SW FireCLIME

Phase 2 - Modeling management effectiveness in current and future climates

JOINT FIRE SCIENCE PROGRAM

NORTHERN ARIZONA UNIVERSITY

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

USGS science for a changing world

THE UNIVERSITY OF ARIZONA

NATIONAL PARK SERVICE

Forest Stewards Guild

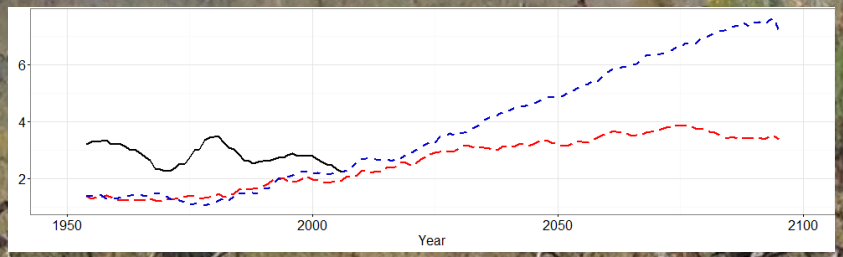
U.S. FISH & WILDLIFE SERVICE

The Nature Conservancy

Rocky Mountain Research Station

SW FireCLIME: A scientist-manager partnership to

- evaluate and interpret information on climate-fire dynamics,
- test new management scenarios, and
- provide guidelines for managing regional resources under a changing climate



Four Phase Process

- **Phase 1- Science Synthesis:** Literature review and workshop of regional scientists and managers (September 12-14, 2016).
- **Phases 2 and 3- Modeling, Scenario Building, Modeling…etc.:** Phases 2 and 3 work in tandem to model current treatments into the future with a changing climate and get reiterative feedback from land managers on effectiveness of treatments and possible novel management strategies.
- **Phase 4 – Joint Interpretation and Synthesis:** managers and scientists will interpret model results and discuss the implications for current and future management practices in a Synthesis Workshop.

Goals of this Webinar/Phase

1. To present climate-fire modeling results of three management scenarios.
2. To get feedback on these results
3. To develop new management scenarios to model
4. In the future, meet again to evaluate the results of the new scenarios.

Terminology

- Business as Usual: Reflects current management practices.
- Stretching the Box: Extends current management in extent, treatment type, etc. Funding may not support these actions now but there is value in exploring them.
- Out of the Box: Moving out of the current realm of management scenarios to completely new ideas and strategies. These ideas may go beyond current social and political acceptance but again, this is a risk-free way to explore.

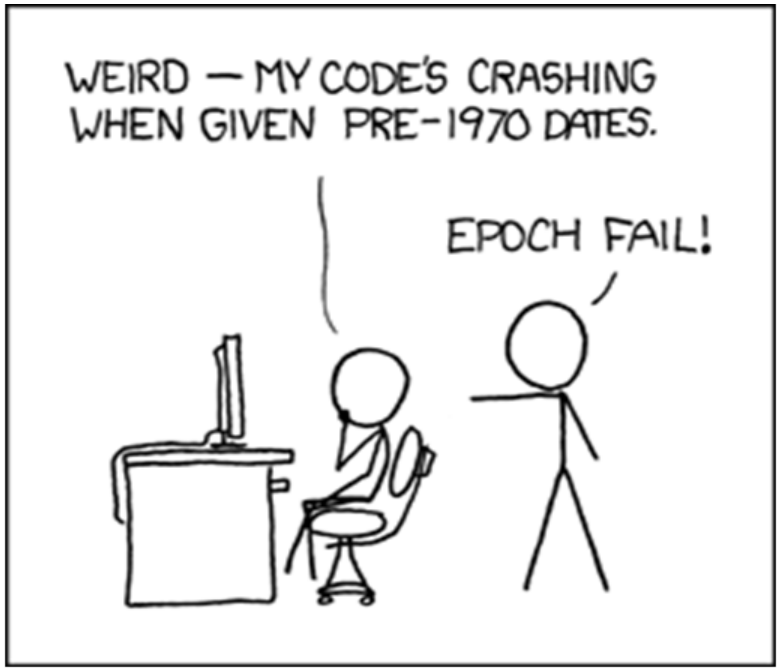
Modeling overview

What are good uses for landscape models?

- Provide inferences about times and places for which there is no primary, observed data
- Test and compare management actions and effects without risks
- Bracket uncertainties: compare various future climates
- Opportunity for collaborative decision-making among researchers and managers

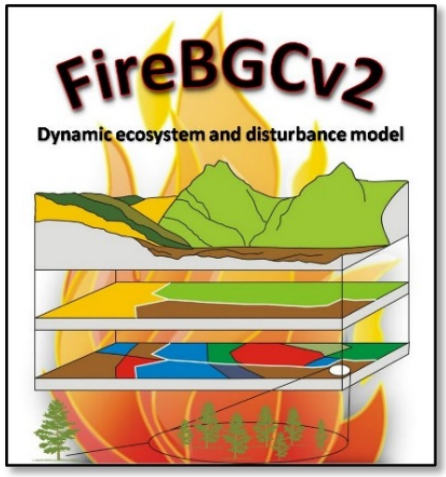
Caveats for landscape simulation models used in this project

- Results are best assessed at landscape scales – can't play "my favorite pixel"
- Both models pick treatment locations according to stand conditions, not other priorities (e.g., WUI).
- No other natural disturbances (e.g., bark beetles, windthrow) included



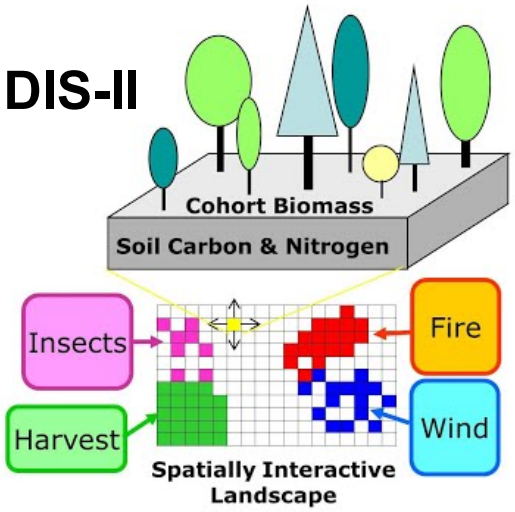
The models: LANDIS-II, FireBGCv2

1. Simulate large spatial and long temporal scales
2. Spatial processes: fire, diseases, seed dispersal
3. Simulate interacting disturbance and vegetation responses to climate
4. Model individual tree species
5. Can incorporate management activities
6. Weather and climate drive model processes



Keane, R. E., R. A. Loehman, and L. M. Holsinger. (2011), Gen. Tech. Rep. RMRS-GTR-255.

LANDIS-II



http://www.landis-ii.org/

Modeling design

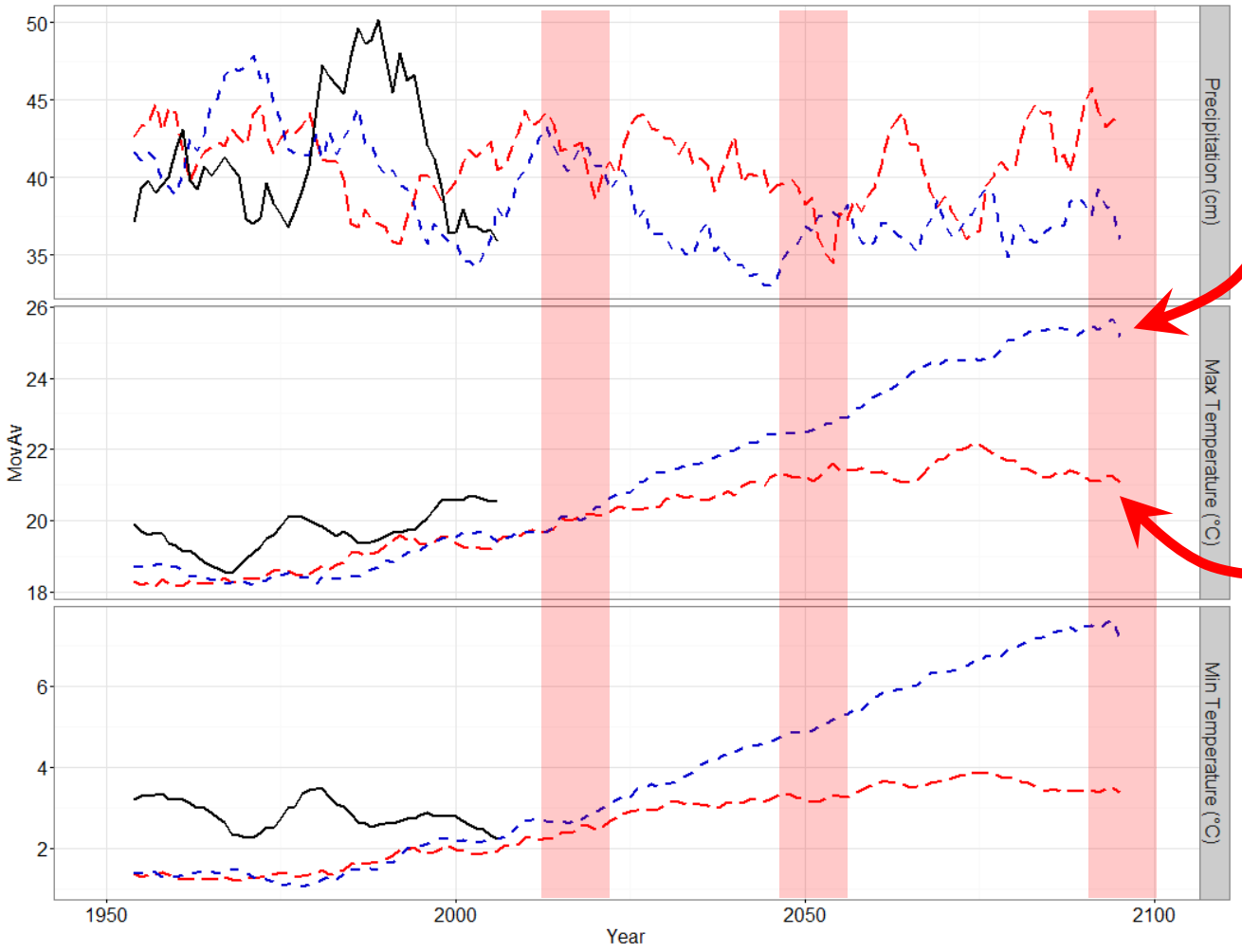
- **2 landscapes:**
  - Kaibab Plateau, AZ
  - Jemez Mountains, NM
- **3 climates:**
  - Contemporary (instrumental weather, 1950s - 2005)
  - Warm, Semi-Dry – CCSM4 climate model, RCP4.5 emissions scenario (2000-2100)
  - Hot, Dry – HADGEM2-ES climate model, RCP8.5 emissions scenario (2000-2100)
- **3 management scenarios:**
  - Fire suppression only (LANDIS-II) or “Hands-off” (FireBGCv2)
  - “Business as Usual” - current treatments, fire suppression
  - “Stretched Business as Usual” – 3x current treatments, fire current suppression

