Biological Conservation 181 (2015) 182–189

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Implementing backcasting for conservation: Determining multiple policy pathways for retaining future targets of endangered woodlands in Sydney, Australia

Ascelin Gordon *

School of Global Urban and Social Studies, RMIT University, GPO Box 2476, Melbourne 3001, Australia

ARTICLE INFO

Article history:
Received 8 August 2014
Received in revised form 11 October 2014
Accepted 22 October 2014
Available online 3 December 2014

Keywords:
Backcasting
Biodiversity offsets
Conservation policy
Cumberland plain woodland
Habitat degradation
Urban development

ABSTRACT

Developing conservation policy is a challenging process, often impeded by a lack of clear objectives and a limited understanding of the pathways to achieve them. Here, the utility of target-based 'backcasting' is demonstrated for developing effective conservation policies. Backcasting encodes social values by requiring a desired future state be selected as a target; it then involves searching for multiple pathways to reach this state from the present. This approach is demonstrated with a case study examining policy options for mitigating impacts from the growth of Sydney on a critically endangered woodland community. A model was developed to predict changes in woodland area over time in response to a range of processes: declines in habitat condition; legal and illegal clearing for development; and the implementation of biodiversity offsets to compensate for clearing. Using a target of retaining 60% of the current woodland distribution in 50 years time, the backcasting analysis involved searching for all combinations of processes that would achieve this target. Results demonstrate how backcasting provides a structured way to explore the trade-offs and robustness of combinations of policy interventions leading to a desirable future. For this case study, the most viable way of achieving the target may be to ensure the offset policy is adequate and enforced. If this was not feasible, the analysis shows that reducing the rate at which habitat is declining in condition would be most important in opening up other policy options. This study provides the first quantitative demonstration of backcasting in a conservation context.

1. Introduction

A pervasive problem in the global attempts to conserve biodiversity is evaluating the extent to which conservation focused policies achieve their goals (Bennear and Coglianese, 2005; Ferraro and Pattanayak, 2006). There are many reasons why this poses such a challenge, including factors internal to the policy development cycle such as poorly defined objectives or a lack of political will for accountability (Ferraro and Pattanayak, 2006). External factors pose an even greater challenge and include the temporal delays between policy interventions and on-ground outcomes, uncertainties in the baseline data from which to measure performance and a lack of resources to monitor outcomes at appropriate temporal and spatial scales (Bull et al., 2014; Bottrill et al., 2011; Griscom et al., 2009).

Together, these factors complicate the policy development cycle and often result in traditional ex-post evaluations of policy outcomes being unfeasible. They also add considerable uncertainty in determining how existing conservation-focused policies should be refined, or how new policies should be structured. A number of approaches have been proposed to help address these issues including scenario analysis, adaptive approaches and resilience thinking (Peterson et al., 2003; Groves and Lempert, 2007; Polasky et al., 2011). Here, it is proposed that 'backcasting' is added to this list as a complementary and under-utilised approach for supporting the development of effective conservation policies.

'Backcasting' has different meanings across fields of science and was first used as an alterative to forecasting in the early 1980s for developing energy policy (Robinson, 1982). However the origins of backcasting go back further to the 1970s when Amory Lovins proposed a 'backwards-looking-analysis' to overcome difficulties in long-term energy forecasting (Robinson, 1982). An interesting aspect of backcasting is that it is an explicitly normative approach in that it involves defining a *desired* future state as a target, and then determining multiple pathways to traverse from the current state to the future state (Dreborg, 1996). It can be thought of as temporally opposite to forecasting, which involves extrapolating current trends and is often used with scenario analysis (Cinq-Mars and Wiken, 2002). One of the strengths of the backcasting approach is that it

* Tel.: +61 3 9925 9930.
E-mail address: ascelin.gordon@rmit.edu.au

http://dx.doi.org/10.1016/j.biocon.2014.10.025
0006-3207/

is explicitly based on searching out multiple pathways to meet future objectives, and can thus encourage a broader view of relevant factors, leading to the systematic consideration of options that may not otherwise be considered 'feasible' (Manning et al., 2006).

There have been numerous interpretations of backcasting (Holmberg, 1998; Höjer and Mattsson, 2000; Vergragt, 2005) and although the technique has significant potential in a conservation context, its use to date has been limited and qualitative. These qualitative approaches have proposed using backcasting for planning ambitious restoration projects (Manning et al., 2006), as a tool for participatory scenario planning (Palomo and Montes, 2011) and for determining general incentives for ecosystem conservation (Cinq-Mars and Wiken, 2002).

Here, a quantitative example of target-orientated backcasting (Wangel, 2011) is presented (henceforth referred to as "backcasting") using a case study examining policy development to mitigate biodiversity impacts from the growth of Sydney, Australia. The utility of backcasting is demonstrated in a modelling context by exploring multiple policy options likely to meet future conservation targets for retaining critically endangered woodlands on the Cumberland Plain to the west of Sydney.

