

Using Landscape Models to Inform Climate Adaptation Strategies in the Southwest



Article

Can Land Management Buffer Impacts of Climate Changes and Altered Fire Regimes on Ecosystems of the Southwestern United States?

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Adaptation Strategies

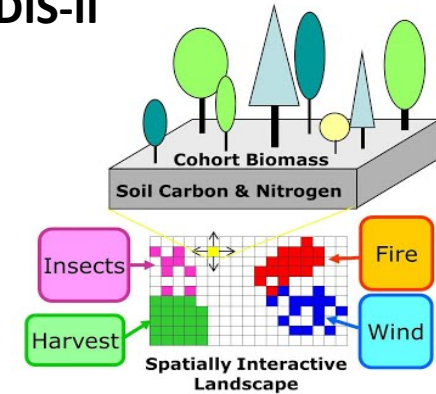
Swanston et al. 2016; Millar et al. 2007

1. Resistance – buffer or protect from change
 - Fire suppression, Rx burning, maintain refugia
2. Resilience – promote the return to normal conditions after a disturbance
 - Rx burning, thinning, promote heterogeneity/diversity
3. Transition – actively facilitate or accommodate change
 - Plant new species, remove maladapted species

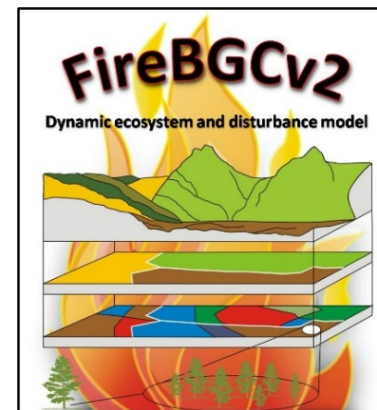
LANDIS-II and FireBGCv2: Forest Landscape Simulation Models

- Simulate large spatial and long temporal scales
- Spatial processes: fire, seed dispersal, climate variability
- Simulate interacting disturbance and vegetation responses to climate
- Model individual tree species
- Can incorporate management activities

LANDIS-II

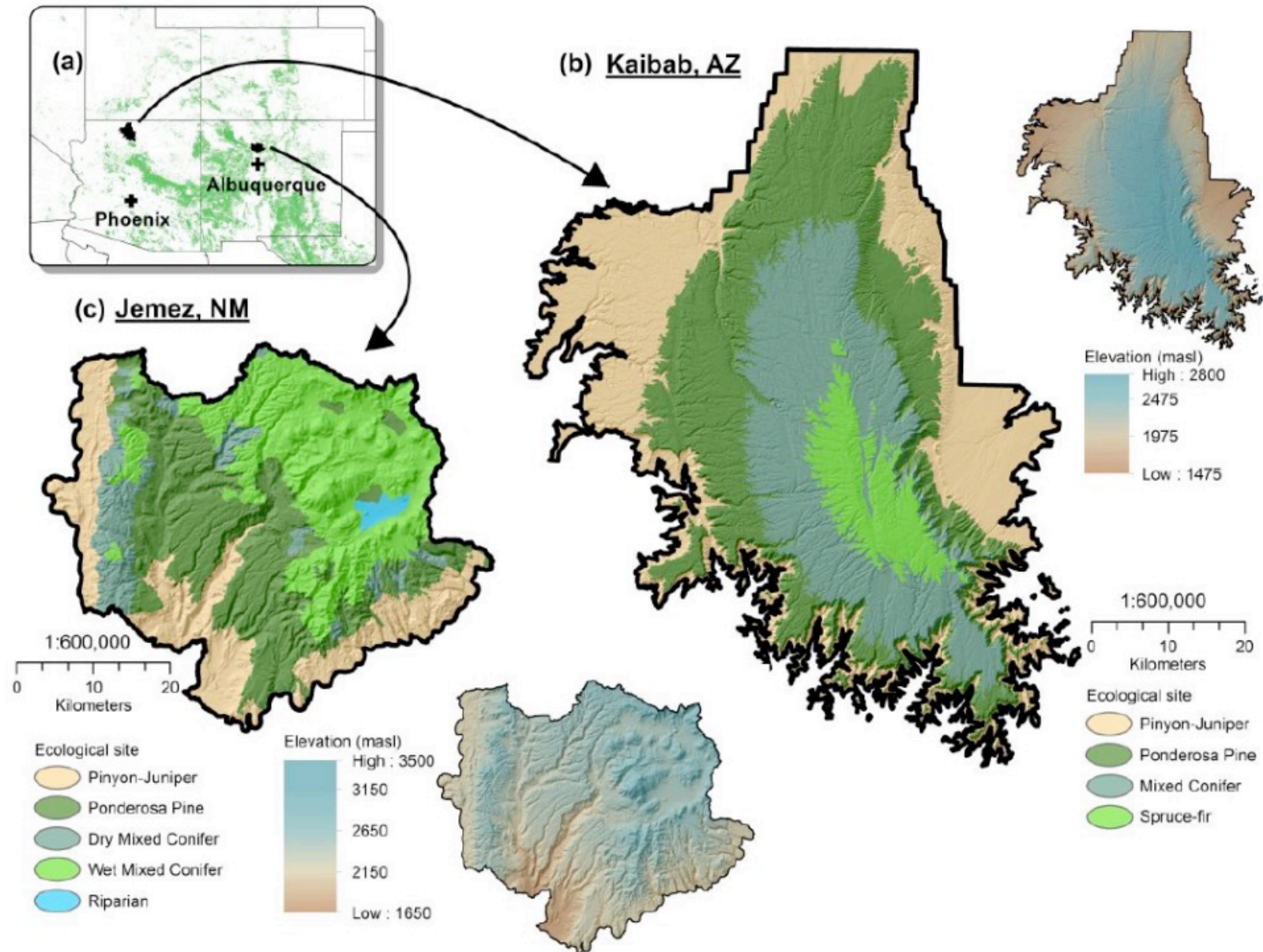


<http://www.landis-ii.org/>



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

Study Landscapes: Jemez, NM and Kaibab, AZ



Modeling design

Landscapes:

1. Kaibab Plateau, AZ – LANDIS-II model
2. Jemez Mountains, NM – FireBGCv2 model

Climates:

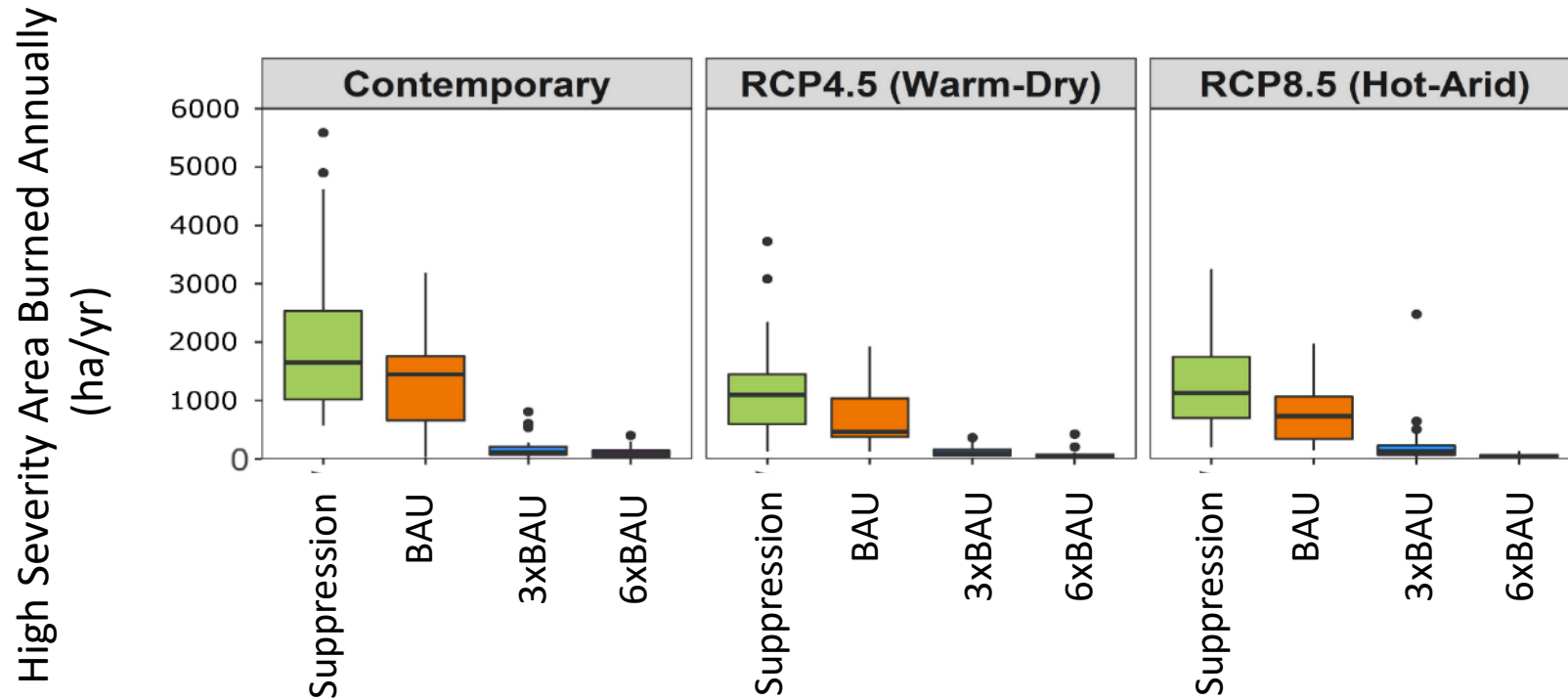
1. Contemporary - Instrumental weather (1960 - 1990)
2. Warm, Semi-Dry – CCSM4 GCM, RCP4.5 (1990-2090)
3. Hot, Arid – HADGEM2-ES GCM, RCP8.5 (1990-2090)