Climate scenarios

Precip

Max Temp

Min Temp



Hot & Dry

Warm & Semi-dry

Time Period

10-20 years

40-50 years

90-100 years

We asked…

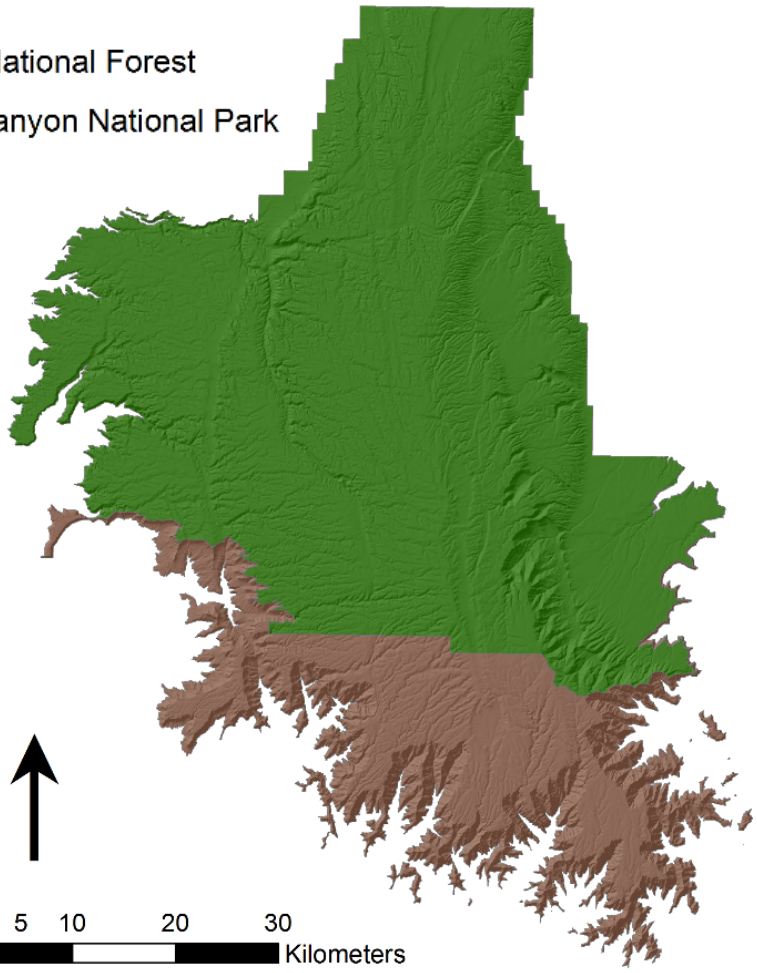
1. Effects of climate changes (RCP4.5 vs. RCP8.5)
2. Changes in fire? *Area burned, crown fire*
3. Changes in forests? *Composition, basal area or biomass, structure*
4. ***Where*** are we seeing big changes in fire and forests?
5. ***When*** are we seeing big changes in fire and forests?
6. **Management effectiveness – did treatments work?**

Results from the Kaibab

Kaibab Plateau study area

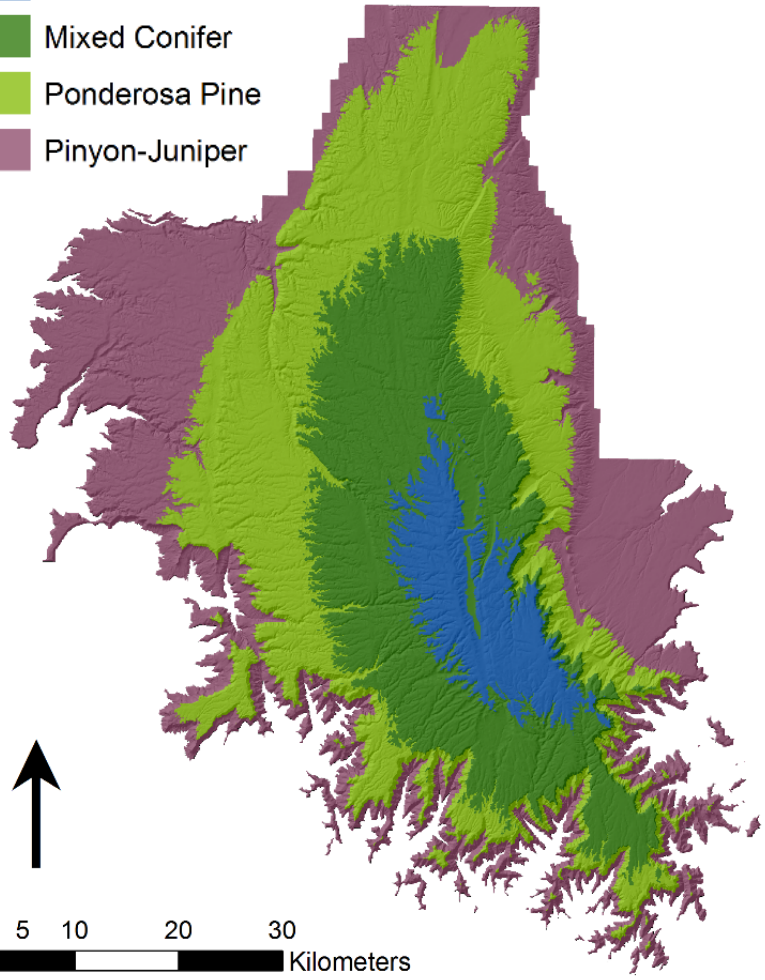
Ownership

- Kaibab National Forest
- Grand Canyon National Park



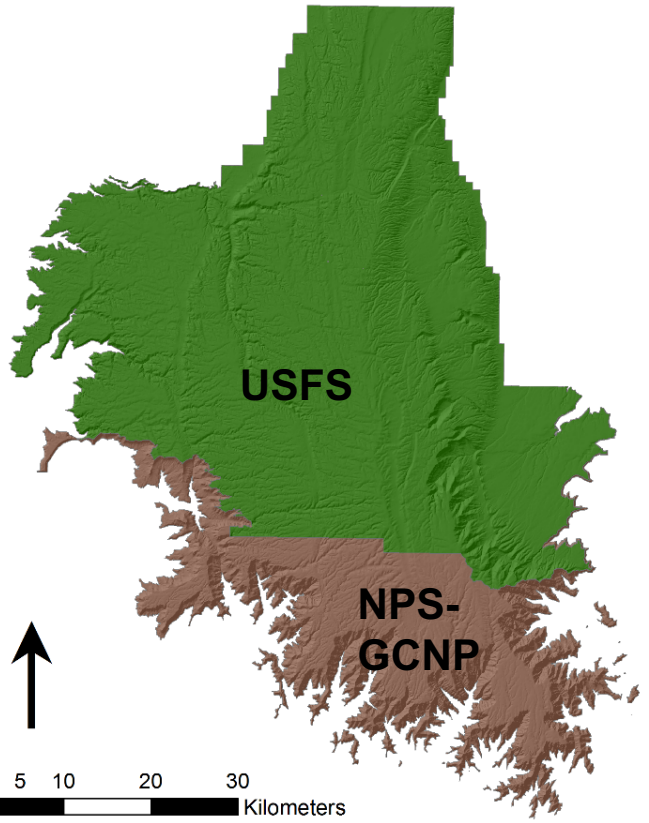
Ecological Sites

- Spruce-Fir
- Mixed Conifer
- Ponderosa Pine
- Pinyon-Juniper



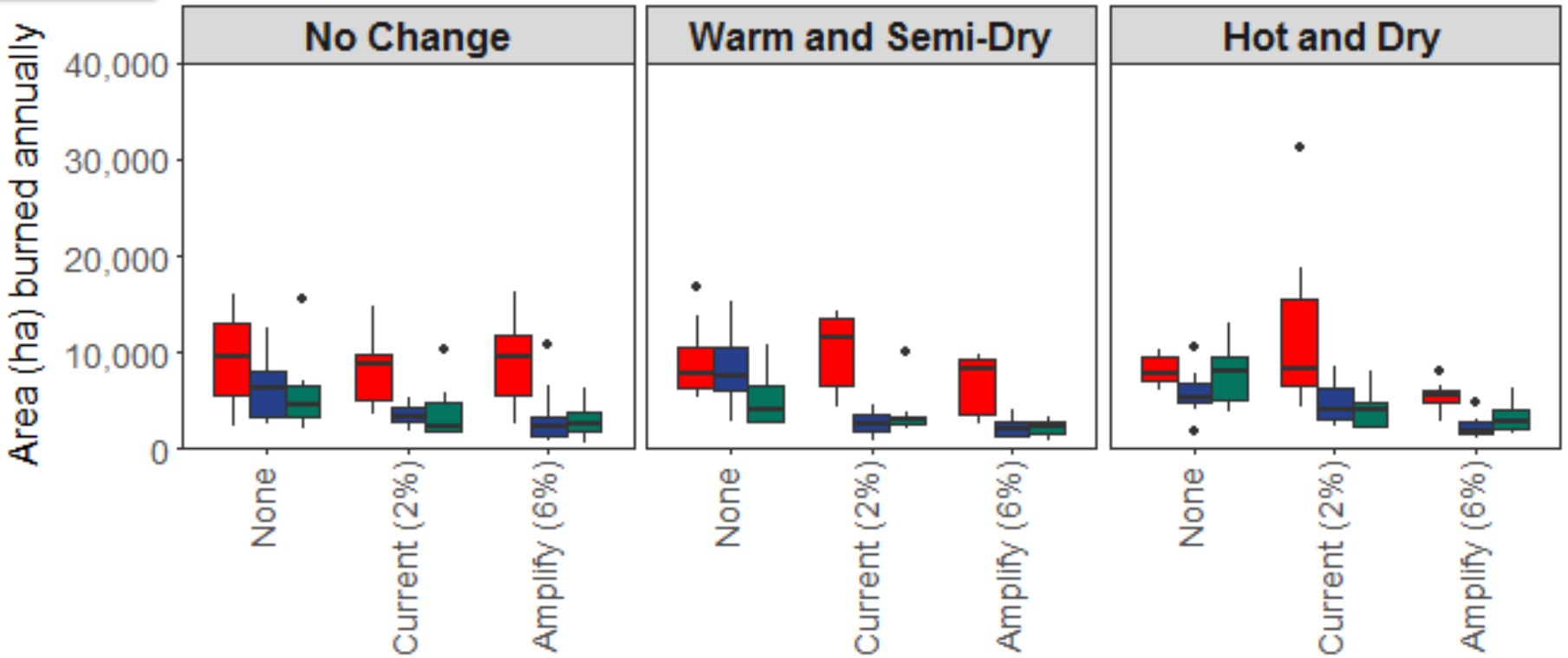
Management scenarios

- Based on annual rates of treatment during the last 10 years for each ownership
- Treatment rates are specific to different forest types: spruce-fir, mixed conifer, ponderosa pine, and pinyon-juniper



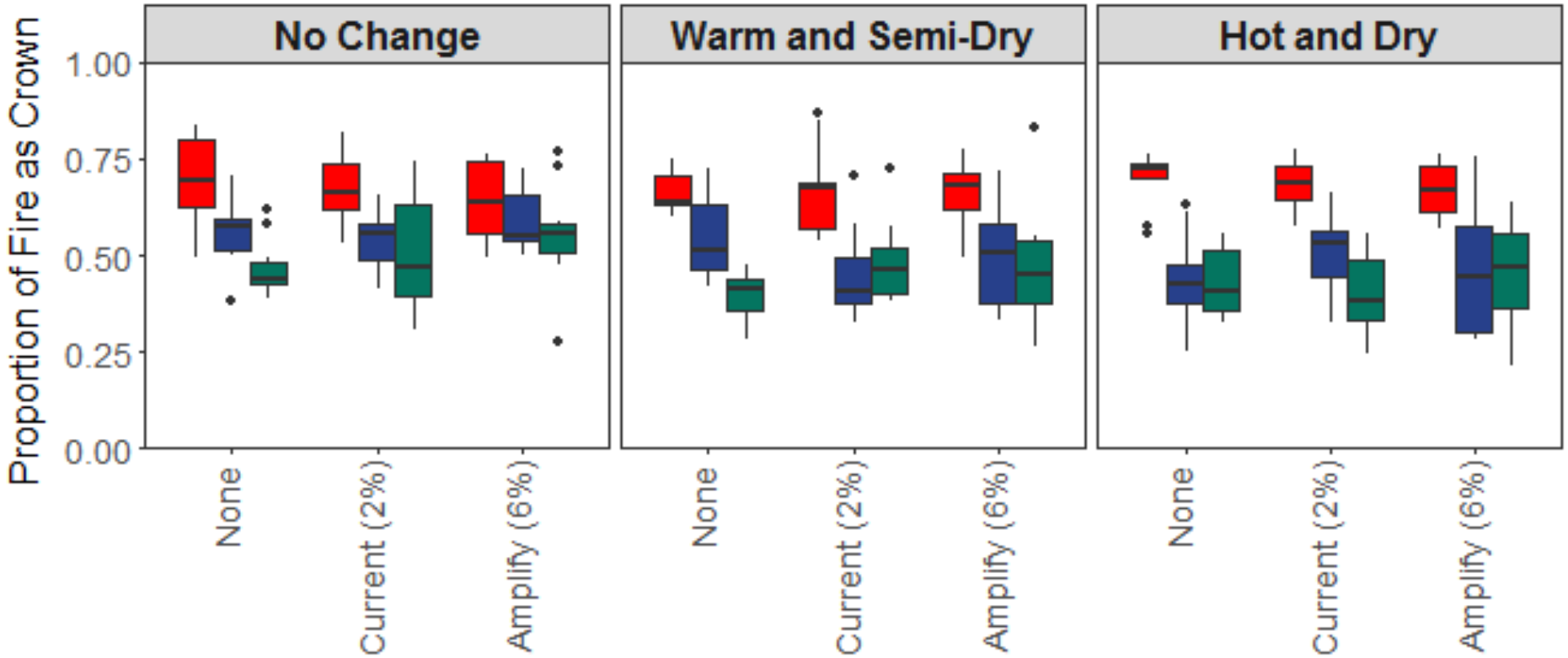
	Current (BAU)		Amplify (3X BAU)	
	Annual Treatments - ha (% of ownership)			
Owner	Thin	RxBurn	Thin	RxBurn
USFS - KNF	635 (0.3%)	2273 (0.9%)	1905 (0.9%)	6819 (2.7%)
NPS - GCNP	--	2702 (3.1%)	--	8106 (9.3%)

