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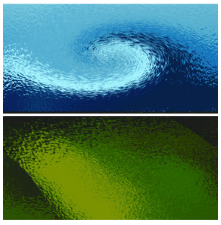

VIEW POINT

Ecosystem functioning and the legacy of MarBEF

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View Point

Spring 2009 saw the finale of the successful European Union Network of Excellence MarBEF (Marine Biodiversity and Ecosystem Functioning). The network, funded under the E.U. *Sustainable development, global change and ecosystems research programme*, brought together researchers from some 94 different institutes in an unprecedented collaborative investigation of European marine biodiversity and ecosystem functioning. The aims of the network were to understand how marine biodiversity varies across spatial and temporal scales and levels of biological organisation, to generate theory, models and tests of the relationship between marine biodiversity and ecosystem function, and to understand the economic, social and cultural value of marine biodiversity. As such, it presented researchers from a range of disciplines the opportunity to come together to examine some of the major issues relating to the distribution of diversity and its importance for maintaining functioning ecosystems. It is opportune, in the period following the conclusion of the network, to consider some of the issues raised during its 5-year life and how the knowledge gained from such endeavours can contribute to the wider field of ecological theory development that has, traditionally, been dominated by the terrestrial sciences.

One pertinent issue that has arisen from the cross-disciplinary collaborations is differential understanding of what is meant by the term ecosystem functioning. It is not a purely pedantic issue, because the term can mean different things to different people and this has implications for how research is conducted and perceived. Intuitively, it is about ecosystems working as they should. However, this is a rather vague concept that does little to facilitate the development of testable hypotheses. Our understanding of function has expanded over the years and we have a range of sophisticated definitions to choose from. The concept, depending on personal preferences, bridges disciplines from ecology and chemistry (e.g. flow of energy and nutrients, stability, biomass) through to economics and social sciences (e.g. goods and services). Such wide coverage is appropriate for a multi-dimensional concept, but it presents opportunities for confusion and miscommunication. While we are unlikely to reach the stage of having one definitive definition, it is important to be clear about what we mean when discussing ecosystem function. National and international policy increasingly demands the preservation of

functioning ecosystems and we must be able to successfully communicate what we understand by this term to each other, to policy-makers and to the public.

One further issue arising from the work of the MarBEF network is how we can best qualify or quantify ecosystem function. The range of approaches for measuring function is as diverse as the range of definitions, with each having advantages and disadvantages. Biogeochemical methods (e.g. measures of nutrient fluxes) elucidate the chemical elements of system processes, but do not directly account for the biological entities that regulate them. Biological approaches (e.g. traits-based approaches, such as productivity measures and trophic group or biological traits analysis) consider the functional roles of species, but provide only proxy measures of the flow of materials through the system. From this perspective, a search for one 'best' measure of function is fruitless. In reality, what is required to fulfil the goals of theory development, policy making and environmental management, is a collection of tools to measure and assess function, from which one or more can be selected as appropriate to the aims of individual studies. This multi-tool approach is ripe for development and the marine community, in which coupled ecology-geochemistry studies are now quite common place, is well positioned to take the lead in providing the knowledge-base underpinning it.

The relationship between diversity and function is an area that has seen significant development during the five years of MarBEF. The nature of the relationship and the use of experimental manipulative approaches in this context, has been the subject of considerable debate since the BEF (biodiversity-ecosystem function) field exploded in the early 1990s. In his recent defence of experimental BEF research, Emmett Duffy (2009) wrote that "…most research has been [more] narrowly-focussed, employing small-scale, highly controlled experiments with designs whose relevance to natural ecosystems and realistic extinction scenarios is often unclear". Duffy does go on to show how these approaches have made significant contributions to knowledge on functioning in real-world ecosystems. However, there are still issues to be resolved, not least of which is a discussion on whether, and how, experimental approaches should be combined with observational studies. Marine species number in the thousands and experimental manipulations are, by their nature, small scale controlled conditions that cannot fully replicate natural ecosystems. Such approaches will not, in themselves, provide all the answers. In the preface to the summary of the 2000 conference *Biodiversity and ecosystem functioning*: *synthesis and perspectives*, held in Paris, France, the organisers (Loreau *et al.*, 2004) explained how science progresses through "periods of empirical and theoretical development bracketed by periods of synthesis". The 2000 conference represented a synthesis of the previous decade of research. It is perhaps, some ten years on, time for a further period of synthesis to examine what we have learned in the intervening period. Fostering discussions on how the results of experimental studies can be combined with macro-ecology and modelling, to provide a deeper understanding of biodiversity and ecosystem functioning, would be beneficial to all involved.

While a variety of functional variables have been utilised in BEF research, the biodiversity element has, to date, been interpreted mainly as equating to species richness and other possibilities have received relatively little attention. However, broadening the net to encompass additional aspects of biodiversity, such as assemblage structure, can be highly informative for theory development. For example, Bremner *et al.* (2003) have shown that, in some cases, heterogeneity in assemblage structure is associated with homogeneity in function but, at the other end

of the spectrum, homogeneity in structure may be accompanied by heterogeneity in function. In other words, assemblages that look similar to each other may function differently and assemblages that look different to each other may function in much the same way. Observations of changes in structure, but not function, add weight to the theory that there exists some degree of functional 'insurance' in ecological systems, which is delivered through the abilities of functionally-similar species to compensate for each other under changing environments (e.g. Frost *et al.* 1995, Yachi & Loreau 1999). Alternatively, observations that similarly-structured assemblages can function differently to each other are also informative, because they illustrate the importance of rare species. Although they do not play a key role in determining structure, rare species may, through the cumulative effects of shared traits, be rather more important in terms of function. Rarity has been a topic of some interest over the years, but these species are often given little attention or, indeed, disregarded in contemporary studies of assemblage structure. Their cumulative effects and potential to compensate for dominant species in the face of biodiversity changes do, however, make them indispensable for understanding the maintenance of ecosystem function. Marine systems - being species-rich, dominated by rare species and composed of diverse combinations of species and habitats - provide a fertile testing-ground in which to develop the theories of functional insurance, compensation and rarity.

The MarBEF network can be considered a successful endeavour, with knowledge and understanding gained on many important issues. However, as always in ecological research, answers tend to prompt more questions. The marine community is well placed, due to the nature of their study ecosystems and the collaborations developed through MarBEF and other such endeavours, to play a key role in tackling these issues in the coming years. However, this will require continued collaborative efforts, which are often constrained by suitable funding opportunities, as well as better links between the schools of marine and terrestrial ecology.

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