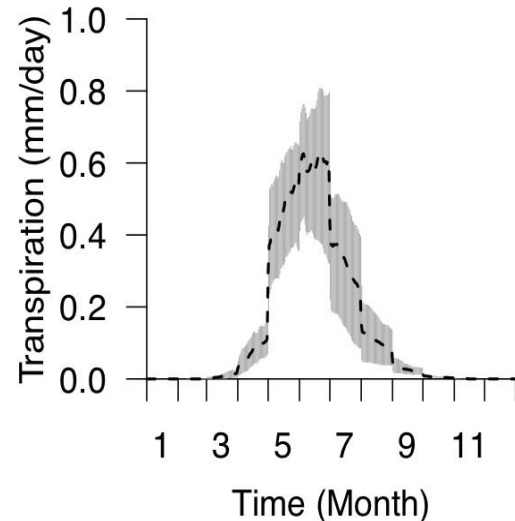
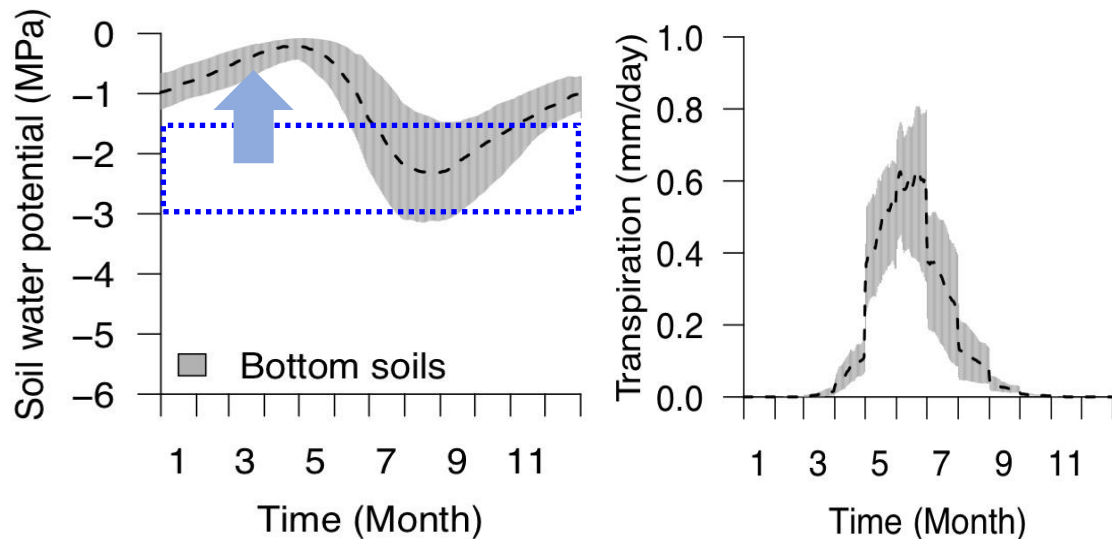
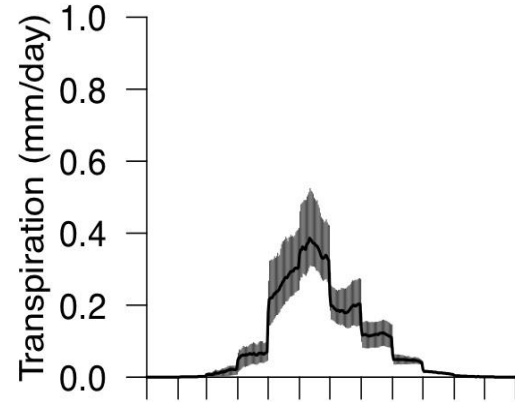
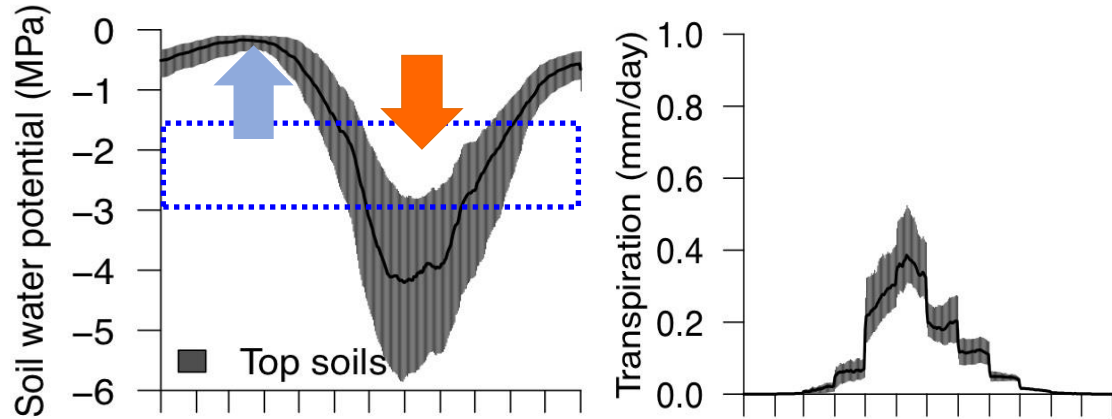
- Soil moisture in big sagebrush ecosystems
- Impact of changing climate
- Implications for vegetation



# Soil moisture in sagebrush systems

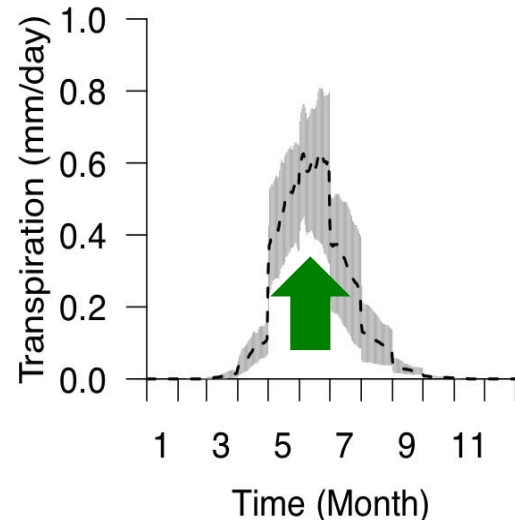
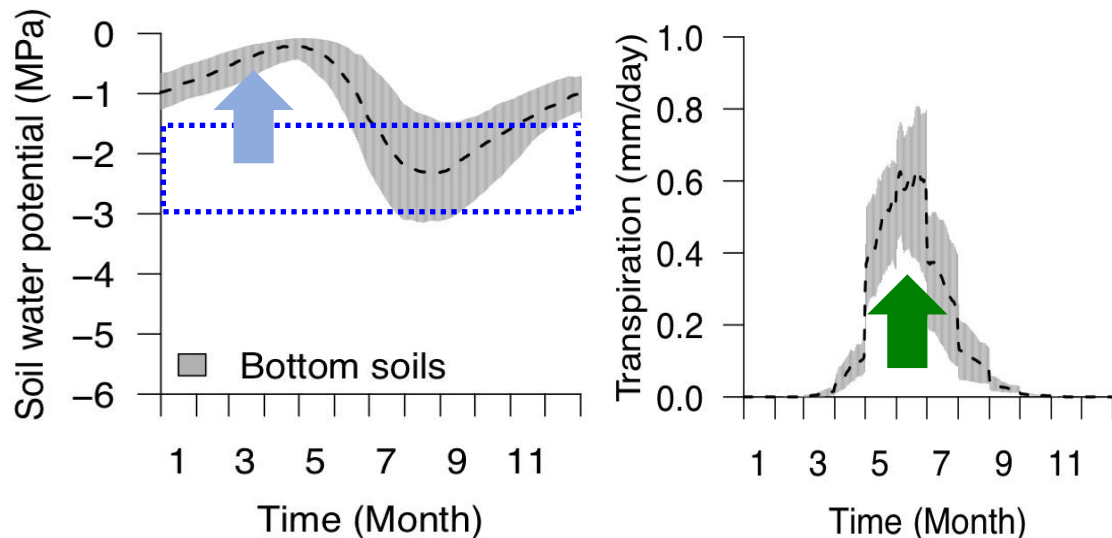
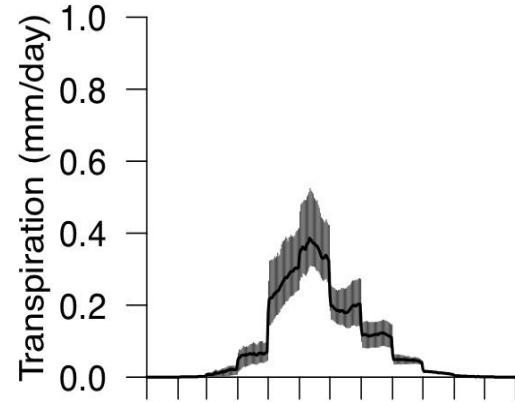
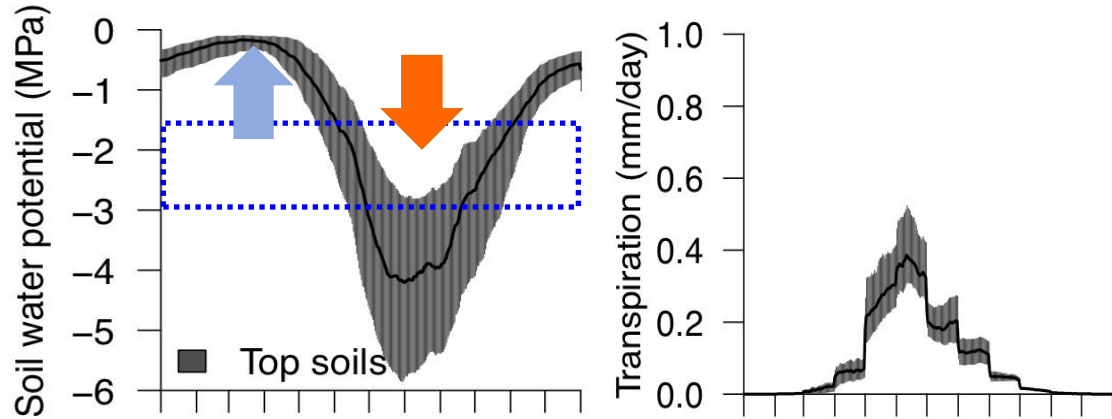


# Soil moisture in sagebrush systems



- Seasonal water dynamics defined by cool season recharge of soil water
- Summer dry period in top soil layers

