Trait based approaches to understanding and maximizing ecosystem resilience

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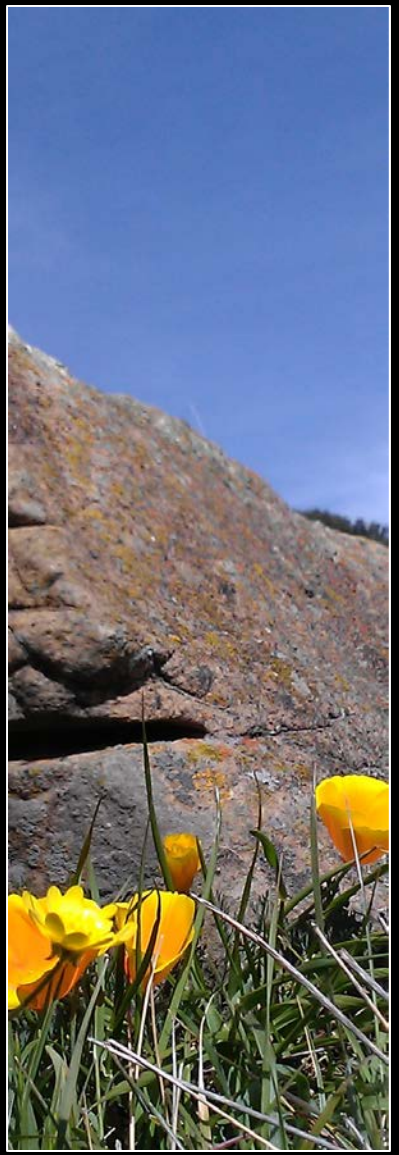


Photo credit: State of the nation


Fwy
1½
91
Riverside
Photo credit: LA times


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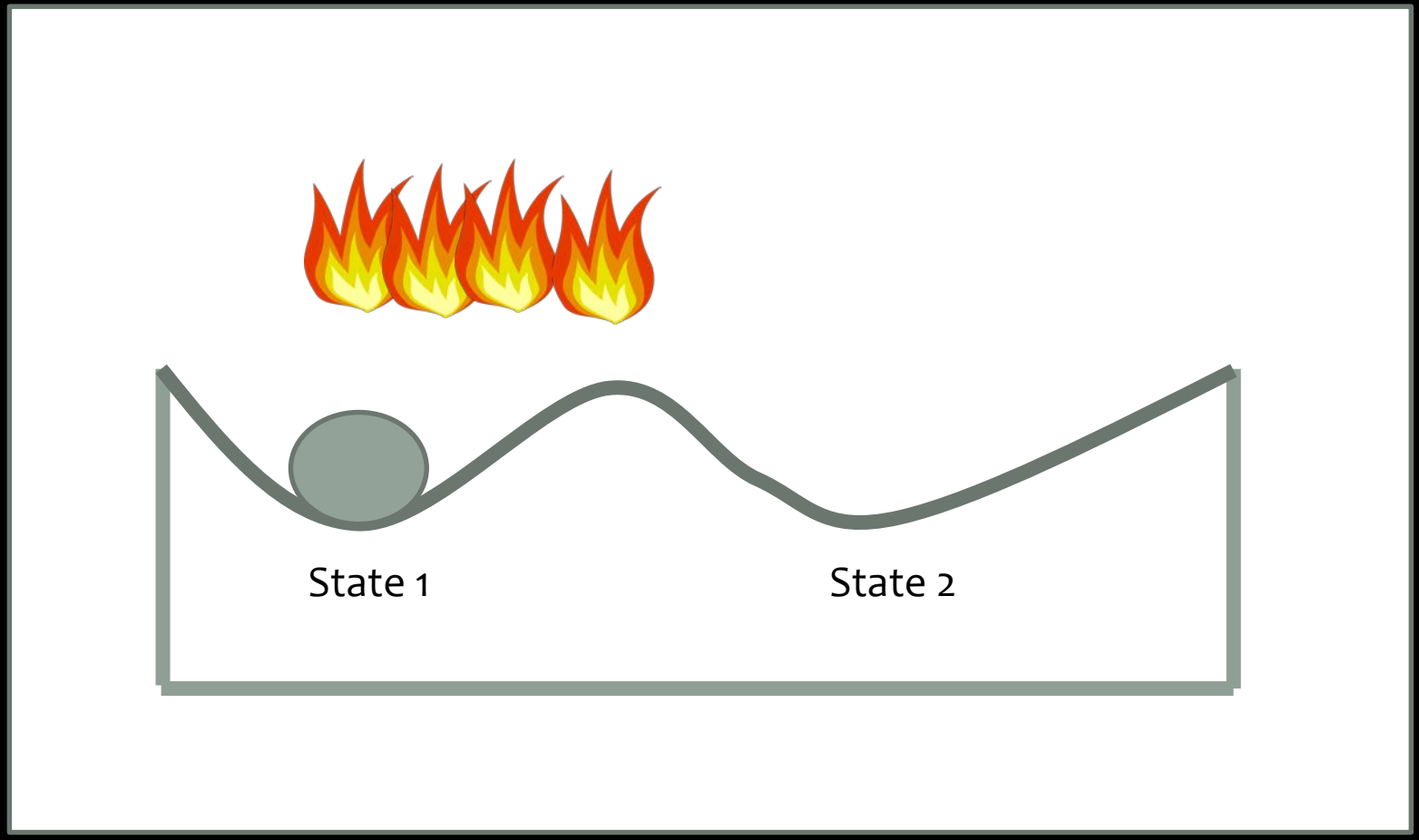
Can we manage our systems for resilience?

