

# Future Forest Vulnerability to Drought and Fire in the Western US

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photo P. Buotte

# Overview

- CLM Modifications
- Evaluation against observations
- Application of mods to climate scenarios
- Drought vulnerability metrics
- Fire vulnerability metric

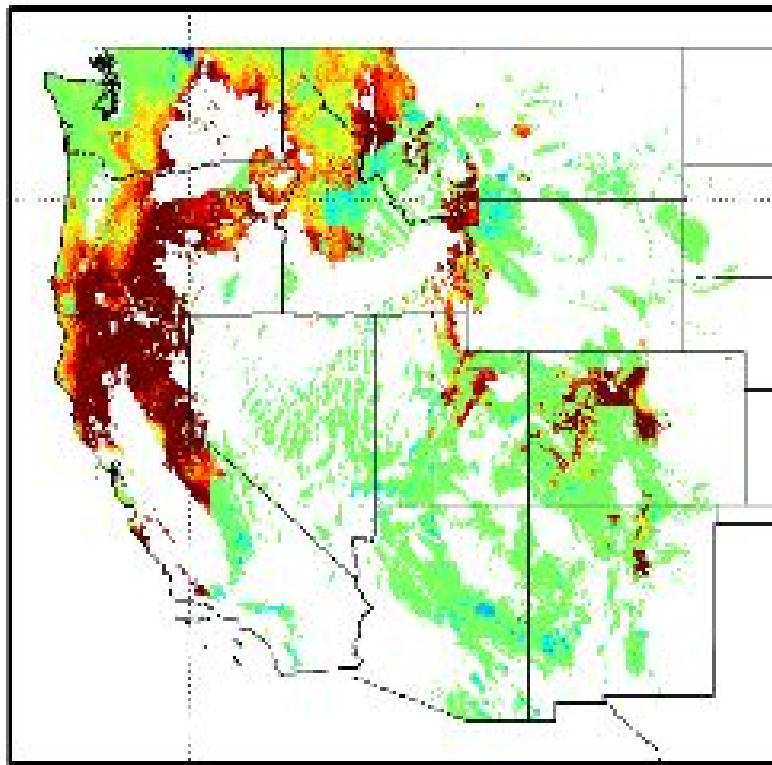
# Modifications to CLM 4.5

1. Forest-specific Plant Functional Types (13 PFTs)
  - Physiological parameters from the literature
  - PFT distribution from Ruefenacht et al. 2008
2. Tree responses to drought
  - PFT-specific stomatal closure
  - Increased leaf shed during soil water stress
3. Prognostic fire tuning
  - Reduced population effect on ignitions
  - Adjusted fuel limits
  - Climatological 4-km lightning from NASA database

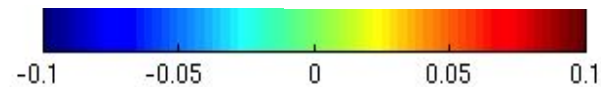
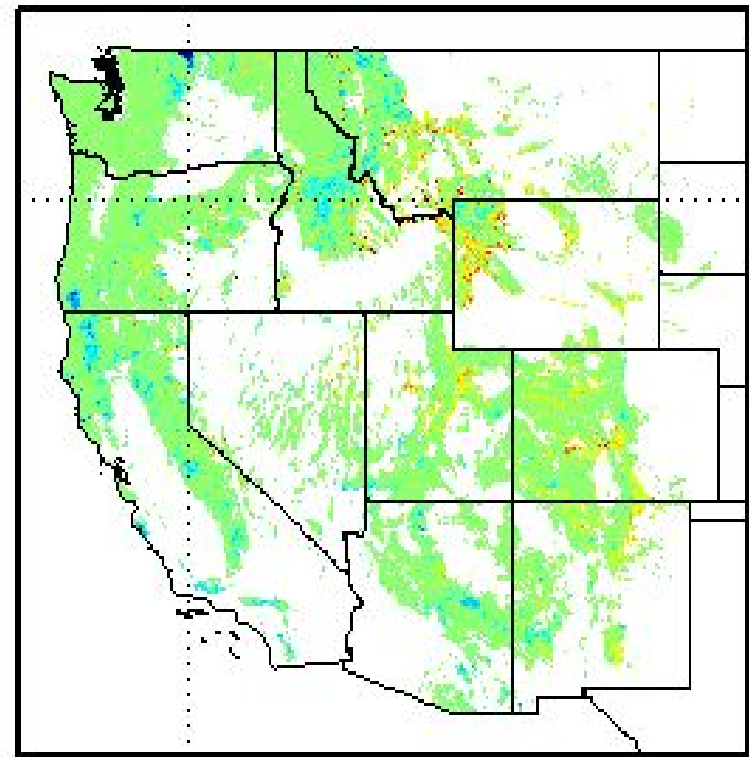
# CLM Evaluation