Management Scenarios:

1. Suppression – Fire suppression, no management
2. BAU (1.5%) – Thinning and Rx burns, 67 year rotation for Ponderosa and Dry Mixed Conifer
3. 3xBAU (4.5%) – Thinning and Rx burns, 22 year rotation
4. 6xBAU (9%) – Thinning and Rx burns, 11 year rotation

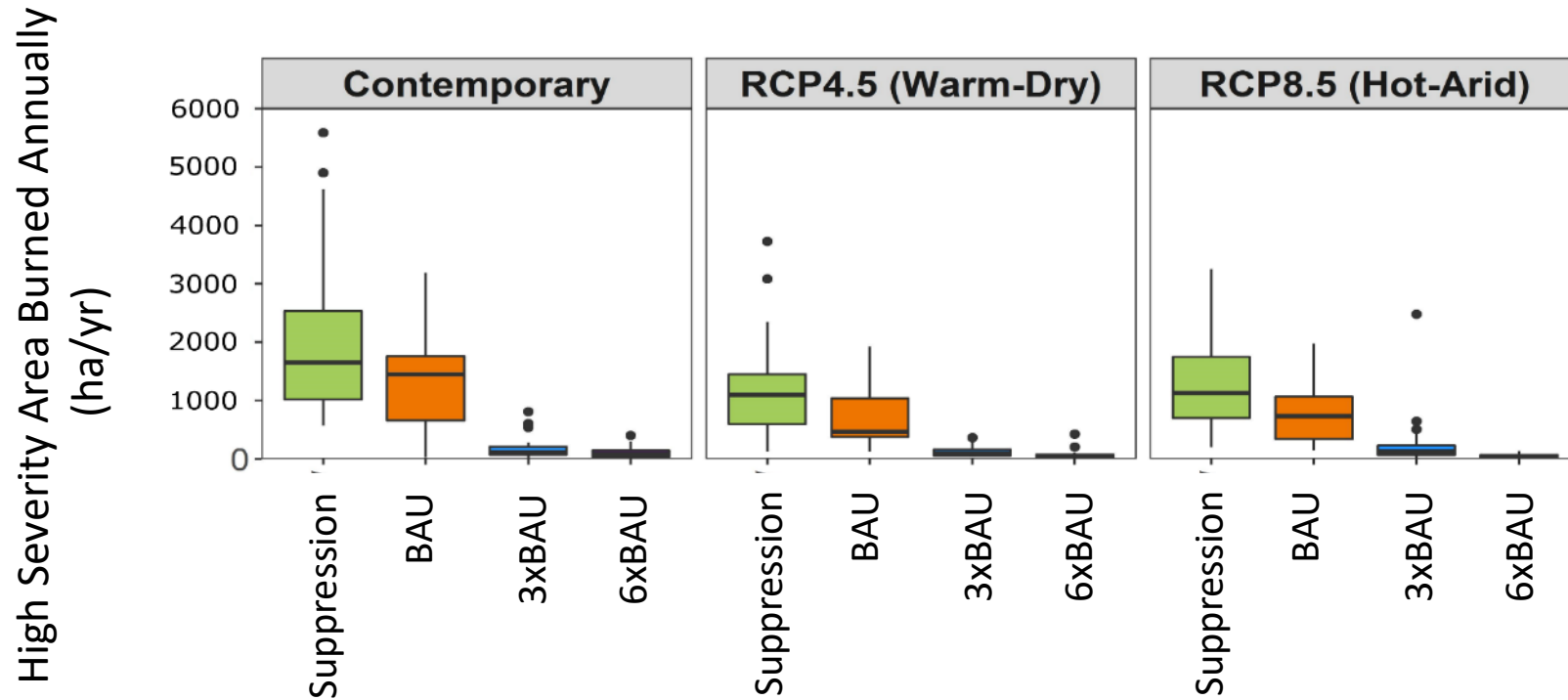
Includes
Suppression Too

Kaibab Plateau: mixed conifer and ponderosa pine High Severity Area



- High severity area burned **is reduced** with increased treatment
- Reduction in high severity slows turnover and transition...could be very important!!
- However, this was not seen in the Jemez!!!

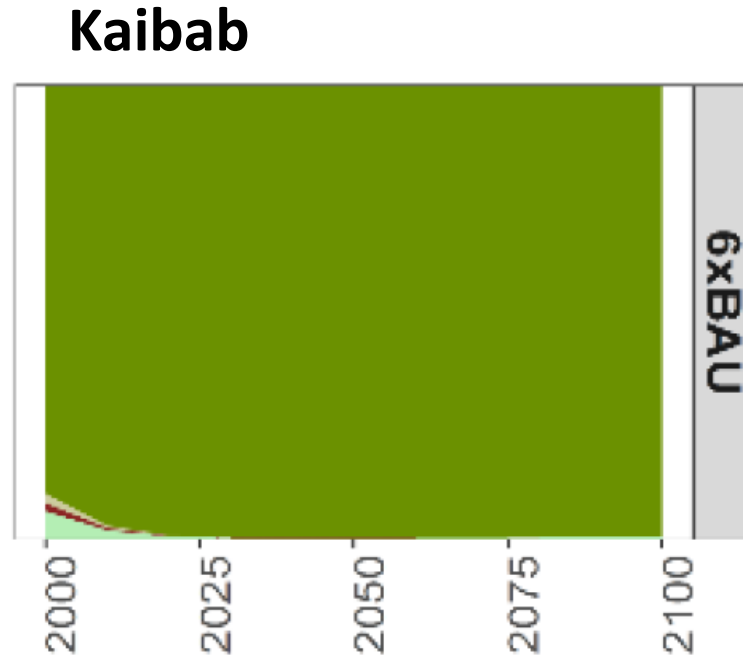
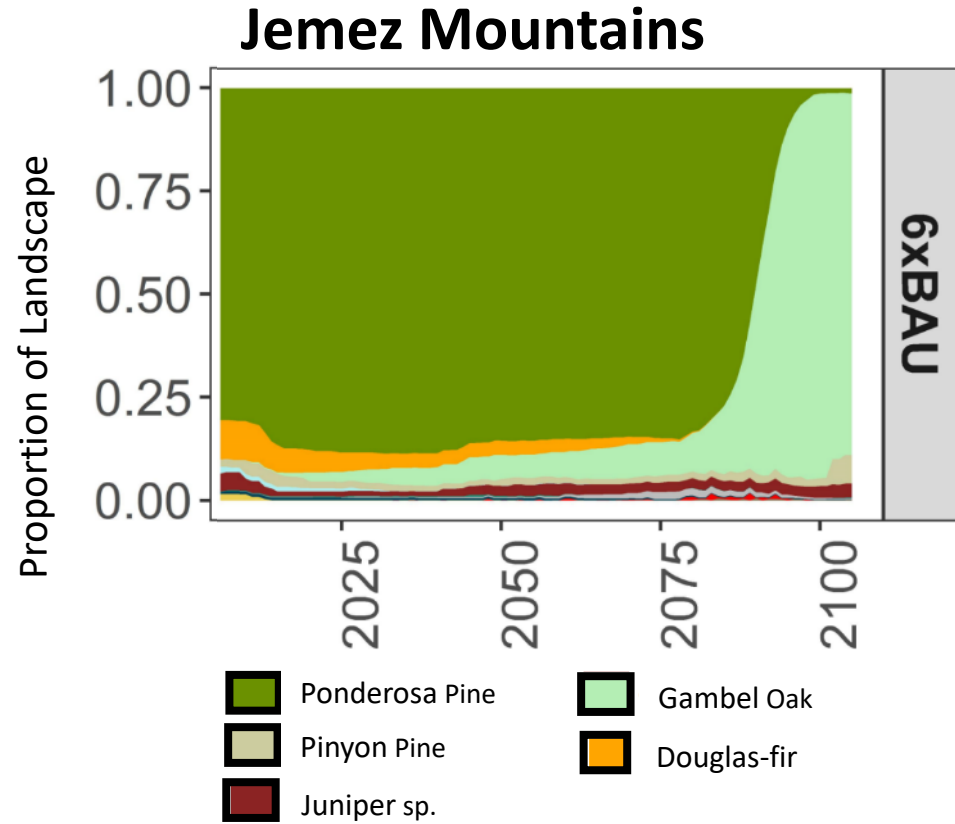
Kaibab Plateau: mixed conifer and ponderosa pine High Severity Area



