The challenges of integrating climate change into forest planning at multiple scales -- from landscape HRV and FRV to NRAP

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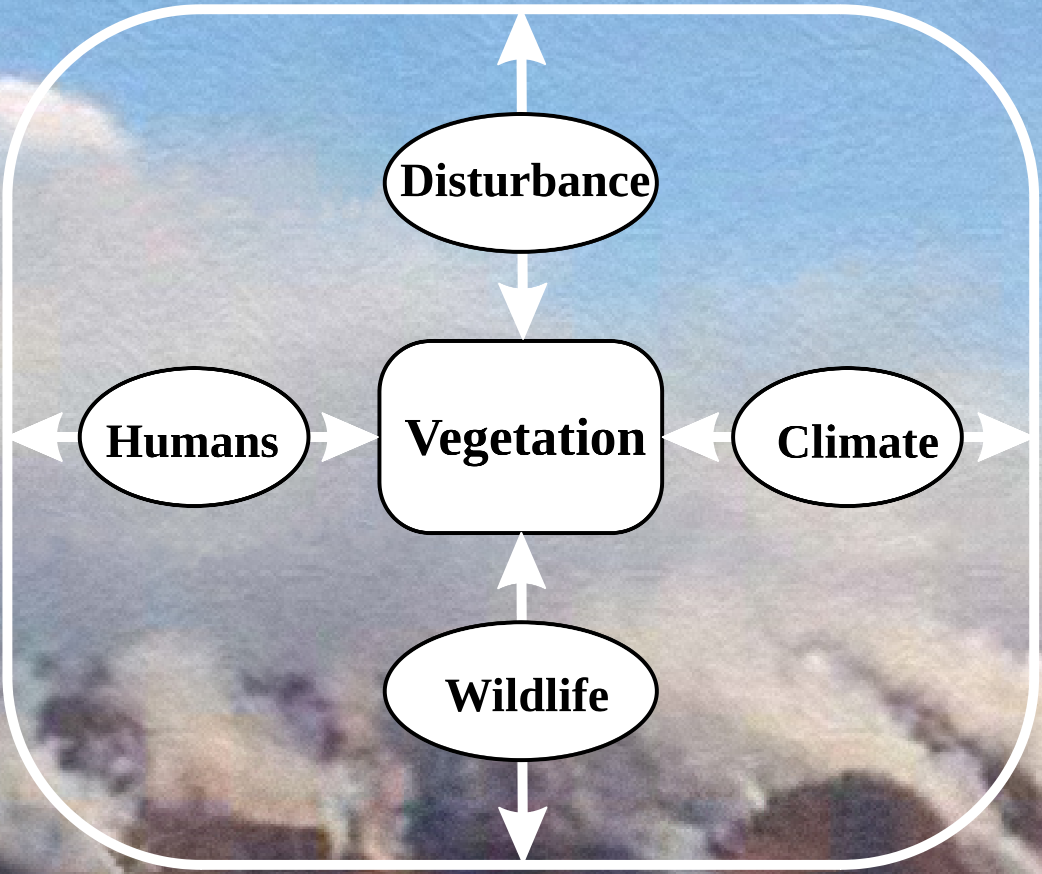
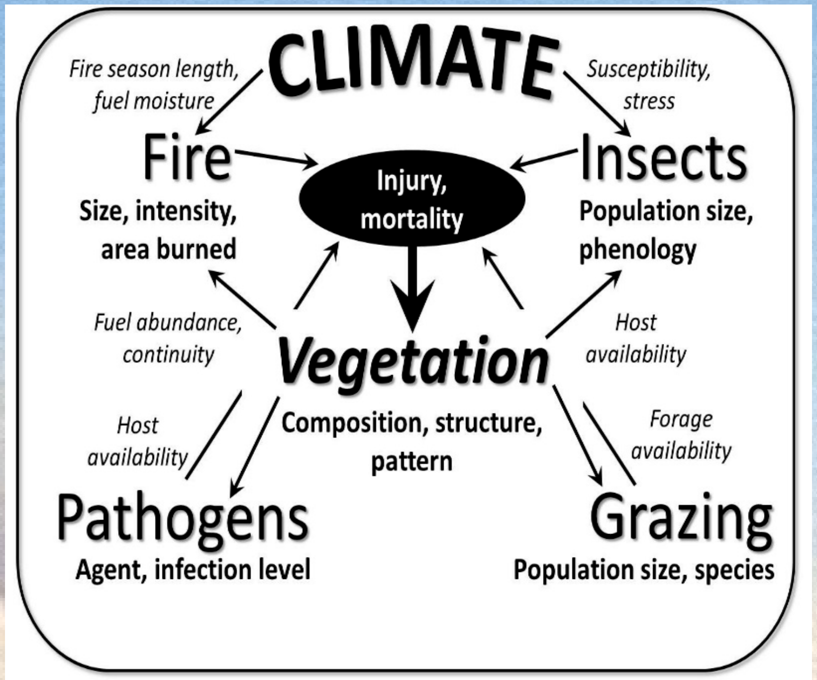
Integrating climate change into forest planning is "Wicked HARD"!

Many Reasons

Interactions

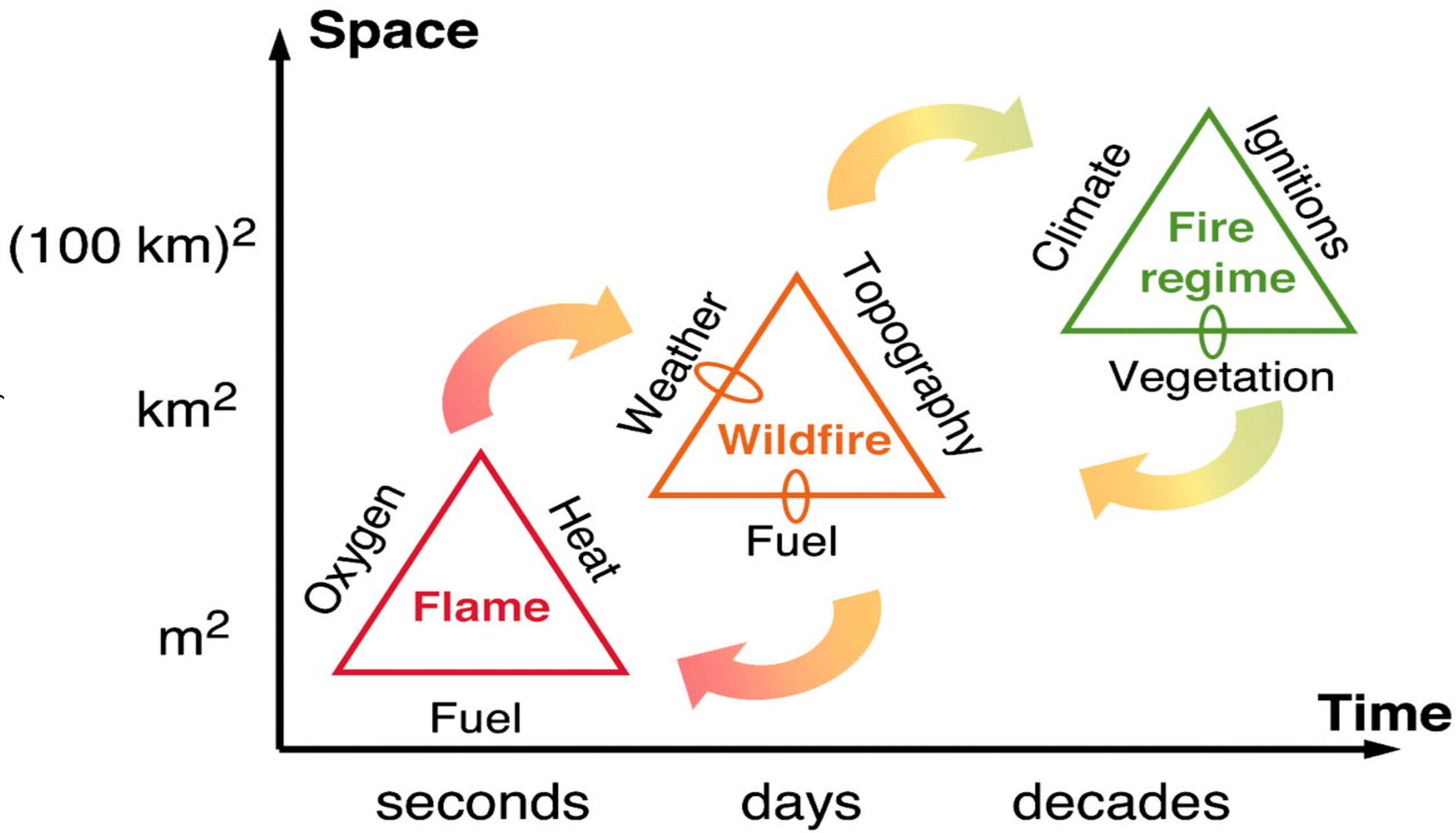
all climate change impacts result from complex interactions between climate, vegetation, topography, humans, and a host of other factors





