Biodiversity drives ecosystem multifunctionality: A meta-analysis


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Acknowledgements

• Authors of original studies

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What’s so good about biodiversity?

“...unequivocal evidence that biodiversity loss reduces the efficiency by which ecological communities capture biologically essential resources, produce biomass, decompose and recycle biologically essential nutrients.”

- Cardinale et al. 2012 Nature
“The very definition of ecosystem services prejudices a discussion, which focuses on them to the exclusion of ecosystem disservices.”

-Maier 2012
The *net* diversity effect

Net balance of positive, negative, and neutral effects

**Ecosystem multifunctionality** = the suite of ecosystem properties that underpin functioning ecosystems
Tradeoffs prevent all functions from being maximized
Objectives

To generalize the consequences of changes in biodiversity for ecosystem multifunctionality

1. Averaging approach
2. Multiple threshold approach
94 manipulative experiments measuring 343 functions
Averaging Approach

Does the average level of many functions increase with increasing richness?

Response

Does the average level of many functions increase with increasing richness?

Positive slope = positive effect of diversity on the average of all functions
Average multifunctionality $\sim \log(\text{Richness}) + (\text{Richness} | \text{Study}) + \epsilon$

Declining from 3 species to 1 species = -10% change in average multifunctionality
Averaging Approach – Shortcomings

Results are no different than analysis of single functions
Averaging Approach – Shortcomings

- Do intermediate values represent extreme functions or functions performing at medium levels?
Threshold Approach

Does the number of functions exceeding a threshold increase with increasing richness?

Positive slope = positive effect of diversity on the number of functions above a threshold
Threshold Approach

• Tradeoffs mean the number of functions > threshold ≠ total number of functions

• What is a threshold?
  • % of the maximum
  • Management target
  • Arbitrary numbers (0.25, 0.5, 0.75)

• Exceed threshold by a little or by a lot?
Threshold Approach

Does the number of functions exceeding a threshold increase with increasing richness?

Positive slope = positive effect of diversity on the number of functions above a threshold
Multiple Threshold Approach

Does the number of functions exceeding multiple thresholds increase with increasing richness?

Positive slope = positive effect of diversity on the number of functions above a threshold
Does the number of functions exceeding multiple thresholds increase with increasing richness?

Positive slope = positive effect of diversity on the number of functions above a threshold
Multiple Threshold Approach

• Continuum from 1-99% thresholds

• By a little or by a lot

• At which threshold does diversity has its maximum effect?

• After which threshold does diversity cease having a positive effect?
Multiple Threshold Approach

\[ \text{No.}\ fn > \text{threshold} \sim \text{Richness} \ast \text{No.}\ fn + (\text{Richness}\mid\text{Study}) + \epsilon \]

- Decreasing intercepts represent tradeoffs in monoculture
- Diverse treatments sustain all functions up to 81% of their max
Multiple Threshold Approach

- **Linear coefficient** $\beta$ values: $\beta_0^2$, $\beta_0^5$, $\beta_0^8$, $\beta_1^0$, $\beta_0^8$

- **Threshold** values: $0$, $1$

- **Richness** values: $0$, $1$, $2$, $3$

- **# Fn > Threshold** values: $0$, $1$, $2$, $3$

- **Linear coefficient** vs. **Threshold** graph shows different $\beta$ values.
Multiple Threshold Approach

\[ \text{No.}\, fn > \text{threshold} \sim \text{Richness} \times \text{No.}\, fn + (\text{Richness} | \text{Study}) + \epsilon \]
Multiple Threshold Approach

At which threshold does diversity have its maximum effect?
Multiple Threshold Approach

Diversity sustains functions at increasingly higher thresholds as more functions are considered.
Multiple Threshold Approach

After which threshold does diversity cease having a positive effect?
Diversity brings more functions closer to their maximum
Conclusions

• Diversity increases the average level of multiple functions
• Diversity increases the number of functions above a threshold, particularly as more functions are considered
• In general, the positive effects of diversity outweigh the positive effects

• Byrnes et al. 2014 *Methods Ecol Evol*

  install_github(“jebyrnes”, “multifunc”)

Questions? jslefche@vims.edu
Multiple Thresholds – Generality

- **Primary producer**
- **Herbivore**
- **Carnivore**
- **Dead organic matter**
- **Detritivore**
Multiple Thresholds – Simulation

The diagram illustrates the diversity effect across different thresholds for various datasets, including Cedar Creek (E120) and Wardle et al. 2003. The x-axis represents the threshold values (0 to 1), and the y-axis shows the diversity effect ranging from -1.0 to 1.0.
Averaging Approach – Generality