Long term effects of burn severity and fire frequency on vegetation in the Mojave Desert

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A Multi-Scale Approach

Remote Sensing Data

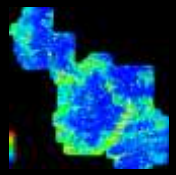
Fire

Climate

NDVI

Spatial Distribution of Fire

1972 - Present



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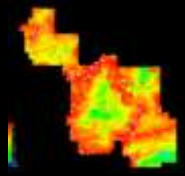


Adjusted by SDM's

Vegetation Plots (Chronosequence)

Structure

(Cover, biomass, density)

Composition

(Identity, relative abundance)

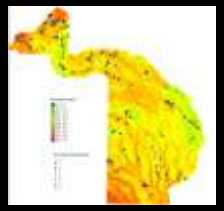
Vegetation State-Transition & Fire Risk Models

SDM's

Presence/absence

Abundance

(*B. rubens, B. tectorum & E. cicutarium*)



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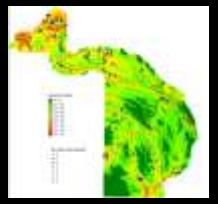

Adjusted by SDM's

Purpose of Talk

- Emphasize thinking as much as data
- Put post-fire vegetation dynamics in an ecological context
  - Contrast and link traditional views of succession with "newer" concepts of community dynamics

Classic Concepts of Succession…

- Connell-Slatyer pathways
  - Facilitation
  - Tolerance
  - Inhibition

Facilitation Model

End up with what you started with (more or less)

Traditional View of Post-fire Vegetation Dynamics

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

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Inhibition Model

Replacement of one community type with another

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The Grass-Fire Cycle & Transformer Species

- Annual grasses and alteration of fire regimes
  - *Schismus* spp.
  - *Bromus rubens*
  - *Bromus tectorum*
  - Main concern has been ***fire frequency***
  - But what about severity?
    - Continuous
      - dNBR
      - RdNBR
    - Severity class

Tolerance Model

Mix of “early” and “late” succession species

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But 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

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Expanding Our Thinking About Postfire Vegetation Dynamics In The Mojave

- Alternative states
  - Discrete assemblages of species not necessarily in equilibrium
  - Can 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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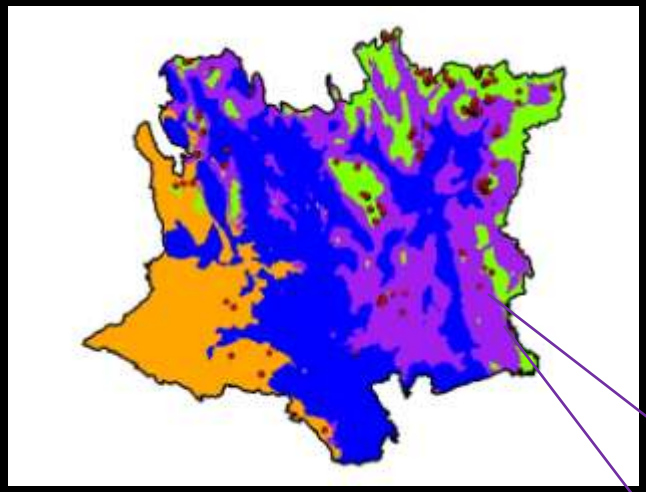
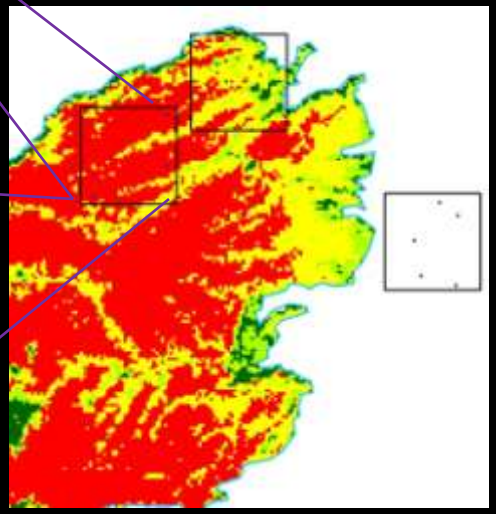
Key Questions

- How does fire influence succession trajectories?
- Are succession patterns similar among elevation zones?
- What is the link between succession pathways and metacommunity dynamics?
- How persistent are alternative states?

Sampling Design

- Space-for-time
  - 501 plots (2009)
    - N = 69 unburned
    - N = 432 3 - 35 YPF
  - 129 plots (2011)
    - N = 87 unburned
    - N = 42 3 - 20 YPF
  - 121 plots (2012)
    - N = 45 unburned
    - N = 126 10 - 40 YPF
- Hierarchical sampling
  - Elevation zone
  - Years postfire x frequency x severity class
  - Site (1 km^2)
    - 3-5 plots per site
  - Plot (0.10 ha)





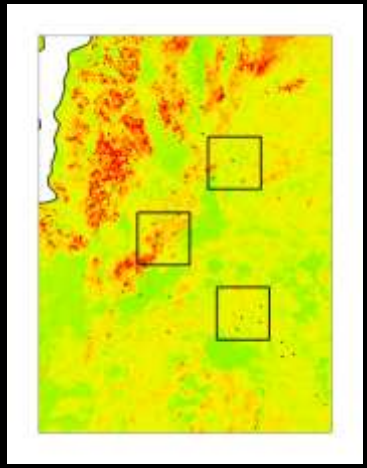
The Data

- Numerous metrics for succession
- Structure
  - Diversity
    - Hill's series
      - N0 (species richness)
      - N1 (exponent of *H'*)
      - N2 (Simpsons Index^{-1})
    - E1/D (N2/N0)
  - Woody and herbaceous cover
  - Woody-herb ratio
    - Cover
- Composition
  - Turnover
  - Relative abundance of Bromes, Schismus and *Erodium*