Scale

all climate change responses are scale dependent in both time and space



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

Climate Projections

all climate projections have a high degree of uncertainty that increases with finer scales

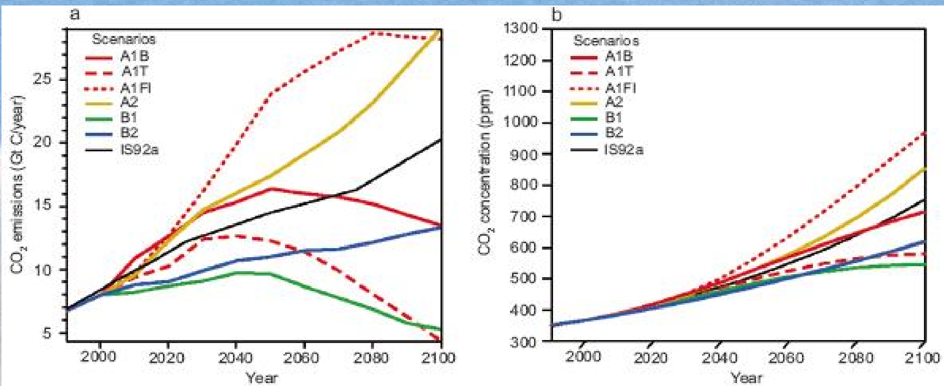


Fig. 1. Emissions scenarios (a) and concentrations (b) used in AR4.
Source: IPCC-WGI, 2007.

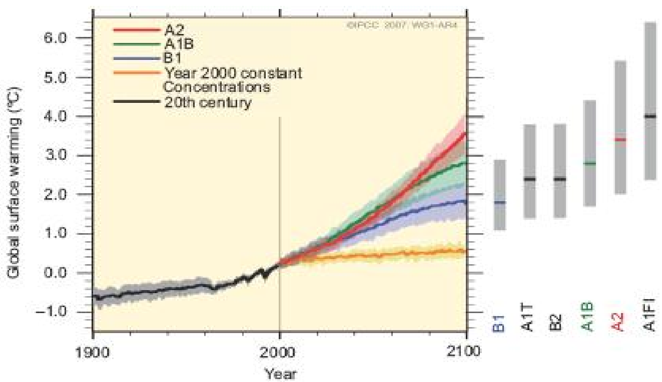
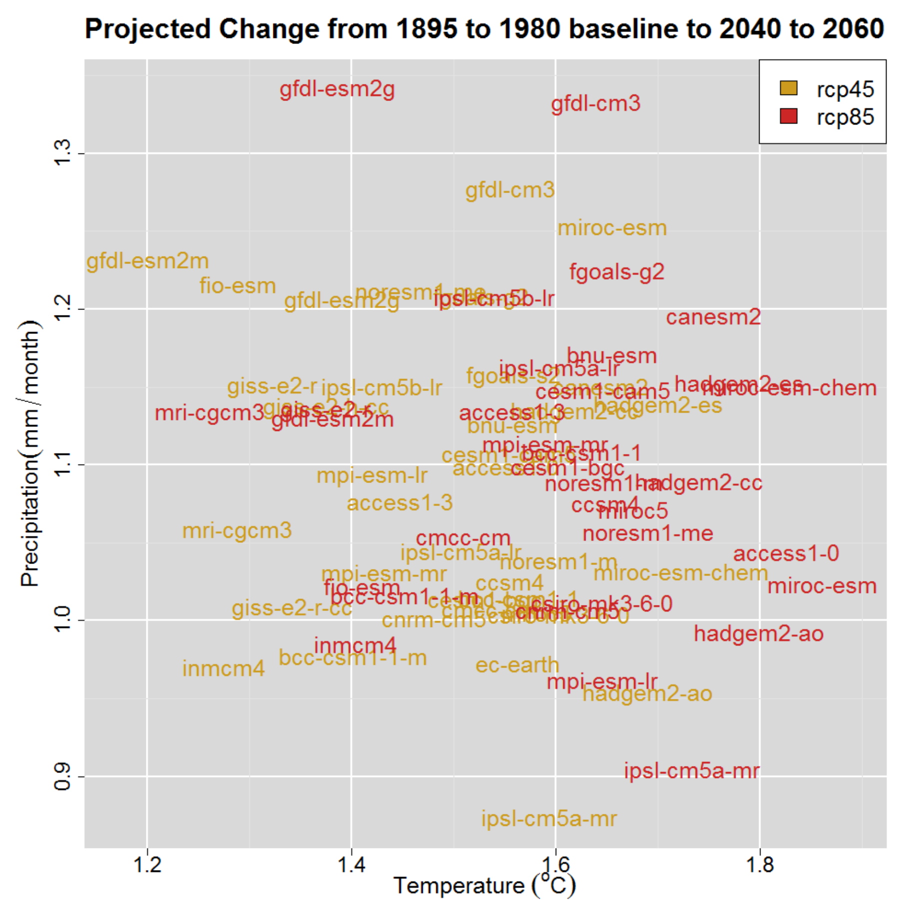
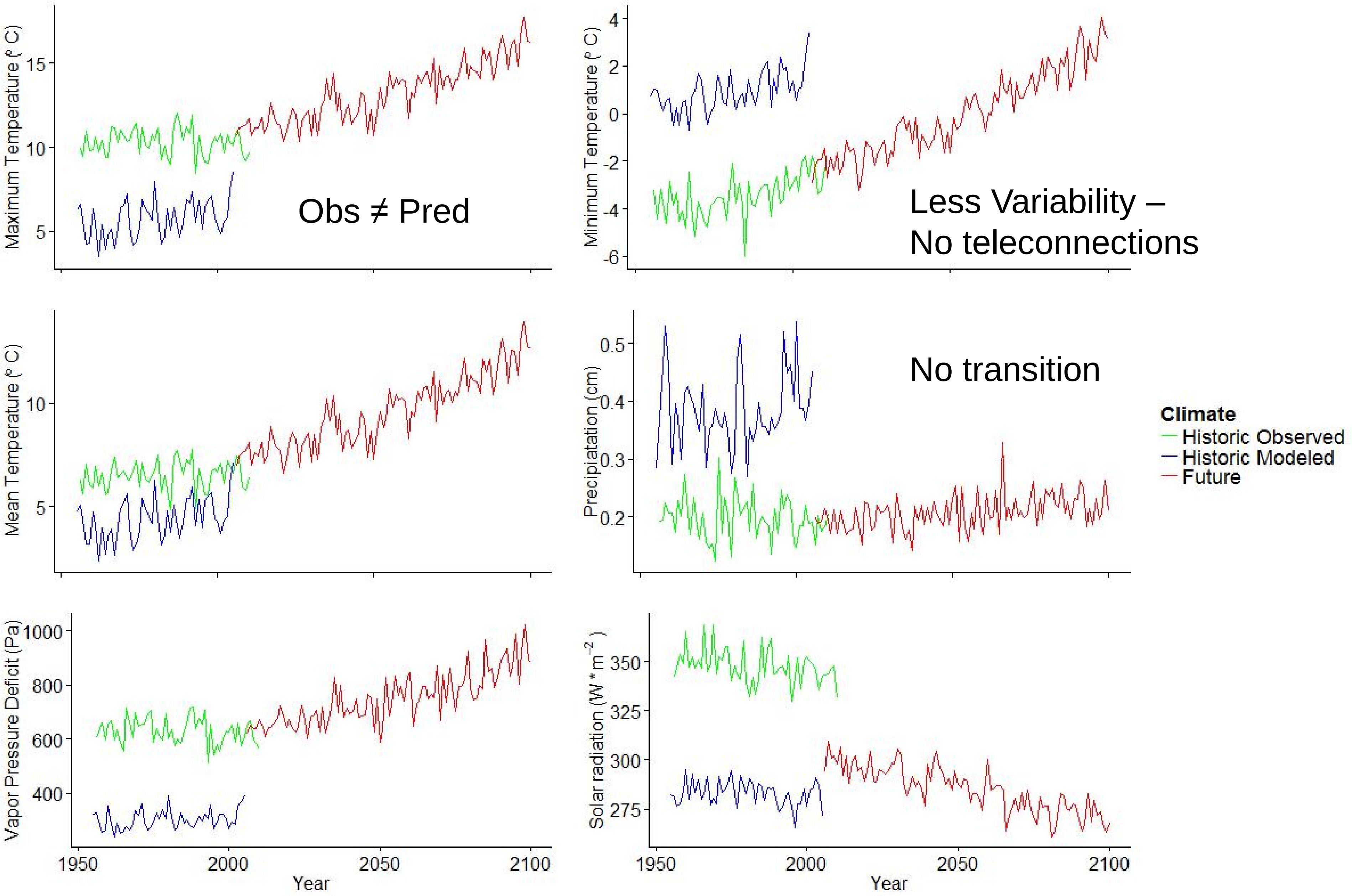


Fig. 1c. Temperature scenarios used in AR4.
Source: IPCC-WGI, 2007



from Talbert and others (2014)

Sula, Montana CMIP5 Data Extrapolation – 4 km



Integrating climate change into forest planning

This presentation:

