Climate change, fire, and vegetation dynamics for northern Rockies:

Managing uncertainty

Bob Keane and Rachel Loehman
USDA Forest Service
Rocky Mountain Research Station

Fire, Fuel, and Smoke
Science Program

Climate Change Impacts

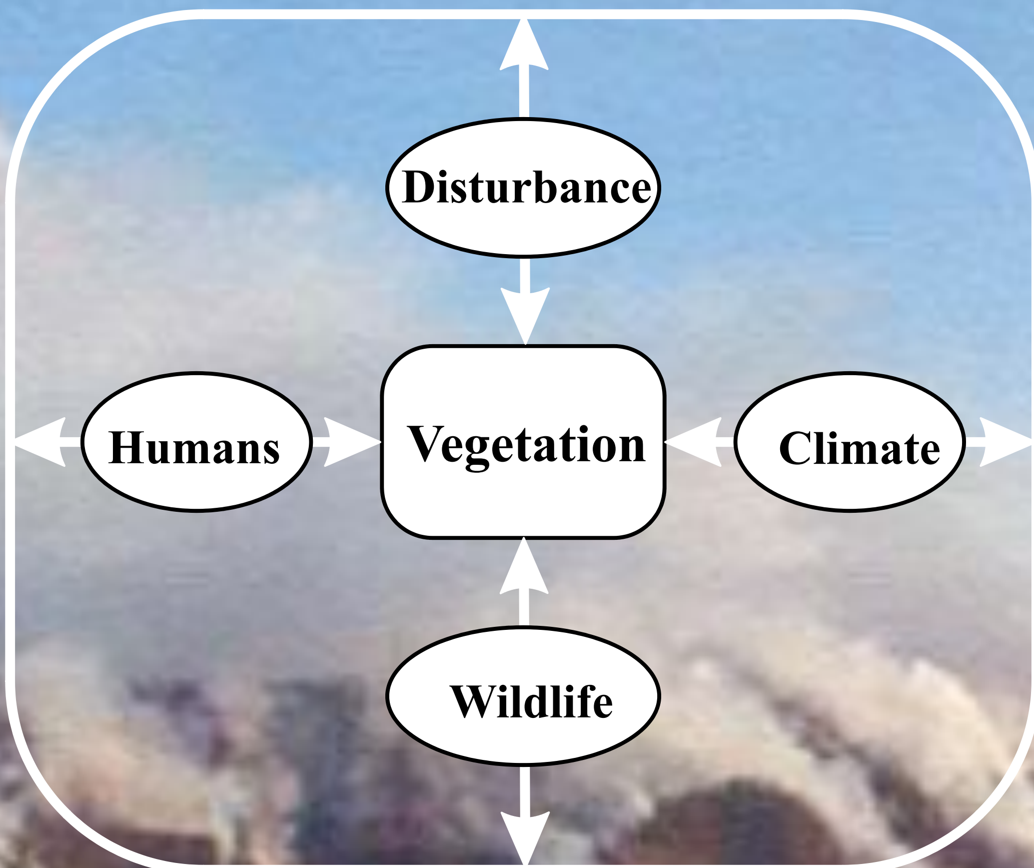
Predicting landscape changes
Three simple guidelines:

- "**C**hange is constant"
- "**I**t's never easy or simple"
- "**E**verything is local"

Climate change

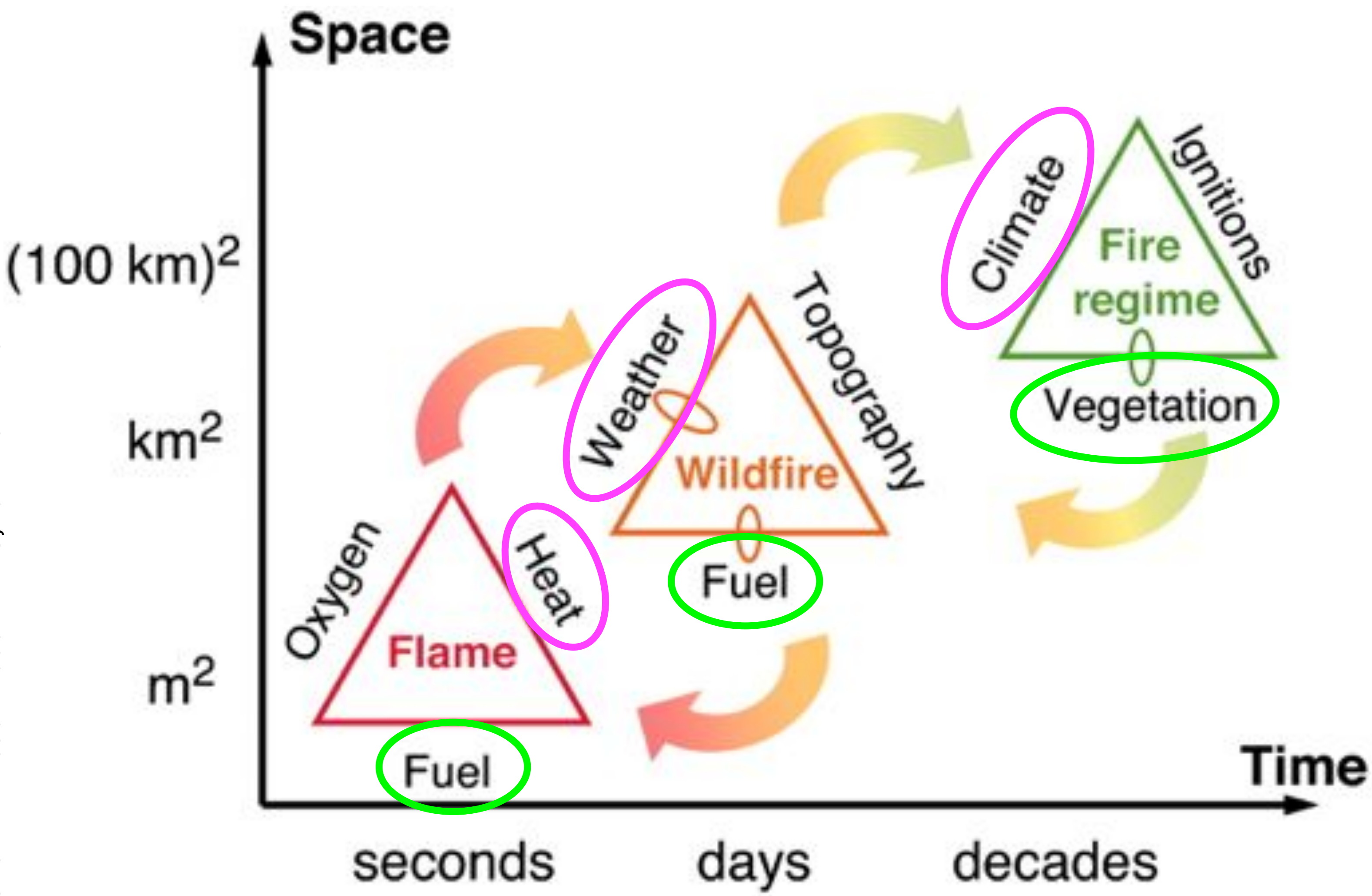
Landscape effects

Result from complex interactions between climate, vegetation, topography, and humans



