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Conservation implications of recent advances in biodiversity–functioning research

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ABSTRACT

Studies have shown that increasing diversity has a positive influence on many ecosystem functions and services, for example, biomass productivity. However, most diversity–functioning studies have derived their conclusions (1) from considering only random species assemblages, (2) from small spatial scales – often micro- and mesocosm experiments, (3) from studying merely a single trophic level, and (4) studies from a small number of biomes dominate. Critics argue that these studies provide little basis to evaluate the consequences for biodiversity loss in the real world. Here we re-consider the latest research focusing on each limitation in turn to highlight the possible lessons for real-world conservation from recent biodiversity–ecosystem function (BEF) research. Tentative general lessons from recent research include: (1) the need to urgently forestall human-induced extinction (i.e., non-random extinction) over large areas, in order to avert large negative functional consequences which may be more pronounced at larger scales and (2) preserve relatively intact communities because biotic interactions across the multi-trophic levels may have a synergistic contribution to the overall functioning of a system. However, considering the complexity of the community dynamics of natural systems, we recommend using natural systems – and understanding the basic physiological features and ecological roles of the species within them – because they implicitly include realistic extinction process, trophic structures and spatial–temporal scales as a useful way of increasing the relevance of future BEF studies to conservation.

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1. Introduction

Degradation of the biosphere, inflicted by human actions, often makes the headlines of newspapers. Such interest is often aroused based on a simple ecological rationale: A reduction of biological diversity may ultimately rebound on the well-being of ecosystem functioning that regulate the Earth system upon which humans depend. More formally, under the United Nations Earth Summit in Rio de Janeiro in 1992, which was reinforced in Johannesburg in 2002, one of the key reasons for conserving biological diversity is that it promotes human well-being by providing for the conditions and processes that sustain and fulfil our lives, commonly termed 'ecosystem services' (MEA 2005).

Within ecological science there has been a large focus on whether a reduction in the diversity of the entities of organisms – biodiversity – is impacting ecological processes (Morris, 2010) and impacting ecosystem services (Naeem et al., 2009) in a negative way. Recent meta-analytical studies of this biodiversity–ecosystem

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Table 1
Summary of empirical/observational biodiversity–ecosystem functioning studies that are discussed in the text.

References	Study system/spatial scale	Trophic level	Extinction type	Ecosystem response (unit)	Study duration	Key results
Duffy et al. (2005)	Seagrass mesocosms	Multi-trophic	Controlled	Plant total biomass (g)	42 days	Increasing herbivore richness enhanced seagrass biomass only in the presence of predators
Finke and Denno (2005)	Salt marsh mesocosms	Multi-trophic	Controlled	Cordgrass aboveground biomass (g m^{-2})	c. 2 months	Increasing richness of predators that eat only preys has no impact on plant biomass. However, increasing richness of predators that also eat other predators reduced plant biomass
Gamfeldt et al. (2005)	Marine microbial system	Multi-trophic	Controlled	Consumer and prey biovolume ($\times 10^4$ μm^3)	21 days (c. 40 consumer generations)	Increasing consumer richness enhanced consumer biomass and reduced prey biomass. Increasing prey richness also enhanced consumer biomass in the presence of high consumer richness
Gonzalez and Chaneton (2002)	Temperate moss microecosystem/ moss carpets on rocks and boulders	Single trophic	Non-random	Community-level total biomass (mg)	12 months	Species loss caused by habitat fragmentation led to decline in community abundance and biomass
Hambäck et al. (2000)	Coastal system/one 500-m transect on the shore in Northern Sweden	Multi-trophic	Field observation	Leaf damage resistance (proportion of leaf damage)	Complete life cycle of herbivore	Herbivory damage to focal plant was reduced by the presence of non-host species
Jonsson (2006)	Freshwater mesocosm	Single trophic	Controlled	Leaf breakdown (g mg shredder mass^{-1})	20 weeks	Species richness of detritivorous insect larvae increased leaf breakdown rate over time in resource-limited systems
Larsen et al. (2005)	Agricultural and natural systems/ 14 farms and adjacent natural areas across Yolo County, California	Single trophic	Non-random	Bee pollination (number of pollen desposition)	Field observation	Species loss of bees led to greatly reduced pollination services
Larsen et al. (2005)	Forested islands/29 islands across a 430,000 ha lake in Venezuela	Single trophic	Non-random	Dung burial rate (g h^{-1})	Field observation	Species loss of beeltes led to greatly reduced dung burial rate
Smith and Knapp (2003)	Natural grassland/72 plots across a 3487 ha prairie in Northeastern Kansas	Single trophic	Non-random	Plant total aboveground net primary production (ANPP) (g m^{-2} year^{-1})	Growing seasons of 2 years	Dominant species maintained plant ptoductivity with the loss of rare species. But ANPP eventually declined in the long term
Steiner (2001)	Freshwater mesocosm	Multi-trophic	Controlled	Prey total biomass (mg/L)	42 days	Prey heterogeneity could prevent predators from reducing their overall biomass
Tylianakis et al. (2008)	Semi-natural grassland/19 plots across two grassland landscapes in Central Germany	Single trophic	Field observation	Plant belowground biomass (g)	Growing season of 1 year	Plant diversity positively affected plant productivity. But this effect was increased when the soil nutrients were spatially heterogeneous
Tylianakis et al. (2008)	Agricultural and natural systems/ 48 plots across three cantons in Southwest Ecuador	Single trophic	Field observation	Parasitism rate of bees and wasps by parasitoids (proportion of infection)	16 months	Parasitoid diversity positively affected parasitism rates. But this effect was enhanced when the insect hosts were heterogeneously distributed
Tylianakis et al. (2008)	Coffee agroforests/24 plots across a agricultural landscape in Central Sulawesi	Single trophic	Field observation	Coffee flower pollination (proportion of flowers that set fruits)	35 days	Bee diversity positively affected coffee pollination rates. But this effects was stronger with increasing spatial heterogeneity of coffee flowers