Using Landscape Models to Inform Climate Adaptation Strategies in the Southwest

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Southwest FireCLiME

JOINT FIRE SCIENCE PROGRAM

Adaptation Strategies

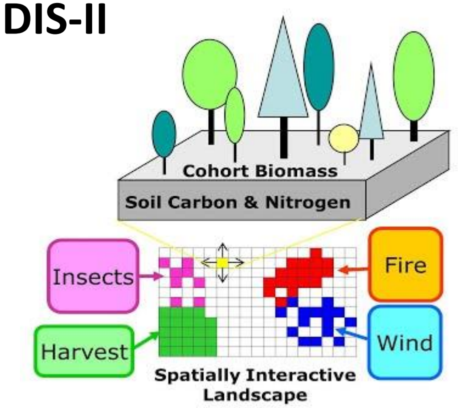
Swanston et al. 2016; Millar et al. 2007

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

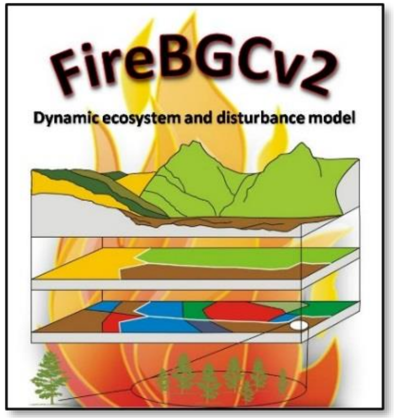
LANDIS-II and *FireBGCv2*: Forest Landscape Simulation Models

- 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

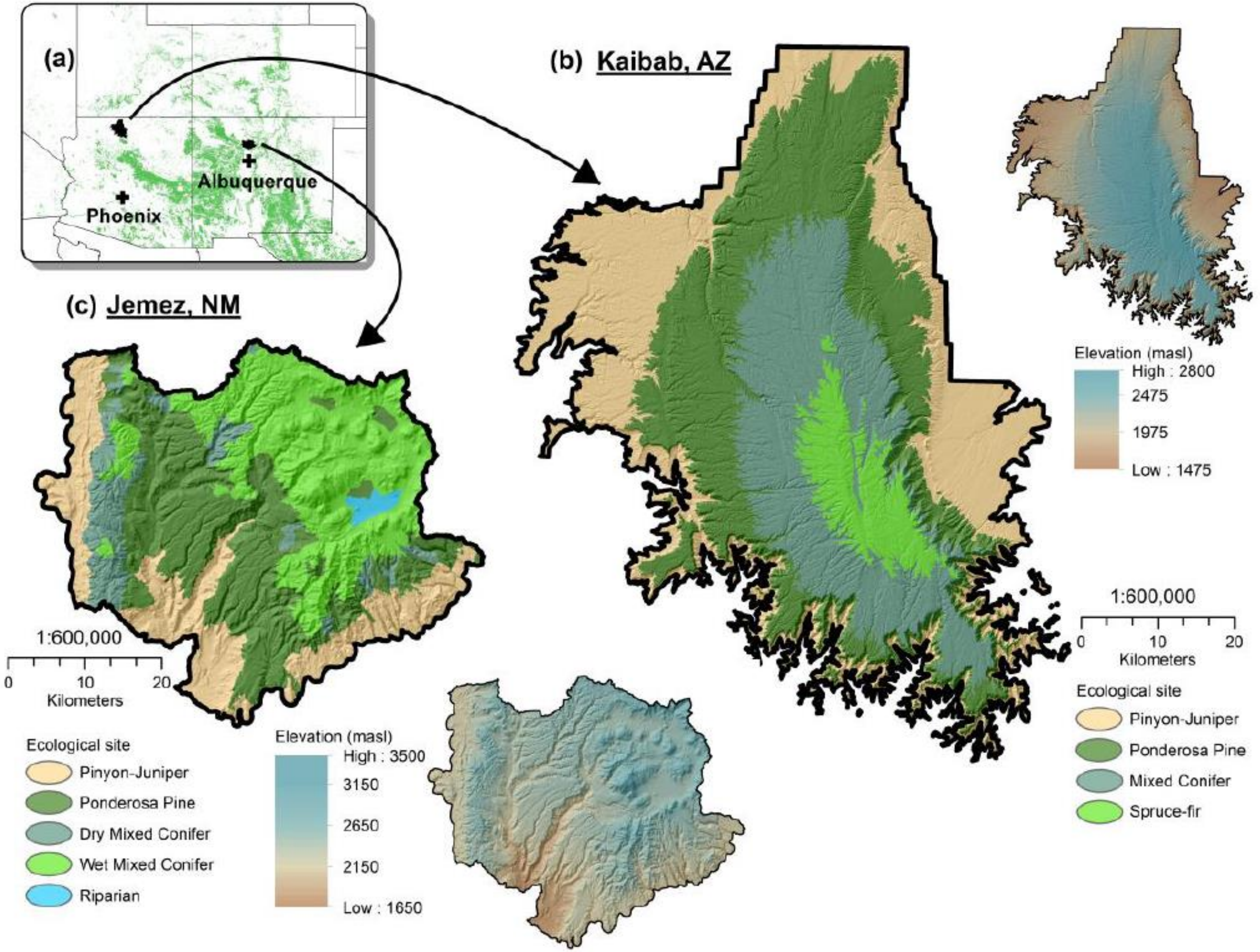


http://www.landis-ii.org/



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:

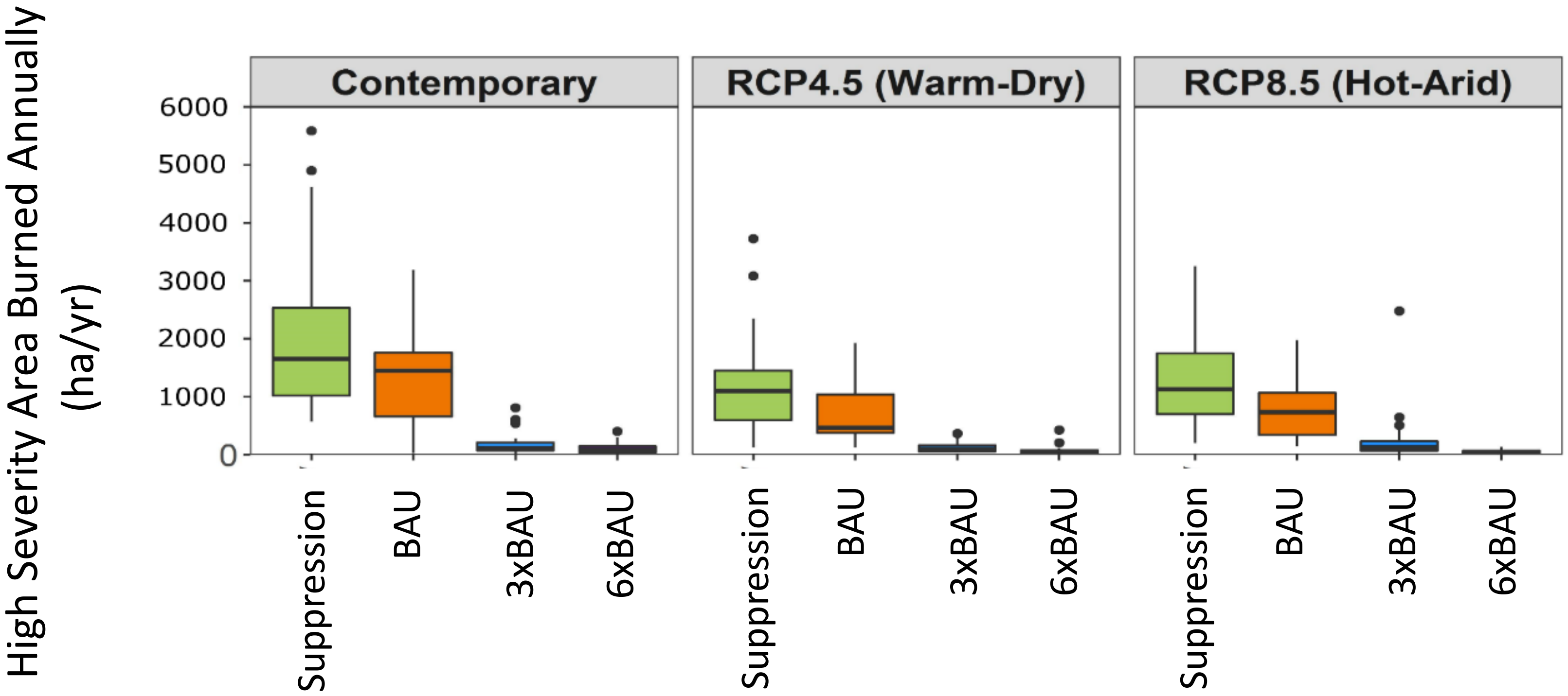
1. *Contemporary* - Instrumental weather (1960 - 1990)
2. *Warm, Semi-Dry* – CCSM4 GCM, RCP4.5 (1990-2090)
3. *Hot, Arid* – HADGEM2-ES GCM, RCP8.5 (1990-2090)