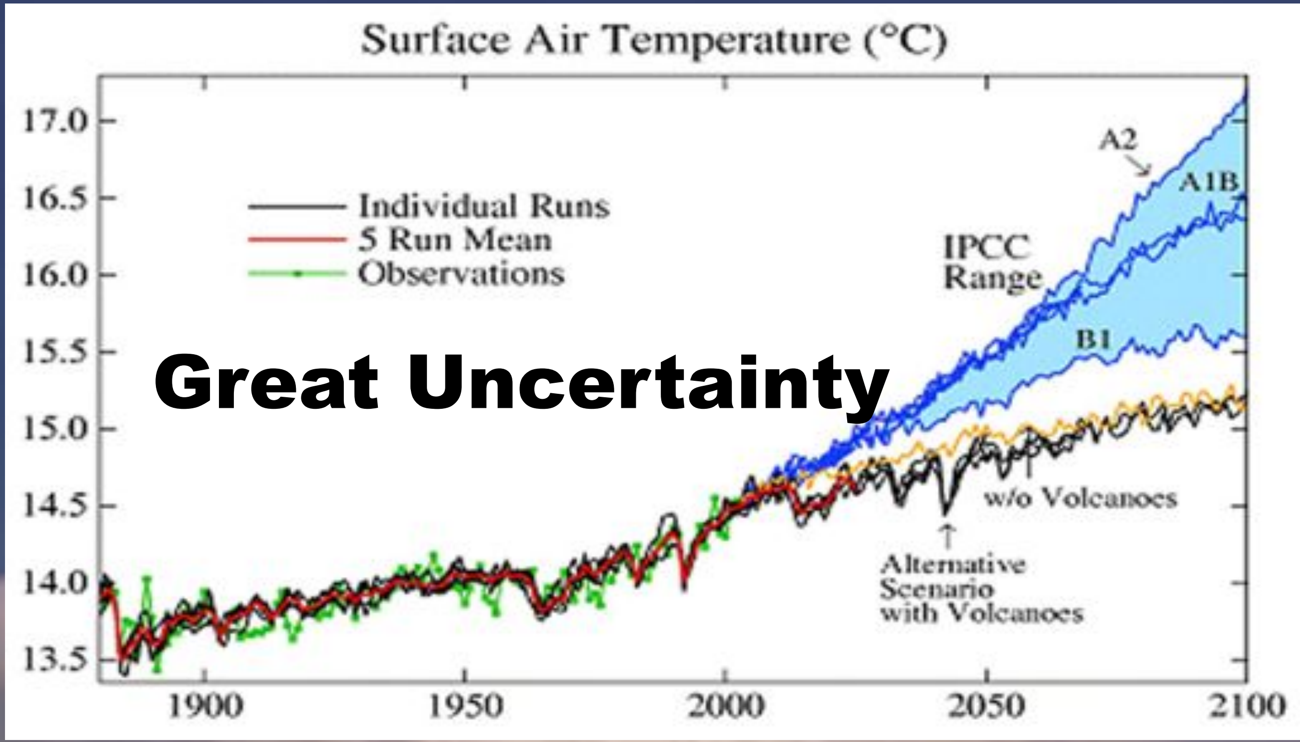
Lodgepole pine, Yellowstone NP

Scale influences climate change response



Moritz M. A. et.al. 2005. PNAS;102:17912-17917

21st Century Global Warming



<u>Climate Simulations for IPCC 2007 Report</u>

- **Climate Model Sensitivity 2.7-2.9°C for $2xCO_2$**
  (consistent with paleoclimate data & other models)
- **Simulations Consistent with 1880-2003 Observations**
  (key test = ocean heat storage)
- **Simulated Global Warming < 1°C in Alternative Scenario**

<u>Conclusion</u>: Warming < 1°C if additional forcing ~ 1.5 W/m^2

Source: Hansen et al., *to be submitted to J. Geophys. Res.*

Uncertainty

Climate change projections are difficult because of the high degree of uncertainty

Climate Change Impacts

Predicting landscape change

Four major approaches:

- "Ask the expert"
  - Deduction, inference, association
- "Study it"
  - Empirical and experimental studies
- "Analyze it"
  - Bioclimatic envelope statistical modeling
- "Simulate it"
  - Biophysical simulation modeling

Exploring climate change dynamics

Interactions between disturbance, land use, landscapes, ecosystems

- Immense complexity in ecology makes expert opinion, field studies, statistical modeling difficult
  - *Long time spans*
  - *Large spatial areas*
  - *Diverse linkages, feedbacks, and interactions*
  - *High variability in ecological processes*

Climate Change and Wildland Fire

Less Uncertainty

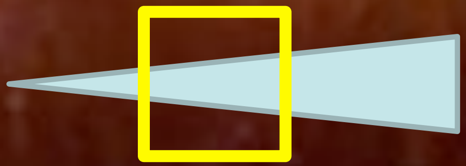
- Already seeing climate impacts?
- Tight climate linkage – Fuel Moisture

A literature review of possible effects

Climate Change and Wildland Fire – Western MT

Longer Fire Seasons

- Earlier frost dates
- Deeper droughts
- Fuels will be drier longer
- More of landscape will be drier longer
- Lower humidity, higher temperature
- Disrupted phenologies and fire adaptations



Climate Change and Wildland Fire

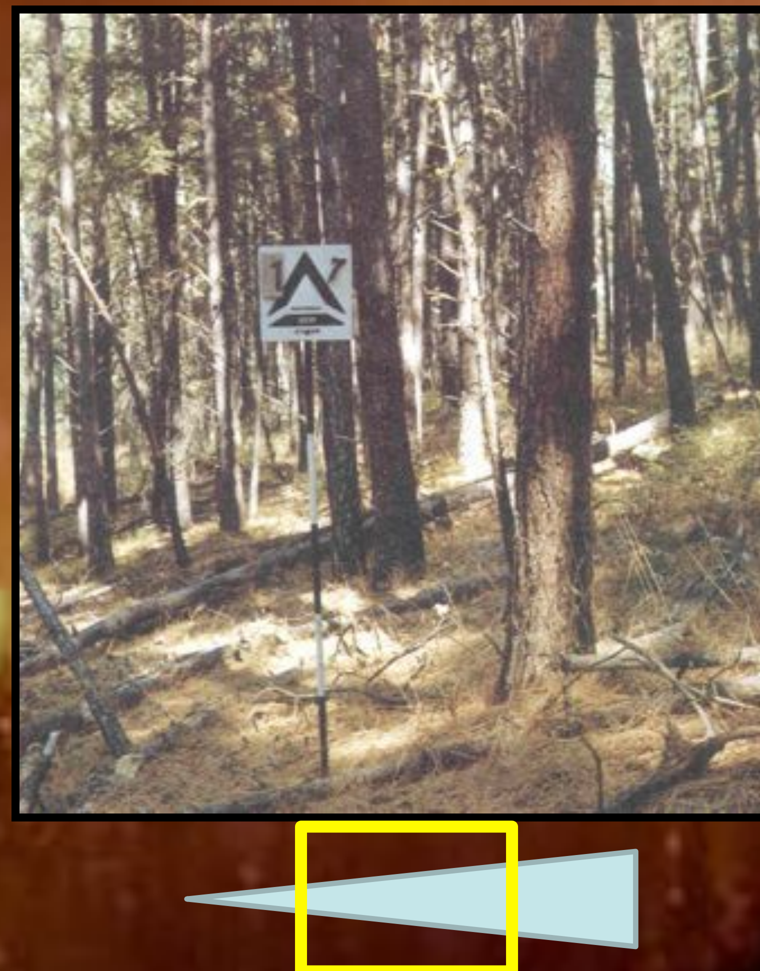
Increased Lightning

- More convective storms
- Greater storm intensity
- 30% increase in global lightning
- Greater occurrence during drought
- Higher cloud to ground strikes
- Greater number of positive strikes

Climate Change and Wildland Fire

Increased fuel production

- **Higher productivity results in an increase in burnable biomass**
- **Increased fuels will be more contagious and connected**
- **Productivity will increase canopy fuels**

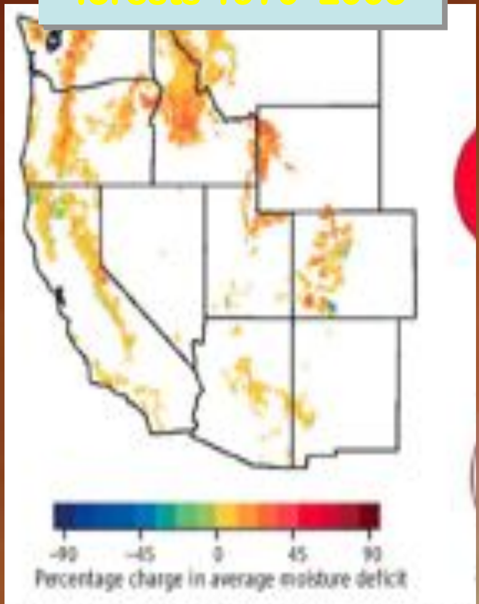


Climate Change and Wildland Fire

Larger fires

- **Fires are predicted to be larger for the following reasons:**
  - Greater fuel accumulation
  - Continuous fuel beds
  - Greater chance for higher winds
  - More of landscape in drought
  - Burn longer with long fire seasons