Resistance
Resilience
Transition

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RCP 8.5, 6XBAU, Ponderosa Pine Composition

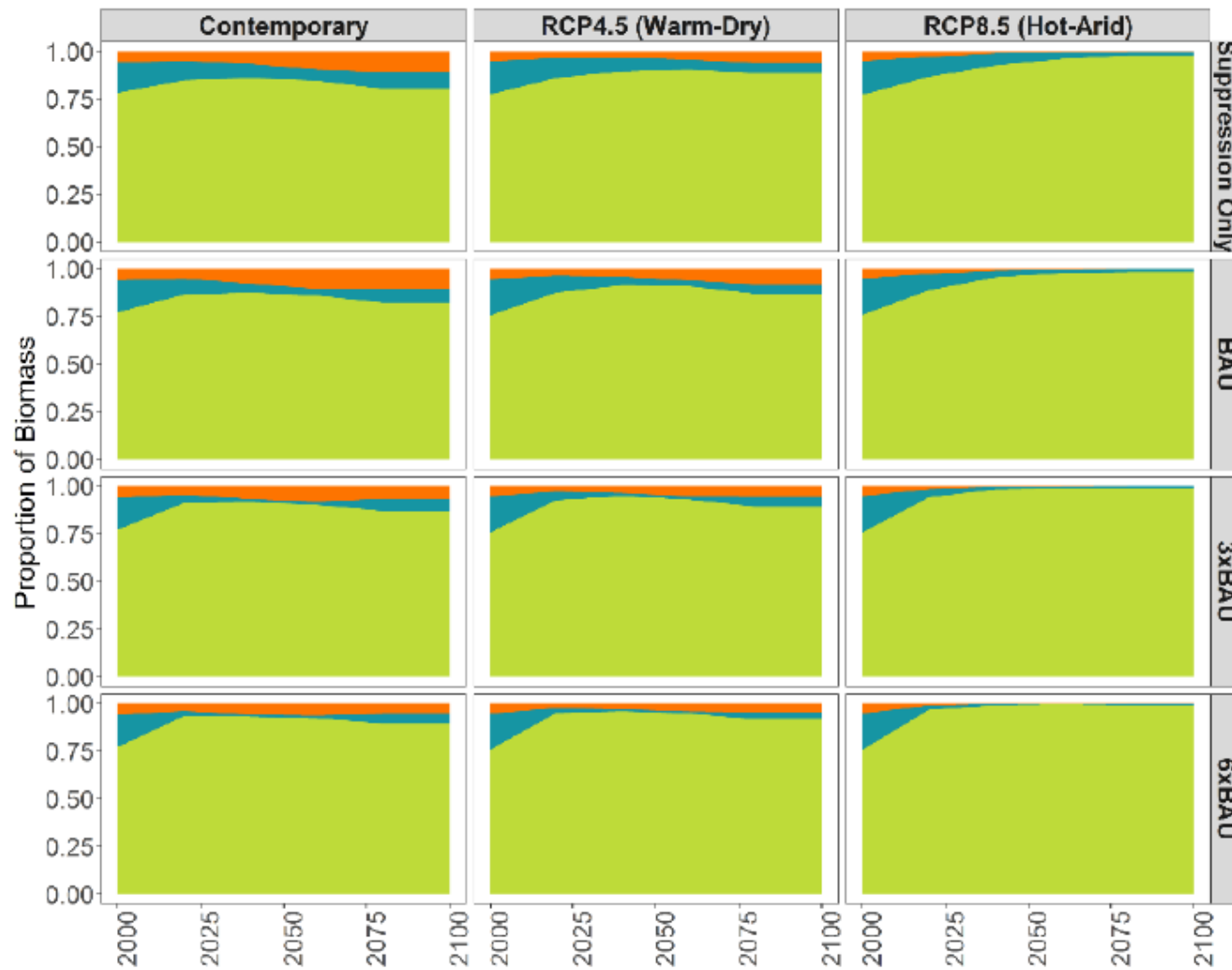


Resistance
Resilience
Transition

- Over longer time periods started to see ponderosa give in to juniper...

- Compositional change from ponderosa pine to gambel oak
- Thinning and burning does not improve the situation
- Turnover from fire, drought, and regeneration failure