2. Methods

2.1. Study area

The Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community (henceforth referred to as "CPW") occurs primarily to the west of Sydney, in the state of New South Wales (NSW), Australia. This threatened ecosystem has been extensively cleared for agriculture and urban development. Its pre-1750 coverage was estimated to be 125,450 ha, and now 9% (10,726 ha) of this original area is estimated to remain (State of New South Wales, 2011). Less then 10% of the current CPW extent is represented in formal conservation reserves with the remainder occurring predominantly on private land (State of New South Wales, 2011). As the CPW community is now listed as "critically endangered" under the Australian Government's Environment Protection Biodiversity Conservation (EPBC) Act (Commonwealth of Australia, 2009), actions impacting the community are only subject to approval under specific conditions.

To meet Sydney's projected population growth, expansions of two Urban Growth Centres are planned, which includes the development of areas that will result in clearing significant amounts of CPW over the next 30 years (State of New South Wales, 2010). To compensate this loss, "biodiversity offsets" (Bull et al., 2013) will be implemented inside and outside the Growth Centres, resulting in CPW being protected and managed. The intention behind the offsets is that the gains in ecological condition and the avoided clearing of CPW will "offset" the clearing of CPW for urban development (Gordon et al., 2011). These offsets are required under both NSW state legislation (State of New South Wales, 2010) and the EPBC Act (Commonwealth of Australia, 2012). Additional background is given in Appendix A.

In addition to urbanisation, there are other threats to the remaining CPW. The most significant being legal and illegal clearing of vegetation outside the Growth Centres and the decline in ecological condition of the community due primarily to invasive plant species such as the African Olive and African Love Grass (State of New South Wales, 2011).

2.2. Modelling the change in CPW over time

A model developed to predict changes in CPW extent over time was written in *python* using a new open source modelling framework entitled *Tzar* (Gordon et al., 2013). Construction and parameterisation of the model was undertaken by utilising the expert opinion and data obtained from relevant experts within in two Australian Government Departments: the Environment Assessment and Compliance Division of the Federal Department of the Environment, and the NSW Office of Environment and Heritage. Further details are given in Appendix A.

The model predicts changes in the total area of CPW over time for the next 50 years in one-year time steps and incorporates the development and offset processes. Six land-use categories were used in the model (Table 1), and these categories determined where clearing and offsets could occur and how the condition of the CPW would change. The initial areas of CPW in each land-use category are given in Table A2 of Appendix A.

The scenario modelled here meets requirements for both NSW State legislation and Federal legislation (the EPBC Act). For each parcel developed the EPBC Act allows for half the CPW on the parcel to be cleared, provided an offset comprising twice the area of the cleared CPW is implemented. As the remaining CPW on the parcel can count towards this offset, a parcel with an area A of CPW can have $A/2$ cleared with an offset consisting of $A/2$ retained on the parcel and $A/2$ of CPW protected outside the Growth Centres. The relevant NSW state legislation is the State Environmental Planning Policy (SEPP; State of New South Wales, 2006). Over the next 30 years the SEPP and the EPBC Act together allow 594 ha CPW to be cleared within Growth Centres. The SEPP specifies that 518 ha CPW will be included as offsets within the Growth Centres and an additional 594 ha of CPW need to be implemented outside the Growth Centres to meet the EPBC Act offset requirements.

2.2.1. Modelling declines in CPW condition

Although there are good estimates of the current extent of CPW (NSW Scientific Committee and Simpson, 2008), there is limited information about its current condition or the rate at which its condition is declining. As there is strong evidence (State of New South Wales, 2011) combined with expert opinion that habitat decline is occurring, a habitat decline process was included in the model. Due the lack of information, no assumptions were made about the condition dynamics of any of the CPW apart from the fact that each year a fixed proportion, d, degrades to a level where it is no longer classified as CPW (or where it is not economically viable to restore; Table 2). Apart from the *protected* and *offset* land uses where CPW is assumed to be managed (Table 1), all remaining CPW is subject to this decline. For an area of unmanaged CPW, A, the decline of CPW in time step $t + 1$ given by

$$A_{t+1} = A_t - d \times A_t, \quad 0 \leqslant d \leqslant 0.02. \qquad (1)$$

Expert estimates of the upper plausible bound of parameter d was 0.02, resulting in a loss of 2% of the unmanaged CPW per year (Table 2). The actual value for d will depend on both the distribution of the current condition of the patches of CPW, as well as the rate at which they are degrading. This approach is effectively modelling the lower tail of the condition distribution, where d determines that rate at which CPW "drops off" from being in low condition to no longer being assumed to be CPW.

2.2.2. Modelling clearing and offsets

The loss of CPW each time step is given by two terms: $A_t^{dev,oGC}$ and $A_t^{dev,iGC}$ representing the area of CPW cleared outside and inside the Growth Centres, respectively. $A_t^{dev,oGC} = c$, which can be expanded to

$$A_t^{dev,oGC} = p \times c + (1 - p) \times c \qquad (2)$$

while