moisture deficit in forests 1970–2003



Wildfires >1,000 ha 1970–2003

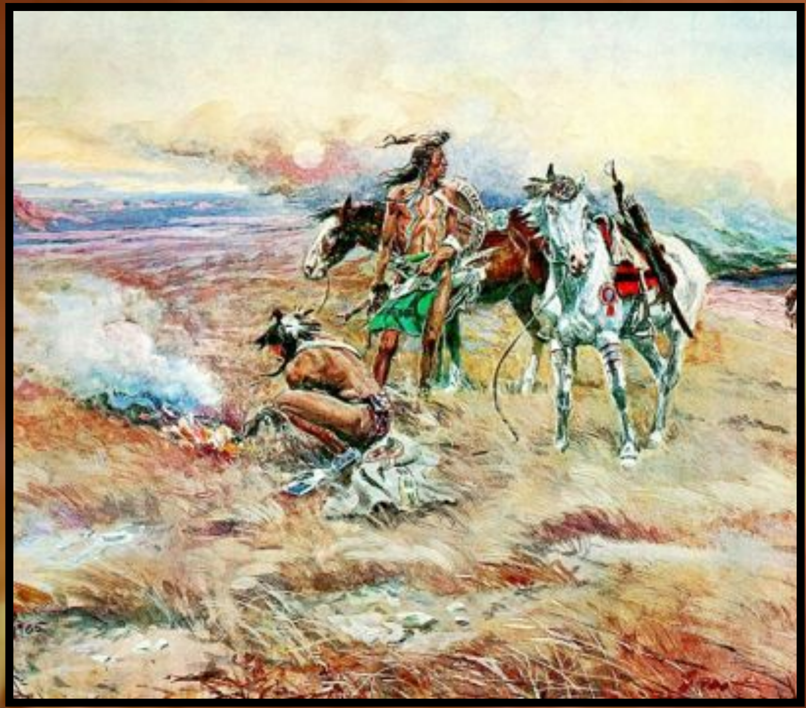
Greater fire intensities & Higher fire severities

- **More severe fire is expected because of the following:**
  - High accumulated fuels
  - Denser tree canopies
  - Widespread drought conditions
  - High wind events
  - Previous fire management -- Exclusion

Climate Change and Wildland Fire

An Historical Perspective

- **Ten to 100 times more land burned prior to European Settlement**
  - National historical fire return interval 17-22 years
- **Large fires were common but rarely catastrophic**
- **Most ecosystems are adapted to fire**
- **Climate driven increase in wildland fire is mostly a anthropogenic concern**



Native American burning

Climate Change and Wildland Fire

Situational Awareness

- **Seven decades of fire exclusion**
- **Introduction of exotics**
- **Extensive land use changes**
  - Grazing
  - Logging
  - Development
  - Urban interface

Successful fire suppression

Future Fire Dynamics

Literature searches & statistical analysis don't address spatial relationships

It is now possible that a large fire can burn an area the size of a land management unit

Factors governing this dynamic

- **Degree of management**
- **Tolerance of society**
- **Magnitude of climate change**

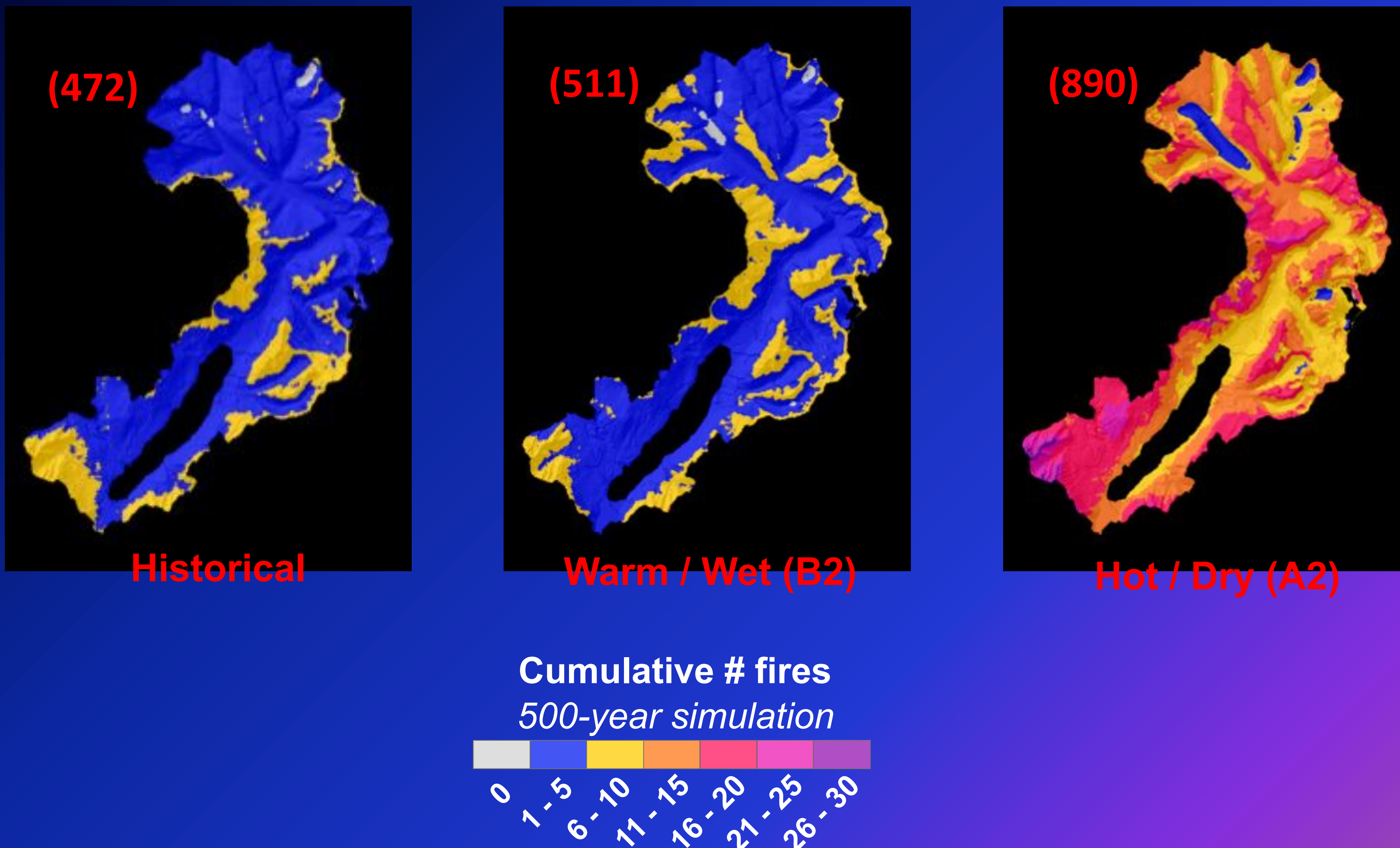
FireBGCv2:
A research simulation platform for exploring fire, vegetation, and climate dynamics

Keane, Robert E.; Loehman, Rachel A.; Holsinger, Lisa M. 2011. **The FireBGCv2 landscape fire and succession model: a research simulation platform for exploring fire and vegetation dynamics. Gen. Tech. Rep. RMRS-GTR-255. Fort** Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 137 p.