Fire: Area Burned

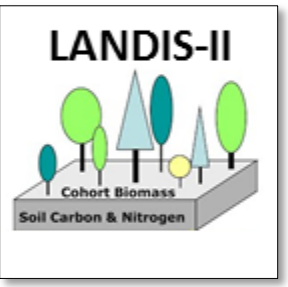


- Lots of fire in 10-20 years (red)
- Start to see treatment effect after 40 years (blue and green)
- Management has more of an impact than climate

Fire: Crown Fire



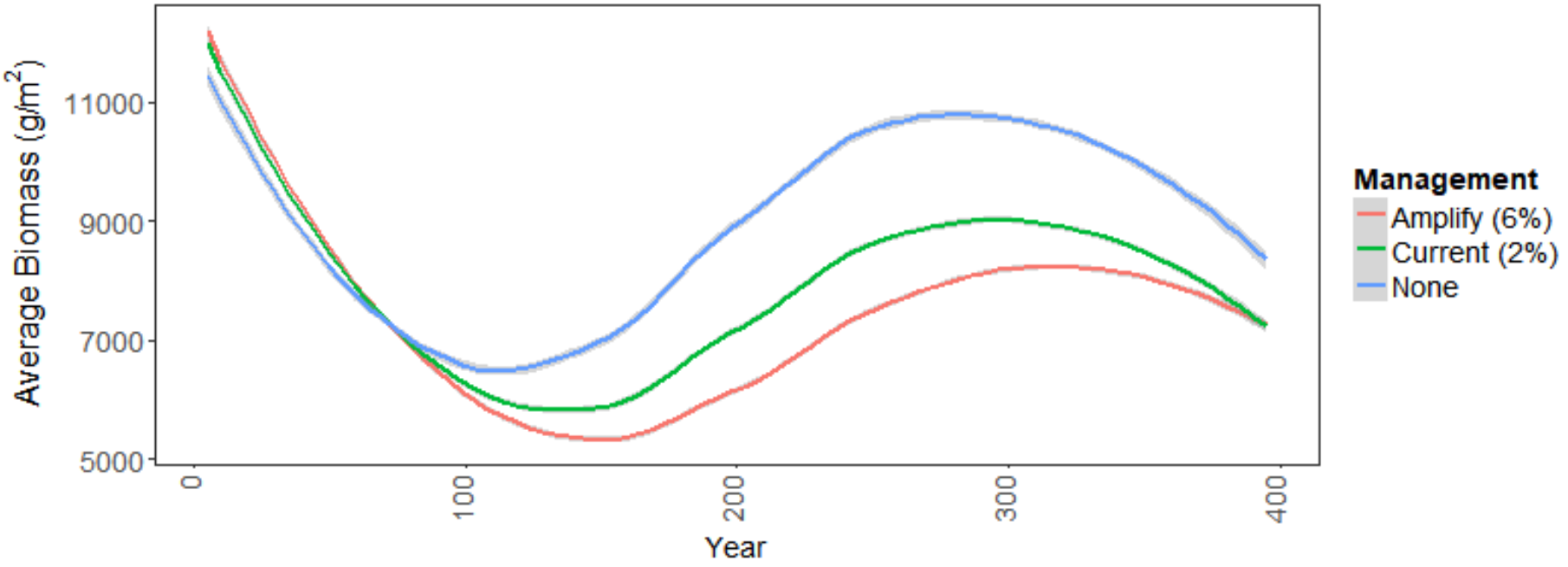
- High proportion of crown fire
- Management has more of an impact than climate



Forests: Biomass

- Biomass decline
- Most drastic in the Hot & Dry scenario
- Management has no effect

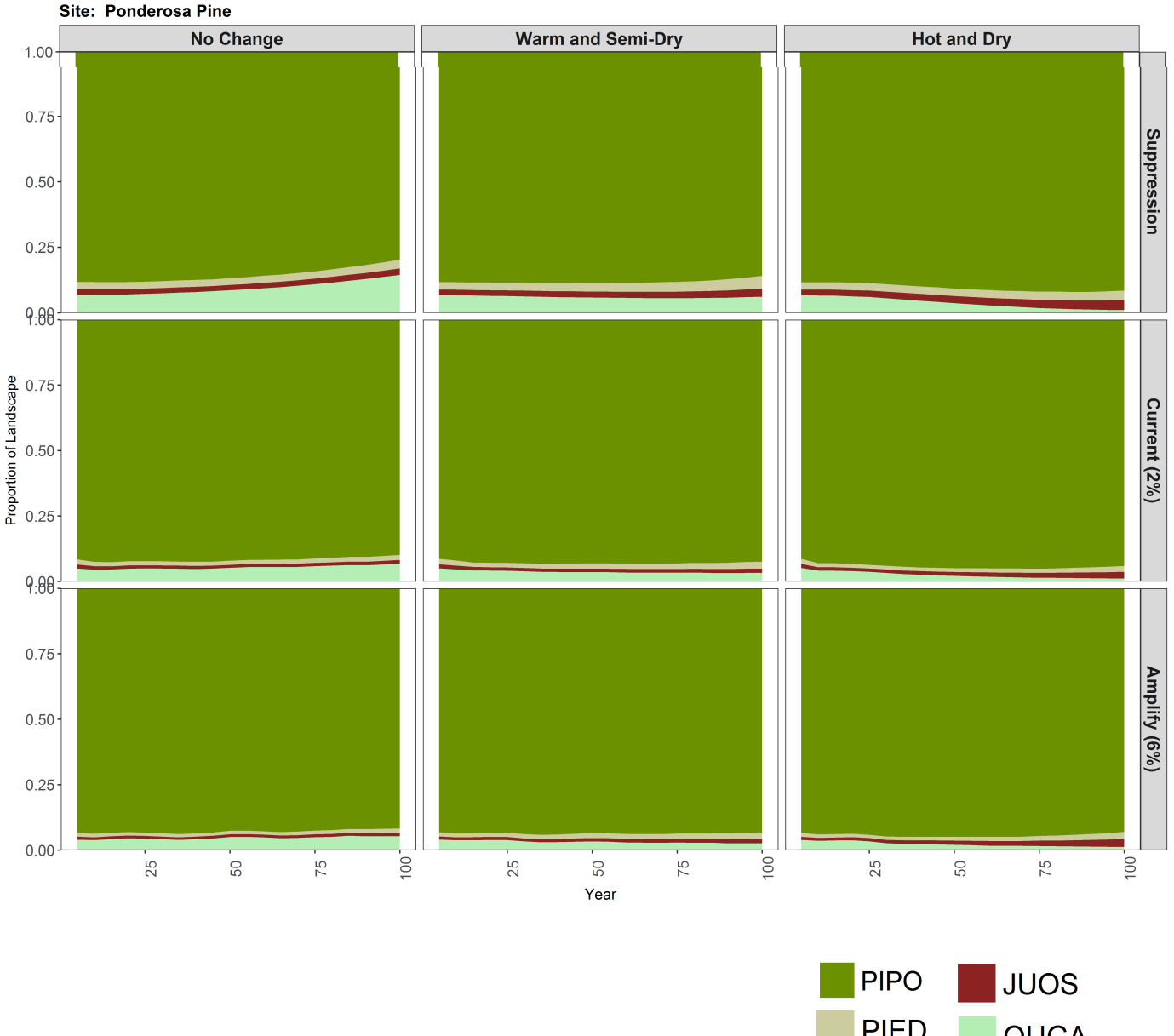
Forests: Biomass



- Biomass declines through the middle of the next century
- Frequent burning and thinning delays biomass recovery

Ponderosa Pine: Spp. composition

- Little compositional change, BUT remember biomass decline
- Lower elevation species establishment is delayed (see Juniper in 200 years)
- No impact of management