- Engineering Resilience
  - the ability of a system to recover state/function following disturbance

Holling, 1996

Photo credit: greenliving.com

Can we manage our systems for resilience?



Why do some ecosystems have irreversible responses to environmental change while others recover relatively quickly?

Photo credit: greenliving.com

Alpine tundra

- Impacted by:
  - Longer growing season
    - Mid-summer drought
  - Nitrogen deposition
- Evidence for resilience

esa ECOSPHERE

Changes in alpine vegetation over 21 years: Are patterns across a heterogeneous landscape consistent with predictions?

Marko J. Spasojevic,[1] William D. Bowman,[2,3,4] Hope C. Humphries,[4] Timothy R. Seastedt,[2,4] and Katharine N. Suding[5,†]

Southern California Coastal Sage Scrub

- Impacted by:
  - Climate change
  - Nitrogen deposition
  - Fire
  - Exotic species
- Limited resilience

Loma Ridge, Orange County, California

Journal of Applied Ecology 1999, **36**, 544–554

Lack of native species recovery following severe exotic disturbance in southern Californian shrublands

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Altered water and nitrogen input shifts succession in a southern California coastal sage community

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How can we maximize resilience in our system?

Functional traits

Resilience

How can we maximize resilience in our system?

- In theory:
  - the function of any given species lost to a disturbance can be replaced by other functionally redundant species in high diversity ecosystem

    (Holling, 1973, Walker, 1995, Elmqvist et al., 2003, Suding, 2011)

- In theory:
  - More diversity = more resilience

How can we maximize resilience in our system?

- In theory:
  - the function of any given species lost to a disturbance can be replaced by other **functionally redundant** species in **high diversity ecosystem**

    (Holling, 1973, Walker, 1995, Elmqvist et al., 2003, Suding, 2011)

- In theory:
  - More diversity = more resilience
  - More functional diversity and more functional redundancy?

Functional trait-based approaches in ecology

Functional traits – organismal characteristics linked to fitness that mediate responses to, and effects on, the environment

Advantages of trait-based approaches

- Easily generalize across systems and species

- Short
- Perennial
- Forb
- Low Specific Leaf Area
- Rhizomatous
- Low C:N
- High concentrations of secondary chemicals
- Slow relative growth rate

Advantages of trait-based approaches

- Easily generalize across systems and species
- Provides insights when experimental approaches are more challenging

Around 200 years old

500 year old – old growth

Advantages of trait-based approaches

- Easily generalize across systems and species
- Provides insights when experimental approaches are more challenging
- Mediate responses to, and effects on, the environment



Can trait based approaches be used to understanding and maximizing ecosystem resilience?

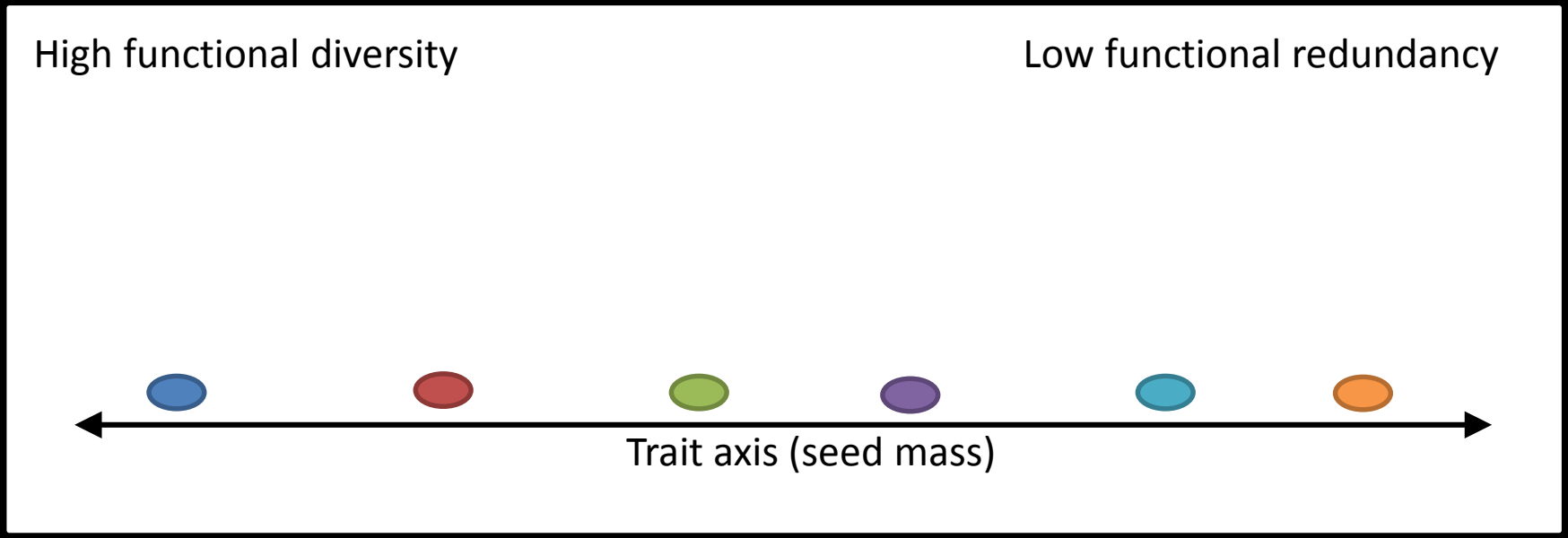
How does functional diversity influence resilience?

