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

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Fire regime controls: climate, ignitions, vegetation

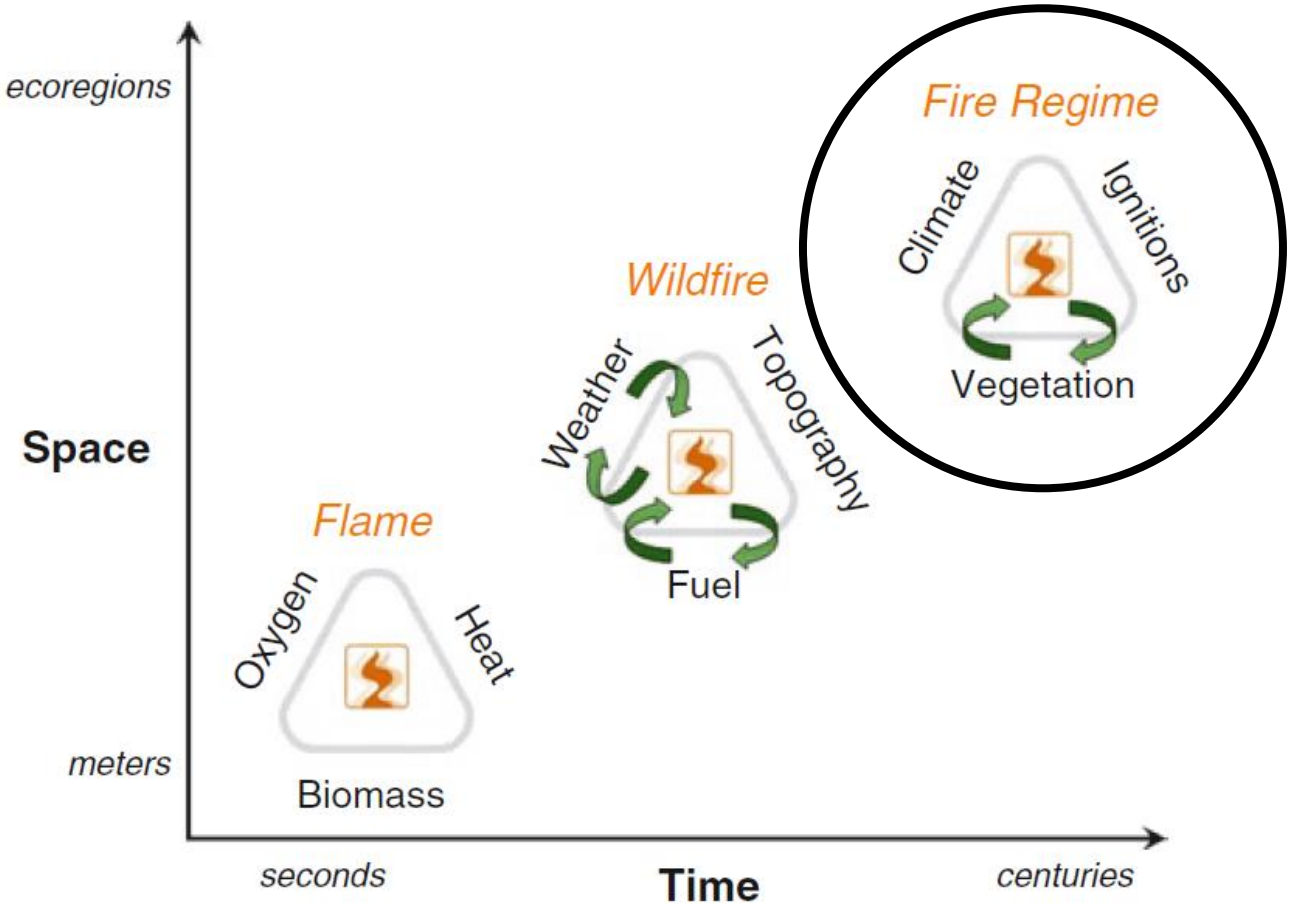
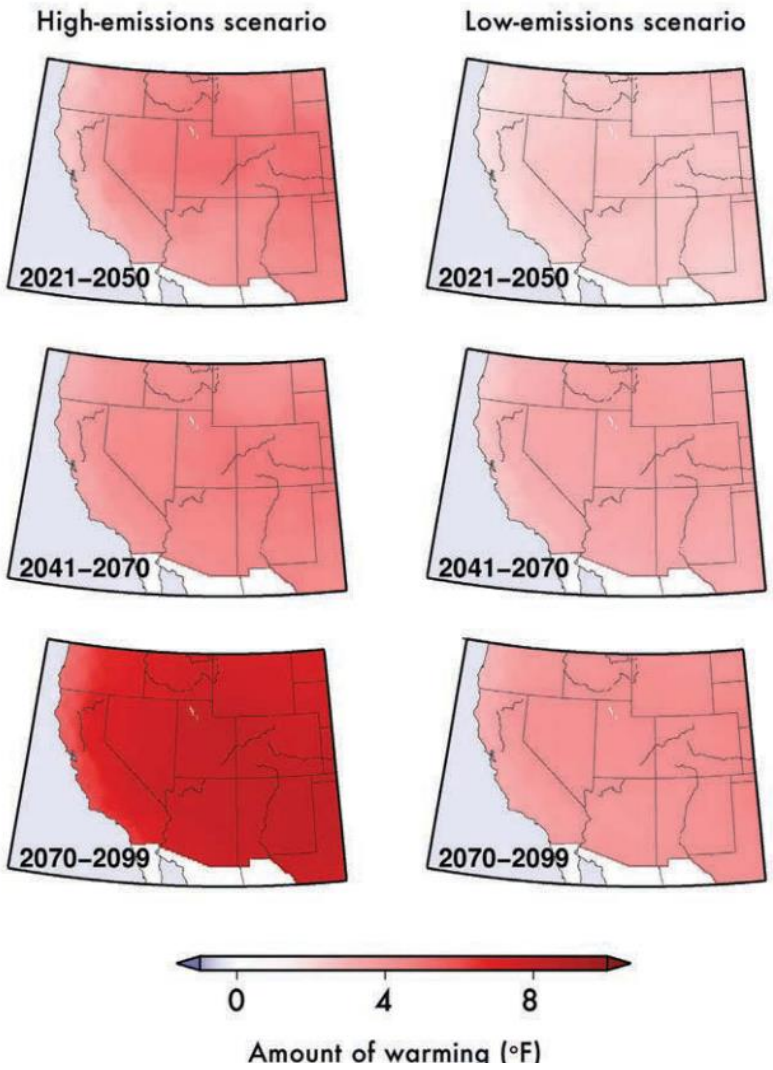