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

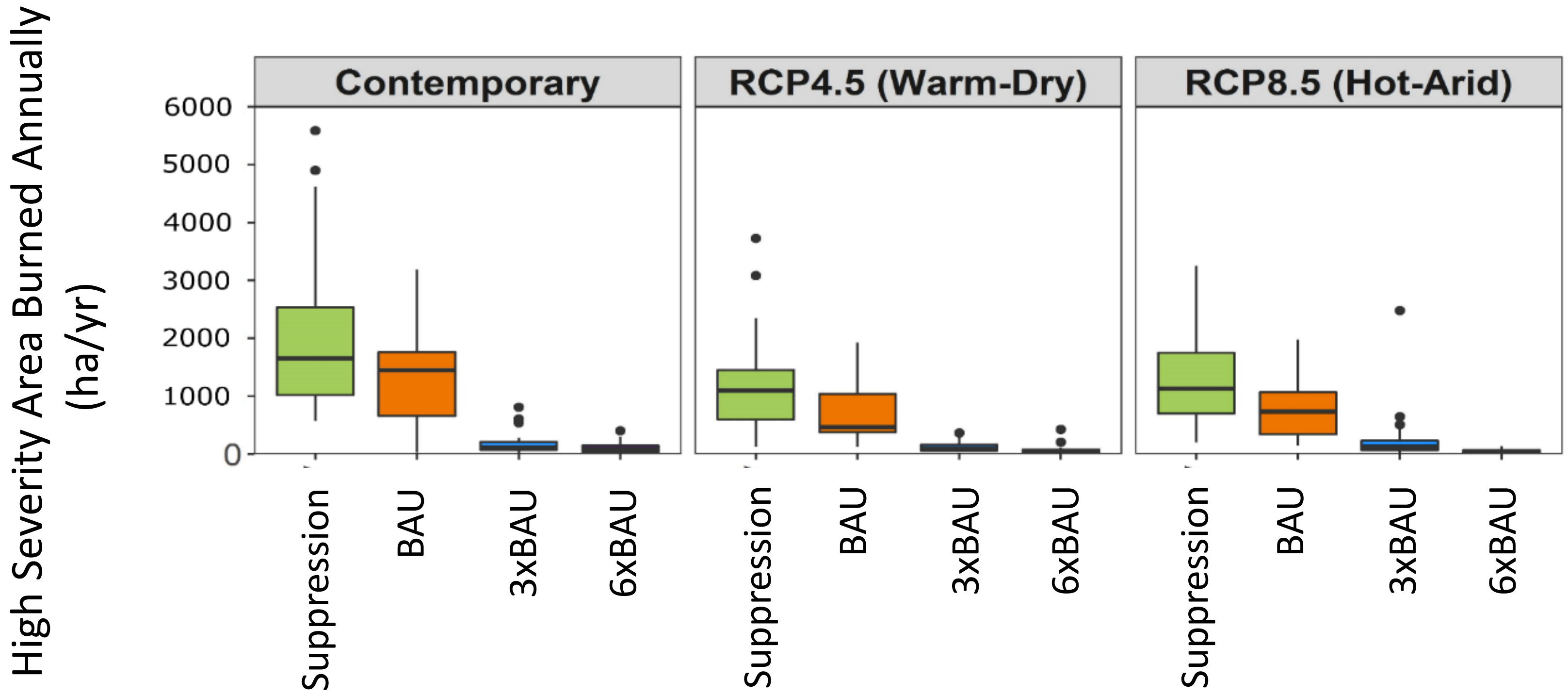
Includes Suppression Too (scenarios 2–4)