Kaibab Plateau: mixed conifer and ponderosa pine Age Class

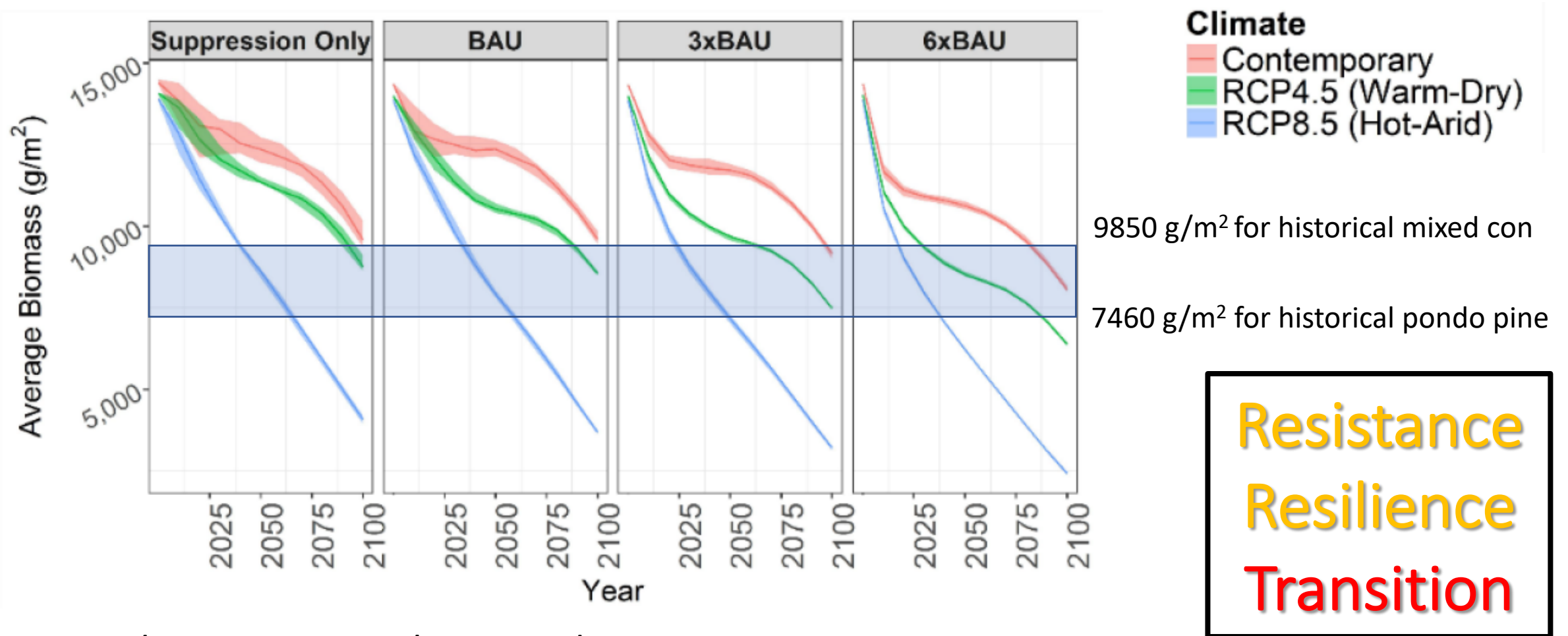


Age Class
0-49
50-99
100 plus

Resistance
Resilience
Transition

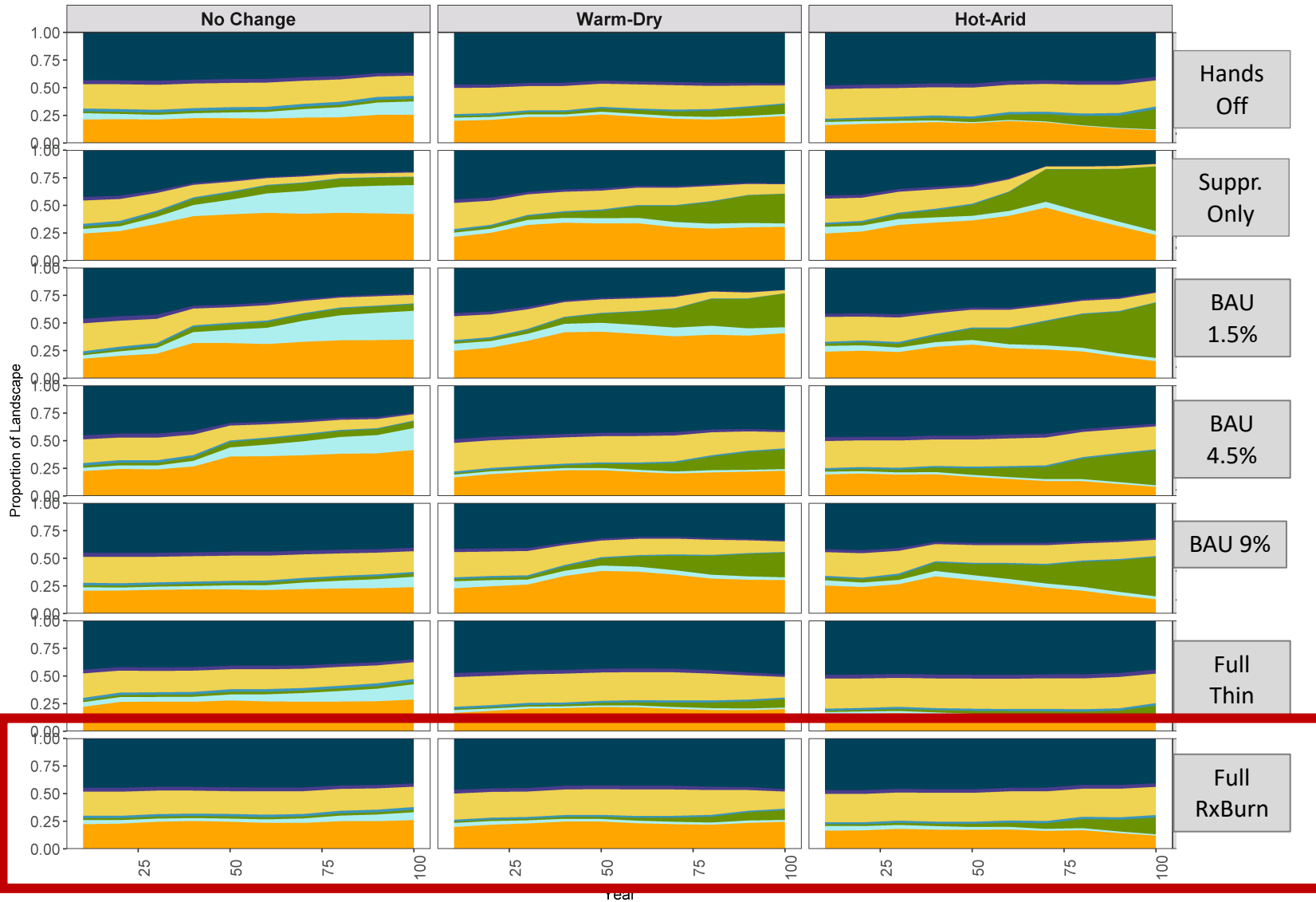
- Regeneration failure with climate scenario as see a shift to older trees
- Compounded by biomass loss (next slide). No gain in biomass in older cohorts, loss of younger cohorts
- Warm-dry does allow for some ponderosa pine regeneration

Kaibab: mixed conifer and ponderosa pine biomass



- Drastic decrease in tree biomass despite treatment
- Climate scenario matters!!
- Due to regeneration failure (shown by age structure shifts to older cohorts)
- Overall forest decline and likely type change from forest to woodland or grassland

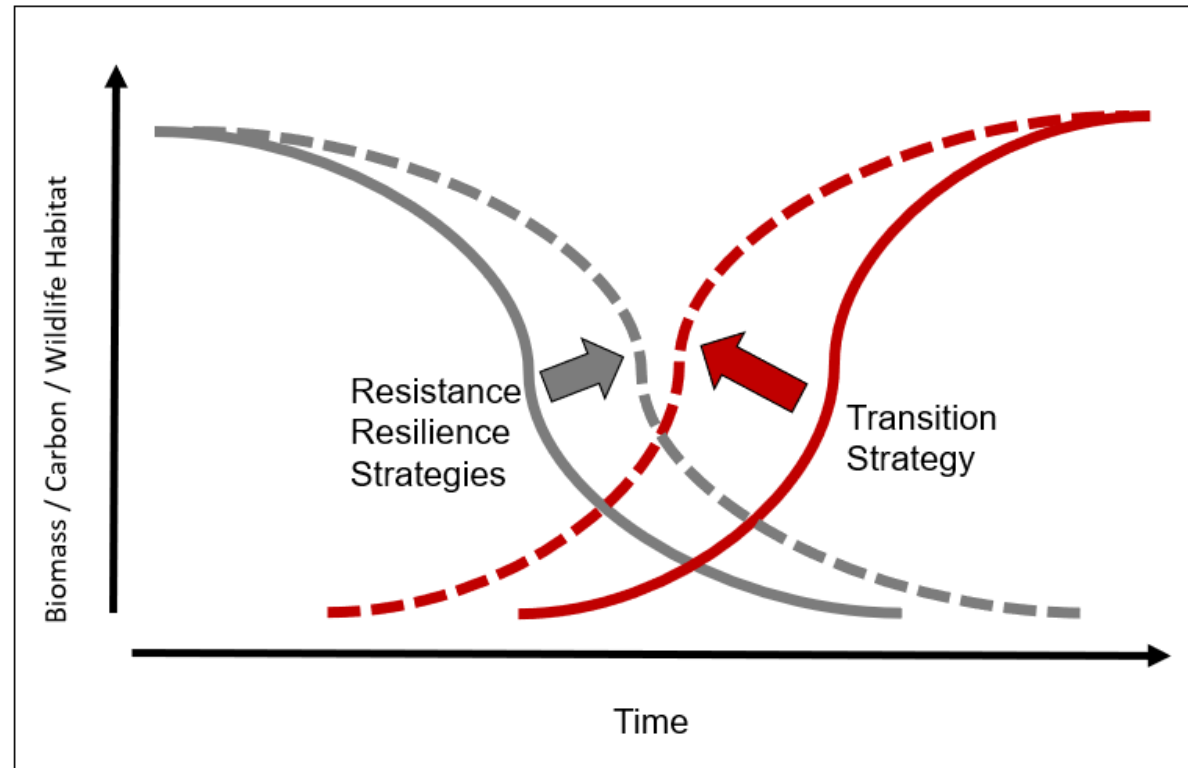
Kaibab Results: Spruce-Fir Species Composition




- Forest type with the most noticeable change in composition.
- Increase in ponderosa pine at expense of spruce, fir, and douglas fir. Loss of aspen.