– the function of any given species lost to a disturbance can be replaced by other **functionally redundant** species in **high diversity ecosystem**

(Holling, 1973, Walker, 1995, Elmqvist et al., 2003, Suding, 2011)

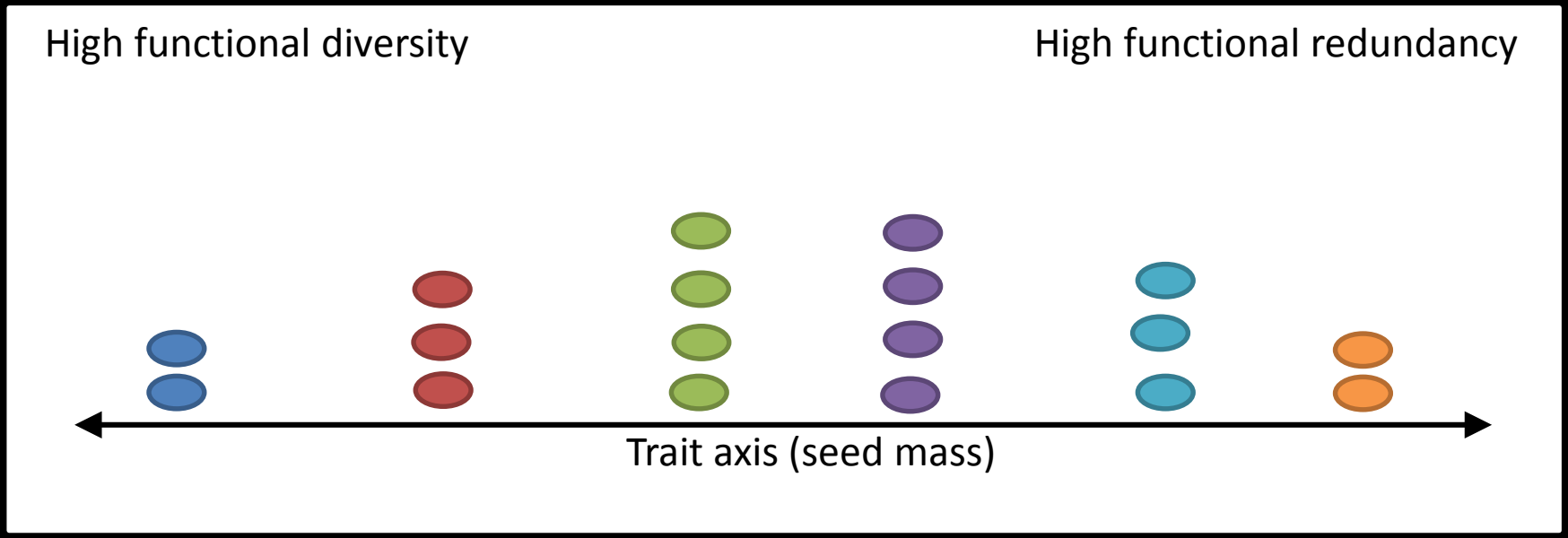
How does functional diversity influence resilience?

– Functional richness = the range of functional strategies in a community



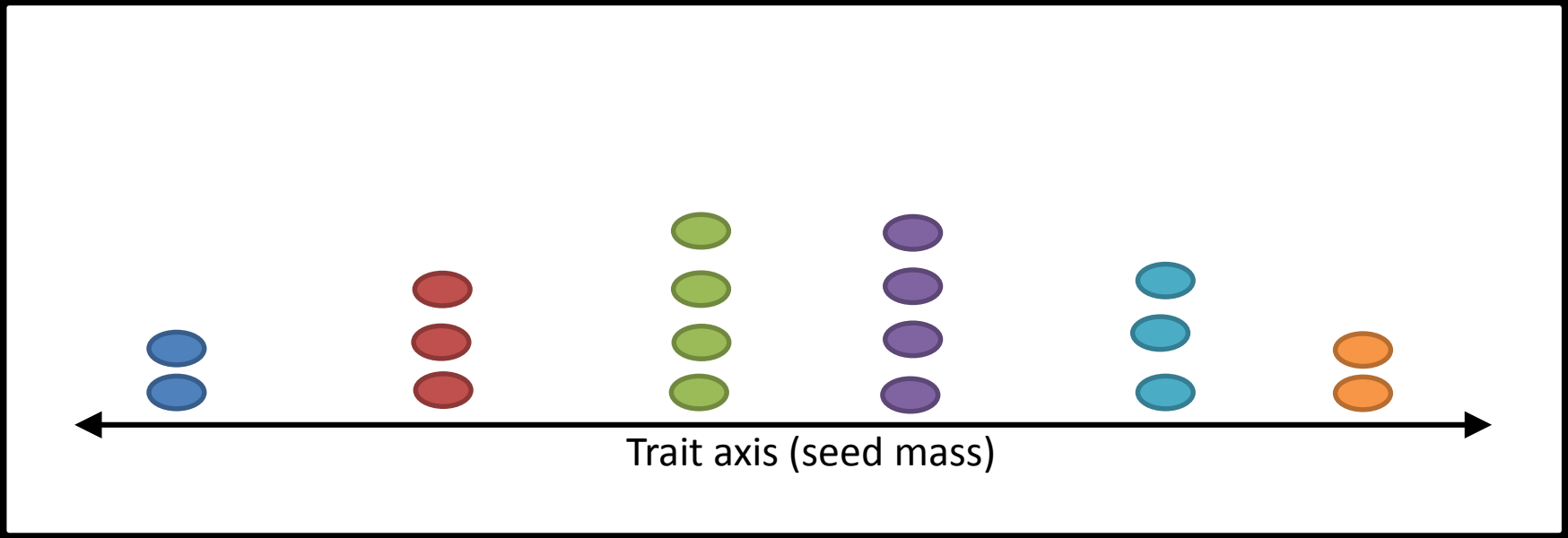
How does functional diversity influence resilience?