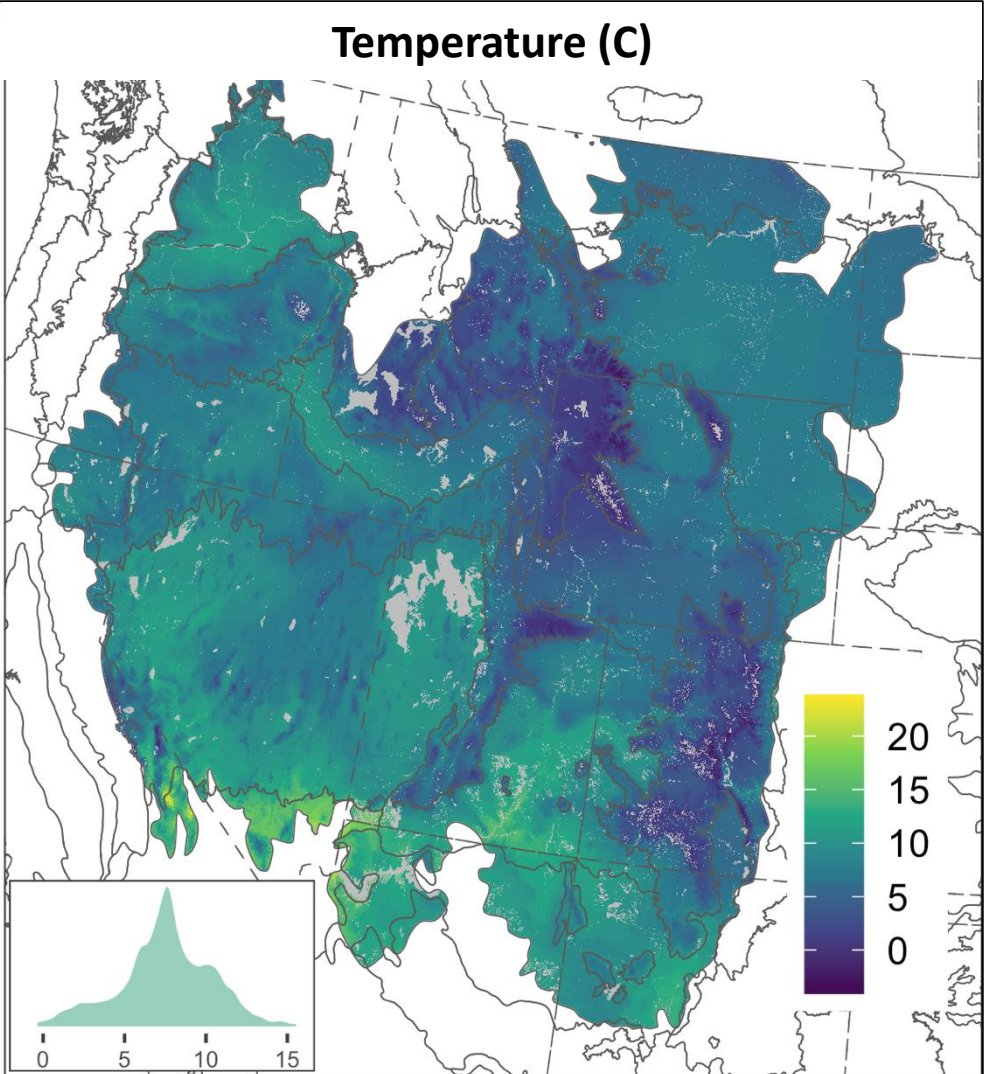
# Soil moisture in sagebrush systems



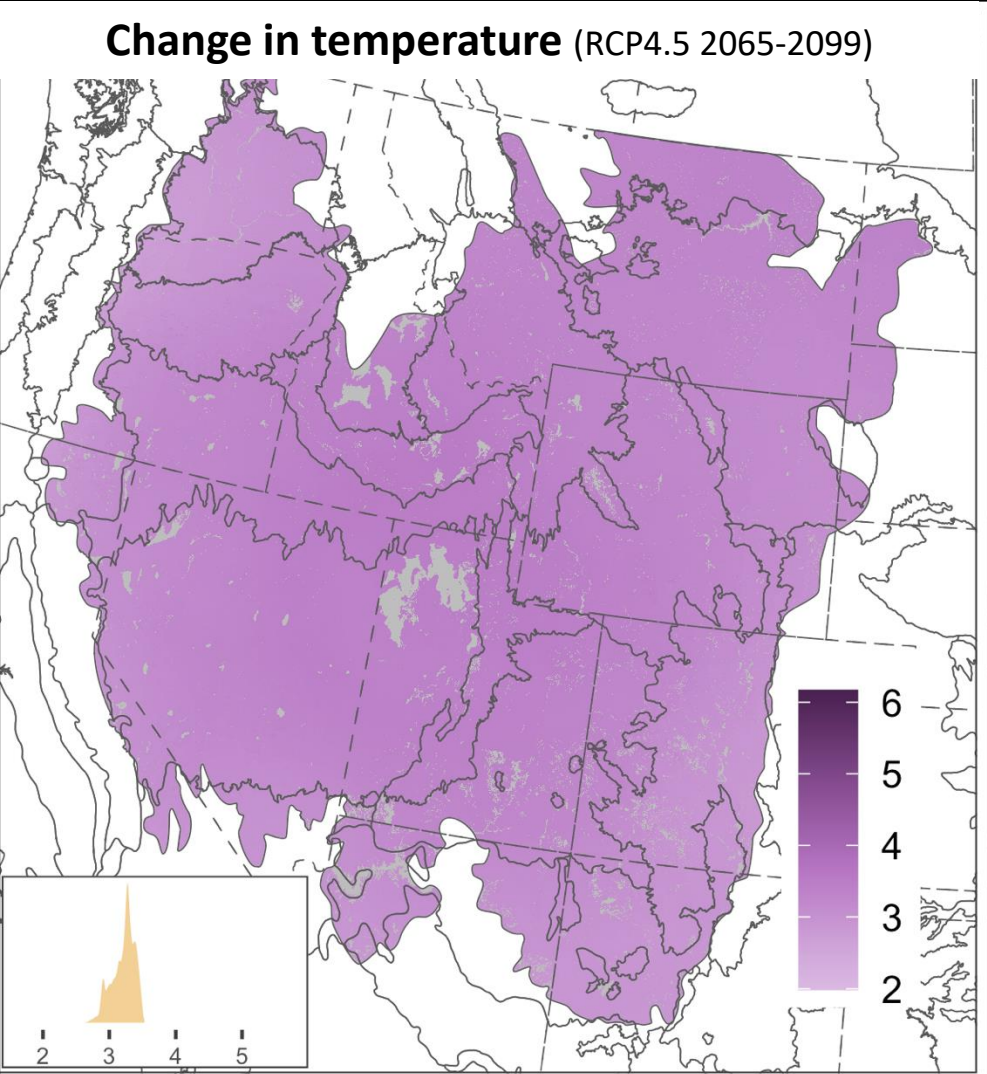
- Seasonal water dynamics defined by cool season recharge of soil water
- Summer dry period in top soil layers
- More transpiration from bottom than top soil layers
- Sagebrush ecohydrological niche: utilization of deep, seasonally-stored water

# Temperature

Temperature (C)

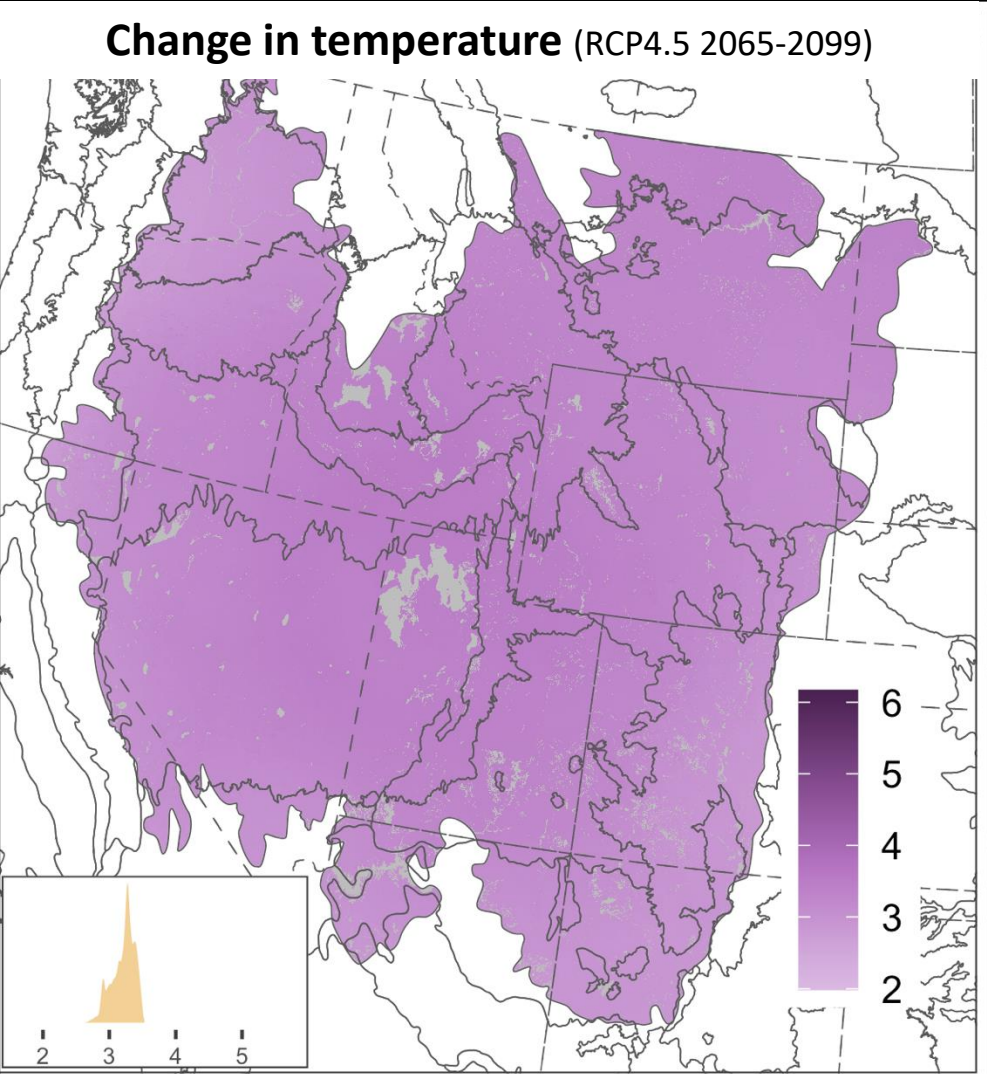
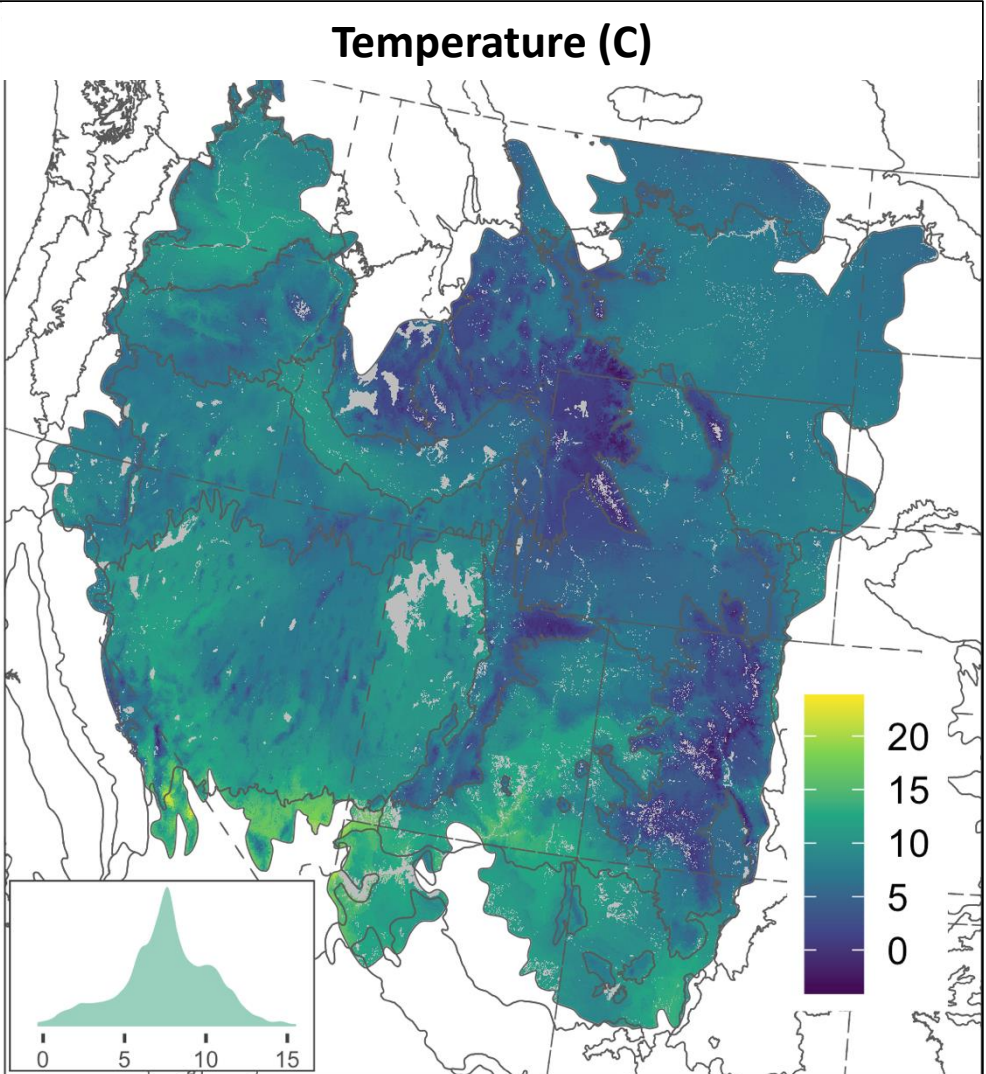


Change in temperature (RCP4.5 2065-2099)



# Temperature

- Robust increases in all places & all seasons
- Perhaps slightly greater increases in north & summer

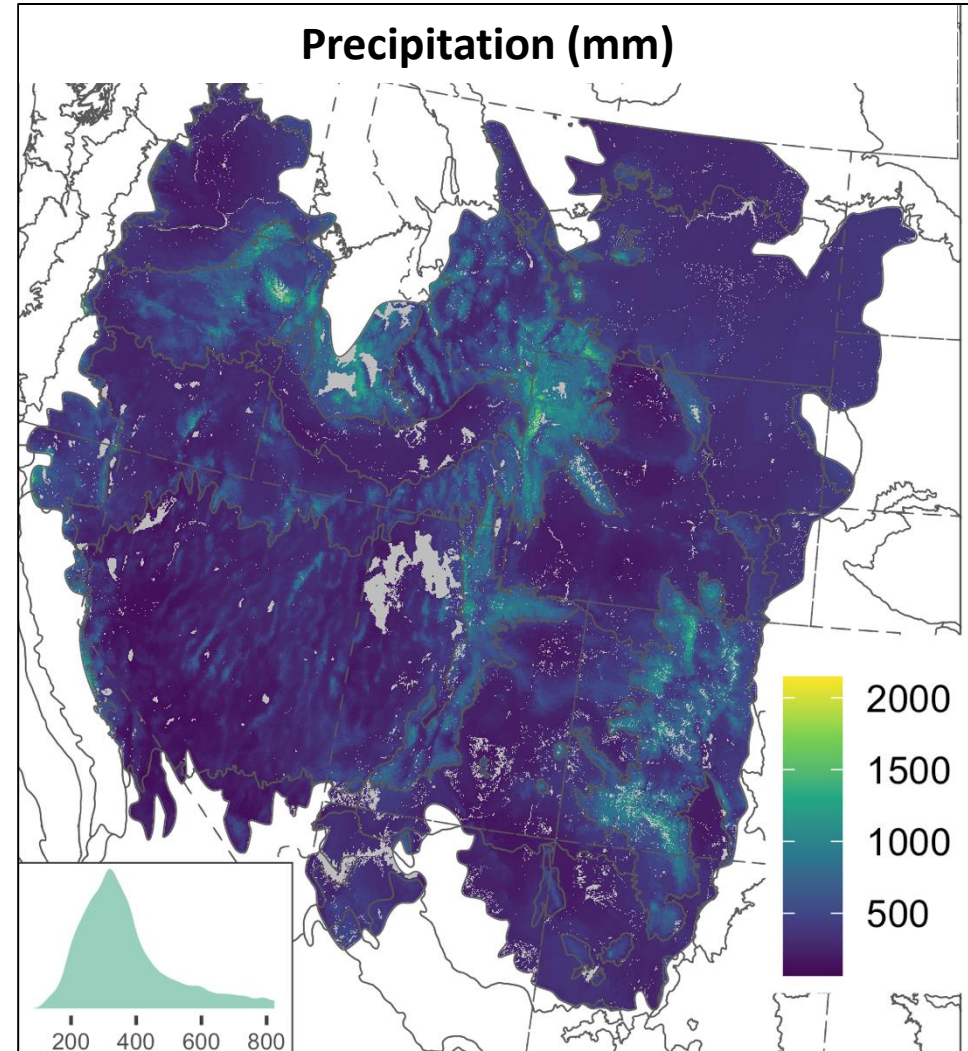


- Impacted by ↑ T
- growing season length
  - frost dates
  - vapor pressure deficit (VPD)
  - potential evapotranspiration (PET)
  - meteorological drought & aridity indices