Conclusions

- Thinning and burning (resistance and resilience strategies) will not prevent vegetation reorganization under major climate change scenarios
- Transition strategies will be important as landscapes reorganize under future climate conditions
- But resistance, resilience and transition strategies may all be important in easing this transition





Gradients of productivity and flammability drive fire regimes in the SW US

Larissa Yocom

Utah State University

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University of Arizona

Andi Thode

Northern Arizona University

Mike Crimmins

University of Arizona

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Will Flatley

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U.S. Forest Service

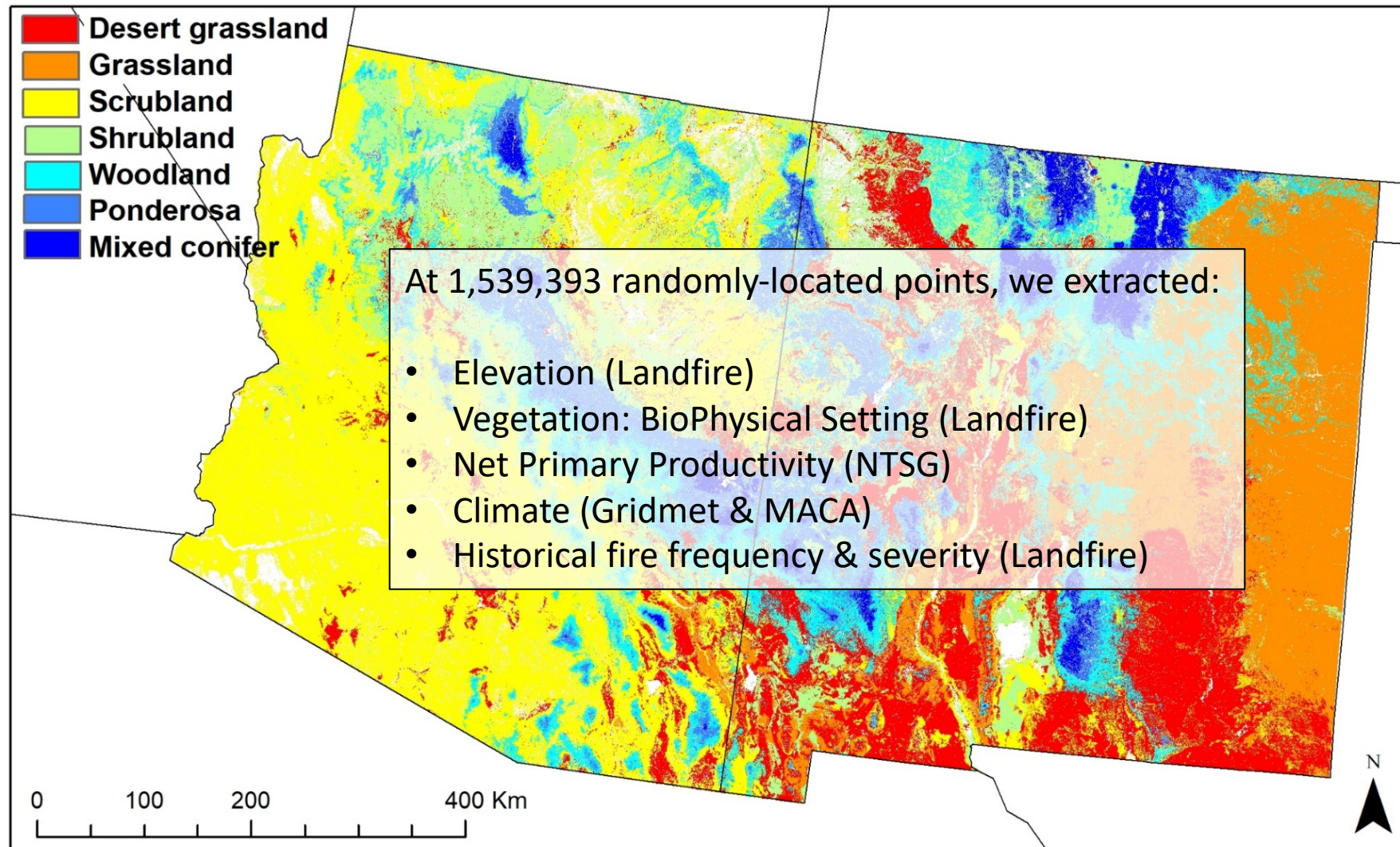
Windy Bunn

National Park Service

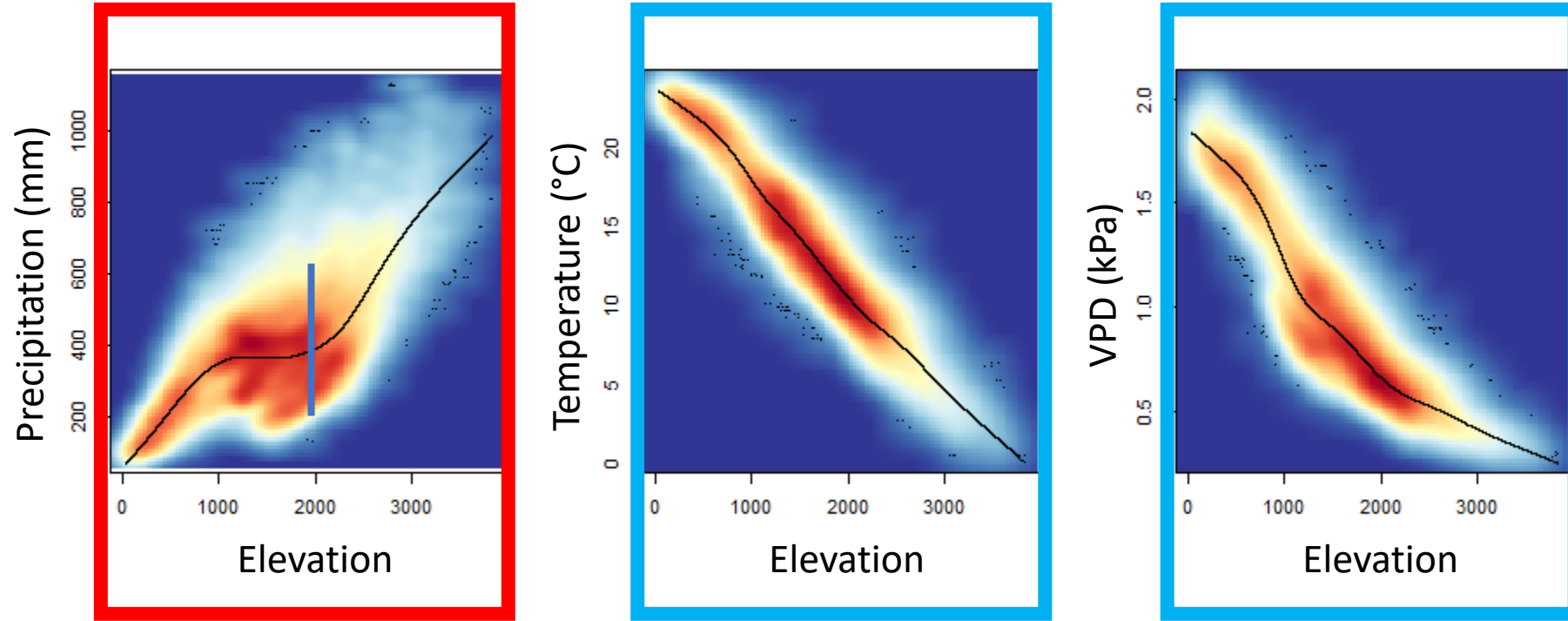