– Functional dispersion = the diversity of strategies in a community



How does functional diversity influence resilience?

- Do we need a wider range of strategies, species with a diversity of strategies, or both?
- Given limited resources, which do we maximize?



What factors influence the resilience of productivity to wildfires?

In collaboration with: Christie A. Bahlai, **Bethany A. Bradley, Bradley J. Butterfield, Mao-Ning Tuanmu**, Seeta Sistla, Ruscena Wiederholt and Katharine N. Suding

Photo credit: discovery magazine

Biodiversity – resilience relationship

- In theory:
  - the function of any given species lost to a disturbance can be replaced by other functionally redundant species in high diversity ecosystem

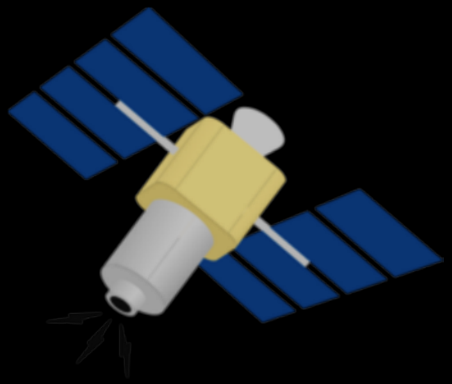
    (Holling, 1973, Walker, 1995, Elmqvist et al., 2003, Suding, 2011)

- In practice:
  - Evidence is generally limited in scope and localized scale
  - To date, no studies have tested this relationship at large spatial scales