## Area Burned 1984-2008

before fire tuning



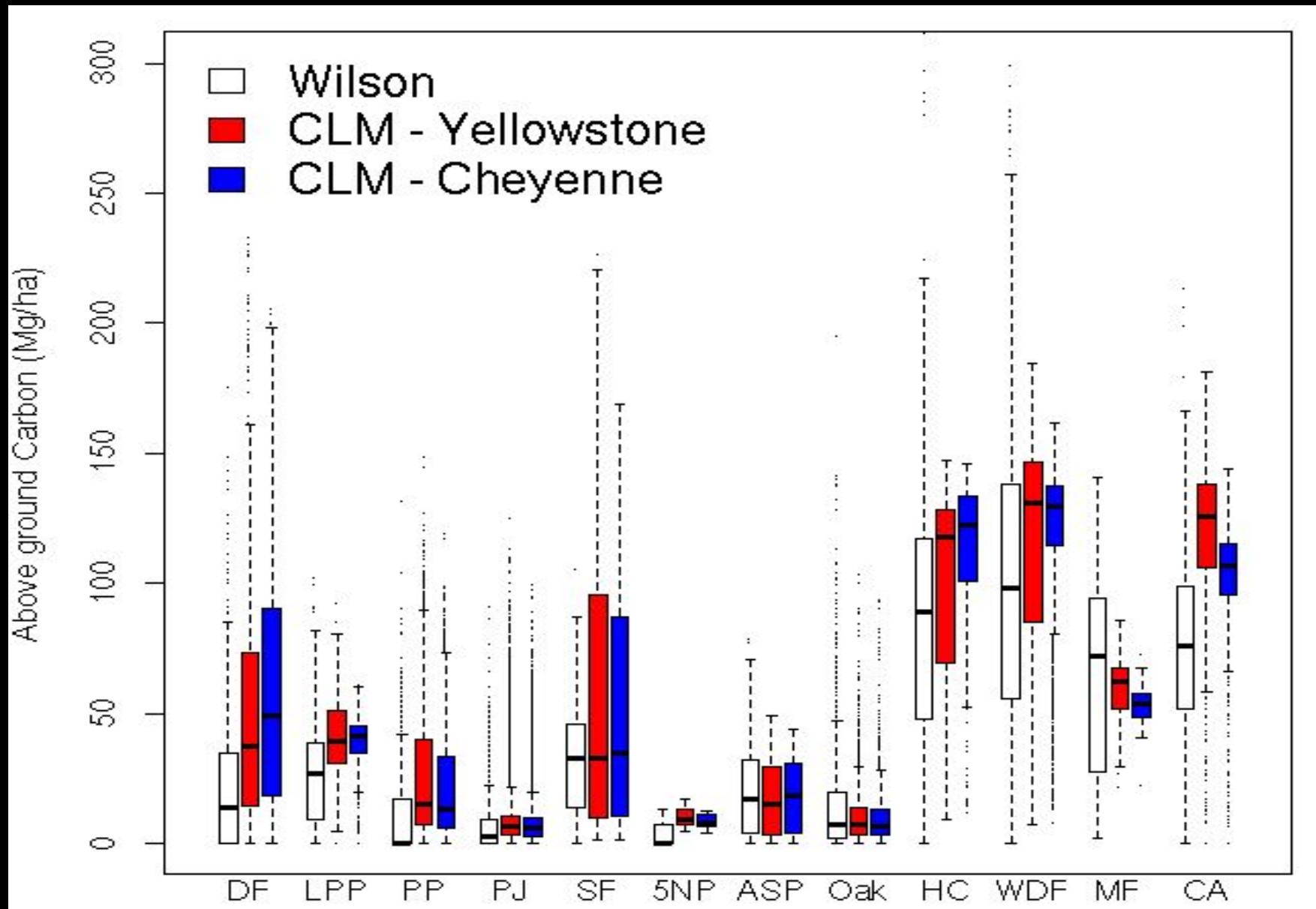
after fire tuning



CLM 4.5 area burned minus MTBS observed  
(fraction of grid cell)