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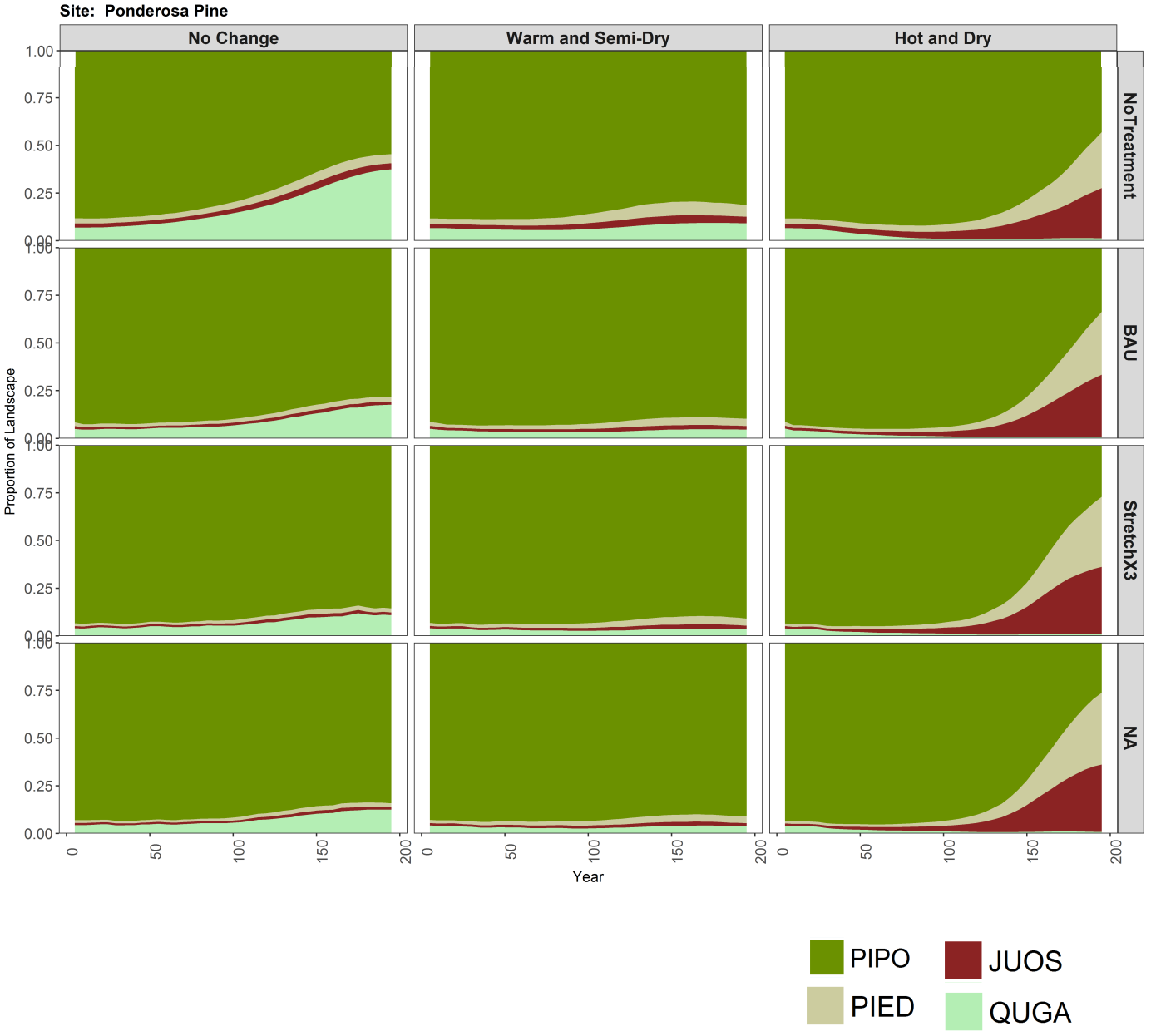
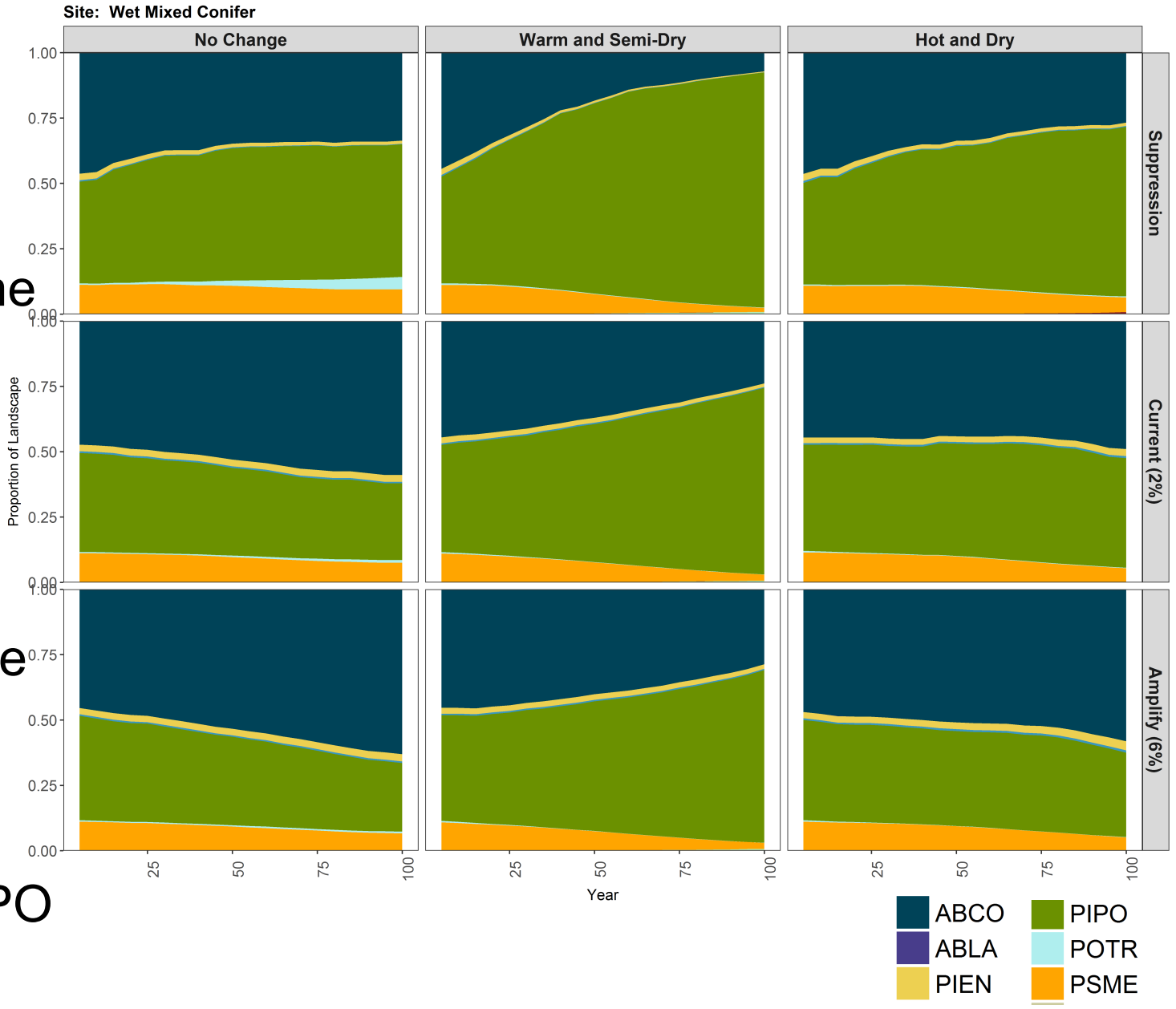


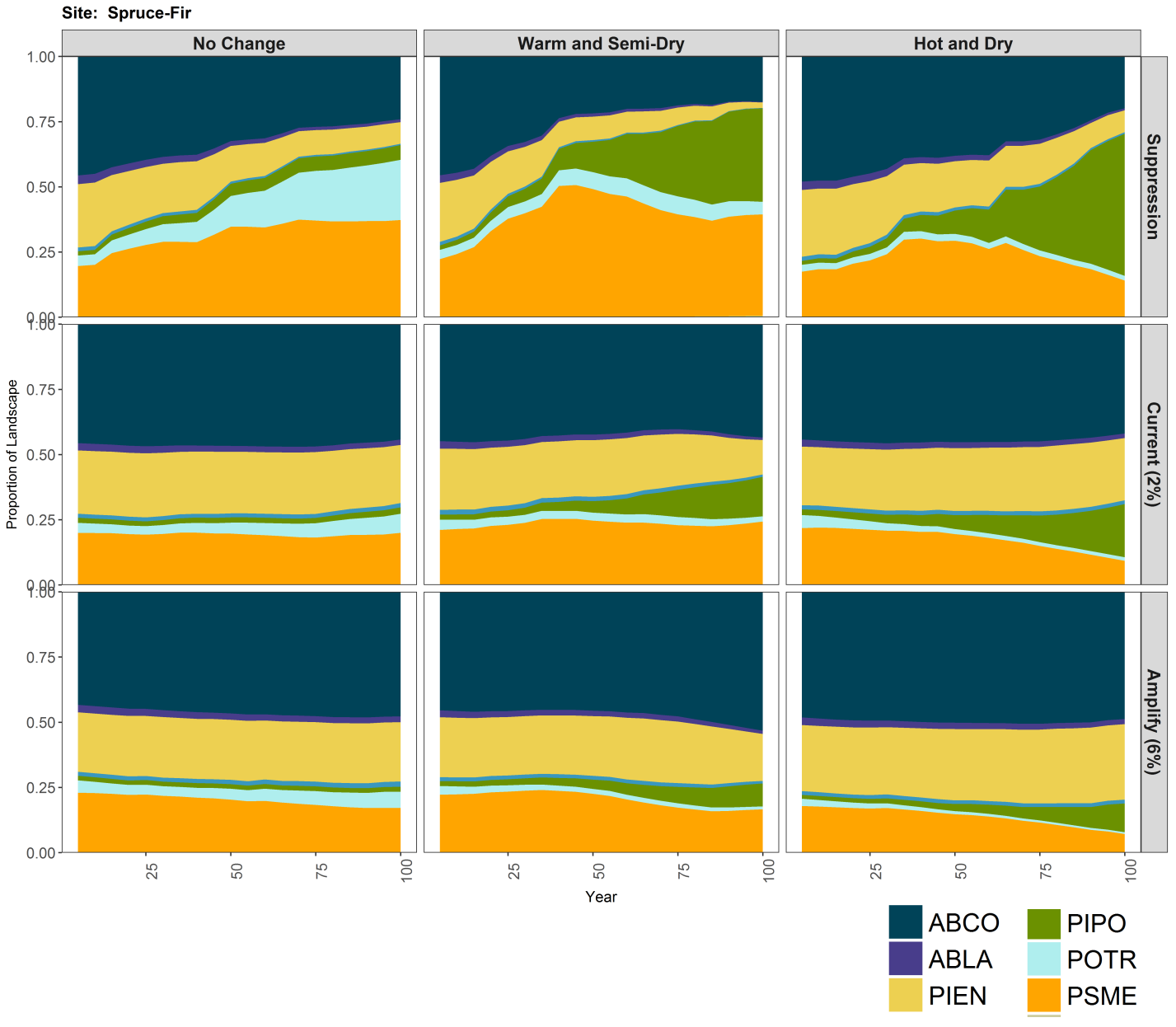
Mixed Conifer: Spp. composition

- Shift towards ponderosa pine
- Management delays compositional change
- Hot-dry climate delays compositional change – but due to low PIPO regeneration



Spruce-Fir: Spp. composition

- Shift towards ponderosa pine
- Decline of spruce, fir and aspen
- Management delays compositional change – this helps to conserve Spruce-fir!



We asked…

1. Effects of climate changes
2. Changes in fire?
3. Changes in forests?
4. *Where* are we seeing big changes?
5. *When* are we seeing big changes?
6. Management effectiveness – did treatments work?

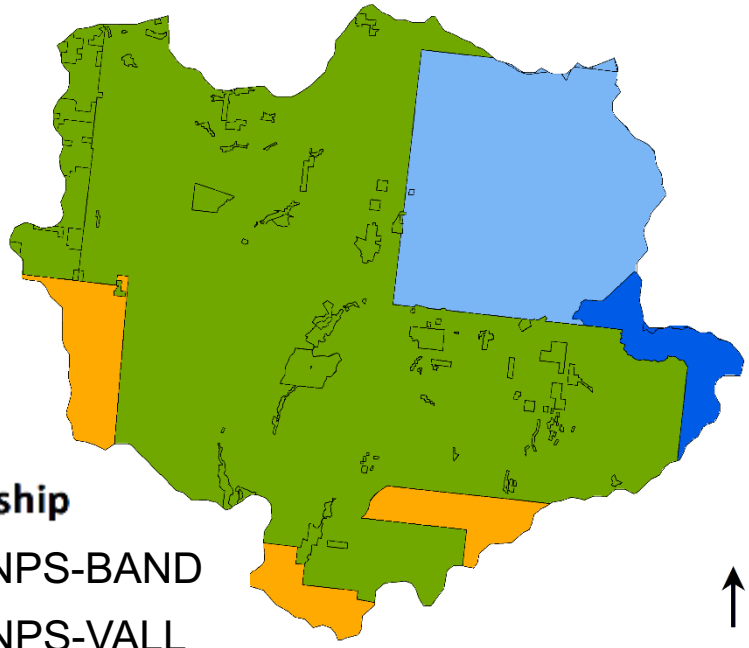
We found…

- ***Fire*** **+** ***regeneration failure*** drives biomass decline and compositional change

- High elevation forests
- Later in the century, when warming and drying is more pronounced
- Treatments have some impact delaying change

