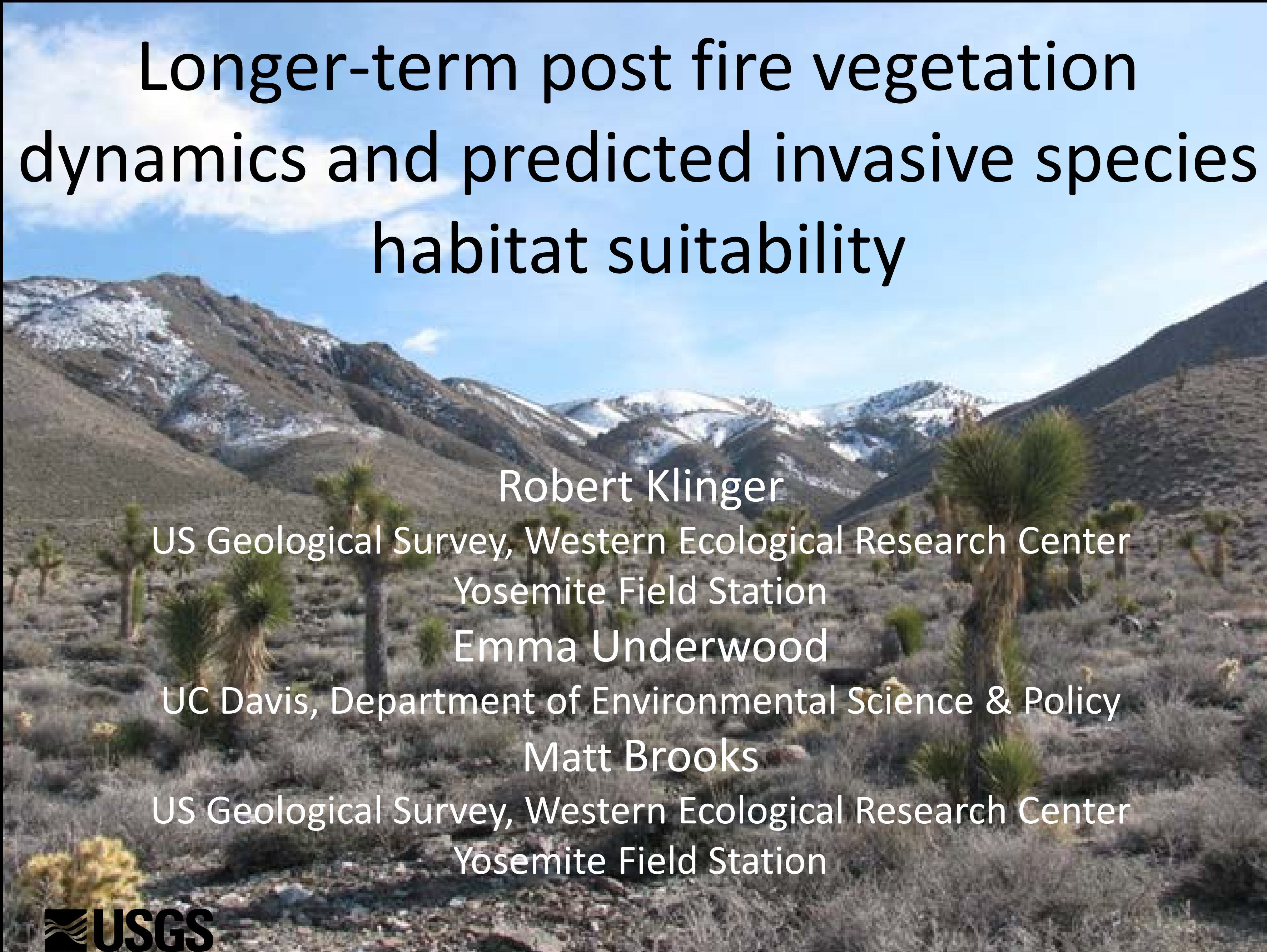


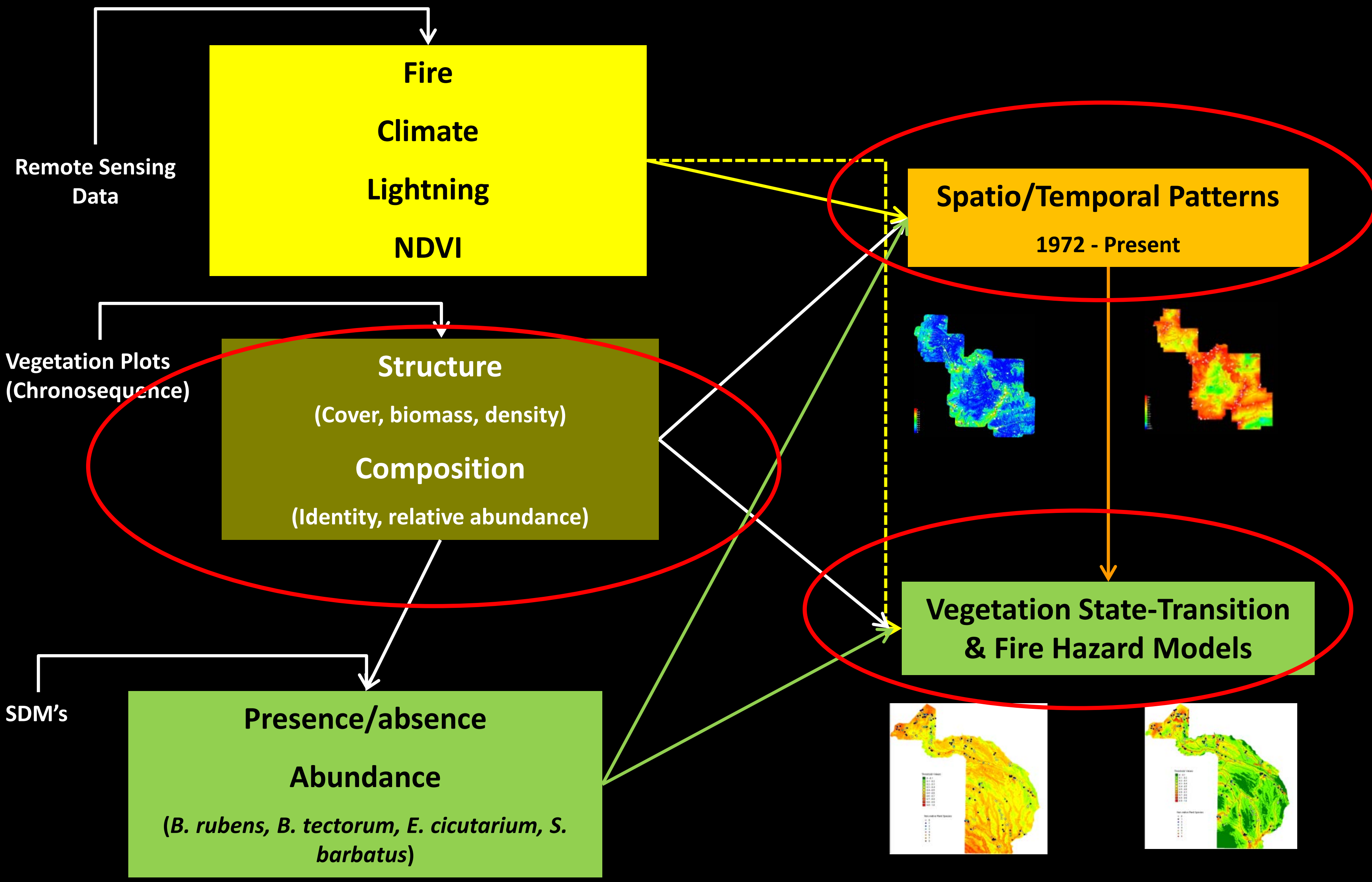
Longer-term post fire vegetation dynamics and predicted invasive species habitat suitability

Robert Klinger
US Geological Survey, Western Ecological Research Center
Yosemite Field Station
Emma Underwood
UC Davis, Department of Environmental Science & Policy
Matt Brooks
US Geological Survey, Western Ecological Research Center
Yosemite Field Station

Emphasis

- Relationship between fire severity, fire frequency, time since fire and post-fire vegetation dynamics
  - Contrast traditional views of succession with "newer" concepts of community dynamics
  - Emphasize process instead of simple patterns
- Modeling habitat suitability of four invasive annual plants
  - Infer potential for alternative vegetation states at landscape scale

Integrated Multi-Scale Project



Classic Concepts of Succession

Facilitation Model

Traditional view of post-fire succession in the Mojave

Are These Appropriate Models?

- Shortcomings
  - Simplistic
  - Deterministic and linear
  - Not much data
  - *But this does not make it wrong*
  - Observations and data indicate formation of alternative communities

ENLC archives

So Are There Other Useful Ways To Think About Postfire Vegetation Dynamics In The Mojave?

- Metacommunities
  - A “community of communities” linked by dispersal and local environmental conditions
  - Interplay between regional and local factors

2006

2007

ENLC archives

Expanding Our Thinking About Postfire Vegetation Dynamics In The Mojave

- Alternative states
  - Discrete assemblages of species not necessarily in equilibrium
  - Result from *random fluctuations* in colonization and establishment leading to different succession pathways and a range of communities with distinct species composition
  - Non-directional!

2006

2007

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Key Questions

- What are the relative influences of severity and frequency on succession trajectories?
- Are succession patterns similar among elevation zones?
- What is the link between succession and metacommunity processes?
- How persistent are alternative states?

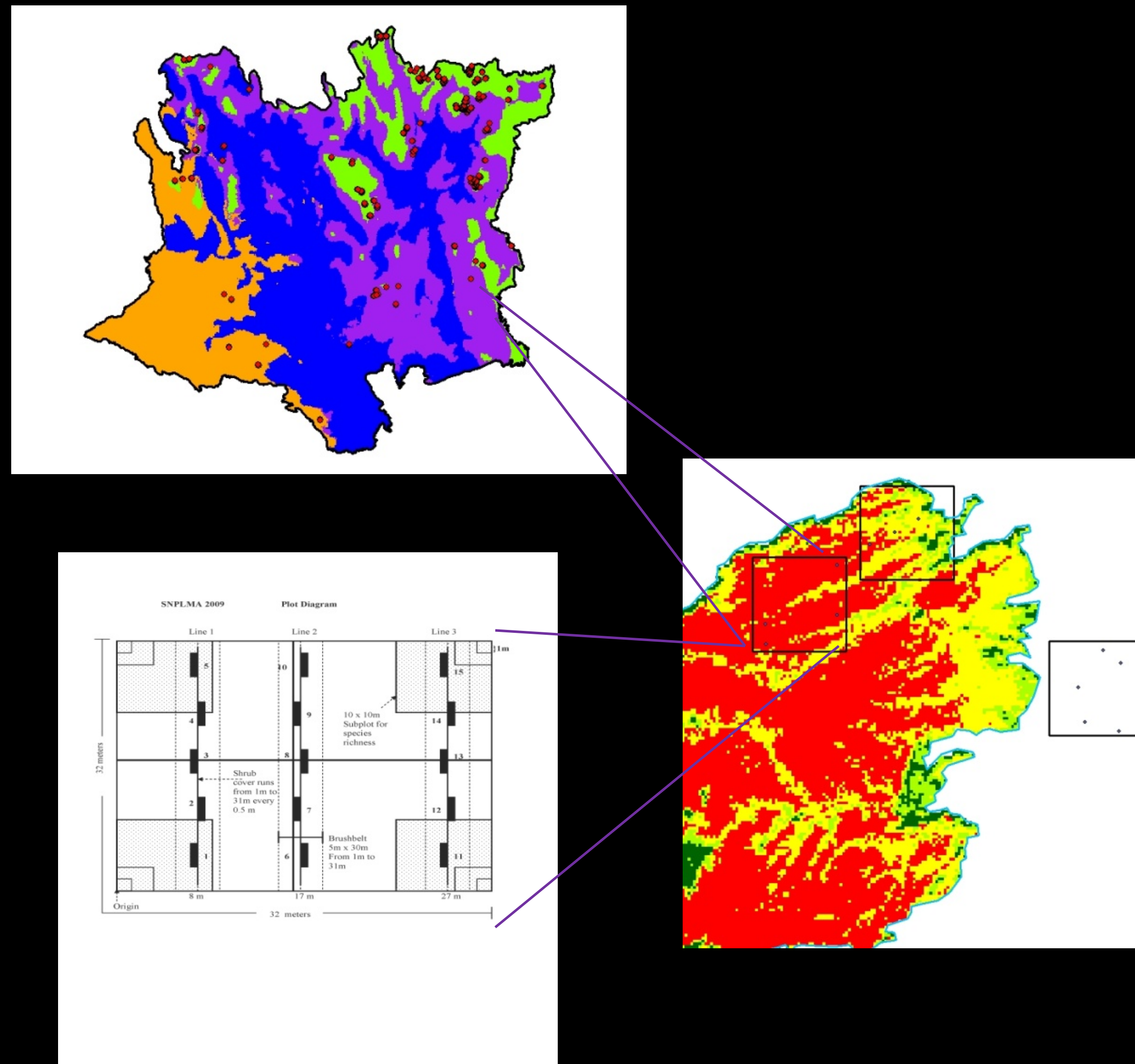
The Grass-Fire Cycle & Transformer Species

- Annual grasses and alteration of fire regimes
  - *Schismus* spp.
  - *Bromus rubens*
  - *Bromus tectorum*
- Evidence that cycle is becoming more common in Mojave

  Esque & Schwalbe 2002
  - Main concern has been ***fire frequency***
  - But what about severity?

Sampling Design

- Space-for-time (N = 807)
  - 501 plots (2009)
    - N = 69 unburned
    - N = 432 3 - 35 YPF
  - 129 plots (2011)
    - N = 87 unburned
    - N = 42 3 - 20 YPF
  - 141 plots (2012)
    - N = 45 unburned
    - N = 96 10 - 40 YPF
  - 36 plots (2013)
    - N = 21 unburned
    - N = 15 8 - 20 YPF
- Hierarchical sampling
  - Elevation zone
  - Years postfire x frequency
  - Site (1 km^2)
    - 3-5 plots per site
  - Plot (0.10 ha)



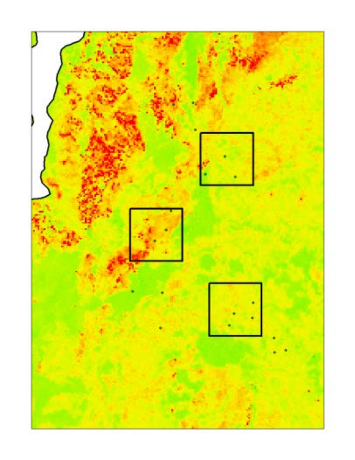
Metrics Of Succession

- Structure
  - Diversity
    - N0 (species richness)
    - N2 (Simpsons Index^{-1})
    - E1/D (N2/N0)
  - Woody and herbaceous cover
  - Woody-herb ratio
    - Cover
- Composition
  - Species identity and relative abundance
  - Relative abundance of Bromes, Schismus and *Erodium*

Time Since Fire, Frequency, and Severity

This ain't no fully crossed randomized block design!!!