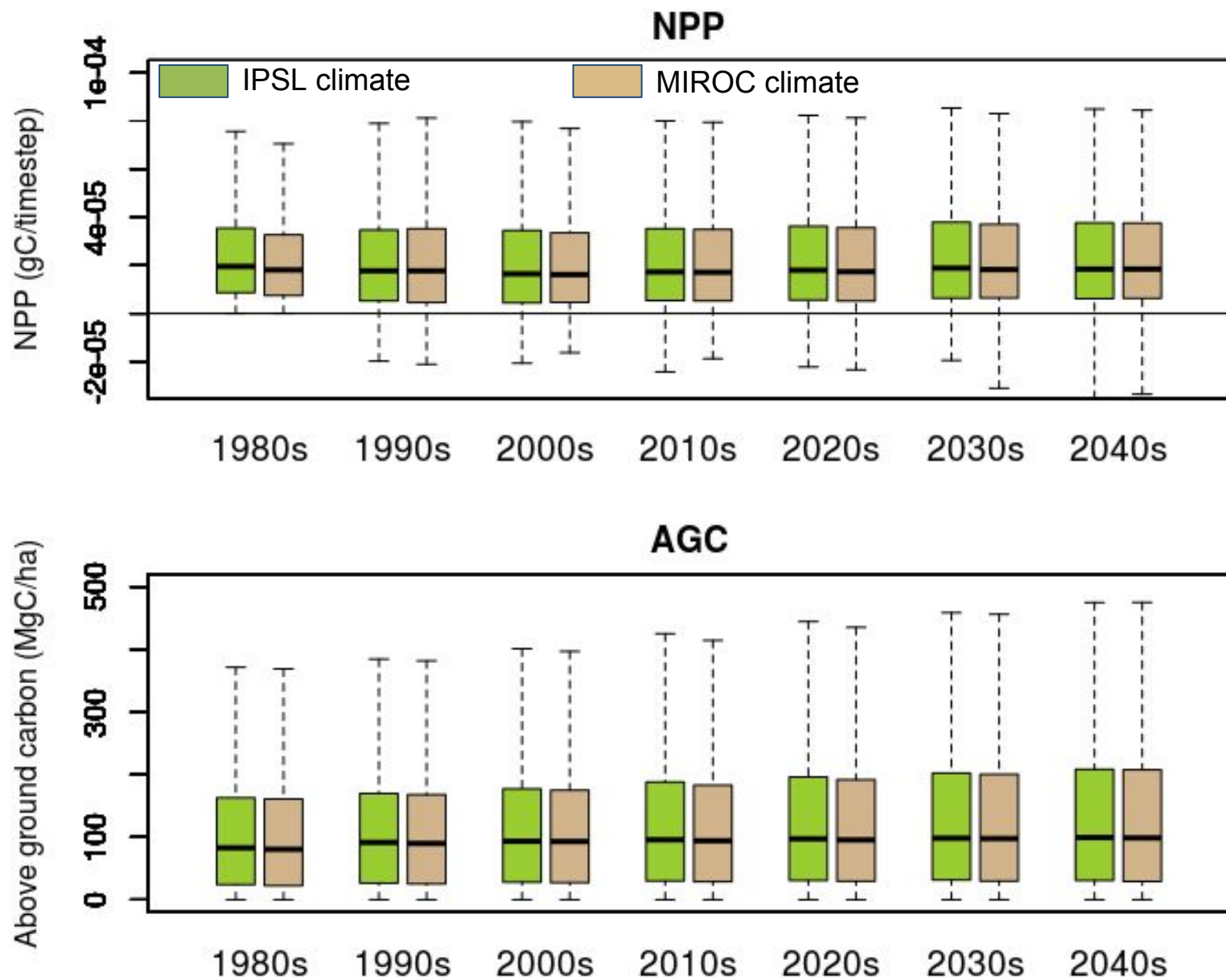
# CLM Evaluation

## Above Ground Carbon





# CLM Results



# Patterns Vary Among PFTs

## AGC Example

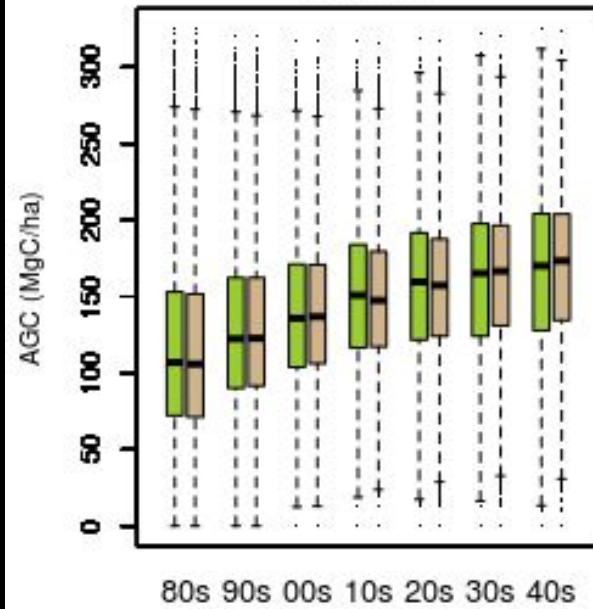


IPSL climate

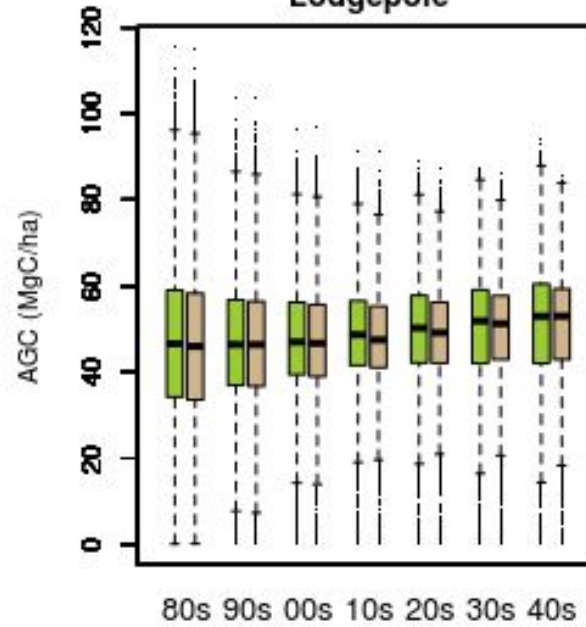


MIROC climate

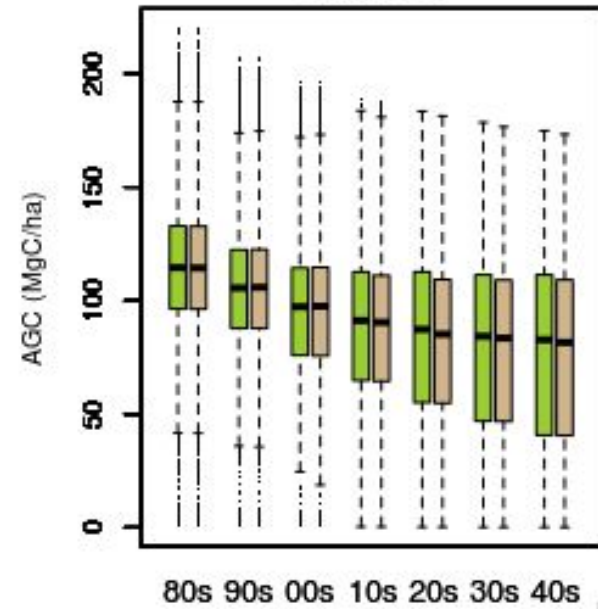
### Doug Fir



### Lodgepole



### CA Mixed



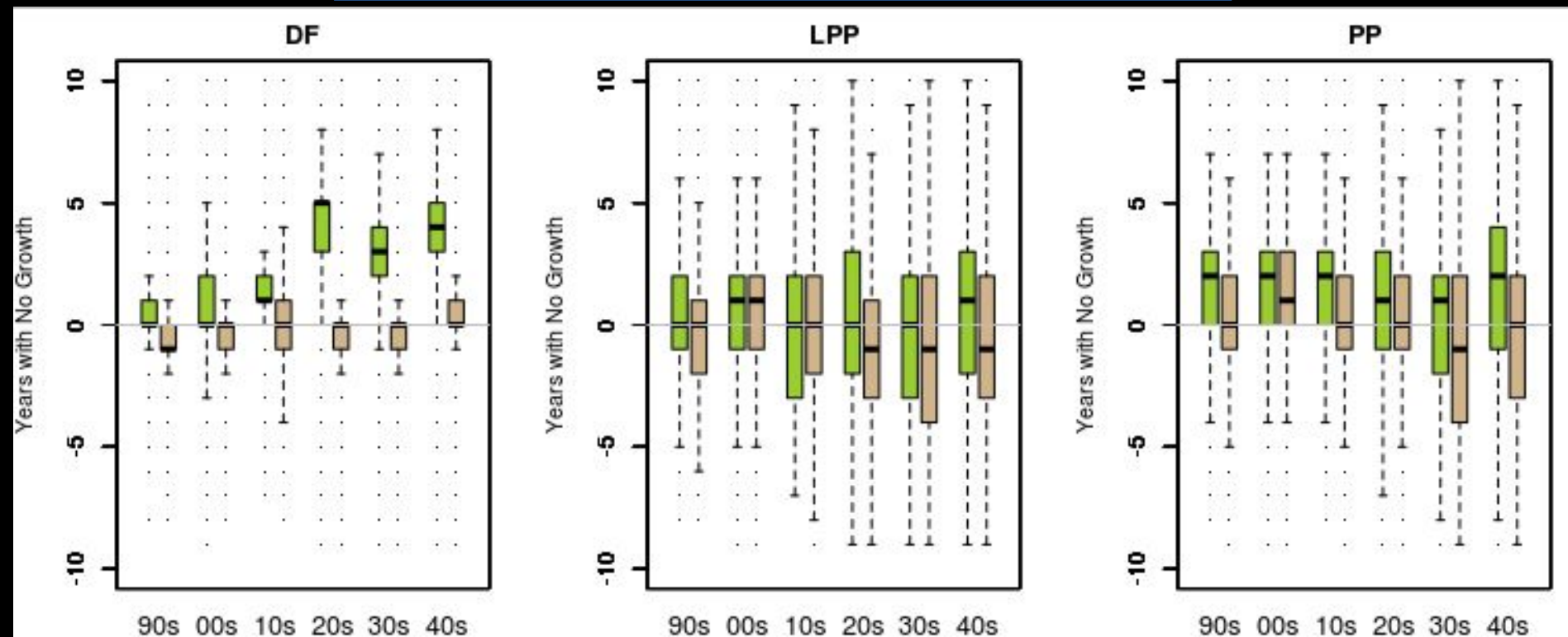
# Drought Vulnerability Metrics

1. Prolonged Vulnerability: Years with no stem growth
  - 0 - 1 year = low vulnerability
  - 2 - 3 years = medium vulnerability
  - $\geq 4$  years = high vulnerability
2. Short-term Vulnerability: Annual NPP = 0
  - 0 years = low vulnerability
  - 1 year = medium vulnerability
  - $>1$  year = high vulnerability