Results from the Jemez

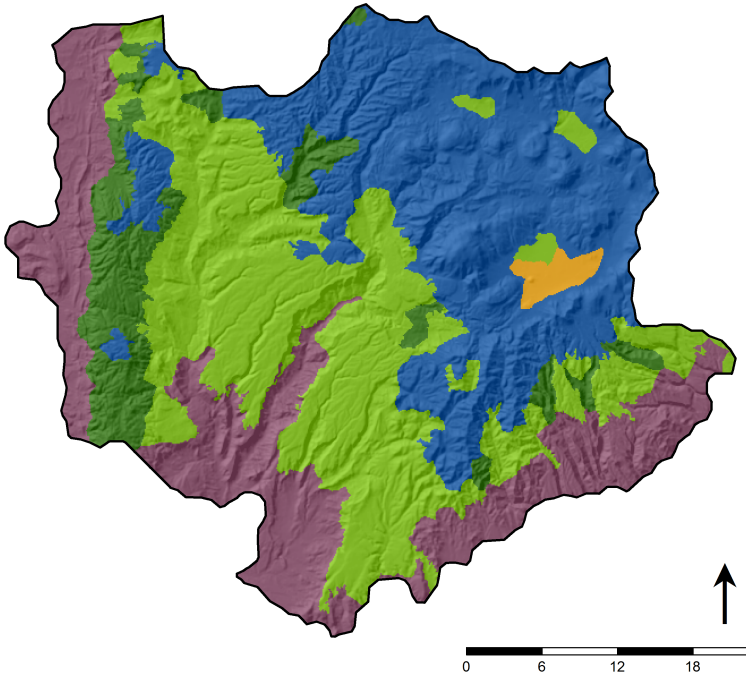
Jemez Mountains study area



Ownership

- NPS-BAND
- NPS-VALL
- Tribal
- USFS

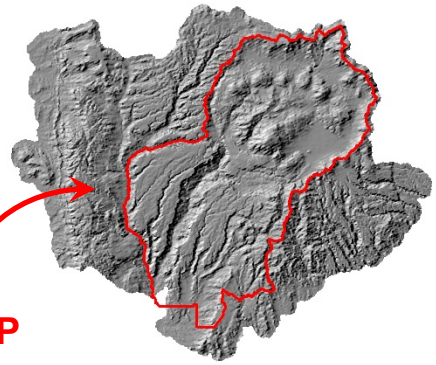
0 6 12 18 24 KM



0 6 12 18 24 KM

Ecological Sites

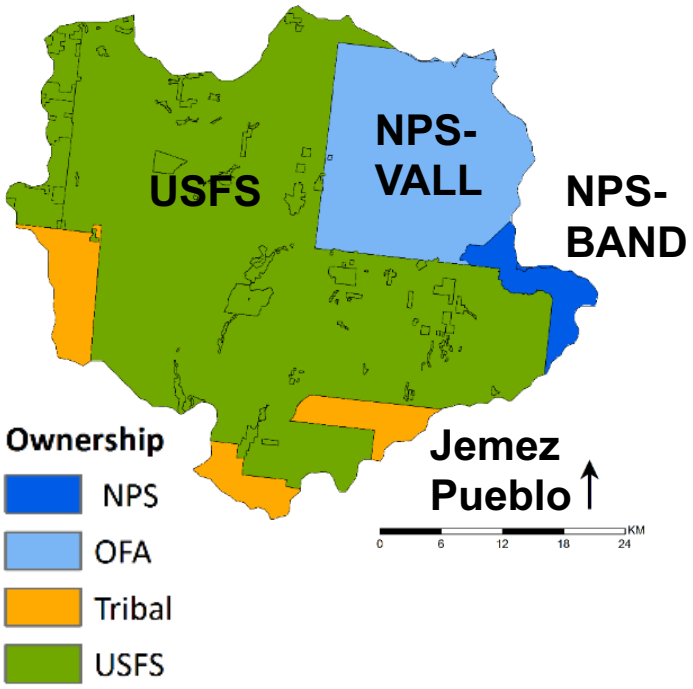
- Dry Mixed Conifer
- Pinyon-Juniper
- Ponderosa Pine
- Riparian
- Wet Mixed Conifer



Southwest Jemez CFLRP

Management scenarios

Based on *Final Environmental Impact Statement for the Southwest Jemez Mountains Landscape Restoration Project, Santa Fe National Forest, Sandoval County, NM*

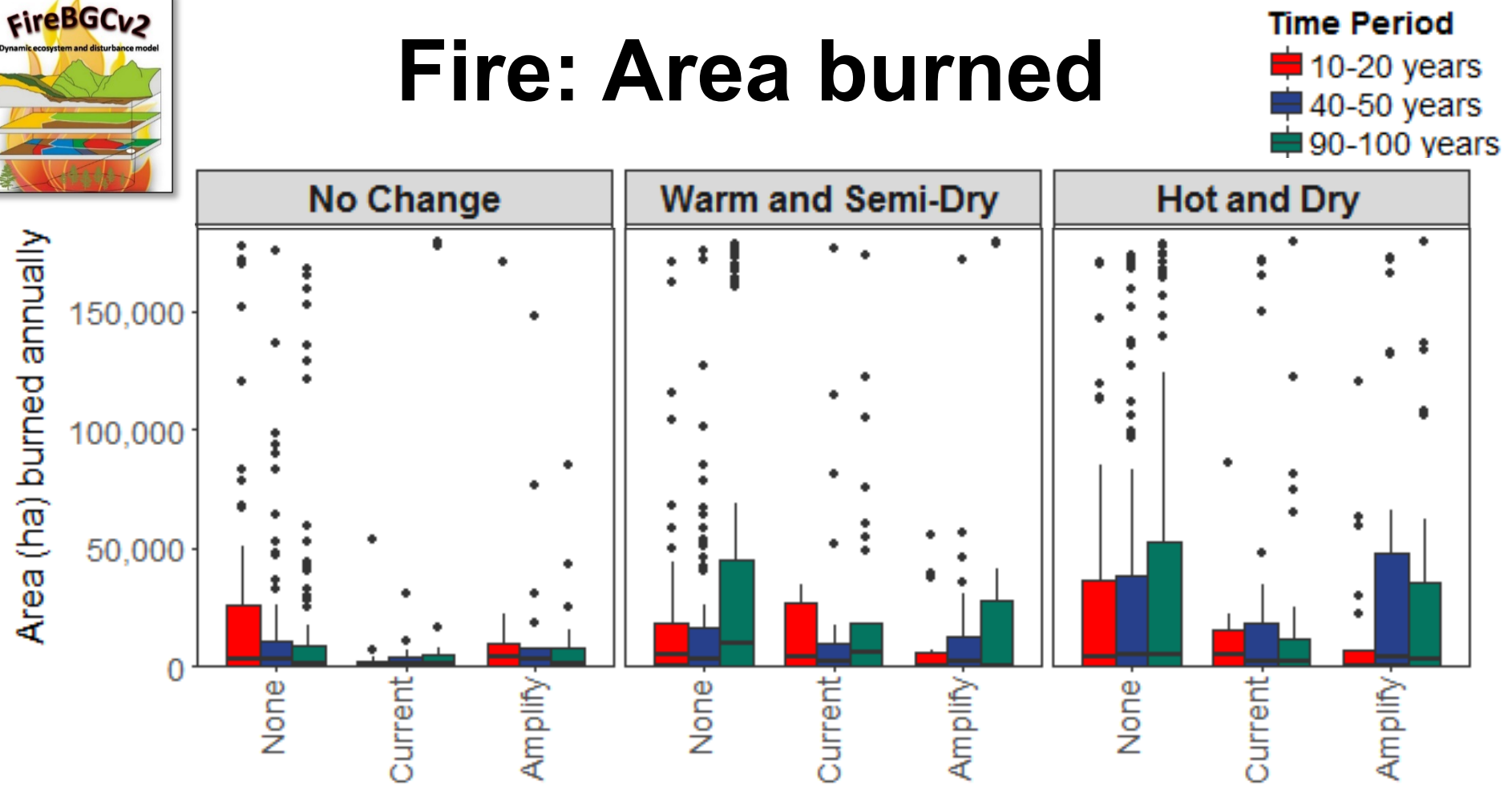


BAU scenario based on Alternative 1: The Proposed Action
Goals:

- Restore structure, function, and resilience of ponderosa pine and dry mixed conifer forests
- Reduce potential for uncharacteristically severe and intense wildfires while promoting low-intensity, frequent surface fires.
- Improve function of riparian ecosystems and streams, improve fish and wildlife habitat, vegetative diversity, and water quality.
- Provide for sustainability of archaeological sites, traditional cultural properties, sacred sites, and forest resources and areas associated with traditional practices.

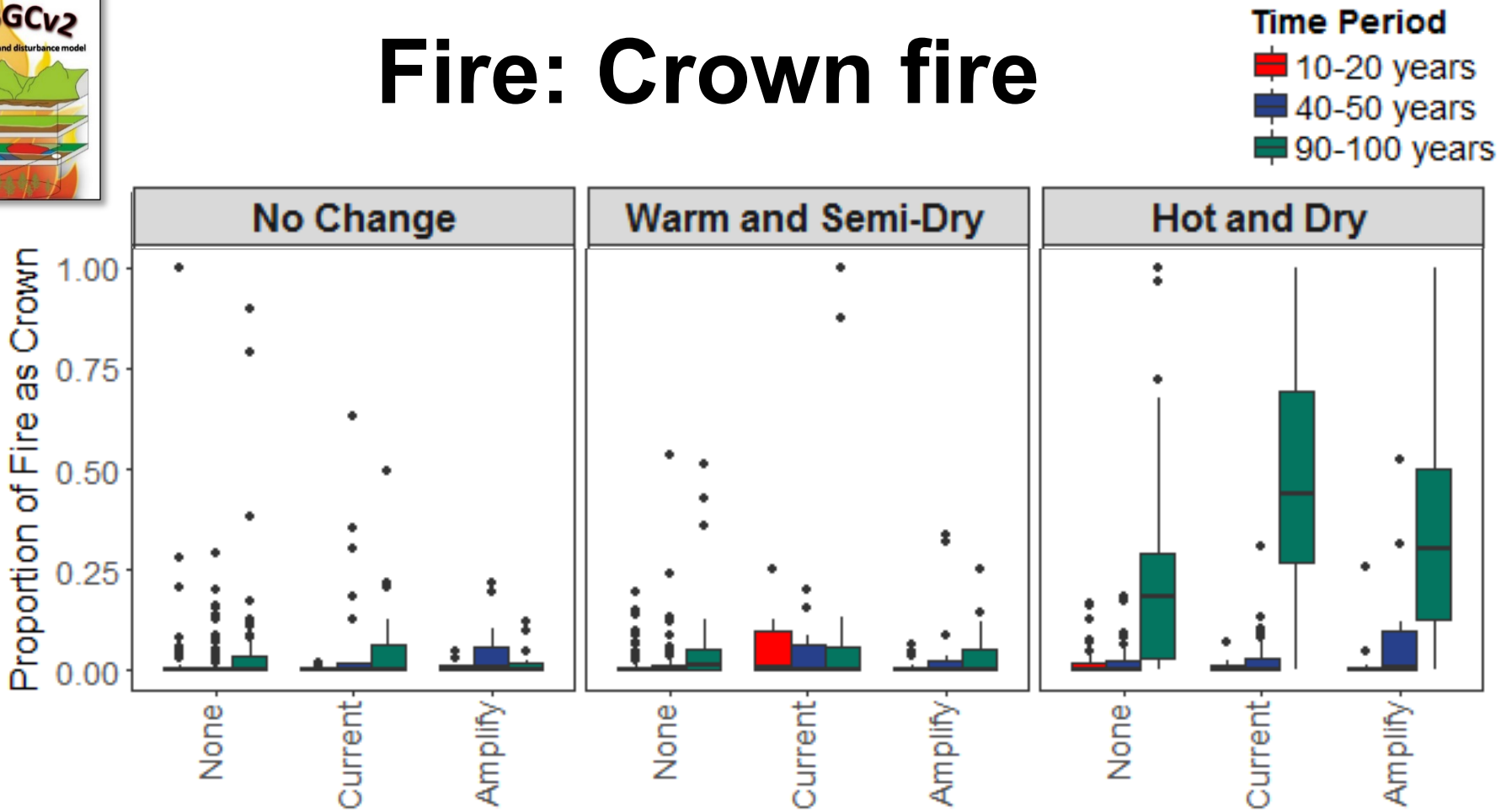
	Current (BAU)			Amplify (3x BAU)		
	Annual Treatments - ha (% of simulation area)					
Owner	Thin/Partial Removal	Thin/Full Removal	Burn	Thin/Partial Removal	Thin/Full Removal	Burn
NPS - BAND	10 (0.01%)	0	125 (0.07%)	30 (0.02%)	0	375 (0.21%)
NPS - VALL	406 (0.22%)	343 (0.19%)	1520 (0.84%)	1218 (0.67%)	1029 (0.57%)	4560 (2.52%)
Jemez Pueblo	75 (0.04%)	0	686 (0.38%)	224 (0.12%)	0	2059 (1.14%)
USFS	1222 (0.67%)	397 (0.22%)	600 (0.33%)	3667 (2.02%)	1191 (0.66%)	1801 (0.99%)