- Discuss HRV, FRV and their implications in climate change futures
- Present a climate change context
  - Species distribution models
  - Simulation models
- NRAP Vulnerability assessments

Integrating climate change into forest planning

Ecological ranges and variability terms

- **HRV – Historical range and variability**
  - No exotics, historical climate and disturbance regimes, no management
- **FRV – Future range and variability**
  - Exotics, future climates and disturbance regimes, management?
- **NRV -- Range and variability used in forest planning**

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Ranges and variability Concepts:

- There are no “true” HRV, FRV or NRV – only approximations
- HRV assumes ecosystem or landscape biota is adapted to or has coevolved with the biophysical environment
- Has an inherent spatial and temporal scale

Integrating climate change into forest planning

Usefulness of HRV into the future:

- Represents the best expression of ecosystem or landscape historical legacy
- Can be used as a reference for ecosystem and landscape health, resiliency, biodiversity
- FRVs has issues:
  - Biota has evolved under HRV not FRVs
  - Uncertainty in climate
  - Too much subjectivity in what is included in FRVs such as exotics, management

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Climate change context

Climate Change Context

Predicting future landscape change

Four major approaches:

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

Old Climate scenarios *(HadCM3 GCM - Mote 2003, Mote et al. 2007)*

- H-Historical climate (recorded weather)
- B2 (A1B): WARM AND WET (+1.6ºC; +9% ppt)
- A2: HOT AND DRY (+4ºC; -7% precip.)

Based on IPCC (2007) projections

New Climate Scenarios (Hadley synthesis of 7 GCMs)

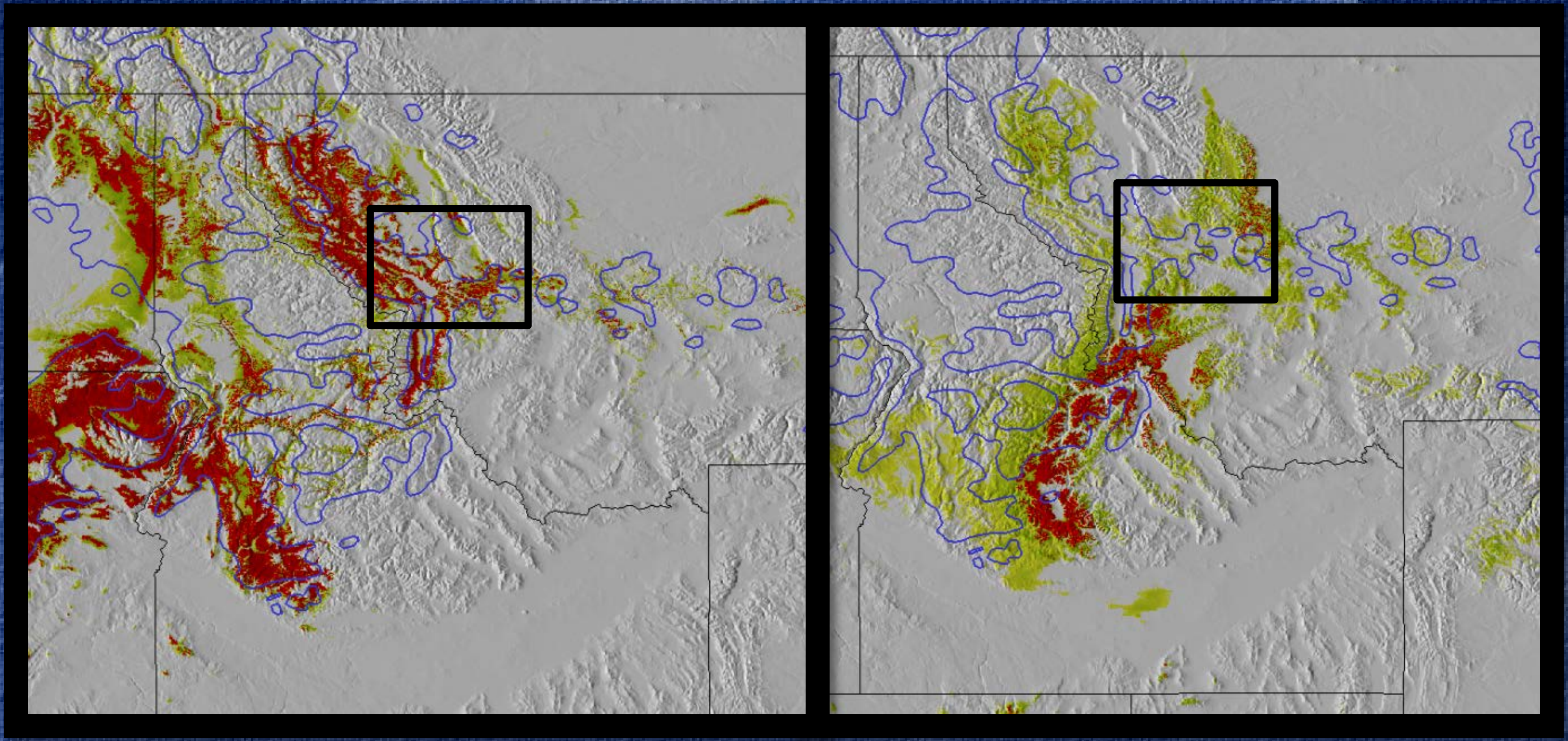
- H-Historical climate (recorded weather)
- RCP4.5: WARM AND WET (+2.6ºC; +130% ppt)
- RCP8.5: HOT AND DRY (+5ºC; 90% ppt)

