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Multifunctionality does not imply that all functions are positively correlated

J Byrnes

JS Lefcheck
Virginia Institute of Marine Science

L Gamfeldt

JN Griffin

F Isbell

LETTER

Multifunctionality does not imply that all functions are positively correlated

The recent publication by Bradford et al. (1) argues that indices of ecosystem multifunctionality—the simultaneous performance of multiple ecosystem functions (2)—are only useful if all component functions "respond to community change in a positive correlated fashion." We contend that this argument fundamentally misinterprets the concept of ecosystem multifunctionality.

In their paper, Bradford et al. manipulate soil community complexity and nitrogen content; they find that complexity increases multiple indices of multifunctionality. In looking at single functions, however, they find that complexity increases only some functions and even has a negative impact on one function. They conclude that because of this lack of uniform response across individual functions, the positive trend in multifunctionality indices misrepresents the whole system response to increasing complexity.

Bradford et al.'s conclusion suggests a fundamental misunderstanding of the concept of multifunctionality. They state that, for multifunctionality indices to be meaningful, all functions must be positively correlated. This is simply not correct. The correct inference is that increasing complexity increases multifunctionality, but cannot simultaneously maximize all functions. Their conclusion that the use of multifunctional indices are questionable in advancing theoretical understanding and management is therefore unfounded.

As stated in our own discussion of the definition and proper approach to multifunctionality (2), which is cited multiple times by Bradford et al. (1), multifunctionality indices provide a measurement of the simultaneous performance of multiple ecosystem functions. All functions are not required to exhibit a similar response to any given driver. In fact, quite the opposite is true. The multiple threshold index (sensu 2) explicitly incorporates tradeoffs in both the direction and magnitude of individual effects (3).

Further, we advised that researchers examine both summary indices and individual functions to understand how single function responses result in multifunctionality (2). However, Bradford et al. mistakenly imply that insights from one approach somehow invalidate results from the other. According to Bradford et al.'s argument, summarizing statistics for complex systems, such as those provided by the multifunctionality approach, are misleading because they hide the underlying distribution of observations. By this logic, any empiricist that has drawn conclusions based on an arithmetic mean is guilty of the same fallacy. No statistician would argue that variation in data invalidates estimates of a mean.

Last, Bradford et al. state that the blind use of multifunctionality indices could have serious negative consequences for managing multifunctional ecosystems. We agree: the blind use of any index is problematic. The indices we present are flexible in that they can weight functions differently (or even exclude nonrelevant ones) to reflect management priorities. If managers wish to maximize particular ecosystem functions, that is where efforts should be targeted.

We hope that other researchers will not adopt the incorrect definition of multifuncionality used by Bradford et al. We are beginning to move beyond an exclusive focus on single functions in community and ecosystem ecology to a full understanding of ecosystem multifunctionality as a unified phenomenon. We hope that, despite the recommendation of Bradford et al., other researchers continue to study the forest, as well as the individual trees.

***Jarrett Byrnes*[a,1], *Jonathan S. Lefcheck*[b], *Lars Gamfeldt*[c], *John N. Griffin*[d], *Forest Isbell*[e], *and Andy Hector*[f]**

[a]*Department of Biology, University of Massachusetts Boston, Boston, MA 02125;* [b]*Department of Biological Sciences, Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, VA 23062;* [c]*Department of Biological and Environmental Sciences, University of Gothenburg, SE-40530 Gothenburg, Sweden;* [d]*Department of Biosciences, Swansea University, Swansea SA2 8PP, United Kingdom;* [e]*Department of Plant Biology, University of Georgia, Athens, GA 30602; and* [f]*Department of Plant Sciences, University of Oxford, Oxford OX1 3RB, United Kingdom*

1 Bradford MA, et al. (2014) Discontinuity in the responses of ecosystem processes and multifunctionality to altered soil community composition. *Proc Natl Acad Sci USA* 111(40): 14478–14483.

2 Byrnes JEK, et al. (2014) Investigating the relationship between biodiversity and ecosystem multifunctionality: challenges and solutions. *Meth Ecol Evol* 5(2):111–124.

3 Perkins DM, et al. Higher biodiversity is required to sustain multiple ecosystem processes across temperature regimes. *Glob Change Biol*, 10.1111/gcb.12688.

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[1]To whom correspondence should be addressed. Email: jarrett.byrnes@umb.edu.