Trophic complexity alters the diversity-multifunctionality effect in experimental grassland mesocosms

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Introduction

• Diversity has a positive effect on single ecosystem functions and can also affect multiple ecosystem functions simultaneously[1]
• Multifunctional effect depends on species contribution to each function
• Diverse communities support more functions, but at average values[2]
• Less diverse communities support fewer functions at high values
• => Effect increases, then decreases with percent-function threshold values
-"Jack-of-all-trades" effect (JTE)[2]

• Biodiversity loss across trophic levels affects single functions[3]
• Trophic levels - increase[4] or decrease[3] strength of diversity-function relationships
• Lack of consensus between observational and experimental studies
• Difficult to predict diversity-multifunction relationships in multitrophic communities

• To estimate effect of biodiversity loss across trophic levels on ecosystem function, need to address effect of multiple trophic components on ecosystem multifunctionality

Question and hypotheses

How does trophic complexity alter the biodiversity-multifunction (BMF) relationship?

The BMF curve has been empirically determined[3] as in Fig 1.

We hypothesize two independent trophic effects:
- change in JTE through change in correlations between ecosystem functions
- change in diversity effect through altered complementarity or selection effect

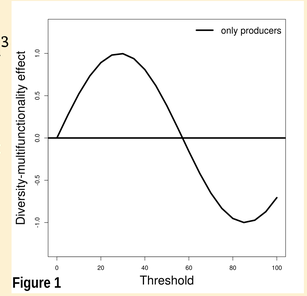

Figure 1

In Fig 2, we predict the two mechanisms to affect the curve as:
- change in the point at which the effect becomes negative
- change in the height of the peak and trough

Comparing BMF curves of communities with different levels of trophic complexity, we infer mechanisms of trophic control

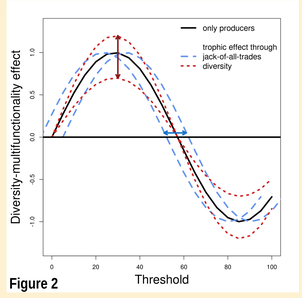

Figure 2

Methods

Data from manipulated grassland mesocosm experiment at Cedar Creek Ecosystem Reserve, Minnesota, USA

Mesocosm communities of 1m^2 (Fig 3) with
5 plant diversity levels (1, 2, 4, 8, 16 species) x
4 trophic complexity levels
-only plants = "NONE"
-plants + aboveground mesofauna = "INS"
-plants + litter mesofauna = "LIT"
-plants + aboveground mesofauna + litter mesofauna = "BOTH"

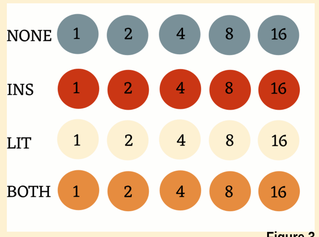

Figure 3

Community values of ecosystem functions measured after 1 year
1. Aboveground biomass
2. Root biomass
3. Soil water retention
4. Biomass recovery in 1 year after harvest

Multifunctionality analyzed as per Hector and Bagchi, 2007 and Van der Plas et al., 2016.

Results

1. Biodiversity within producers increases levels of single ecosystem functions in agreement with previous studies, but trophic complexity has no effect on single ecosystem functions, in contrast with earlier understanding[5].

2. Producer diversity increases number of functions maintained above moderate thresholds (Fig 4), as seen across ecosystems[1].

3. Trophic complexity has a significant effect on number of ecosystem functions maintained above moderate thresholds (Fig 4), but effect of trophic complexity disappears at high thresholds.

4. The identity of the trophic component (INS, LIT or BOTH) affects the number of functions maintained above a given threshold.

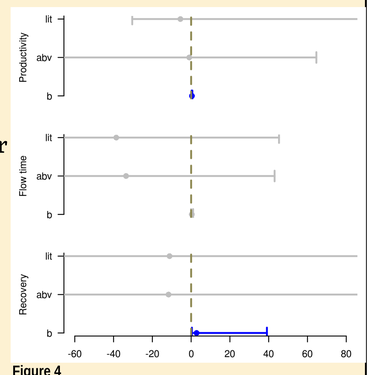

Figure 4

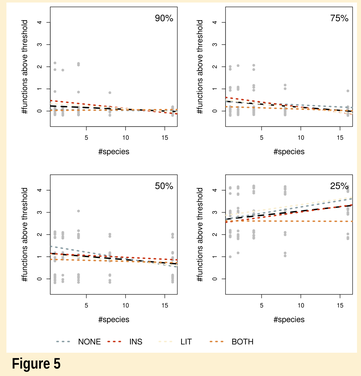

Figure 5

More results

5. Trophic complexity affects the BMF curve with both taxonomic (Fig 6) and functional (Fig 7) diversity, similar to single-function studies on grasslands[5,6]
- "INS" treatments have higher BMF magnitudes than "NONE"
- "BOTH" treatments have lower BMF magnitudes and earlier shifts to negative biodiversity effects

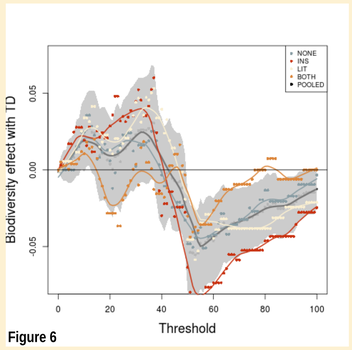

Figure 6

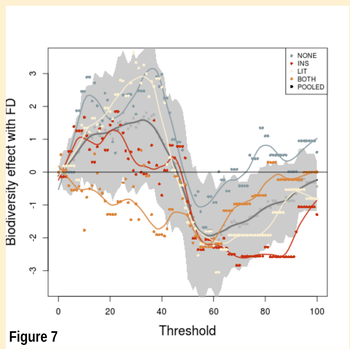

Figure 7

Conclusions

1. We report the first experimental test of the effects of trophic complexity on the BMF relationship.
2. Our results show that the non-producer trophic levels can have measurable impacts on ecosystem multifunctionality through both altering correlations between functions and the biodiversity effect on single ecosystem functions.
3. Trophic complexity can alter multifunctionality even if it has no significant effect on single ecosystem functions.
4. Multitrophic biodiversity loss, therefore, can be more damaging to ecosystems than previously estimated with single ecosystem functions.

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