Based on IPCC (2011) projections

Integrating climate change into forest planning

The Species Distribution Model

Ponderosa Pine

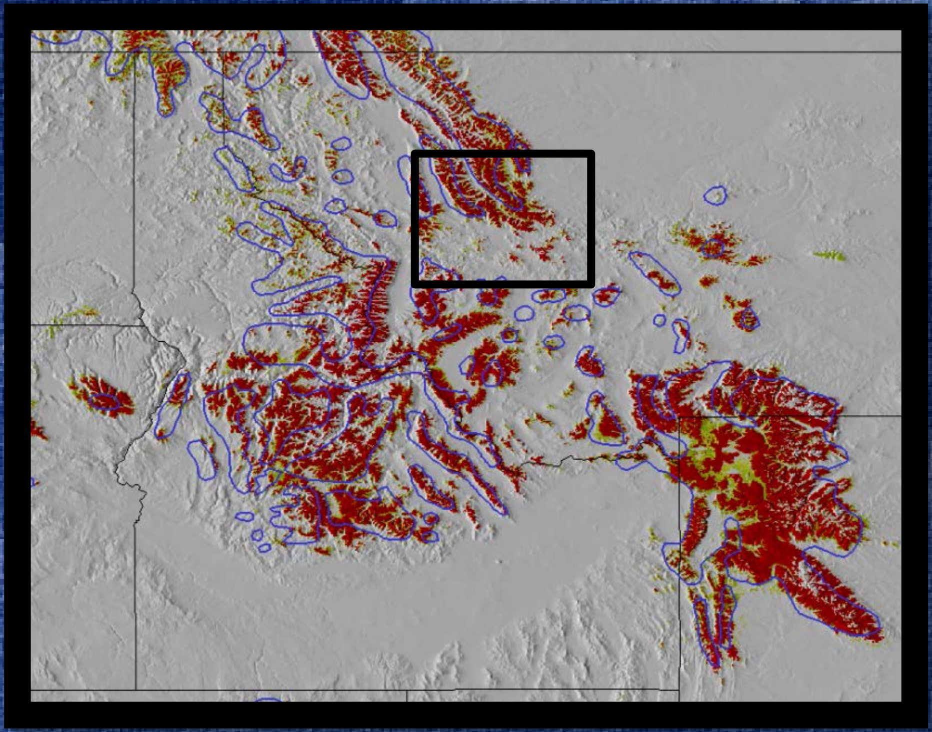


Current distribution

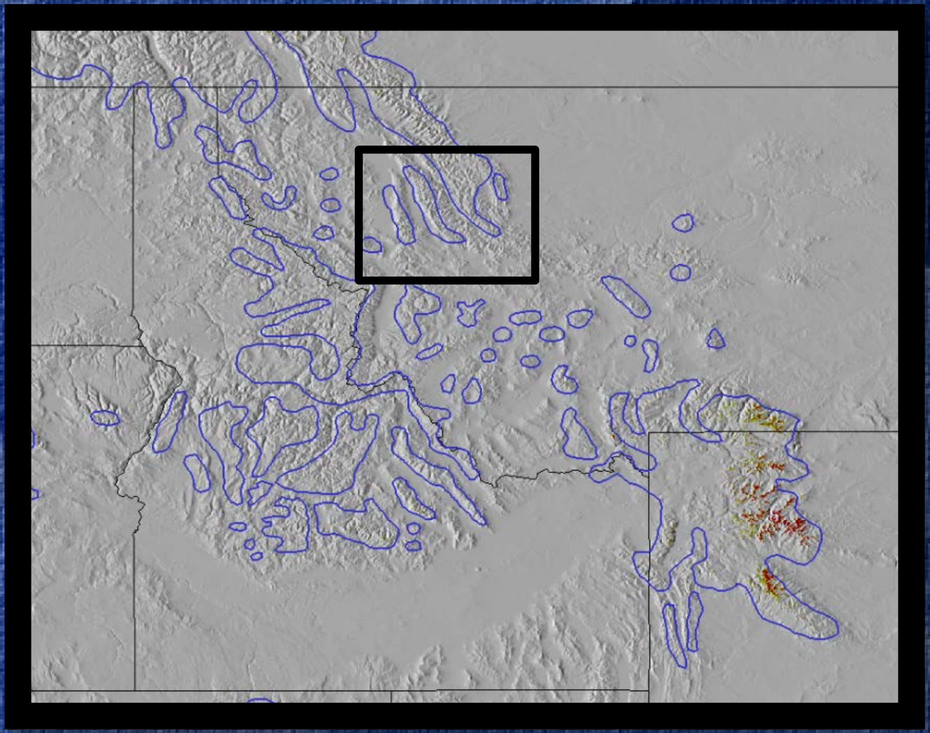
Distribution in 2090 – A2 Climate

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

Whitebark Pine



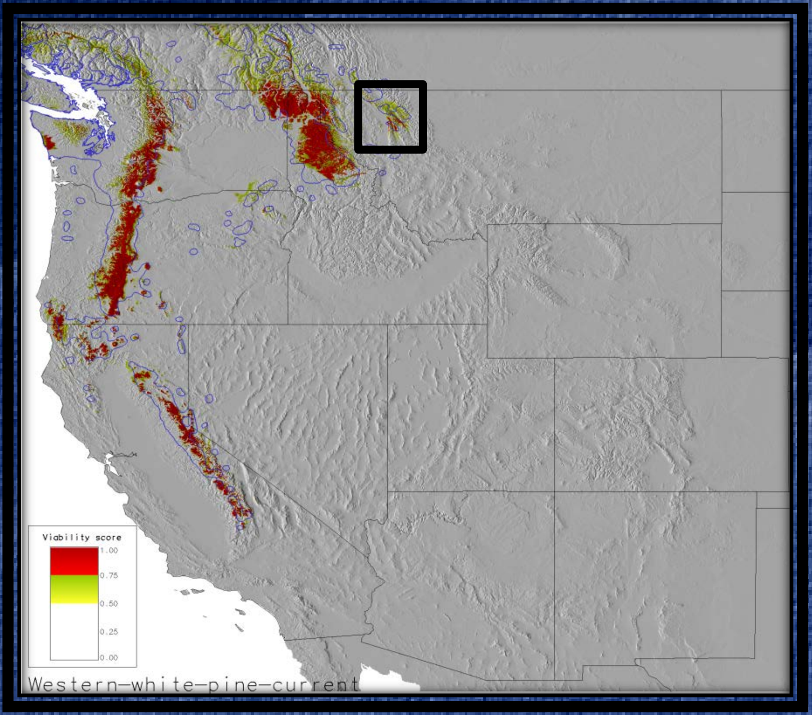
Current distribution



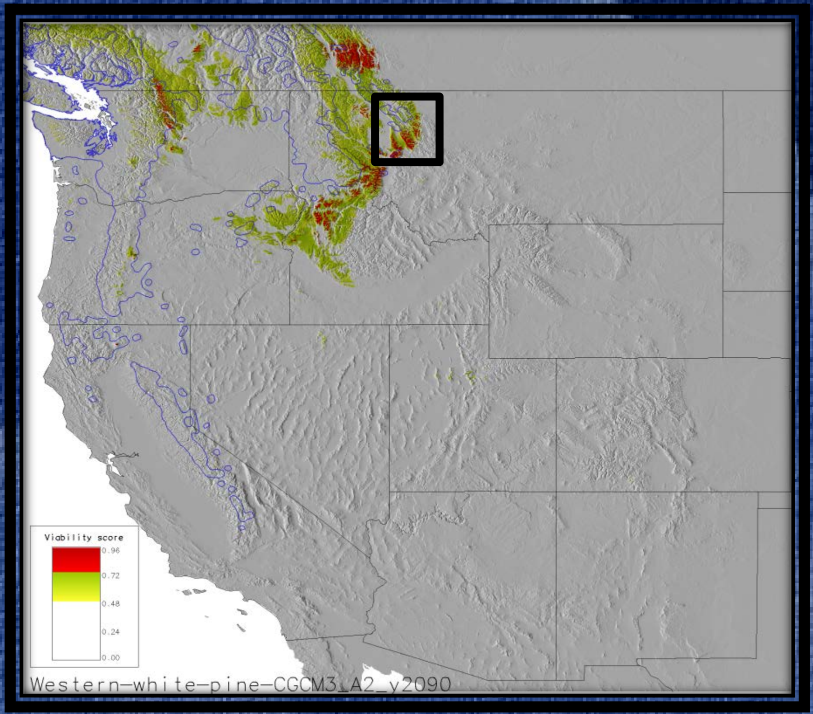
Distribution in 2090 – A2 Climate

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

Western White Pine



Current distribution



Distribution in 2090 – A2 Climate

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

Climate Change
Statistical Modeling Efforts
Changes in Vegetation in western MT

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

Future Vegetation Dynamics
The Species Distribution Model

Potential Usefulness

- No quantification of variability
- Greatly dependent on climate change scenario
- Quantifies climate niches only – no species demography and disturbance

Provides interesting coarse scale information but its use is limited at fine scales

Integrating climate change into forest planning

The Landscape Simulation Model

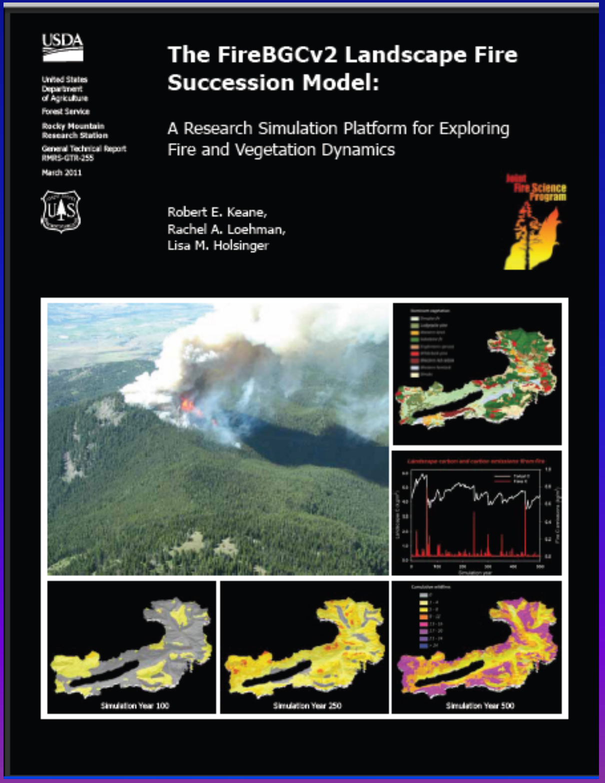
Integrating climate change into forest planning

The Landscape Simulation Model

Advantages of a Simulation approach:

- Create a deep & extensive HRV time series
- Compare management alternatives
- Simulate climate change implicitly
- Include other land use factors: exotics, development, agriculture

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



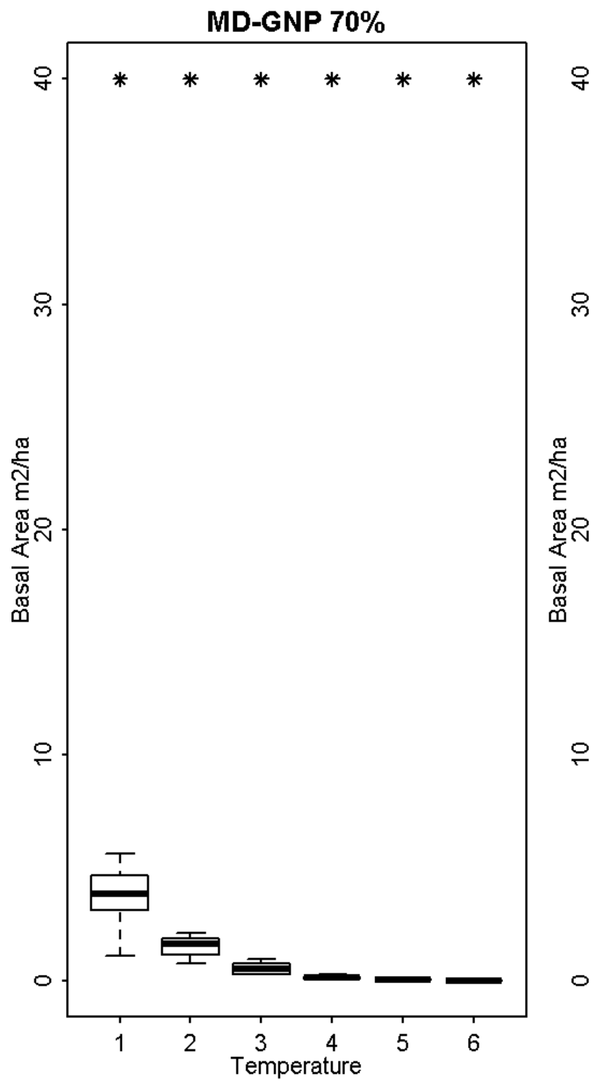
Keane, Robert E.; Loehman, Rachel A.; Holsinger, Lisa M. 2011. **The FireBGCv2 landscape fire and succession model: a research simulation platform for exploring fire and vegetation dynamics. Gen. Tech. Rep. RMRS-GTR-255. Fort** Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain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