Fire: Area burned



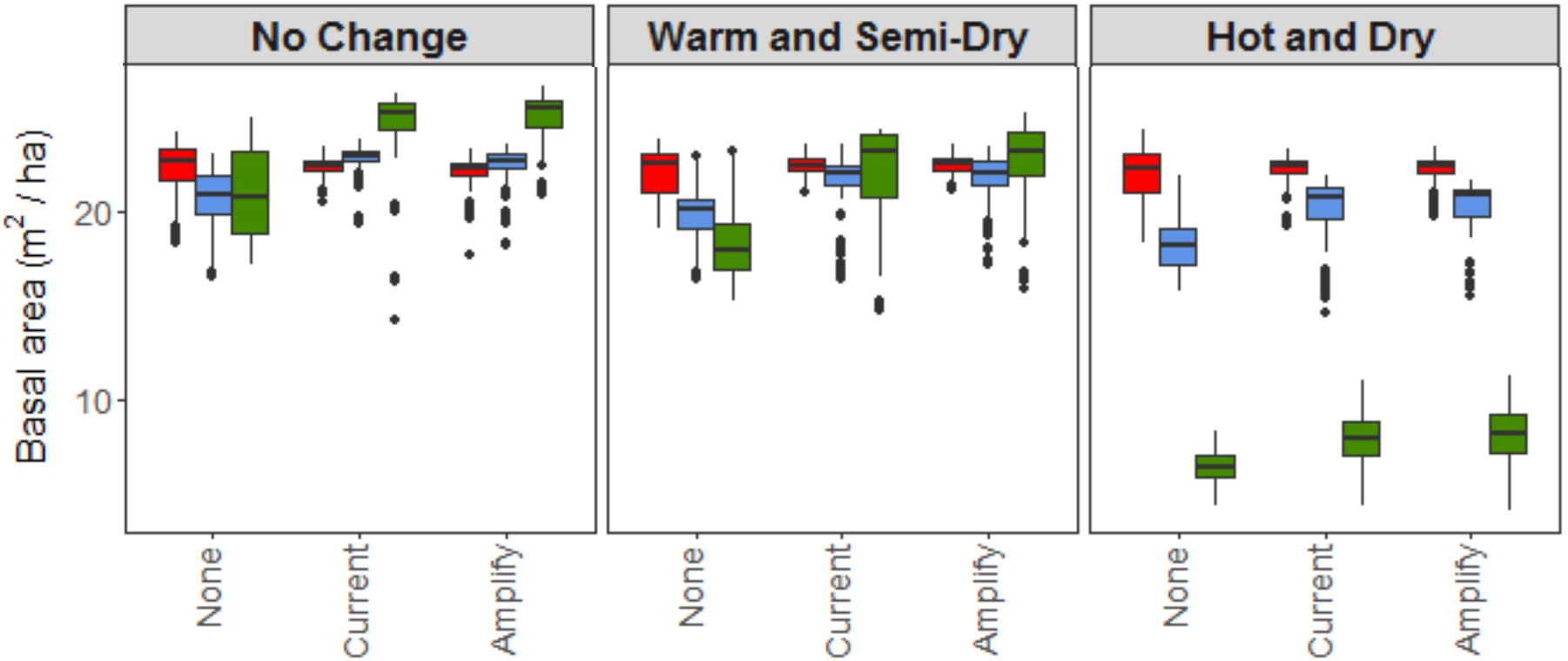
- Lots of variability – large and small fire years, with many small fire years that dominate the data
- Management (esp. 90% suppression level) maintains lower-than historical area burned under current climate but is less effective w/ increasing warming, drying

Fire: Crown fire



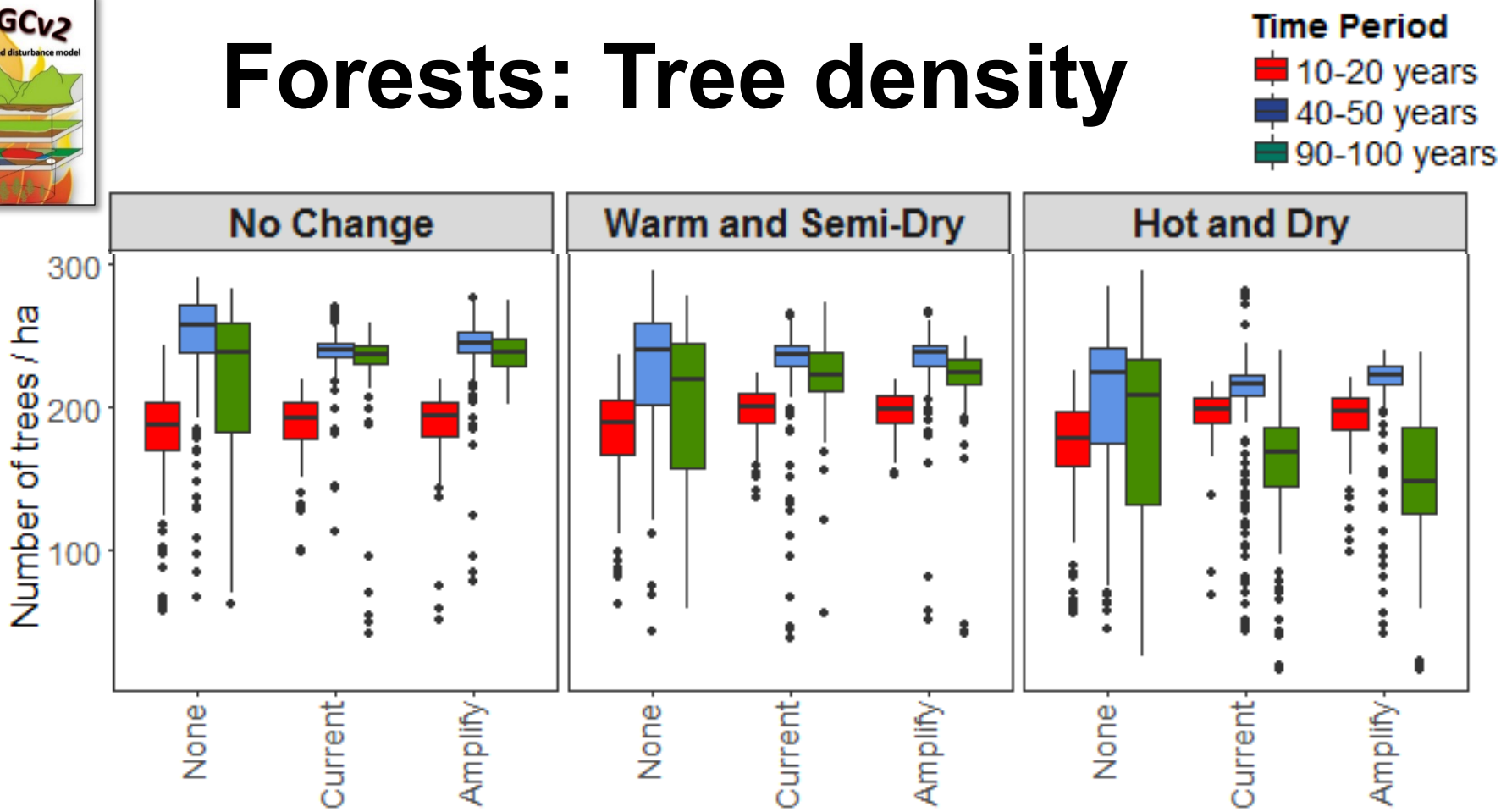
- Late-century hot, dry conditions result in increased crown fire regardless of management scenario
- Climate change effects on fire override management (suppression) influence on fire

Forests: Basal area



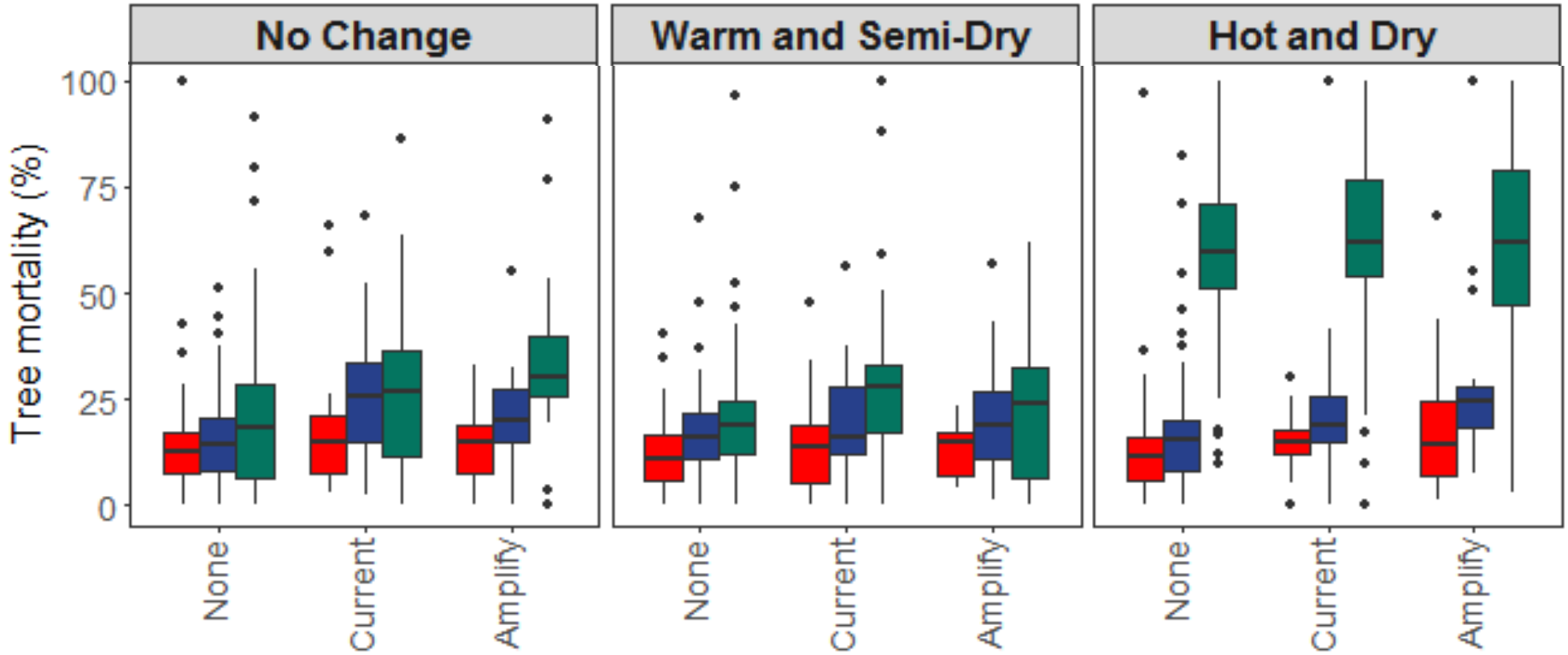
- More fires → lower BA
- Management (esp. 90% suppression level) maintains BA under “No Change” and “Warm & Semi-Dry” climate scenarios, but…
- Late-century “Hot & Dry” climate → much lower BA with increased crown fire, regardless of management scenario

Forests: Tree density



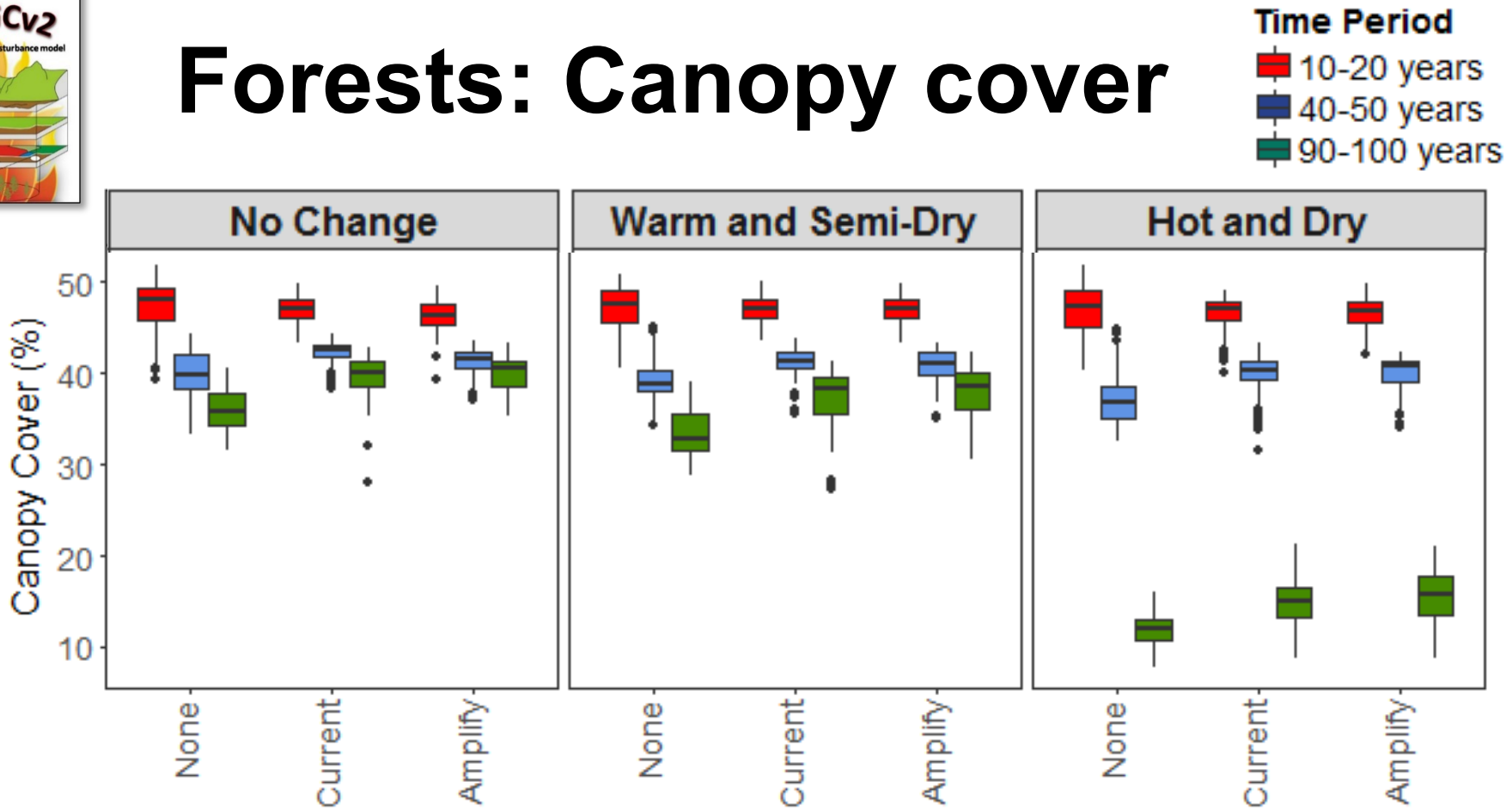
- Why does tree density seem fairly stable, regardless of climate and management?
- Compare with basal area results – these are small stems (saplings) – so, recruitment still ongoing, but mortality is high (fire!)