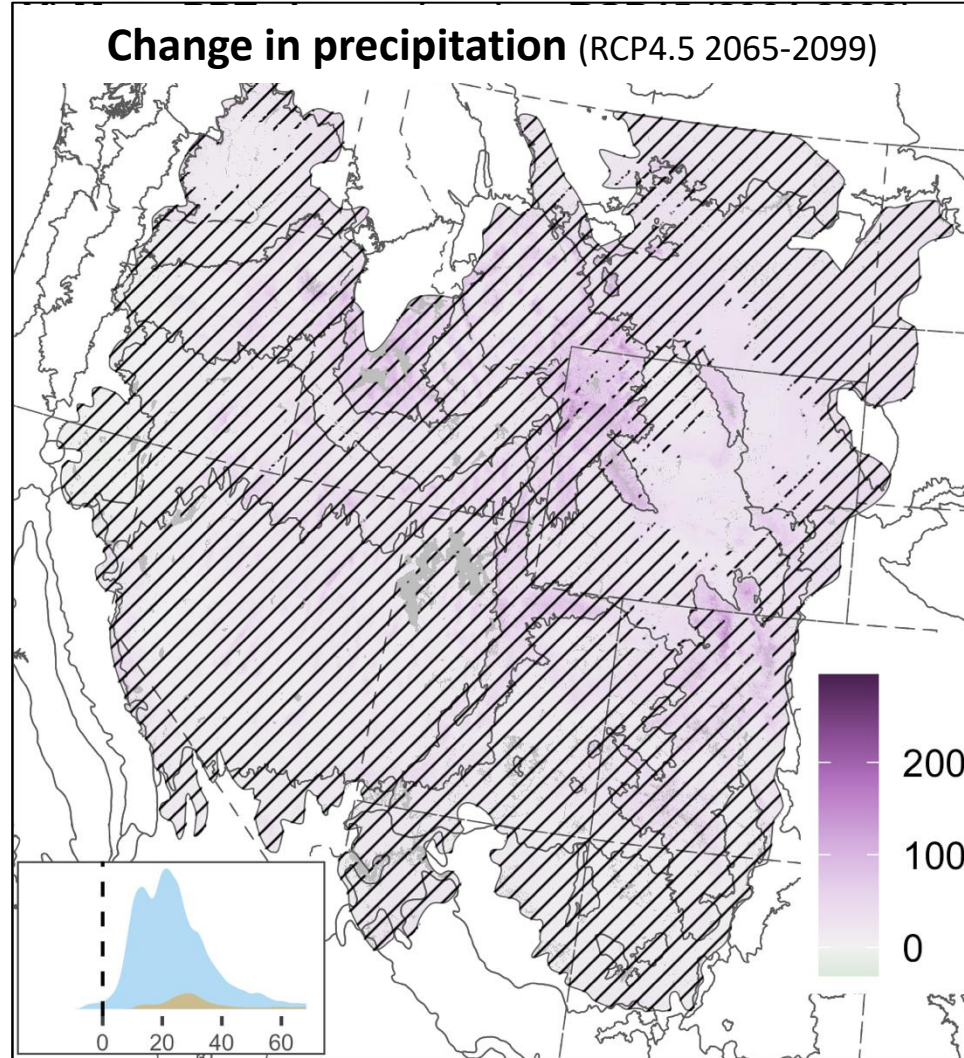


# Precipitation

**Precipitation (mm)**

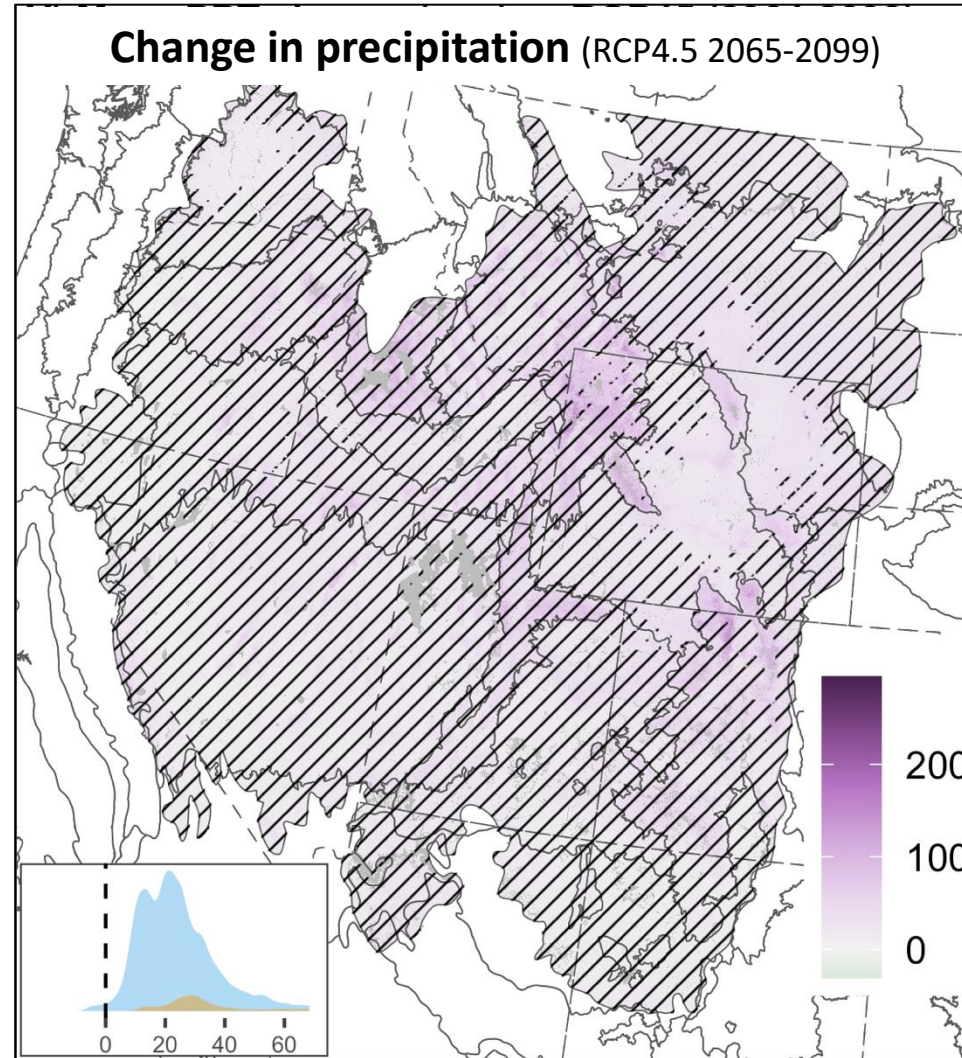
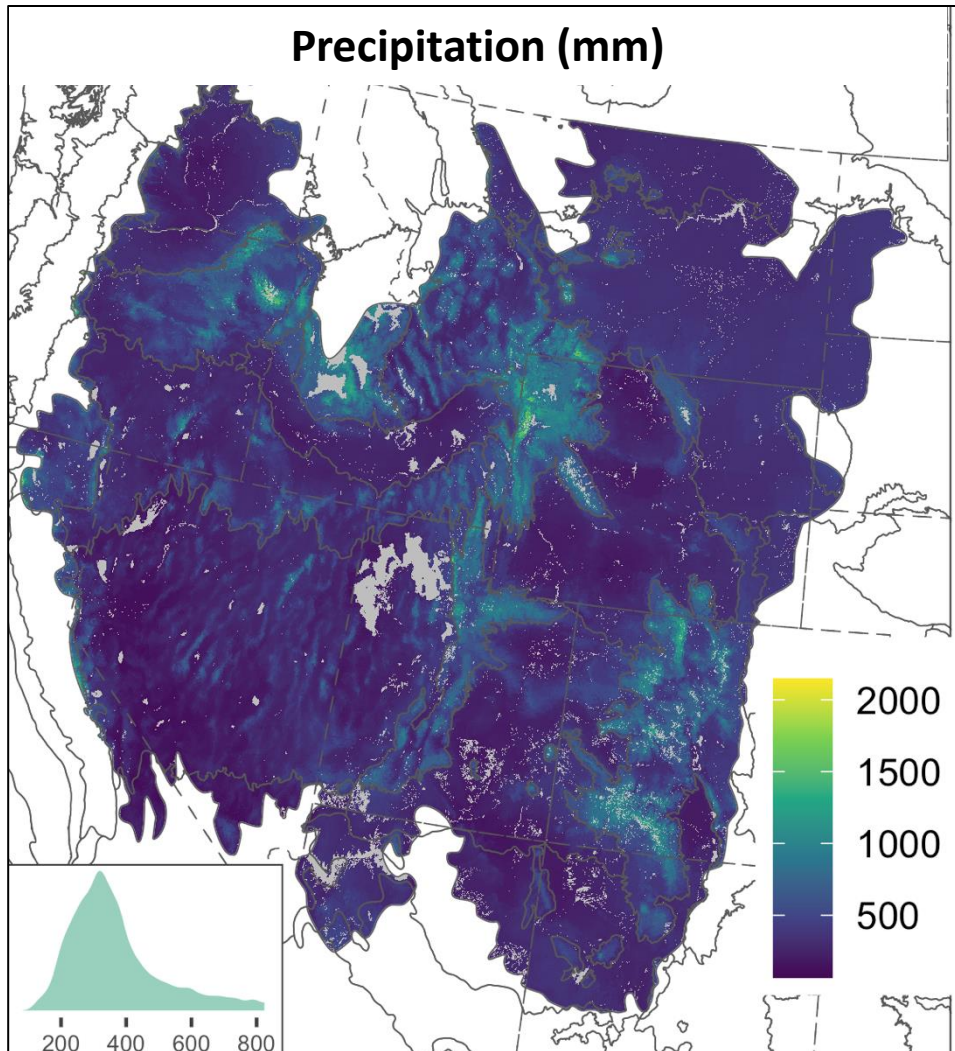


**Change in precipitation (RCP4.5 2065-2099)**

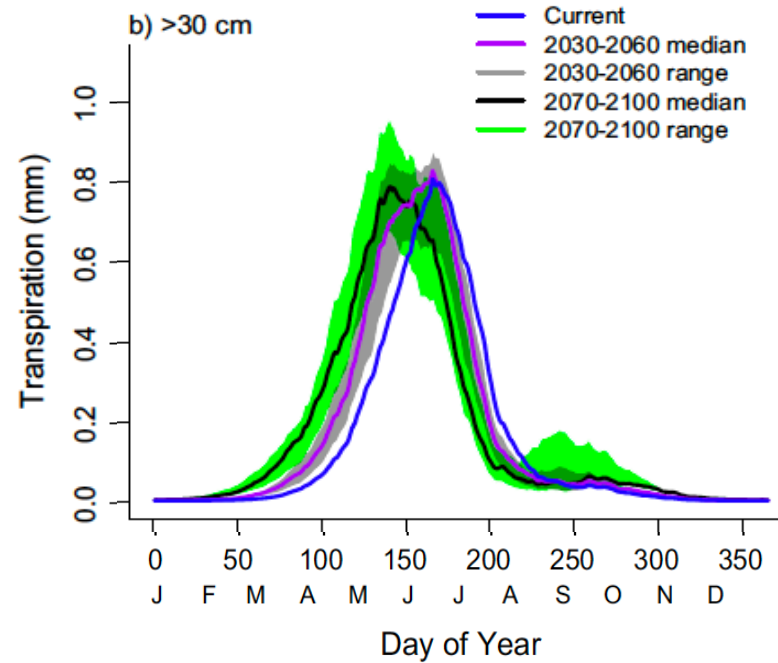
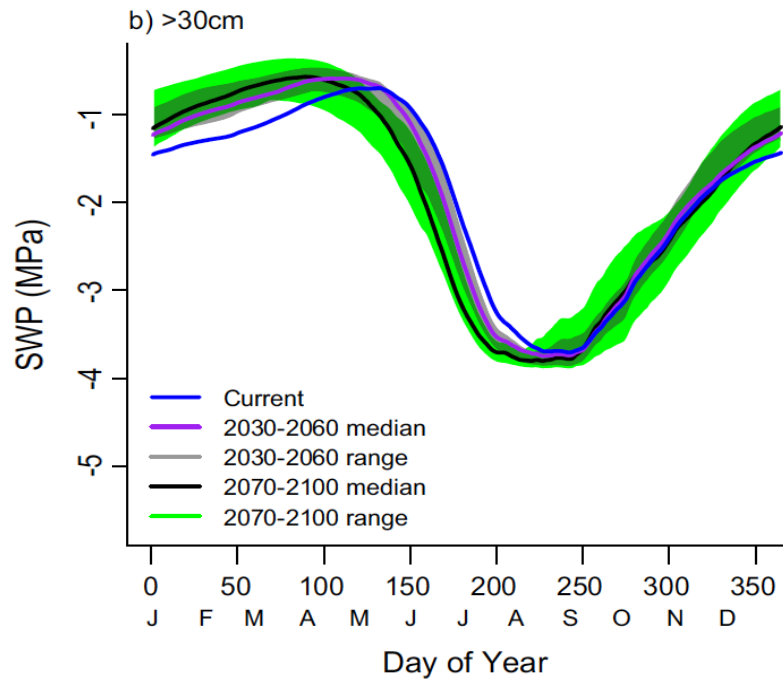


# Precipitation

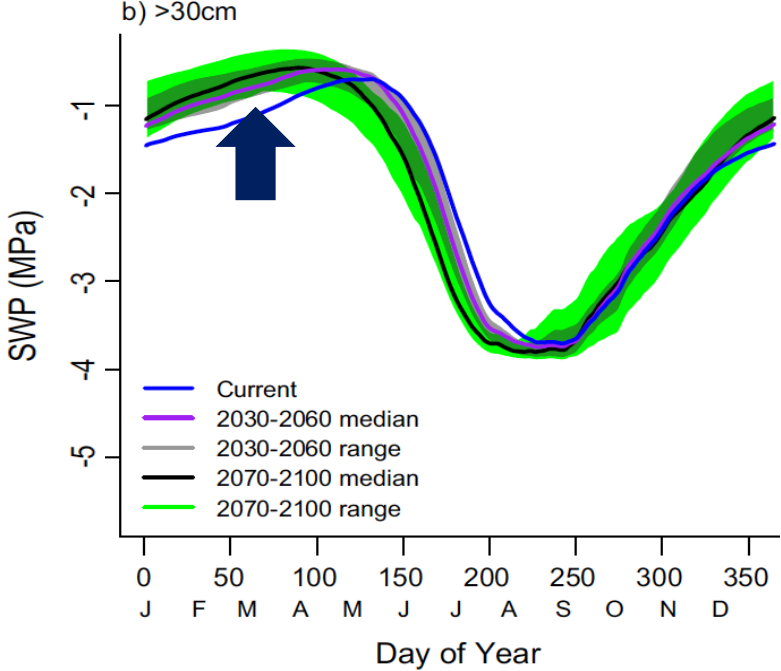
- Changes are generally not robust across models
- Only small changes or modest increases in most places