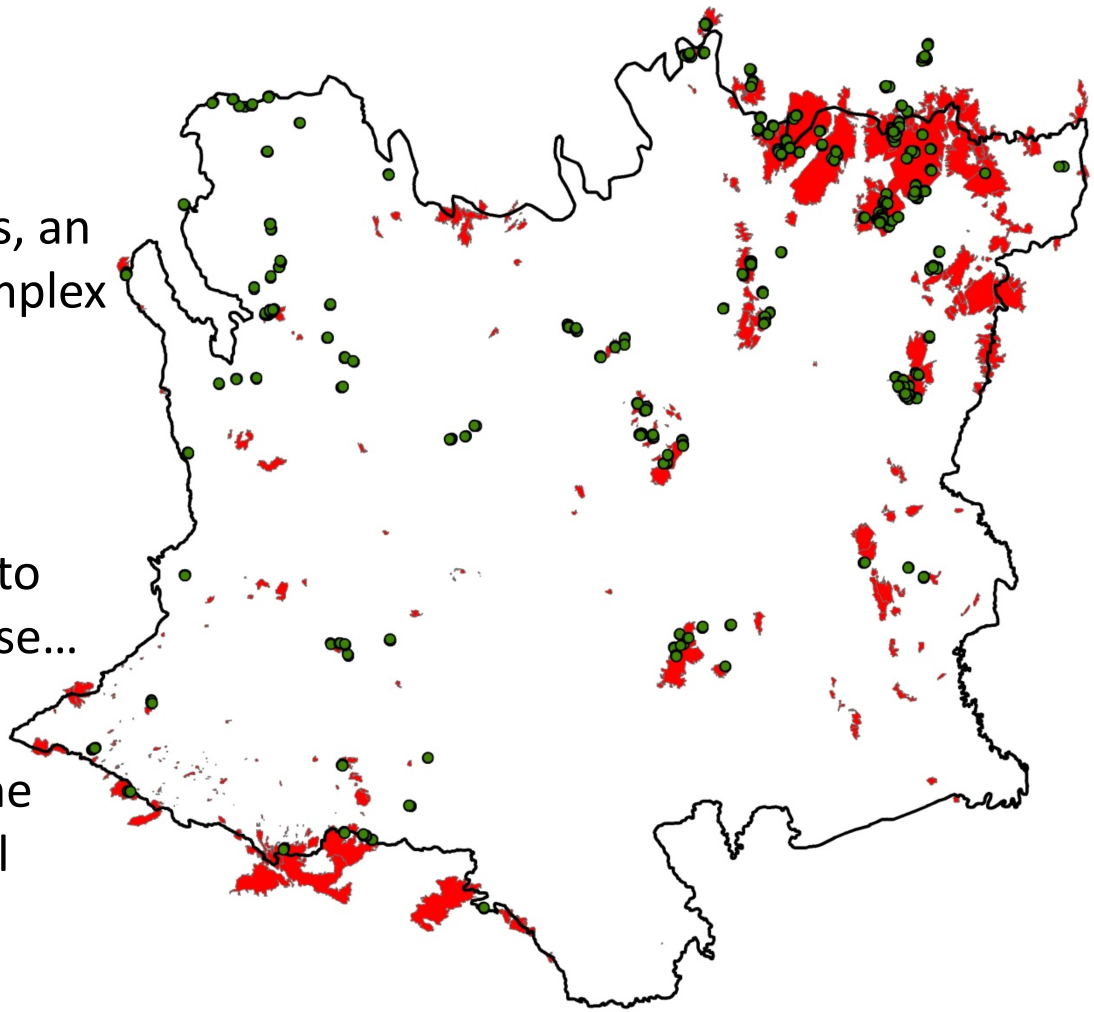
- Ideal situation
  - Similar number of plots in fire frequencies across years post-fire and elevation zones
- Some naturally imposed constraints
  - 2005 and 2006 fire seasons burned a large proportion of high and mid elevation zones
- Not an issue for frequency = 1
- Limited analysis for areas burned 2-3x:
  - > 5 YPF to low elevation zone
  - 3-5 YPF across elevation zones



In other words, an extremely complex and involved analysis!

So I am going to cut to the chase…

…but first some quality control

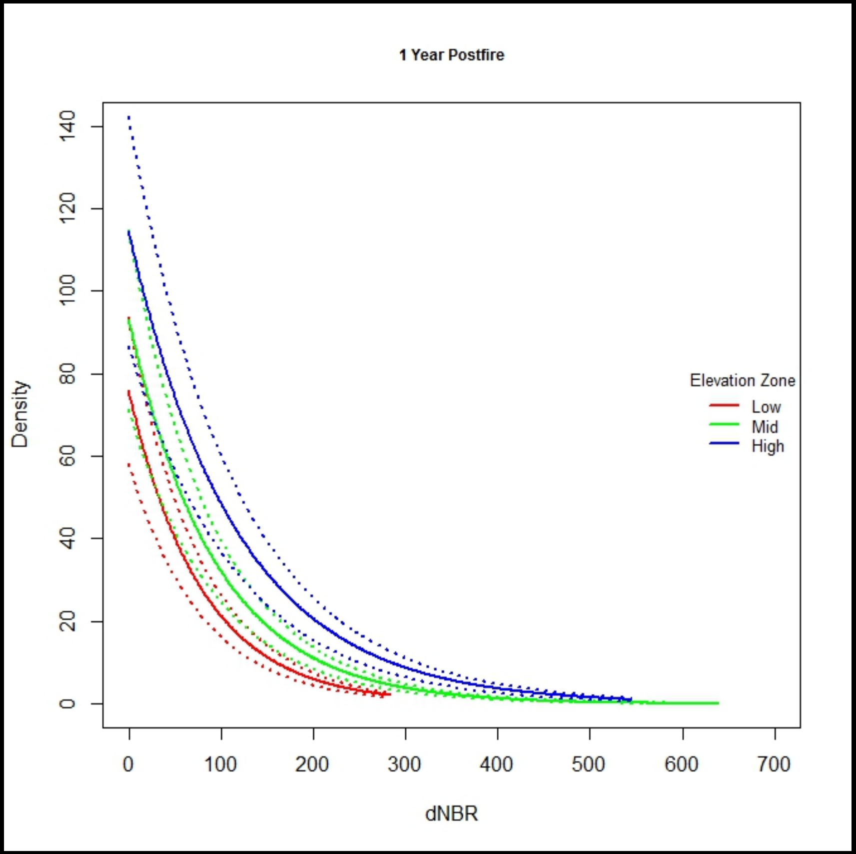


Three Issues Of Great Importance To Vegetation Analyses

- **How well did dNBR compare with on the ground measures of fire severity?**
- **How appropriate was it to use fire severity classes in analyses of:**
  - **Large-scale patterns and trends in severity?**
  - **Vegetation dynamics?**
- **Was there something we could do about the disconnect between dNDVI and dNBR in different time periods**

Was dNBR An Appropriate Measure Of Burn Severity?

YES!



Generalized Linear Mixed Model

A Closer Look At The Burn Severity Classes

- Categorical burn severity layer
  - < 100 dNBR = Unburned
  - 100 – 269 dNBR = Low severity
  - 270 – 659 dNBR = Moderate severity
  - > 660 dNBR = High severity
  - If the severity classes were an appropriate index for analyses across fires then we should see distinct and clear separation of dNBR curves among the severity classes
  - Addresses the question “What is a good remotely sensed measure of fire severity?”

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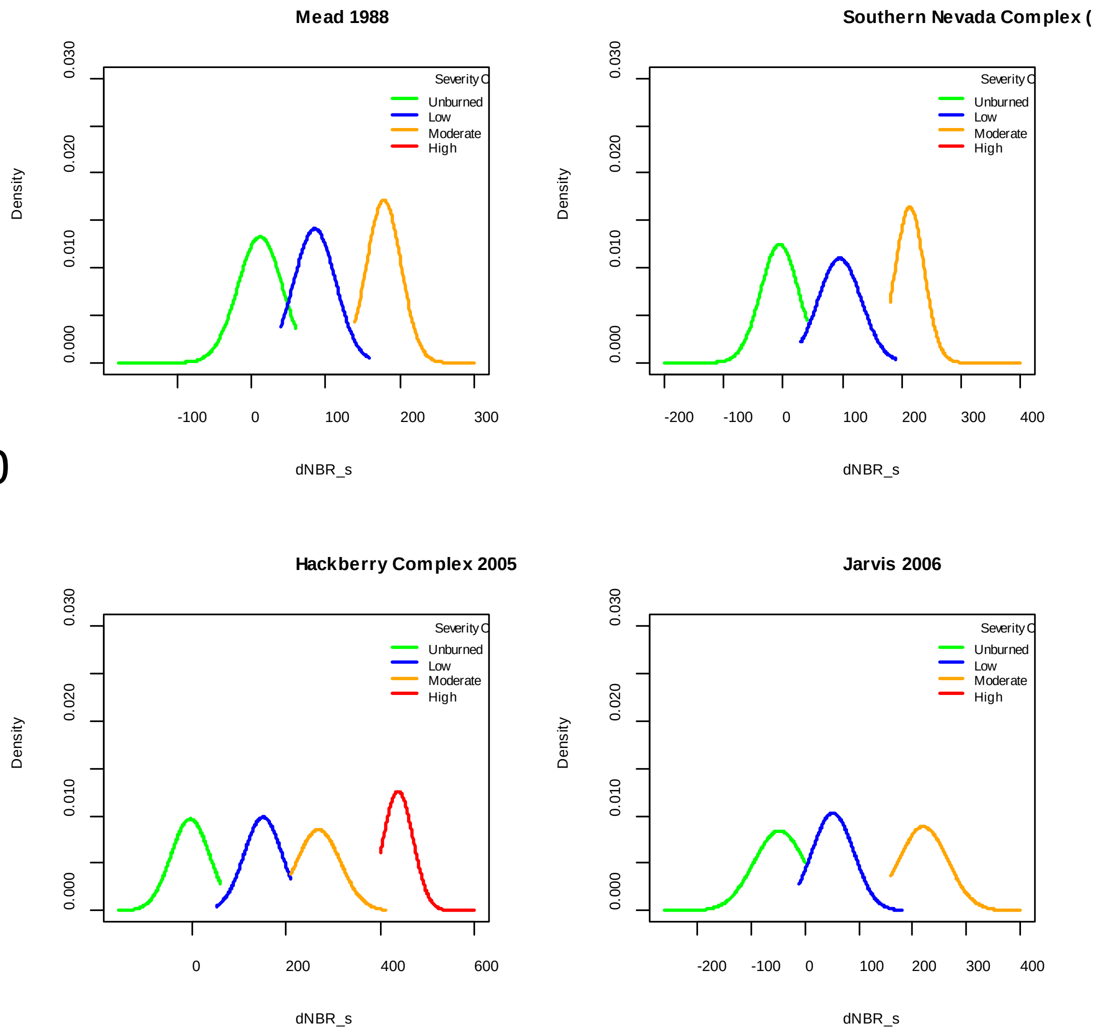
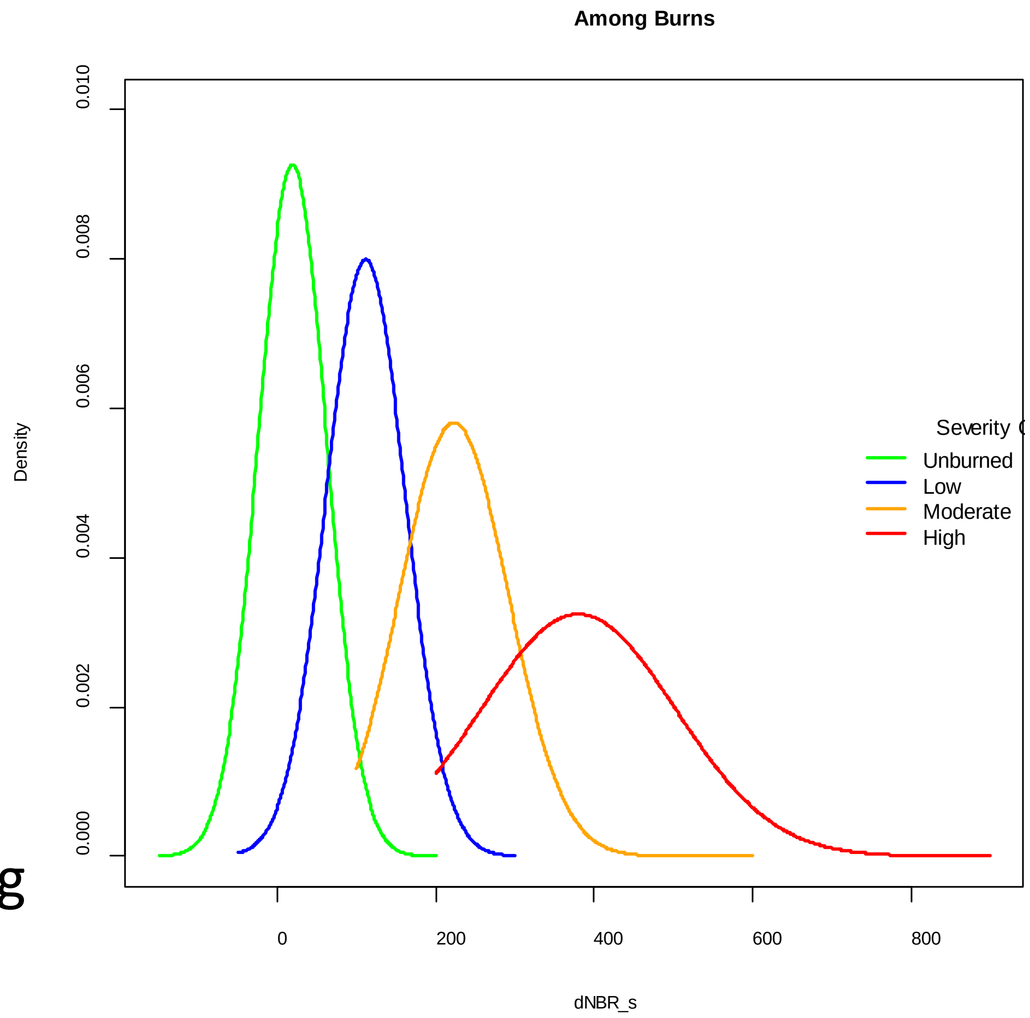
Separation in dNBR Curves Within Burns

- Approach
  - Generate 250,000 random points across 30 burns
  - Conduct 10,000 bootstrap simulations (N = 60% of points within each of the 30 burn perimeters)
  - Calculate the overlap in the curves among classes
- Found low overlap
  - 2% - 7%



Separation in dNBR Curves Among Burns

- Approach
  - Generate 250,000 random points across 30 burns
  - Conduct 1,000 bootstrap simulations (N = 10,000 points per burn) across the 30 burn perimeters
  - Calculate the overlap in the curves among classes
- Found high overlap
  - 24% - 41%
- Found overlap even among non-adjacent classes