CLIMET
Climate-Landscape Interactions on a Mountain Ecosystem Transect

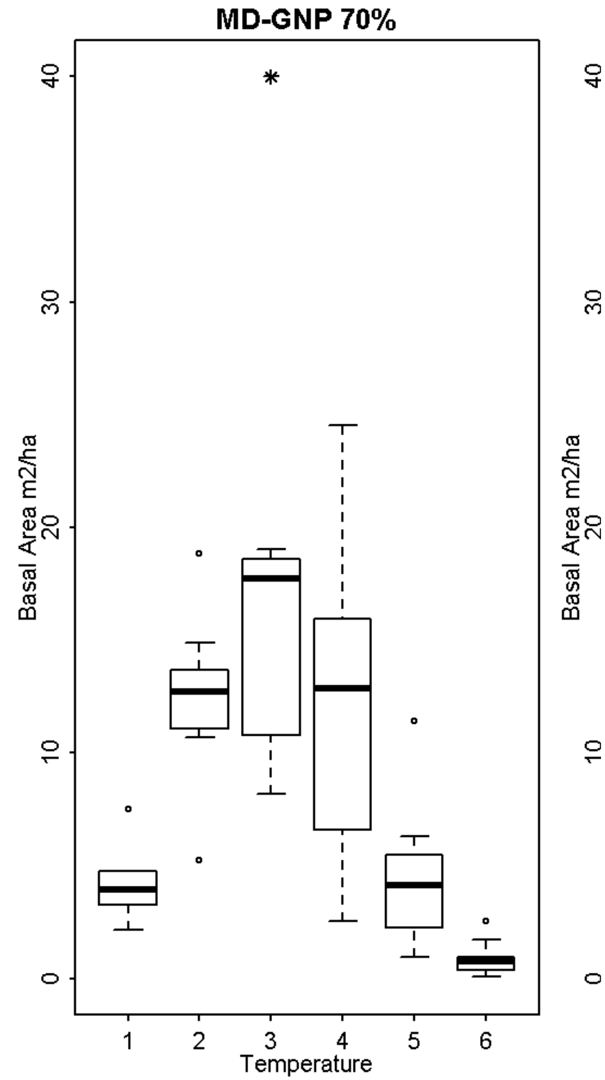
FireLab
MISSOULA, MONTANA

Dominant species changes

Glacier NP



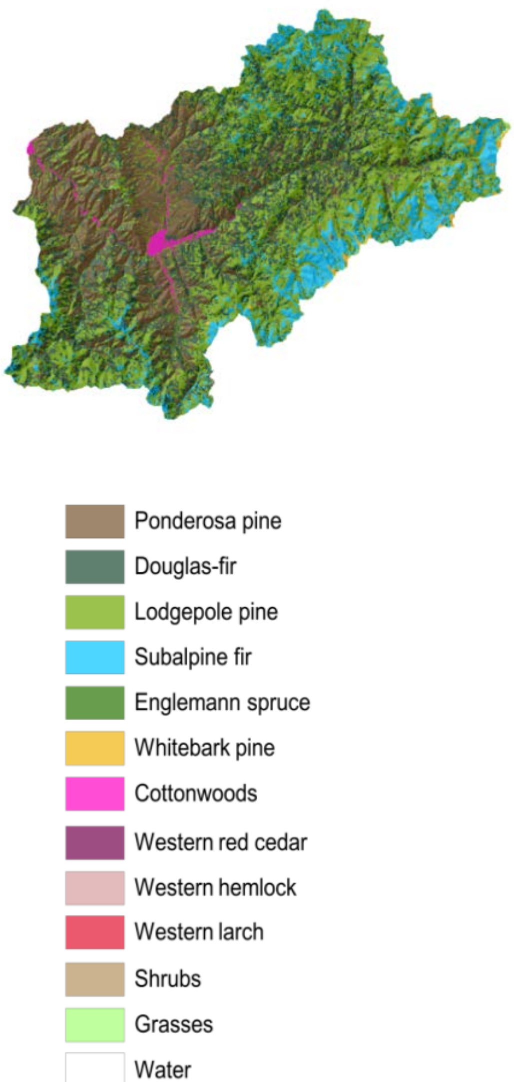
Subalpine fir

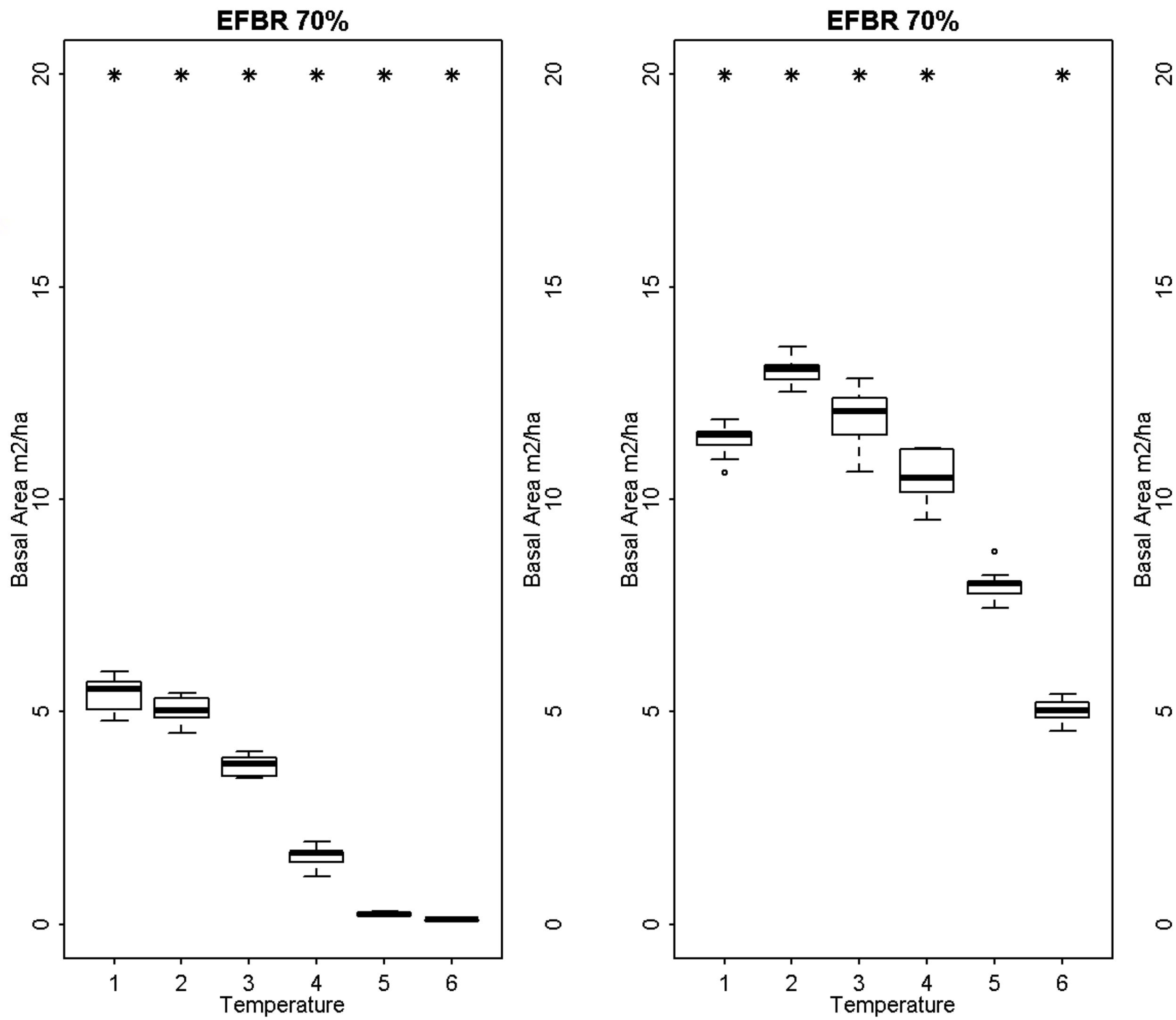