Figure: Moritz, Hessburg and Povak in McKenzie et al. 2011

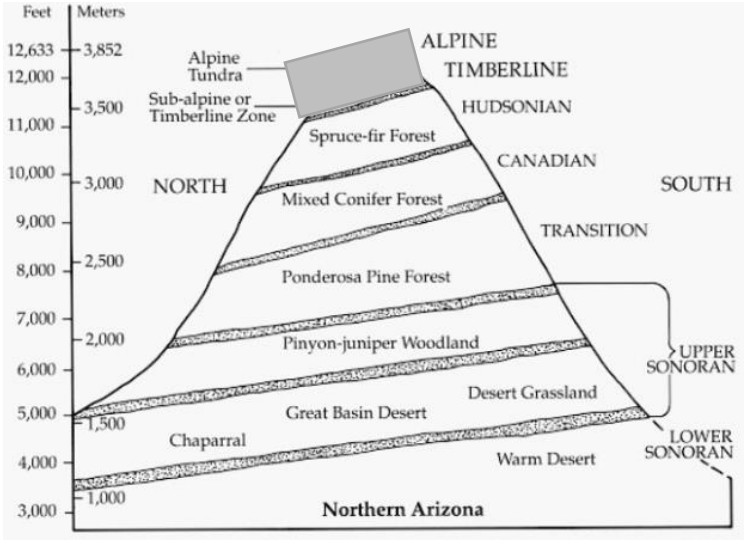
Climate & vegetation are changing



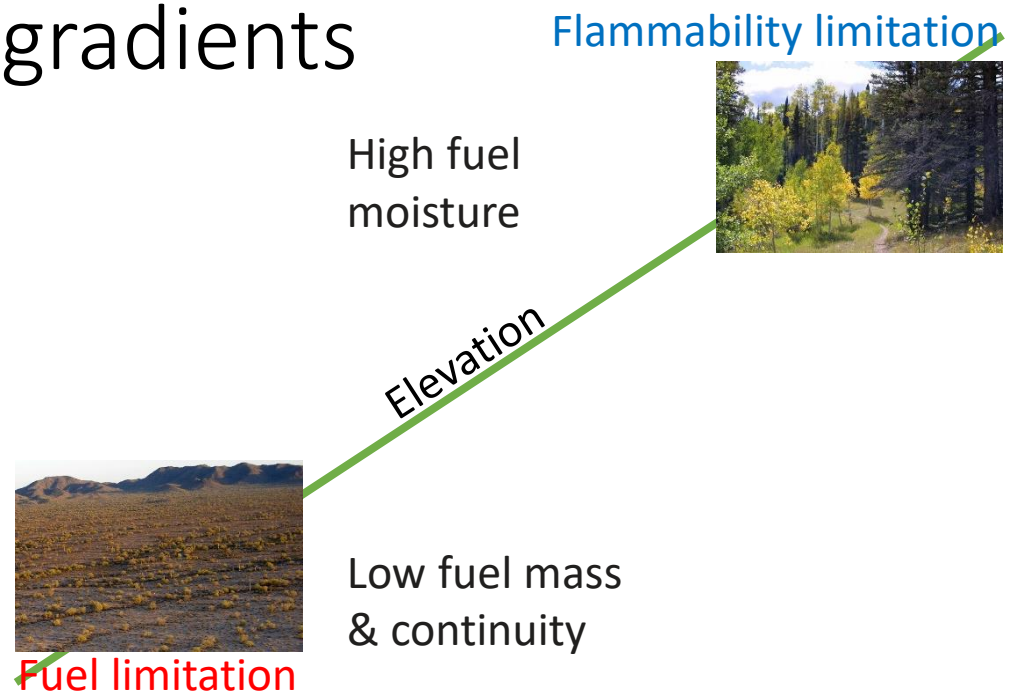
Cayan et al. 2013

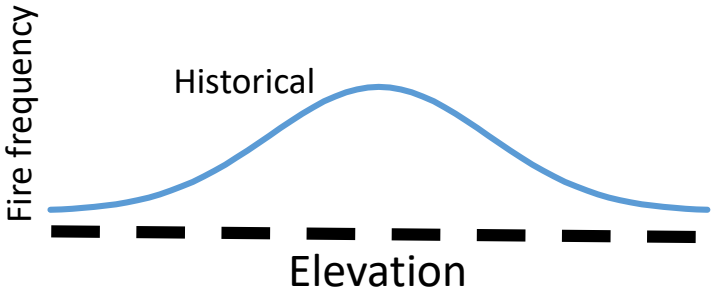
C.D. Allen in McDowell & Allen 2015

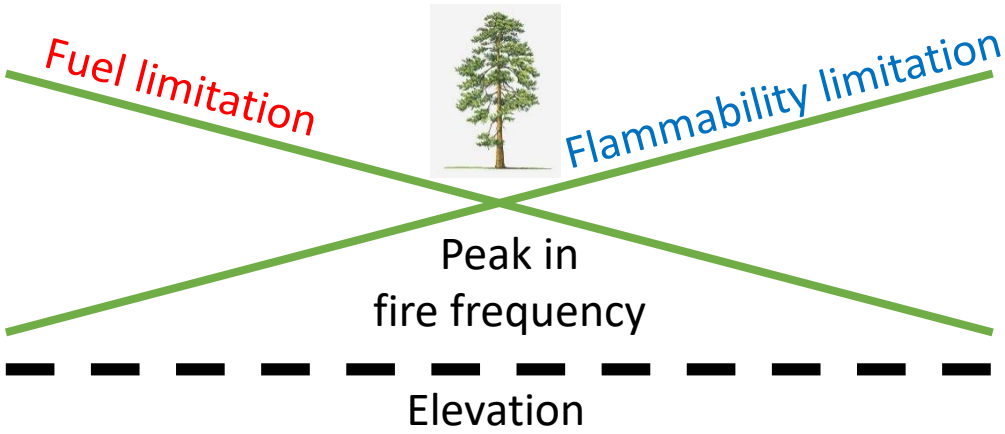
Vegetation and fire regimes vary along elevation gradients