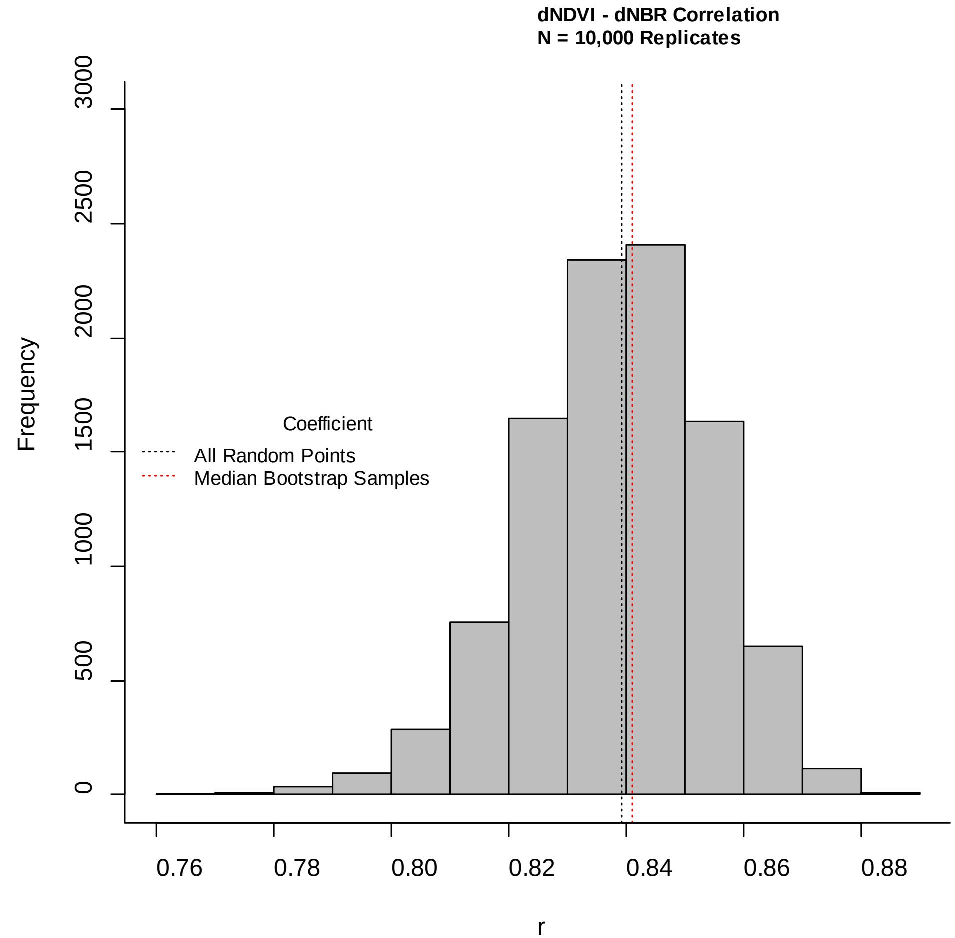


Relationship Between dNBR and dNDVI

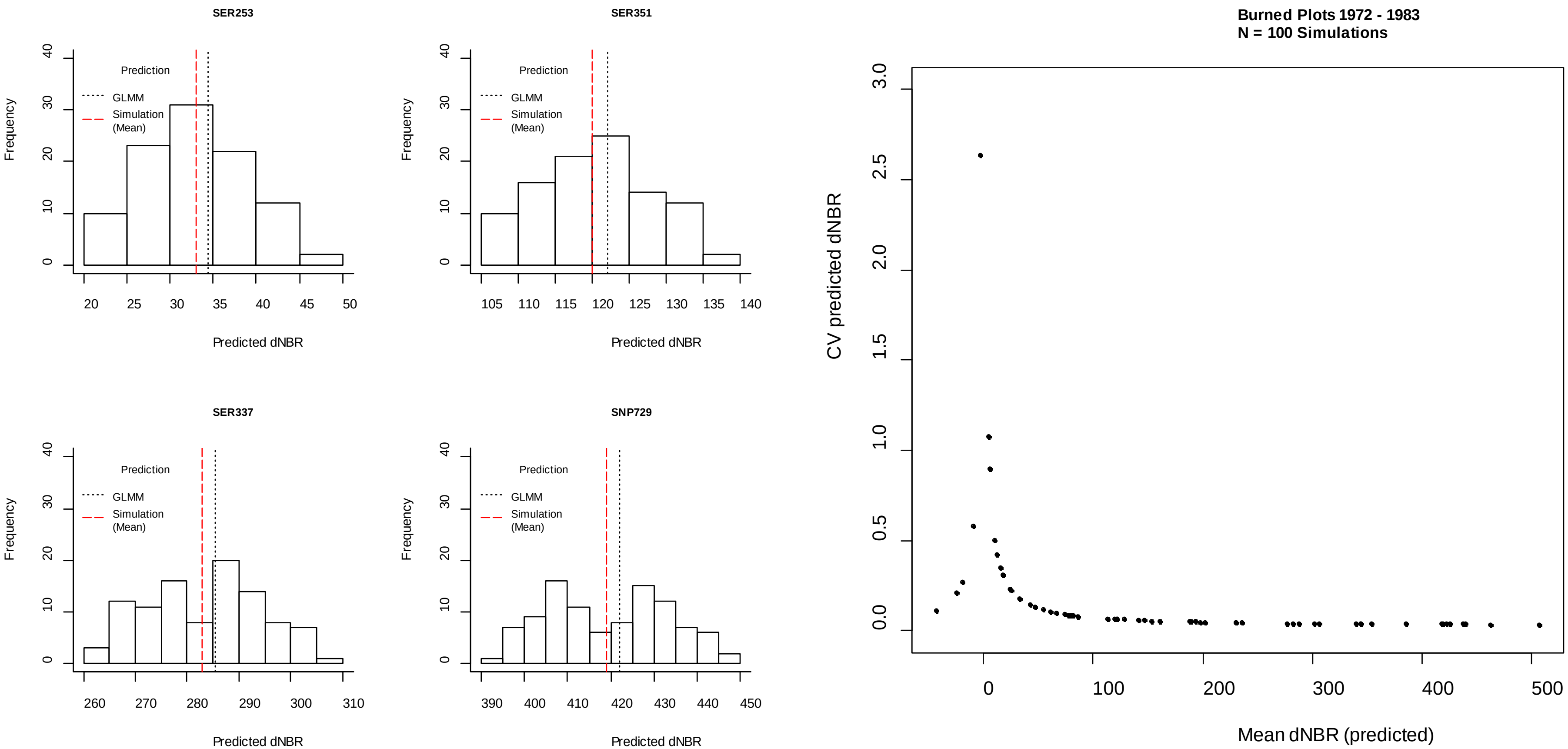
- Could we make reasonable predictions of dNBR 1972-1983 based on dNDVI-dNBR relationship 1984-2010?
  - If so we could use dNBR for vegetation analyses
  - If not could use dNDVI

Relationship Between dNBR and dNDVI

- Approach
  - Generate 66,188 random points across 237 burns
  - Conduct 10,000 parametric bootstrap simulations (N = 1000)
  - Calculate the distribution of correlation coefficient among the simulations
- Found moderately strong correlation
  - r = 0.841