Shaula Hedwall

USFWS

Study area

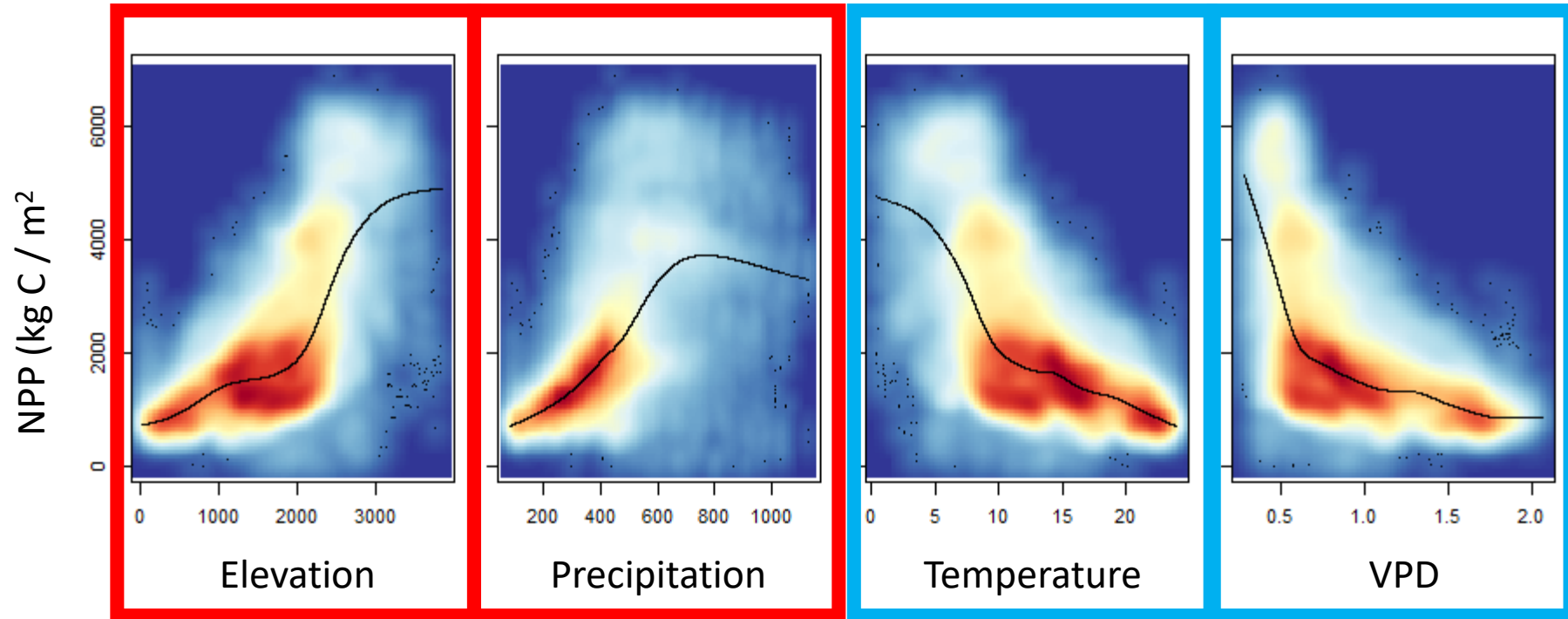


Precip, Temp and VPD *across* elevation



- Precip tends to increase with elevation (positive relationship) but wide variability
- Temp and VPD have a strong negative relationship with elevation

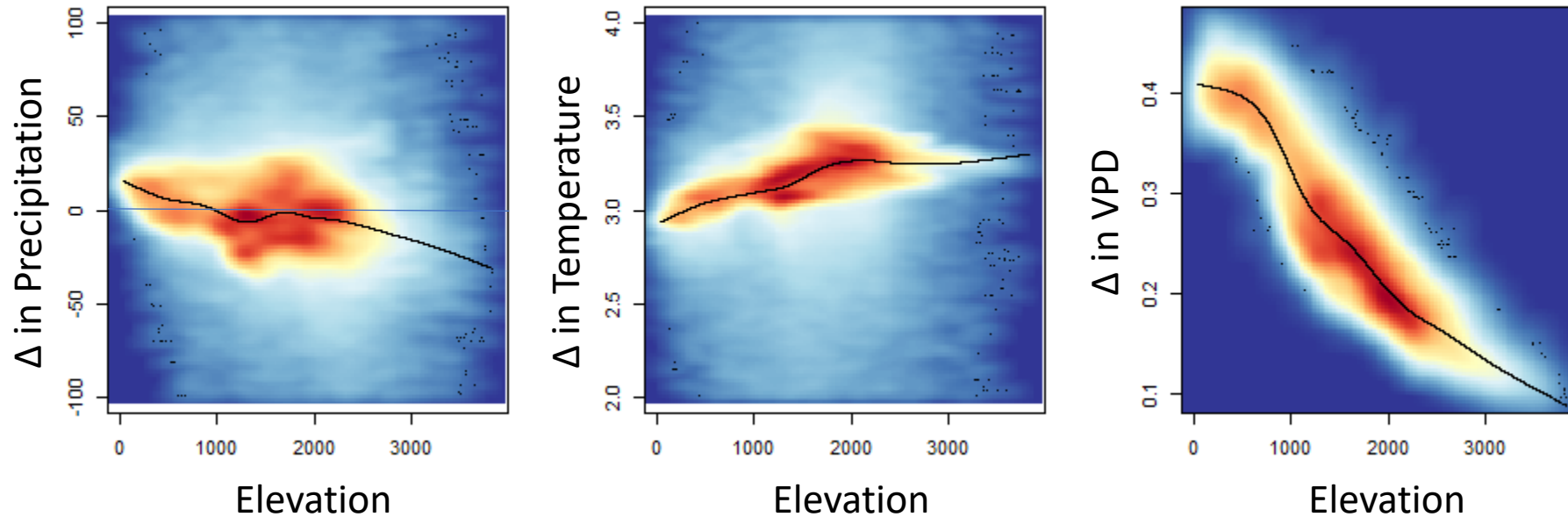
Net Primary Prod across Precip, Temp and VPD



- Elevation and Precip need to have a positive relationship with NPP
- Temp and VPD have a negative relationship with NPP

Projected changes in climate are variable across the elevation gradient

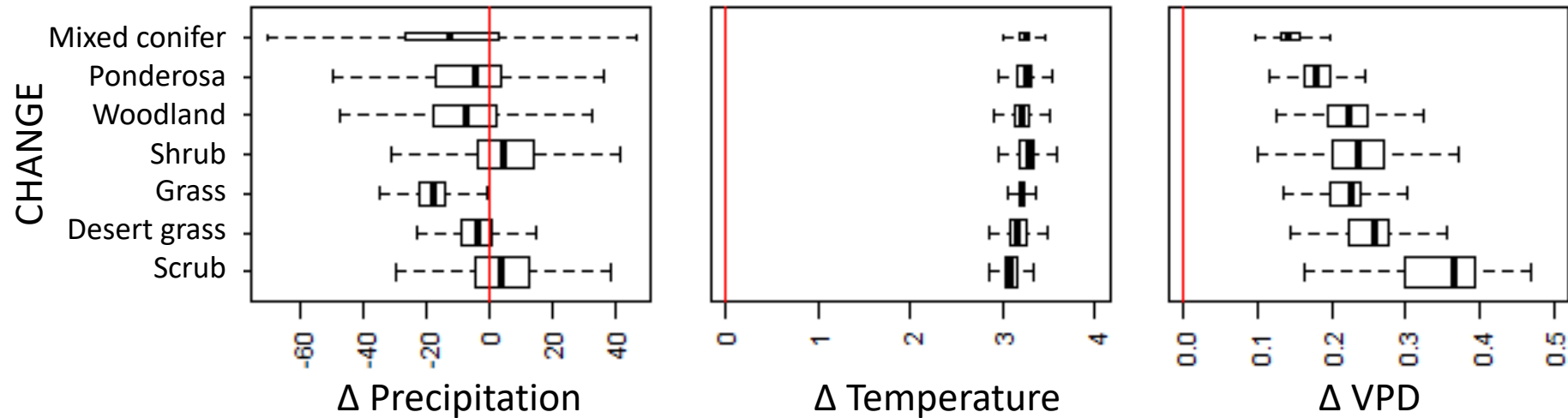
- RCP 8.5 scenario, 2040-2069 vs. 1981-2010



- Precip change has lots of variation, but lower elevations get slightly more precip; higher elevations slightly less
- Temp change is more consistent with 3 to 3.5 degree increase
- VPD change has a negative relationship with elevation