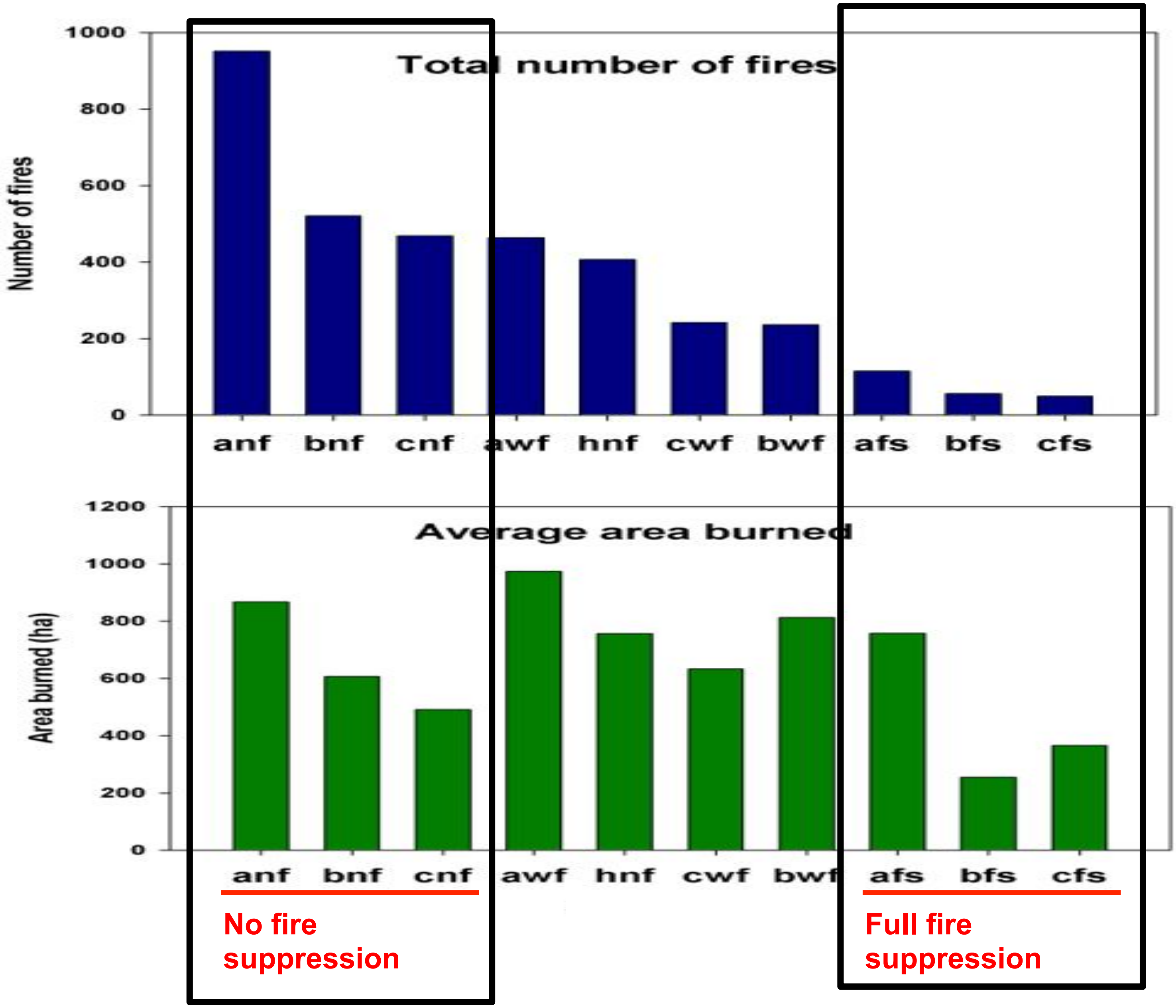
CLIMET
Climate-Landscape Interactions on a Mountain Ecosystem Transect

FireLab
MISSOULA, MONTANA

Glacier National Park
Fire regimes in changing climates



Number Fires vs Area Burned

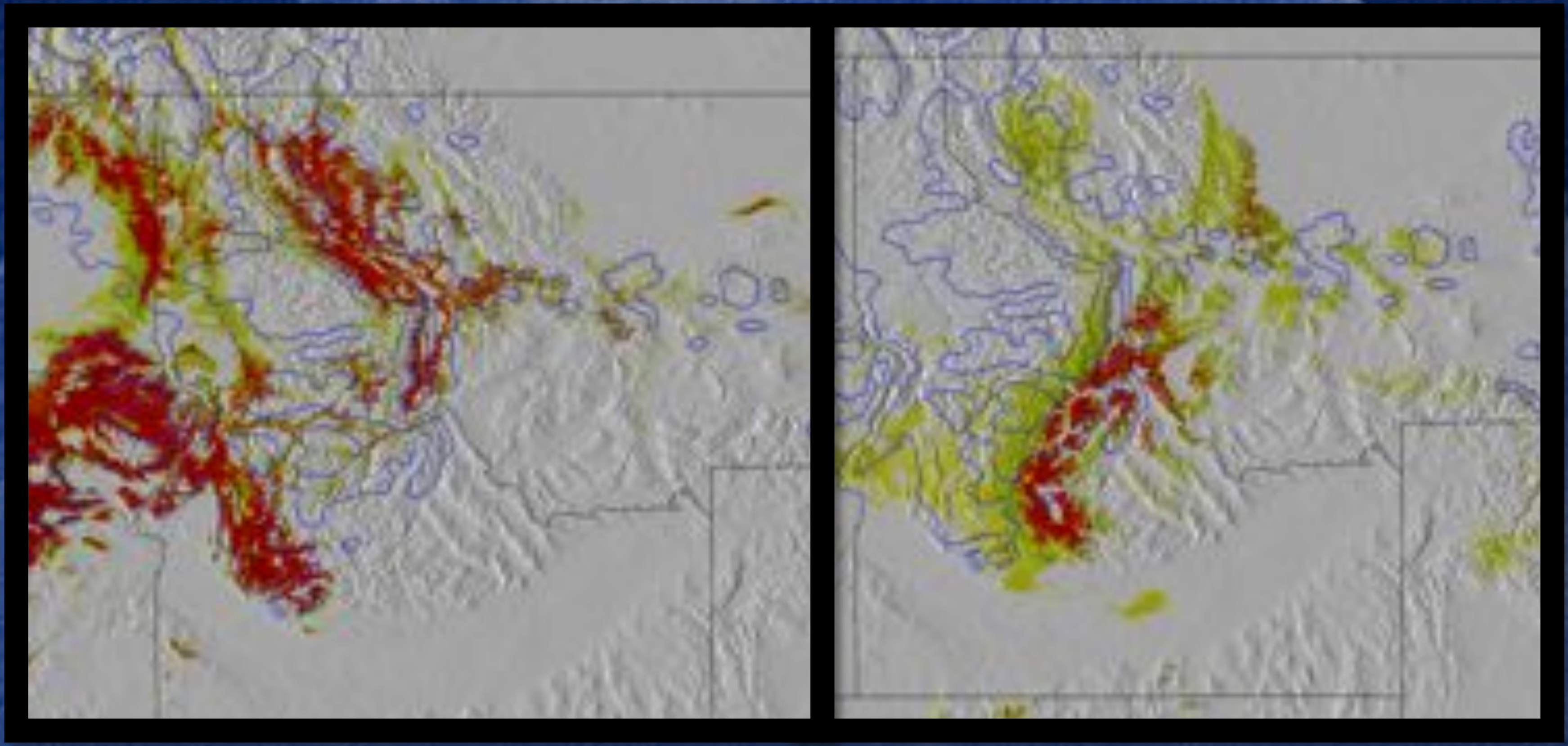


Climate Change and Vegetation Dynamics

More Uncertainty

- Many interactions
- Many life cycles
- Long lived organisms
- Broad climate linkage

