Advancing the integration of human behaviour into biodiversity decision-making

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

Matthew Selinske
BA University of Minnesota, MSc Imperial College

School of Global Urban and Social Studies
College of Design and Social Context
RMIT University

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DECLARATION

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed.

Matthew John Selinske

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DEDICATION

I dedicate this thesis to my four family members, who I lost over the past four years, my grandparents, Steven and Jeanette, and my uncles Roger and Craig. All exceptional people and I profoundly miss them. To Craig for his kindness, to Roger for his generosity and encouraging my love of gardening and nature, and to my grandmother and grandfather, two of my best friends.
PREFACE

This is a thesis ‘with publications’ and is composed of papers either published, in review or in preparation that report the original research undertaken throughout the research program. These papers are compiled for this thesis with minor amendments and are collectively preceded by an introduction to the research program and followed by a conclusion that draws together the key outcomes and findings of the collective research.

Each paper is a self-contained account of the research that it reports, with its own abstract, introduction, methods, results and discussion. This inevitably results in some degree of overlap and repetition, and I ask in advance for the reader’s patience. To afford the reader some respite from this format, references from each chapter have been consolidated and provided at the end of the thesis, immediately before the appendices.

The work presented here is predominantly my own. Publications and contributions from others are detailed below.

The work presented in Chapter 2 is an edited version of the published paper:


Contributions:

AK assisted in thematic analysis. All co-authors provided feedback, interpretation of review results and editorial assistance.
The work presented in Chapter 3 is an edited version of a paper in preparation and to be submitted to *Conservation Science and Practice*:


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SB and FF provided guidance to systematic review design, coding of articles, interpretation of results, and editorial assistance.
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BC and NT contributed to collection and analysis of data. All co-authors co-developed the ideas and provided editorial assistance.
Peer reviewed publications or book chapters during PhD candidature

The following list incorporates all articles published during candidature including, but not limited to, those in the thesis.


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ABSTRACT

Reversing biodiversity loss is one of the great challenges that we face as a society. Human behaviour, individually and collectively, is the driver behind this loss; hence understanding and changing human behaviour is key to preventing further degradation of biodiversity. It is increasingly recognised that the social sciences have much to contribute towards a more effective knowledge-, theory- and evidence-base to underpin biodiversity conservation. While there is already a body of work within the conservation social sciences literature that contributes knowledge and understanding of the human and social elements in social-ecological systems, further research specifically focussed on human behaviour is needed. Greater integration of insights from psychology into conservation science, policy, and practice is necessary, but multiple challenges exist.

This thesis builds on existing literature bases in the social sciences and conservation psychology and engages insights from other disciplines to advance the integration of human behaviour into conservation science and practice. To do this, I specifically: outline methods to prioritisre human behaviours impacting biodiversity and demonstrate them with case studies; use a novel elicitation method to generate effective interventions and implementation considerations to change a specific high-impact behaviour; undertake a systematic literature review to examine the existing methods used to predict human behaviours; and evaluate the behavioural outcomes of financial incentives in conservation programs.

I first assess the level of uptake of psychology in conservation science. I find that while there is an increase in psychology literature in conservation journals, it is modest compared with background growth in the conservation literature. This lack of engagement from the field of psychology in biodiversity conservation issues may stem from the complex nature of behaviours that impact biodiversity and the inherent difficulty in changing them. In consideration of these findings, I suggest ways to further integrate the two disciplines.

Drawing on the first chapter’s recommendations, I elicit from experts a prioritised list of behaviours that impact biodiversity. To achieve this, I use a structured elicitation method
known as a modified nominal group technique to elicit opinions during a workshop of conservation experts and stakeholders in Victoria, Australia. These experts provided relative estimates of the impact of individual behaviours on Victorian biodiversity and, additionally, the plasticity or changeability of the behaviour. This list provides guidance for the Victorian Government to consider and could be used to inform behaviour change strategies for the benefit of biodiversity in Victoria.