Time Since Fire, Frequency, and Severity

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

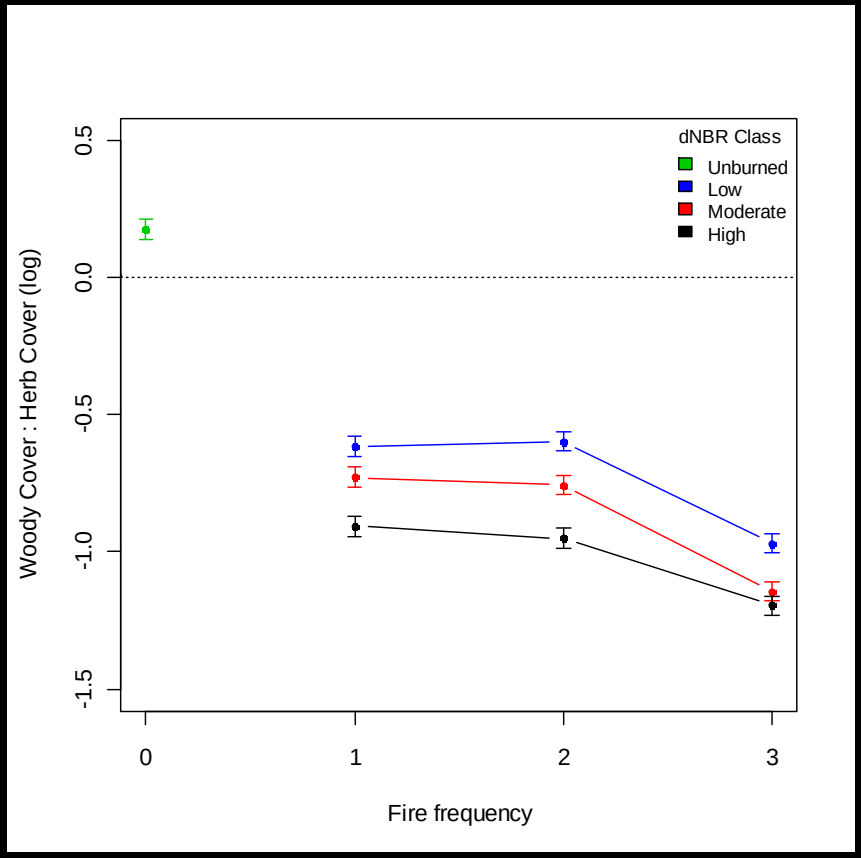
- Two analysis sets
  - Relationship between fire frequency and severity in sites < 6 years postfire
    - 1-3 burns since 1972
    - Four severity classes
  - Relationship between years postfire and severity for sites that burned once in the last 35 years
    - Approximately 75% of burned area in Mojave
    - 3 – 35 years postfire
    - Four severity classes
- Generalized linear mixed models (GLMM's)
- Canonical Correspondence Analysis



Structure

Frequency x Severity

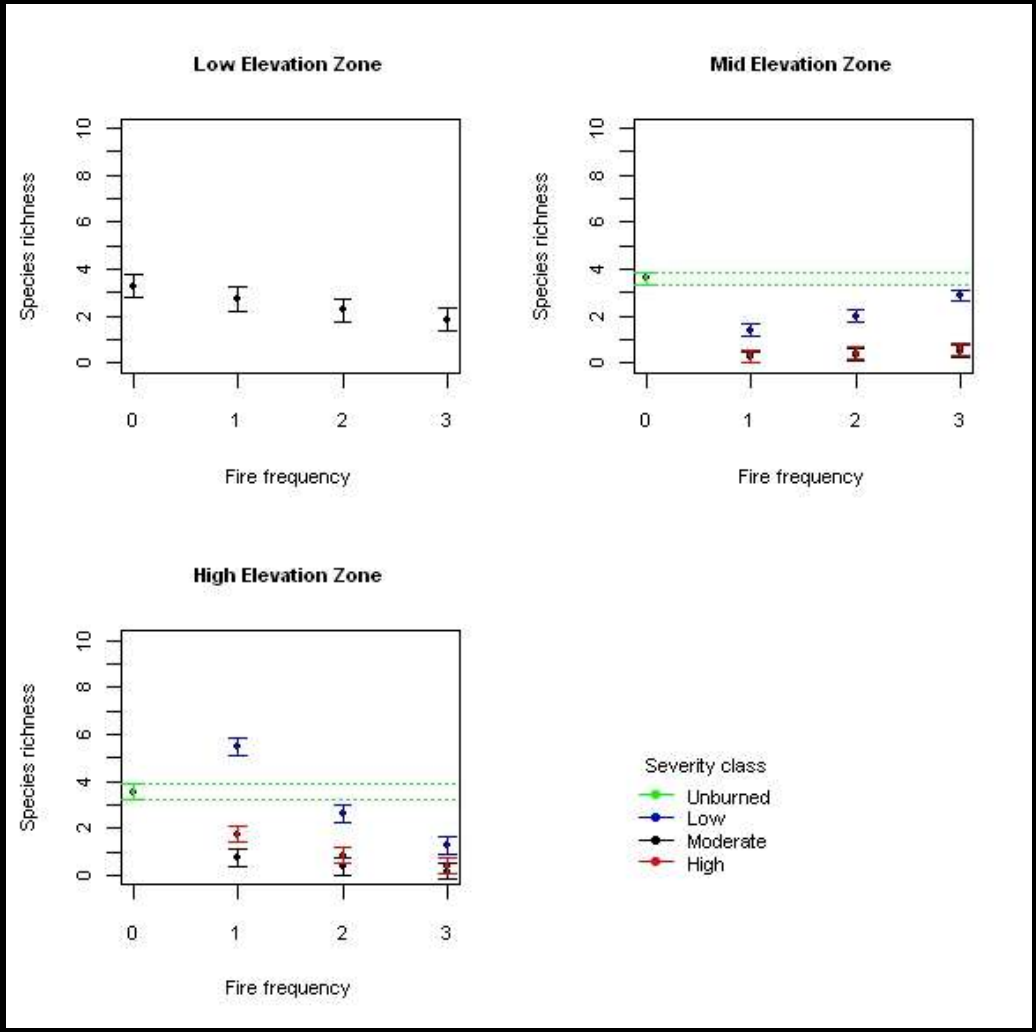
- Woody cover decreases with fire severity and fire frequency
- Herbaceous cover increases with severity across fire frequency
- Consistent pattern across elevation zones



Diversity Patterns

Woody Species – Frequency x Severity

- **Summary of general patterns**
  - Patterns varied across elevation zones
  - Low
    - Richness decreased with increasing frequency
    - Pattern consistent across severity classes
  - Mid
    - Frequency x severity interaction
  - High
    - Frequency x severity interaction
    - Low severity differed from pattern in mid elevation zone