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



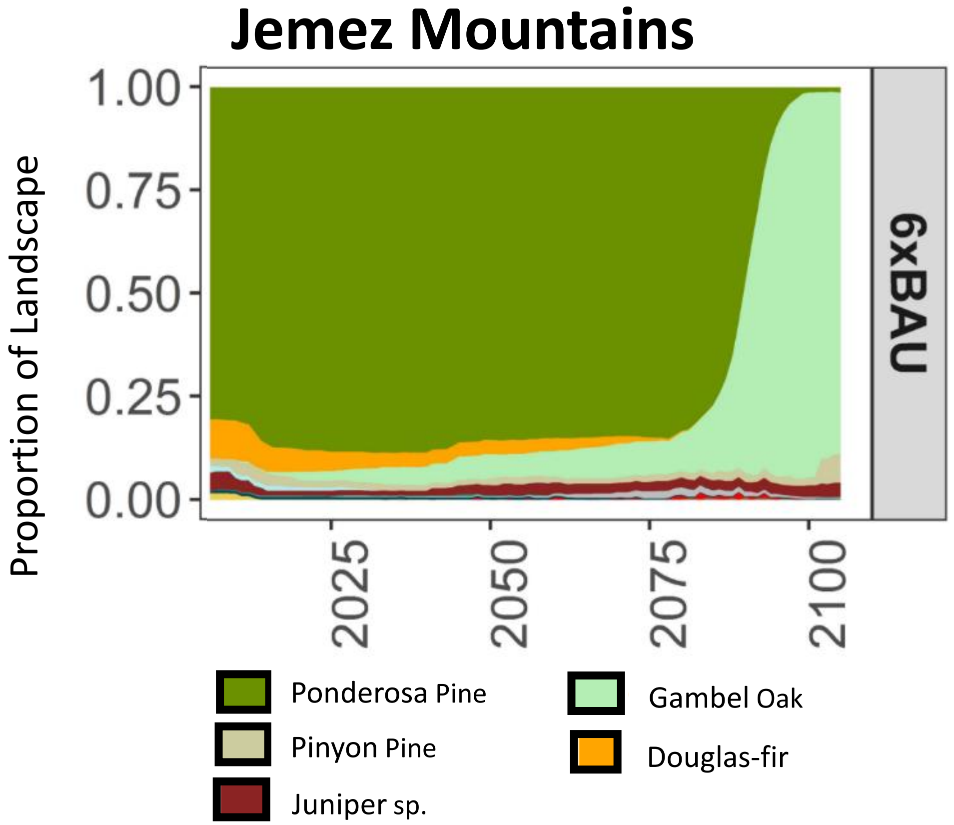
Resistance

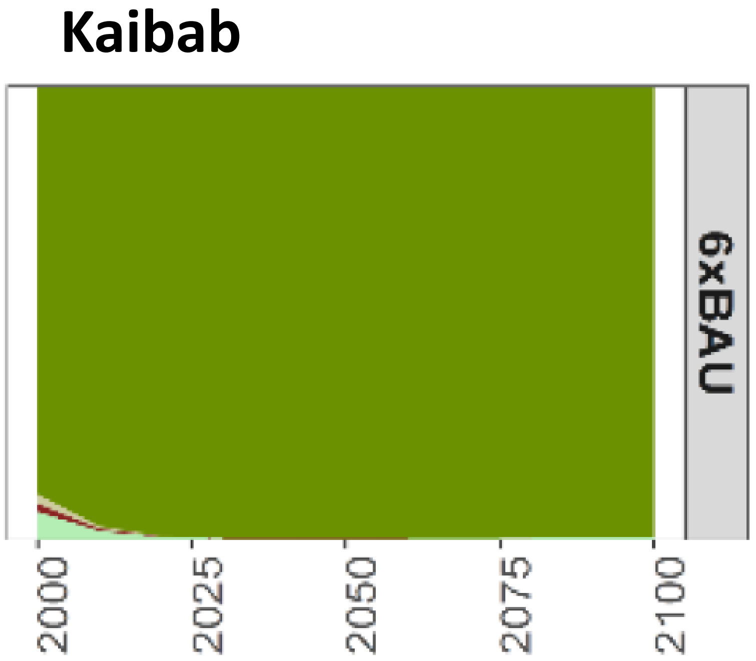
Resilience

Transition

- 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!!!

RCP 8.5, 6XBAU, ***Ponderosa Pine* Composition**



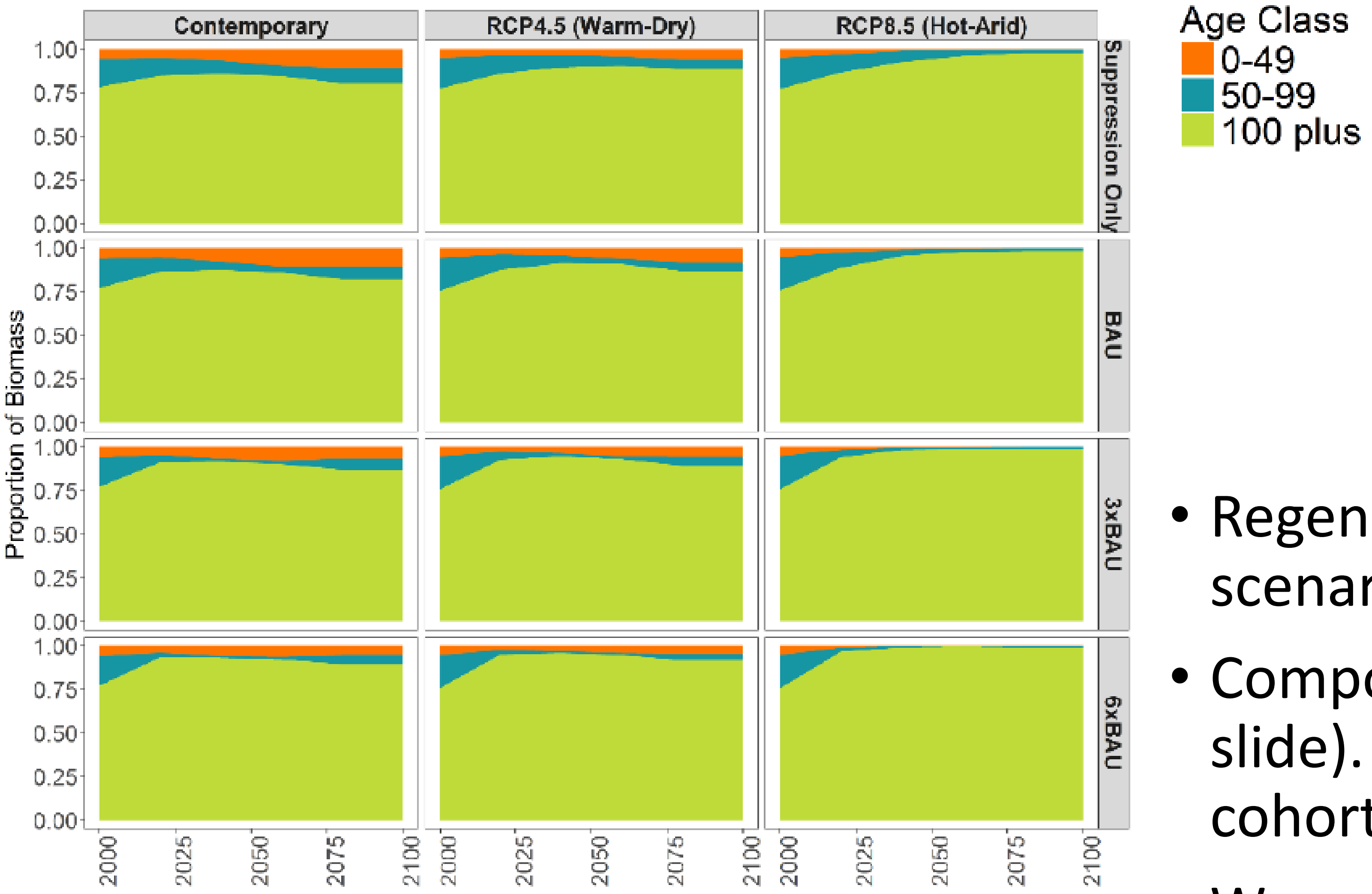


Resistance
Resilience
Transition

- Over longer time periods started to see pondo 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