Forests: Tree mortality

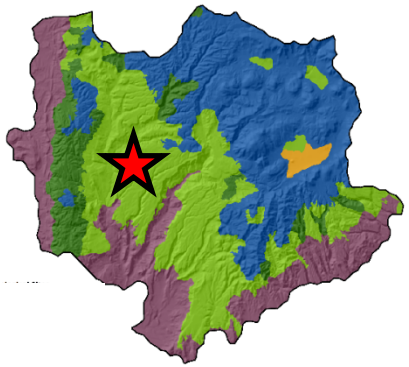


- More fires w/ “Hot & Dry” climate → increased tree mortality
- Tree Mortality and Crown Fire follow the same patterns
- Forests persist in early successional stages (low BA, fairly stable density)

Forests: Canopy cover

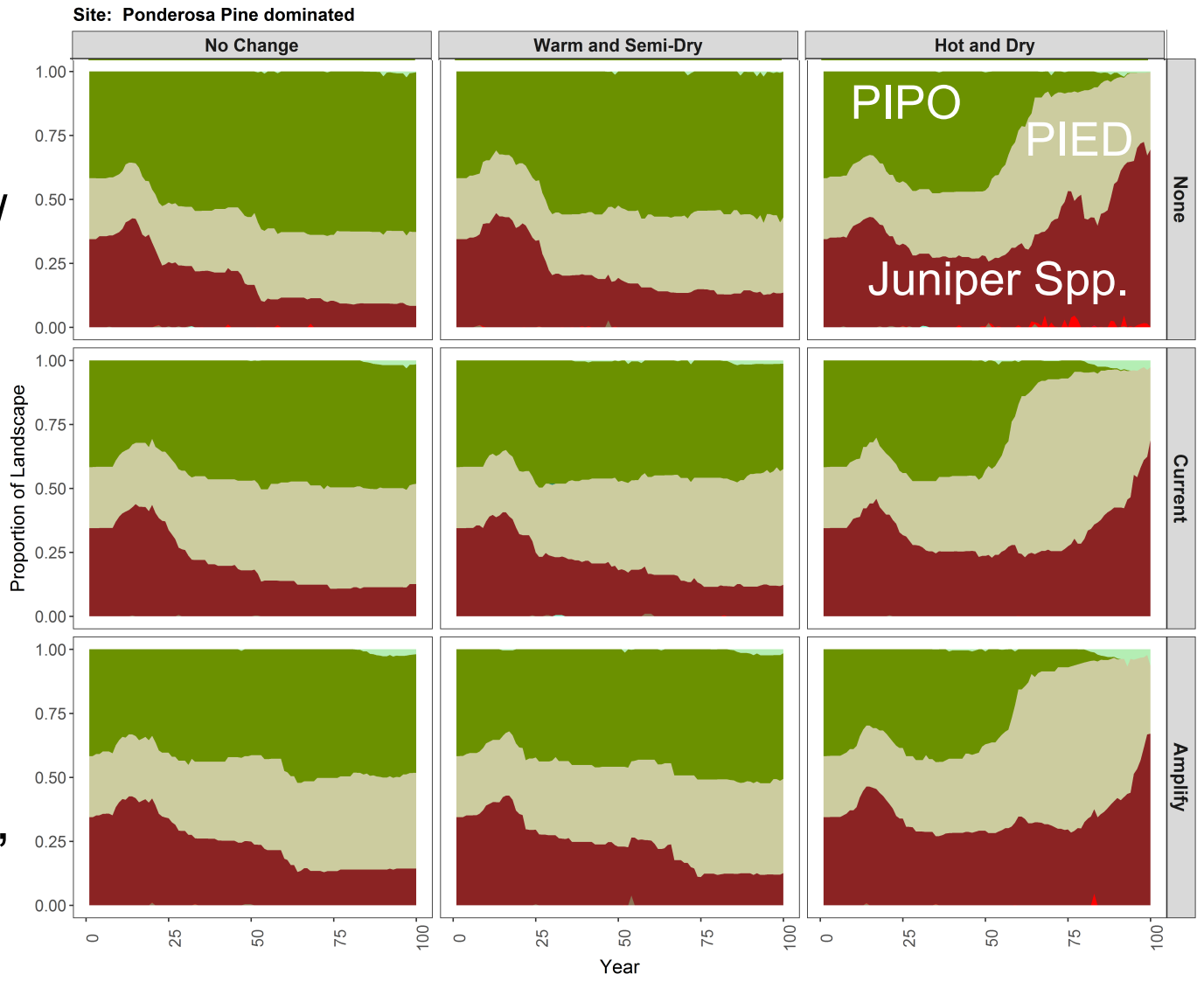


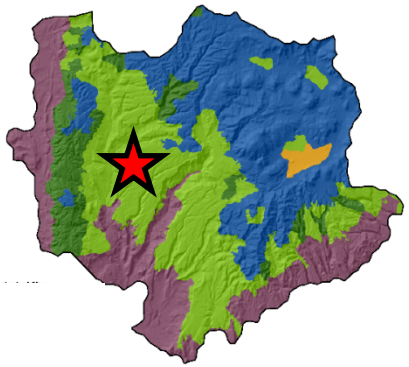
- Late-century “Hot & Dry” climate results in reduced landscape canopy cover regardless of management scenario
- Number of stems not the issue – trees are smaller, burn and then re-establish, burn then re-establish, and…
- Species compositional changes to woodlands reduce canopy cover



Dry forests: Spp. composition

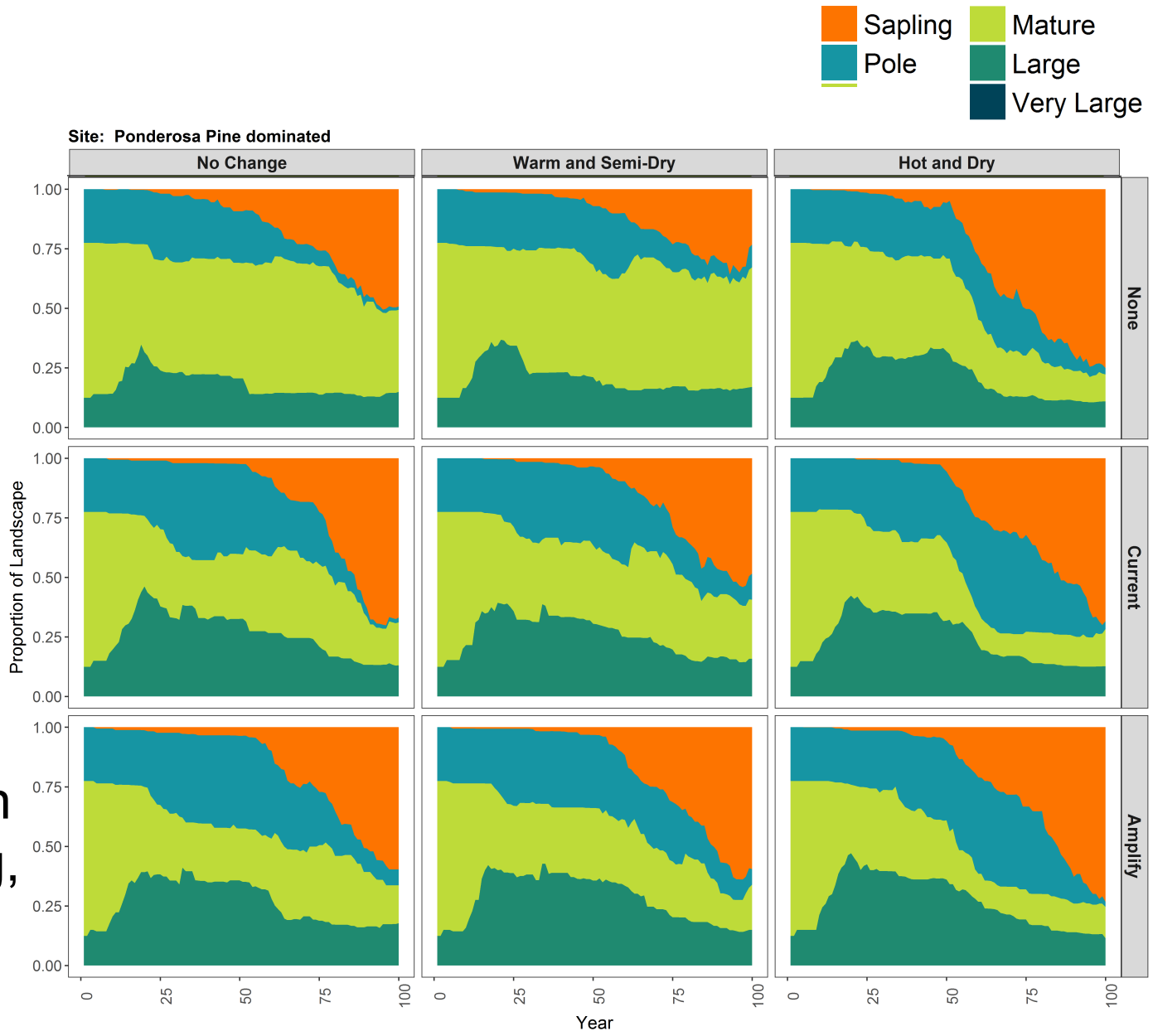
- Ponderosa pine less dominant w/ warming, drying
- Juniper and piñon increase (no *ips*!)
- Forest transition to woodland w/ hottest, driest climate scenario, late 21st century





Dry forests: Structural stage

- Fire increases saplings – more forest gaps
- Larger trees maintained w/ No Change climate, no suppression
- Increased crown fires w/ warming, drying decrease larger trees