Ponderosa Pine

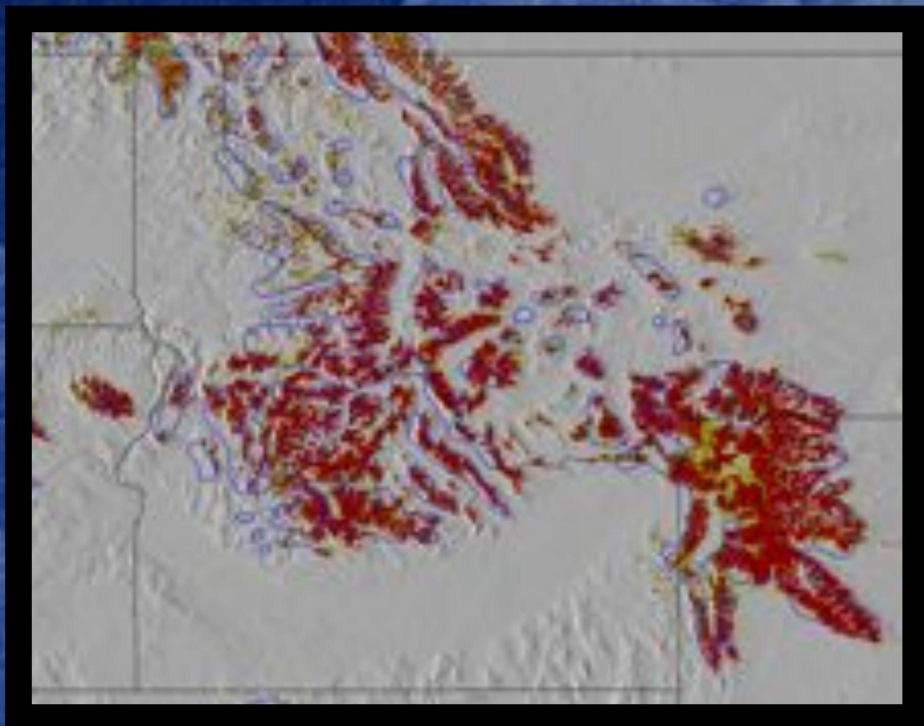


Current distribution

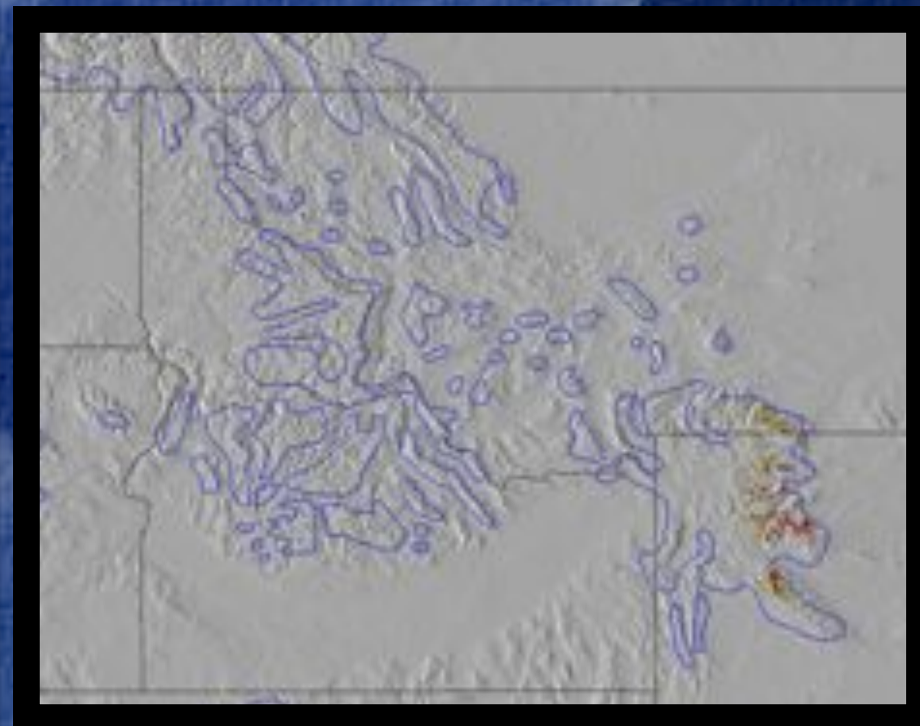
Distribution in 2090 – A2 Climate

http://forest.moscowfsl.wsu.edu/climate/species/speciesDist/Ponderosa-pine/

Whitebark Pine



Current distribution



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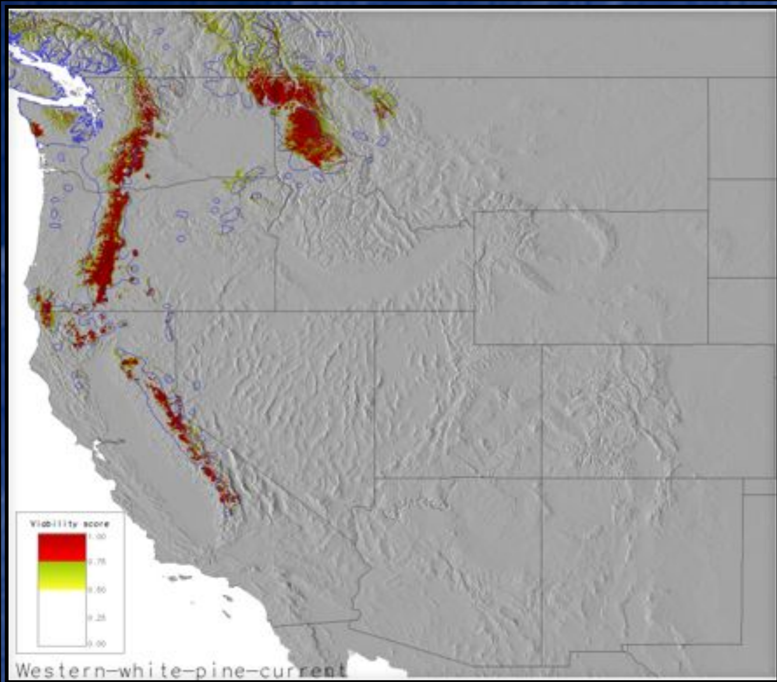
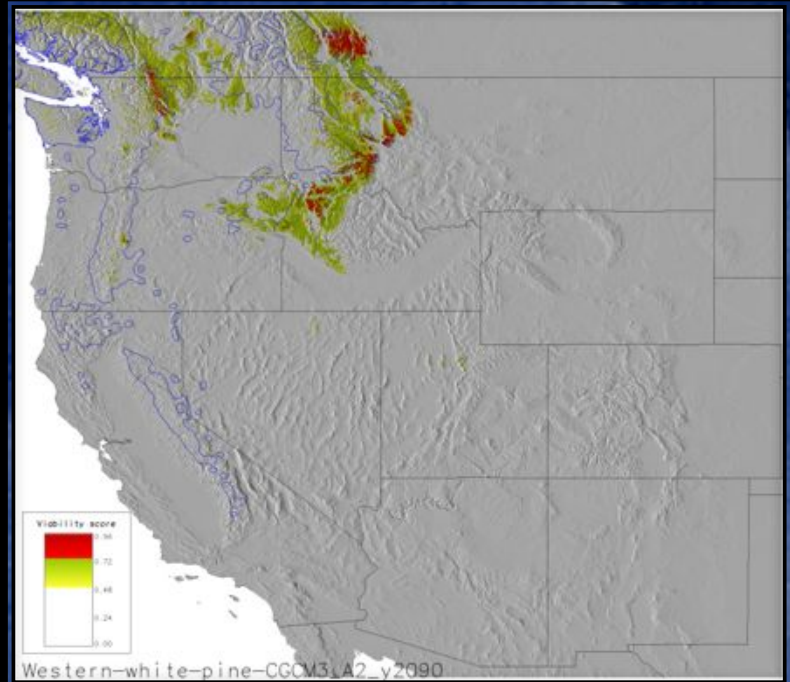
Western White Pine



Current distribution



Distribution in 2090 – A2 Climate

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Climate Change

Statistical Modeling Efforts

Changes in Vegetation

Projections

- Increases in western white pine, grand fir
- Decreases in ponderosa pine, whitebark pine, lodgepole pine, subalpine fir, alpine larch

Problems

- Emphasize only climate-vegetation relationships
- Don’t recognize genetics, dispersal, life cycles, and most importantly disturbance

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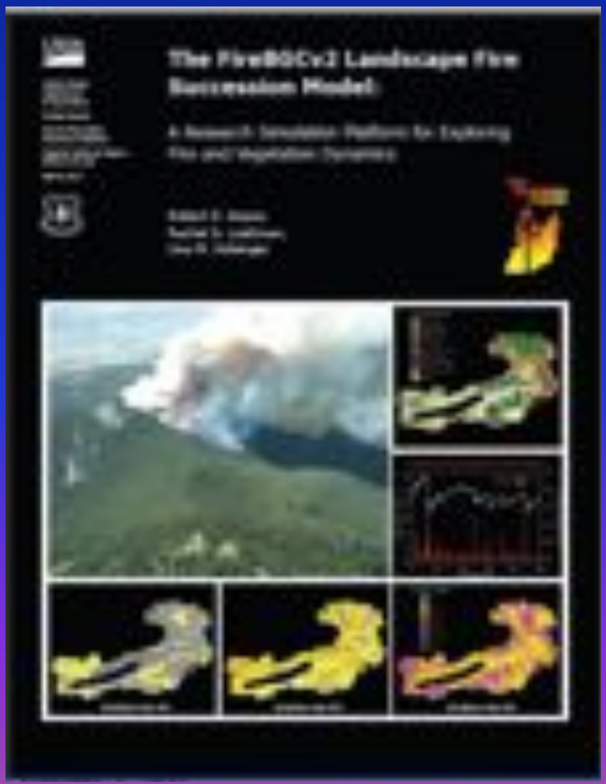