# Prolonged Vulnerability: Years with No Growth Relative to 1980s

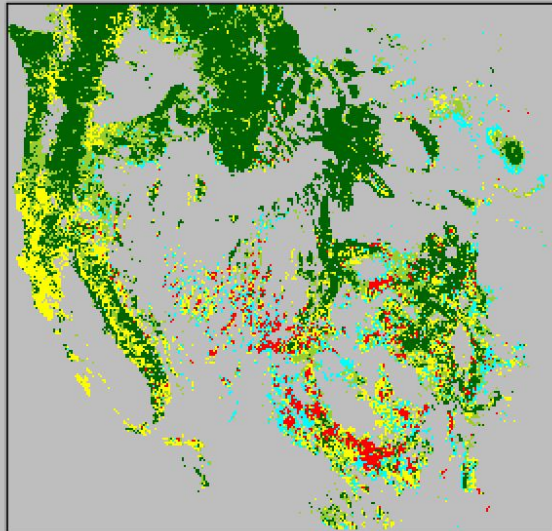
IPSL climate      MIROC climate



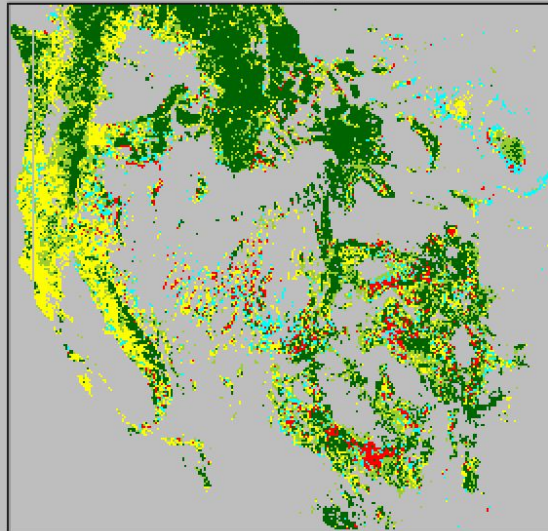
# Prolonged Vulnerability from IPSL & MIROC