Merriam's Life Zones

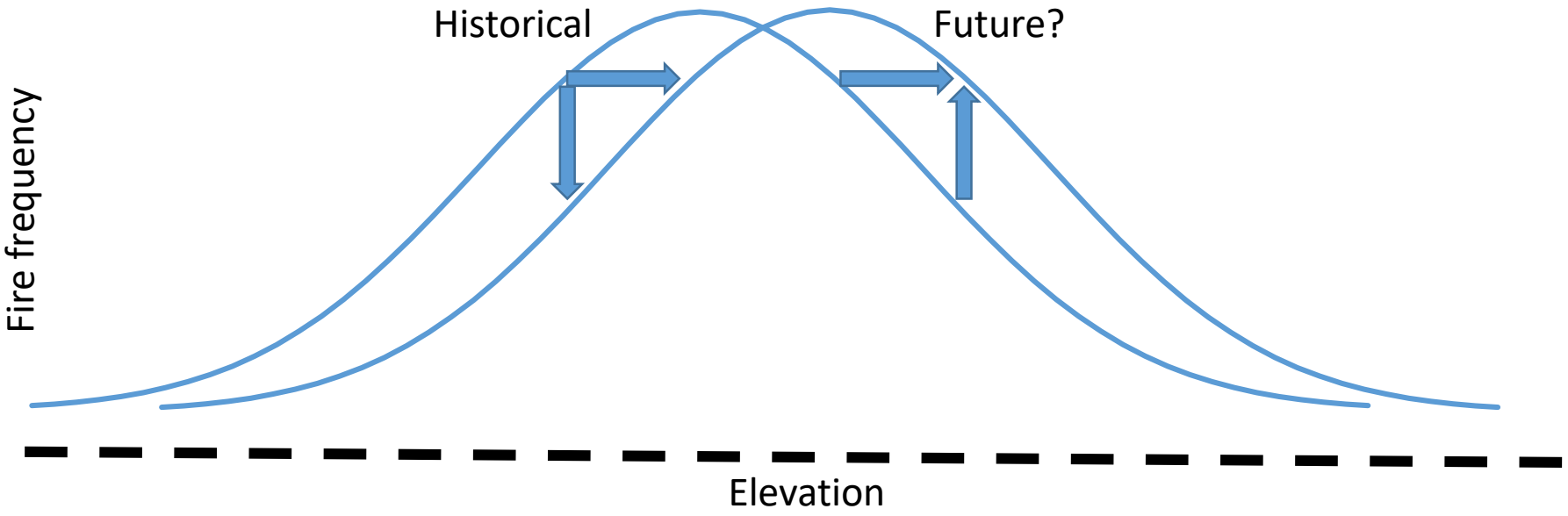




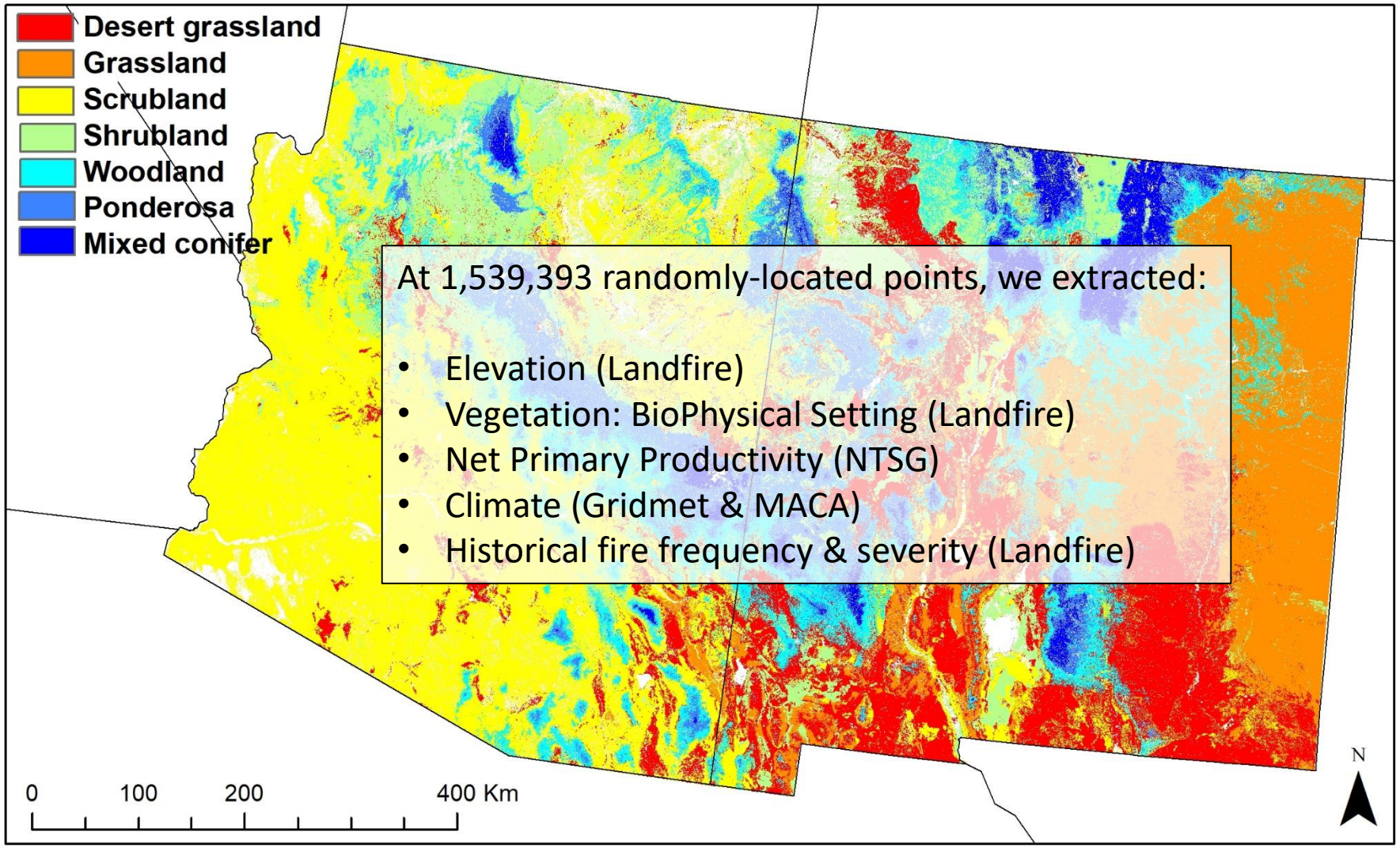


Questions

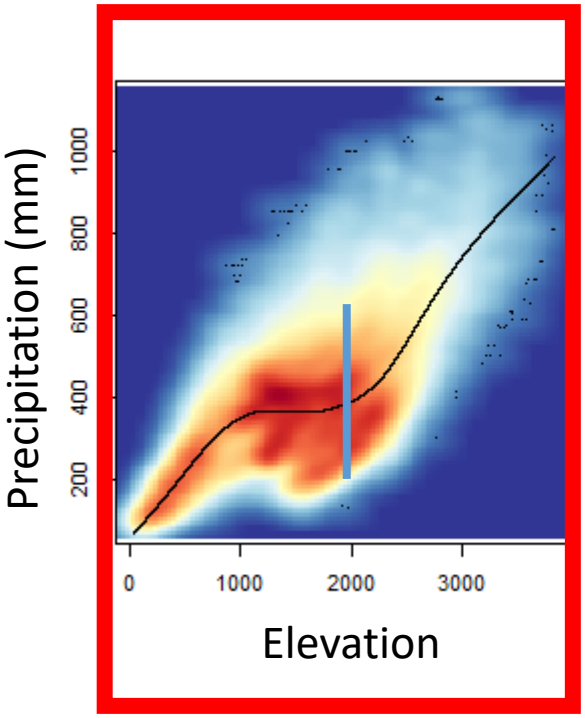
- Do we see this curve in available data?
- What is likely to happen to fire activity in the future?

