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Short Communication

A method to identify drivers of societal change likely to affect natural assets in the future, illustrated with Australia's native biodiversity

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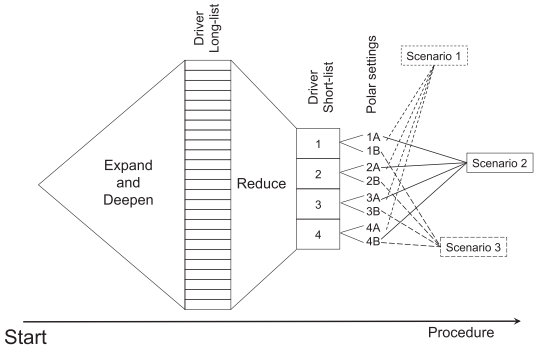
HIGHLIGHTS

- Natural assets are under increasing anthropogenic pressures.
- Possible futures for such assets are affected by many drivers of change.
- Construction of sets of key drivers enables framing of future scenarios.
- Local and global drivers will affect natural assets very differently.
- Identifying sets of key drivers is an important stage for scenario development.

GRAPHICAL ABSTRACT



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ABSTRACT

Human society has a profound adverse effect on natural assets as human populations increase and as global climate changes. We need to envisage different futures that encompass plausible human responses to threats and change, and become more mindful of their likely impacts on natural assets. We describe a method for developing a set of future scenarios for a natural asset at national scale under ongoing human population growth and climate change. The method involves expansive consideration of potential drivers of societal change, a reduction of these to form a small set of key drivers to which contrasting settings are assigned, which we use to develop a set of different scenarios. We use Australia's native biodiversity as the focus to illustrate the method.

1. Introduction

Pressures on natural assets such as natural resources, ecosystem services and native biodiversity continue unabated, with most pressures increasing (Millenium Ecosystem Assessment, 2005; Foley et al., 2011). Threats primarily are driven by humans, namely, the on-going growth in human populations (Gerland et al., 2014), the accelerating rates of exploitation of natural resources (York et al., 2003), and many

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problems arising from global traffic of materials (Lenzen et al., 2012) and biota (Bellard et al., 2016). Worldwide, climates appear to be changing more quickly than expected, tracking the worst-case trajectories envisioned a decade ago (Rammig and Mahecha, 2015). Most threats to natural assets are strongly linked with economic activity and growth, but some futures may better balance economics and environment than others (TEEB, 2010; Hatfield-Dodds et al., 2015).

We need to develop ways to envisage the potential outcomes of these rapidly changing forces on natural assets (Devictor et al., 2012). 'Scenarios' are one way to envisage the future because they are designed specifically to describe current, medium-term and long-term strategic thinking, decisions and actions (Amer et al., 2013). Scenarios are not predictions per se but are intended to envisage how the focal element is likely to fare under different assumptions, decisions and actions (Coreau et al., 2009; Raupach et al., 2012a). There are many methods for scenario development in a field that has grown considerably from the early 1960s (Amer et al., 2013), with differences in focusing on different aspects and reasons for scenario development (Bishop et al., 2007).

We describe a method for developing a set of different future scenarios for a natural asset at national scale under ongoing human population growth and climate change, which is the main concept of this paper, consisting of several important aspects. This method can be applied to natural assets that are not usually included in economic costs-benefits analyses (i.e. 'externalities') (TEEB, 2010). Specifically, we consider the native biodiversity component of natural assets for Australia as the focal element. We focus on current and future trends in human-related pressures on native biodiversity because these might be managed to address declines in native biodiversity (Millenium Ecosystem Assessment, 2005). Humans are likely to respond quickly to climate change so that biodiversity is likely to have to deal with direct (physiological stress, ecosystem dysfunction) and indirect (humans doing things differently) effects of climate change. To consider futures with human-related pressure on native biodiversity, the scenarios are predicated on the assumption that there will be a substantial increase in Australia's population size by 2050 to c. 35–45 million (Australian Bureau of Statistics, 2015), although the distribution of the population is uncertain. For climate change, global greenhouse-gas emissions are assumed to increase with concomitant changes in regional climates (Timbal et al., 2015), although the severity and spatial variation of change are uncertain (Bhend and Whetton, 2015; Moise et al., 2015), particularly for precipitation (Nikolokis et al., 2011). Our focus is at the national scale because nations have the autonomy to develop and to implement policies strategically to serve national interests and to buffer global influences. The management of natural assets generally is vested at this scale, such as native biodiversity conservation and restoration investment over decades (Lake, 2005; Muir, 2014). The method involves the consideration of many potential drivers of change to avoid overlooking potentially important drivers. We reduce this long list to a shortlist of 'key drivers' that are used to generate a set of different scenarios. A schematic of the procedure is shown in Fig. 1. We use known links between proximate pressures and native biodiversity (Millenium Ecosystem Assessment, 2005) to build a bridge between societal change and effects on native biodiversity.