Western hemlock

Dominant species changes

Bitterroot NF

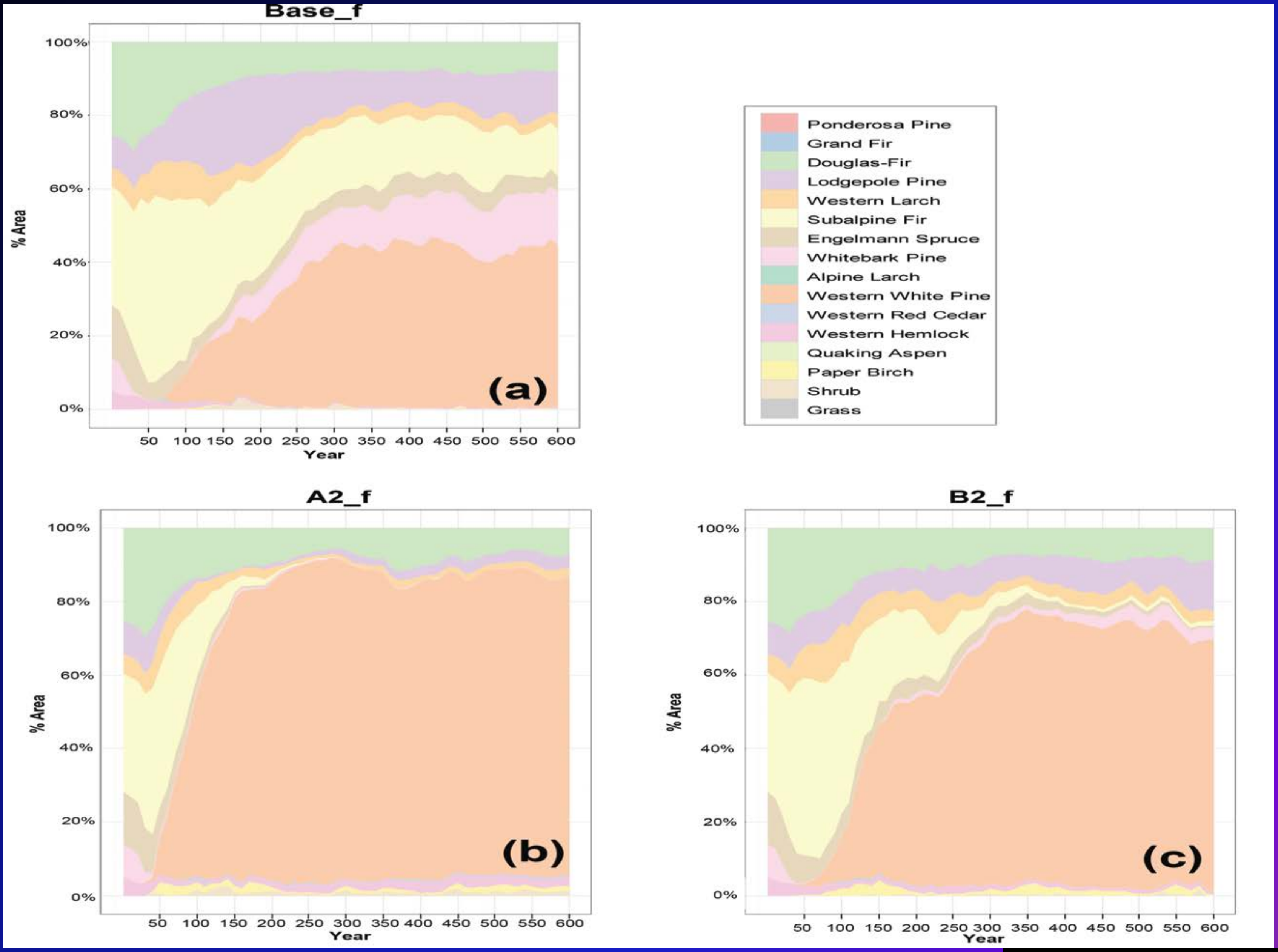




Lodgepole pine

Douglas-fir

Western White Pine – NW Montana



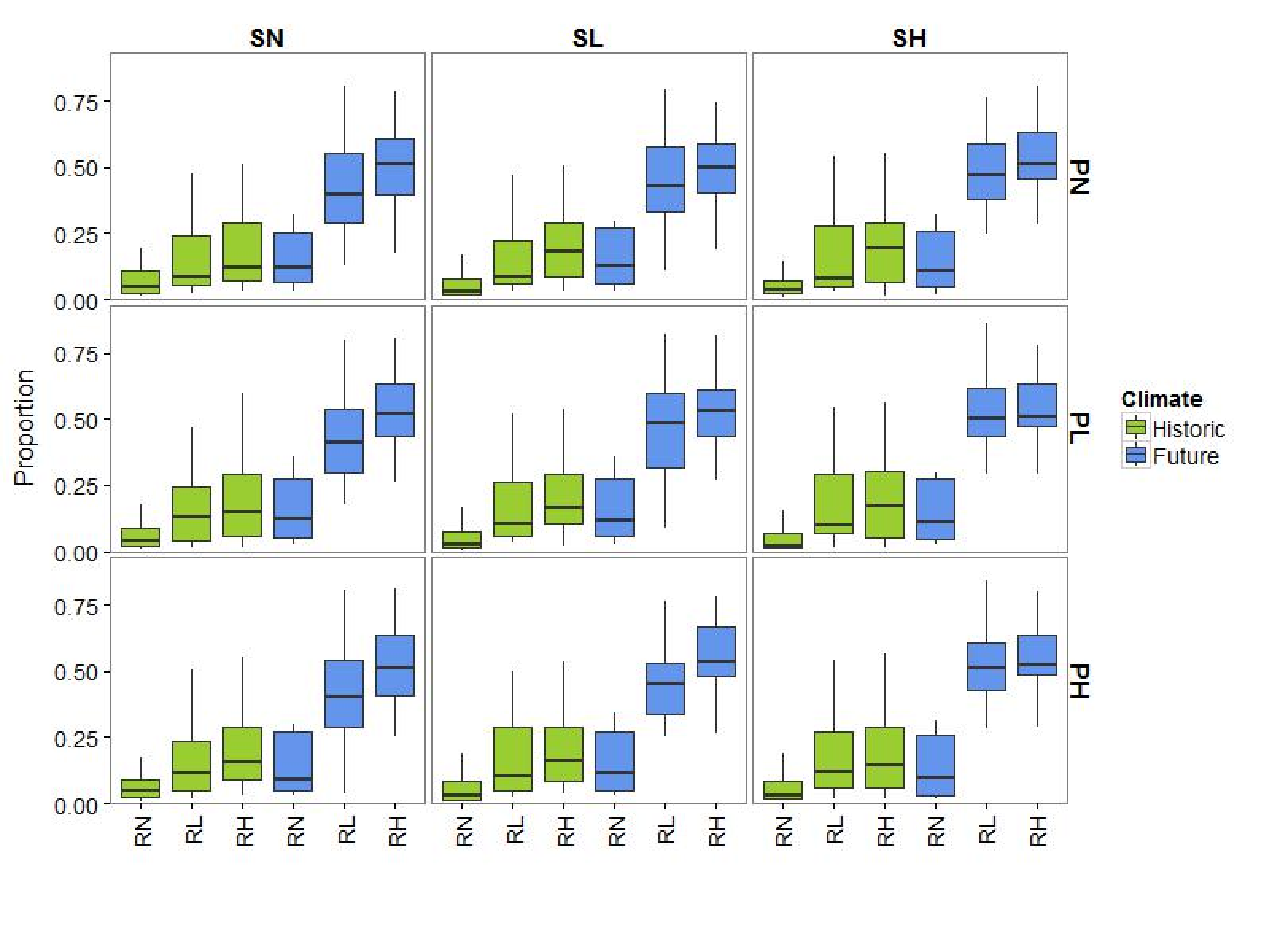
Loehman et al. 2011 Forests.