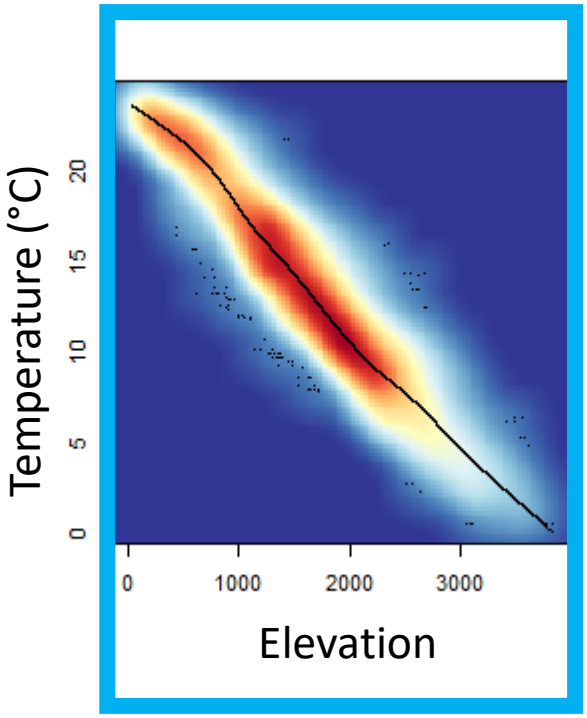


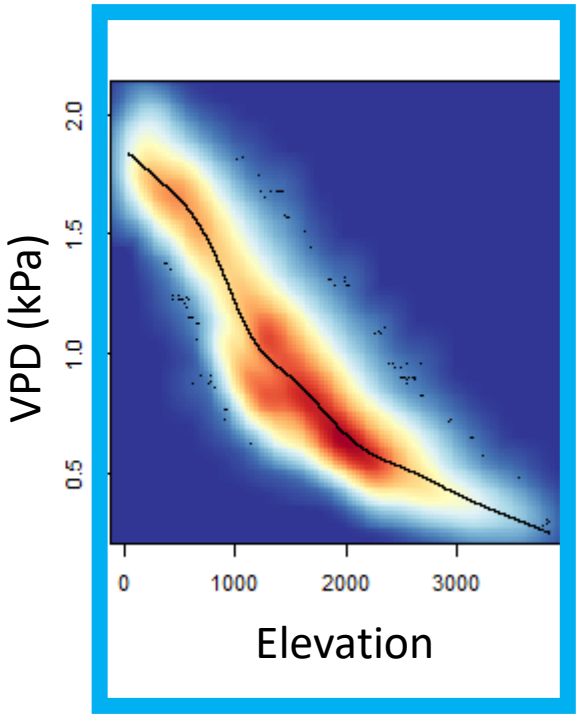
Study area


Desert grassland
Grassland
Scrubland
Shrubland
Woodland
Ponderosa
Mixed conifer
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)
0
100
200
400 Km
N