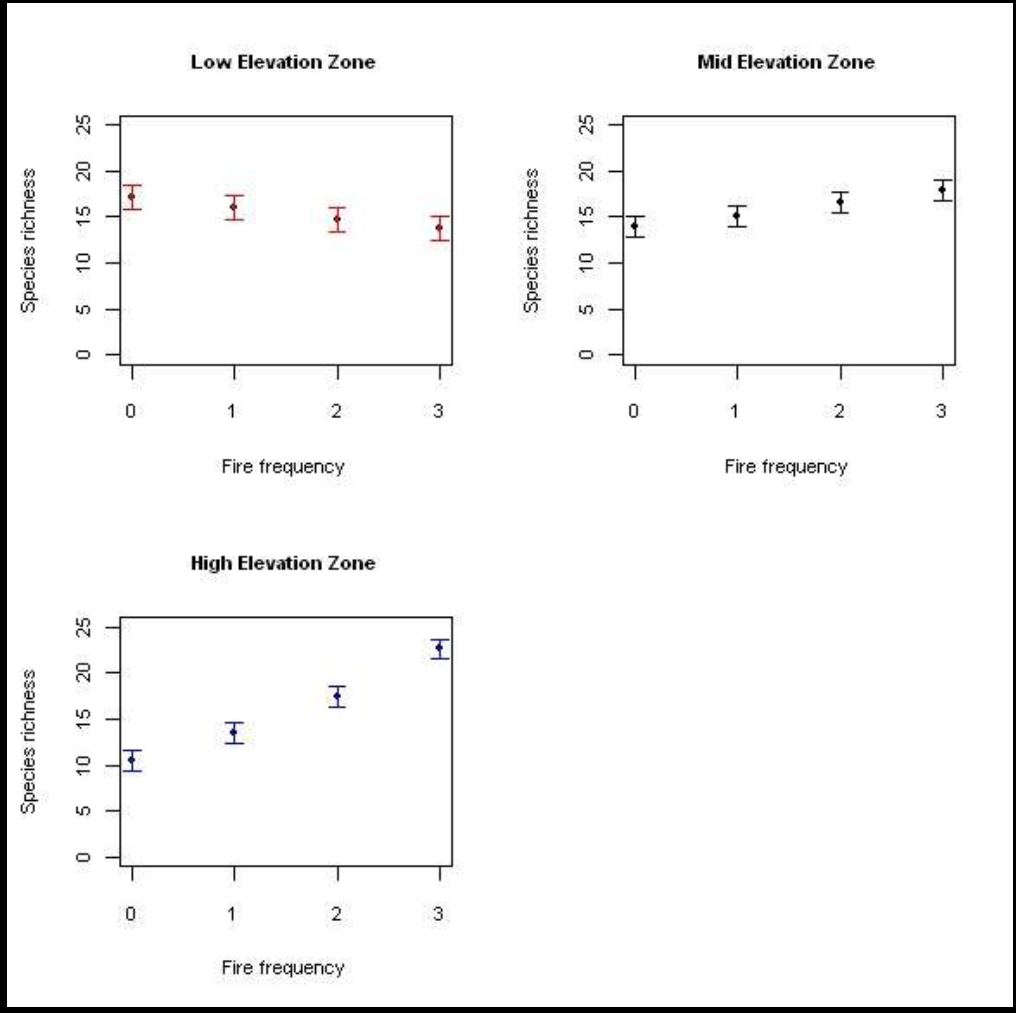


Consistent with inhibition pathway

Diversity Patterns

Herbaceous species – Frequency x Severity

- **Summary of general patterns**
  - Varied across elevation zones
  - Patterns consistent across severity classes
  - Low
    - Richness decreased across frequency classes
  - Mid and High
    - Richness increased across frequency classes

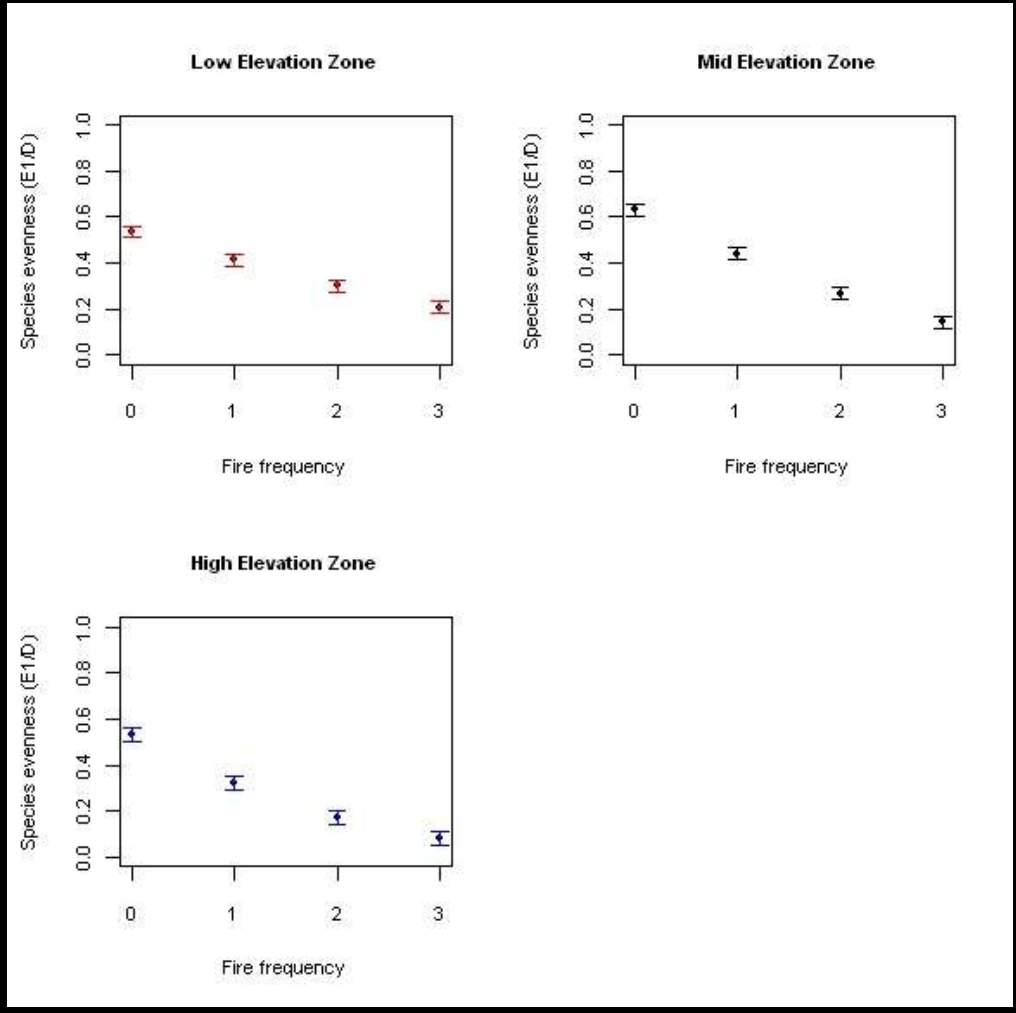


Consistent with inhibition pathway

Diversity Patterns

Herbaceous species – Frequency x Severity

- **Summary of general patterns**
  - Evenness decreased in all elevation zones
  - Pattern consistent across severity classes