Future ranges of variation

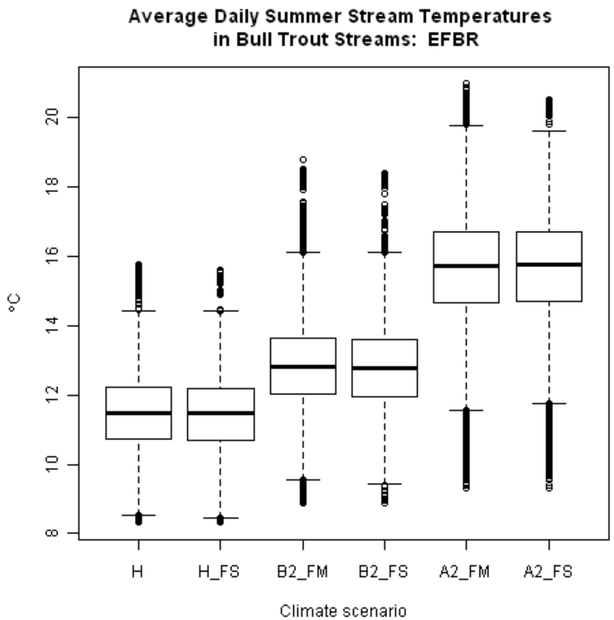
Whitebark pine, Montana, USA

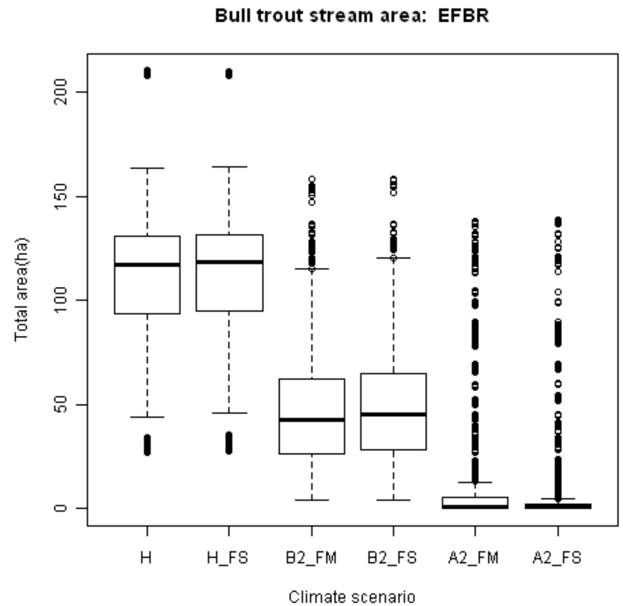
Wind River, GYE

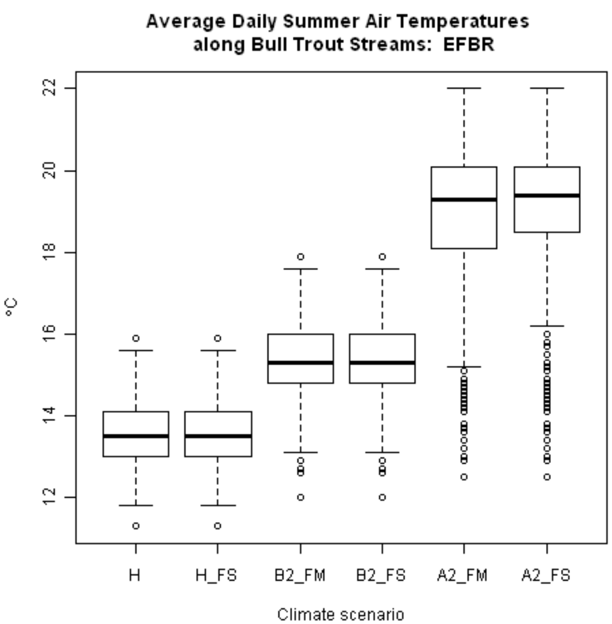
West Central, MT

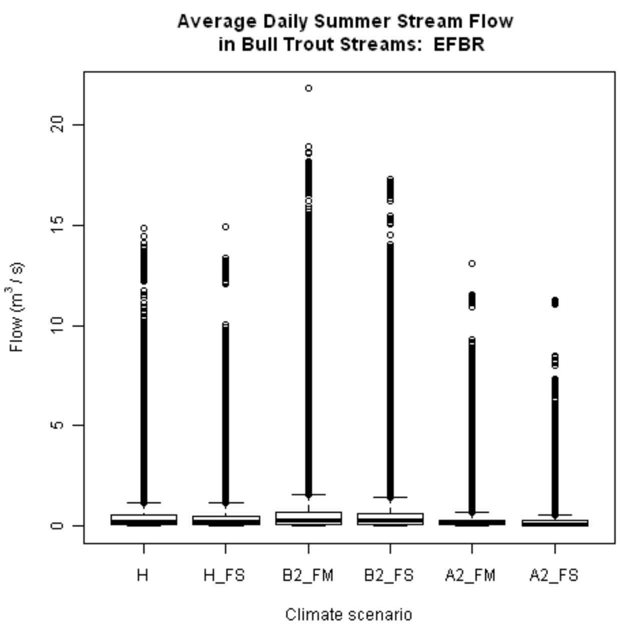


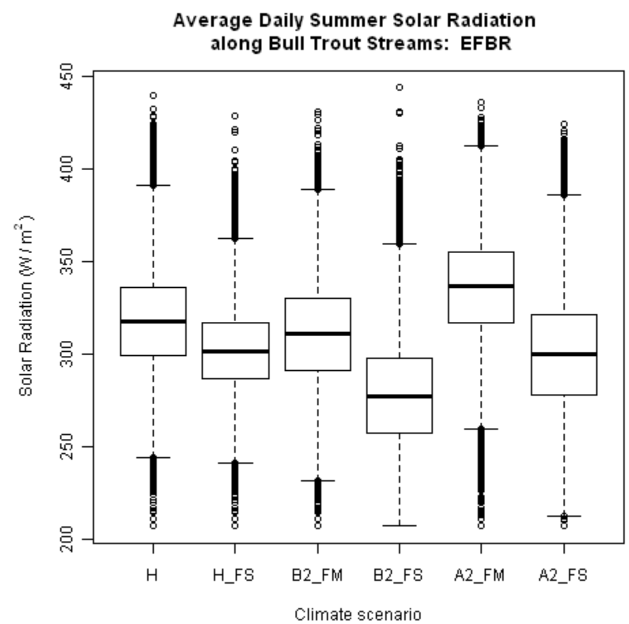
Simulation Results: East Fork Bitterroot River





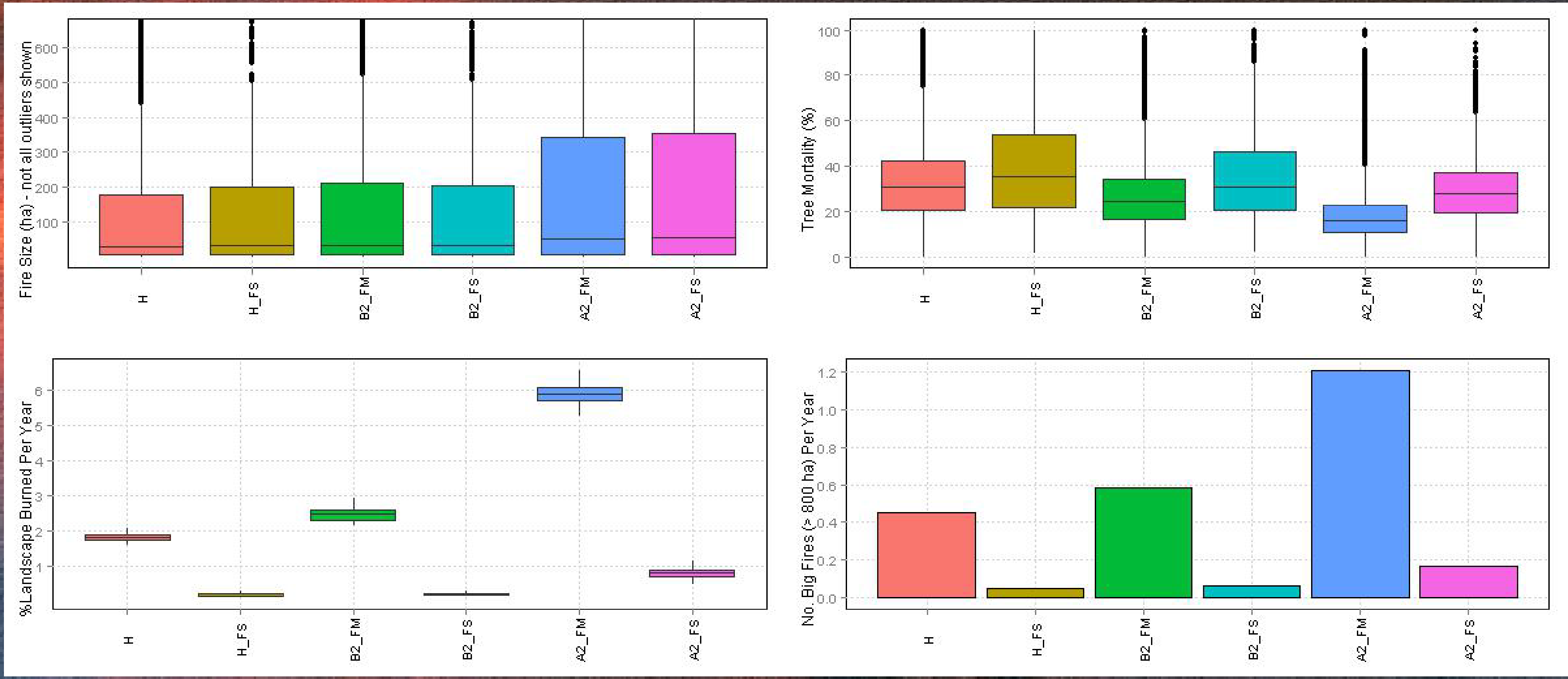






East Fork Bitterroot River

Fire dynamics in a changing climate



NRAP Vulnerability Assessment

General Results

Keane, R.E.; Mahalovich, M.F.; Bollenbacher, B.; Manning, M.; Loehman, R.; Jain, T.; Holsinger, L.; Larson, A.; Webster, M. 2016[in press]. Forest vegetation. In: Halofsky, J.E.; Peterson, D.L.; Dante-Wood, S.K.; Hoang, L., eds. 2016. Climate change vulnerability and adaptation in the Northern Rocky Mountains. Gen. Tech. Rep. RMRS-GTR-xxx. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station