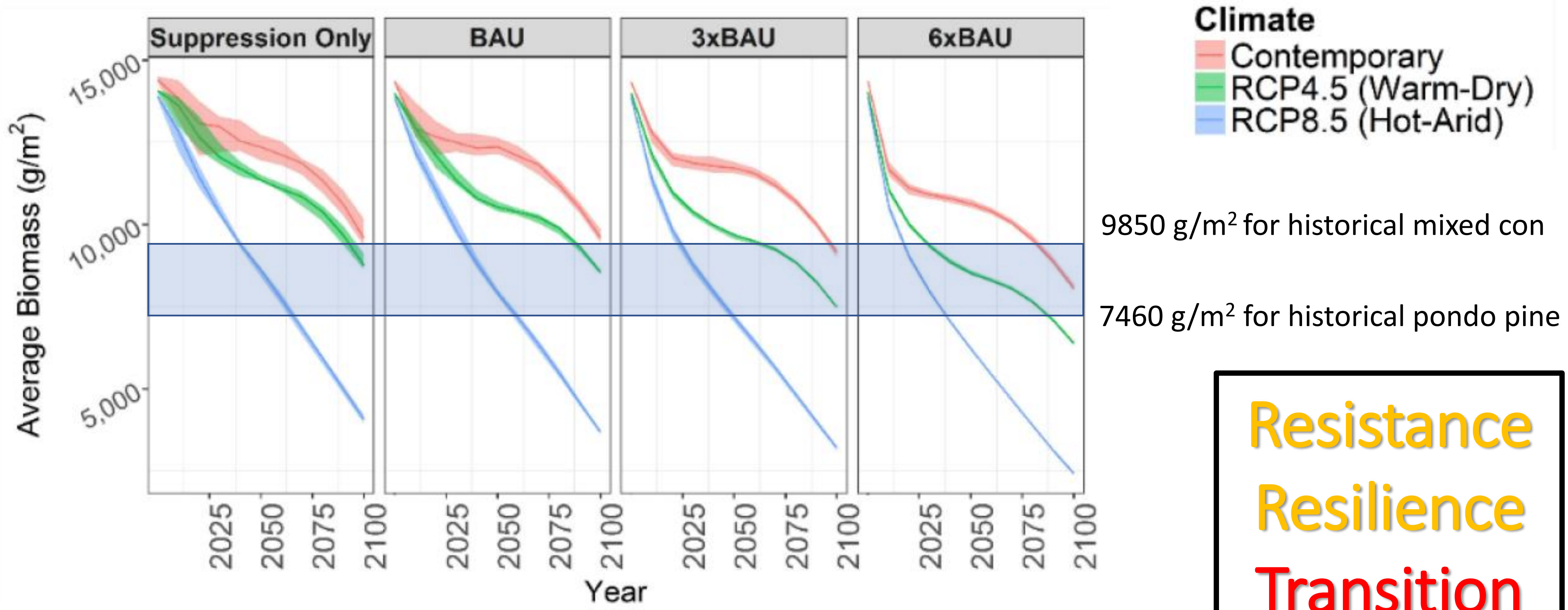
Resistance

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 pondo pine regeneration

Kaibab: mixed conifer and ponderosa pine biomass



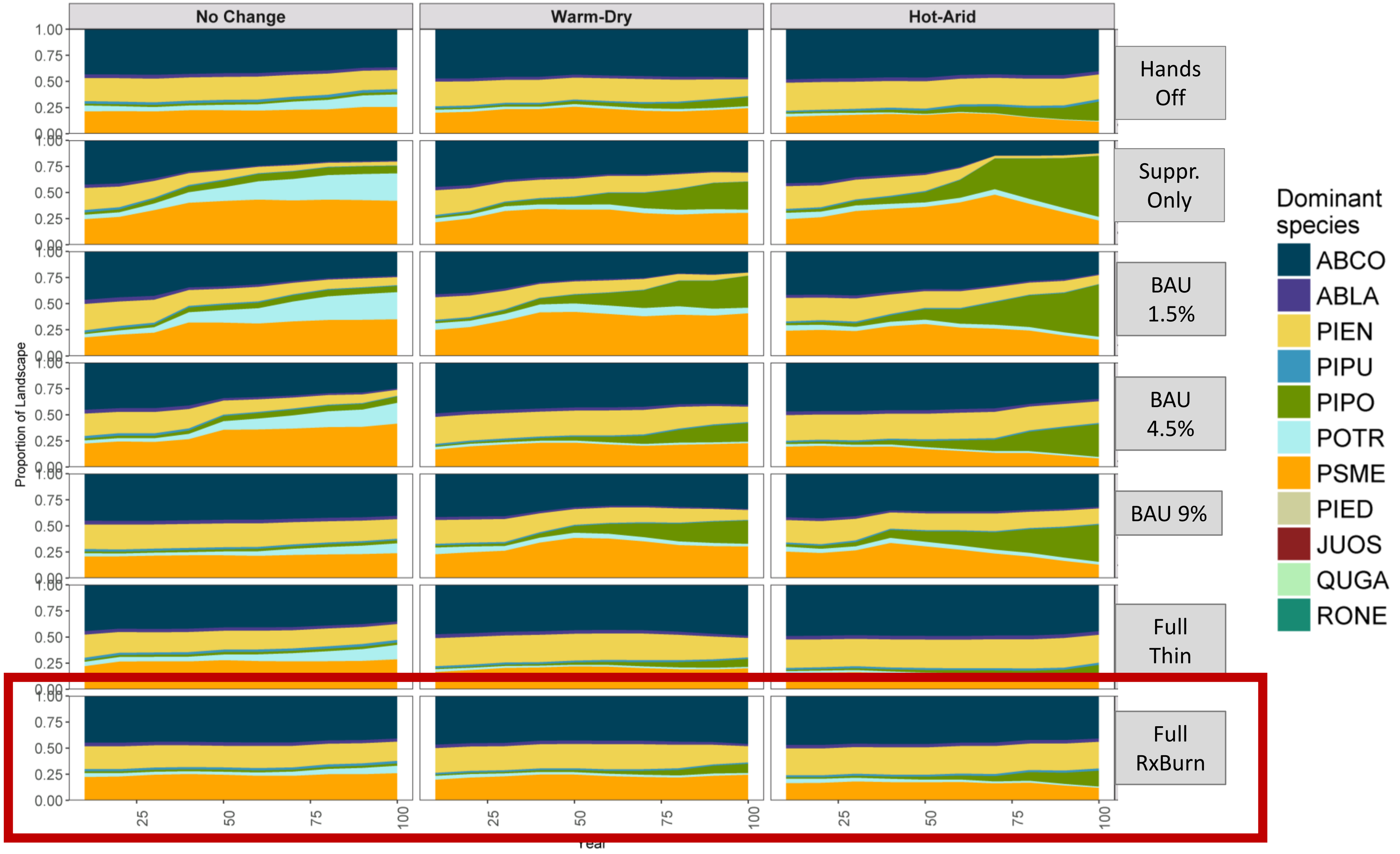
9850 g/m^2 for historical mixed con

7460 g/m^2 for historical pondo pine

Resistance
Resilience
Transition

- 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

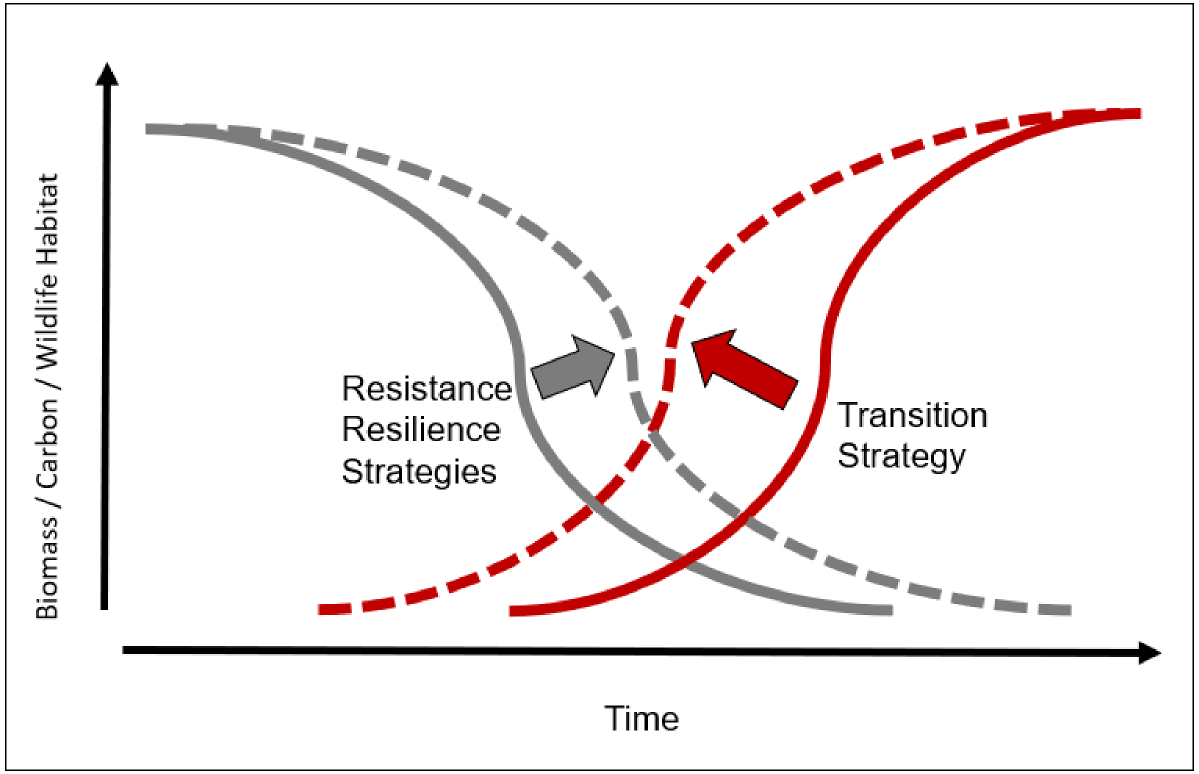
Kaibab Results: Spruce-Fir Species Composition