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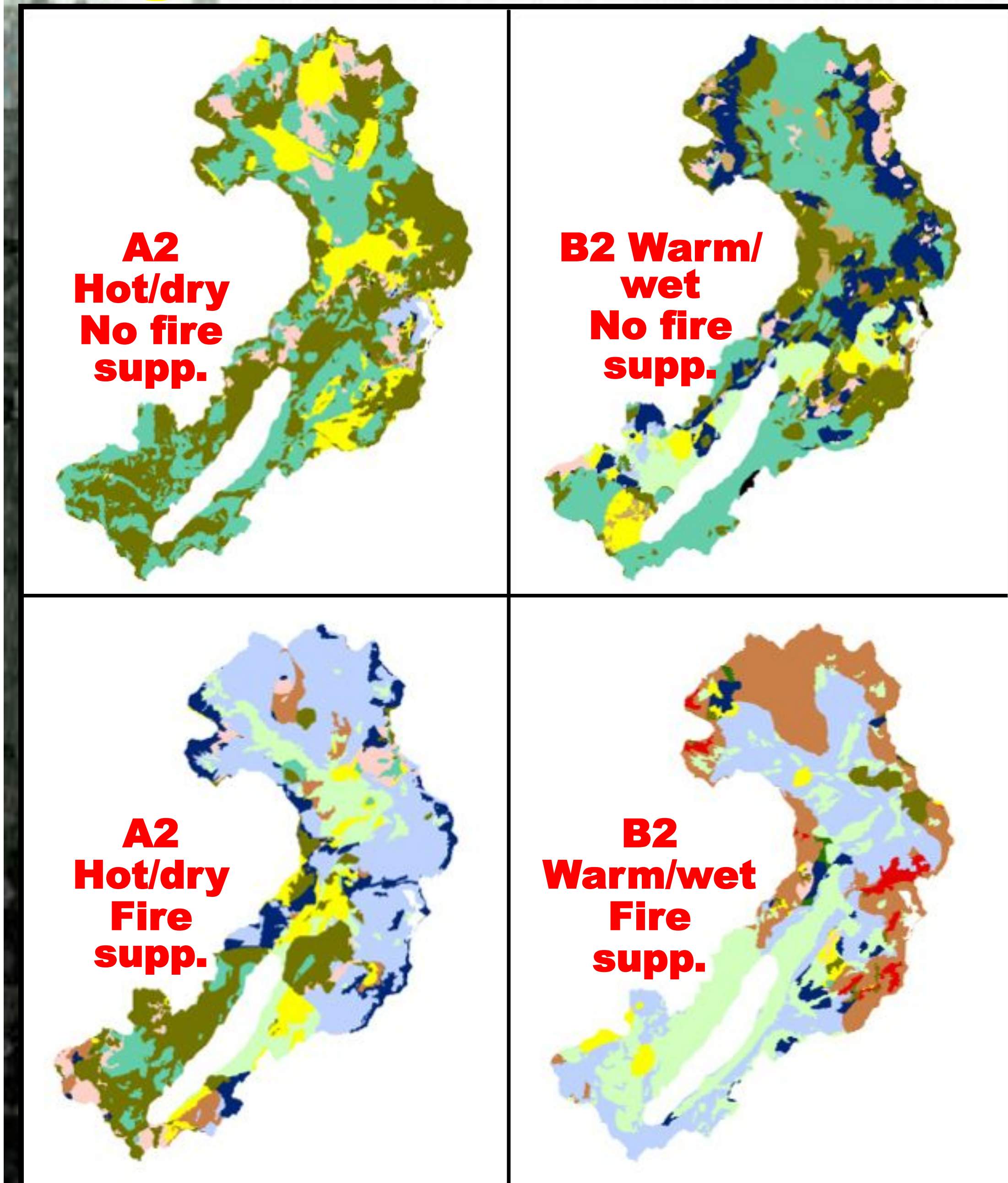
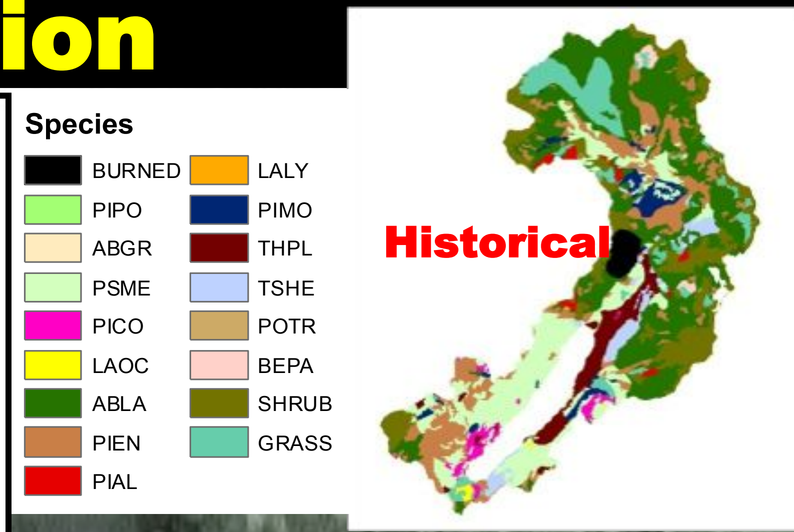
MISSOULA, MONTANA

Vegetation composition



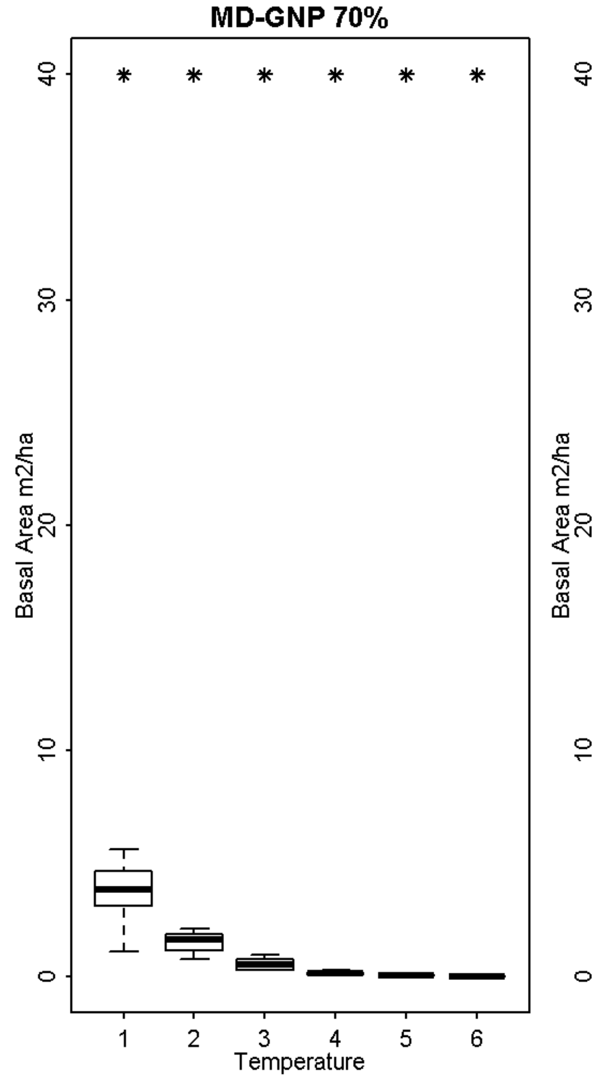


Fire Suppression
- Spruce/fir replaced by hemlock/cedar
- Hem/cedar replaced by P. Pine and D. fir

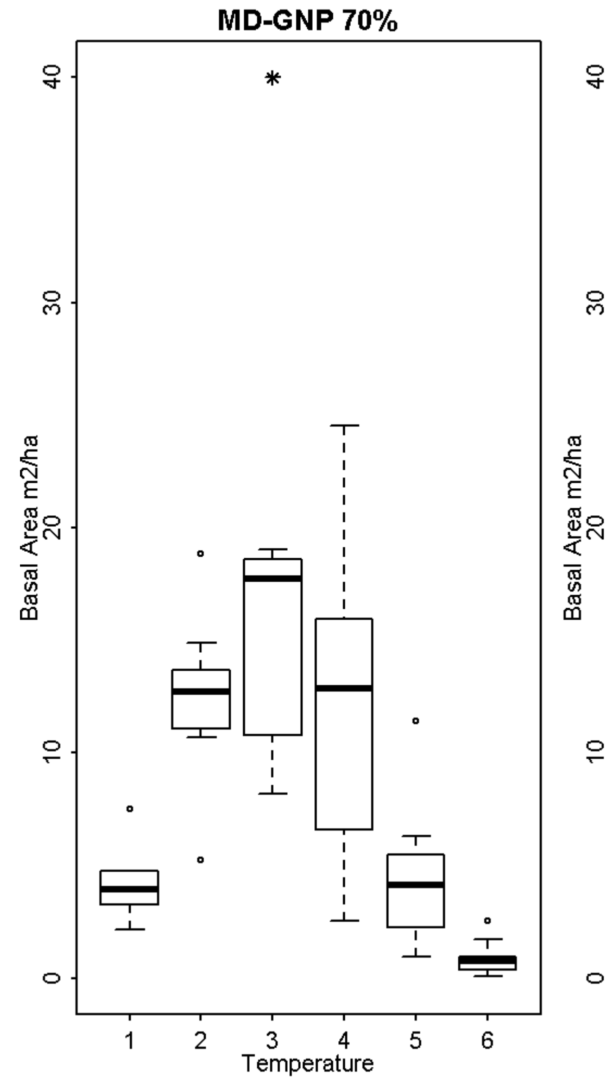
No Fire Suppression
- Lodgepole to w. larch
- Lodgepole to ponderosa pine