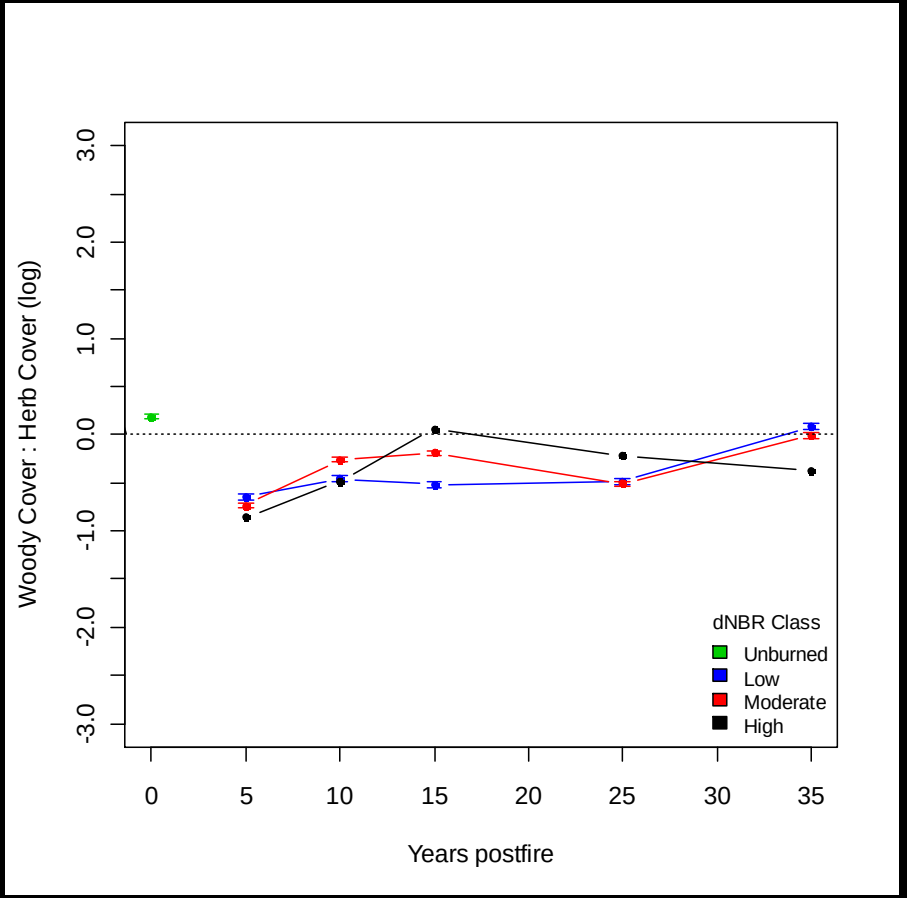


Consistent with inhibition pathway

Structure

Years Postfire (YPF) x Severity (single burns)

- Woody cover eventually similar to unburned conditions in low and moderate severity classes
- Herbaceous cover dominated high severity class
- Consistent across elevation zones