- 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

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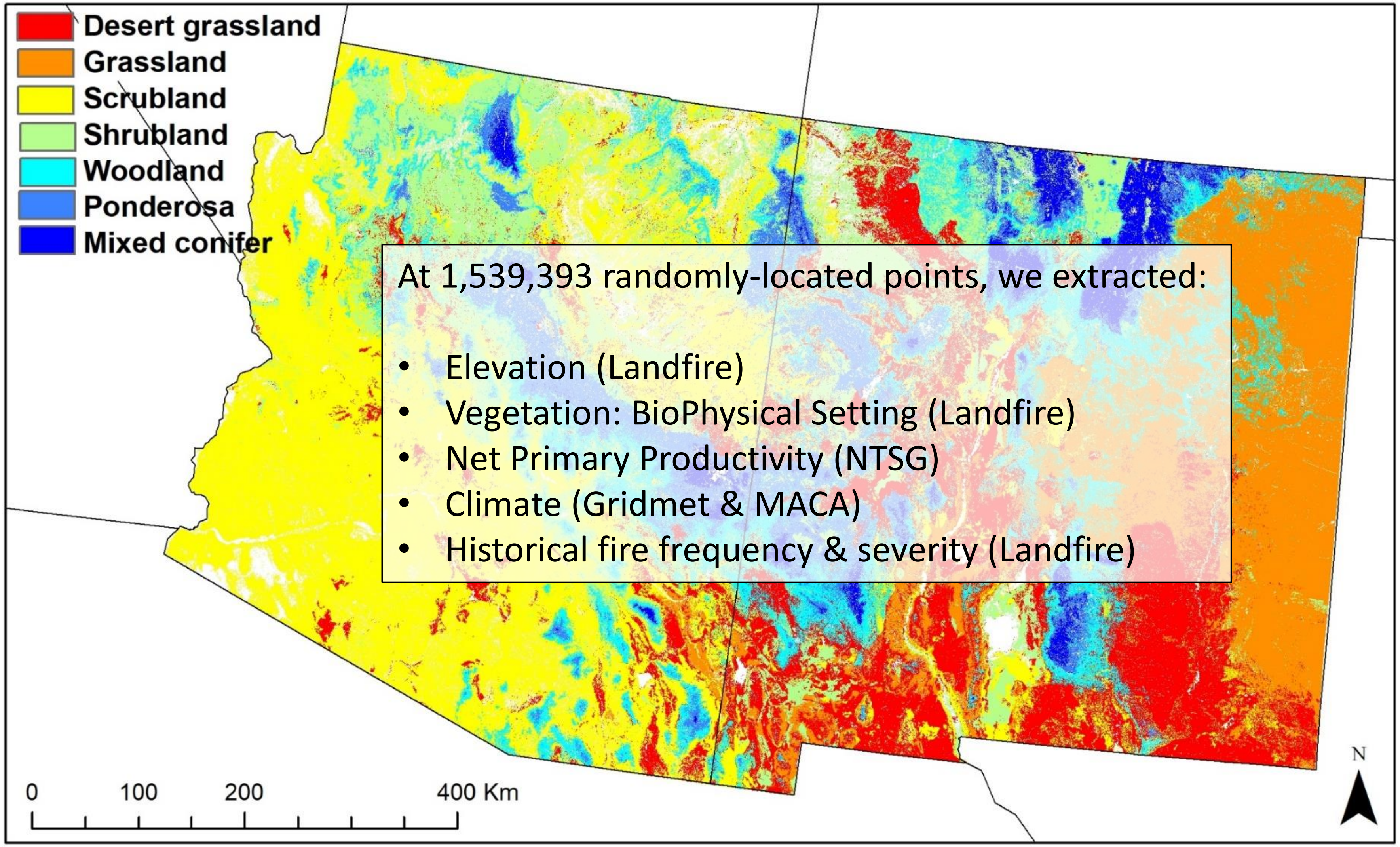
Windy Bunn
National Park Service

Shaula Hedwall
USFWS

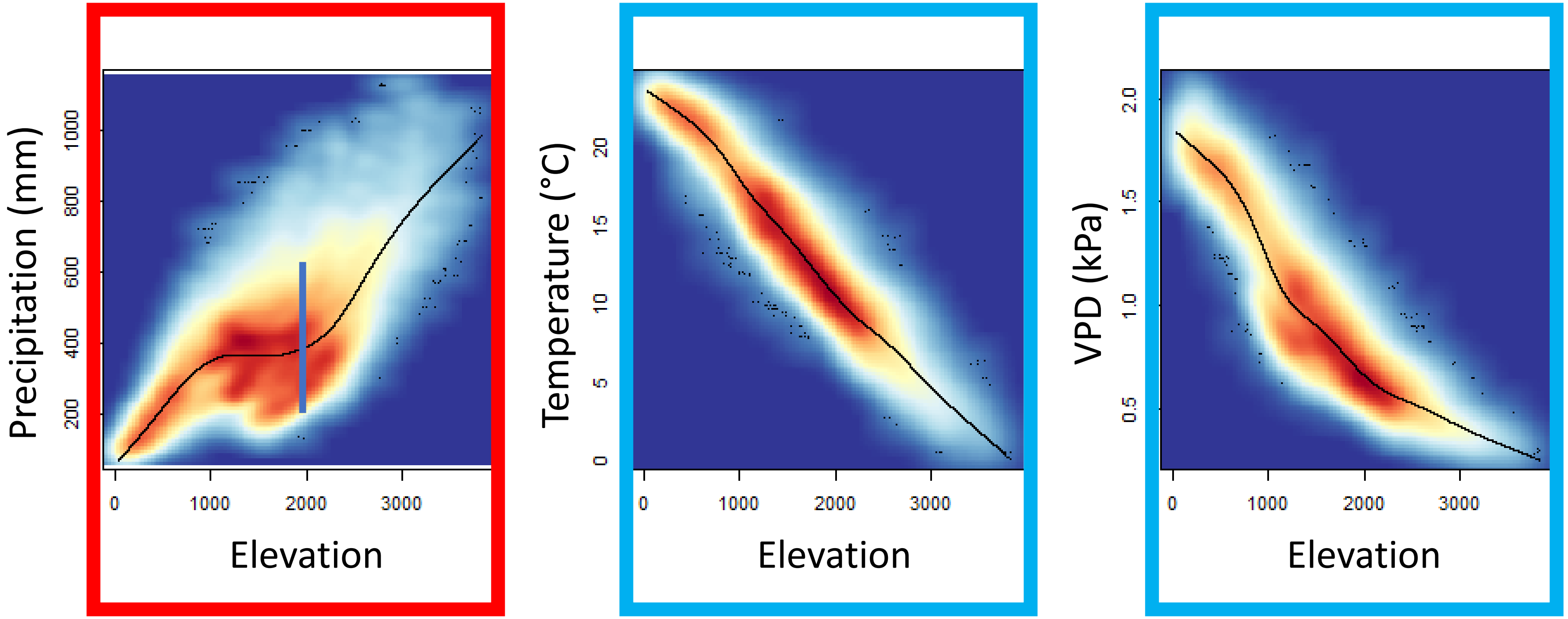
Study area



At 1,539,393 randomly-located points, we extracted:

