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Potential future scenarios for Australia's native biodiversity given on-going increases in human population

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HIGHLIGHTS

- The fate of natural assets under human pressures needs urgent attention.
- Australia's native biodiversity is used as an example of a natural asset.
- Nine scenarios were built to envisage futures for Australia's native biodiversity.
- The distribution of human population increases greatly affects native biodiversity.
- A multiple sustainability scenario offers the best future for native biodiversity.

GRAPHICAL ABSTRACT

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ABSTRACT

Most natural assets, including native biodiversity (our focus), are under increasing threat from direct (loss of habitat, hunting) and indirect (climate change) human actions. Most human impacts arise from increasing human populations coupled with rises in per capita resource use. The rates of change of human actions generally outpace those to which the biota can respond or adapt. If we are to maintain native biodiversity, then we must develop ways to envisage how the biota may be affected over the next several decades to guide management and policy responses. We consider the future for Australia's native biodiversity in the context of two assumptions. First, the human population in Australia will be 40 million by 2050, which has been mooted by federal government agencies. Second, greenhouse gas emissions will track the highest rates considered by the Intergovernmental Panel on Climate Change. The scenarios are based on major drivers of change, which were constructed from seven key drivers of change pertinent to native biodiversity. Five scenarios deal with differing distributions of the human population driven by uncertainties in climate change and in the human responses to climate change. Other scenarios are governed largely by global change and explore different rates of resource use, unprecedented rates of technological change, capabilities and societal values. A narrative for each scenario is provided. The set of scenarios spans a wide range of possible future paths for Australia, with different implications for the future of native biodiversity.

1. Introduction

Native biodiversity is the collection of native species, genetic and ecological variation in a given area. Native biodiversity is integral to

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ecosystem function (Soliveres et al., 2016), and provides many ecosystem services upon which humans rely (Mooney et al., 2009). However, native biodiversity is in steep decline at global (Millenium Ecosystem Assessment, 2005), national (Evans et al., 2011) and local (Fischer et al., 2010) spatial scales. There are many causes, but land-use change (Newbold et al., 2015) and climate change (Intergovernmental Panel on Climate Change, 2015) are at the forefront of pressures that are affecting native biodiversity adversely (Selwood et al., 2015). We need to find ways to achieve a 'safe operating space' for the long-term persistence of humans, the biota and environmental 'health' (Rockström et al., 2009b).

While the current status and pressures on native biodiversity are reasonably well known (Newbold et al., 2015), what is much less certain is the future path we might choose for better balancing human wealth and welfare with the maintenance of the environment, including native biodiversity (Steffen et al., 2011a). There is a need for a forward-looking framework to envisage how native biodiversity, the global environment and human needs will play out in different 'futures' (Steffen et al., 2011b). Futures studies use various methods to think about the future to inform current strategic thinking, decision-making and action (Rigby and Bilodeau, 2007). A commonly used method is scenario development (Amer et al., 2013), and we see the construction of plausible scenarios as an important tool for anticipating and dealing with native biodiversity declines before they become irreversible.

1.1. Scenario development

Scenarios are used increasingly, in many different fields and for different purposes (Börjeson et al., 2006) to deal with uncertainty (Schoemaker, 1991) and to help to make better decisions (Wilkinson and Kupers, 2013). Amer et al. (2013) provided a comprehensive review of the scenario-planning literature, covering scenario-development approaches, quantitative techniques, and means for identifying the most critical drivers of change. Much of future-studies work uses multiple scenarios (Wilkinson, 2009), connecting different futures with the present (Martelli, 2001) through feasible chains of causal relationships (Kahn and Wiener, 1967). Scenario development facilitates discussion on assumptions about the future and precipitates thinking (Raskin, 2005), and expands perspectives that identify influences that might otherwise be overlooked (Wilkinson and Kupers, 2013).

