Do all ecosystem function measures tell the same story about restoration success?

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Measuring Restoration Success

• Restoration success is often measured using diversity/species composition compared to a reference site.

• But we know ecosystems vary – so critical to have range of acceptable end points.

• More studies are now measuring indicators of ecosystem functions.

• Often assume relationships, but largely untested.
Ecosystem Functions

• Basis for self-maintenance in an ecosystem and allow delivery of important ecosystem services.

• Highly interactive and complex.

• Common examples: biomass, nutrient cycling and storage, decomposition and structural aspects of ecosystems
Biodiversity/Ecosystem Function

Ecosystem Function

- Intact Ecosystem
- Degraded Ecosystem

Species Richness/Biodiversity
Data Processing - Recap

- Systematic database search of restoration ecology literature using keywords & criteria

- 67 papers, authors contacted for data
  - 25 papers, 237 restoration sites, 557 data points

- Calculated species composition using Bray-Curtis similarity.

- Also calculated similarity of ecosystem function measures.
Response Ratios - Recap

- Response ratios calculated for each variable within each study using \( \ln(\text{Rest}+1/\text{Ref}+1) \)

- Gives a negative number if restored site is not yet within the range of reference sites.

- If above zero, then is within range of reference sites.
Global Patterns - Recap

Significant, but weak positive relationship between ecosystem function and species composition

$R^2 < 2\%$
Exploring the Variation

- Factors that might affect relationship
  - Ecosystem type
  - Restoration type
  - Ecosystem function type
Modelling

• Modelled this relationship using a GLMM & backwards stepwise model selection.

  – Fixed factors
    • Species composition + ecosystem function type + ecosystem type + restoration type + interactions

  – Random factor
    • Study
Best Fit Model

• Best fitting model
  – Ecosystem Function ~ Species composition + Ecosystem function type + Interaction + Study (random)

• All factors significant & $R^2 = 20\%$ (c.f. $<$2% earlier).

• Explored interaction by separating each function type.
Biomass Accumulation

- Productivity, plant biomass
- Ecosystem function restored 31%
- Ecosystem function > species composition 53%
Biotic Interactions

- Seed dispersal, pollination & soil fauna
- Ecosystem function restored 31%
- Ecosystem function > species composition 69%
Litter & Deadwood Functions

- Leaf litter & deadwood accumulation
- Ecosystem function restored 33%
- Ecosystem function > species composition 56%
Nutrient Functions

• Indicators of nutrient cycling

• Ecosystem function restored 54%

• Ecosystem function > species composition 87%
Soil Functions

- Soil stability, water infiltration & soil temperature
- Ecosystem function restored 58%
- Ecosystem function > species composition 94%
Structural Functions

- Canopy heights, vegetation cover & patches
- Ecosystem function restored 20%
- Ecosystem function > species composition 64%

\[ y = 0.3663x - 0.2667 \]

\[ y = 0.3663 \cdot x - 0.2667 \]
Restoring Ecosystem Function

- Most often restored
  - Soil functions
  - Nutrient functions

- Least often restored
  - Structure
  - Biomass
  - Biotic Interactions
• Biomass and Structural have +ve relationships.

• Litter & Deadwood had no relationship with species composition & at 100% species composition restored, ecosystem function was not necessarily restored.
Redundancy?

- Most types of function appeared to show degree of redundancy (>50% points had ecosystem function closer to being restored than species composition)

- Strongest for Soil and Nutrient functions
  - Many different species can perform the same function?
Why the Differences?

• **Why do groups of ecosystem functions differ?**
  – Less degraded/more resilient functions?
  – Time lag?
  – Some function rely on rarer species or have tighter mutualisms?
  – Targeted by restoration from beginning?
What Function to Measure?

- What are your aims & what is ecological meaningful to the system?

Choice of function measure can influence on whether or not meets restoration goals.
Recommendations for Restoration

• Not all function measures are equal.

• Already showed that you cannot take species composition as a proxy for restoring function, and this is even more so for some functions than other.

• To truly test restoration efficacy should measure functions that are harder rather than easier to return.