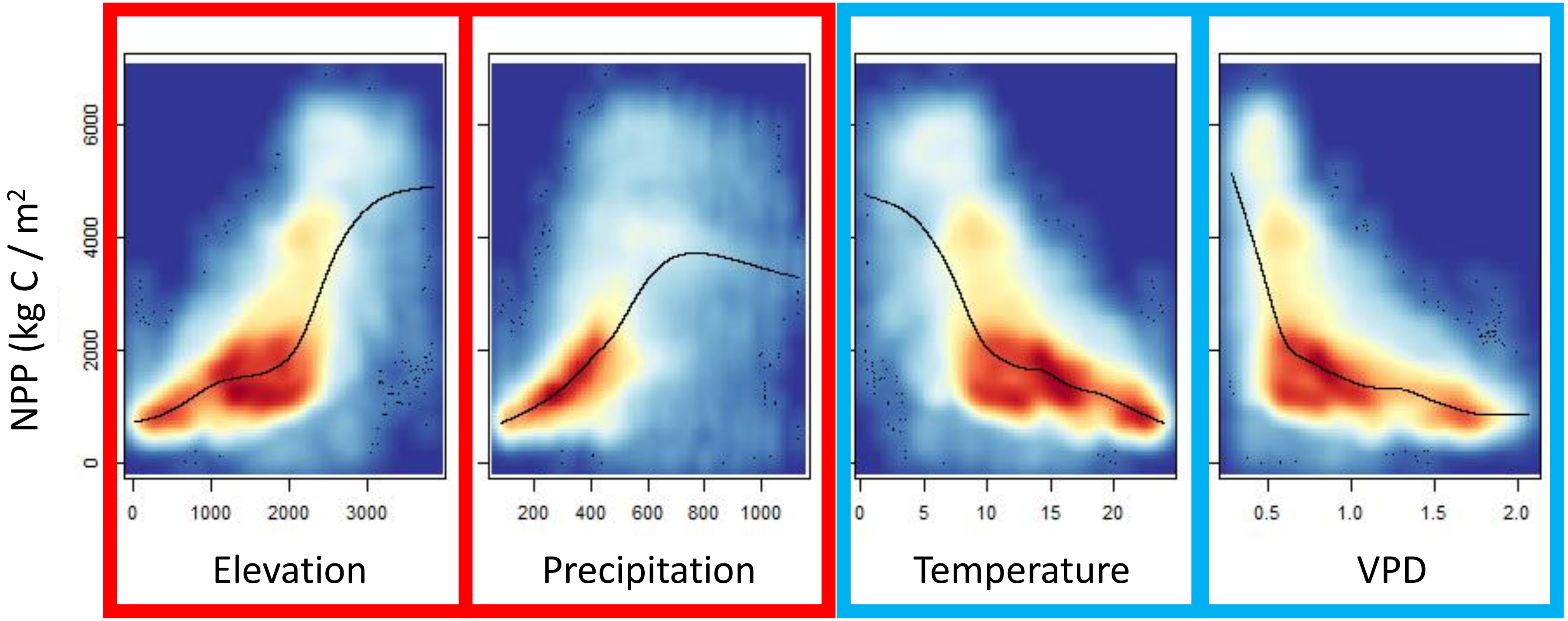
- Elevation (Landfire)
- Vegetation: BioPhysical Setting (Landfire)
- Net Primary Productivity (NTSG)
- Climate (Gridmet & MACA)
- Historical fire frequency & severity (Landfire)

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

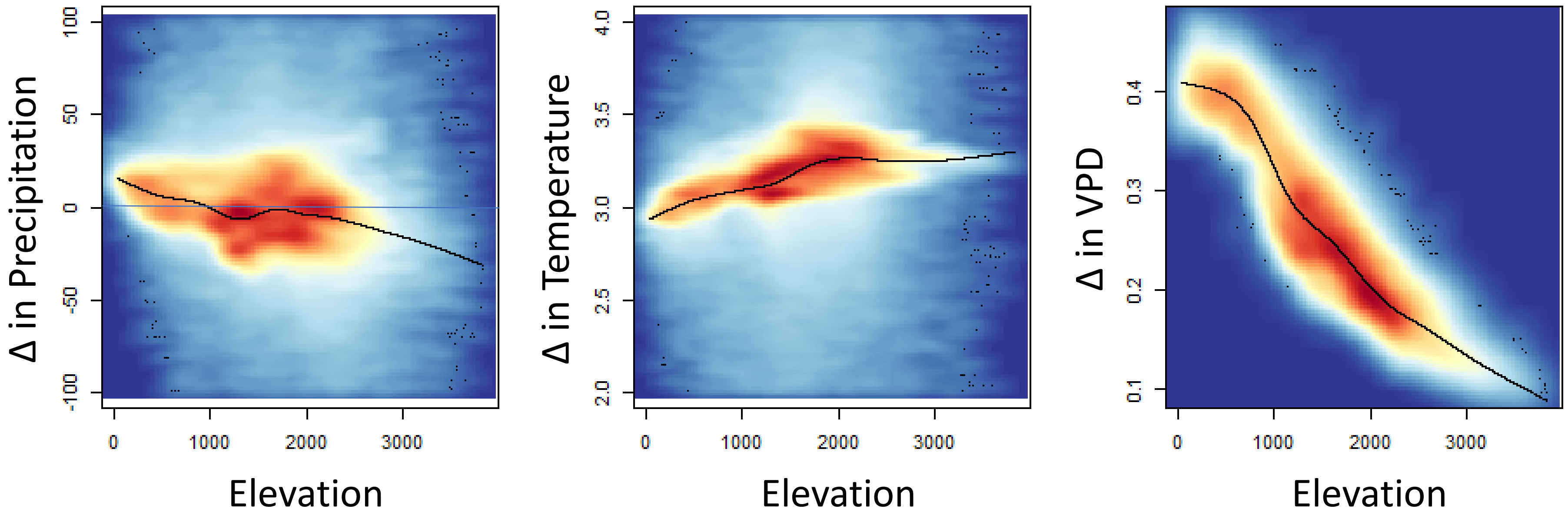
Net Primary Prod across Precip, Temp and VPD



- 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

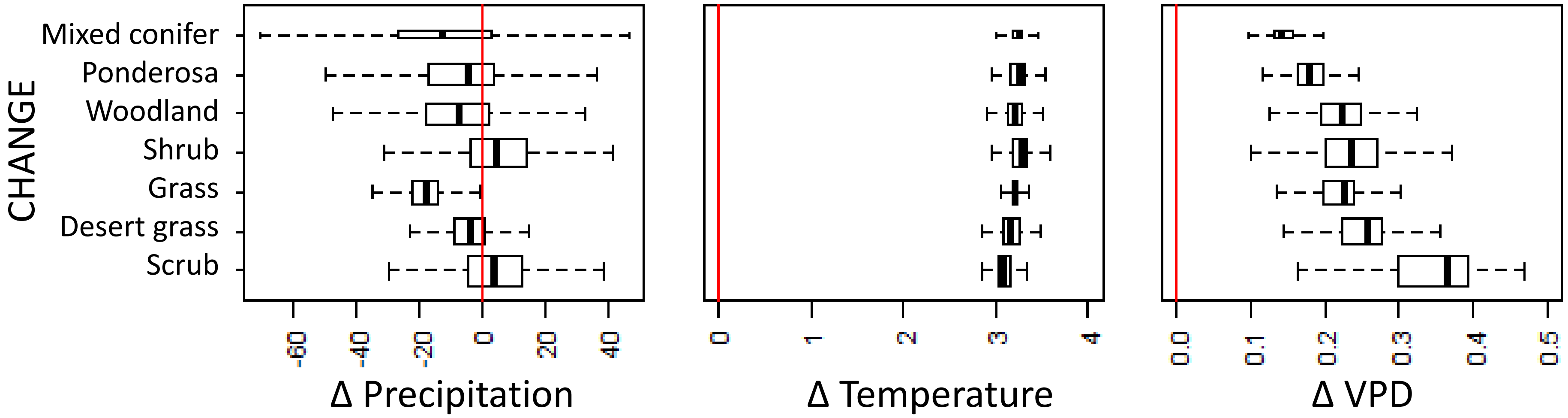
- RCP 8.5 scenario, 2040-2069 vs. 1981-2010