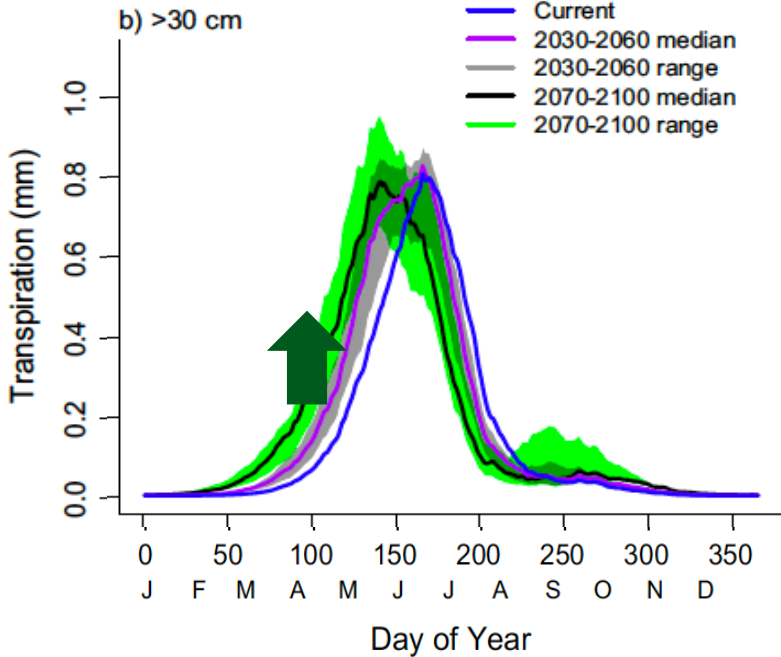
# Soil moisture changes



# Soil moisture changes

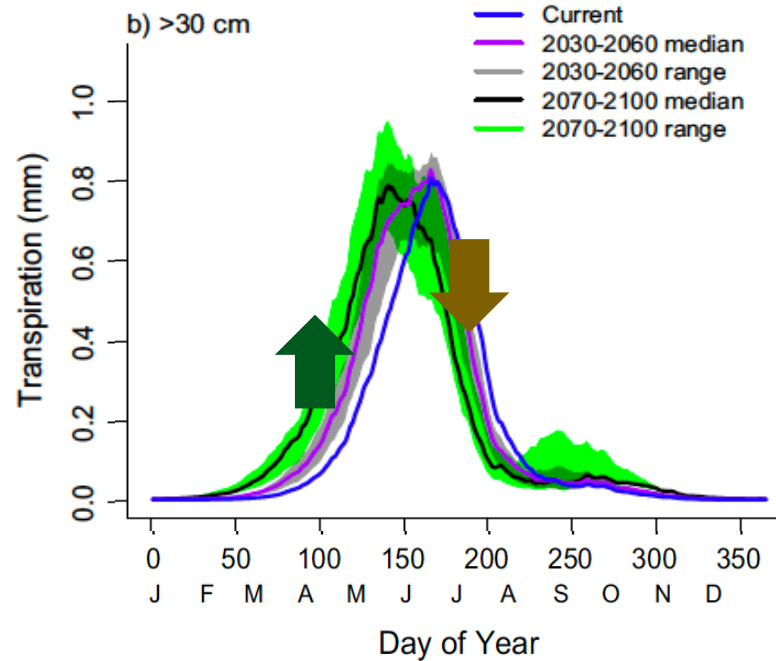
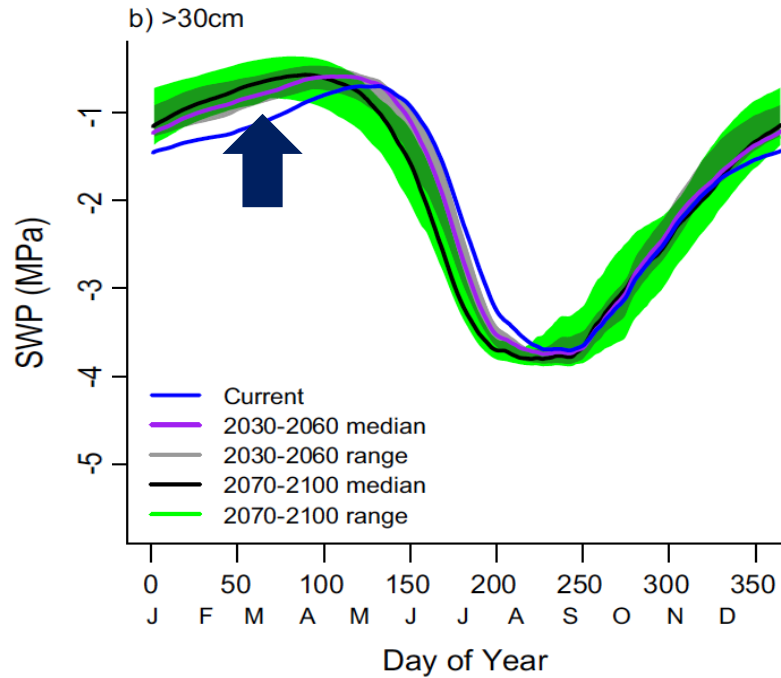


- **Wetter winters**



- **Earlier spring green-up**

# Soil moisture changes

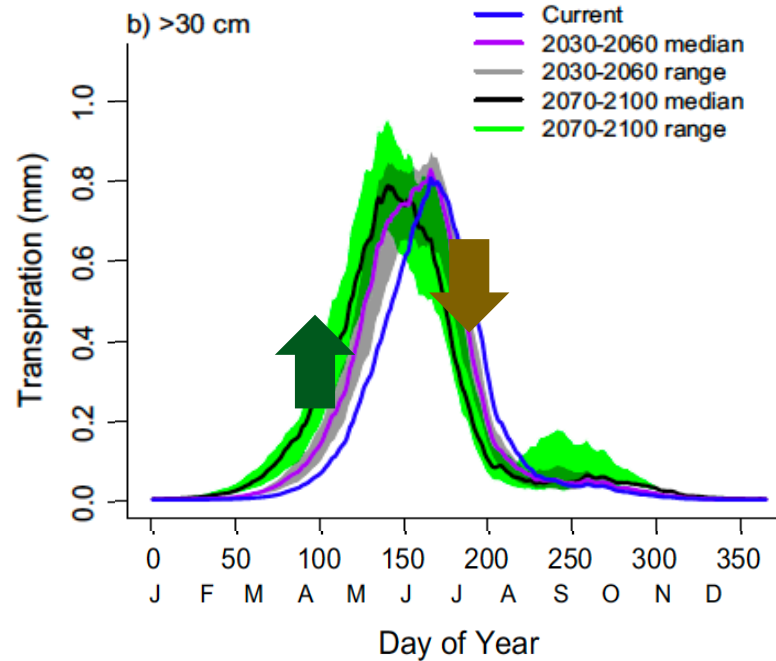
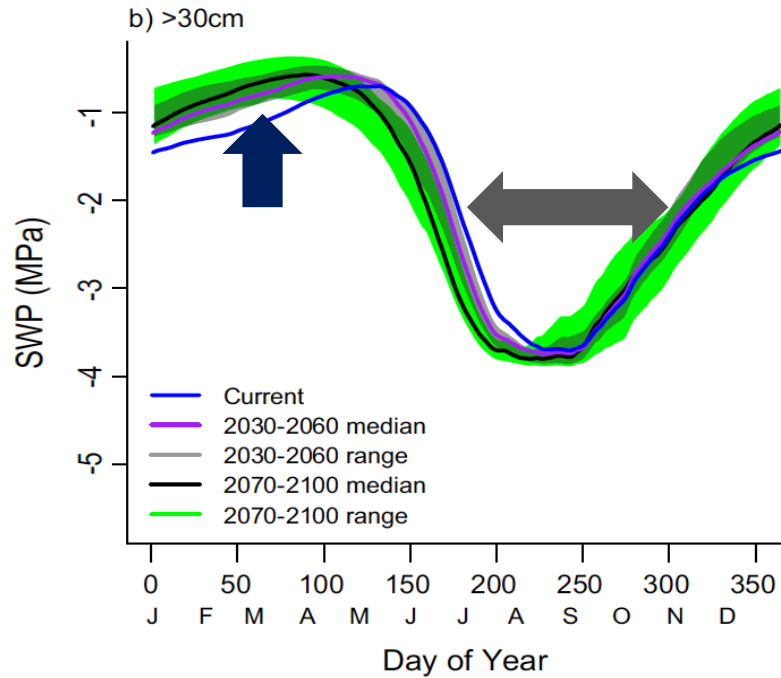


- **Wetter winters**

- **Earlier spring green-up**

- **Earlier senescence**

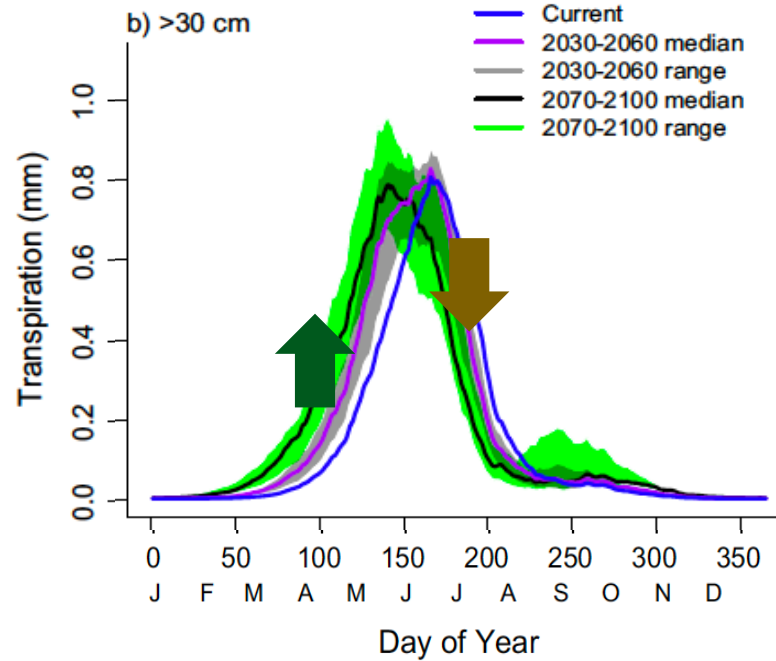
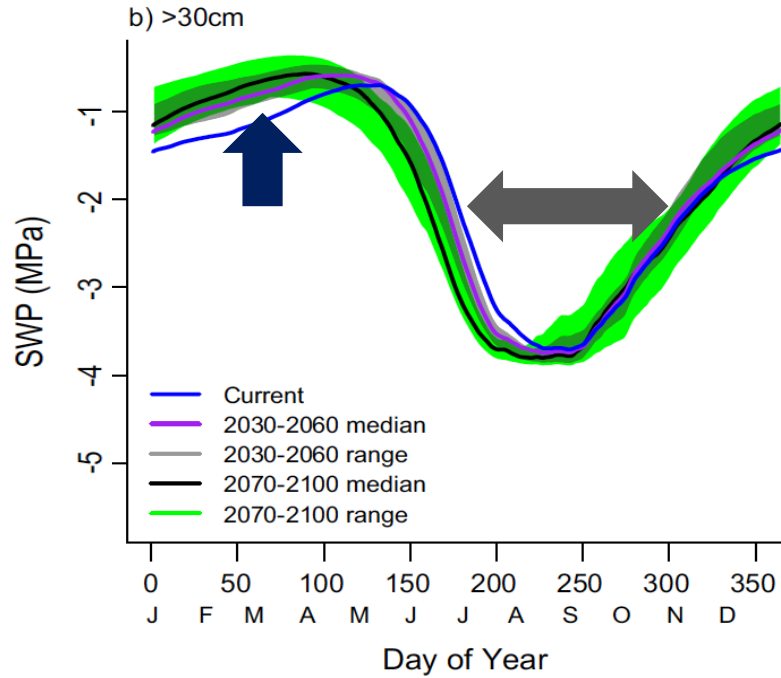
# Soil moisture changes



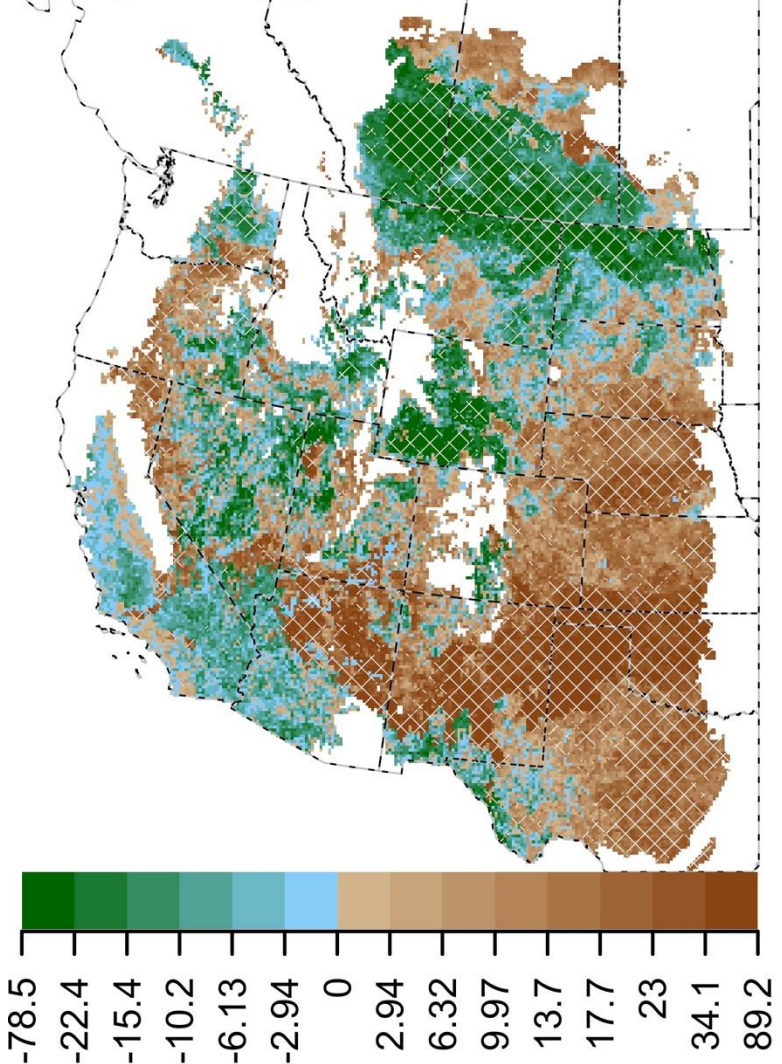
- **Wetter winters**
- **Longer (& hotter) summer dry soil periods**