Dominant species changes

Glacier NP

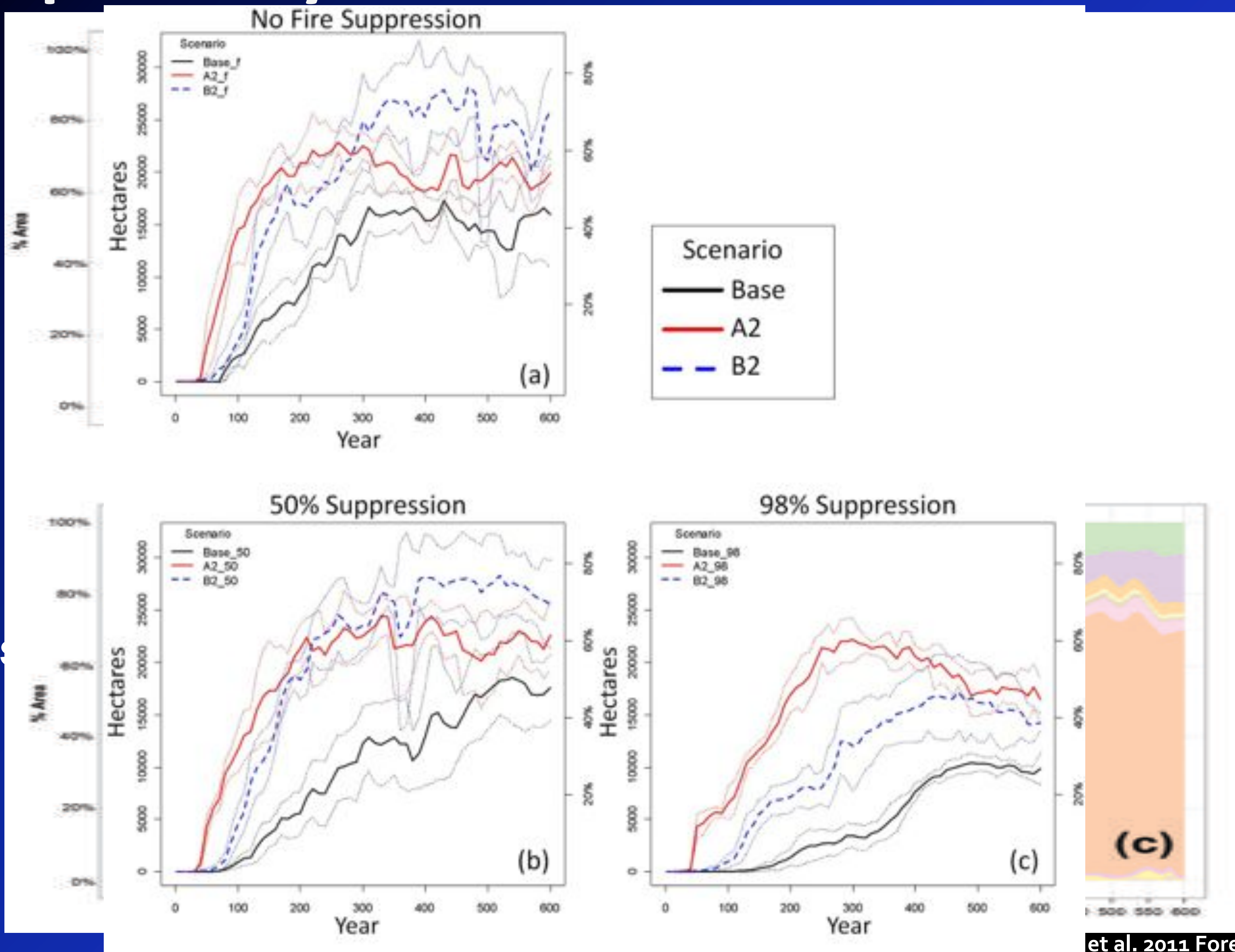


Subalpine fir



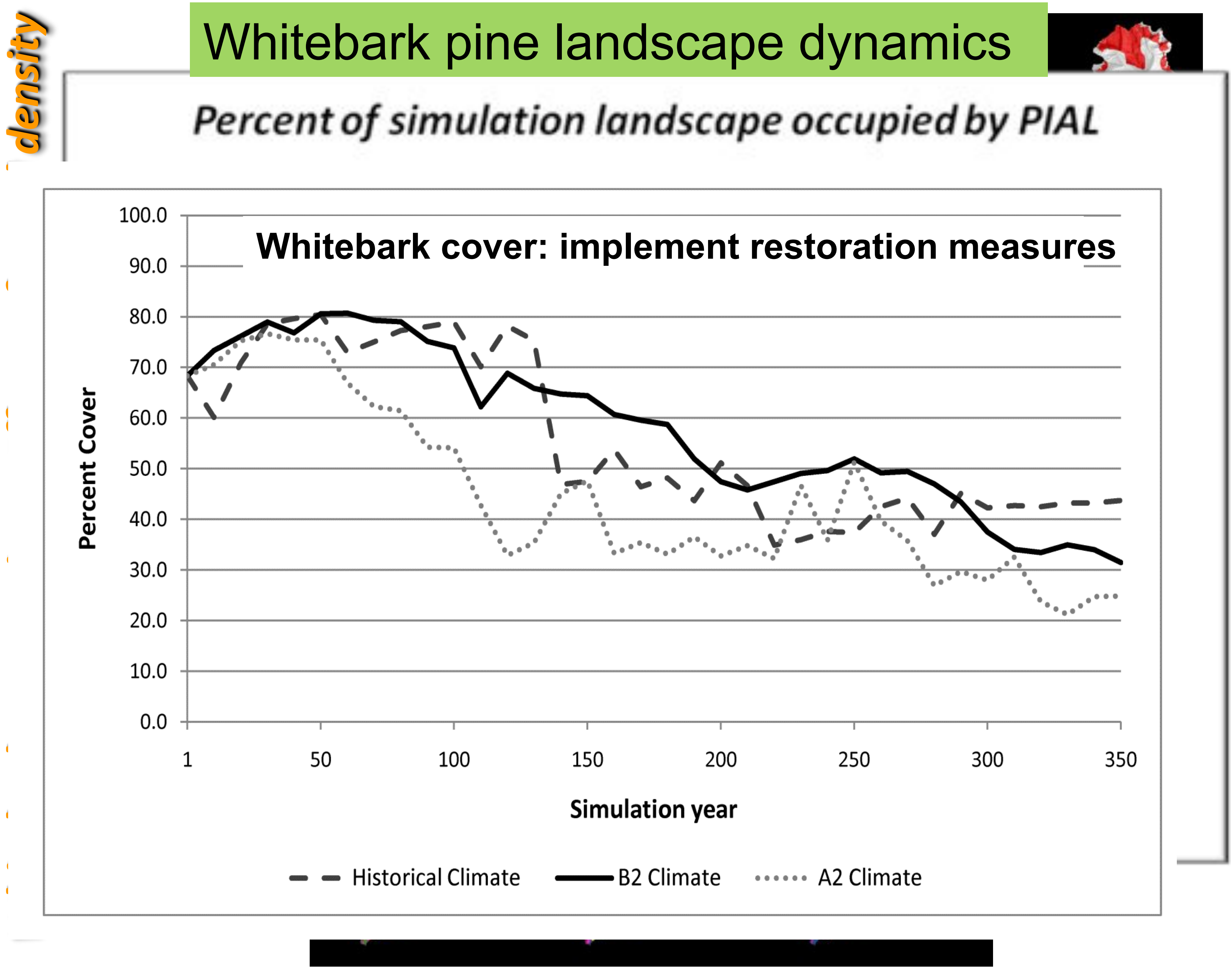
Western hemlock

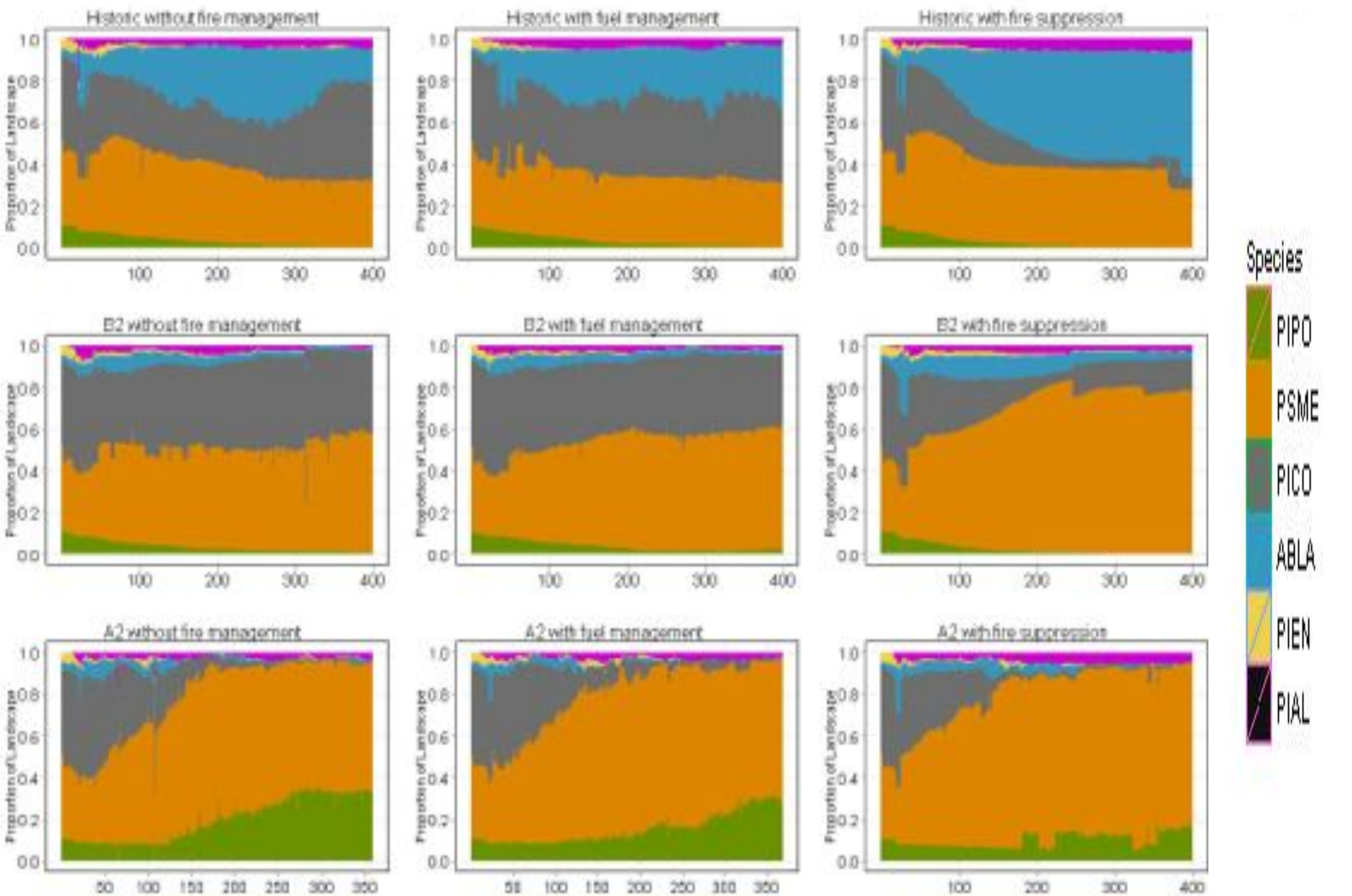
Species Dynamics -Western White Pine



et al. 2011 Forests.

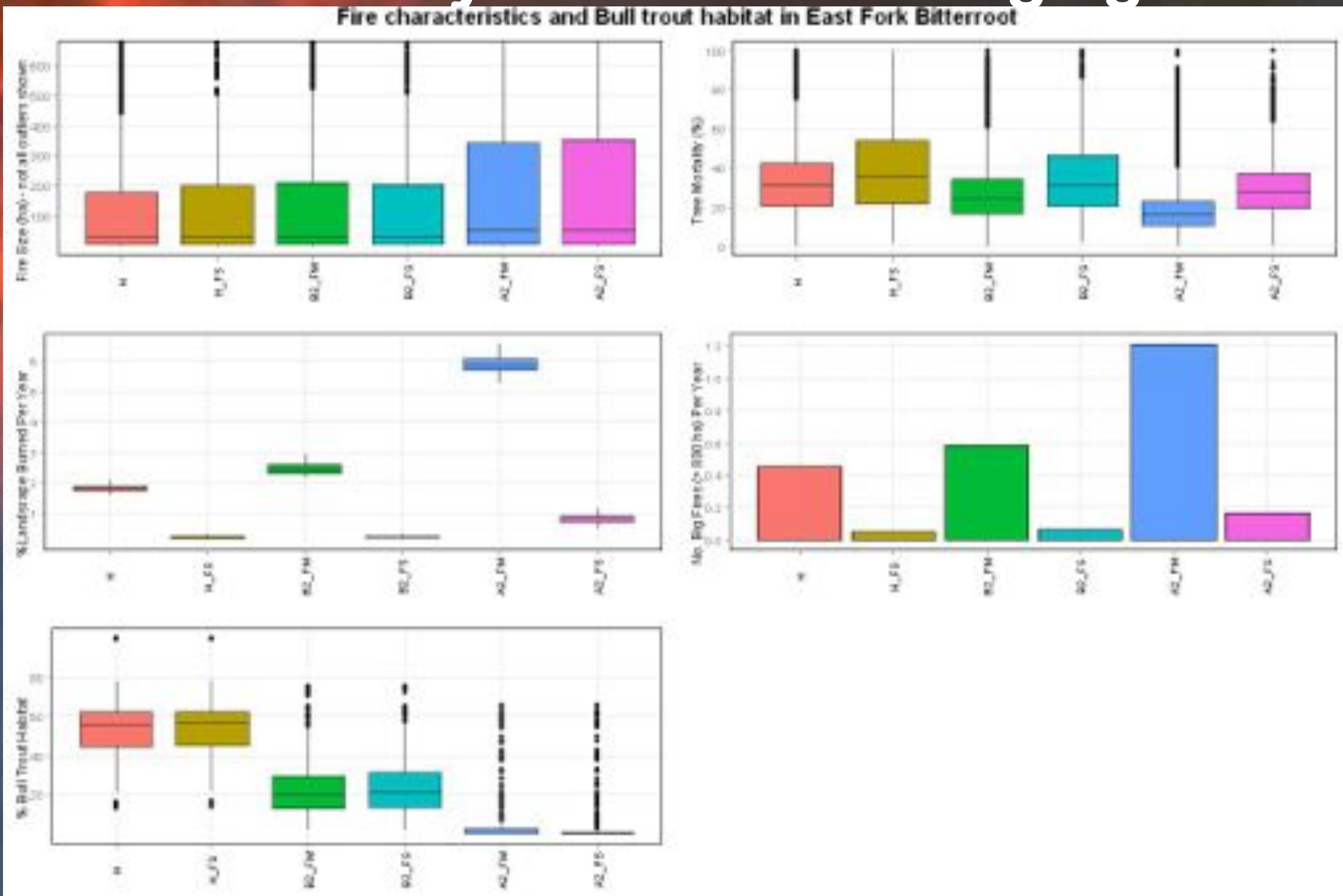
Whitebark pine landscape dynamics




Historic without fire management
Historic with fuel management
Historic with fire suppression
B2 without fire management
B2 with fuel management
B2 with fire suppression
A2 without fire management
A2 with fuel management
A2 with fire suppression
Proportion of Landscape
Species
PIPO
PSME
PICO
ABLA
PIEN
PIAL

East Fork Bitterroot River

Fire and fish dynamics in a changing climate



Managing Uncertainty

- Recognize high levels of uncertainty in decision-making

- Find ways to reduce uncertainty
  - Establish climate change monitoring network
  - Support climate change research

- Accept ecosystems are highly complex and variable

Remember CIE: change is constant, its never easy, everything is local