From this list of prioritised behaviours, I select beef consumption – a major driver of global biodiversity loss – and use this as a case study of how to identify effective interventions for behaviours that impact biodiversity. I undertake a policy Delphi expert elicitation, in which I engage experts in creating a prioritised list of behaviour change interventions and develop an understanding of the important barriers to, and requirements for, implementing these various interventions. Of the 20 interventions identified, I find that there was general agreement that changing social norm messaging, offering beef alternatives, and targeting food providers were likely to be feasible and effective in reducing beef consumption.

Next, through a systematic review of the literature, I investigate tools and approaches that can be used to predict human behaviour in the environmental sciences. These methods are used in a variety of settings, including foreseeing environmental challenges arising as a result of human and social behaviours, ex-ante evaluation of environmental interventions, and designing behaviour change programs and policy changes aimed at changing behaviours. I find that a large number of methods are in use, but they use quite different interpretations of prediction itself (i.e. explanatory versus anticipatory prediction). While the uncertainty in such predictions is likely to be substantial, this is not always taken into account and, additionally, there is a general lack of evaluation of the predictions. Based on my findings, I make recommendations to strengthen the decision-making relevancy of this research by standardising reporting and transparency practices. Substantial research effort is required to build the capacity to make robust, defensible recommendations about human behaviour in environmental systems that are relevant to policy and practice.

Finally, I evaluate ex-post the use of financial incentives in behaviour change programs focussed on private land conservation. I look across three case studies that use varying levels of financial incentives to engage landowners in private land conservation. I find that from the perspective of the landowner, financial incentives can be useful for creating added value to
program participation, but they are not necessarily what drives participation and may have little impact on the long-term stewardship of these properties.

This thesis outlines critical ways for the biodiversity conservation sector to improve its effectiveness through methods and approaches that explicitly incorporate human behaviour. More broadly, this research contributes to the development of a conservation behaviour research agenda to inform future conservation interventions.
1 INTRODUCTION

‘One of the anomalies of modern ecology is that it is the creation of two groups each of which seems barely aware of the existence of the other. The one studies the human community almost as if it were a separate entity, and calls its findings sociology, economics, and history. The other studies the plant and animal community, [and] comfortably relegates the hodge-podge of politics to “the liberal arts.” The inevitable fusion of these two lines of thought will, perhaps, constitute the outstanding advance of the present century.’

Aldo Leopold, Berlin (1935)

Over the last century, the impact of humans on the environment has increased exponentially due to population growth, the industrial revolution and ever-increasing consumption fuelled by economic growth (Cardinale et al. 2012; Marques et al. 2019; Maxwell et al. 2016). This degradation takes place despite broad-based societal support for the conservation of biodiversity (Heberlein 2012a; Meis-Harris et al. 2019) and acknowledgment by policymakers that human wellbeing is dependent on interactions with nature and its provisional services (Millennium Ecosystem Assessment 2005; Sustainable Development Goals 2015). In its inception, conservation science was positioned as a crisis discipline (Soule 1985; Kareiva & Marvier 2012). The crisis the discipline seeks to address fundamentally stems from human behaviour (Schultz 2011).

Human behaviour directly and indirectly influences all threats facing biodiversity through individual and collective actions, or inaction (Paul C Stern et al. 1999; Stern 2000), the behaviour of those in positions of influence (Amel et al. 2017), and collective approval or passive acceptance of environmentally contentious government policy (Newell et al. 2015; Weber 2017). However, human behaviour is also integral to positively altering the trajectory of biodiversity loss, through conservation actions and stewardship (Amel et al. 2017). Small changes by large numbers of individuals can
result in large impacts (Dietz et al. 2009) and just as the drivers are complex and many, so are the ways that humans can change to benefit biodiversity (Amel et al. 2017; Larson et al. 2015). Given the critical role of human behaviour in driving biodiversity outcomes, there have been calls for greater understanding and integration of the social sciences into conservation research and practice (Mascia et al. 2003; Bennett et al. 2017; Reddy et al. 2016).