Scaling up the biodiversity-resilience relationship to large scales

Disturbance = fire

- USGS Landfire - Identify high severity fires



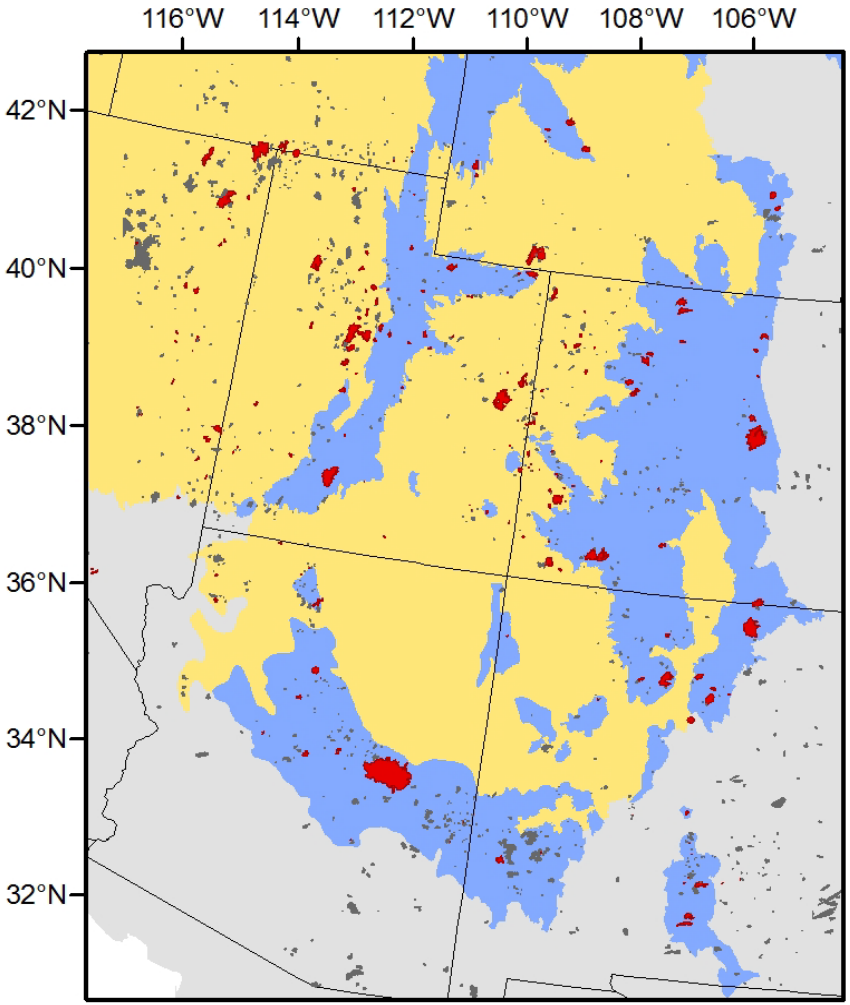
Resilience = recovery of productivity

- Time Integrated NDVI – slope over 10 years
  - Control pixel

Biodiversity

- Species richness
- Seed mass (KEW)
- Fire traits (USDA PLANTS)
  - Fire tolerance
  - Fire resistance
  - Resprout-ability