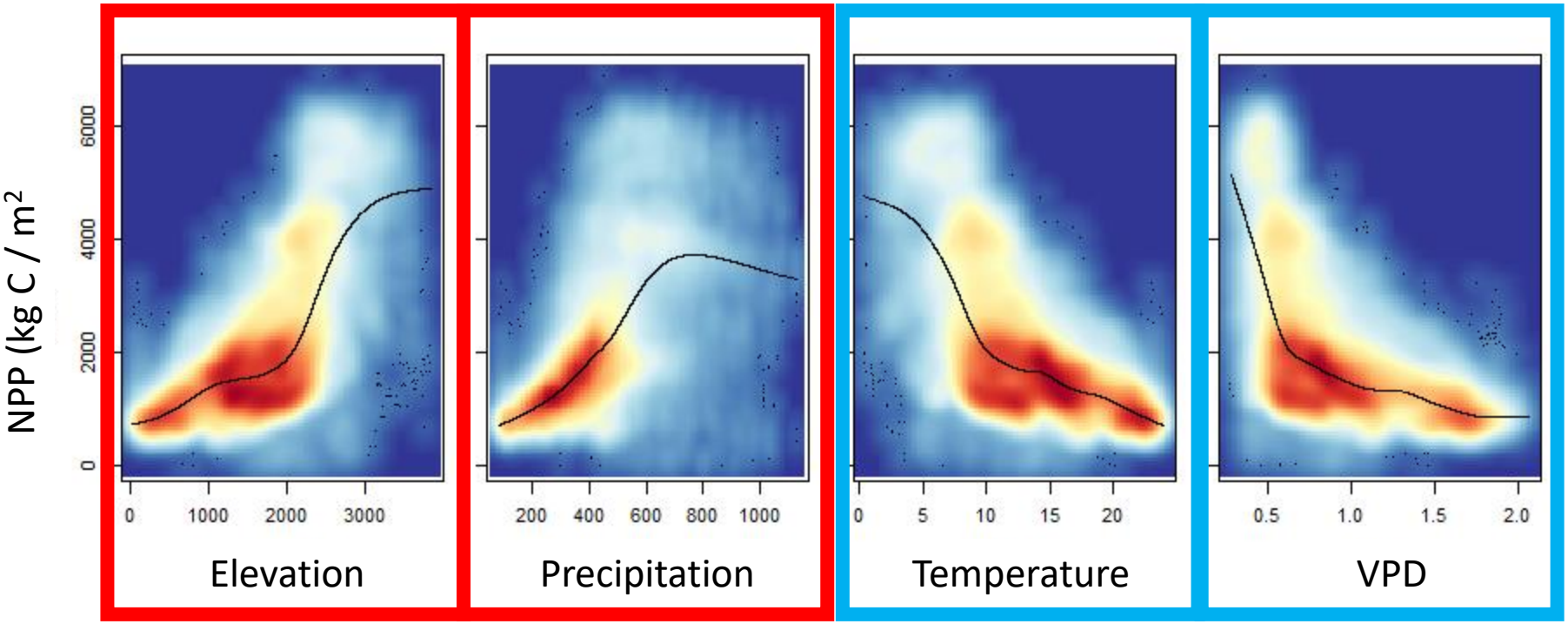
MAP, MAT, VPD *f* elevation



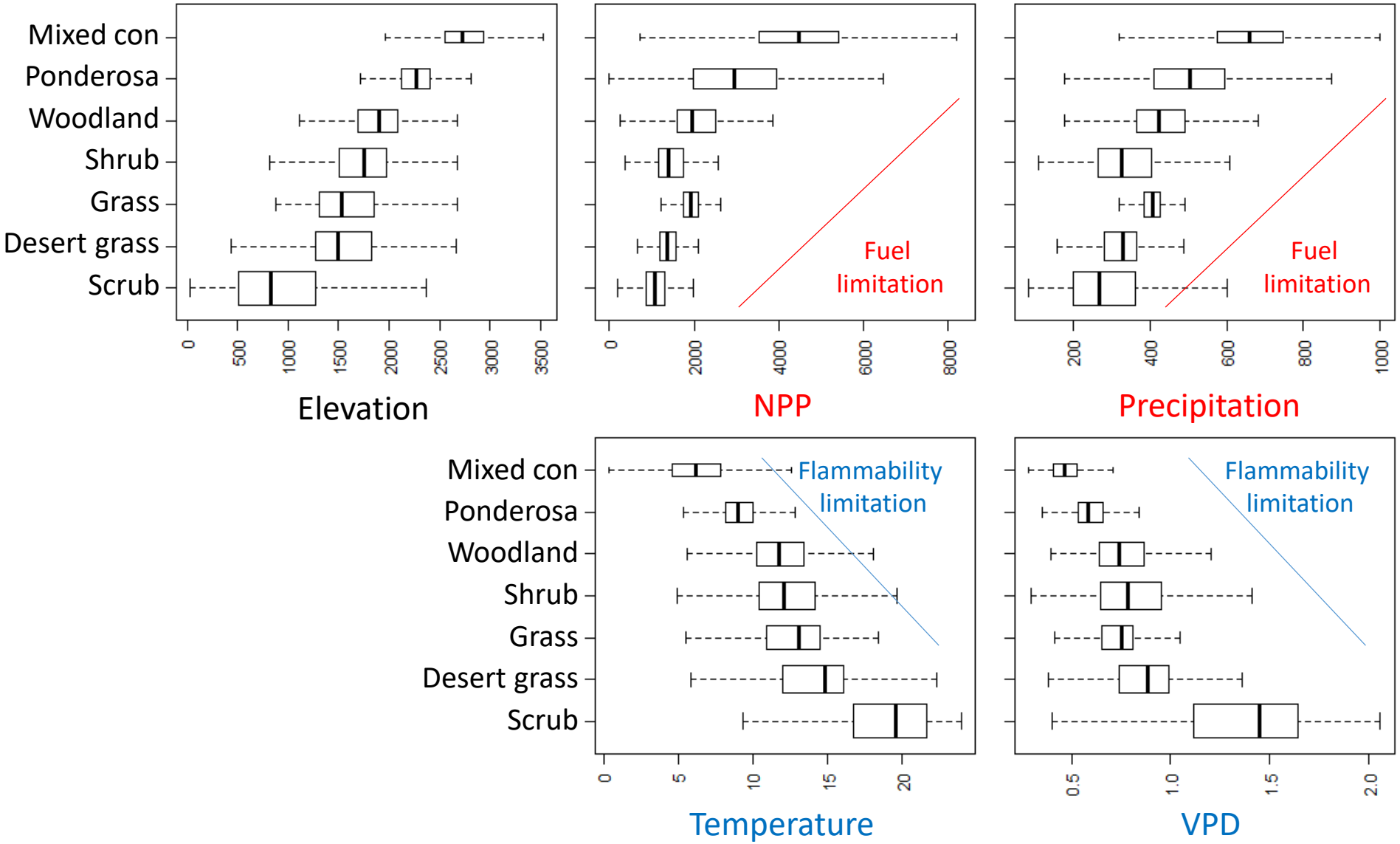




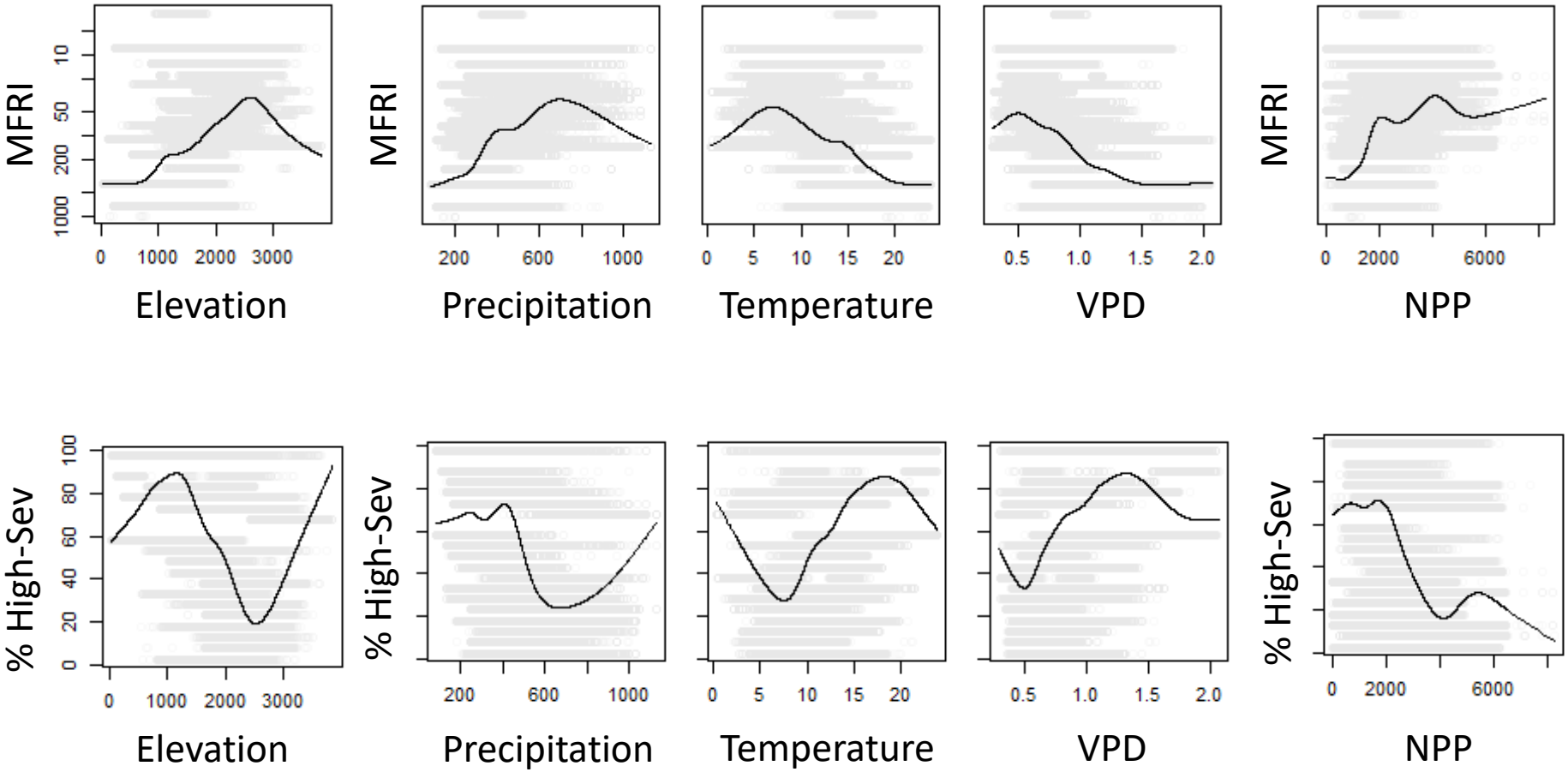
NPP *ƒ* MAP, MAT, VPD