2. Methods

2.1. Building the long list

We undertook an extensive literature search to identify drivers that are known to, or plausibly might, affect the focal element, native biodiversity, by links to human societal change (Sala et al., 2000; Millenium Ecosystem Assessment, 2005; Raupach et al., 2012b; Elmhagen et al., 2015).

Initial considerations in previous applications have included human demography, socio-economic development and technological change as

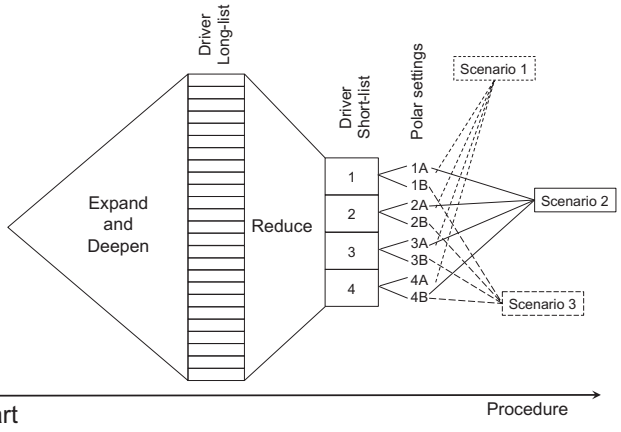

Fig. 1. Schematic of the procedure used to develop a set of different scenarios. Start with the focal element and think horizontally (laterally) and vertically (deeply) about the drivers of change that could directly or indirectly affect the focal element. Compile a long-list of drivers of change. Then reduce this list by selecting the most relevant drivers to the focal element and by conflating multiple drivers under a short-list of key drivers. Assign polar settings for each key driver and use these to develop a representative set of scenarios. Only three scenarios are shown here to illustrate the procedure.

the main drivers (Nakićenović and Swart, 2000). We used a simple conceptual model of the major drivers and influences at the national scale (Fig. 2) that could affect the focal element (Raskin, 2005). We considered interactions, subordinate factors under each of the four sets of drivers of change (viz. human population, economic and social development, agriculture and land use, energy and technology) and strategy (elected governments and their policies). We also considered different time scales over which drivers may act.

Deeper consideration (Inayatullah, 2007) was afforded to drivers known to or likely to affect native biodiversity. We asked: what are driving the pressures on Australian native biodiversity and what are the proximate impacts on native biodiversity and from which drivers do these emerge? The logic train here is: change in driver → change in society → change in proximate pressures on native biodiversity → change in native biodiversity. Apart from climate change, we considered the following major proximate pressures on native biodiversity (Sala et al., 2000; Foley et al., 2005; Millenium Ecosystem Assessment, 2005):

- Land use (land clearing, habitat loss, habitat fragmentation, land degradation);
- Resource extraction (resource flow, waste generation);
- Contamination (pollution or toxicity);
- Invasive species (introduction, spread, effects);
- Water extraction, diversion, alterations; and
- Hunting and wild harvest (commercial and recreational).

2.2. Reducing the long list to a key-driver list

To reduce the long list, we evaluated the relevance of each driver (Table 1) using the major proximate pressures on native biodiversity listed just above. Drivers affecting multiple pathways from societal change to change in native biodiversity need particular attention. Where sensible, we conflated multiple drivers into a 'key' driver. For example, the 20 long-list drivers (Table 1: last column) could be conflated, into the four main drivers shown in Fig. 2. The first six drivers in Table 1 could be combined under an 'Economic & Social Development' driver. Changes in any of these six drivers would then be likely to affect the overarching Economic & Social Development driver. The effect of the Economic & Social Development driver is the collective consequence of changes in these six drivers.

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