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Transdisciplinary synthesis for ecosystem science, policy and management: The Australian experience

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HIGHLIGHTS

- Structured synthesis advances science through transdisciplinary collaboration.
- Synthesis centres can effectively facilitate transdisciplinary synthesis.
- Syntheses draw on unifying frameworks, culturally resonant narratives and big data.
- Benefits include conceptual, methodological, policy, career and research outcomes.
- Continuity of programmes is essential to fully reap their benefits.

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ABSTRACT

Mitigating the environmental effects of global population growth, climatic change and increasing socio-ecological complexity is a daunting challenge. To tackle this requires synthesis: the integration of disparate information to generate novel insights from heterogeneous, complex situations where there are diverse perspectives. Since 1995, a structured approach to inter-, multi- and trans-disciplinary[1] collaboration around big science questions has been supported through synthesis centres around the world. These centres are finding an expanding role due to ever-

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[1] Transdisciplinary: A theory, methodology, point of view or perspective that transcends entrenched categories and engages both researchers and practitioners in formulating problems in new ways to address real-world problems (e.g. eco-health, ecosystem services).

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accumulating data and the need for more and better opportunities to develop transdisciplinary and holistic approaches to solve real-world problems. The Australian Centre for Ecological Analysis and Synthesis (ACEAS <http://www.aceas.org.au>) has been the pioneering ecosystem science synthesis centre in the Southern Hemisphere. Such centres provide analysis and synthesis opportunities for time-pressed scientists, policy-makers and managers. They provide the scientific and organisational environs for virtual and face-to-face engagement, impetus for integration, data and methodological support, and innovative ways to deliver synthesis products.
We detail the contribution, role and value of synthesis using ACEAS to exemplify the capacity for synthesis centres to facilitate trans-organisational, transdisciplinary synthesis. We compare ACEAS to other international synthesis centres, and describe how it facilitated project teams and its objective of linking natural resource science to policy to management. Scientists and managers were brought together to actively collaborate in multi-institutional, cross-sectoral and transdisciplinary research on contemporary ecological problems. The teams analysed, integrated and synthesised existing data to co-develop solution-oriented publications and management recommendations that might otherwise not have been produced. We identify key outcomes of some ACEAS working groups which used synthesis to tackle important ecosystem challenges. We also examine the barriers and enablers to synthesis, so that risks can be minimised and successful outcomes maximised. We argue that synthesis centres have a crucial role in developing, communicating and using synthetic transdisciplinary research.

1. Introduction

The rapid increase of human impacts on the world and compounding environmental and social costs have been paralleled by an acceleration of data and knowledge generation. This ever-increasing volume and complexity of scientific data, along with an emphasis on reductionism, has favoured scientific specialisation and knowledge fragmentation (Sidlauskas et al., 2010; Hampton and Parker, 2011). The complexity and profundity of current environmental challenges, however, requires solutions that transcend traditional disciplinary boundaries and synthesise knowledge (Carpenter et al., 2009).

Synthesis is necessary to integrate disparate, often incomplete, information from multiple sources, sectors and disciplines, and to enable extrapolation over large spatial and temporal scales. Synthesis enables the development of new models and hypotheses that can address complexity and lead to improved environmental awareness, understanding and solutions to problems (Peters, 2010; Hampton and Parker, 2011; Kemp and Boynton, 2012). The need for synthesis to tackle environmental challenges has been recognised and responded to internationally by, *inter alia*, the IPCC (Intergovernmental Panel on Climate Change), IGBP (International Geosphere-Biosphere Programme), IHDP (International Human Dimensions Programme on Global Environmental Change), and recently through the linking of these under Future Earth.[2]

Since 1995, synthesis centres have been established around the world to provide a structured approach to inter-, multi- and trans-disciplinary collaboration around big science questions. In contrast to the broad synthesis scope and stakeholder engagement undertaken by the large international synthesis groups, in this paper we focus on ecological synthesis through national and regional synthesis centres. The focus is largely on transdisciplinary integration of biophysical and linked social science (and a certain range of disciplines within this domain) in connection with environmental policy and management. We define transdisciplinary research to mean research involving multiple scientific disciplines in collaboration with policy and management (not solely citizen or community engagement). This contrasts with interdisciplinary research which we take to mean research between academic disciplines in a non-additive or non-transformational way, and multidisciplinary research as research between academic disciplines in an additive manner.

First, we describe the term synthesis and the need for transdisciplinary synthesis to address complex environmental problems. Next, we provide an overview of synthesis centres globally, and focus on the Australian Centre for Ecological Analysis and Synthesis (ACEAS) to demonstrate the capacity for synthesis centres to facilitate trans-organisational, transdisciplinary synthesis. We conclude by discussing the lessons learned from the ACEAS experience about how to overcome barriers to synthesis and to maximise the benefits and desired outcomes.

1.1. What is synthesis?

There is no single synthetic approach to science (Sidlauskas et al., 2010; Cooper et al., 2009) and there are many definitions of synthesis in the scientific literature (Kemp and Boynton, 2012). Scientific synthesis generally relates to an inductive process of integrating disparate elements (i.e. concepts, data, methods, analytical results) from one or more disciplines, to develop a novel integrative insight or model as a primary outcome (Sidlauskas et al., 2010). Synthesis can be systematic and tied to particular methodologies that are quantitative, such as through meta-analyses, or qualitative (Cooper et al., 2009). In its simplest form, 'synthesis' is a creative activity in which the aim is to produce new insights or outcomes that are greater and more meaningful than the constituent parts.

There has been a long history of knowledge integration in ecology, which may have made it easier for ecologists and environmental scientists to embrace synthesis. The discipline of ecology is unlike the more mechanistic physical sciences in that a single process is unlikely to be applicable everywhere and for all time. The search for relatively simple, quantifiable and universal relationships and laws therefore has been challenging and remains unresolved (Cooper, 2003). Ecology is inherently complex due to the variability of its elements across spatio-temporal scales, and so is more a probabilistic than deterministic science. As ecology has matured, understanding has increasingly been facilitated through meta-analyses and syntheses of many studies to produce more general understanding. Similarly, the social sciences also have strived to combine results of disparate studies to understand complex problems; for example, in society and medicine (Cooper et al., 2009).

1.2. The need for synthesis

Effective, informed environmental policy and management needs an evidence base which can be provided through synthesis of existing information. Environmental problems encompass multi-scaled and often multi-jurisdictional complexity, thus requiring inputs from many disciplines, sectors and stakeholders. It is critical not only to understand the biophysical drivers that underpin species persistence or habitat sustainability, but also the dynamics of drivers operating in the social and economic domains, and disparate stakeholder perspectives.

Transdisciplinary synthesis provides a way to integrate disparate knowledge to inform evidence-based policy and practical, feasible management responses. Transdisciplinary research that integrates multiple forms of knowledge and perspectives through participatory engagement, particularly on issues with high stakes and uncertainty, is more

[2] http://www.futureearth.org/.