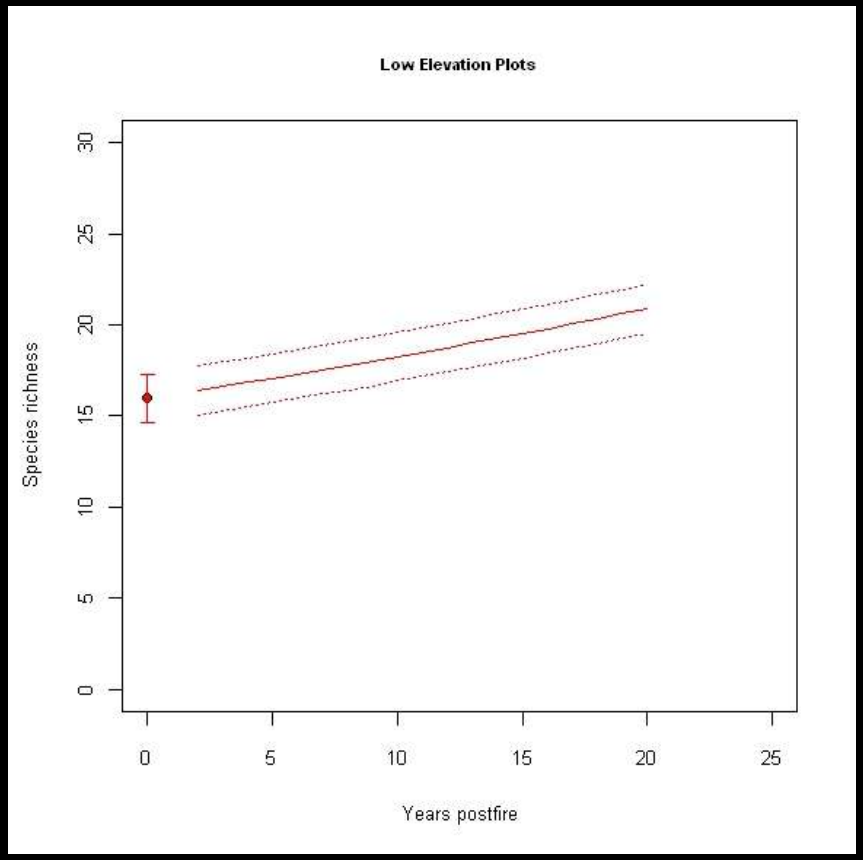


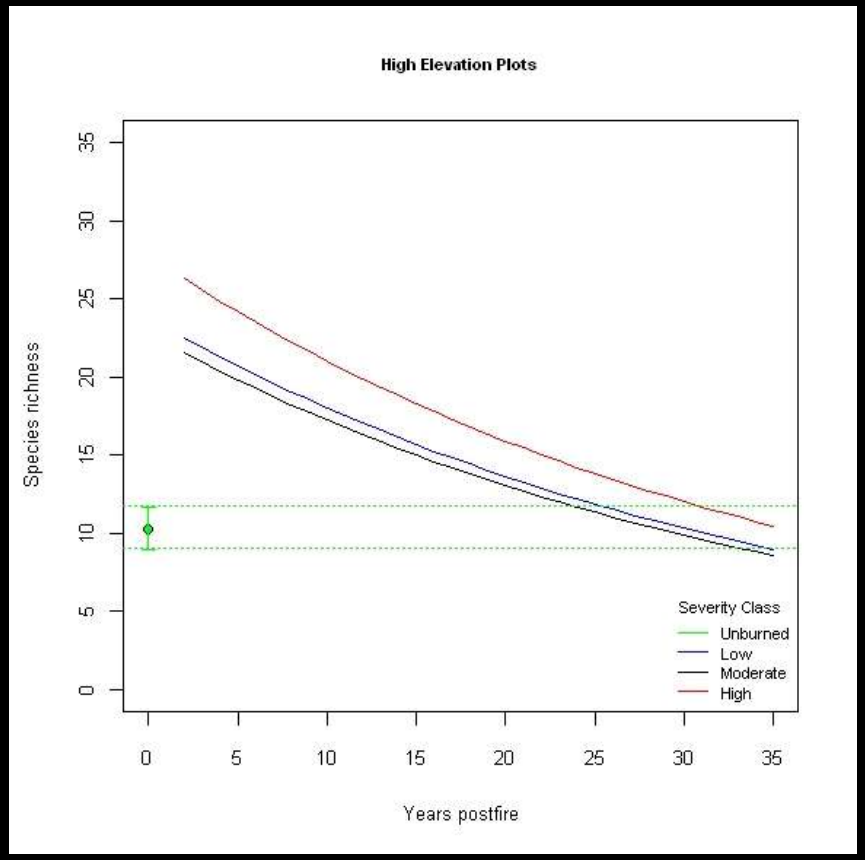
Consistent with tolerance pathway in low and moderate severity burns

Consistent with inhibition pathway in high severity burns

Diversity Patterns

Herbaceous Species – YPF x Severity (single burns)





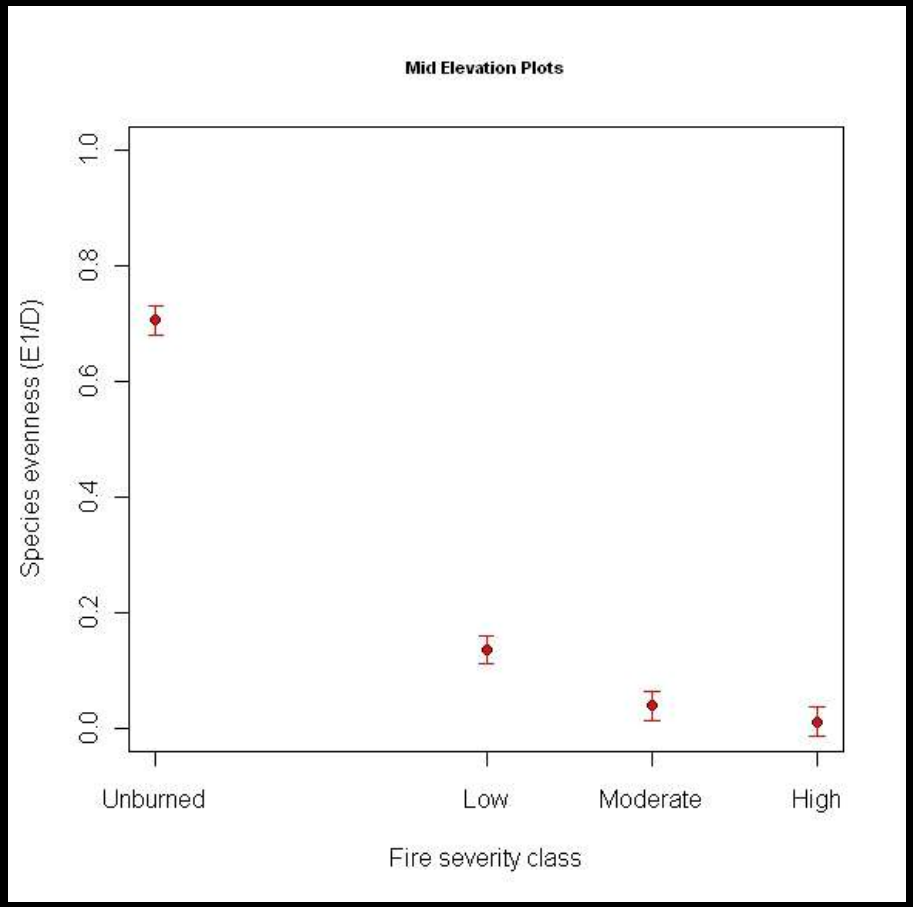
Consistent with inhibition pathway in low elevation zone

Consistent with facilitation pathway in mid and high elevation zones

Diversity Patterns

Herbaceous Species – YPF x Severity (single burns)

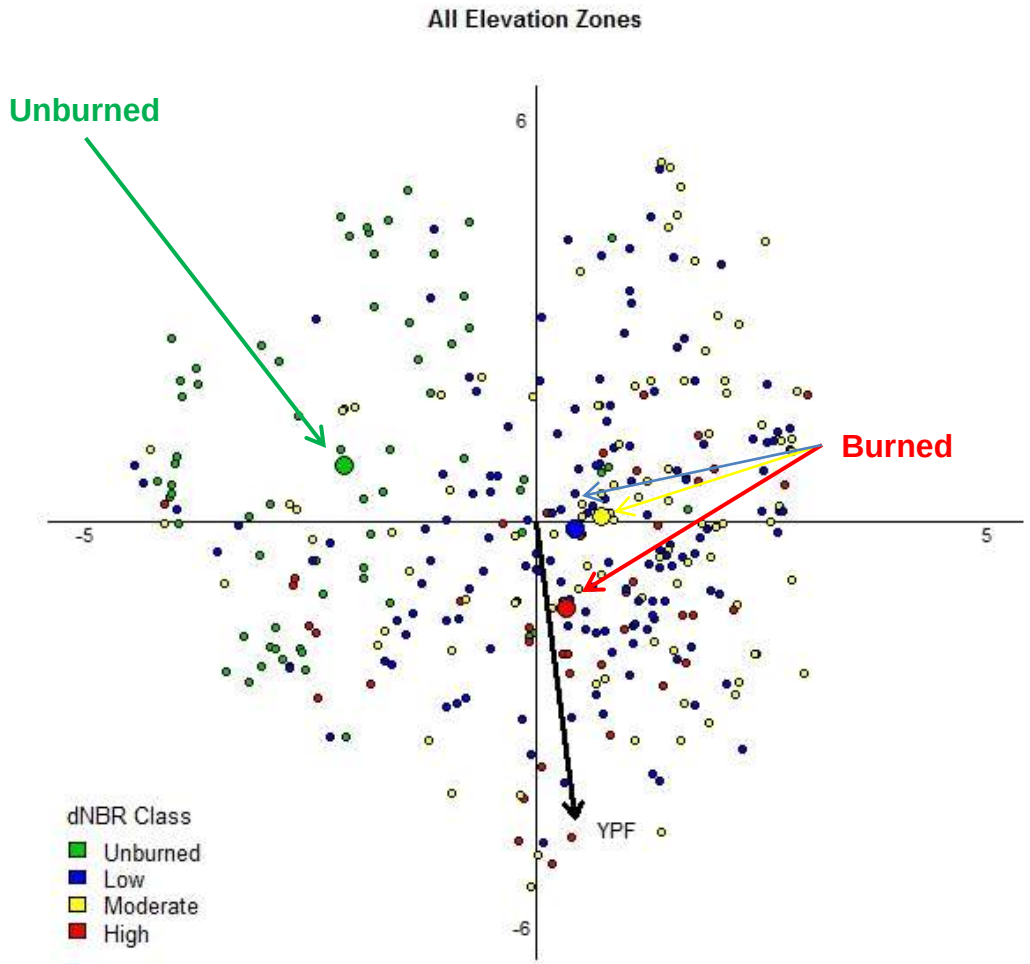
- **Summary of general patterns**
  - Evenness dropped sharply with increasing severity across time and *in all elevation zones*



