Reply to Byrnes et al.: Aggregation can obscure understanding of ecosystem multifunctionality

We manipulated soil animal communities in combination with nitrogen fertilization and found that individual grassland ecosystem functions had contrasting responses across the manipulations (1). We therefore cautioned against using a single multifunctionality index that aggregates individual functions to characterize overall ecosystem functioning (1).

Byrnes et al. (2) contend that this caution misinterprets the concept of ecosystem multifunctionality. They suggest that multifunctionality does not require positive correlation of multiple functions. Moreover, they advise that a multifunctionality framework must assess both individual functions and overall functionality. We agree with both of their points. However, both fail to address the caution raised by our study (1).

We argue that a summary index of multifunctionality will inappropriately characterize relationships between a driver and net ecosystem functioning whenever responses of the individual functions to drivers are context dependent. Our cautions then expressly relate to those cases where the underlying drivers of individual functions are process and/or context dependent. These criteria apply to our study and to most ecosystems.

The issue of aggregating contrasting variables is not limited to ecology and underlies a suite of logical (or inference) fallacies in statistics, such as Simpson's paradox, where statistical summarization changes the interpretation of a mean because a second factor modifies the effect of the first (3). Byrnes et al. (2) state that "No statistician would argue that variation in data invalidates estimates of a mean." This statement misrepresents our argument and the broader issue of logical fallacies: the important question is what we can infer from the mean (3). Where the effects of a driver are context dependent, the resulting variation can invalidate conclusions based on mean estimates summarizing the influence of a single driver (3–5).

We believe the notion of multifunctionality is necessary to enhance ecosystem management. Otherwise, management for only a single ecosystem function is likely to lead to the degradation of co-occurring functions. Nevertheless, we contend that the challenge remains to develop multifunctionality indices that appropriately account for the aggregate effects of contrasting individual functions when their responses depend on multiple drivers that vary in their effects either in space or time. This is especially important as biodiversity-ecosystem functioning studies move toward assessing the relative importance of multiple drivers—not just biodiversity—on ecosystem functioning. Byrnes et al. (2) concluded that the study of ecosystem multifunctionality is about the forest as well as the individual trees. We agree with their conclusion and suggest that the way to understand the forest is to study the trees.

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