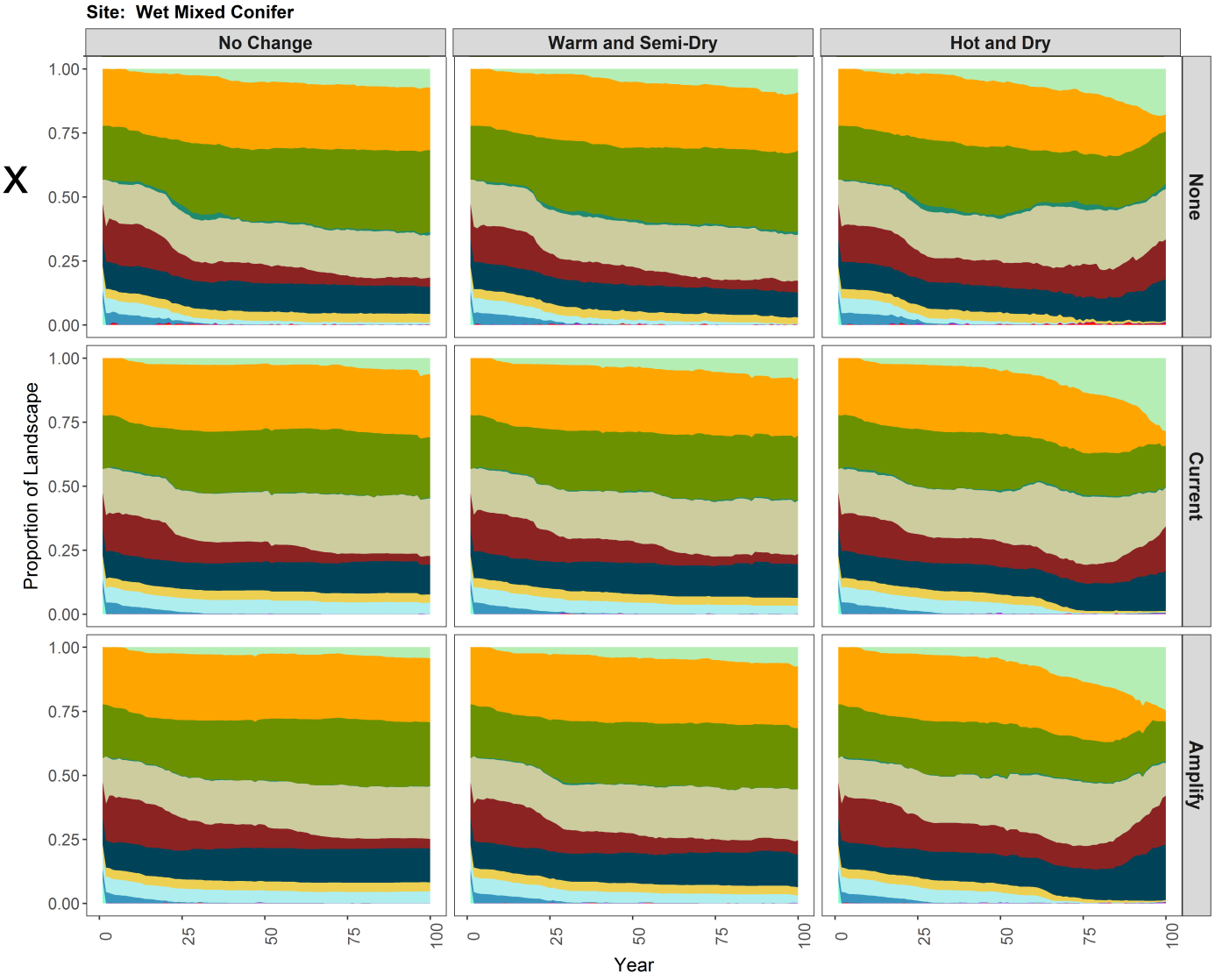


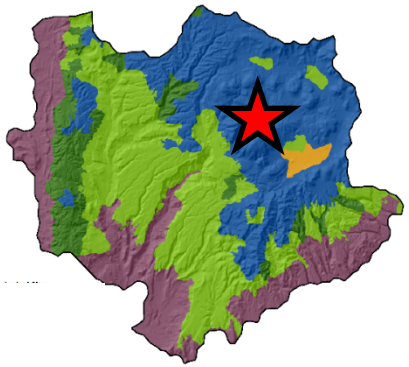
Mesic mixed conifer forests: Species composition

Dominant species

- QUGA
- PSME
- PIPO
- PIFL
- PIED
- POTR
- Juniperous spp.
- ABCO
- PIST
- PIPU
- PIEN

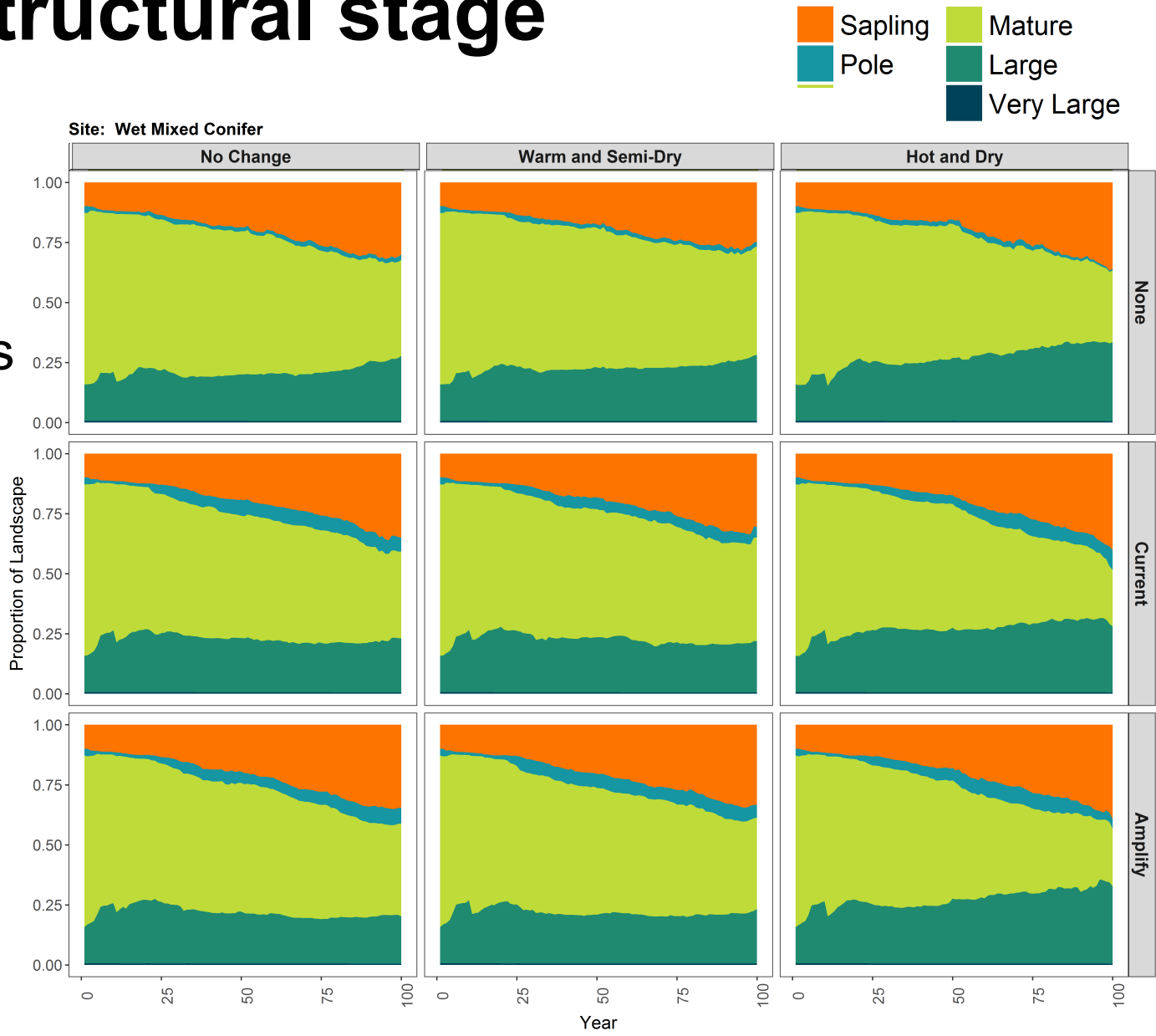
- Compositional mix maintained
- Increased oak w/ hottest, driest climate scenario, late 21st century
- Appear less sensitive to climate (changes in fire regimes) than dry forests





Mesic mixed conifer forests: Structural stage

- Not much difference among scenarios
- Some mature trees surviving and growing into Large tree category
- Some mortality in mature tree class, infill by saplings



We asked…

1. Effects of climate changes?
2. Changes in fire?
3. Changes in forests?
4. *Where* are we seeing big changes?
5. *When* are we seeing big changes?
6. Management effectiveness – did treatments work?

We found…

- RCP8.5 → more fire (esp. crown fire), reduced BA and canopy cover, changes in dry forest structure and composition.

- Particularly in dry forests

- Later in the century, when warming and drying is more pronounced

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- With climate changes, no more effects on fire, spp. Comp. than doing nothing

Where do the models converge and diverge?

Converge

- Climate change has important consequences
- Basal area/biomass decline driven by fire
- Regeneration decline of species in current elevations
- Compositional/structural change
- Uphill movement of species

Diverge

- Differences in the models –
- Management effects: not effective (FireBGCv2) vs. somewhat effective (LANDIS) – could be due differences in percent of area treated or overlapping treatments in FireBGCv2

What information can you provide?

1. **Refine management scenarios**
   - Business as usual
   - Out of the box
2. **Identify management targets**
   - Key indicators of management effectiveness
   - Fire Regime
   - Vegetation
3. **Evaluate next round of model results**

What is your reaction to the modeling results?

What is your opinion of how current management is modeled?

How should we think about "stretched" and "out of the box" management?

Modeling outcomes w/ current, modeled management

- Increased high severity fire
- Changes in structure
- Changes in composition
- Biomass/basal area declines

Novel management options that we'd like to model

- Fire – Rx fire, wildfire
- Fuels treatments
- Forest management – planting, assisted migration

How much, how often, where, when, intensity??

Many thanks to:

SW FireCLIME project team:

Anne Bradley, Windy Bunn, Don Falk, Megan Friggens, Pete Fule, Dave Gori, Shaula Hedwall, Lisa Holsinger, Robert Keane, Tessa Nicolet, Jack Triepke, Craig Wilcox, Larissa Yocom, Cori Dolan

FireBGCv2 modeling:

FHiRE project team: Tom Swetnam, Chris Roos, Matt Liebmann, John Welch, TJ Ferguson, Pueblo of Jemez

National Science Foundation

USFS Rocky Mountain Research Station Fire Sciences Lab

‘Out of box’ management ideas from Workshop 1

Pinon-juniper

- Common garden studies
- Assisted migration: various elevations, dry vs. wet
- Genotype selection for resilient types, e.g. for seed production

Ponderosa Pine

- Selective cut of species to facilitate passive migration
- Landscape-scale clear cutting to prevent fire
- Planting and assisted migration after fires
- Implement post-fire soil stabilization, then walk away

Wet mixed conifer

- Thinning: Increase PIPO, move wet mixed conifer toward dry-type species composition
- Variable density thinning, mix up the heterogeneity
- Increase age/structural stages to promote variable tree sizes
- Prescribed crown fire where appropriate - create some openings, and then have control over the planting to help engineer the resulting landscape
- Plan for 2030, but also think about 2060, because what we plant now will regenerate then
- Enhance aspen to serve as fire break (although vulnerable to drought)

FireBGCv2 management inputs (user specified, can pick all or none, implement by time and space)

Management action	Definition	Input parameters
Clearcut w/ or w/o prescribed burn	Removes ALL trees down to a diameter limit	Max area (yr); Max area (Tx); Min & retention BA (Tx); Retention spp.
Partial cut w/ or w/o prescribed burn	Removes trees by diameter class and species	Max area (yr); Max area (Tx); Retention BA (Tx); Retention spp.; Harvest DBH (min/max); Slash Tx.
Prescribed burn	Prescribed burn	Max area (yr); Max area (Tx); Time since fire (min/max); Stand age (min/max); Intensity (min/max)
Fire suppression	Assigns fire suppression levels by zones	Increased or decreased probability of ignition (suppression level)
Deadwood fuel harvest	Removes down woody fuels and shrubs from surface	Max area (yr); Proportion burned; Harvest pools (1-1,000 hr., shrubs)
Livewood fuel harvest	Removes live trees and shrubs	Max area (yr); Min area (Tx); Proportion burned; Retention BA (Tx); Retention spp.; Harvest DBH (min/max); Slash Tx.
Planting	Live tree planting	Max area (yr); Survivorship; Lag yrs. after fire to treat (min/max); Planting density; LAI limit (Tx).
Salvage logging	Computes volume lost to fire, removes snags	Max area (Tx); Min BA (Tx); Min DBH (harvest and volume calcs.); Retention spp.
Verbenone treatment	Prevents mountain pine beetle (MPB) mortality in trees	Max area (yr); Treatment effectiveness