- 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

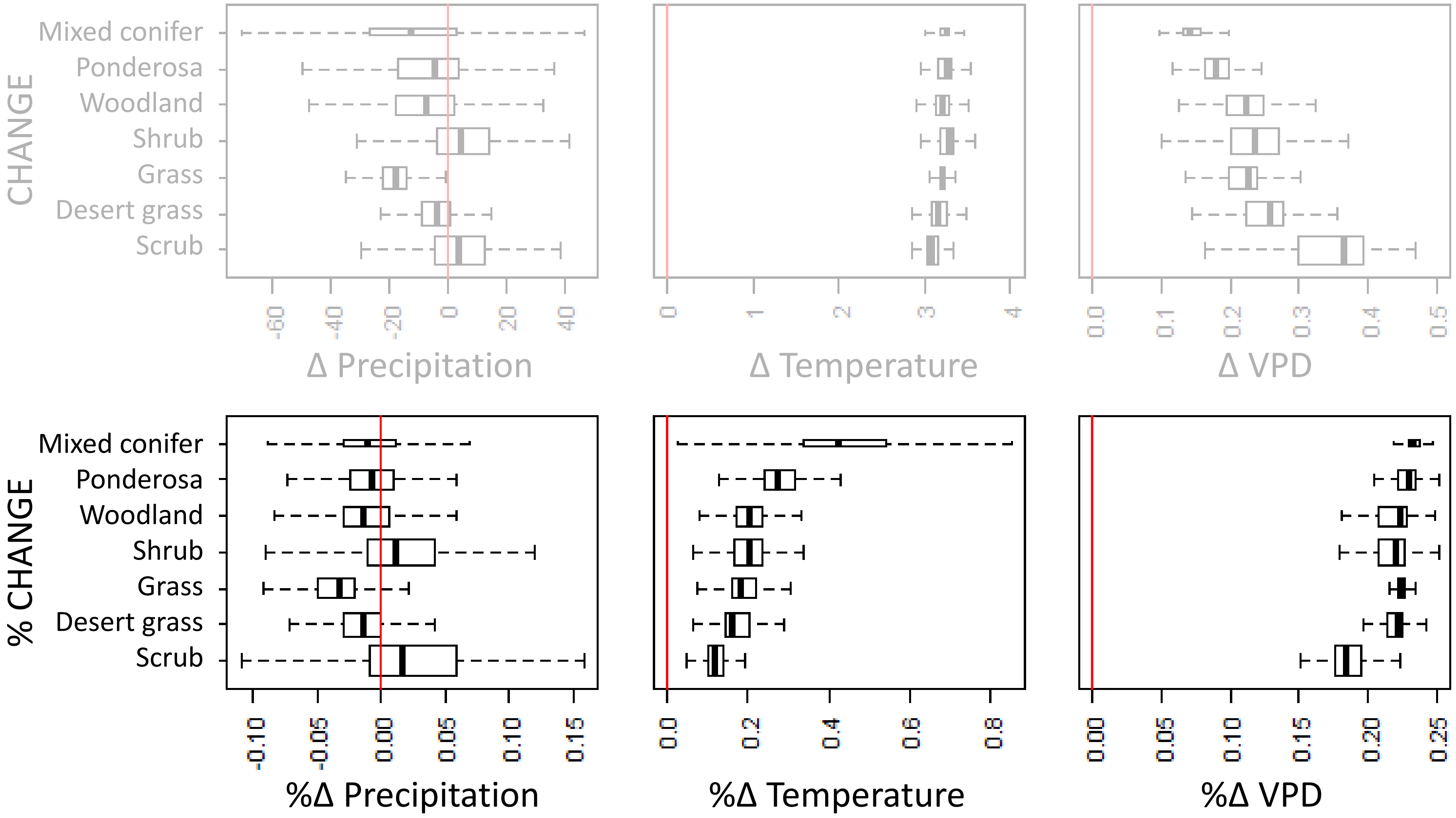
RCP 8.5 scenario, 2040-2069 vs. 1981-2010



- 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

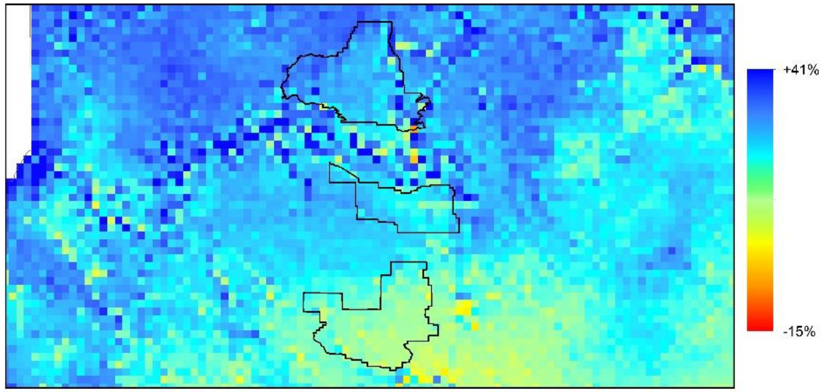
RCP 8.5 scenario, 2040-2069 vs. 1981-2010