133 Wildfires across the Four-Corners



Landfire 1999-2002 Fires

- Fires included in analysis
- Other Fires

Ecoregion

- Cold Desert Woodland
- Forested Mountains
- Other Ecoregions

0 125 250 500

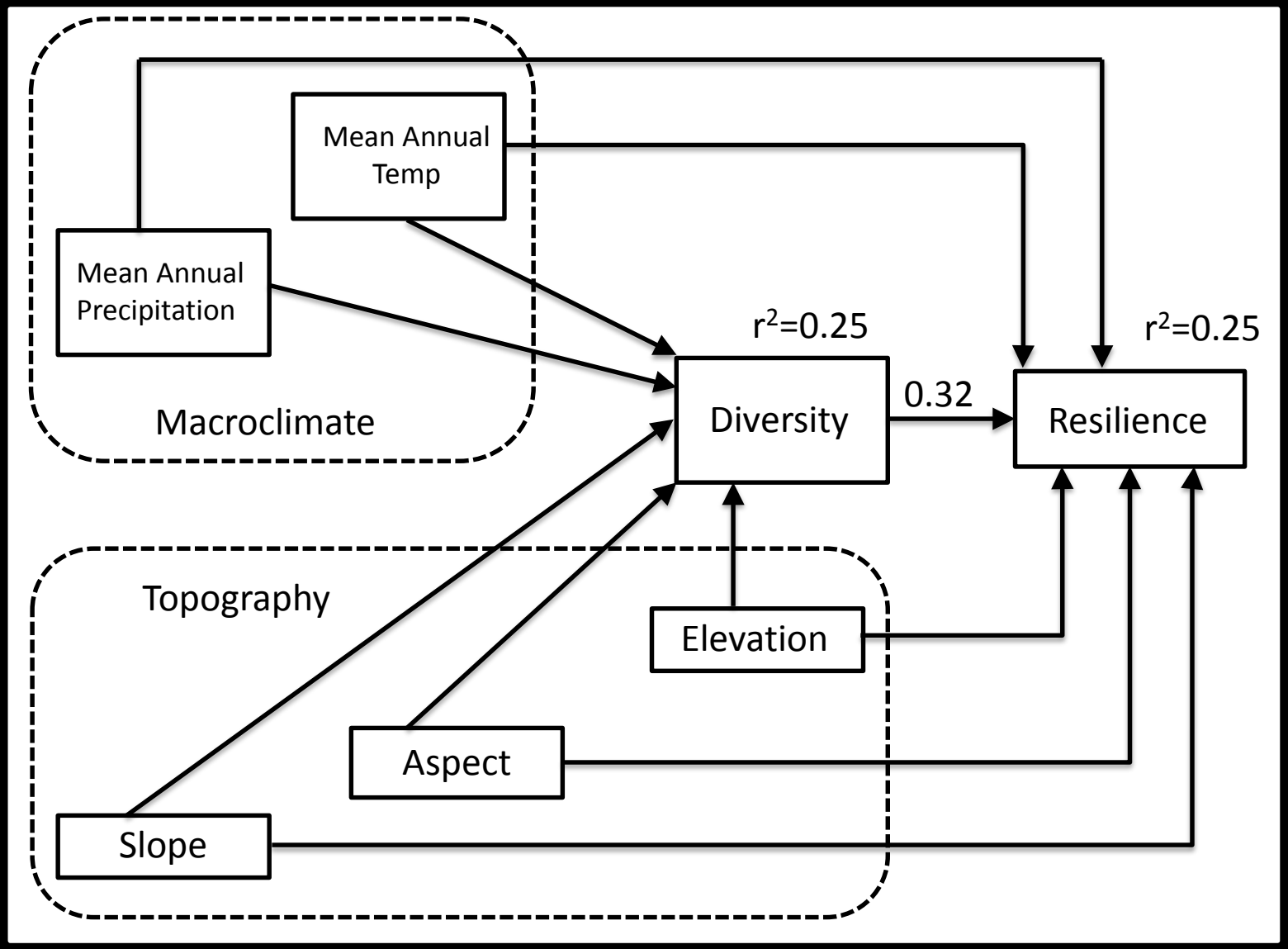
Kilometers

16 vegetation types

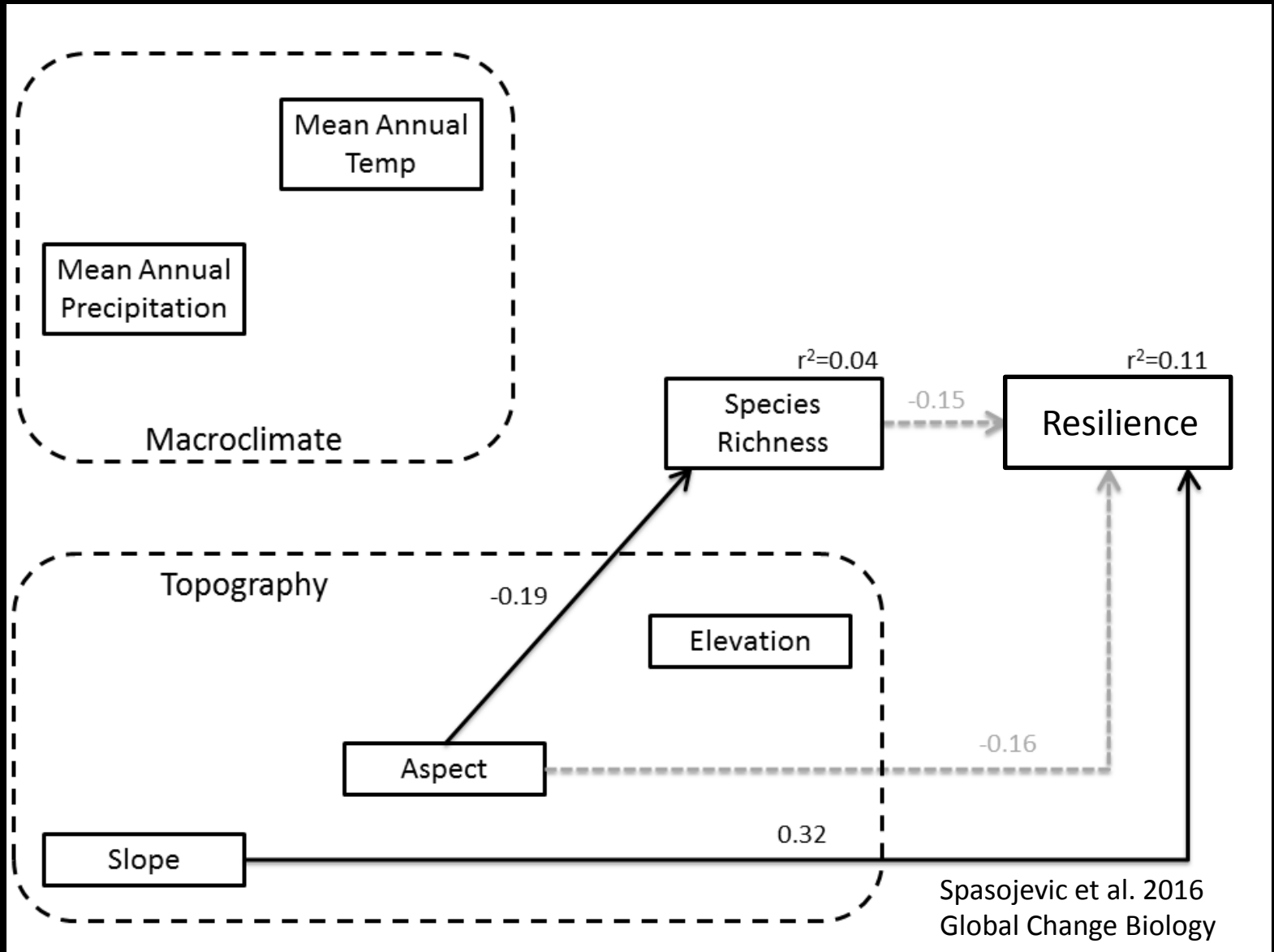
239 species

Spasojevic et al. 2016
Global Change Biology

Are more (functionally) diverse ecosystems more resilient?