Status: Awaiting policy review at RMRS

Use: Reference and guide for integrating climate change into Forest Planning

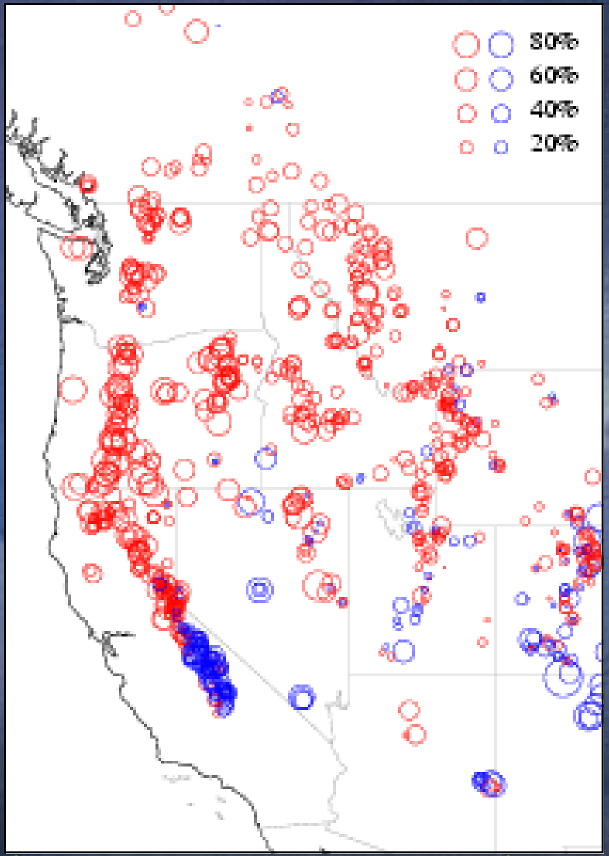
Book: Condensed NRAP document

NRAP Vulnerability Assessment

Climate Change Effect

(in order of importance)

- **Increasing wildfires**
  - Level of management (suppression vs WFU)
- **Increasing drought**
  - Dry vs moist range of a species
- **Longer growing seasons**
- **Increasing insects & disease**
- **Warmer temperatures**
- **Decreasing snowpacks**
- **Increasing productivity**



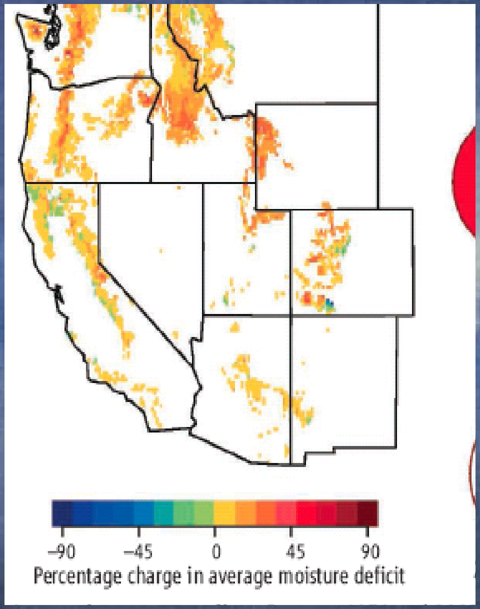
Less spring snowpack

Mote, 2003

NRAP Vulnerability Assessment
Stressors and Current Condition
(in order of importance)

- **100+ years fire exclusion**
- **Advanced succession**
- **Current beetle and disease outbreak levels**
- **Buildup of fuels (canopy, surface)**
- **Current landscape species distributions, abundance**
- **Availability of water**
- **History of drought**

moisture deficit in forests 1970–2003

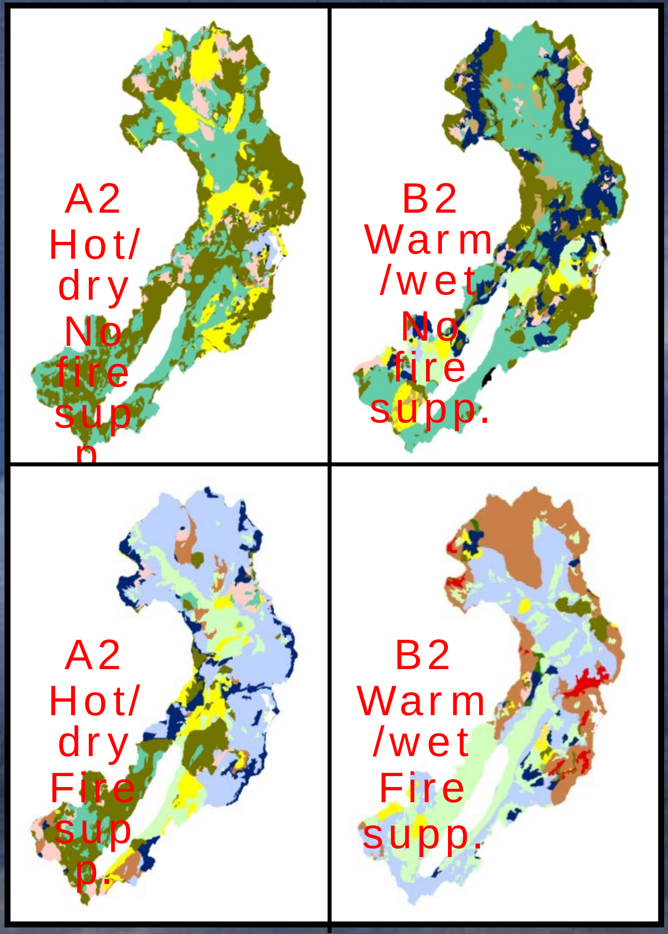


NRAP Vulnerability Assessment

Sensitivity to Climate Change

(in order of importance)

- **Shade tolerance**
- **Fire tolerance**
- **Drought tolerance**
- **Climatic tolerance**
- **Genetic plasticity**
- **Current abundance**
- **Level of stress**
- **Dispersal capability**
- **Adaptive capacity**



NRAP Vulnerability Assessment

Expected Effects

(in order of importance)

Mesic Areas

- Increased growth, productivity
- Accelerating succession
- Greater seed production
- Increased insect and disease exposure
- Loss of mycorrhizae (fire)
- Increased fire mortality

Xeric Areas

- Decreased growth
- Increased fire mortality
- Greater stress – drought, competition
- Decreased reproductive potential
- Increased episodic mortality events

NRAP Vulnerability Assessment

Adaptive Capacity

(in order of importance)

- **Responses to fire**
- **Drought tolerance**
- **Changes in productivity**
- **Seed dispersal characteristics**
- **Ability to survive pests, disease**
- **Genetic capacity – hybridization, adaptive strategy and phenotypic plasticity**
- **Regenerative potential**
- **Available water**
- **Increasing productivity**

NRAP Vulnerability Assessment

Vulnerability Rating

Alpine larch	1
Whitebark pine	2
Western white pine	3
Western larch	4
Douglas-fir	5
Western red cedar	6
Western hemlock	7
Grand fir	8
Engelmann spruce	9
Subalpine fir	10
Lodgepole pine	11
Mountain hemlock	12
Cottonwood	13
Aspen	14
Limber pine	15
Ponderosa Pine-west	16
Ponderosa Pine-east	17
Green ash	18

Vulnerability Assessment

Vulnerability Rating Comparison

Species	NRAP Rating
Alpine larch	1
Whitebark pine	2
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Green ash	18

Species	PNW Rating (Devine et al. 2012)
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Subalpine fir	2
Engelmann spruce	3
Alpine larch	4
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Aspen	6
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Vulnerability Assessment

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Species	Hansen et al. 2010 Vulnerability
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Engelmann spruce	5
Western hemlock	6
Western red cedar	7
Western larch	8
Douglas-fir	9
Ponderosa Pine-east	10
Ponderosa Pine-west	10
Grand fir	11
Aspen	NA
Alpine larch	NA
Western white pine	NA
Cottonwood	NA
Limber pine	NA
Green ash	NA

Integrating climate change into forest planning

NRAP product:

- Contains treatments and recommendations for implementation and mitigation
- Contains general planning guidelines to account for climate change in management
- Contains abundant background material to provide a context for planning and management

Integrating climate change into forest planning

NRAP conclusions:

- Vulnerabilities ratings are subject to local conditions
- Vulnerability dependent on magnitude and rate of climate change
- Integration of NRAP into forest planning is best as context rather than targets

Integrating climate change into forest planning

HRV and FRV Conclusions:

- No climate change projection is suitable for land management analysis as yet
- FRV will never be an appropriate target or benchmark for management of tomorrow's ecosystems and landscapes -- HRV should be compared with FRV
- HRV is probably best for NRV right now

Integrating climate change into forest planning will require:

- Readily available, realistic, vetted, validated climate futures
- A consensus method for determining NRV and its expression for management
- Managers and planners must fully understand climate change science
- A new toolbox that integrates climate futures with contemporary applications (e.g., FVS) to generate NRVs, effects of management alternatives, and FRVs