We build on previous scenario developments (Cork et al., 2012; Raupach et al., 2012; Costanza et al., 2015) and focus specifically on the pressures affecting native biodiversity for Australia as an exemplar. Human responses to some drivers of change, especially climate change, are key elements of our approach (Fig. 1) because these are likely to be faster than the biotic responses to climate change. The set of scenarios spans a wide range of possible future paths for Australia. In the following, we describe and discuss the implications of each scenario on future native biodiversity.

2. Methodology

Our development of multiple scenarios is underlain by two core assumptions (about Australia's population and the greenhouse-gas emissions scenario) and by a suite of 'drivers of change'. While the assumptions limit the potential range of futures, the ones we use are both crucial and most likely at the current time. The drivers were selected through a rigorous process described elsewhere (Pepper et al., 2016), so we do not describe them in detail here.

2.1. Assumptions

We assume two plausible, worst-case assumptions for human population change and greenhouse-gas emissions from a native biodiversity perspective, and we seek to understand effects on the focal element, native biodiversity, within the scope of these conditions. These assumptions are designed to focus attention on the urgency of addressing the threats to native biodiversity as soon as possible (Essl et al., 2015).

First, Australia's population will continue to increase with a relatively high rate by OECD standards for developed economies (United Nations, 2002), and will reach 40 million by 2050. This number approximates the Australian government's upper estimate (Australian Bureau of Statistics, 2015).

Second, greenhouse gas emissions will track the highest of IPCC scenarios (Rahmstorf et al., 2012). Therefore, we assumed the RCP8.5 (Representative Concentration Pathway) emissions scenario of the IPCC Fifth Assessment Report. This corresponds to CO_2 emissions increasing to >~20 Gt C year^{-1} by 2050 with a projected 2 °C average warming. The trajectories of climate-change effects are projected to differ greatly among

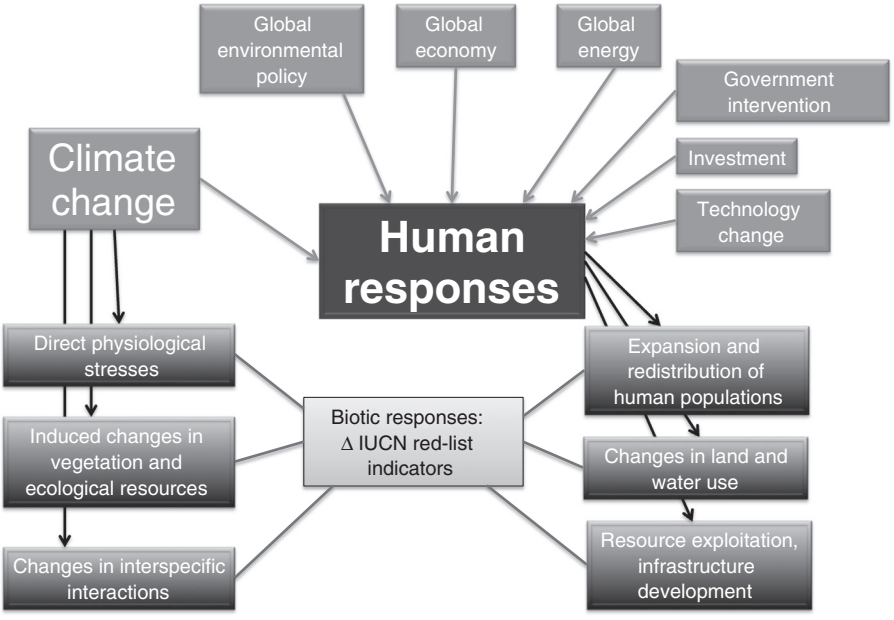

Fig. 1. The interactions between key drivers of change on proximate pressures affecting biotic responses (native biodiversity). These drivers affect human responses, which influence proximate pressures on native biodiversity, while climate change also has direct affect on physiological, structural and behavioural processes, and so, on biotic responses. We focused on the human responses component of this system.