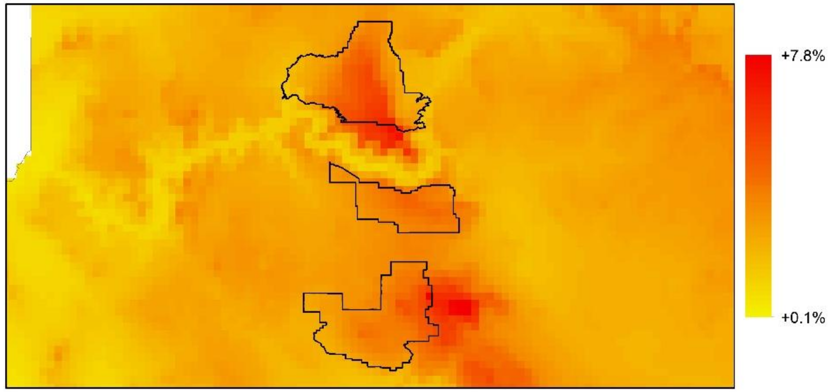
Projected % change in climate variables

RCP8.5, 1981-2010 to 2040-2069

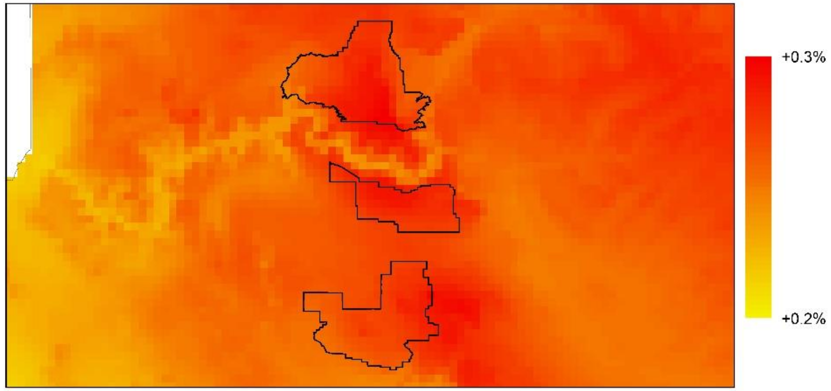
Precipitation



Temperature



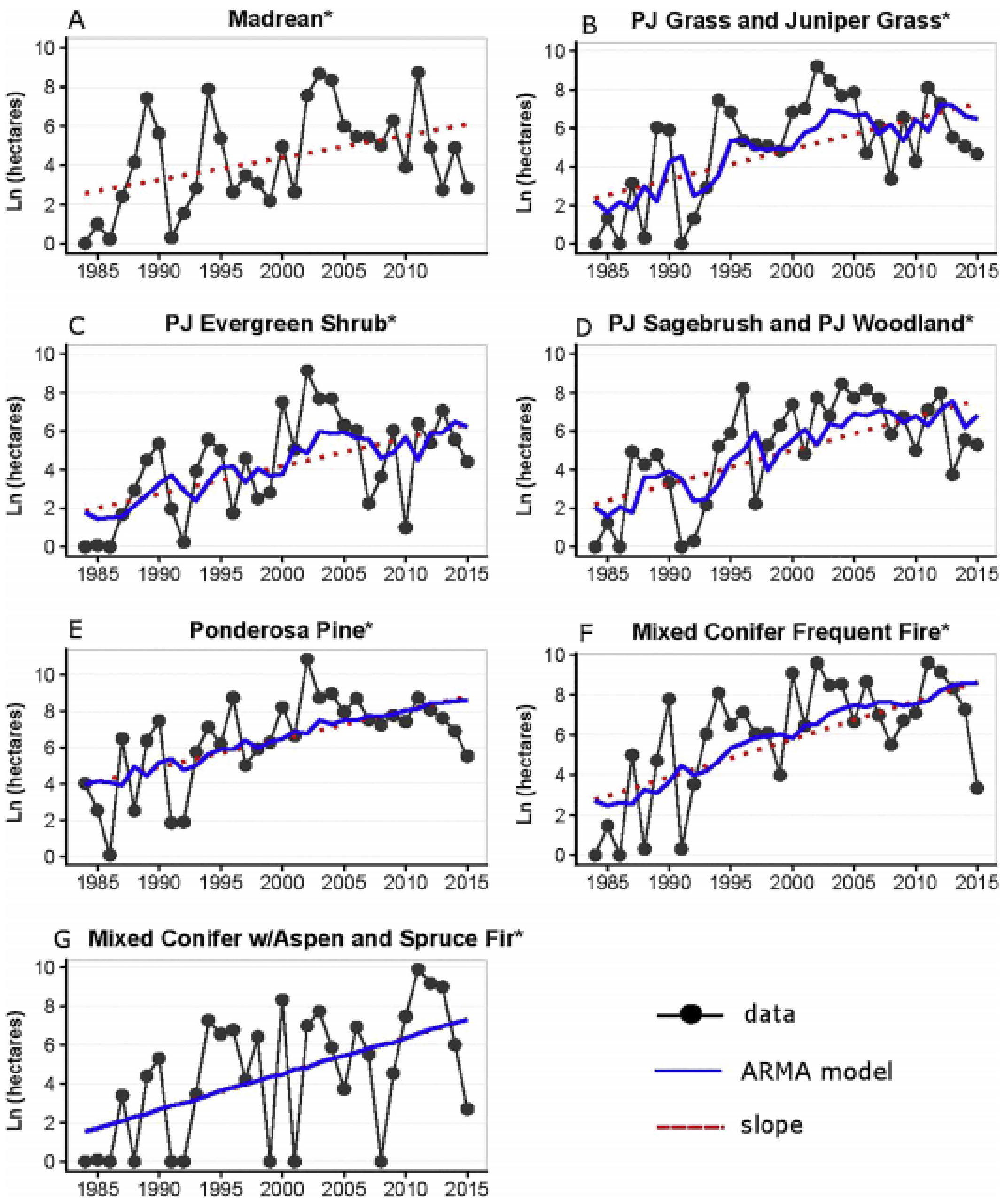
VPD



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

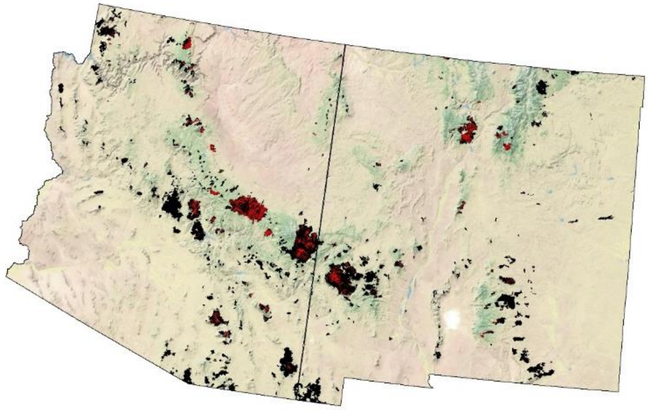
Contents lists available at ScienceDirect

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]



Forest Ecology and Management 460 (2020) 117861

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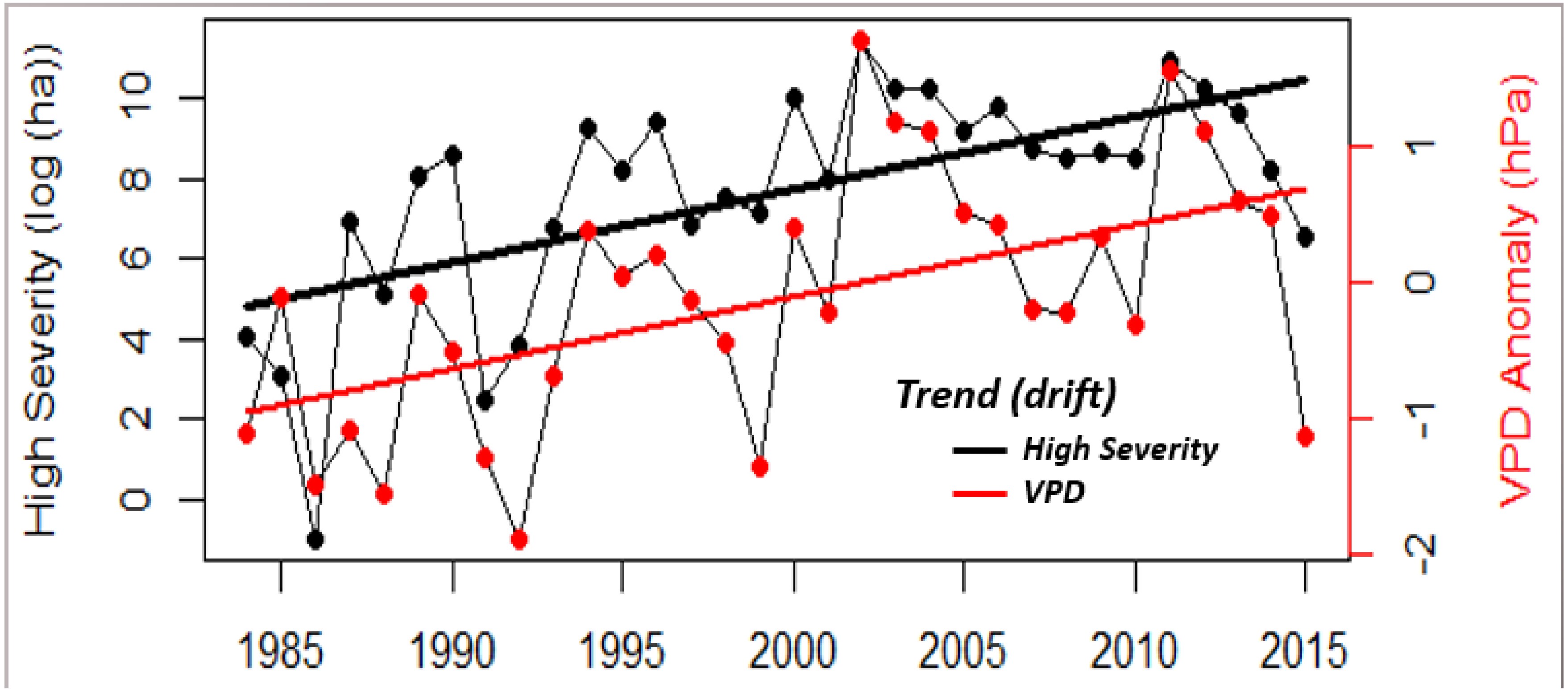
Climate relationships with increasing wildfire in the southwestern US from 1984 to 2015

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