Consistent with inhibition pathway

Community Composition

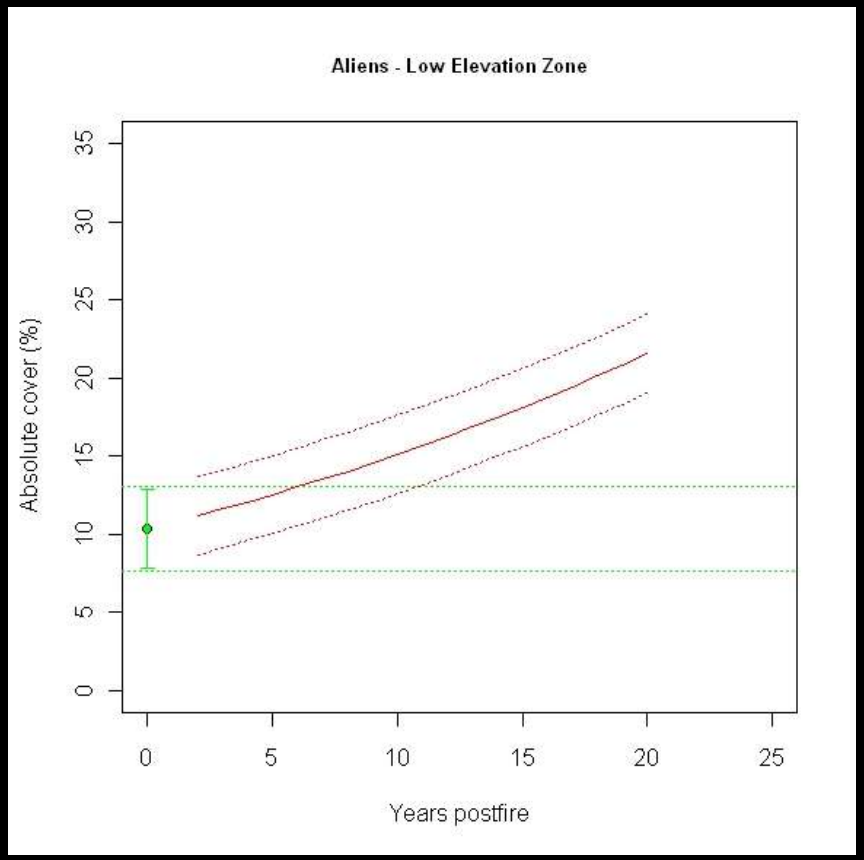
Canonical Correspondence Analysis

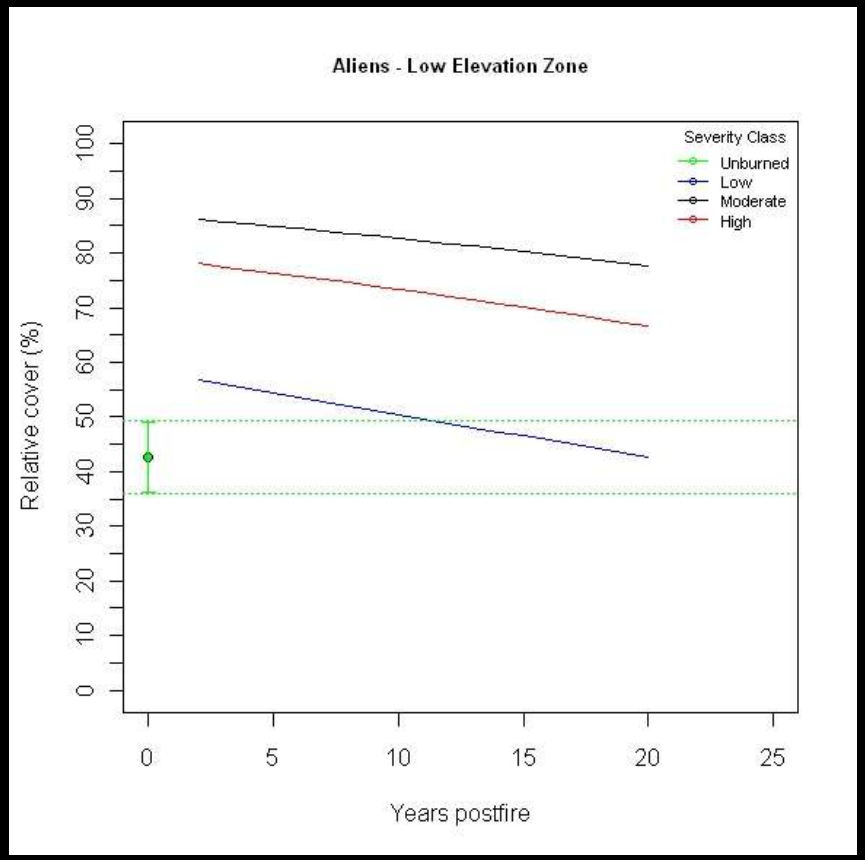


- General trajectories are AWAY from unburned conditions
- Low severity extremely scattered
- Moderate severity moderately scattered
- High severity least scattered
- SOME plots in all classes similar to unburned plots