Vegetation types *ƒ* elevation, climate

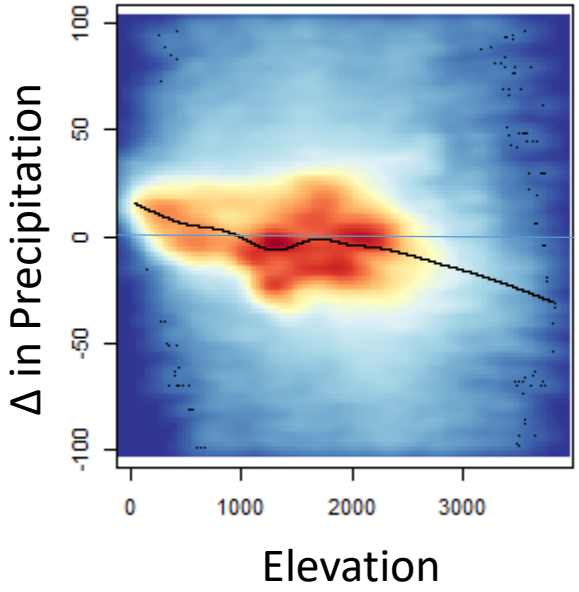


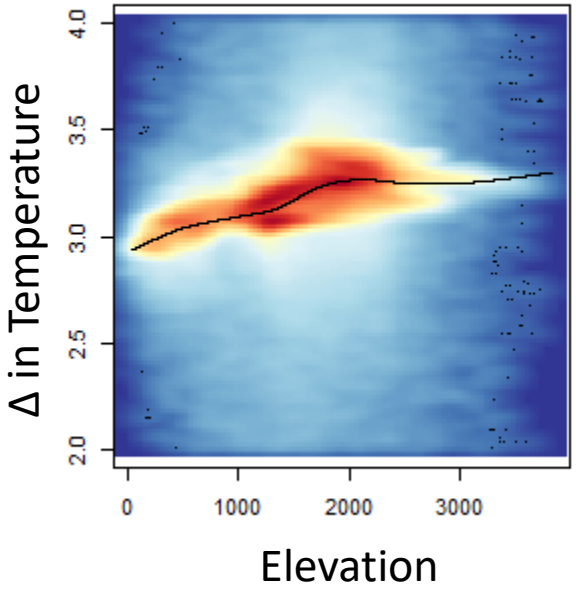
Fire frequency & severity reflect interactions of fuel productivity & flammability