- **Earlier spring green-up**
- **Earlier senescence**

# Soil moisture changes



Longest dry period - bottom soils



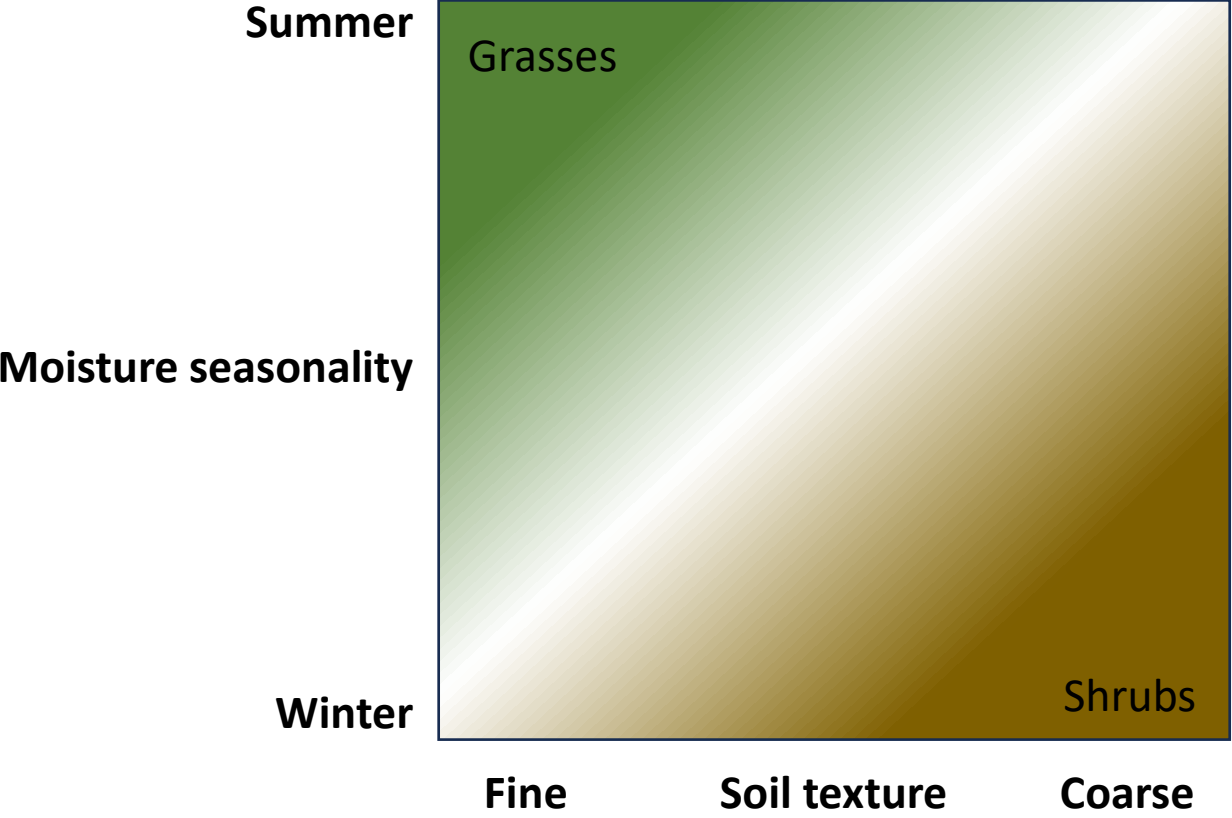
- Wetter winters

- Earlier spring green-up

- Longer (& hotter) summer dry soil periods

- Earlier senescence

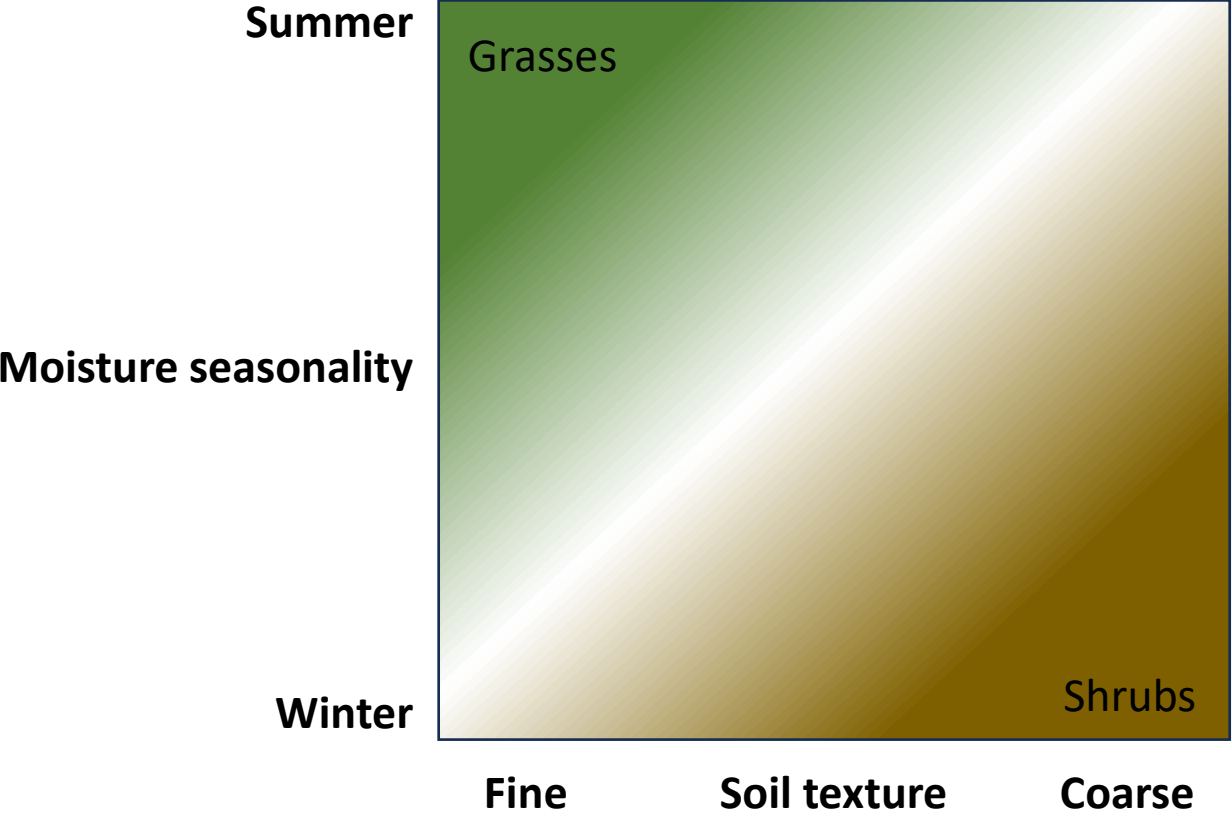
# Soil moisture & plant types



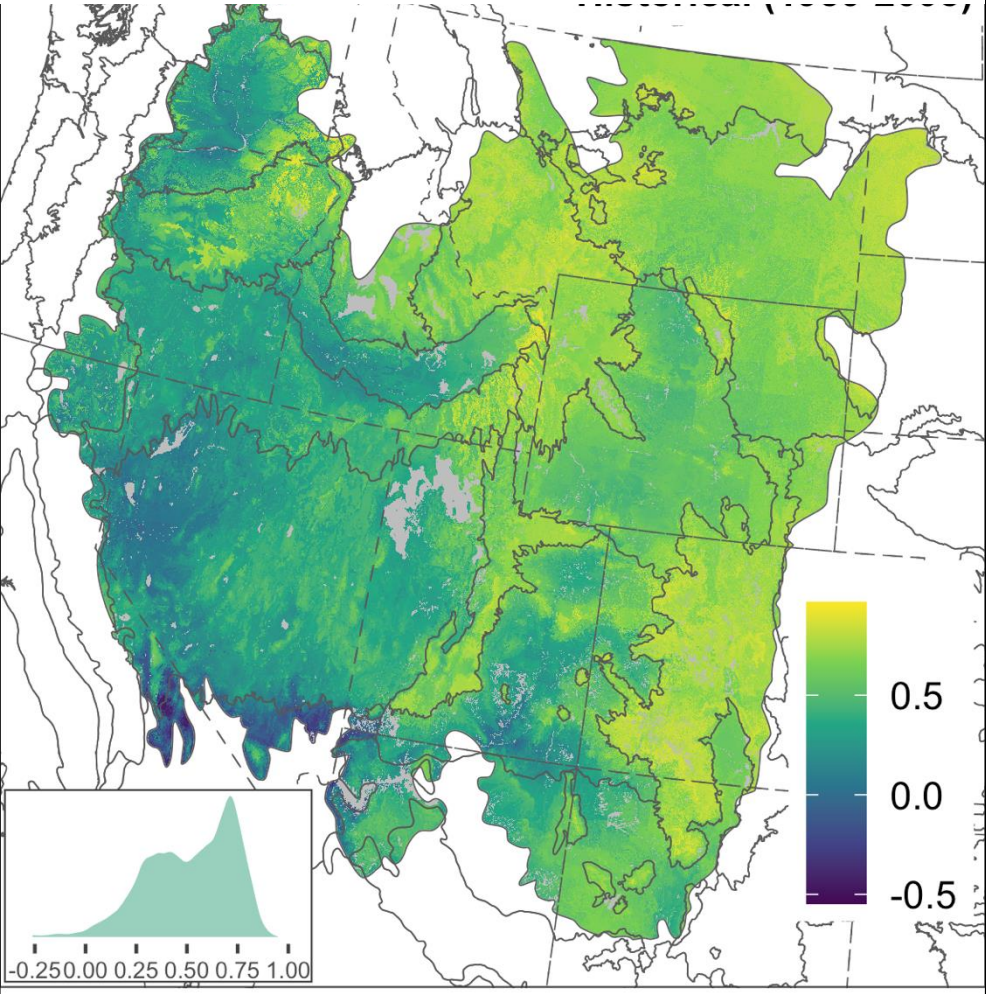
Sala et al 1997 -> Renne et al 2019



# Soil moisture & plant types



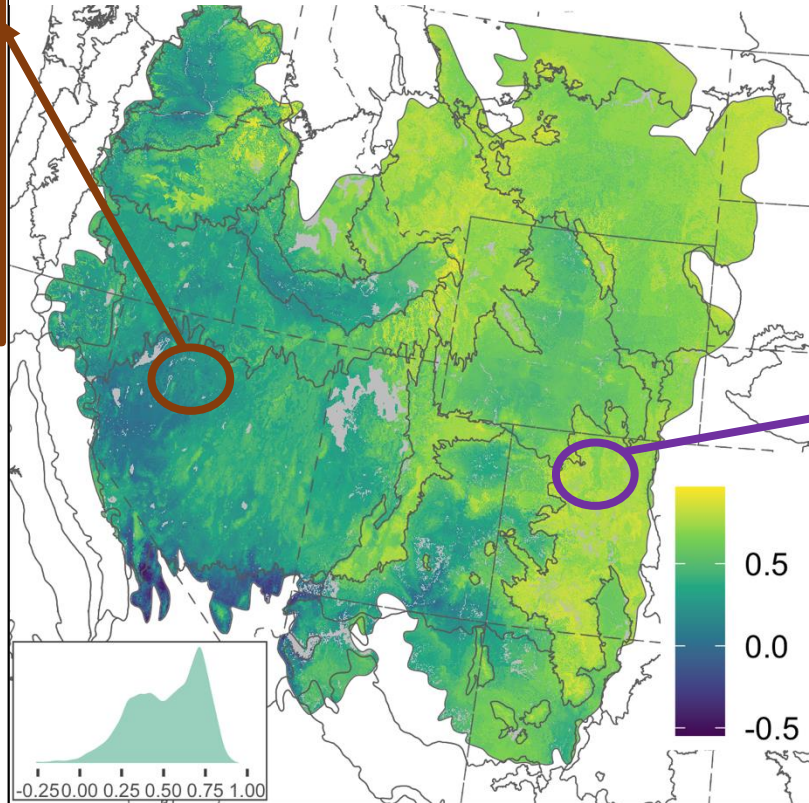
Seasonal timing of growth potential (wet degree days)