Composition

Non-native cover - YPF x Severity

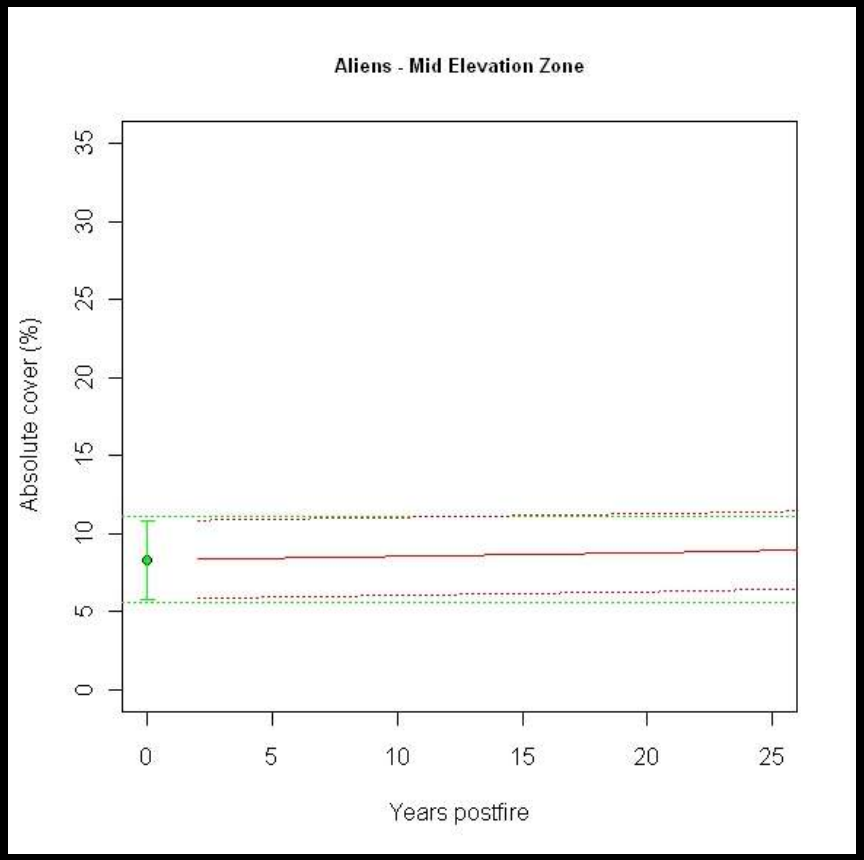


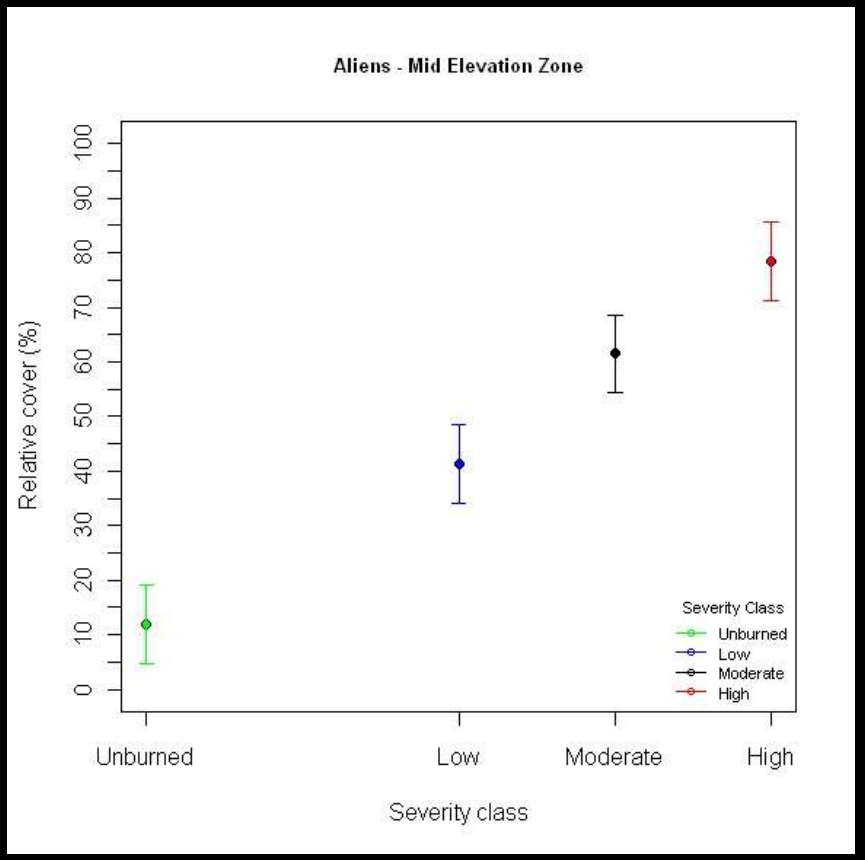


- Low elevation zone

Composition

Non-native cover - YPF x Severity

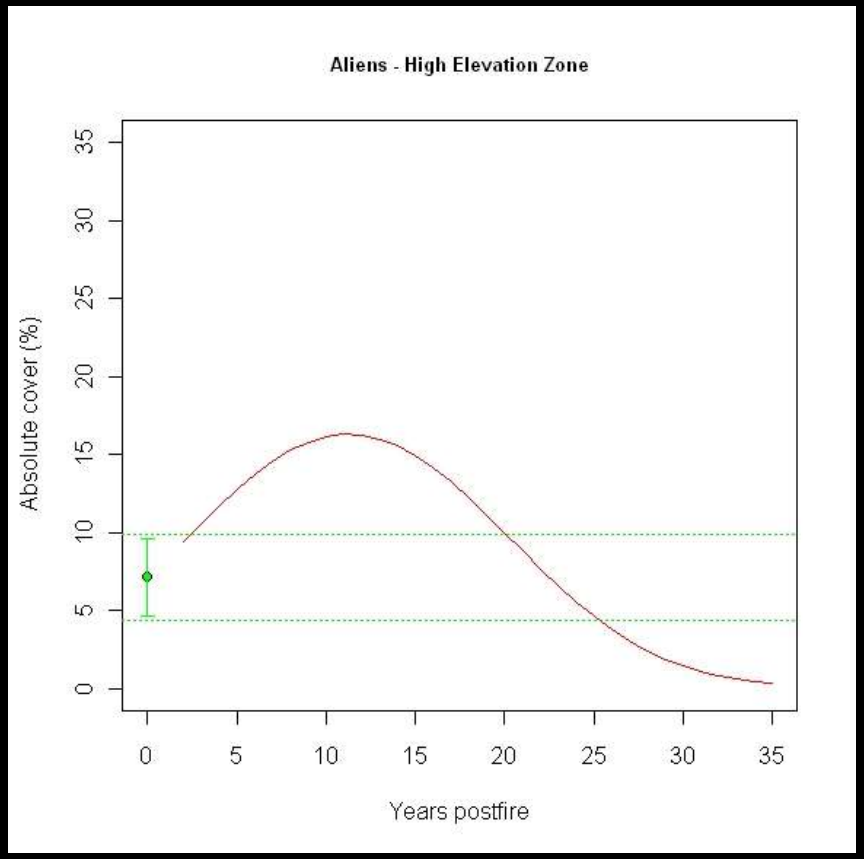


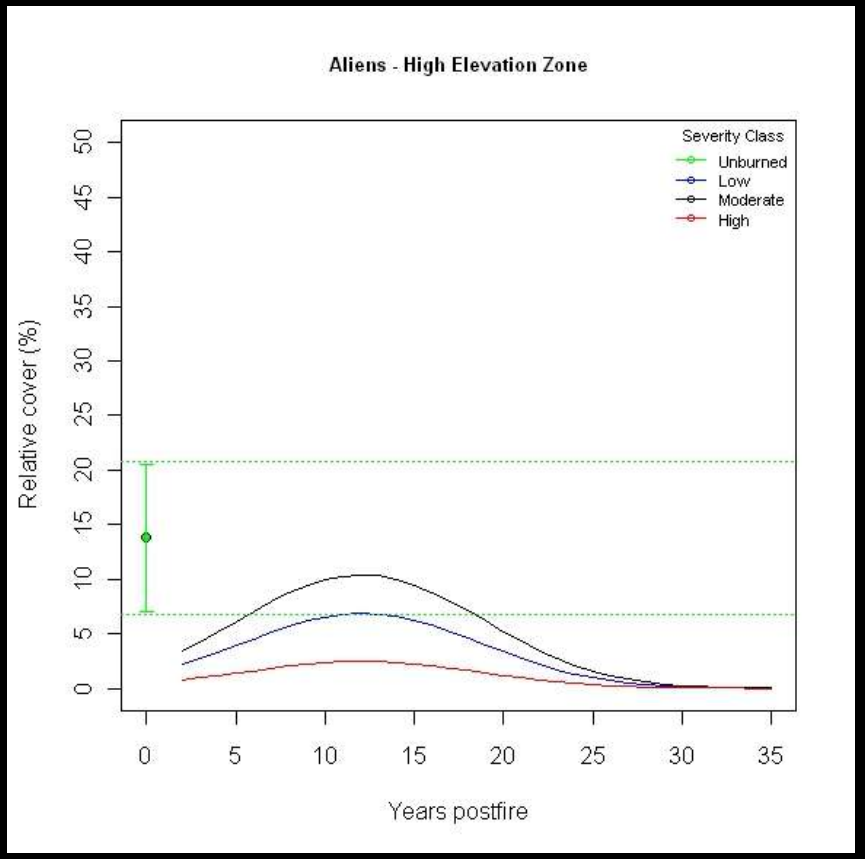


- Mid elevation zone

Composition

Years postfire x Severity





- High elevation zone

Pulling It All Together

- Evidence for all three pathways
  - Spatially AND temporally variable
  - Varied by metric
- How persistent are alternative states?
  - Can be convergence in structure
  - Long-term change in composition (> 30 years) is common
- Variation in succession patterns highlight utility of metacommunity concept
- *Fire frequency, fire severity, and landscape position (elevation) result in patchwork of postfire vegetation communities*

And What Might This Mean For Fire Regimes?