Projected changes by vegetation class

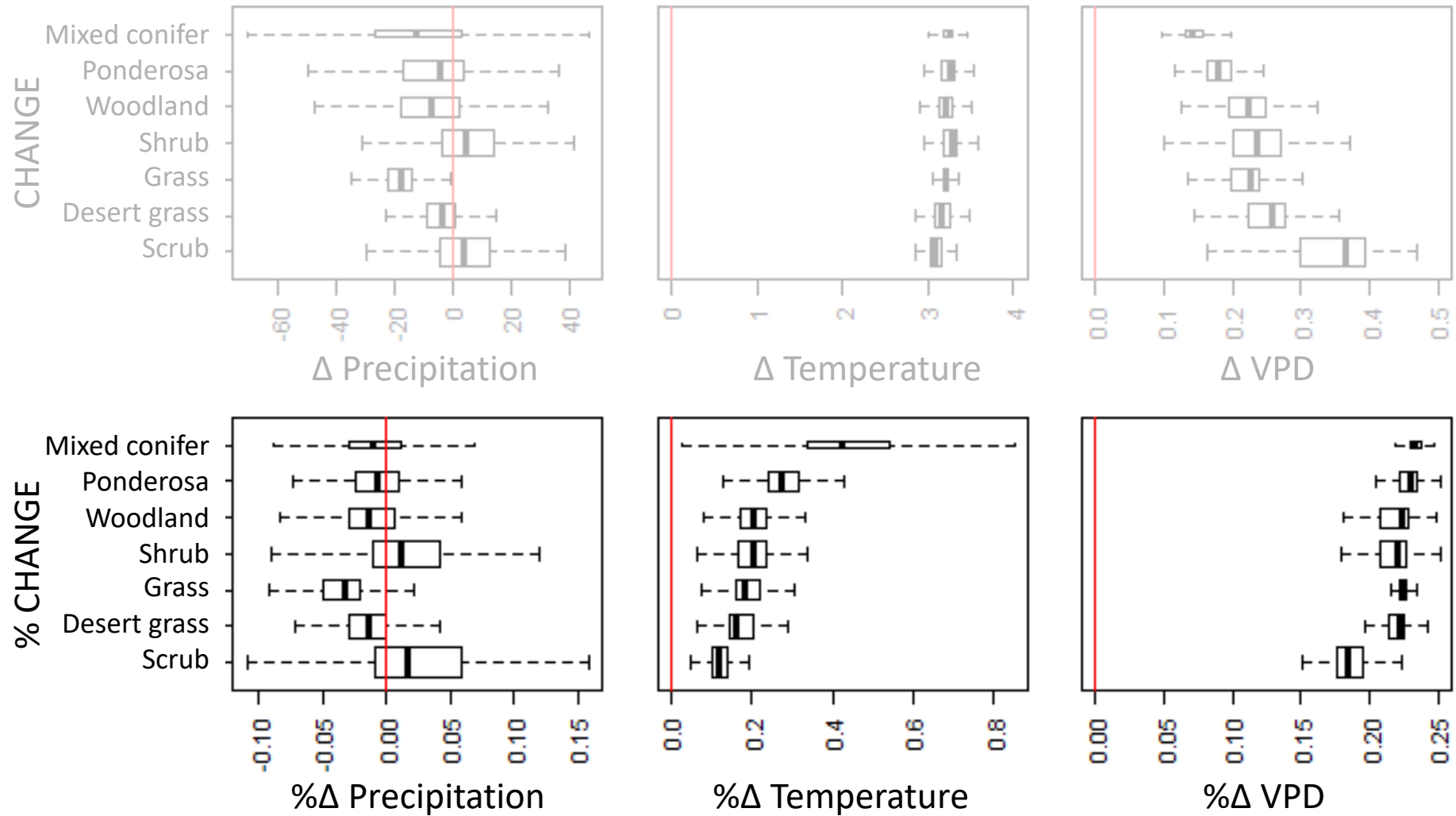
RCP 8.5 scenario, 2040-2069 vs. 1981-2010



- Precip change varies across vegetation
- Temp change is consistent across the classes
- VPD increases the most in the lower elevation vegetation classes

Projected changes by vegetation class

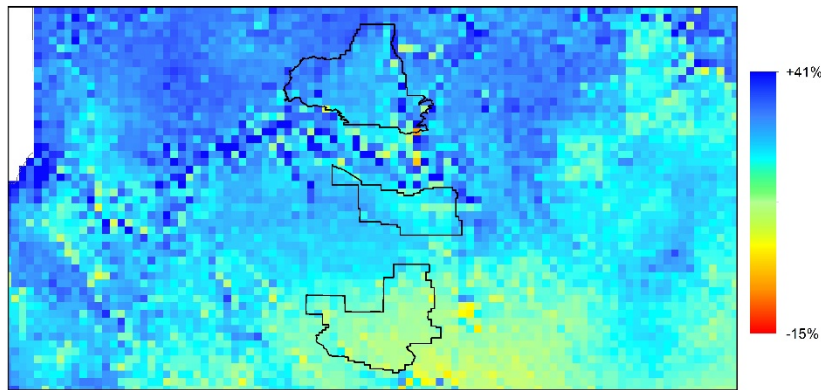
RCP 8.5 scenario, 2040-2069 vs. 1981-2010