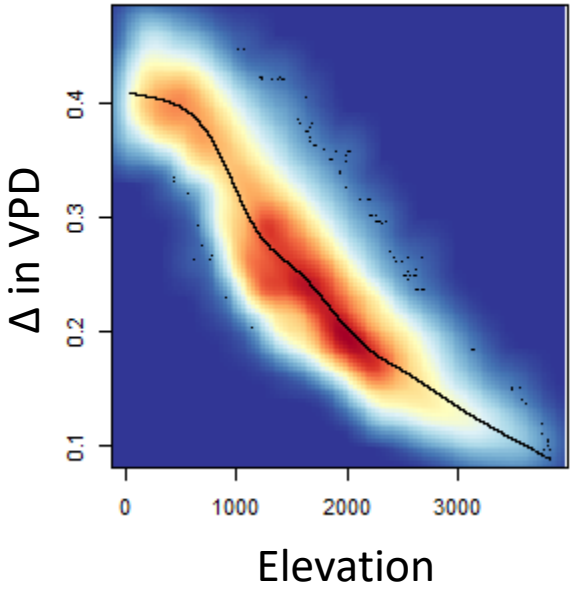


Projected changes in climate are variable across the elevation gradient

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

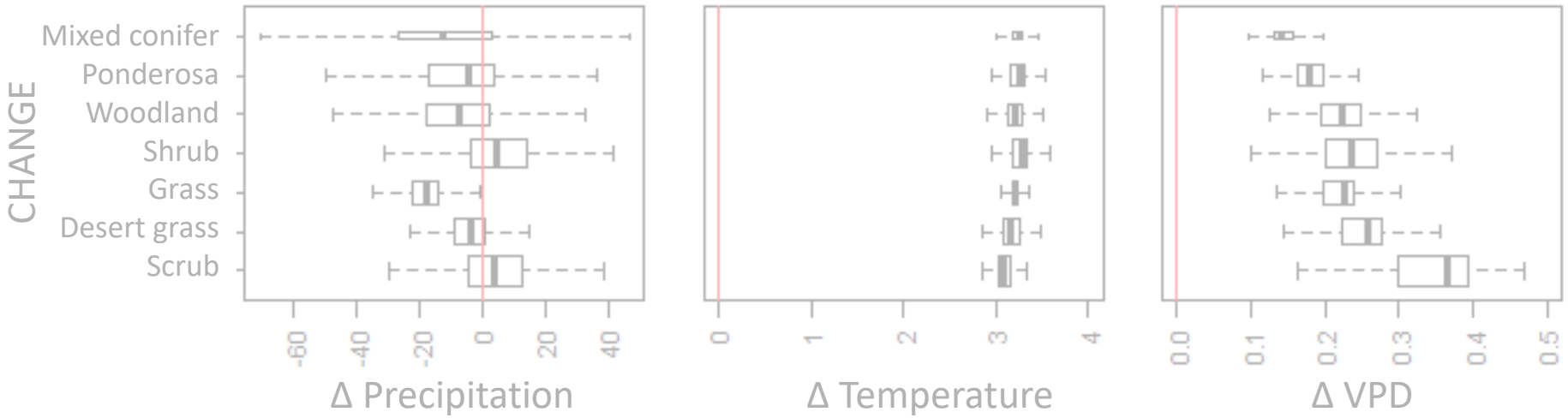






Projected changes by vegetation class

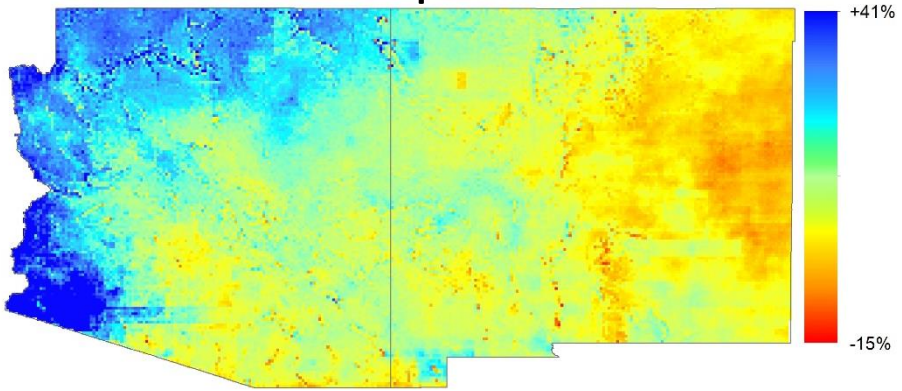
RCP 8.5 scenario, 2040-2069 vs. 1981-2010



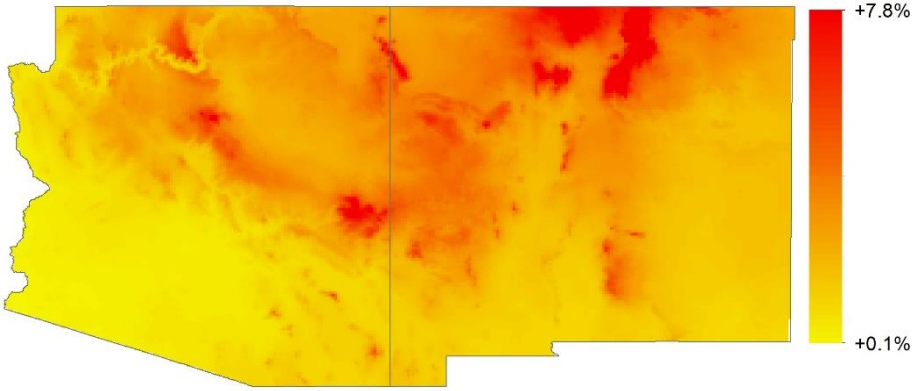
Projected % change in climate variables

RCP8.5, 1981-2010 to 2040-2069

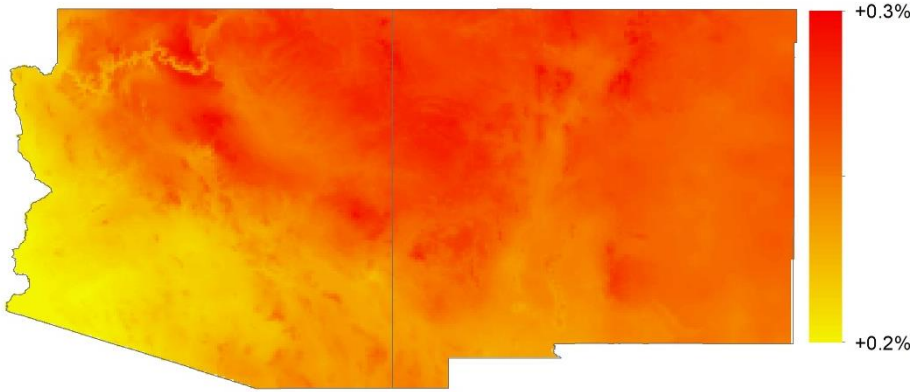
Precipitation



Temperature



VPD



Data from MACA; Abatzoglou and Brown 2011

Caveats

- We focused on historical fire frequency; frequency has already changed
- Historical fire frequency still represents fire potential, because of the crossing of the two fire limitation gradients (fuel load/continuity & flammability)
- Also: a confounding factor of legacy fuels from suppression era

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?

Thank you

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References

- Abatzoglou J.T. and Brown T.J. A comparison of statistical downscaling methods suited for wildfire applications, International Journal of Climatology (2012), 32, 772-780