Grass Fire Cycle Or Abrupt Transition?

- Can have rapid transitions to alternative states
  - Fire as an event instead of series of burns at short return intervals
- Why the rapid transition to non-native annual communities?
  - Dominate seed bank of unburned communities ***at all elevations***
  - Individual and additive effects from species sorting

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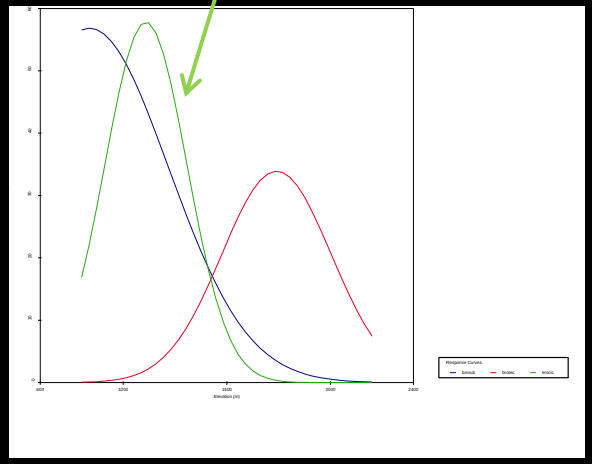
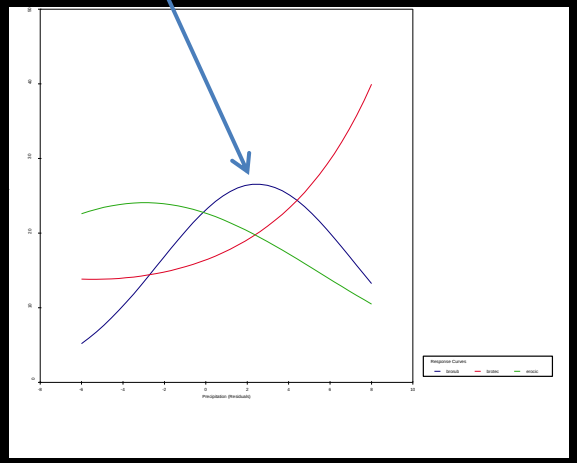
Sorting Of Non-native Annuals Species Along Environmental Gradients

E. cicutarium



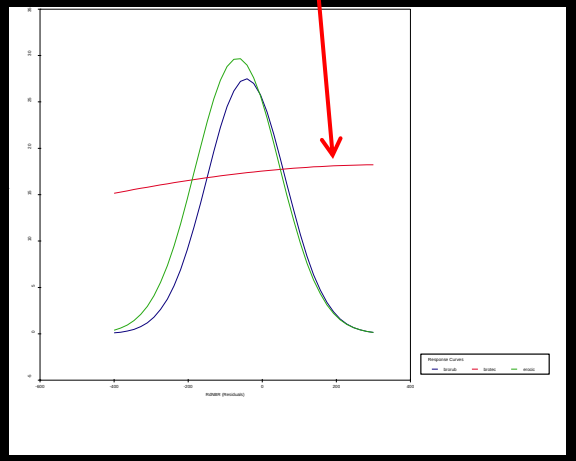
Elevation

B. rubens



Precipitation

B. tectorum



dNBR

Generalized Additive Models

- Overlapping but shifting abundance peaks
- Strong additive effects at low and mid elevations

Multiple, Unpredictable Alternative States

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