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

Vegetation Plots (Chronosequence)

SDM's

Fire
Climate
NDVI

Structure
(Cover, biomass, density)

Composition
(Identity, relative abundance)

Presence/absence
Abundance
(B. rubens, B. tectorum & E. cicutarium)

Spatial Distribution of Fire
1972 - Present

Unadjusted
Adjusted by SDM's

Vegetation State-Transition & Fire Risk Models

Unadjusted
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
Inhibition Model

Replacement of one community type with another
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
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
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!
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
• 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
• 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
Sorting Of Non-native Annuals Species Along Environmental Gradients

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

Generalized Additive Models

Elevation

Precipitation

dNBR

E. cicutarium

B. rubens

B. tectorum
Multiple, Unpredictable Alternative States