Evolving reference systems for longleaf pine ecosystem restoration

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New information to inform longleaf pine restoration?
Restoration

DEGRADED

Perturbation

ORIGINAL
Restoration

Perturbation

Undisturbed trajectory

Time
The restoration arrows...

- If lost process, or components restored, will site recover?
- Is there some barrier that precludes recovery by endogenous means?
- Contingent on nature of perturbation, biophysical conditions before and after
Restoration

Perturbation

Undisturbed trajectory
Developing Dynamic Reference Models and a Decision Support Framework for Southeastern Ecosystems: An Integrated Approach (R. Mitchell; SERDP)
Hold still! I’m trying to fix something here

Reference Sites

Dynamic Range of Variation

Original Range of Variation

Ecological Condition

Restoration Sites

Time

Hiers et al 2012
1. Define/identify reference targets
2. Refine reference conditions
3. Measure change in both reference sites and in landscape (monitoring sites) through time
   - Multivariate analyses (NMDS), distance measure (MD) & confidence intervals
   - Identify plot 90% confidence ellipsoid of Reference conditions
   - Measure distances to Reference
   - Change in proximity to Reference

Incorporates temporal and spatial variation of benchmark ecosystems
Eglin Restoration Experiment

- Compare methods to restore structure: reduce midstory hardwoods, restore herbaceous diversity
- Fire, mechanical removal, herbicide, control
- Resample: 15 years
- Dynamic reference to assess change

(Kirkman et al. 2013)
Eglin Restoration Experiment - Results

(Kirkman et al. 2013)
Some Conclusions

• Over time, fire may accomplish same biodiversity metrics as mechanical, chemical treatments; fire alone is a viable choice

• Dynamic reference approach successfully applied to evaluate restoration treatments and document large scale responses to management
  • Large detailed data set
  • Sites with similar environmental template
  • Research expertise
Values to restoration?

• Can track community changes over long times
• Can focus attention on sites that do not respond to treatments
• Provides internal references to help guide restoration/management into the future with not analogues
Restoration

Perturbation

Undisturbed trajectory
Developing and Testing a Robust, Multi-scale Framework for the Recovery of Longleaf Pine Communities (J. Orrock, E. Damschen, L. Brudvig, J.Walker; SERDP)
Conceptual Model
Objectives

1. Classify understory communities based on degrading factors
2. Compare models for each of 3 locations, and for all sites together
3. Compare model outputs with independent set of reference sites
Methods

- Sample sites (232 1-ha sites)
  - Range of canopy density
  - Recent fire history (1991-2009)
  - Agriculture/forest history
  - Represented dominant LLP soils (4 soils orders)
- Reference sites (38): regional experts
Field Methods

Plot Design:
- 20 x 50 m plots
- Abundance - 5 scales (0.01-9 m²)
- Presence/absence - 7 scales (0.01-1000 m²)
- Species diversity
- Seedbank sampling
- Accommodates experimental treatments
- Carolina Vegetation Survey protocol (transferable)

Controlled for habitat type and major topographic features

Response Variables:
Plant community characteristics:
1) Species diversity (richness and evenness)
2) Species composition (similarity metrics)

Soil OM, Soil Moisture, Litter, Duff
Methods

• Statistical methods
  – Multivariate classification, regression tree analysis
    • RTA splits based on Ag history, tree BA (pine, non-pine, total), fire frequency, time since burn; soil moisture, soil order
  – Quantified biophysical characteristics of classes to compare with References
    • Canonical Analysis of Principal Components (CAP) to compare composition
All Sites

Total burns since 1991 < 4.5

% S.M. < 45.08

Class 1 (n=79)

% S.M. ≥ 45.08

Class 2 (n=16)

Total burns since 1991 ≥ 4.5

Agricultural history

Class 3 (n=58)

% S.M. < 42.12

Class 4 (n=39)

% S.M. ≥ 42.12

Class 5 (n=29)

Forest history

Total basal area ≥ 9.965

Class 6 (n=11)

Total basal area < 9.965
Low fire frequency, Soil moisture <45 (1), >45% (2)

(3) High fire, Ag history

Classes 1-3
Classes 4-6 Frequent fire, forested

Classes 4, 5
- High BA, dry (4) or moist (5) soils

Class 6
- Low BA
Classes vs. Reference

A. CAP Axis 2 vs. CAP Axis 1

B. Species richness/m² vs. Class

C. Species evenness/m² vs. Class

D. Soil organic matter vs. Class

E. Ground cover (%) vs. Class

F. Forest floor depth (cm) vs. Class

Legend:
- Vegetation
- Bare ground
- Down woody debris
- Litter
- Duff

Classes:
1. Low Fire/Low S.M.
2. Low Fire/High S.M.
3. High Fire/High S.M.
4. High Fire/High Tre./Low S.M.
5. High Fire/For/Low Tre./High S.M.
6. High Fire/For/Low Tre.
Reference
A  All Sites

- Total burns since 1991 < 4.5
- Total burns since 1991 ≥ 4.5

  - % S.M. < 45.08
  - % S.M. ≥ 45.08

  - Agricultural history
  - Forested history

  - Class 1 (n=79)
  - Class 2 (n=16)
  - Class 3 (n=58)

B  Fort Bragg

- Agricultural history
- Forested history

  - Class 1 (n=33)
  - Class 2 (n=51)

C  Fort Stewart

- Inceptisols, Spodosols
- Entisols, Ultisols

  - Non-Pinus basal area ≥ 1.277
  - Non-Pinus basal area < 1.277

  - Class 1 (n=9)
  - Class 2 (n=23)

D  Savannah River Site

- Total basal area ≥ 22.76
- Total basal area < 22.76

  - Agricultural history
  - Forested history

  - Class 1 (n=32)
  - Class 4 (n=26)
Location-specific models

- Factors used in all models
- Association with degradation varied
- Reference sites similar to least degraded (CAP) FTS, SRS

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<td>Forest Floor depth</td>
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- Richness richness declined with degradation in each location-specific model; many species unique to a location
Overall...

- 3 gradients produced classes that map onto degradation patterns (distance from reference)
- Broad associations, but substantial site to site variability
- Relative factor importance inferred
  - fire frequency > agriculture legacies > BA
- Quantified breakpoints
  - 4 vs 5 fires and 10 m²/ha BA
- Classes 1-3 most effort to restore?
  - burn only?
  - persistent (> 50 yrs)Ag effects (Brudvig et al 2013)
All Sites

Total burns since 1991 < 4.5  Total burns since 1991 ≥ 4.5

% S.M. < 45.08  % S.M. ≥ 45.08

Class 1 (n=79)  Class 2 (n=16)

Agricultural history

Total basal area ≥ 9.965  Total basal area < 9.965

% S.M. < 42.12  % S.M. ≥ 42.12

Class 3 (n=58)  Class 4 (n=39)  Class 5 (n=29)

Forest history

Class 6 (n=11)
Restoration

Perturbation

Undisturbed trajectory
Dynamic reference

- Monitor change (time)
  - Landscape scale management
  - Restoration treatment effects

- Data: descriptive metrics
  - Repeated measures

- Highlight management needs, priorities

- Widely applicable

Degradation model

- Template for degradation states (spatial variation)
  - Location specific environmental, biotic factors

- Data: descriptive metrics
  - One time

- Research needs, management priorities

- Lots of contingencies, but approach is general
A pause for reflection...