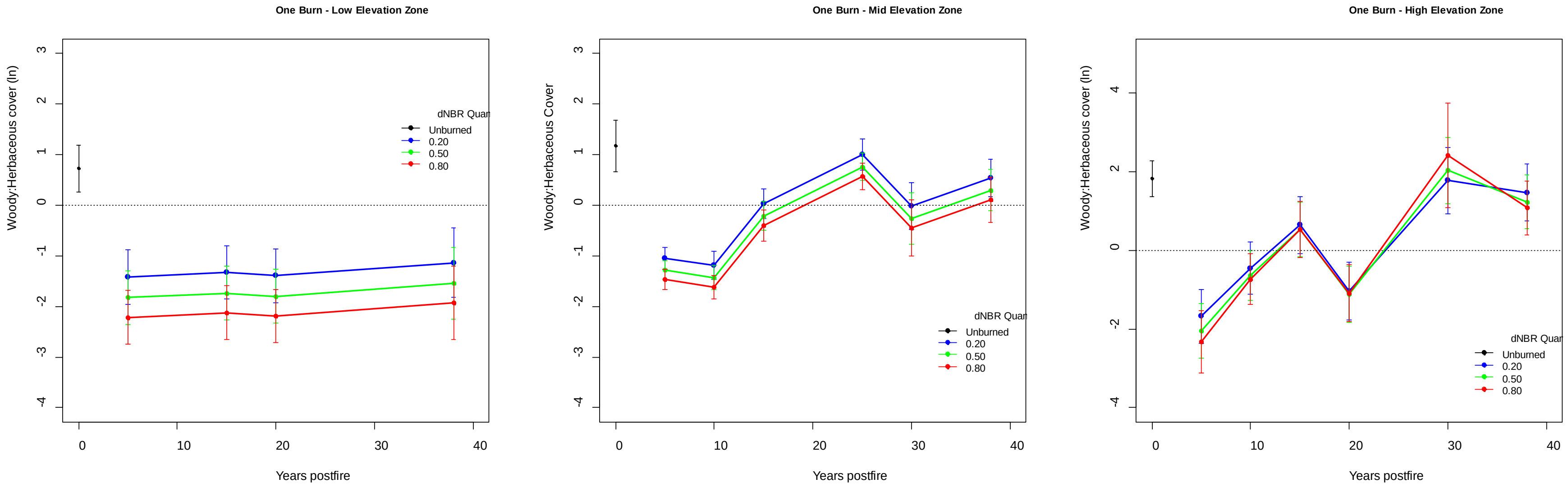
Relationship Between dNBR and dNDVI



Predicted dNBR 1972-1983 from bootstrapping within range of ≈ 50 units

Structure

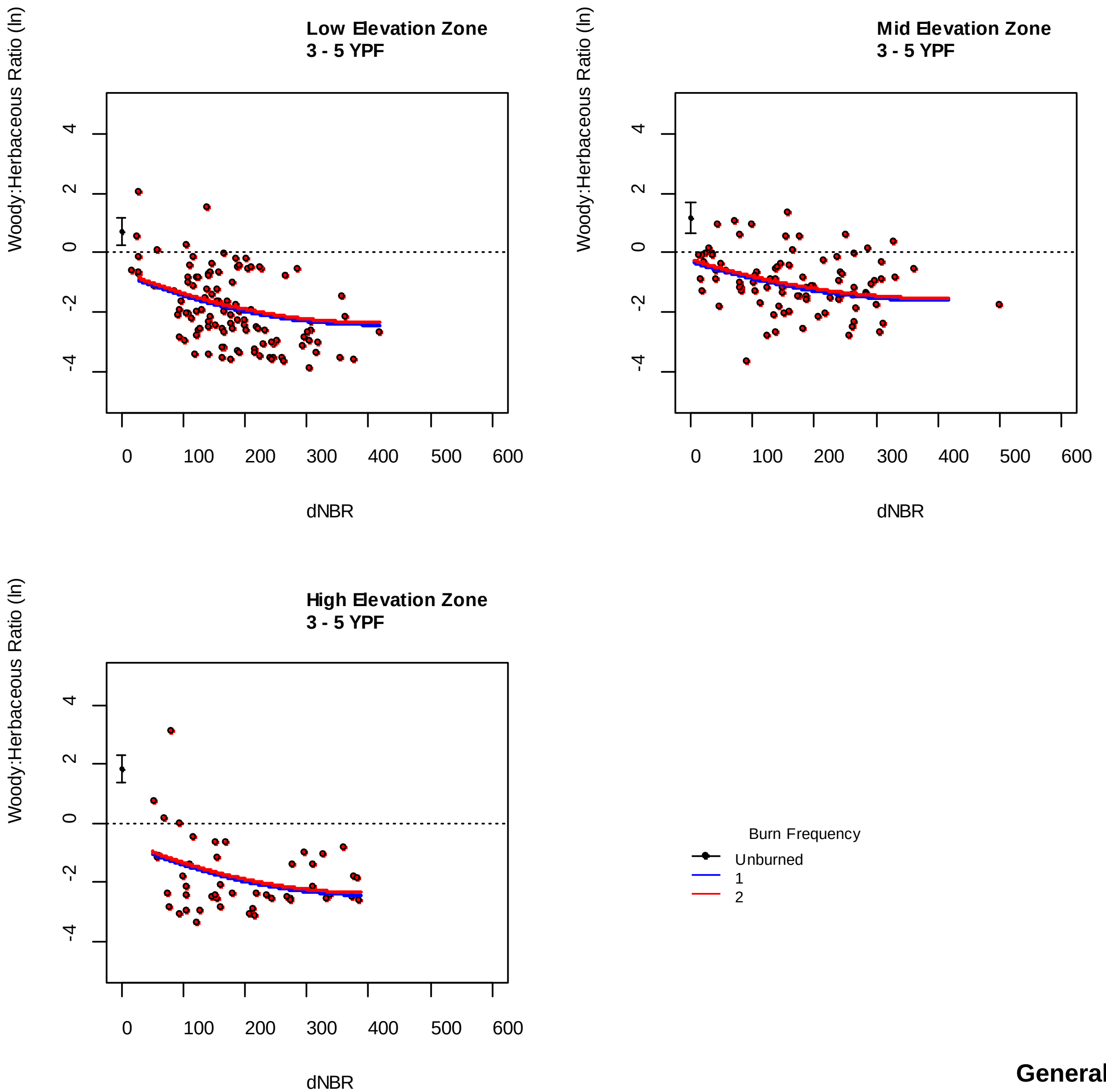
Fire Frequency = 1



Generalized Linear Mixed Model

Structure

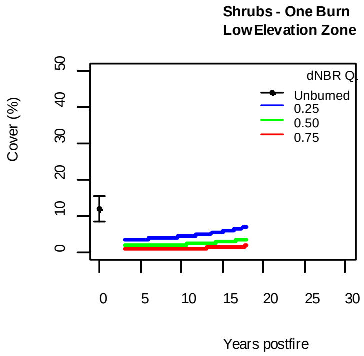
Fire Frequency = 1 or 2

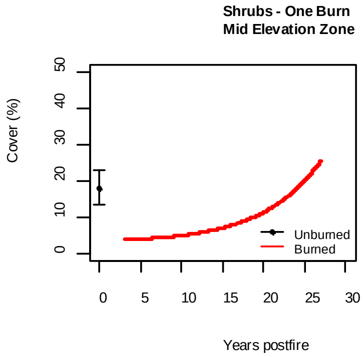


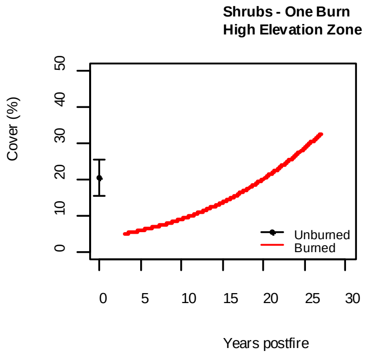
Generalized Linear Mixed Model

Structure

Fire Frequency = 1



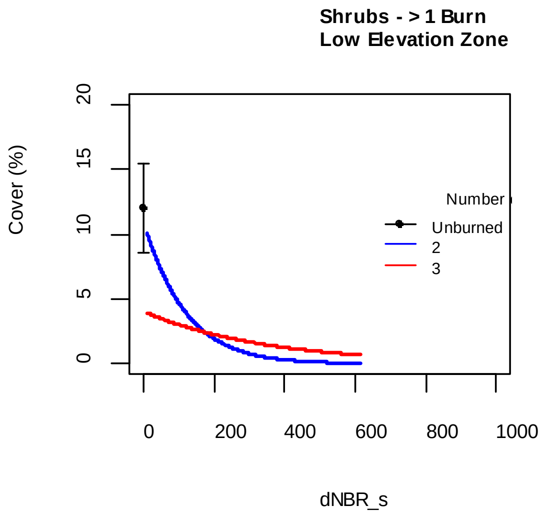


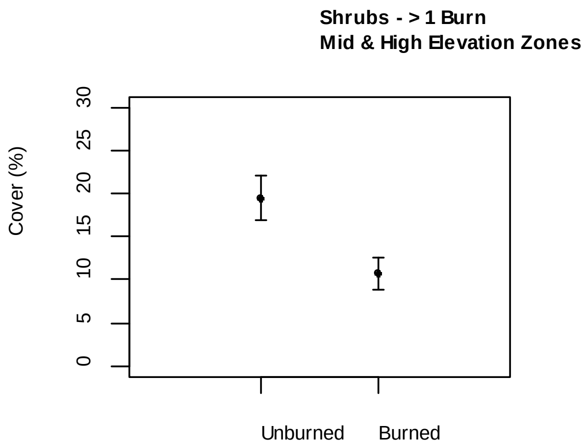


Generalized Linear Mixed Model

Structure

Fire Frequency = 1 or 2

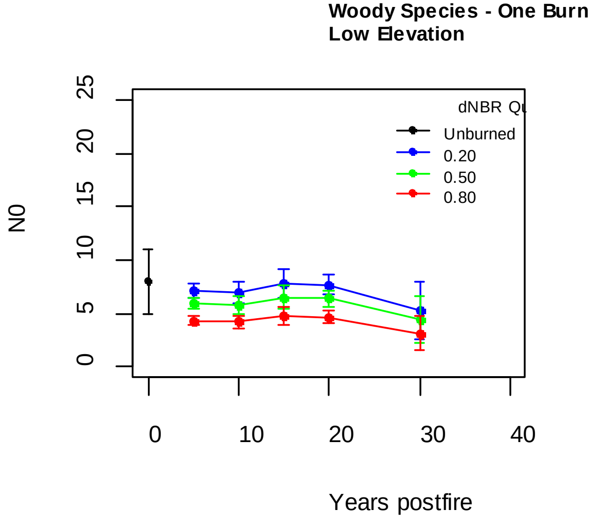




Generalized Linear Mixed Model

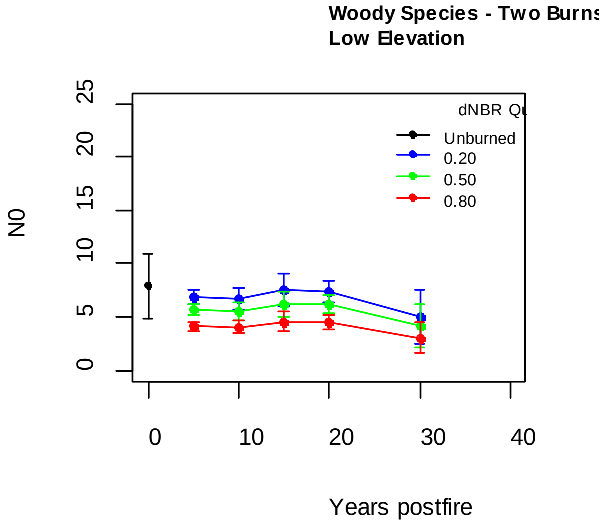
Diversity

Fire Frequency = 1 or 2



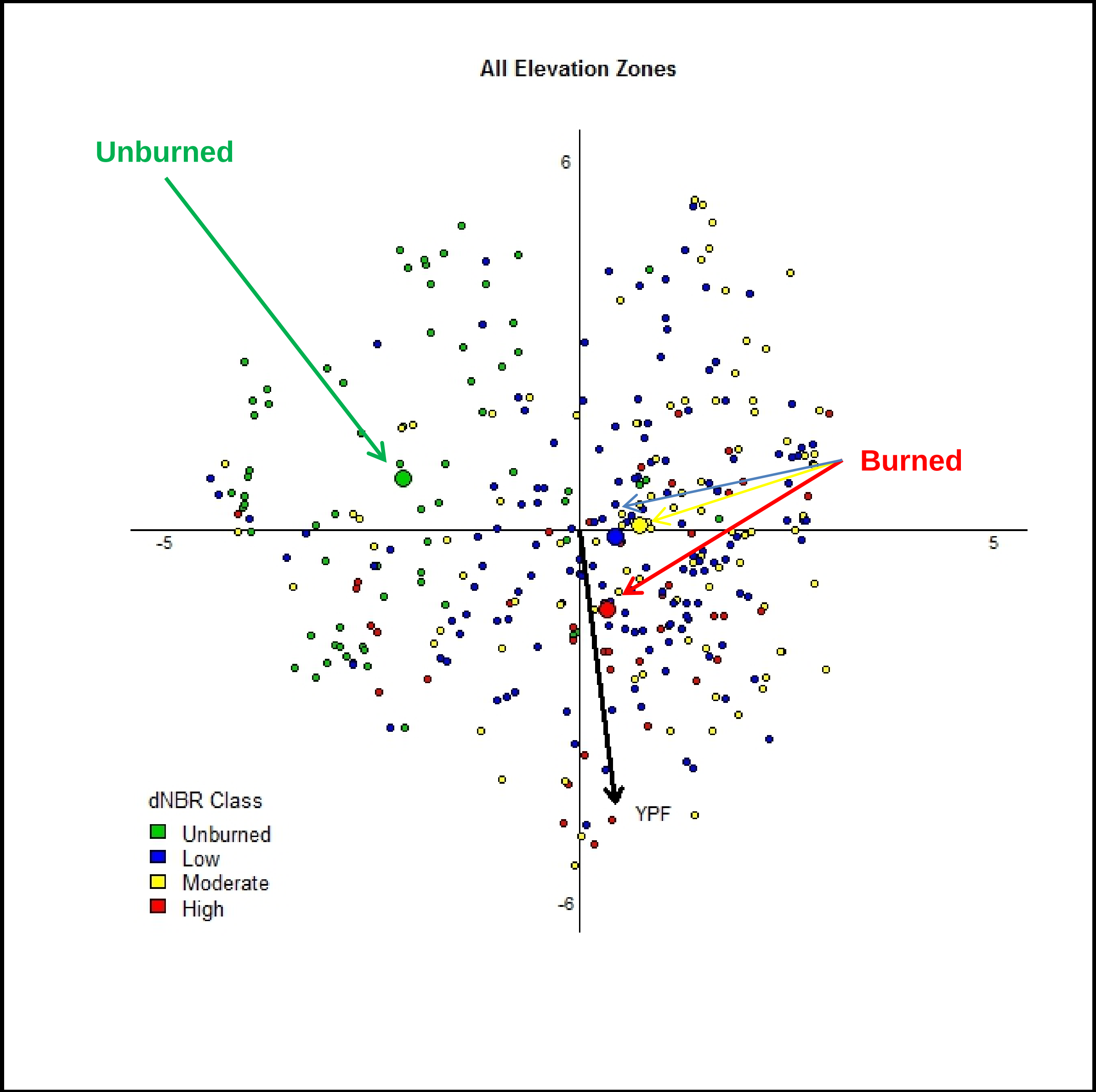
Reduction in woody cover does not ***necessarily*** mean a decrease in species richness

Depends on severity



Generalized Linear Mixed Model

Community Composition

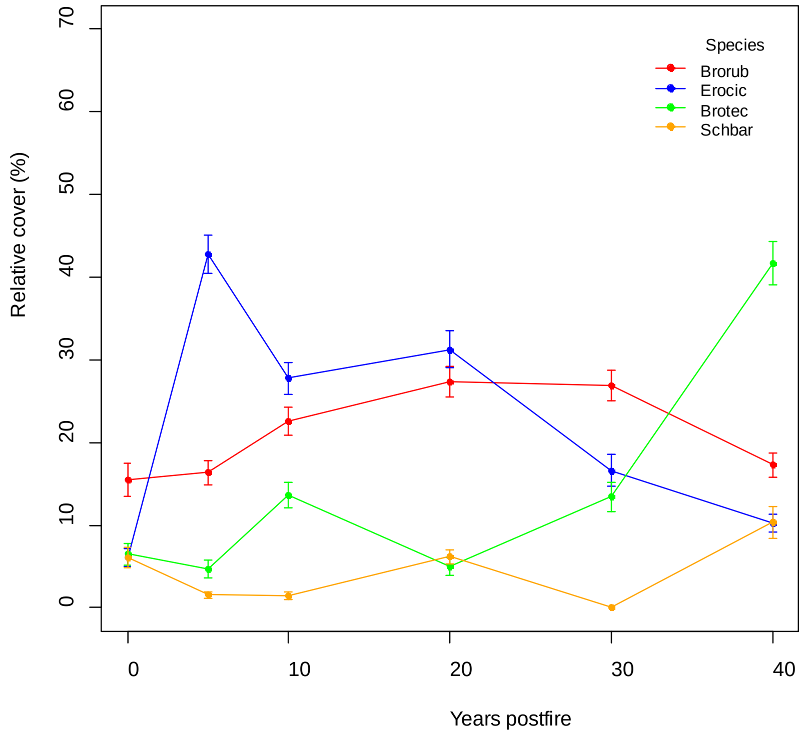


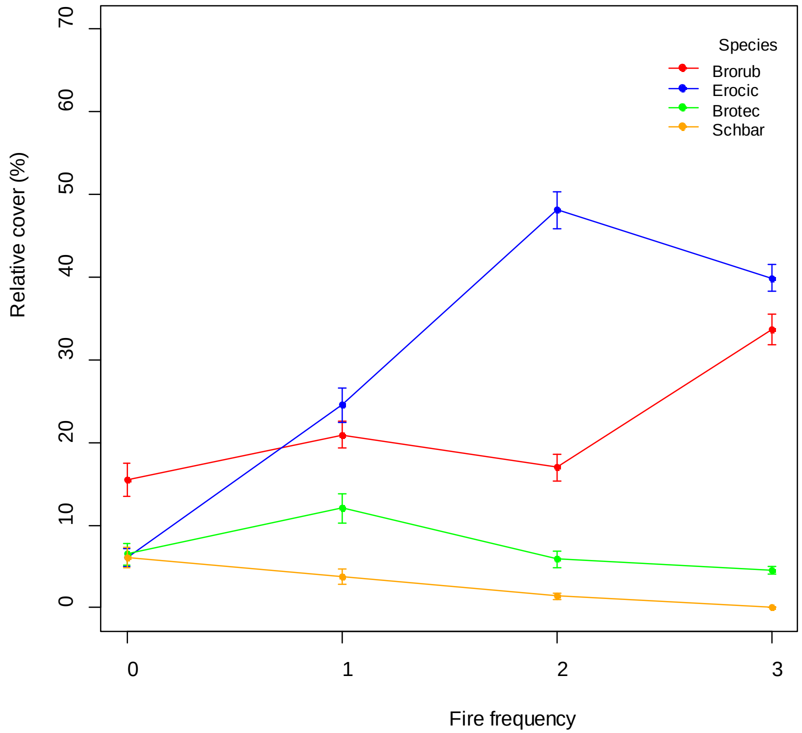
Species Identity & Cover

- General trajectories are AWAY from unburned conditions
- Low severity quantile extremely scattered
- Moderate severity quantile moderately scattered
- High severity quantile least scattered
- ***SOME plots in all severity quantiles were similar to unburned plots***

Distance-based redundancy Analysis

Cover Of Non-Native Annual Grasses & Forbs





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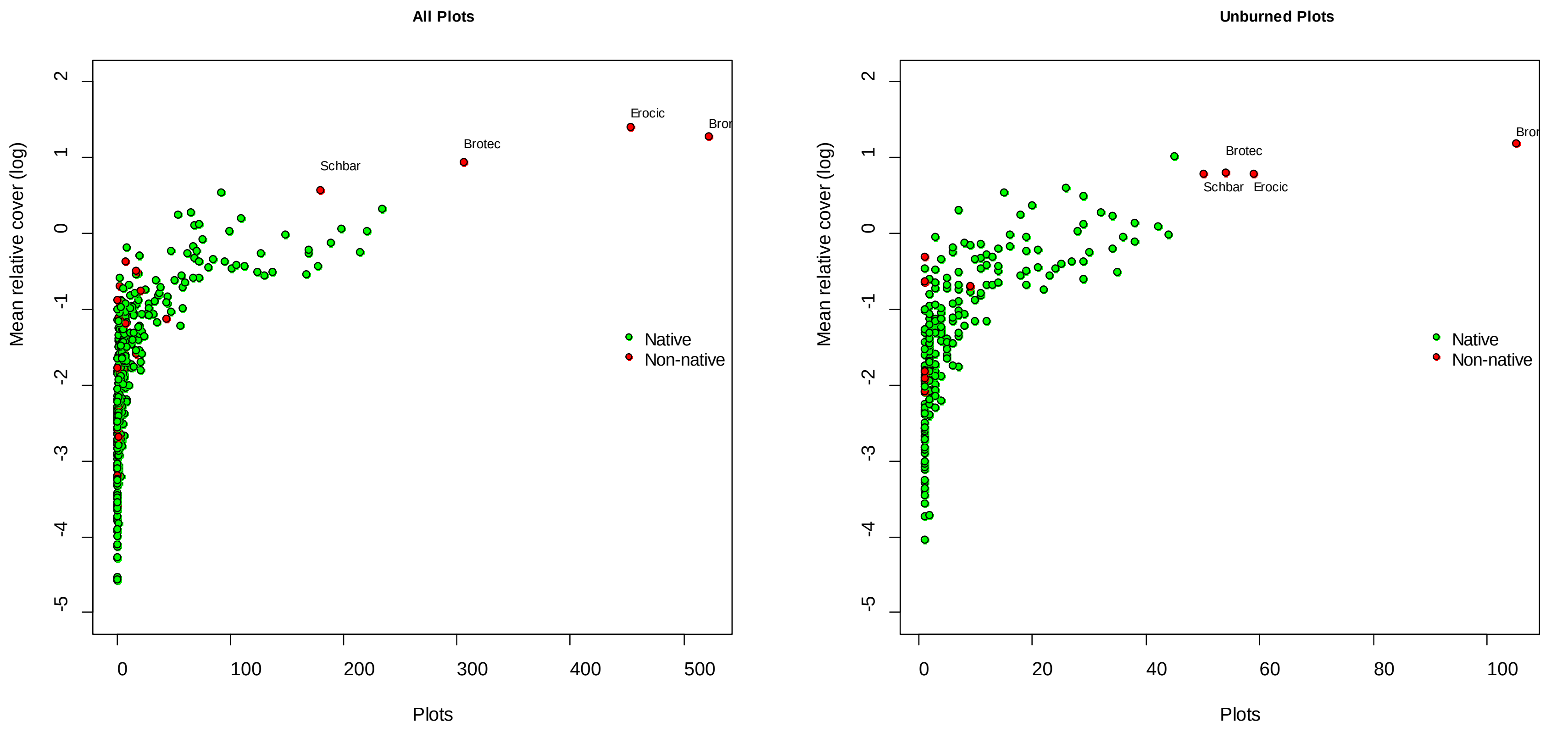
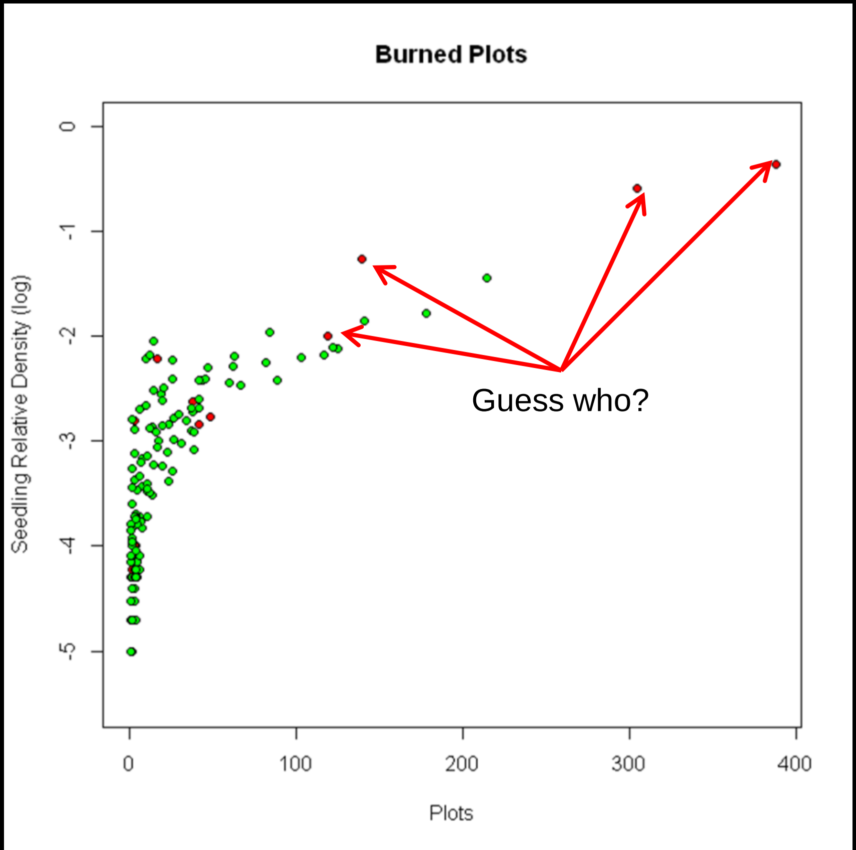
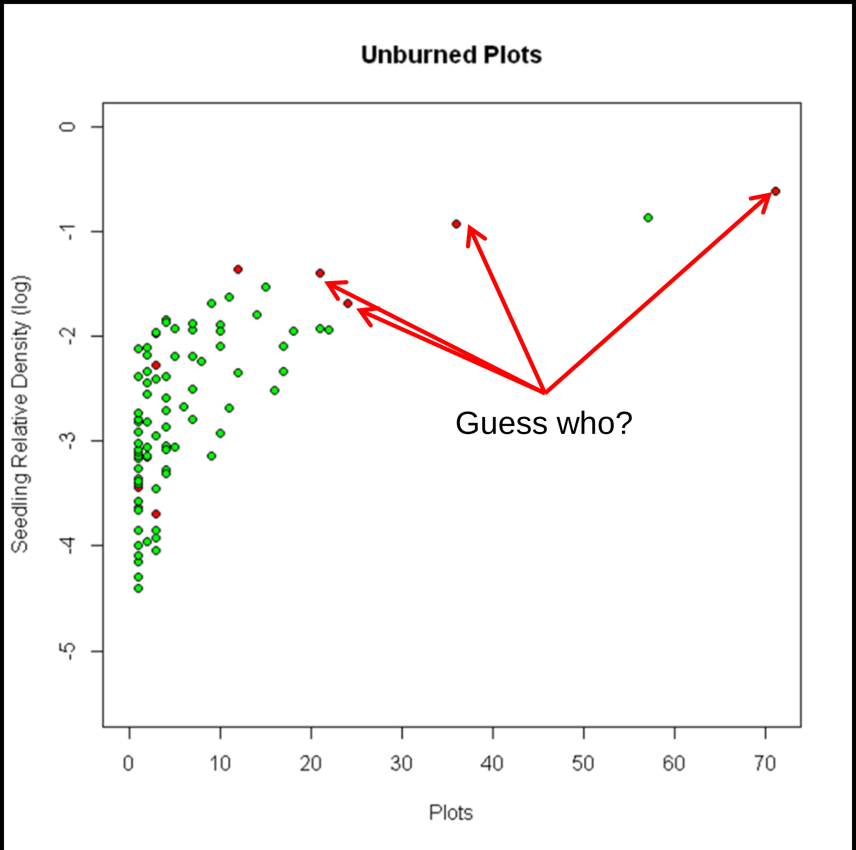
Cover Of Non-Native Annual Grasses & Forbs