# Moisture seasonal timing



Wet degree days seasonal timing

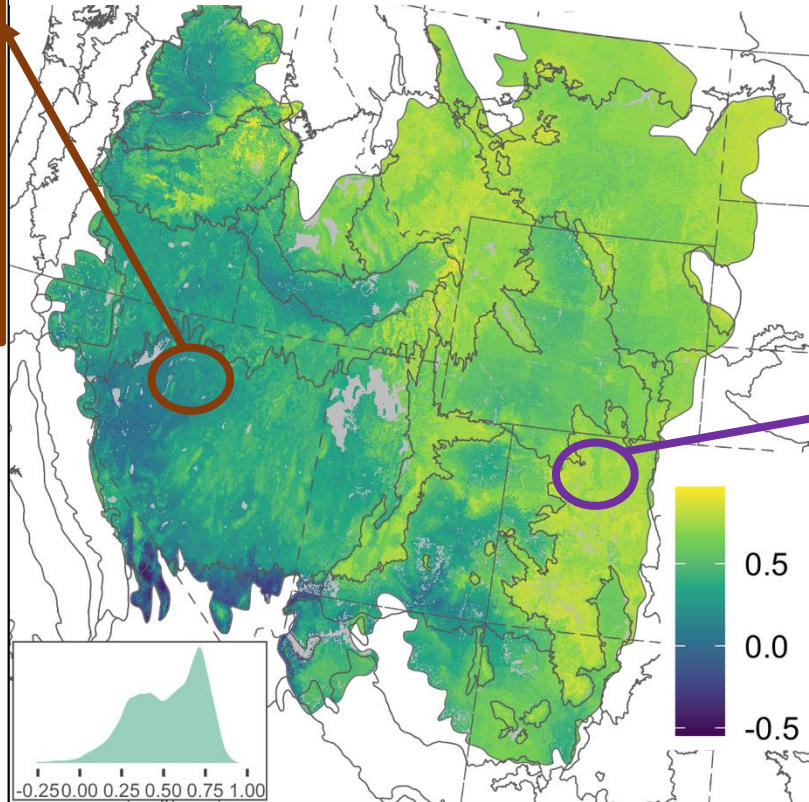


# Moisture seasonal timing

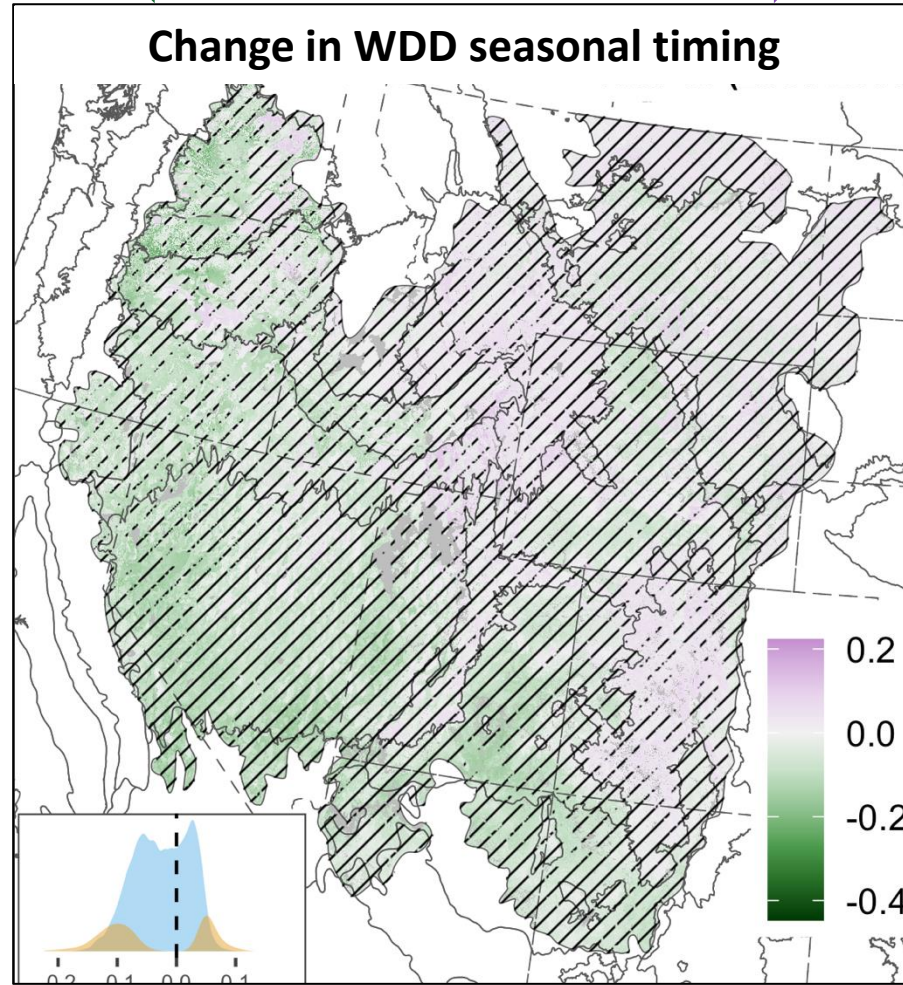
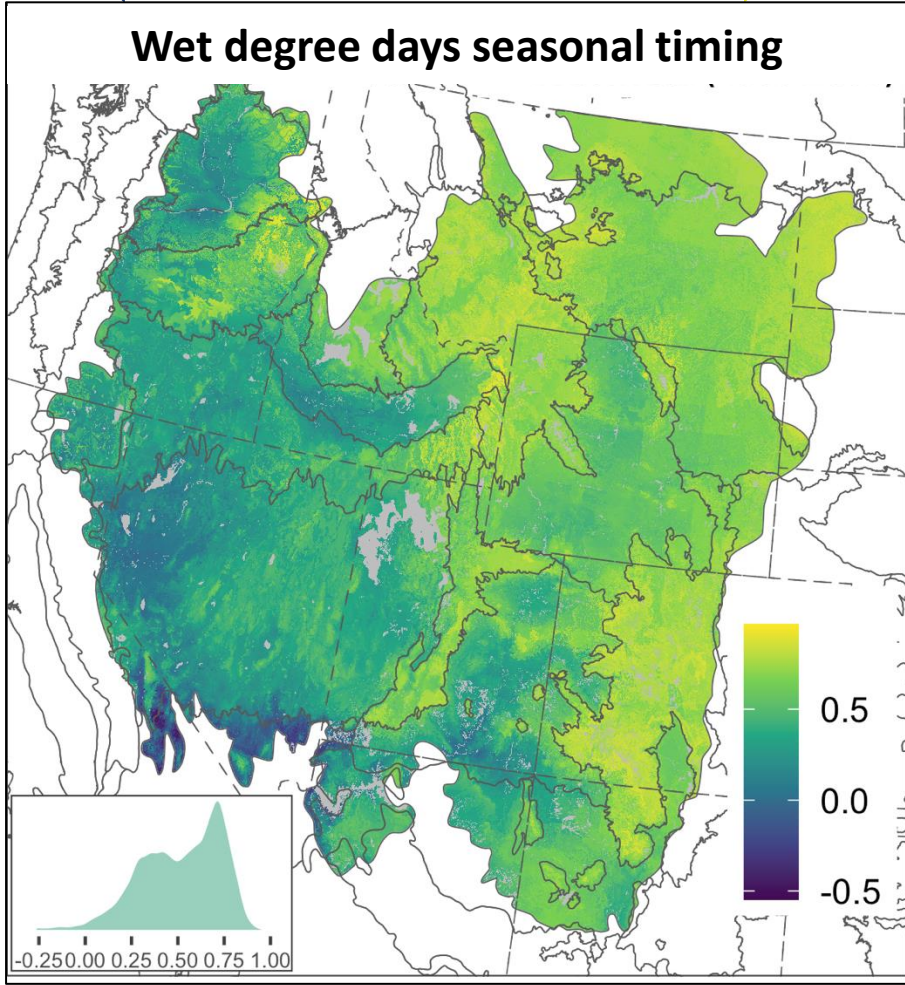
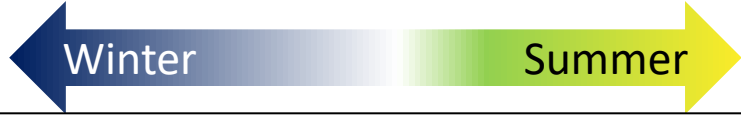
Within the sagebrush region, seasonality of moisture influences balance between shrubs & grasses



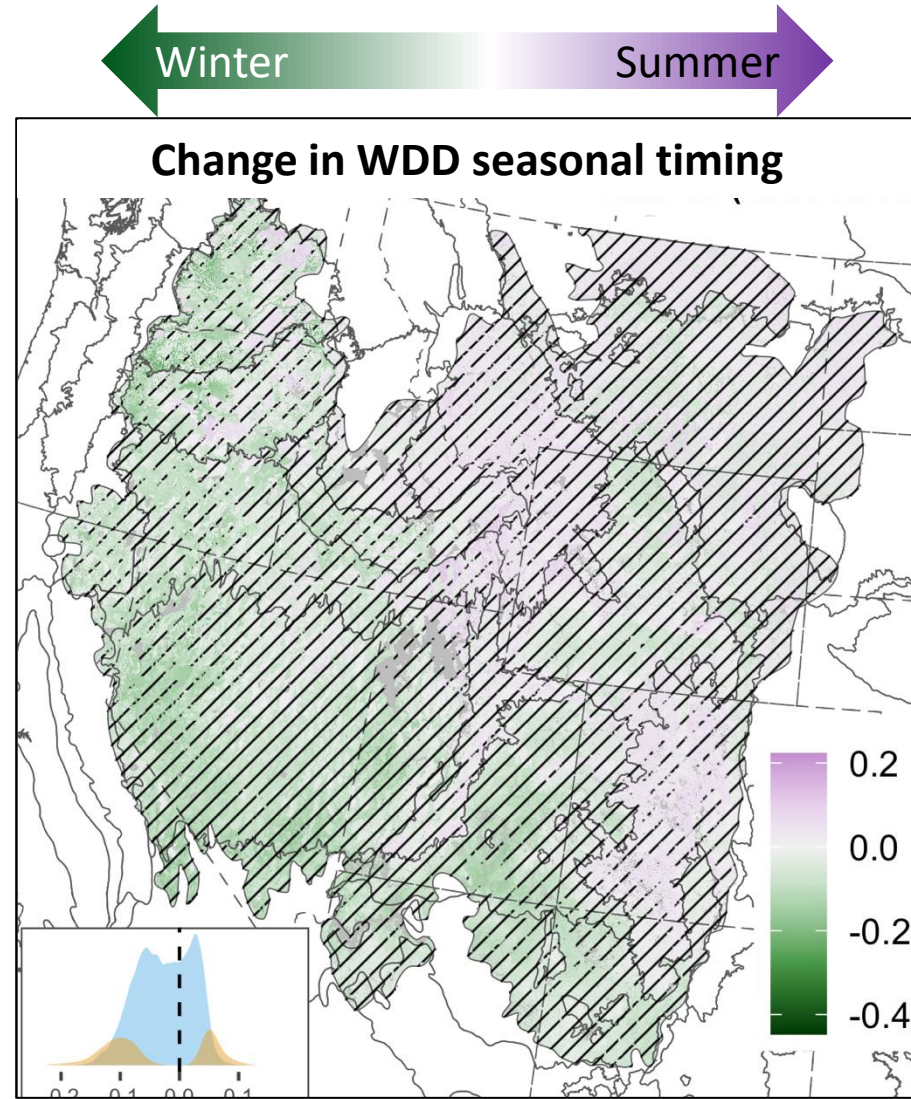
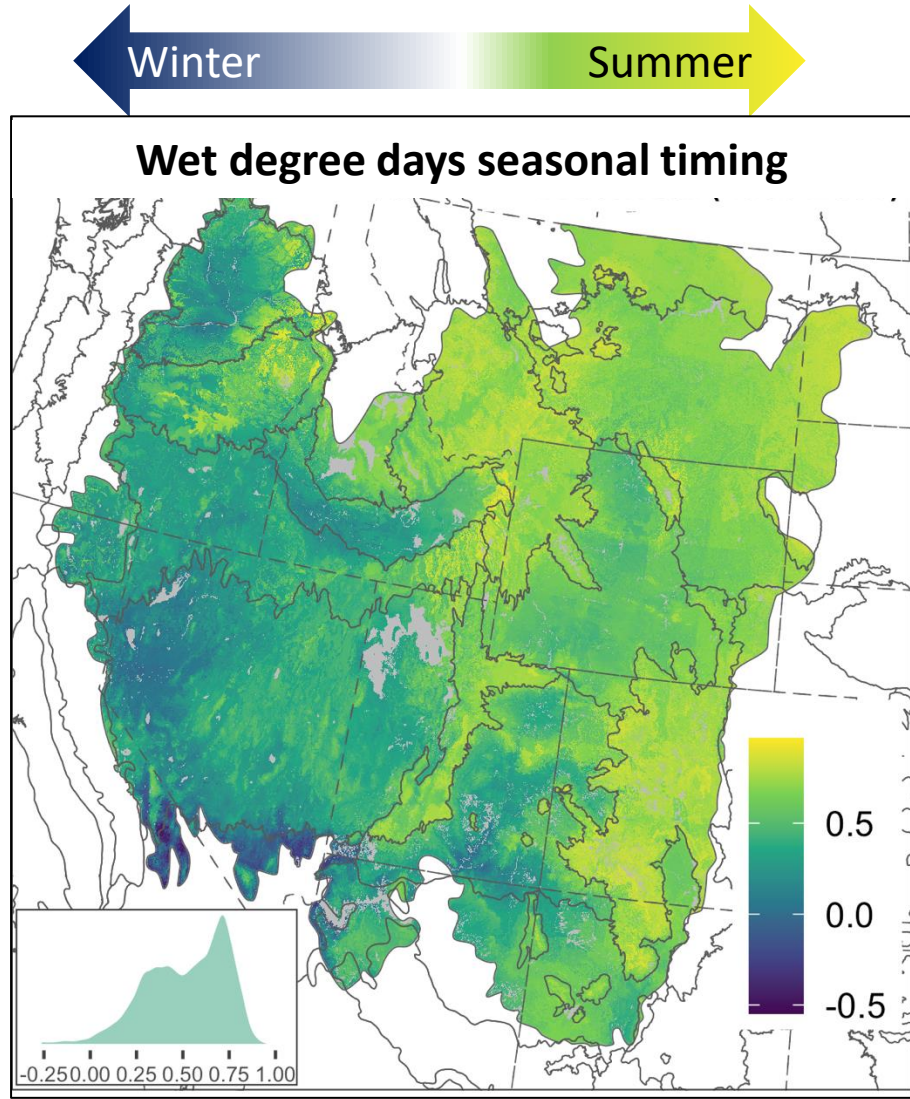
Wet degree days seasonal timing