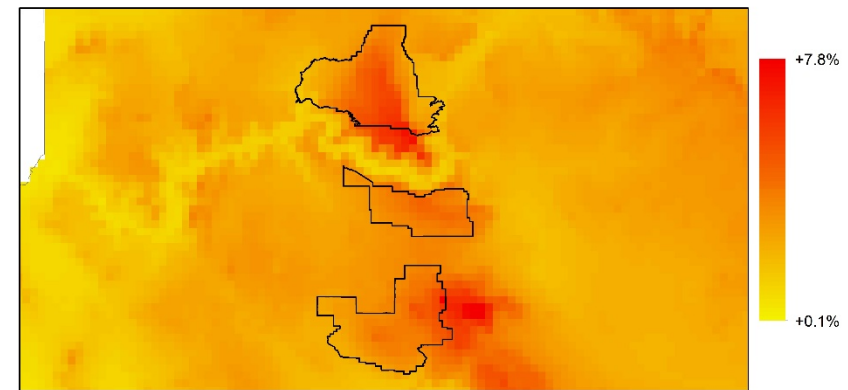
Projected % change in climate variables

RCP8.5, 1981-2010 to 2040-2069

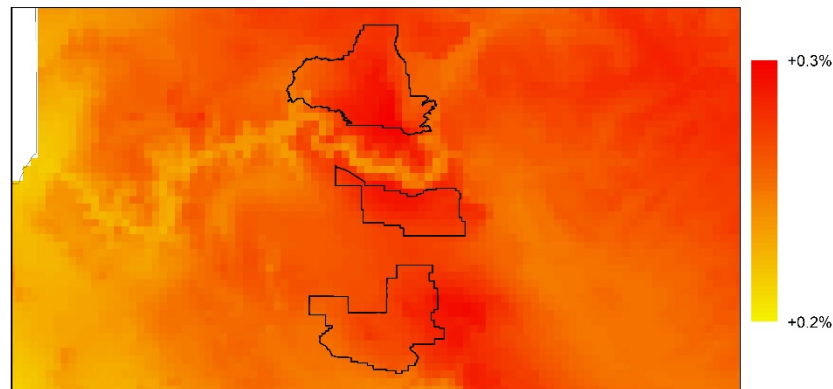
Precipitation



Temperature



VPD

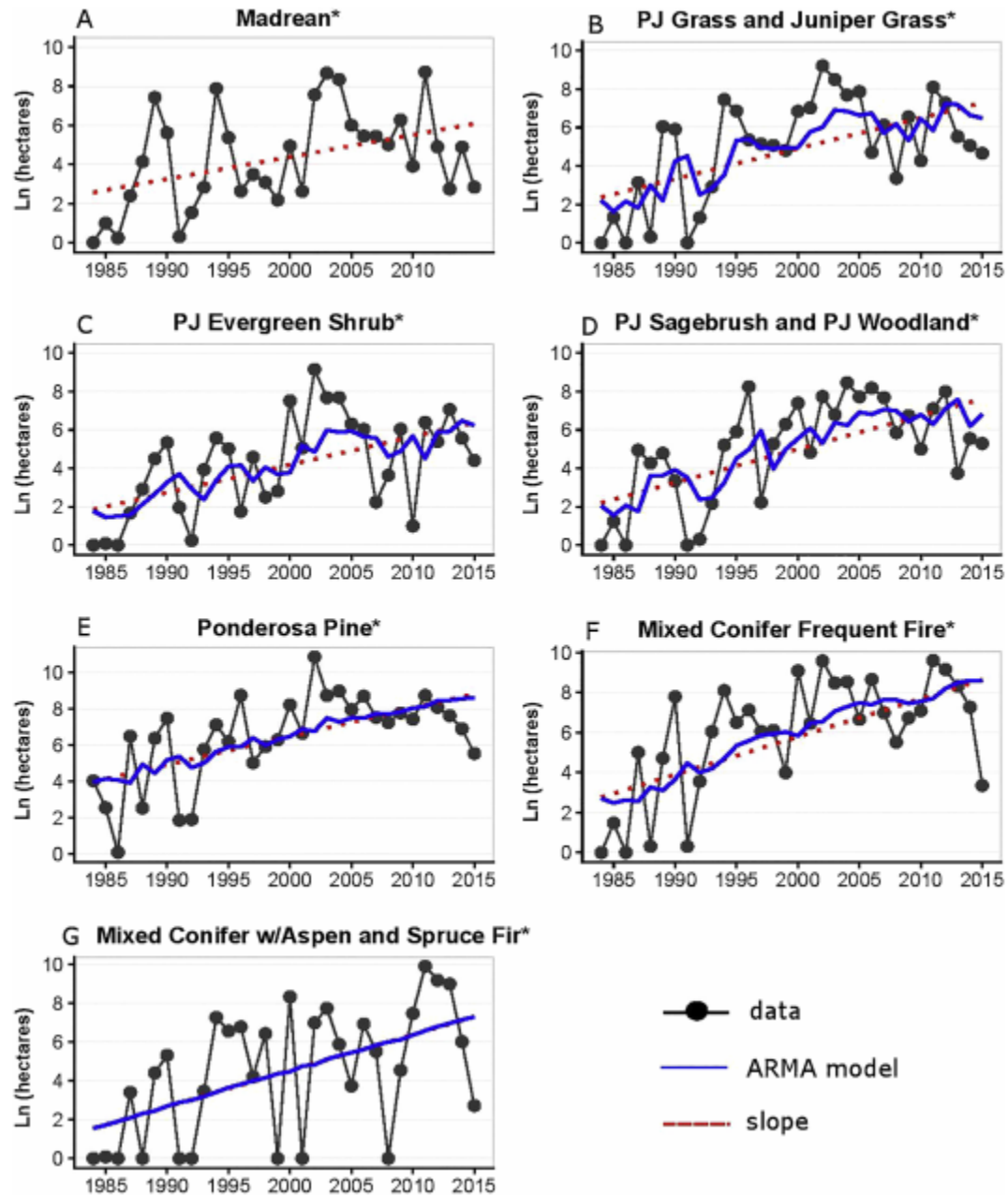


Data from MACA; Abatzoglou and Brown 2011

Conclusions

- Some thoughts
 - Lowest elevations: greatest absolute change
 - Highest elevations: greatest % change
 - Some parts of the gradient have tighter relationships- no wiggle room?
 - Other places on the gradient have wide variability- room for flexibility?
 - If more precip in low-elevation places: they stop being fuels limited
 - If higher temps in high-elevation places: they stop being flammability limited
- Place-based analyses are critical; incorporate feedbacks
- Question: At what scale can we safely generalize about trends and forecasts?

Burn Severity is Increasing Across the Southwest (1984-2013)



Forest Ecology and Management 433 (2019) 709–719



Contents lists available at ScienceDirect

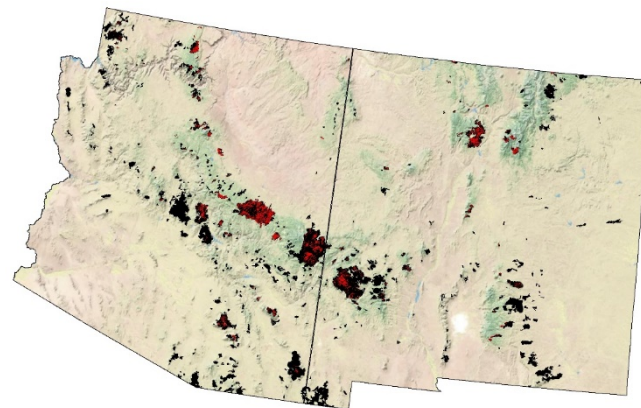
Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco



Increasing trends in high-severity fire in the southwestern USA from 1984 to 2015

Megan P. Singleton^{a,*}, Andrea E. Thode^a, Andrew J. Sánchez Meador^a, Jose M. Iniguez^b





Contents lists available at [ScienceDirect](#)

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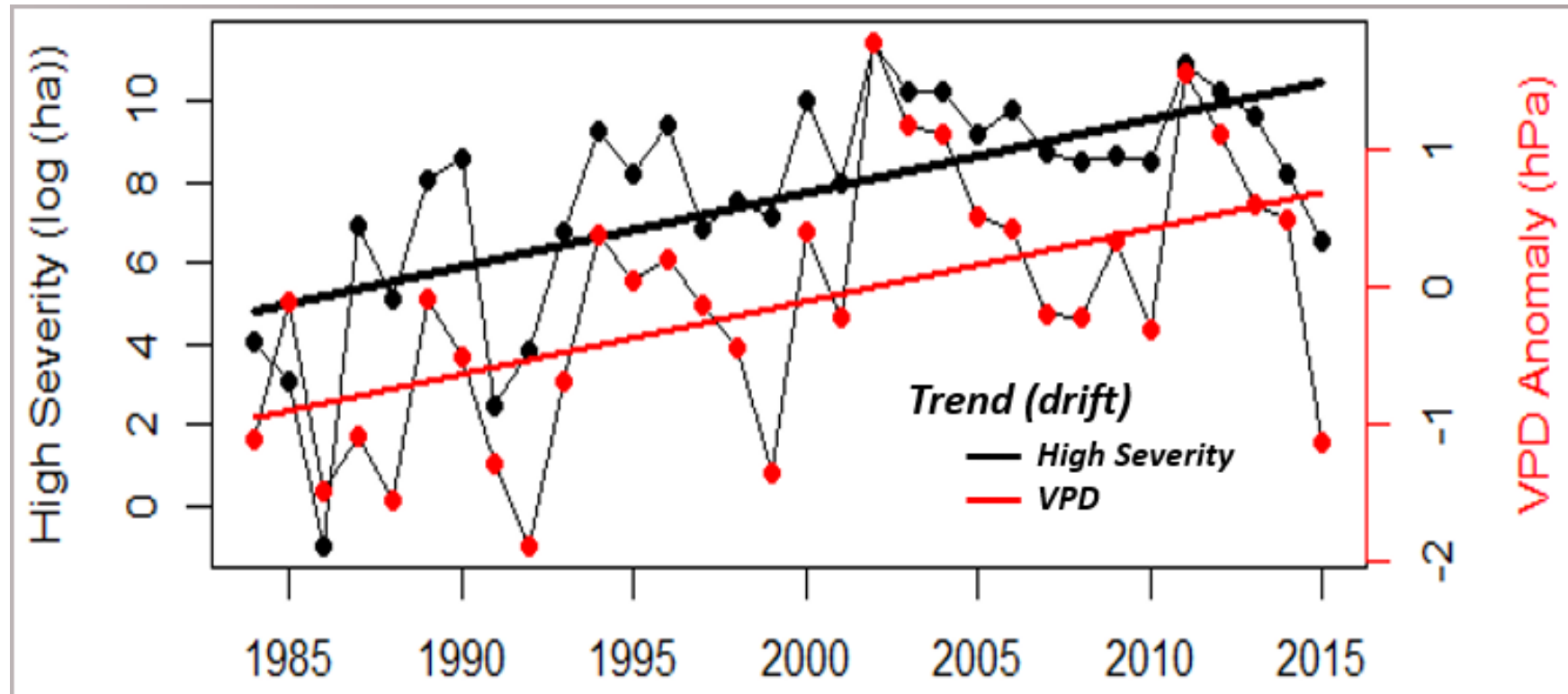


Climate relationships with increasing wildfire in the southwestern US from 1984 to 2015



Stephanie E. Mueller^{a,*}, Andrea E. Thode^a, Ellis Q. Margolis^b, Larissa L. Yocom^c, Jesse D. Young^a, Jose M. Iniguez^d

Vapor Pressure Deficit during the fire season had a strong correlation to area of high severity fire from 1984-2015



Significant Structural Break in 2000...

means a significant increase in high severity area burned after 2000