USGS

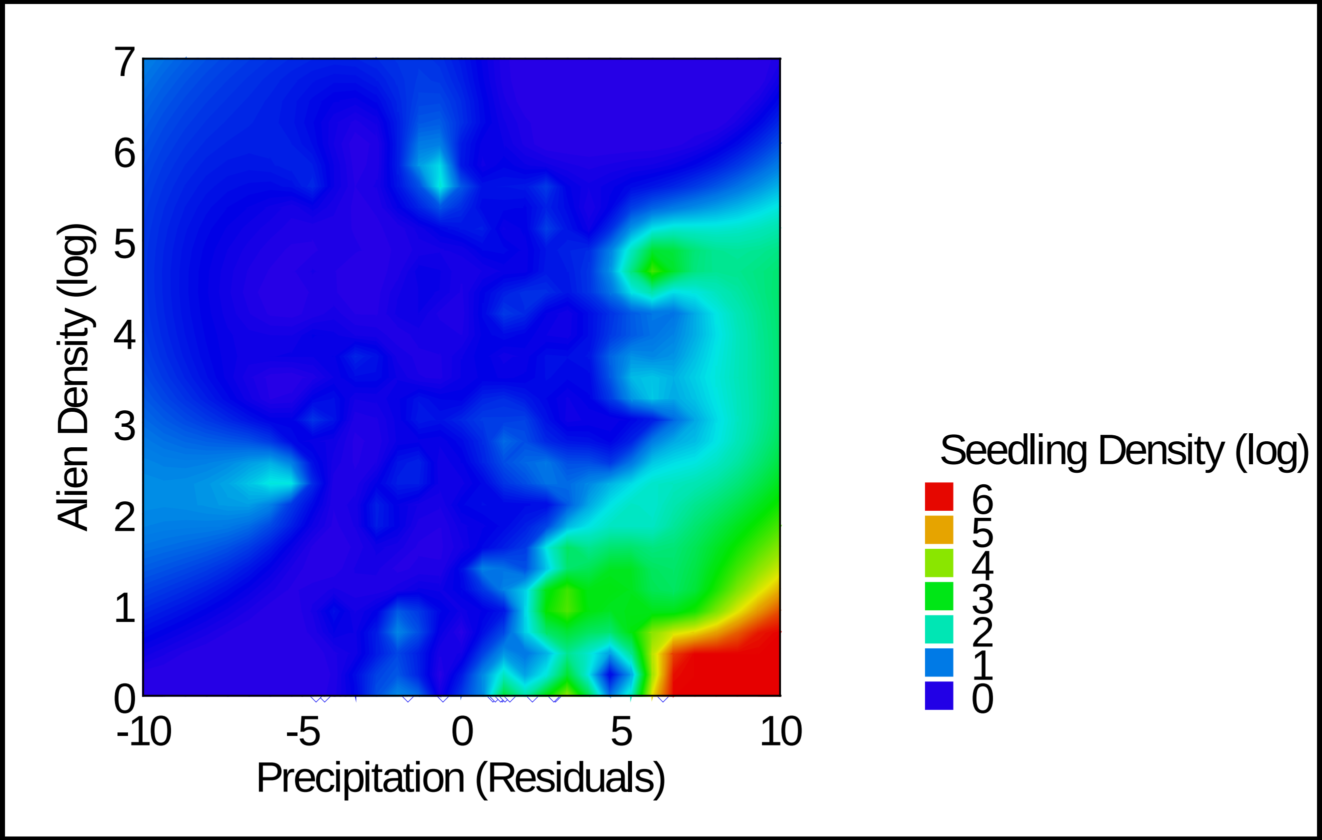
Bridging The Above And Below Ground





Are the hints of future states hidden in the seedbank?

Narrow Window Of Seedling Establishment



- Precipitation
- Non-native density

Grass Fire Cycle Or Abrupt Transition?

- Rapid transition to alternative state after a single burn *with high severity*
  - Most likely in low elevation zone
- Fire as an event instead of short return intervals
  - Non-native annuals dominate herbaceous layer or seed bank of unburned communities ***at all elevations***

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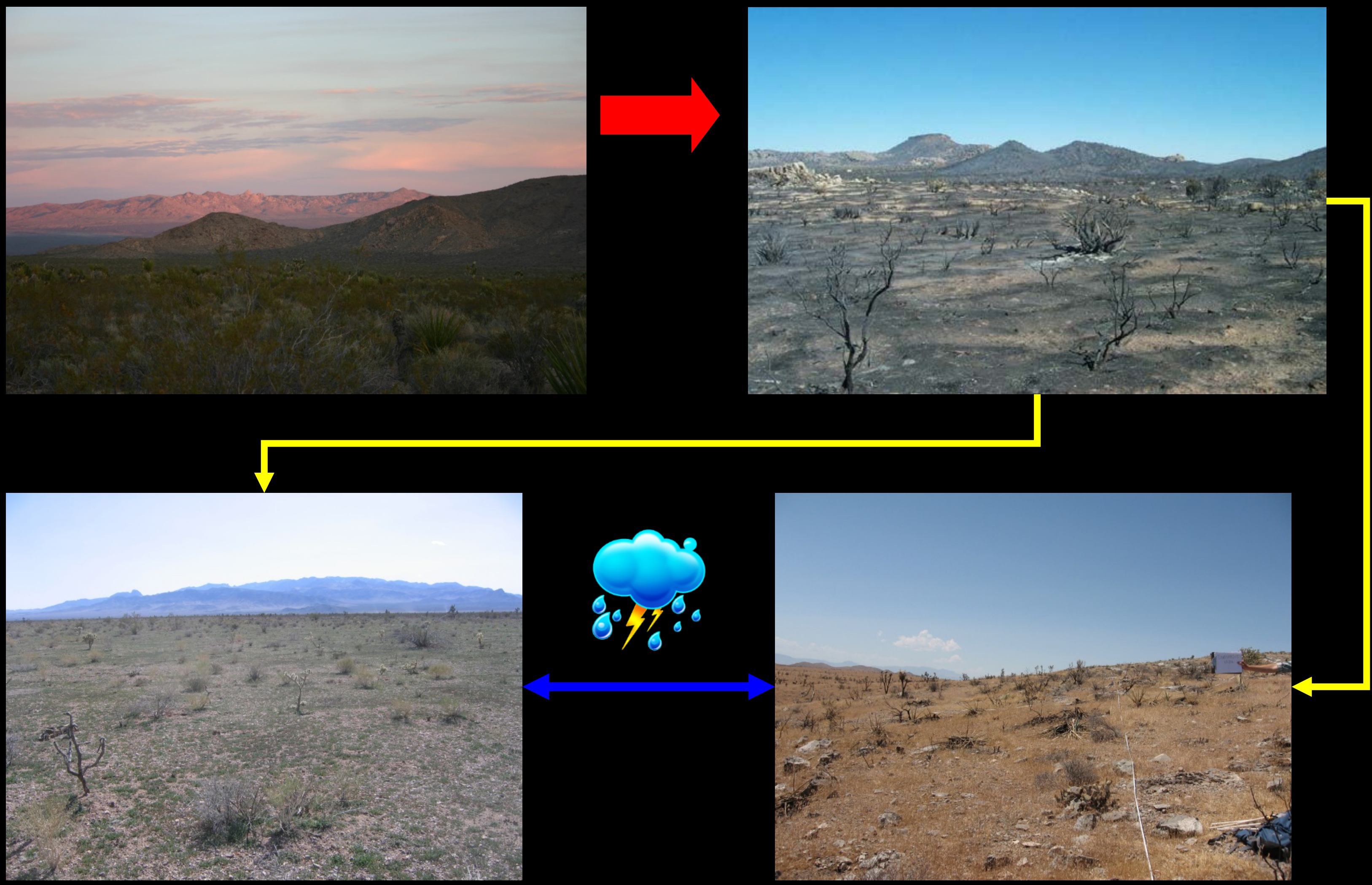
Classiscal Succession Patterns …

…or multiple alternative states



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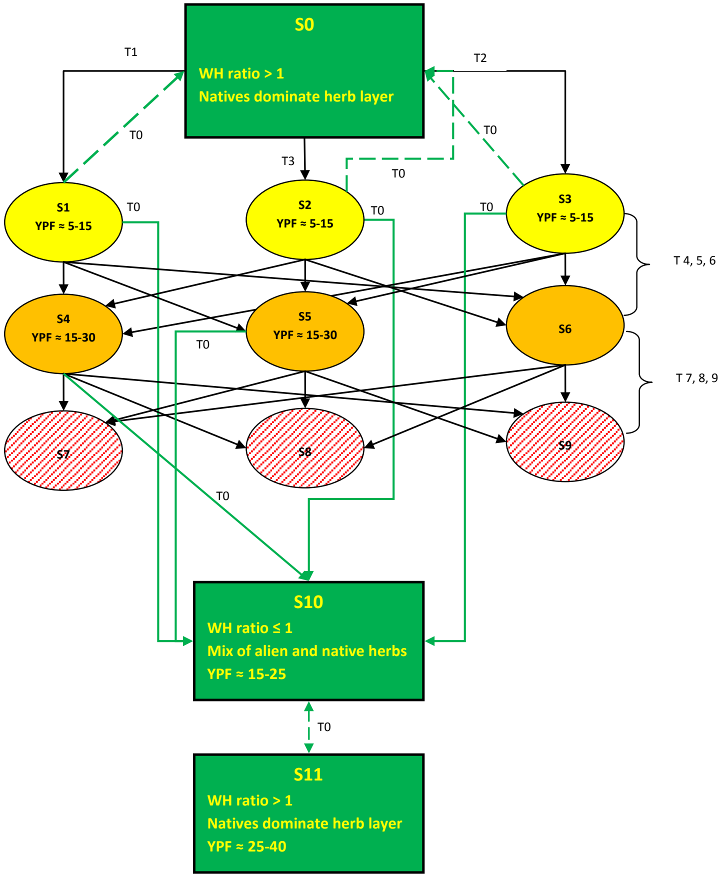
State-Transition Models

- Summarize patterns in postfire vegetation dynamics
- Separate model for each elevation zone



USGS

A Caveat

- The curse of the chronosequence
  - Chronosequences are ***NOT*** time series
  - Interpretation depends on *similarity* in conditions over time
  - Prevents estimates of transition rates in the state-space models

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Pulling It All Together

- Stochastic community assembly rather than deterministic, directional succession
  - Community trajectories shaped by burn severity, frequency and competition from non-native herbaceous species

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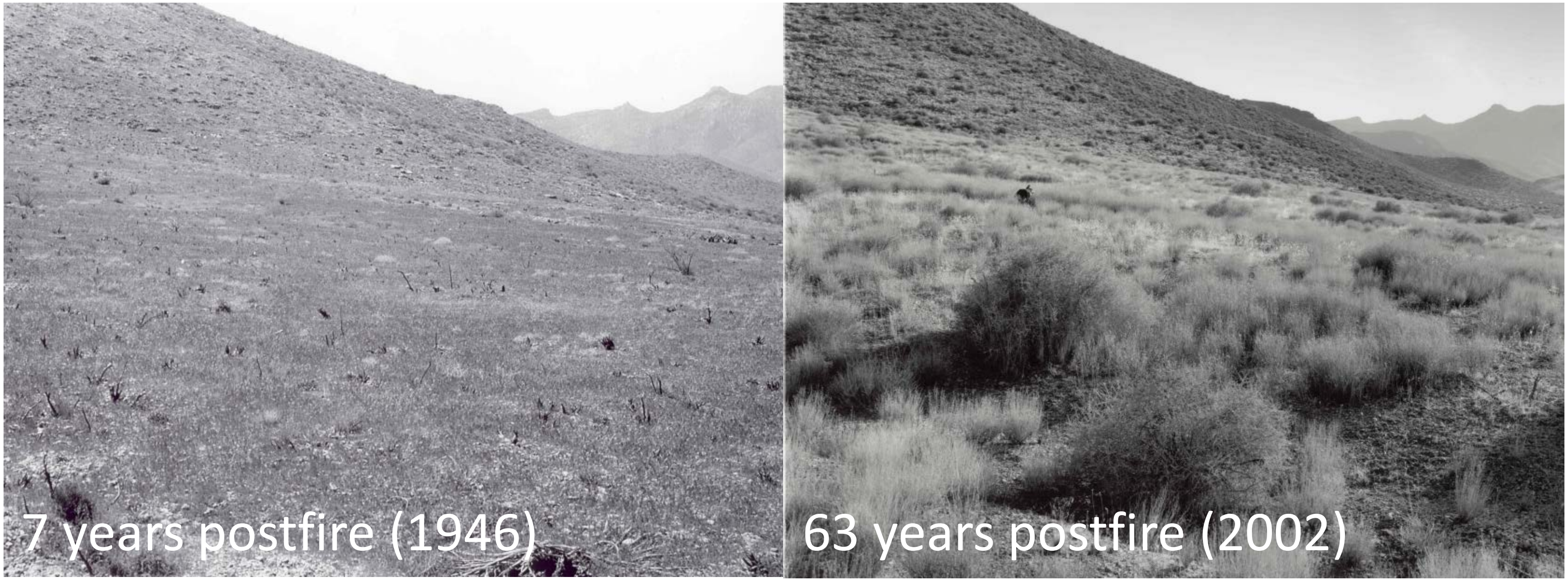
Alternative States May Persist For Long Periods Of Time



Photos by A. Croft, 12 May 1946 and D. Oldershaw, 9 May 2002. The view is looking SW inside the mouth of Horse Spring Basin, in the northeastern Mojave Desert, Lincoln County, NV.