# Moisture seasonal timing



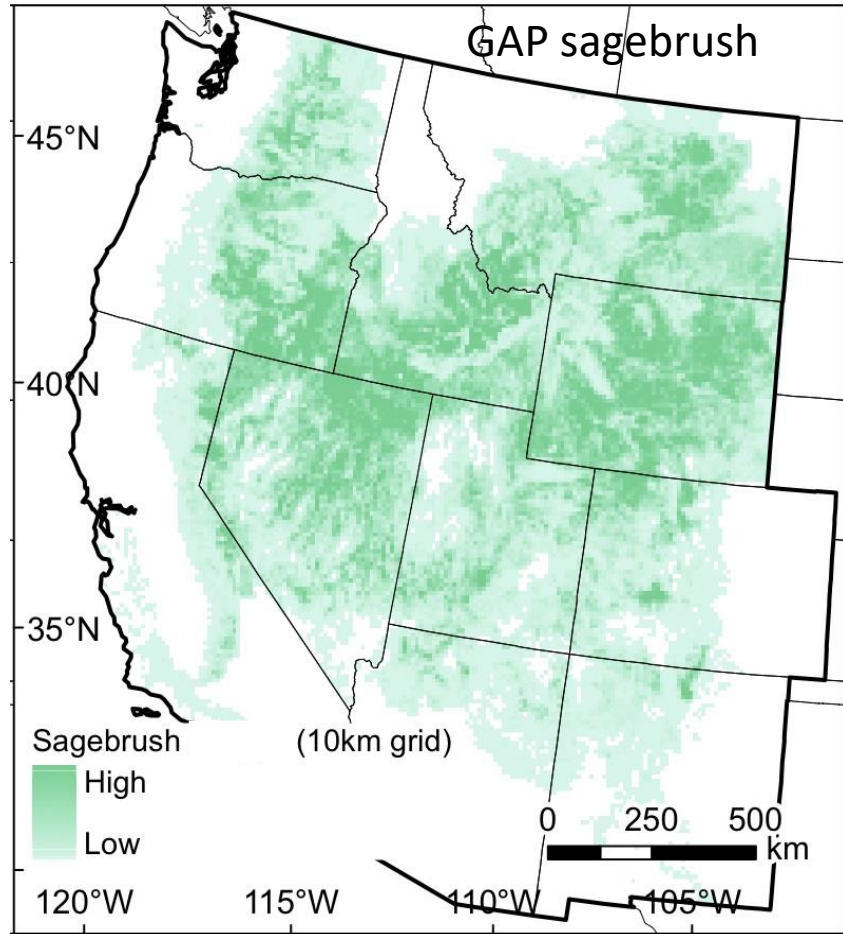
# Moisture seasonal timing



**Future climate:**  
**Increased winter  
moisture in most  
places...**

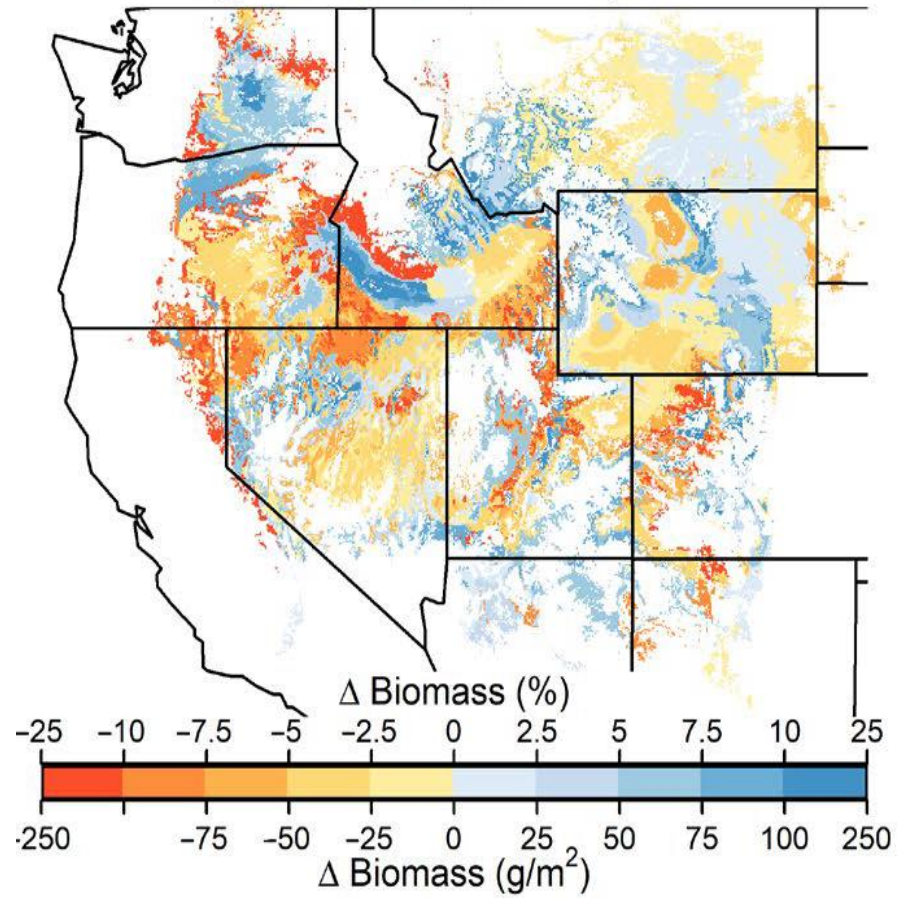
**...may sustain  
existing regional  
gradients in  
shrub-grass  
abundance**

# Implications ... for sagebrush



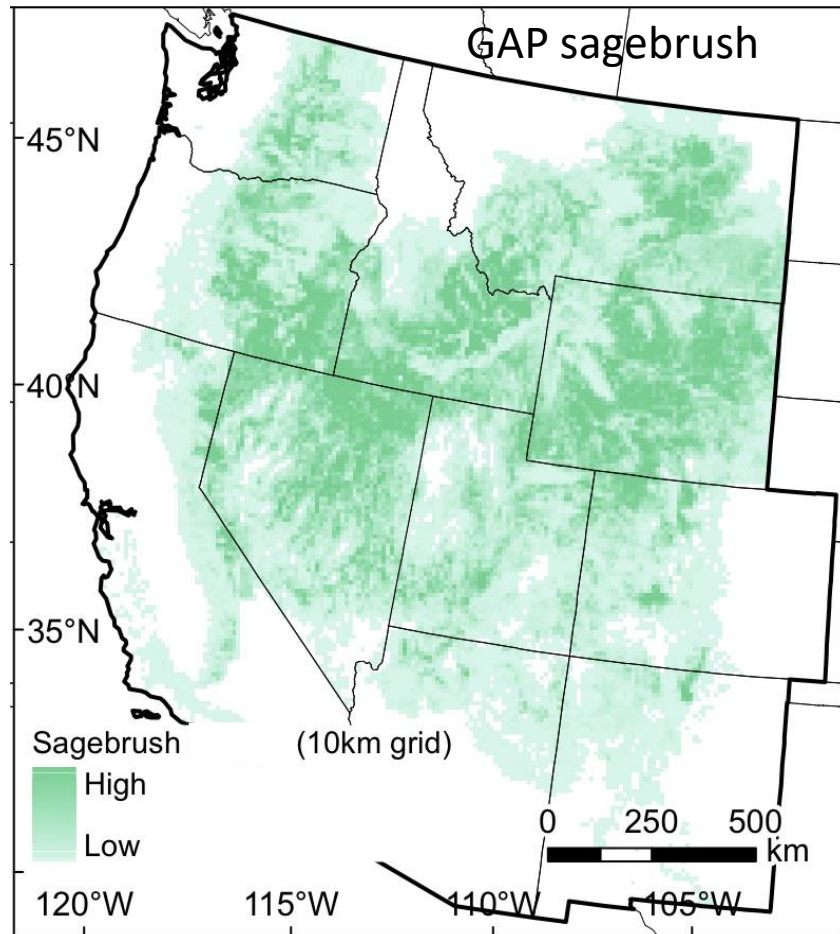
Schlaepfer et al. (2011) Ecohydrology

(c)  $\Delta$  Sagebrush biomass, 2070–2100



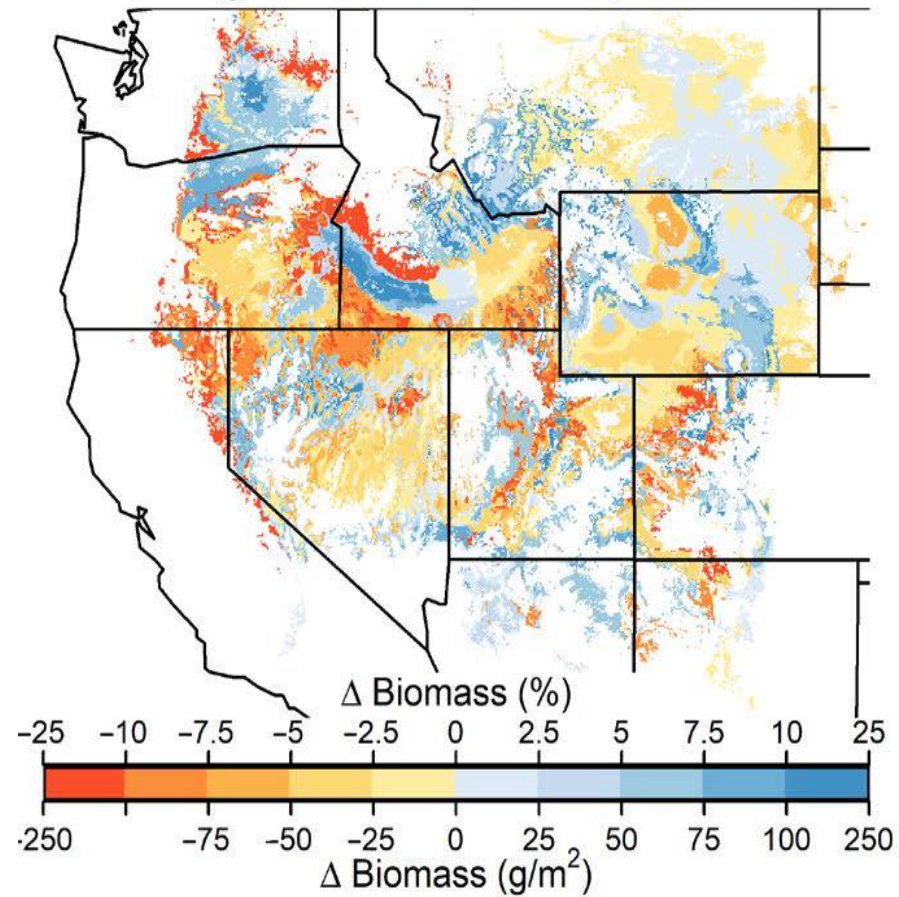
Palmquist et al. (2021) Global Change Biology

# Implications ... for sagebrush



Schlaepfer et al. (2011) Ecohydrology

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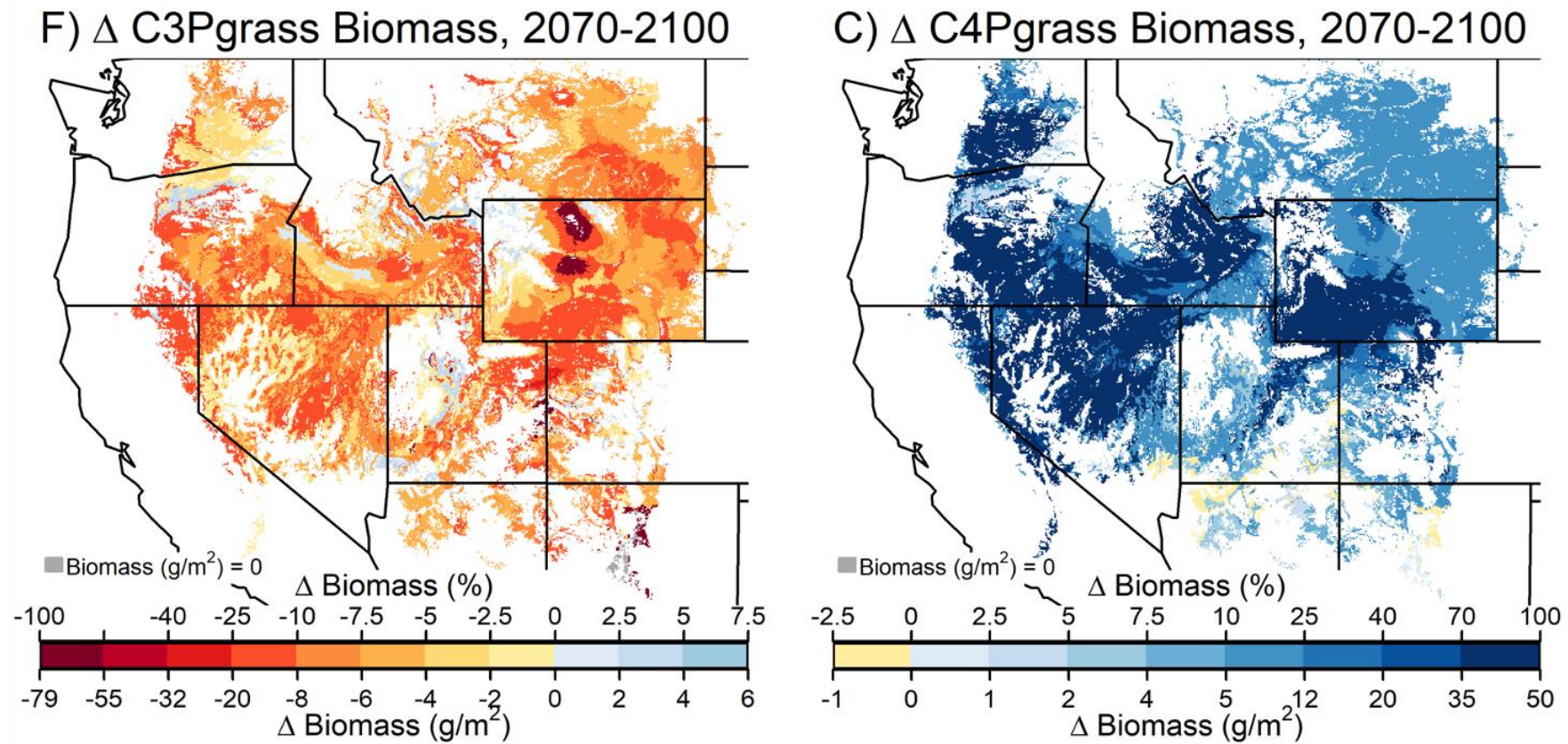
Palmquist et al. (2021) Global Change Biology

**Big sagebrush likely to remain climatically viable within much of the biome\***

**Potential declines in some areas**

(Schlaepfer et al 2011, Still & Richardson 2015)