Both Low    Low & Med    Both Med    Med & High    Both High    Low & High

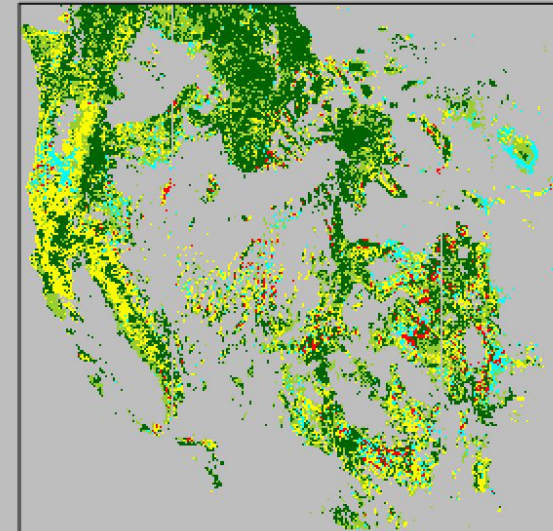
1990s



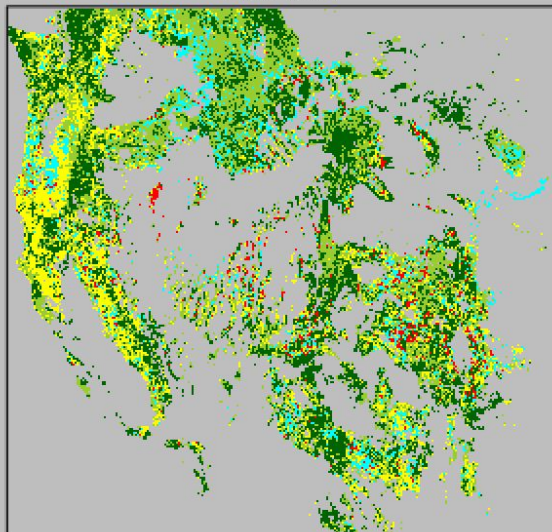
2000s



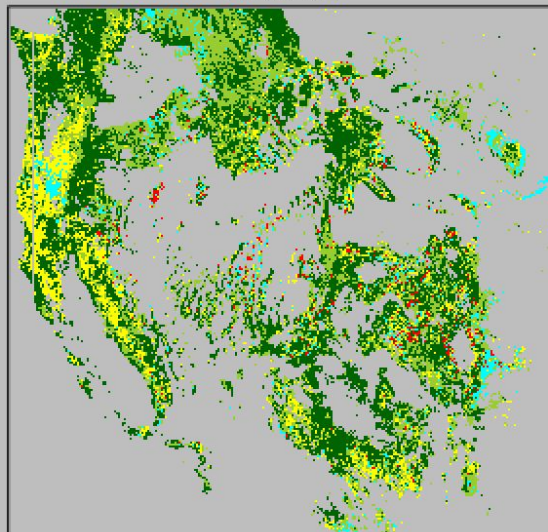
2010s



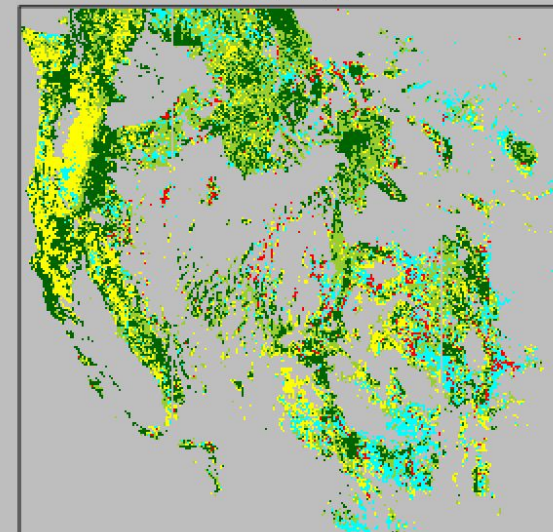
2020s



2030s



2040s

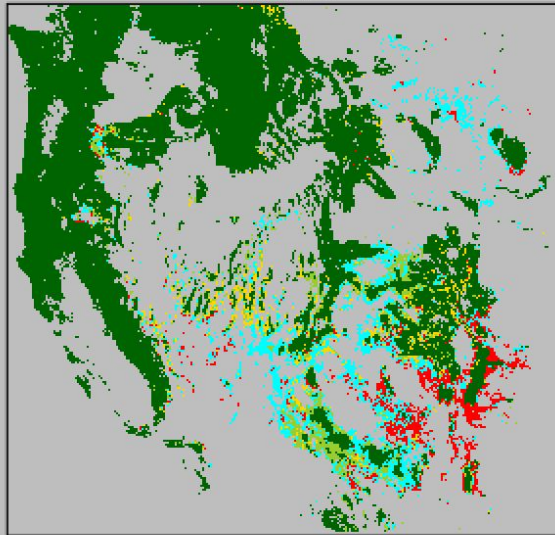




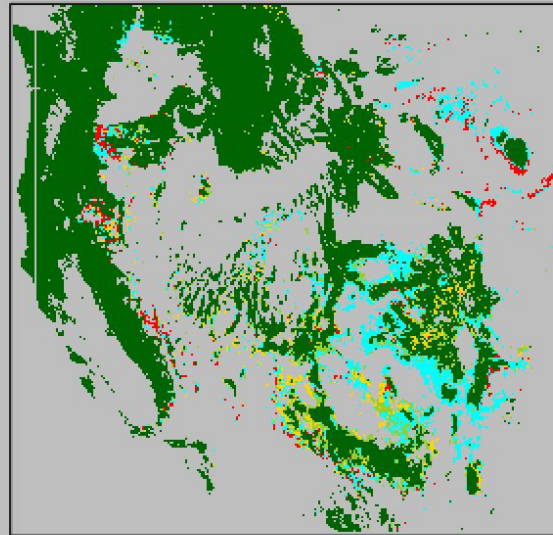
# Short-term Vulnerability from IPSL & MIROC