USGS

Long term effects of a single fire in a mesic blackbrush stand showing red brome and lack of blackbrush recovery

Modeling Invasive Plant Distributions in the Mojave Desert

Aim

- To move from patterns of invasion at the plot to ecoregion scale

Rationale

  - To determine invasions in remote areas
  - To identify potential interactions between species
  - To assist in fire hazard planning

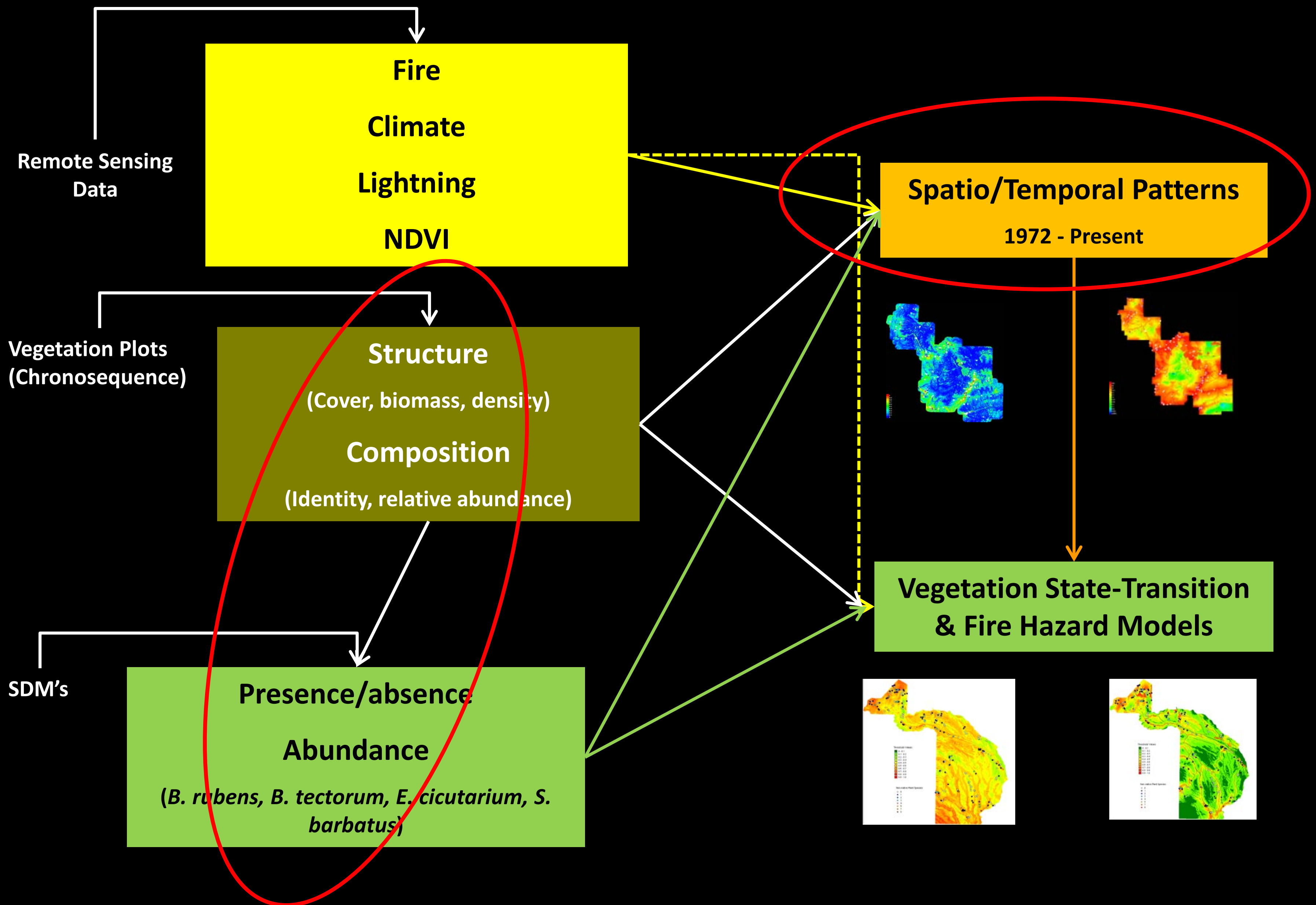
Erodium cicutarium

Bromus rubens

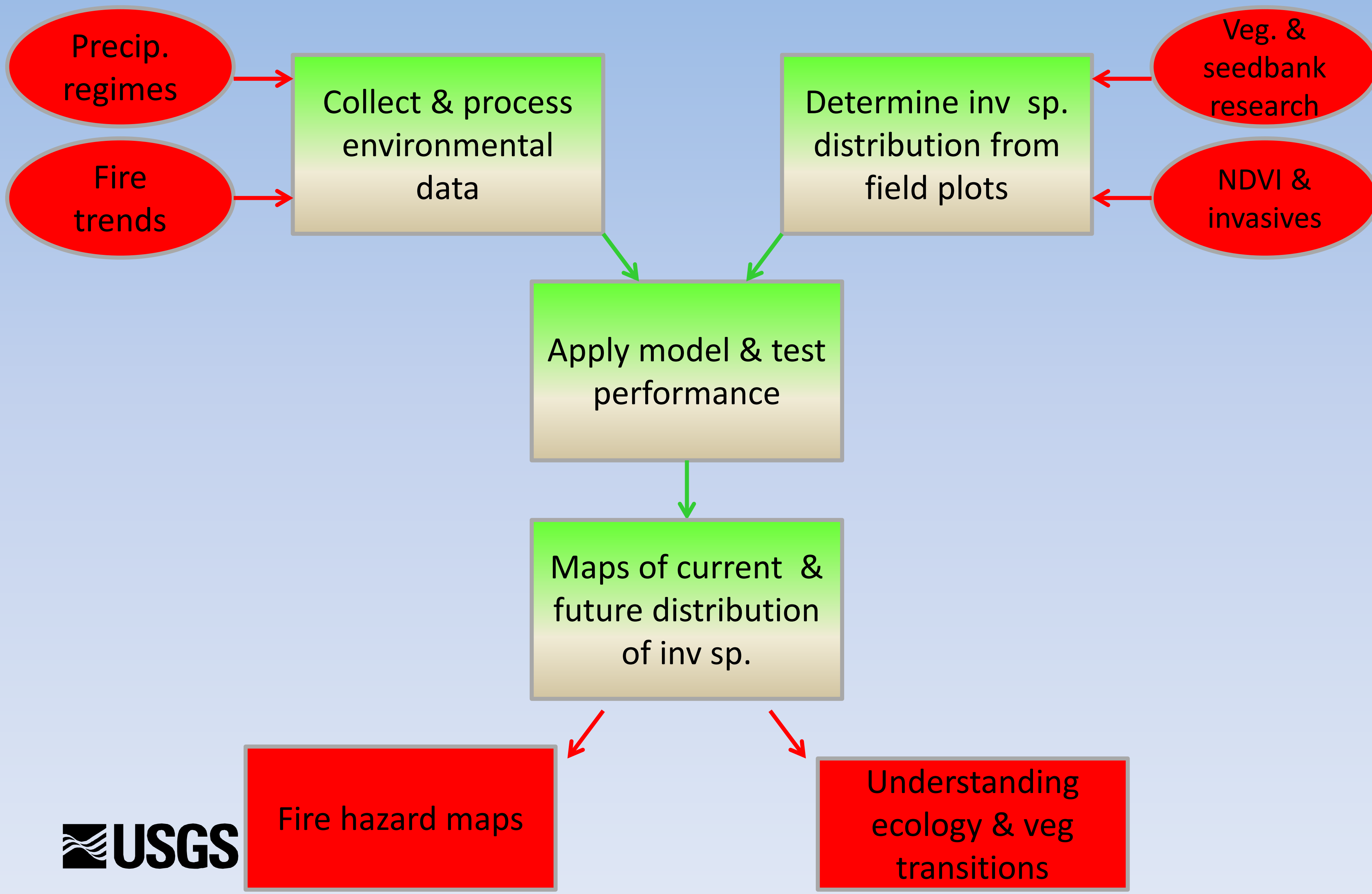
B. tectorum

Schismus barbatus

Integrated Multi-Scale Project



Species Distribution Modeling Component



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Compiling Environmental Data

Climate

(1949-1999 & 2050)

Temp: min, max, mean

Precip x 4

Soil & topography

Soil AWC x2

DEM

Aspect

Slope

PRR

Vegetation & NDVI

Vegetation

% herb cover

% tree cover

% bare ground

NDVI peak

NDVI peak doy

USGS

Preparing Environmental Data

1. Tested for correlations

- e.g., DEM with min, max, mean temp
- annual precip and 3 seasonal precip

2. Final list of variables in model

- slope, aspect, PRR, mean temp, total annual precip, NDVI, and % Tree cover

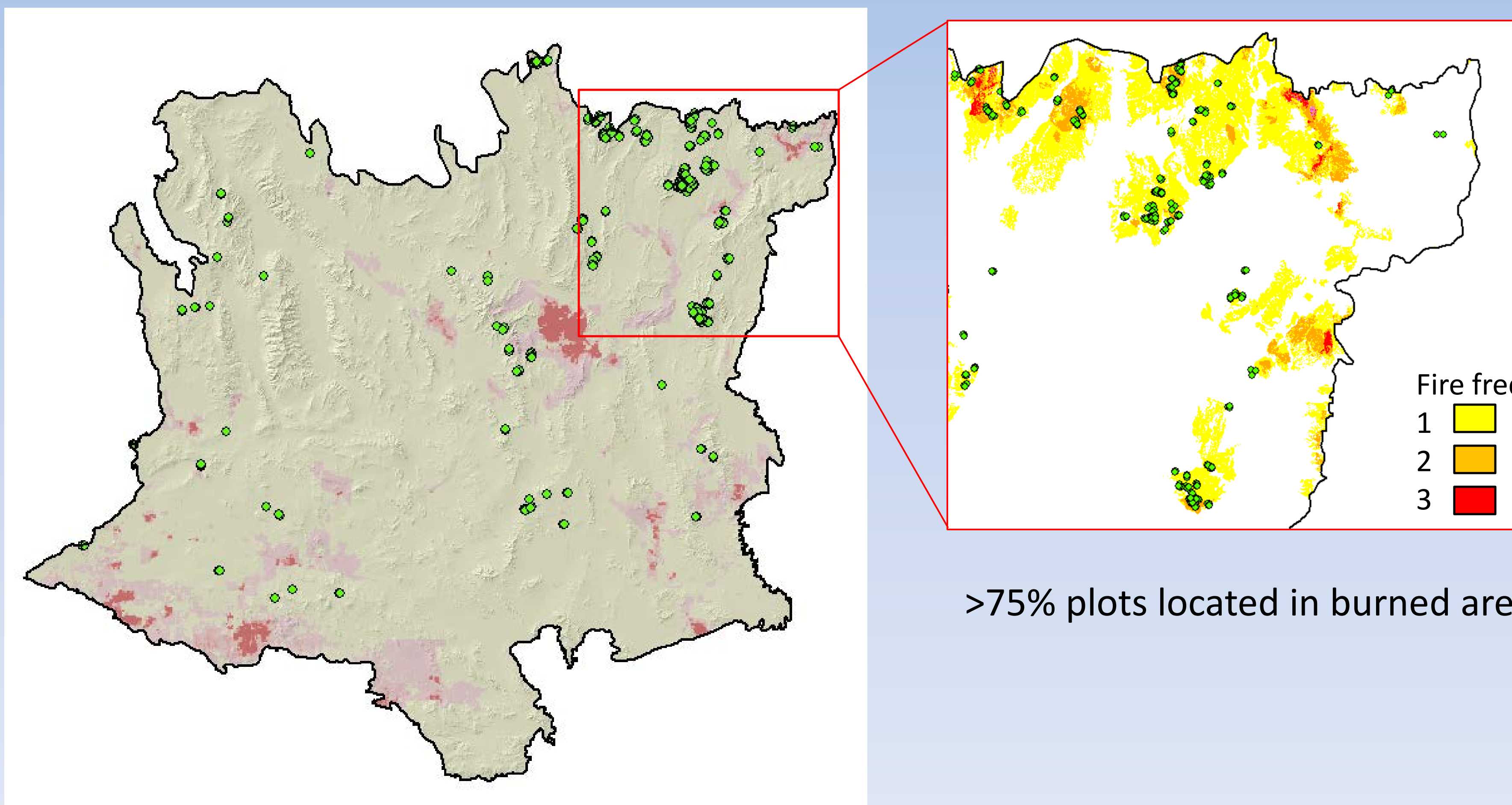
3. Tested for circularity

- % cover *B. rubens* and peak NDVI (r^2=0.04)
- % cover *B. rubens* and % herbaceous cover (r^2=0.01)