- Cayan, D., M. Tyree, K. E. Kunkel, C. Castro, A. Gershunov, J. Barsugli, A. J. Ray, J. Overpeck, M. Anderson, J. Russell, B. Rajagopalan, I. Rangwala, and P. Duffy. 2013. “Future Climate: Projected Average.” In Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 101–125. A report by the Southwest Climate Alliance. Washington, DC: Island Press.
- Hoerling, M. P., M. Dettinger, K. Wolter, J. Lukas, J. Eischeid, R. Nemani, B. Liebmann, and K. E. Kunkel. 2013. “Present Weather and Climate: Evolving Conditions.” In Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 74–100. A report by the Southwest Climate Alliance. Washington, DC: Island Press.
- McDowell, N.G. and Allen, C.D., 2015. Darcy's law predicts widespread forest mortality under climate warming. *Nature Climate Change*, *5*(7), p.669.
- Moritz, M.A., Hessburg, P.F. and Povak, N.A., 2011. Native fire regimes and landscape resilience. In *The landscape ecology of fire* (pp. 51-86). Springer, Dordrecht.
- Running, S.W. and M. Zhao. 2015. User’s Guide, Daily GPP and Annual NPP (MOD17A2/A3) Products, NASA Earth Observing System MODIS Land Algorithm. Missoula, MT.

Formal theoretical prediction

- Two variables, v1 and v2, changing monotonically I opposite direction along an elevation gradient
- Their **product** will peak at mid-elevation
- This can be expressed as the second derivative of the product = 0 at that point