Both Low    Low & Med    Both Med    Med & High    Both High    Low & High

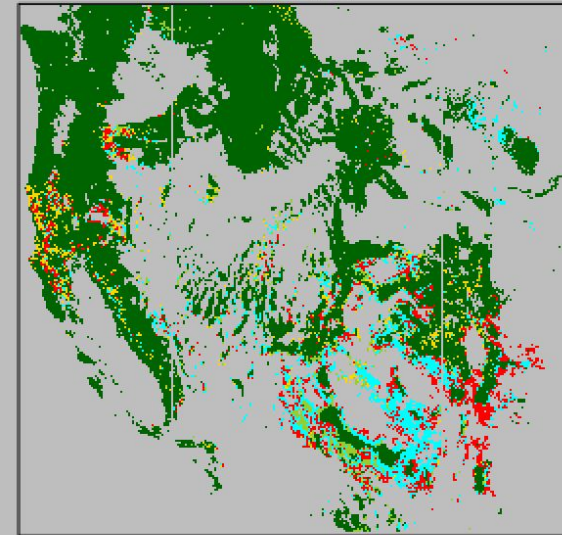
1990s



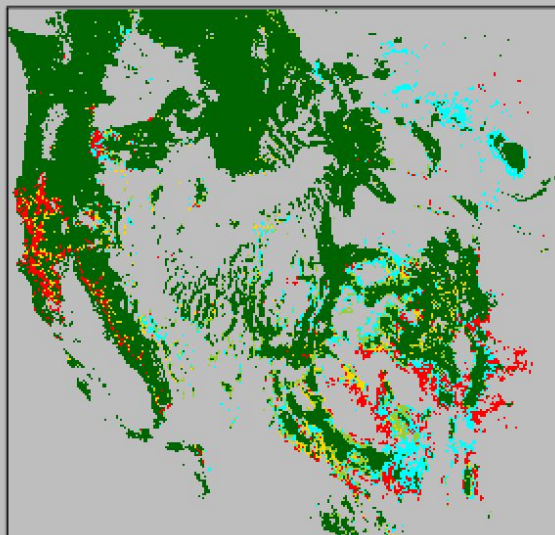
2000s



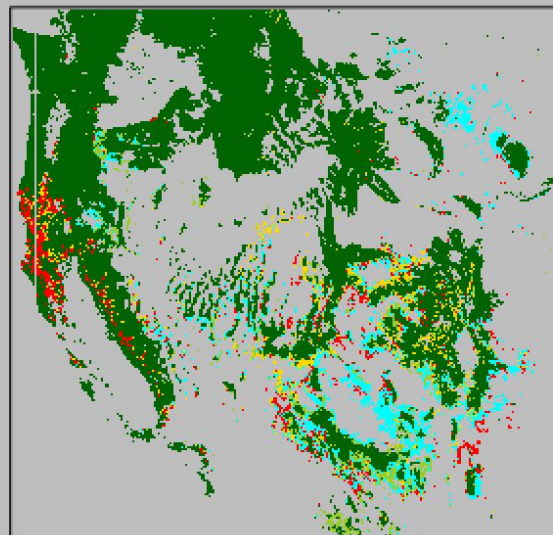
2010s



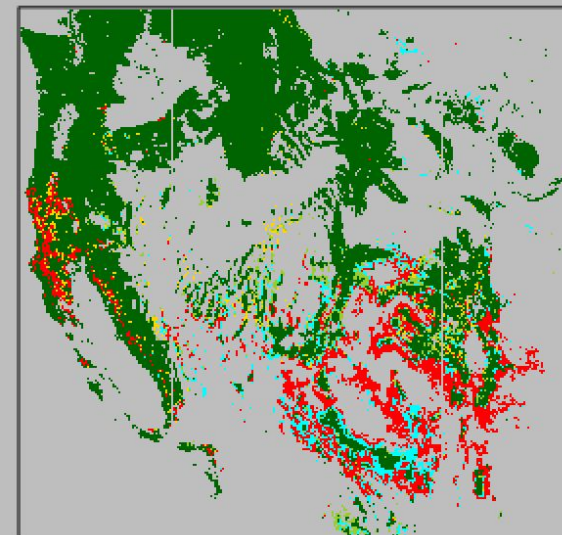
2020s



2030s

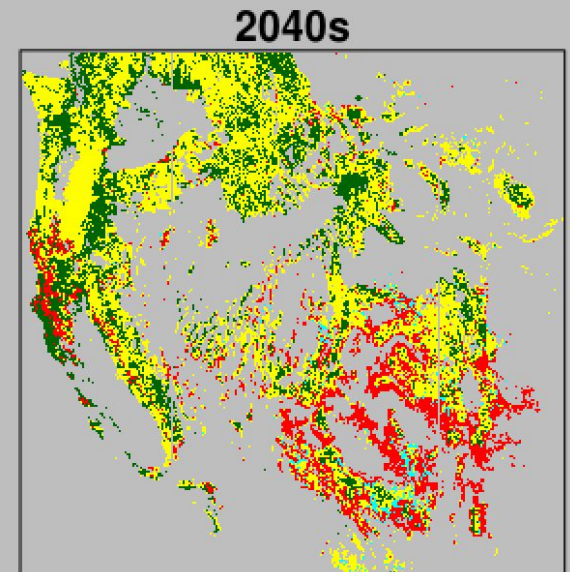
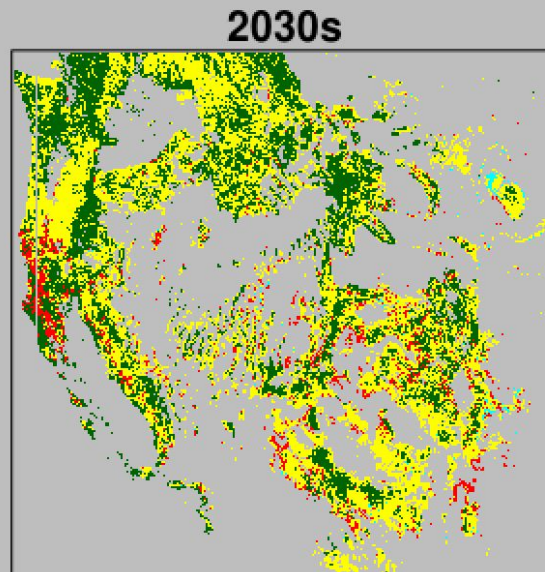
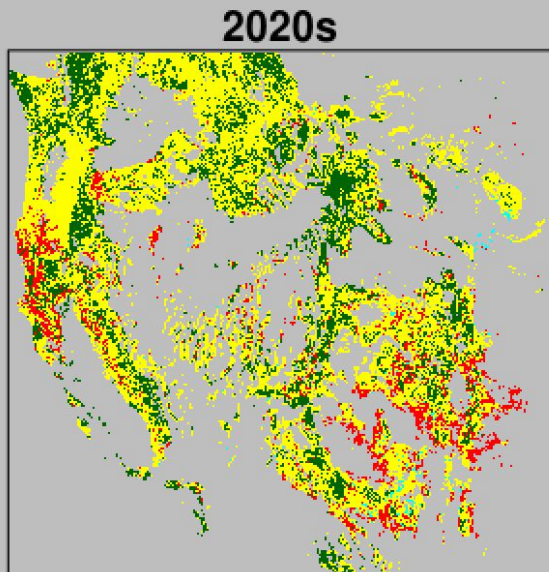
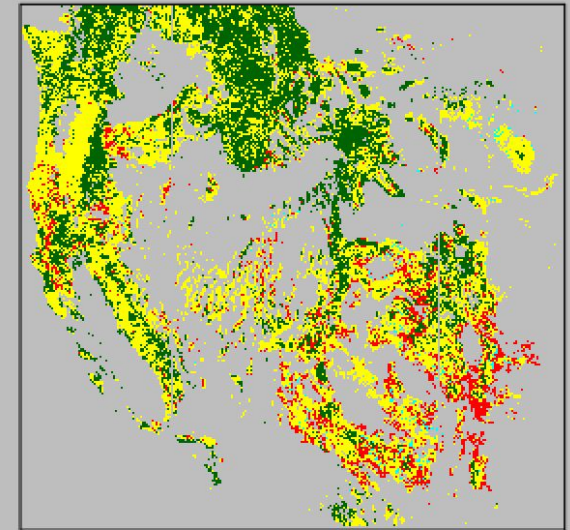
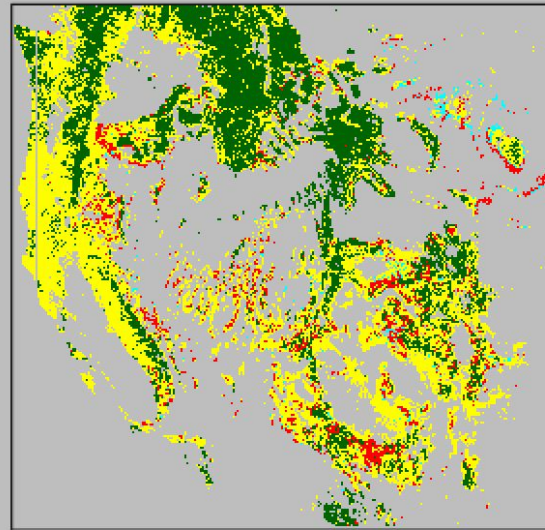
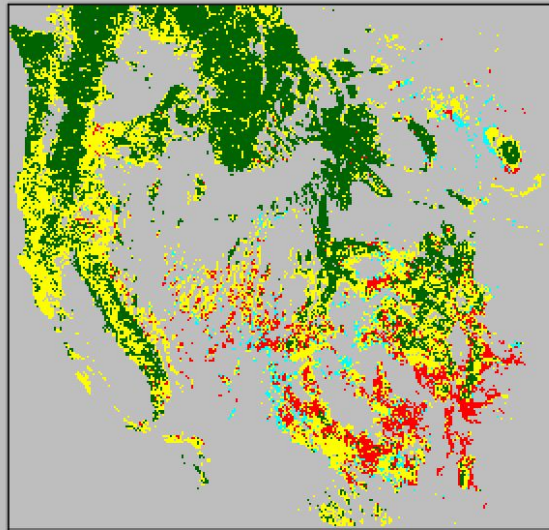
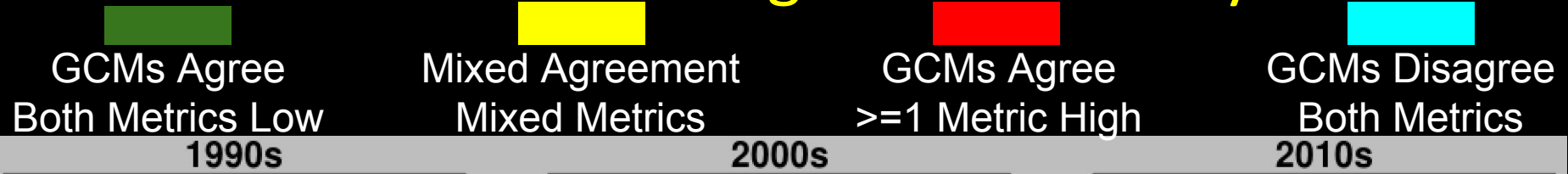