USGS

Compiling Field Data

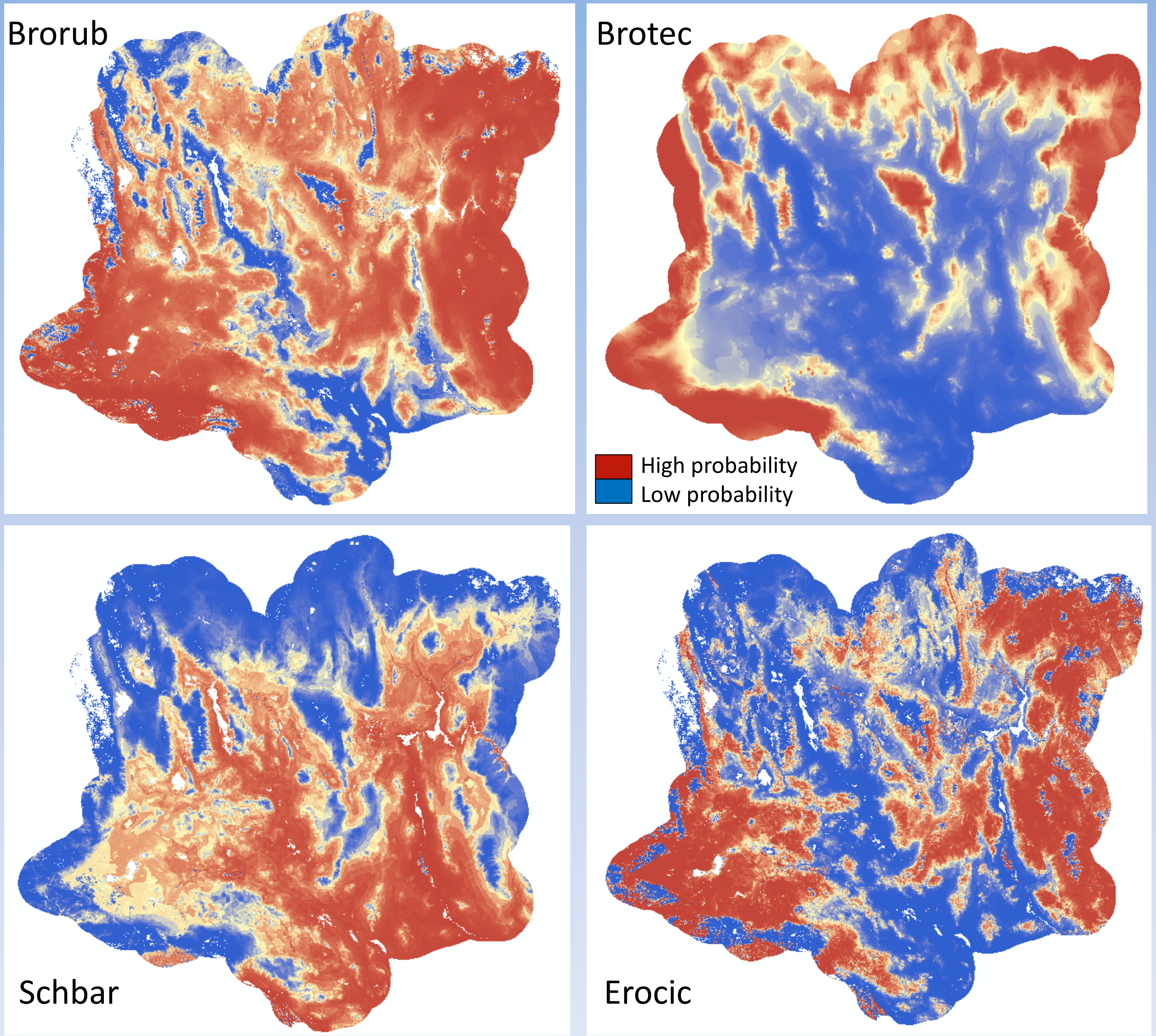
541 plots where *B. rubens* present



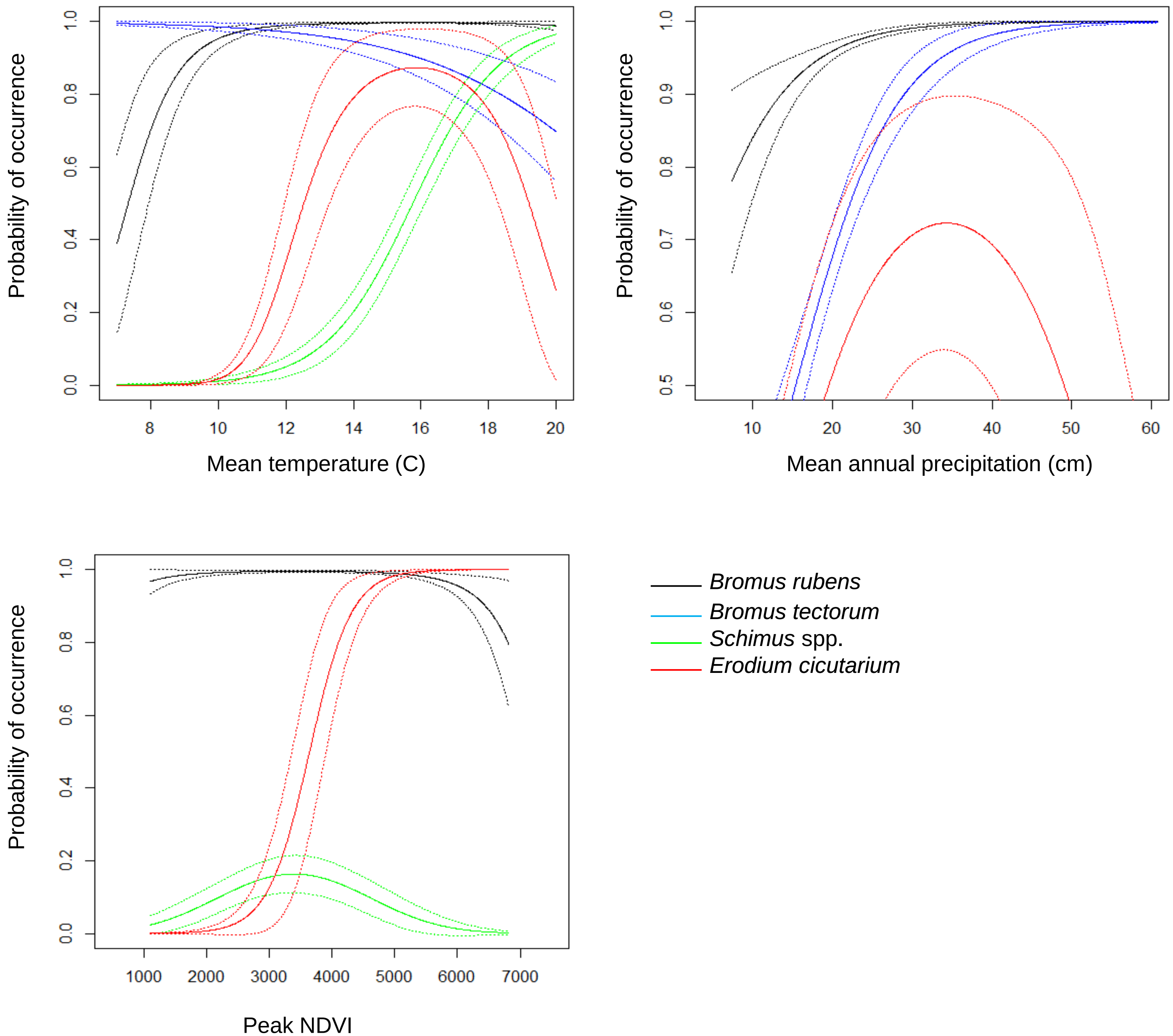
>75% plots located in burned areas

Species Distribution Model Results

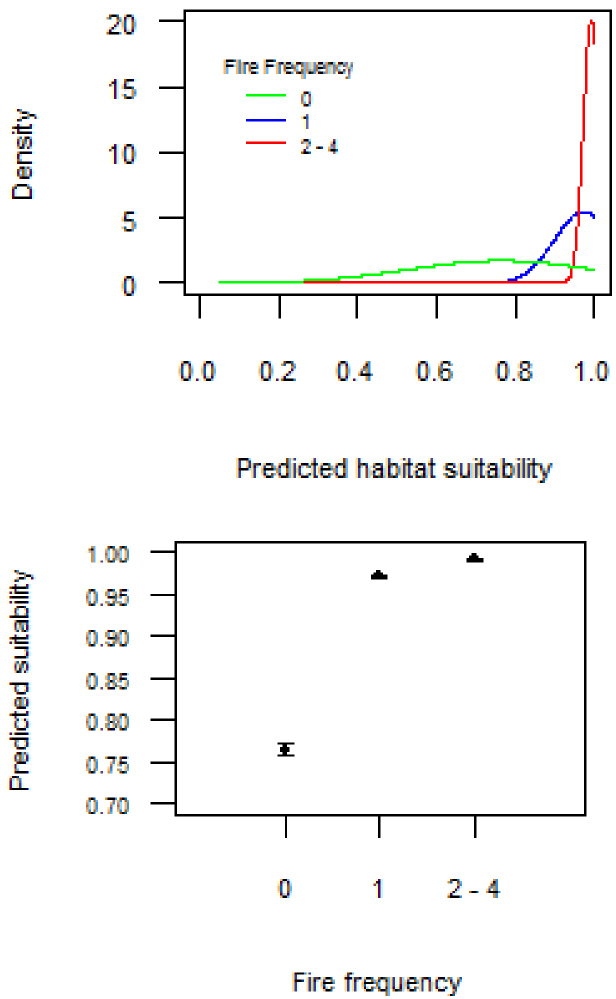
	2 *bromus* comb	*B. rubens*	*B. tectorum*	*Schimus* spp.	*E. cicutarium*
Pseudo r^2	0.339	0.368	0.198	0.311	0.611
RMSPE	3.441	2.539	1.300	2.503	4.761
Std Error	0.059	0.062	0.056	0.082	0.138


Brorub
Brotec
High probability
Low probability
Schbar
Erocic

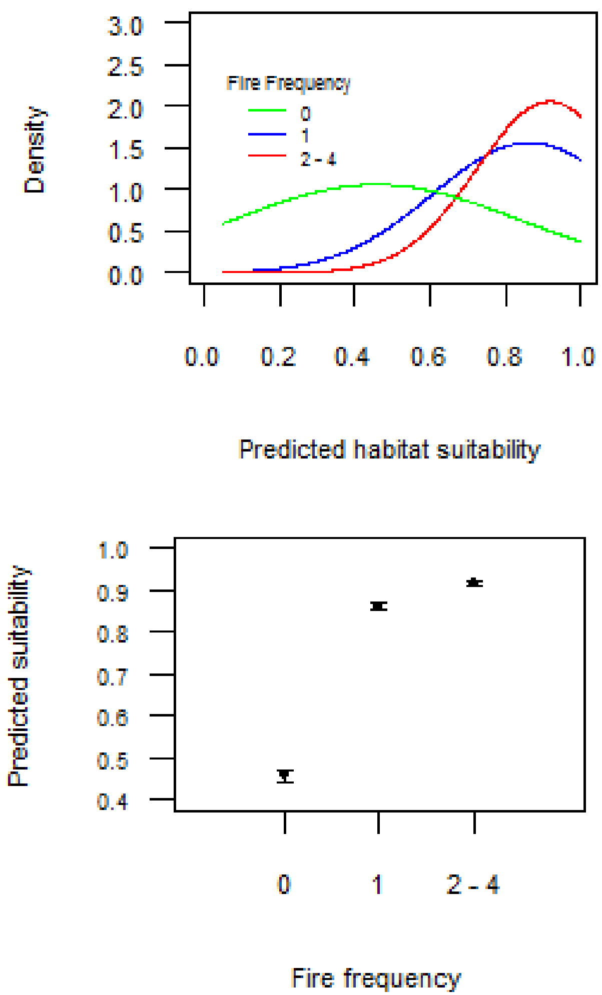
Key Variables Identified



Patterns of Invasion and Fire



2 *Bromes* spp. combined



Erodium cicutarium

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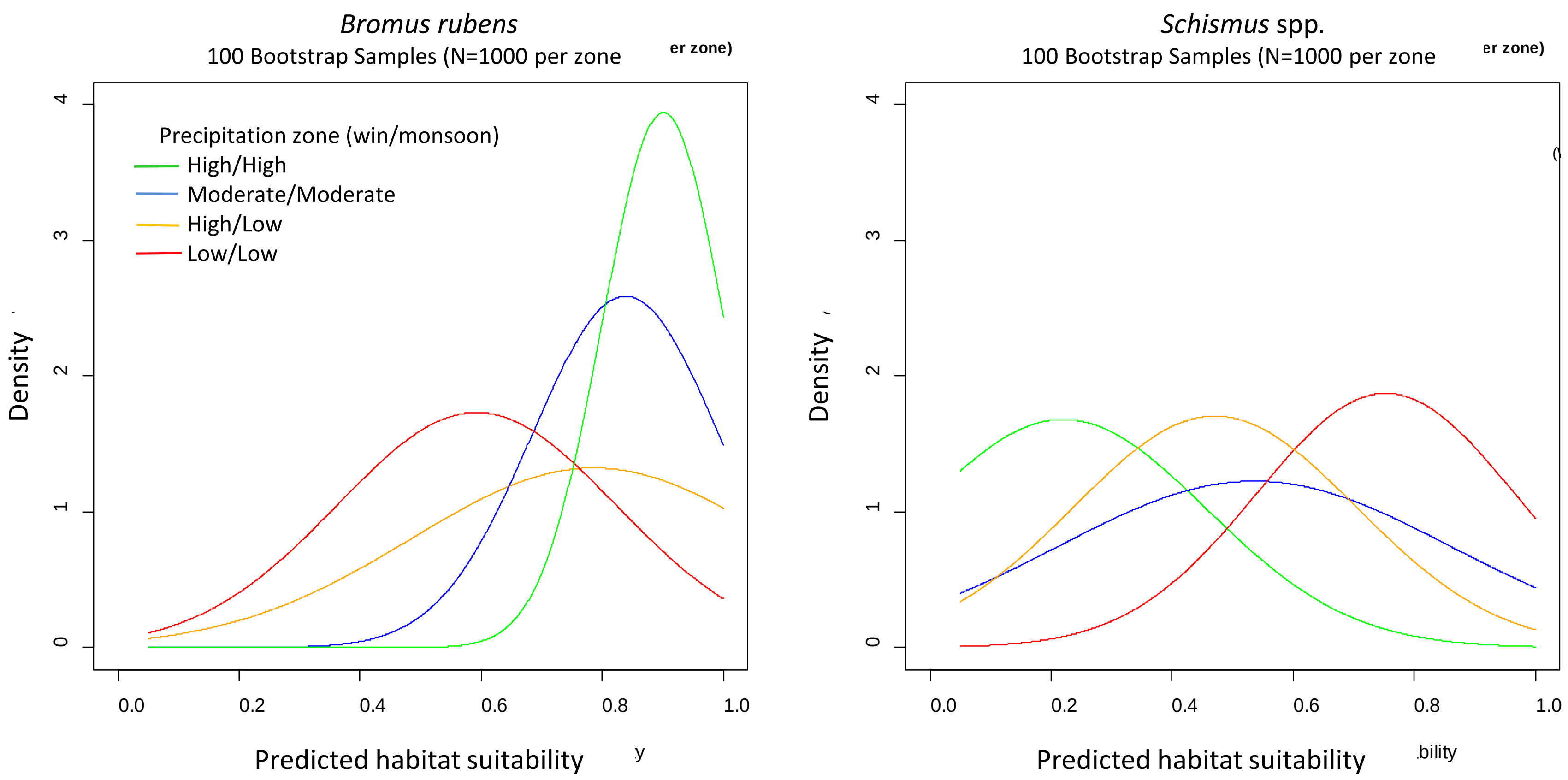
Invasion Suitability & Precipitation Zones



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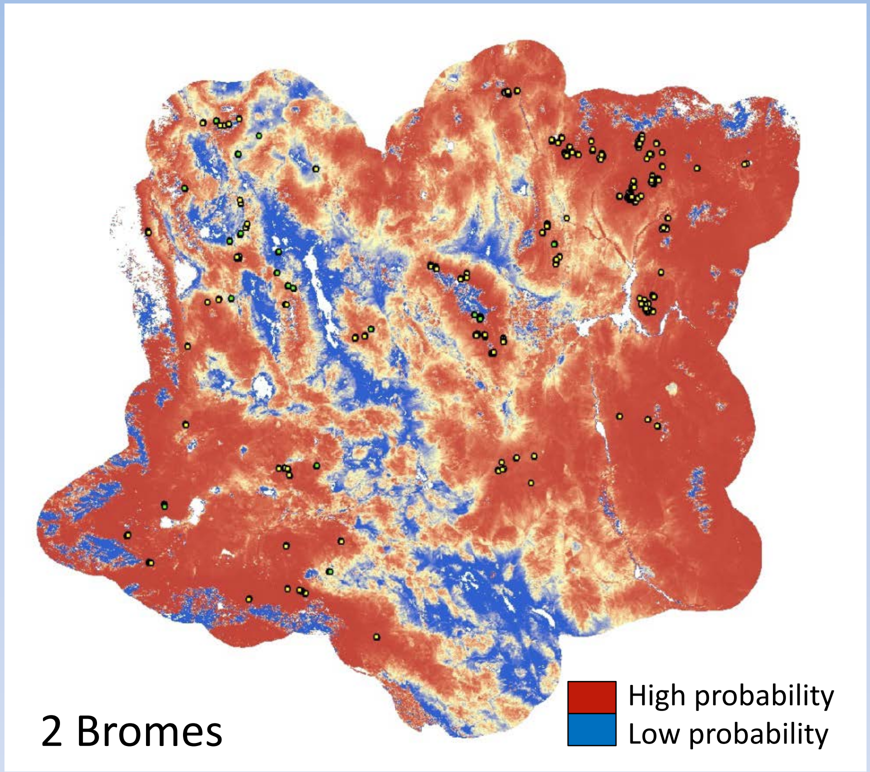
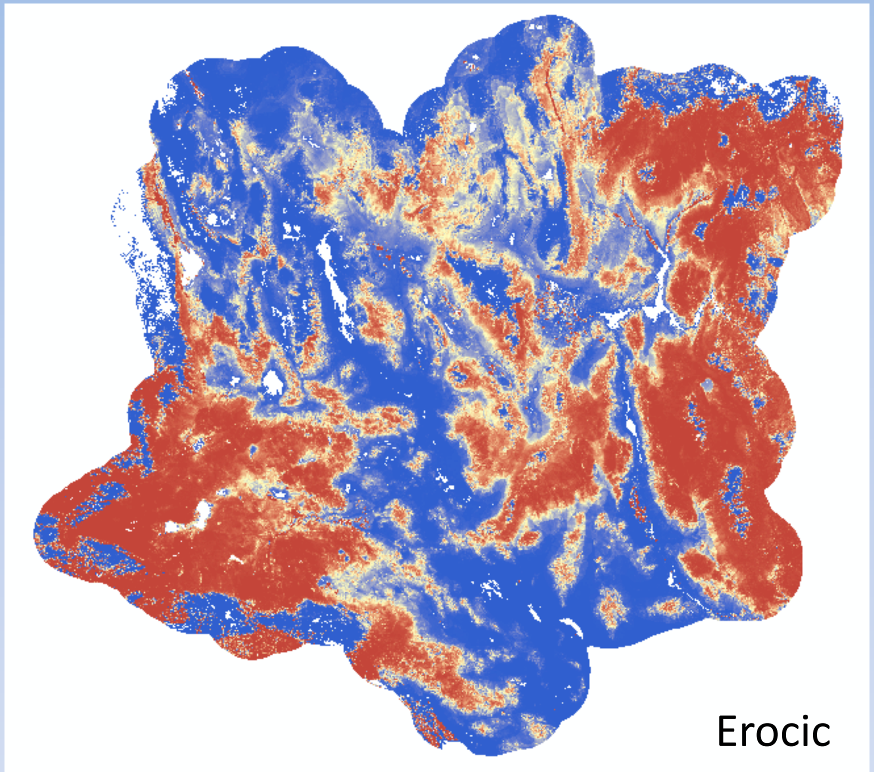
Cumulative Disturbance Impacts