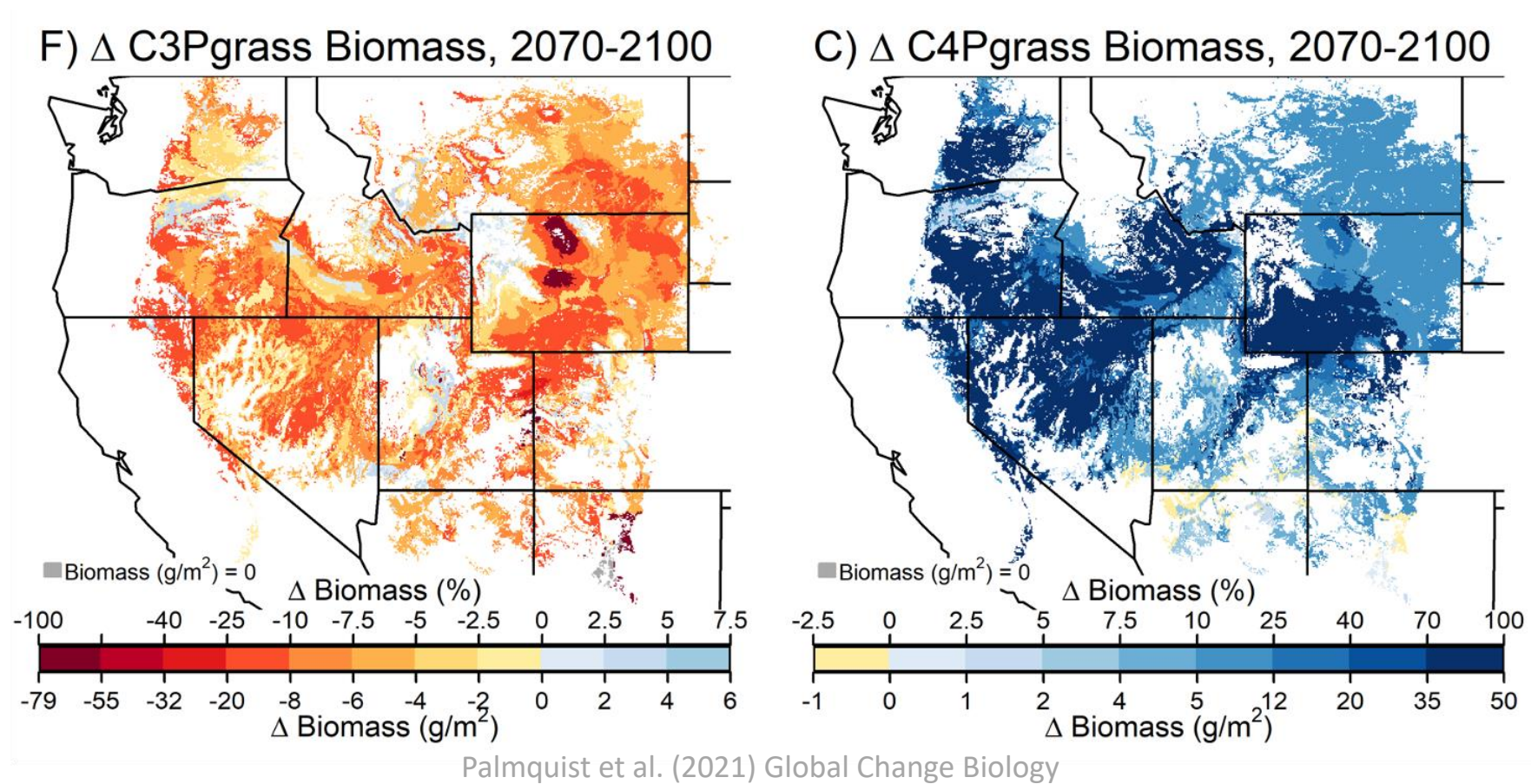
# Implications ... for perennial grasses



Palmquist et al. (2021) Global Change Biology



# Implications ... for perennial grasses



Future temperatures more consistent with warm-season (C4) perennial grasses than cool season (C3) perennials (Havrilla et al. 2023)

Cool season grasses may decline and warm season grasses might increase (Palmquist 2021)

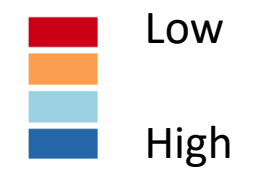
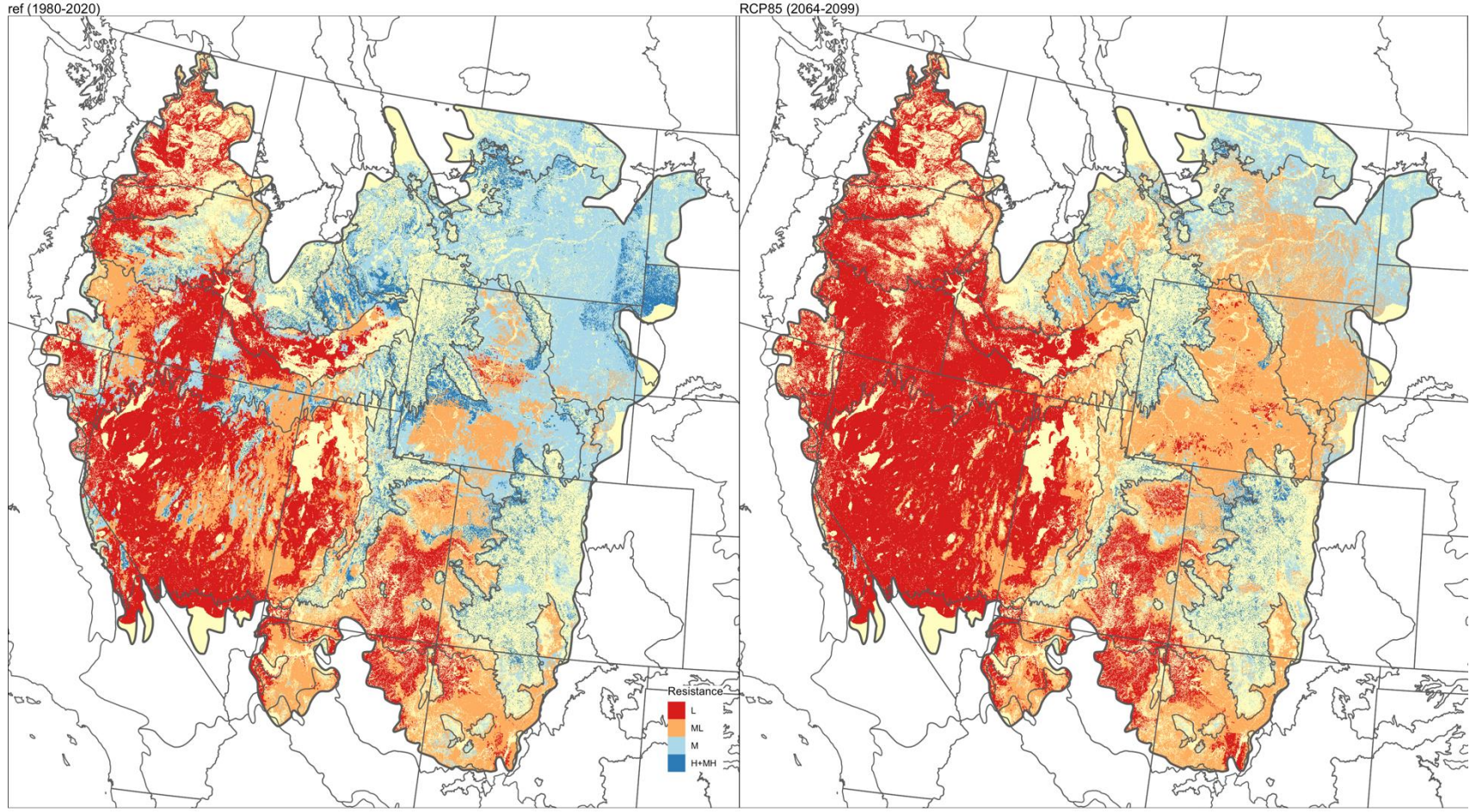
# Implications ... for Resistance & Resilience (R&R)



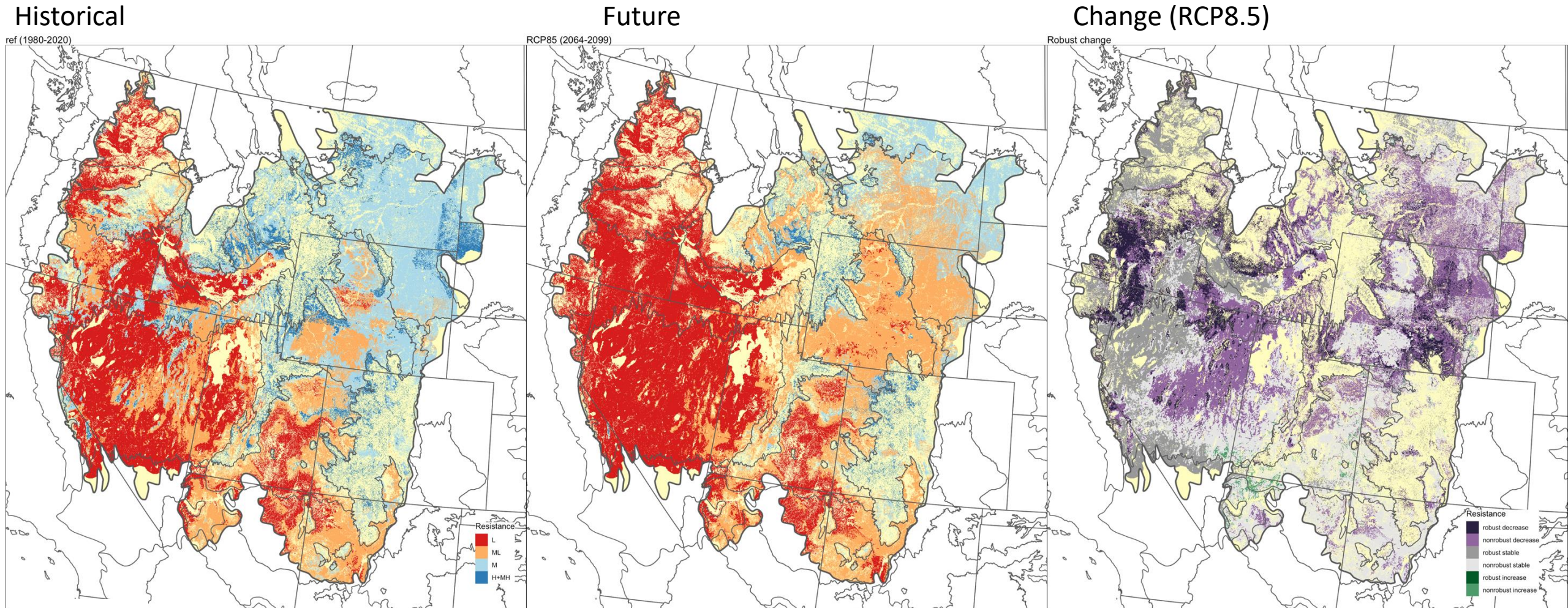
# Implications ... for Resistance & Resilience (R&R)

Historical

Future



# Implications ... for Resistance & Resilience (R&R)



**Low**  
High

**Likely declines in R&R over much of the sagebrush region**

**robust decrease**  
**nonrobust decrease**  
**robust stable**  
**nonrobust stable**  
**robust increase**  
**nonrobust increase**

Schlaepfer et al In Review.

# Take home messages

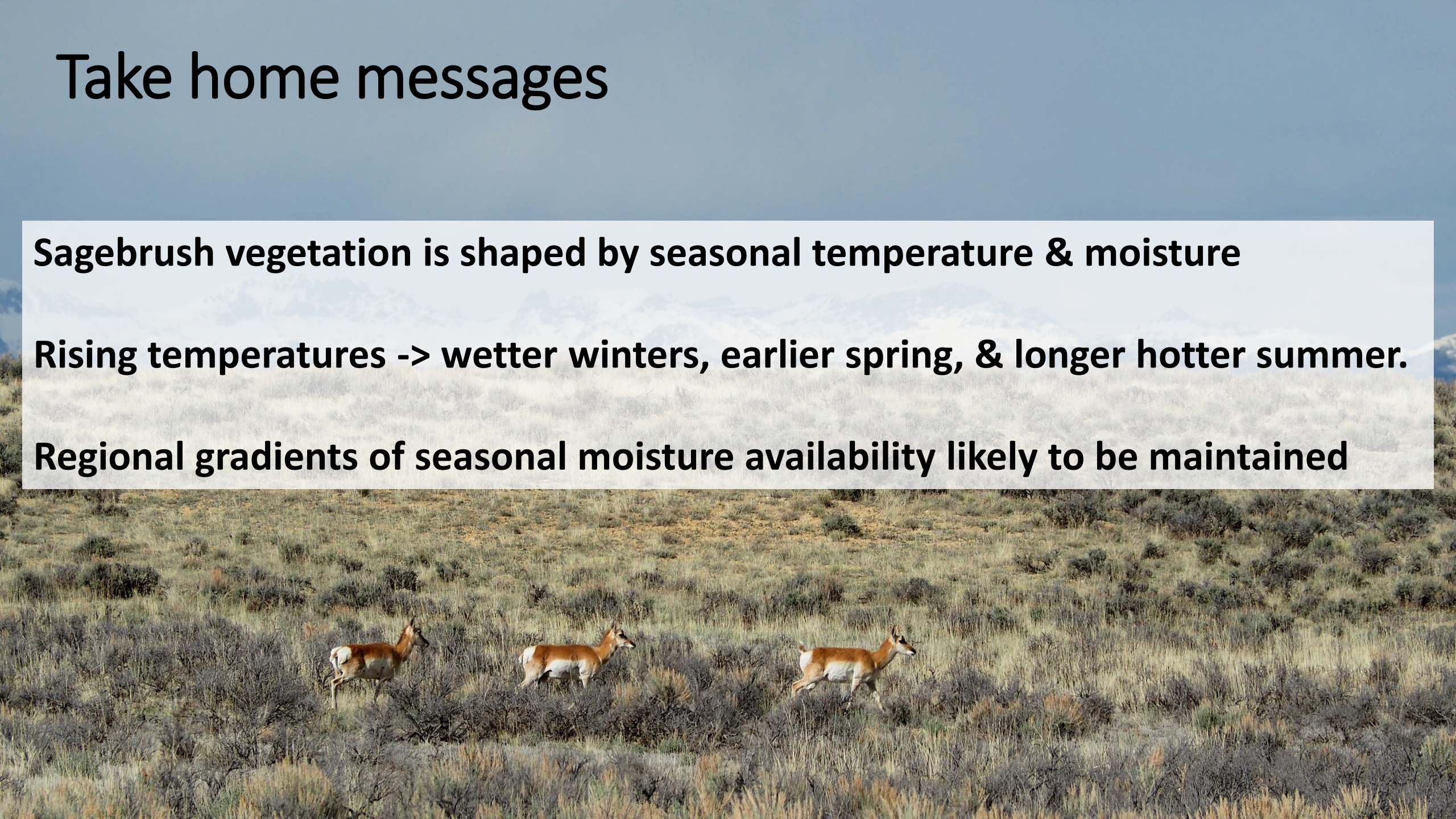


# Take home messages

**Sagebrush vegetation is shaped by seasonal temperature & moisture**

**Rising temperatures -> wetter winters, earlier spring, & longer hotter summer.**

**Regional gradients of seasonal moisture availability likely to be maintained**



# Take home messages

**Sagebrush vegetation is shaped by seasonal temperature & moisture**

**Rising temperatures -> wetter winters, earlier spring, & longer hotter summer.**

**Regional gradients of seasonal moisture availability likely to be maintained**

**Potential vegetation impacts:**

- **Sagebrush decline in only some parts of the region**
- **Perennial grass shifts from cool season to warm season species**
- **Decreased ecological resistance to cheatgrass & resilience to wildfire**