2040s





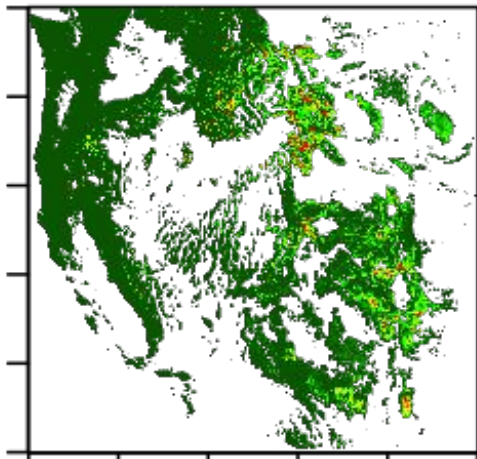
# Combined Drought Vulnerability



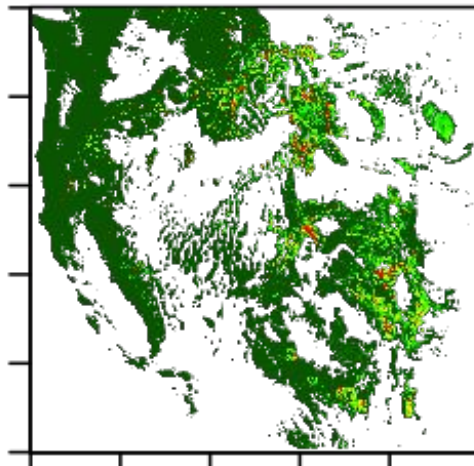


# Area Burned Through Time

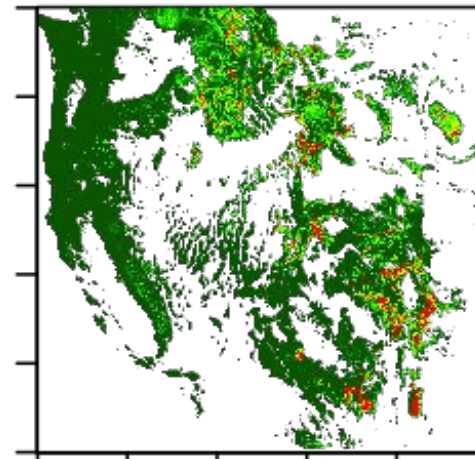
1990s



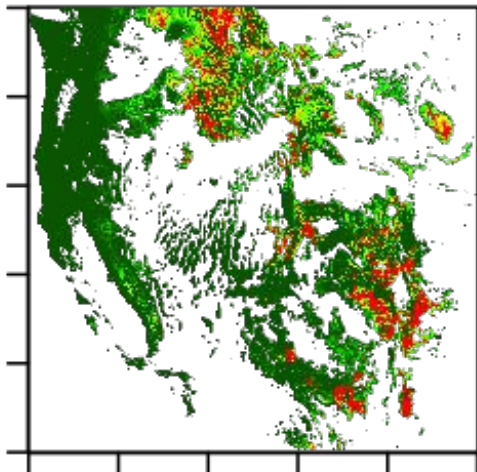
2000s



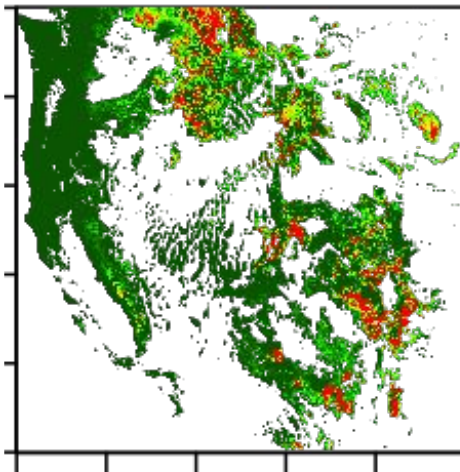
2010s



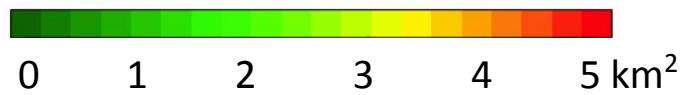
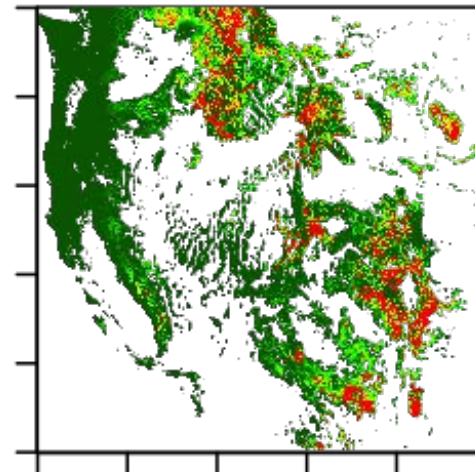
2020s