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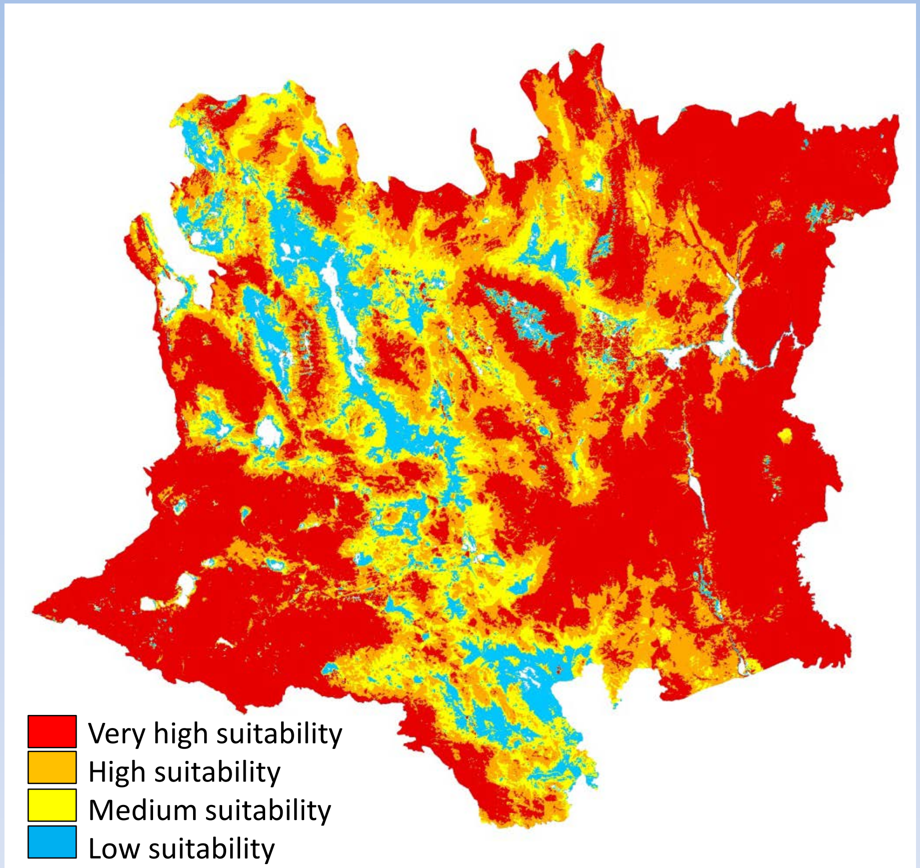
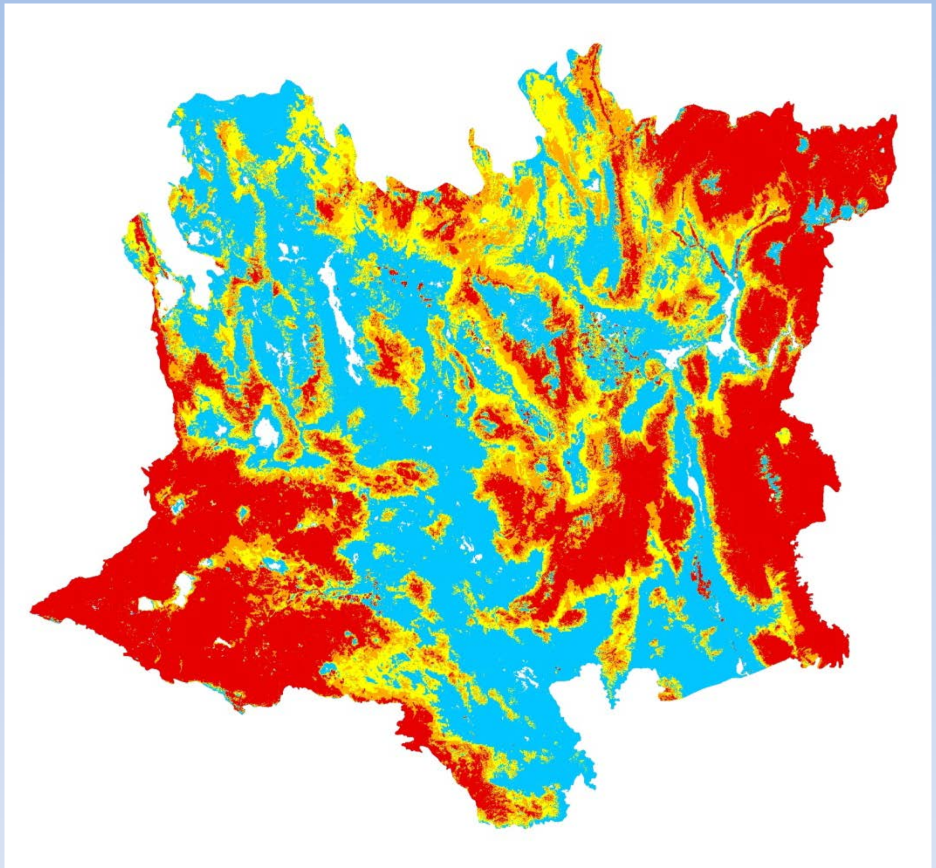
Generating Natural Breaks



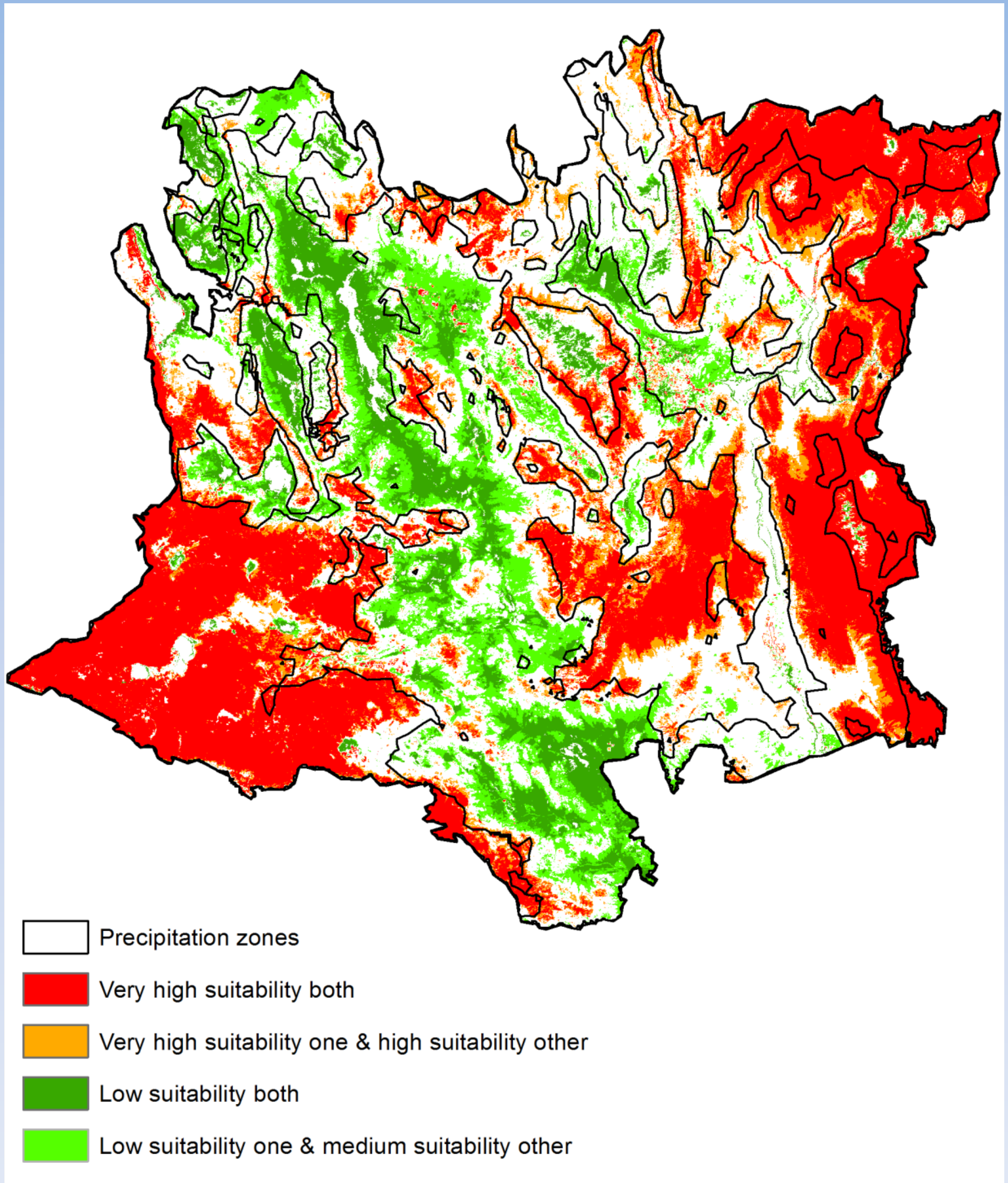


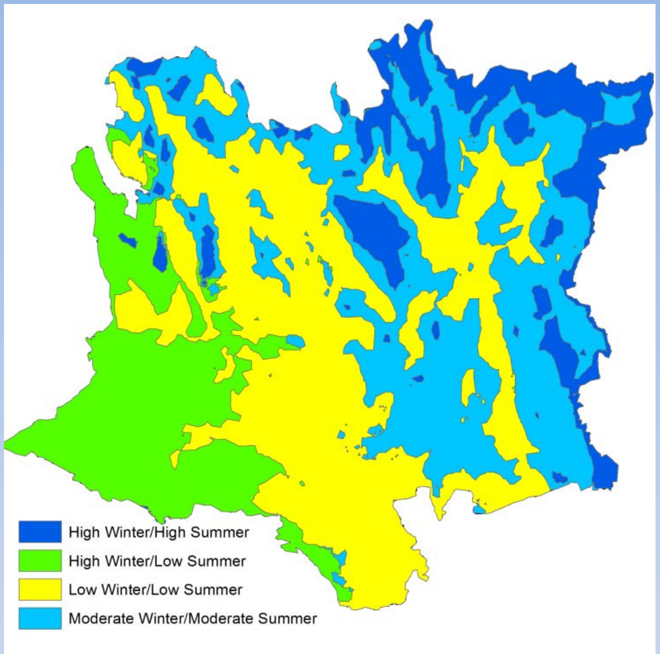
Spatial Overlap of Invasion Suitability

		Erodium cicutarium			
		Low (ha)	**Med**	**High**	**Very high**
***2 Bromus* spp.**	**Low**	1,090,306 (**8%**)	36,428 (0%)	3,668 (0%)	91,566 (1%)
	Med	1,471,465 (11%)	456,527 (4%)	2,446 (0%)	4,222 (0%)
	High	1,151,175 (8%)	1,218,739 (9%)	717,656 (6%)	10,233 (0%)
	Very high	718,362 (6%)	571,142 (4%)	1,231,494 (**10%**)	4,149,494 (**32%**)

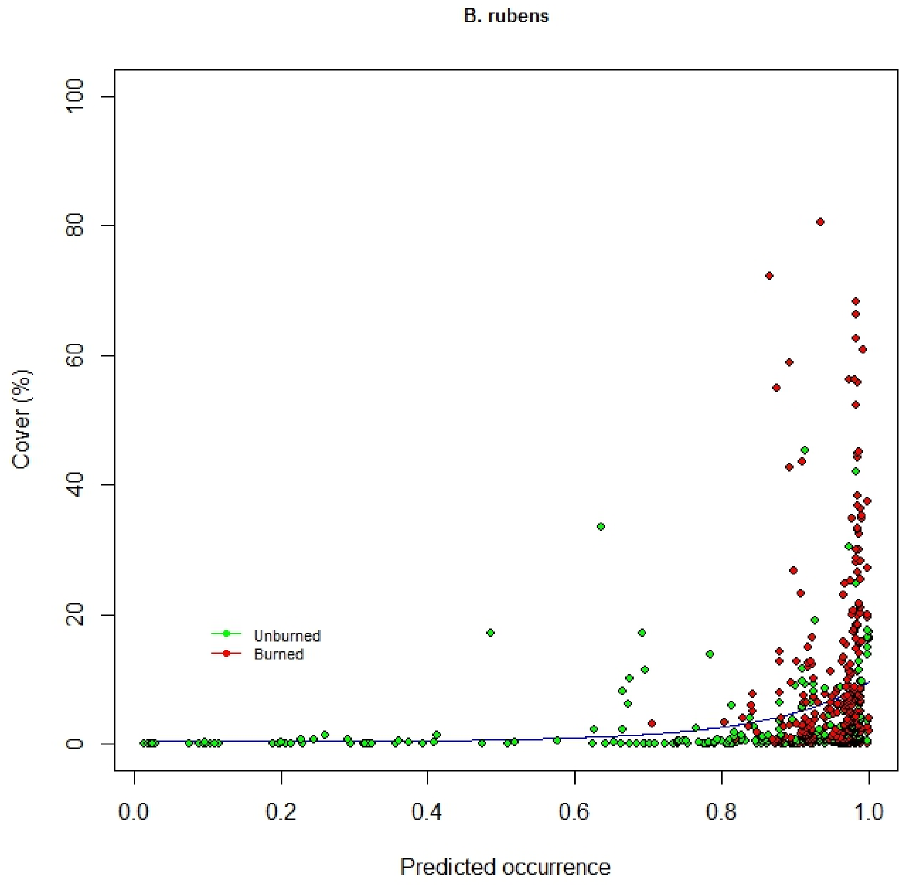
USGS

Cumulative Impacts





Relationship Between Predicted Habitat Suitability & Cover



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