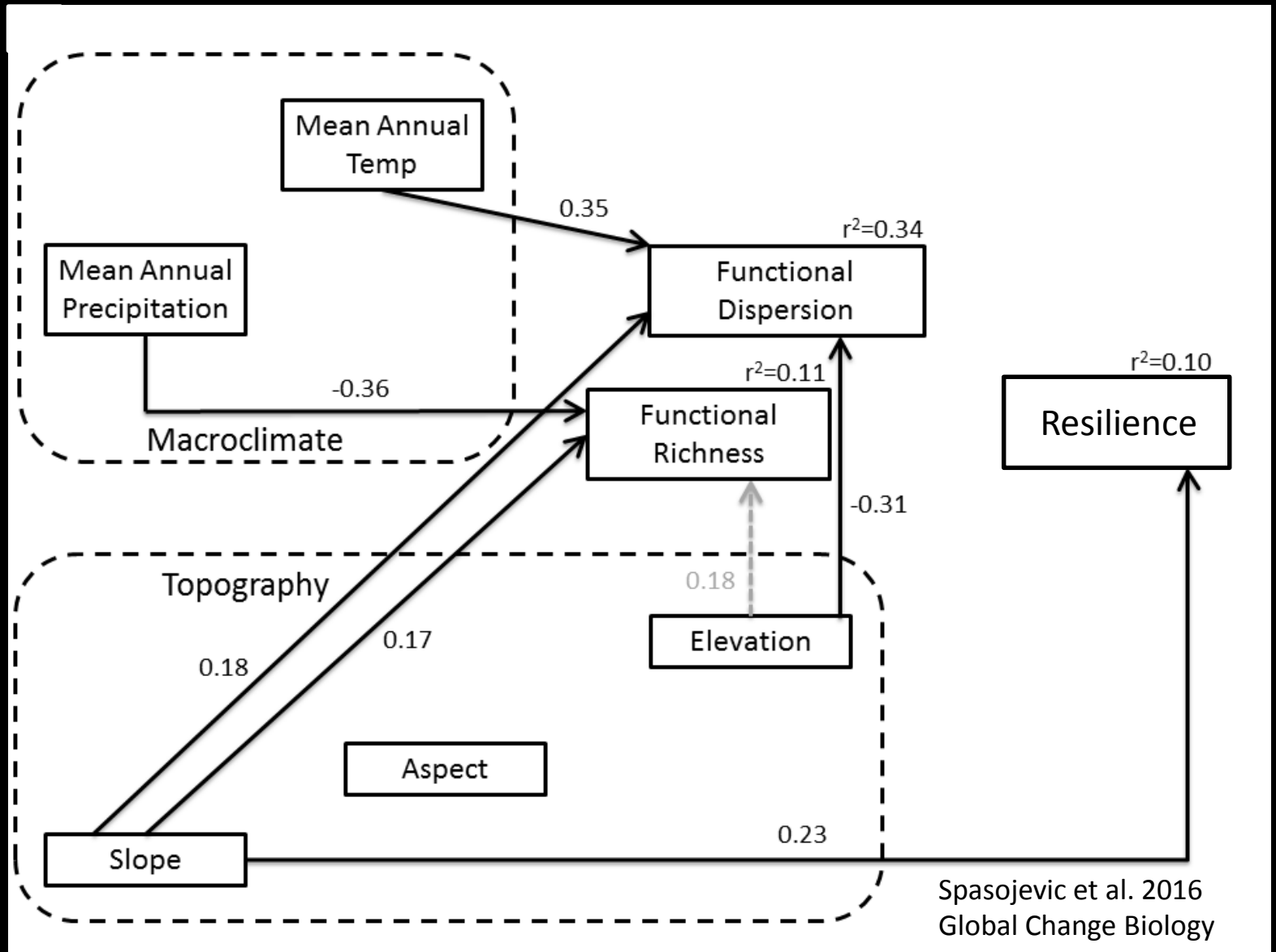


Species richness weakly influences resilience



Spasojevic et al. 2016
Global Change Biology

Seed Mass does not influence resilience



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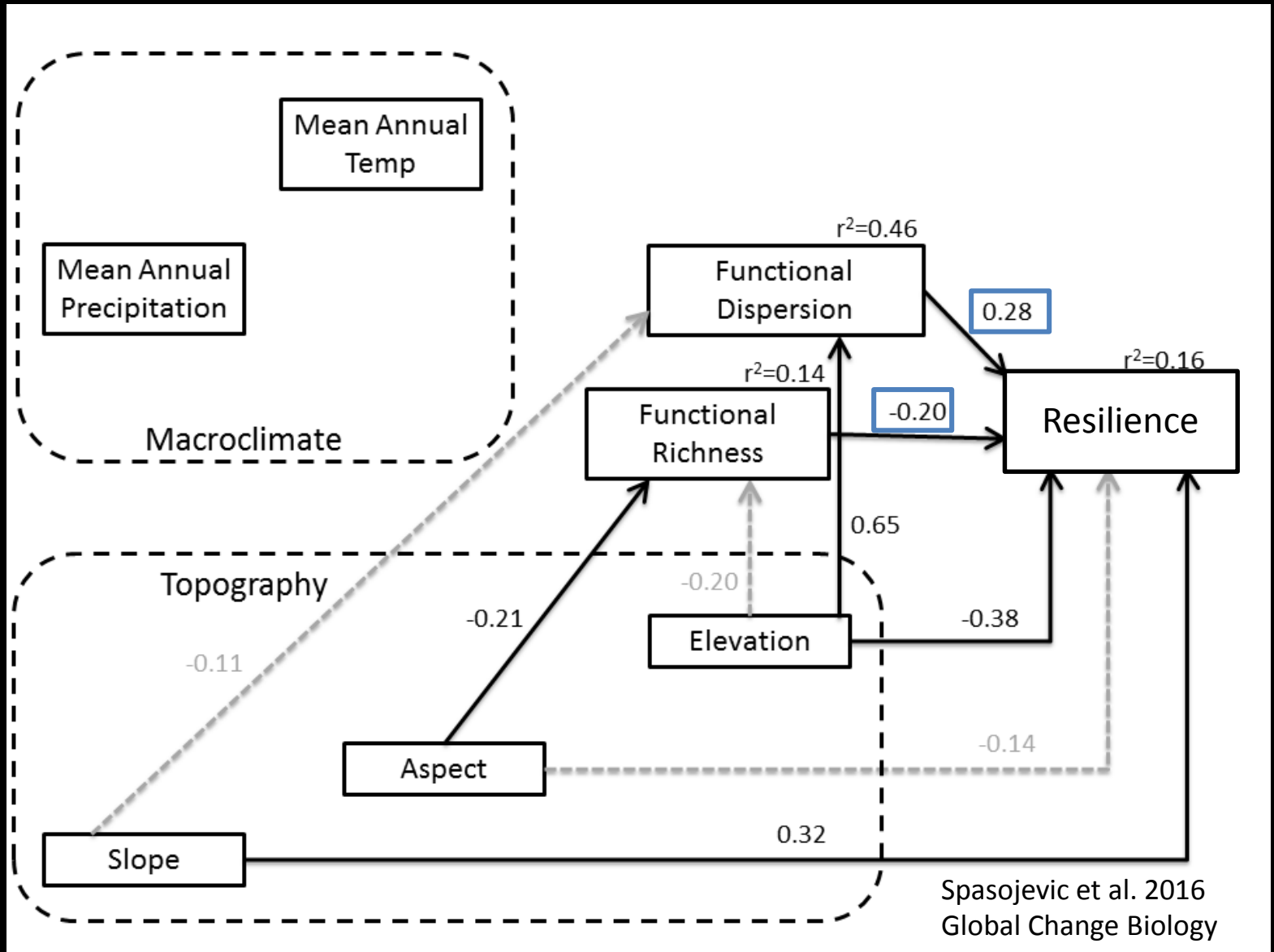
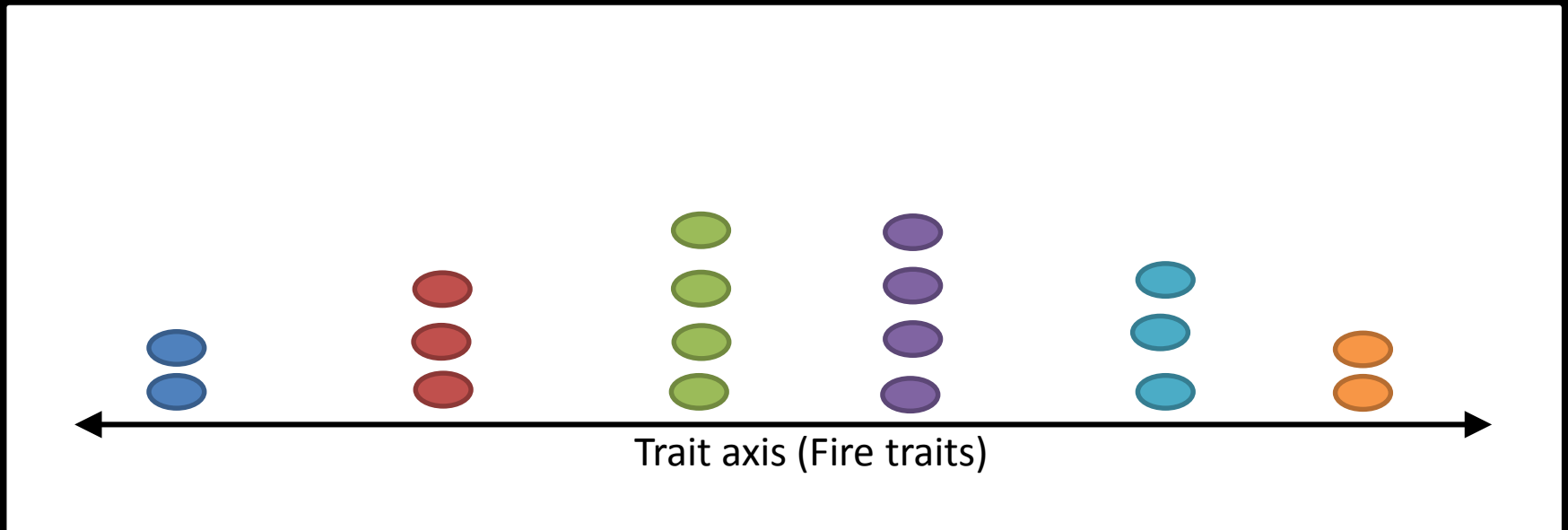
Increased resilience in ecosystems with greater dissimilarity in fire traits



Spasojevic et al. 2016
Global Change Biology

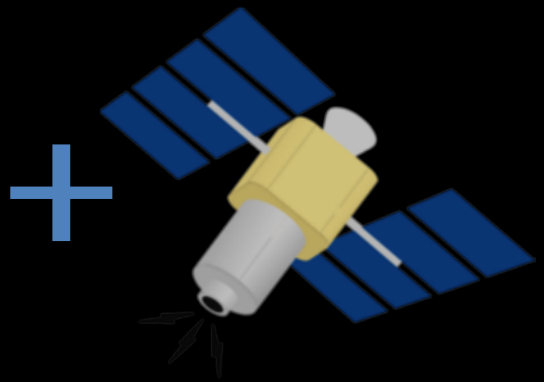
Implications

- A few strategies with a diversity of species may be more important than a wide range of strategies and fewer species
- Still need on the ground tests at landscape scales



Future work and collaborations

- Trait based approaches can help inform restoration and resilience of chaparral to fire
  - Need to link on the ground surveys and trait measurements with remote sensing
  - Need to examine multiple functions



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Questions

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