2030s

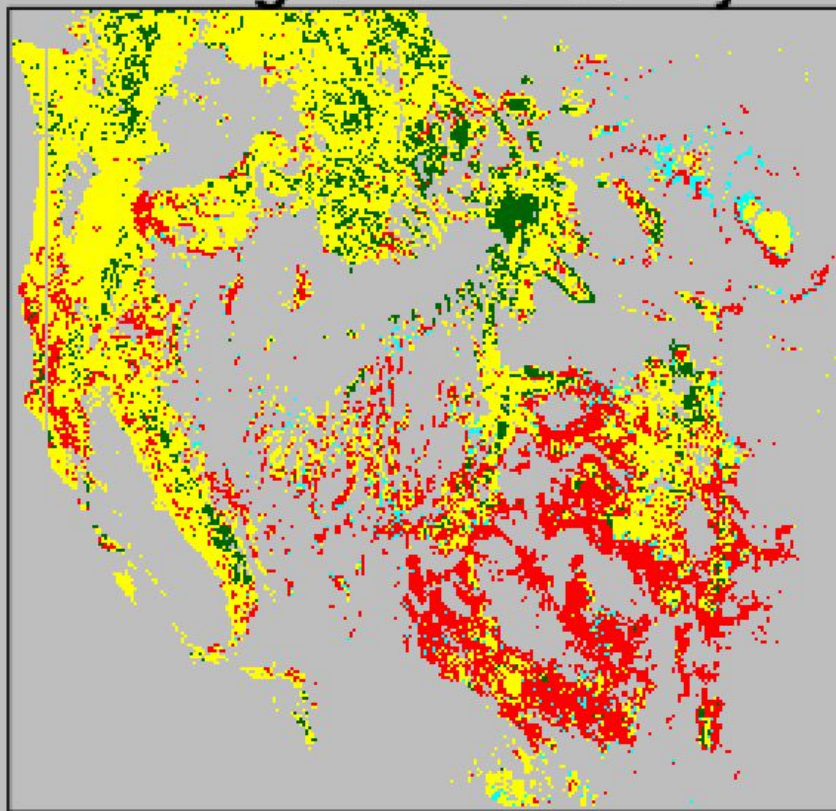


2040s

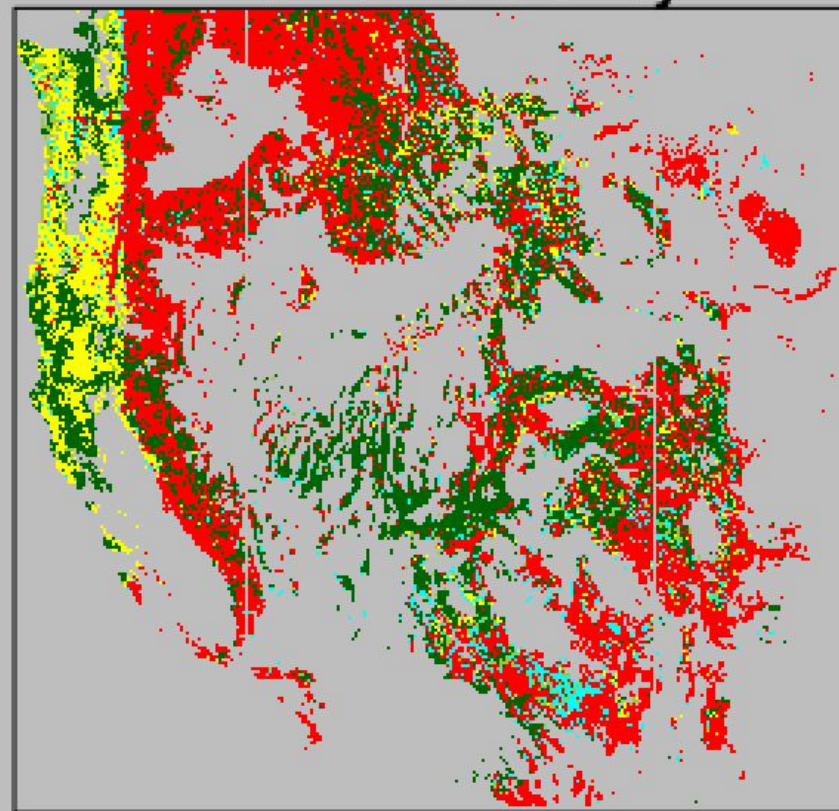


# Drought and Fire Vulnerability 2020s to 2040s

## Drought Vulnerability



## Fire Vulnerability



Always  
Low

Medium

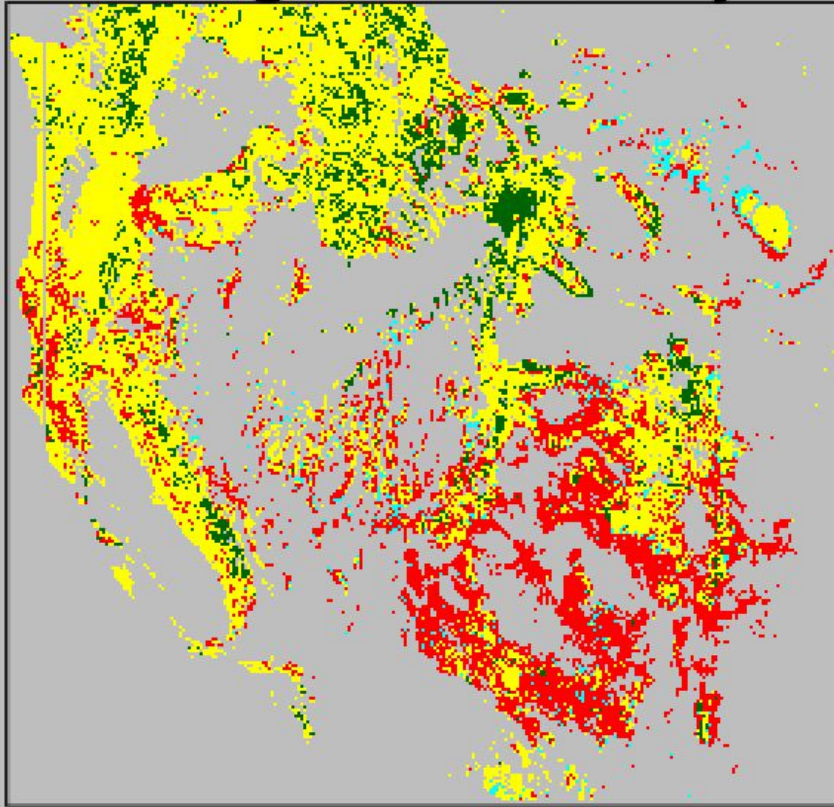
$\geq 1$  Decade High

Uncertain

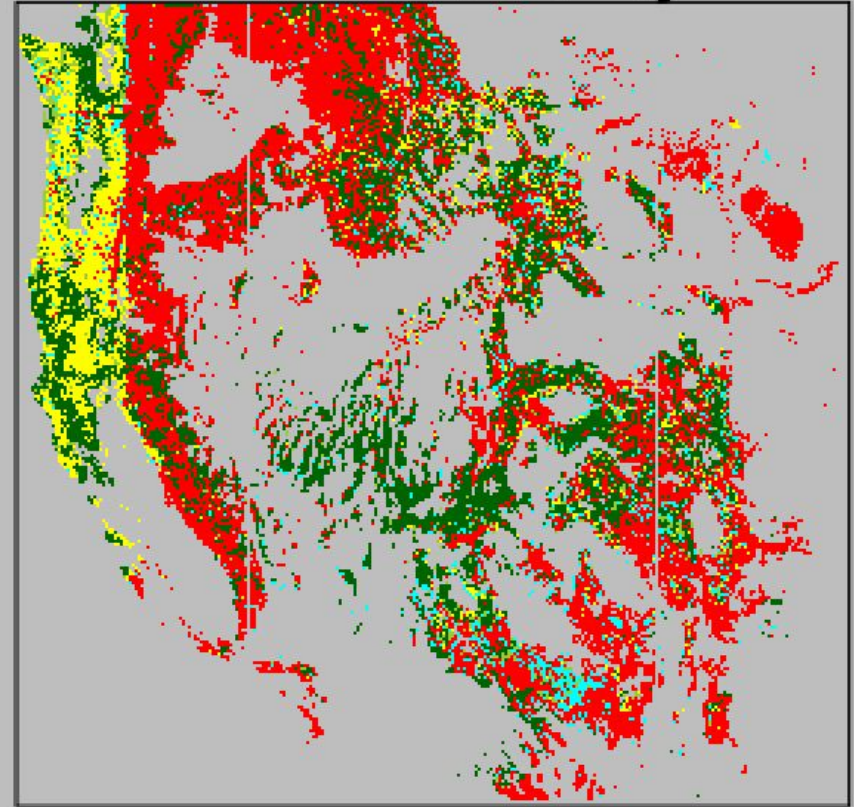


# Conclusions

## Drought Vulnerability



## Fire Vulnerability



 Always Low

 Medium

  $\geq 1$  Decade High

 Uncertain

- Southwest is most vulnerable to drought
- Intermountain is most vulnerable to fire
- Pacific Northwest is least vulnerable overall

# Continuing Work

- Explore ecological characteristics of vulnerable areas
  - Does reduced vulnerability coincide with decreased carbon stocks?
  - Which PFTs are the most vulnerable to each threat?
- Define harvest scenarios targeting vulnerable grid cells
  - Can timber harvest reduce future vulnerability?
- Vulnerability to beetle attack, and economically driven harvest...

*We would like to acknowledge high-performance computing support from Yellowstone (<ark:/85065/d7wd3xhc>) and Cheyenne (<doi:10.5065/D6RX99HX>) provided by NCAR's Computational and Information Systems Laboratory, sponsored by the National Science Foundation.*