Conservation social science
Despite efforts to integrate social sciences into conservation science, they are often viewed as separate disciplines and still face substantial impediments to their integration (Pooley, Mendelsohn & Milner-Gulland 2014). These obstacles include institutional and communication barriers, capacity challenges, and differing disciplinary approaches (Roy et al. 2014; Bennett et al. 2017). While social sciences are increasingly viewed as integral to understanding and preventing biodiversity loss (Reddy et al. 2016), as of yet, insights from social sciences are not fully appreciated, nor explored to the extent needed to mitigate continued biodiversity losses (Cowling 2014a). There are multiple, critical roles for social sciences within conservation science (Bennett et al. 2017). These include (but are not limited to): (1) understanding how conservation programs impact upon human wellbeing (Coulthard, Johnson & McGregor 2011); (2) critically assessing justice and equity issues of conservation interventions (Law et al. 2017); (3) investigating the disconnect between conservation science and policy (Evans & Cvitanovic 2018); and (4) the economic considerations of conservation policy and programming (Gowdy et al. 2010). While there are many classic and applied fields of social sciences that contribute to conservation social science (Bennett et al. 2017), those that constitute behavioural sciences, including psychology, economics and behavioural economics, have much to offer in terms of the integration of human behaviour and decision-making into conservation science. These fields can contribute to designing more effective interventions to change the behaviours of individuals that impact biodiversity, through better accounting of the behaviour of individuals or of collective behaviours.

Psychology, in particular, is key to advancing conservation science as it is focussed on understanding and predicting the causal and mechanistic relationships of human
behaviour (Saunders, Brook & Eugene Myers 2006; Clayton, Litchfield & Geller 2013) and, in application, the development of behaviour change models (Saunders 2003; Cinner 2018). There are multiple subfields within psychology, with insights from social psychology (St John, Edwards-Jones & Jones 2010; Fulton, Manfredo & Lipscomb 1996), environmental psychology (Heberlein 2012a) and behavioural economics (Byerly et al. 2018; Iftekhar & Pannell 2015) already contributing to conservation science. The application of psychological theories, measures, and concepts to conservation issues have recently been grouped under the umbrella of ‘conservation psychology’ (Saunders 2003; Clayton 2005; Saunders, Brook & Eugene Myers 2006).

The promise of conservation psychology
Conservation psychology was born out of the perception that there was a lack of integration of psychology into conservation (Saunders 2003), and those that described the field foresaw it as an amalgam of contributions from other disciplines including environmental sociology (Riley E. Dunlap et al. 2000; York, Rosa & Dietz 2002), environmental psychology (Gifford 2014; Clayton & Saunders 2012), and the human dimensions of wildlife and natural resources (Manfredo & Dayer 2004; Fulton, Manfredo & Lipscomb 1996). Saunders (2003) suggested ways in which conservation psychology could benefit and influence conservation science (Figure 1.1) and proposed two research foci for conservation psychology: 1) the relationships between people and nature; and 2) conservation behaviours (Figure 1.1). These research areas were intended to consider both social and individual behaviours, recognising the structural and social influence on individual behaviours and attitudes (Stern 2000; Heberlein 2012a). Additionally, it was proposed that conservation psychology could advance these research areas by developing theoretical models of conservation behaviours and behaviour change (Miller 2005; Mayer & Frantz 2004) and applying these models to increase connection to nature and change behaviours that impact biodiversity (Veríssimo 2013; Clayton, Litchfield & Geller 2013). Using psychological measures and methods to evaluate the success of conservation interventions is also part of this contribution (Selinske et al. 2019; Ernst & Theimer 2011).
Figure 1.1 Conceptual framework for how conservation psychology could improve conservation (adapted from Saunders et al. [2003]).

There is now a rich body of literature focussed on valuing nature (Fulton, Manfredo & Lipscomb 1996; Ives & Kendal 2014; Gosling & Williams 2010; Rawluk et al. 2018), including research that addresses values and attitudes towards wildlife and nature (Dietsch, Teel & Manfredo 2016), attachment to place (Lokocz, Ryan & Sadler 2011; Selinske et al. 2015), and connection to nature (Davis, Le & Coy 2011; Prévot et al. 2018). However, there are numerous gaps in knowledge when it comes to understanding and predicting the behavioural outcomes of conservation decisions and designing interventions to change behaviours that impact biodiversity (Travers et al. 2019). Research within conservation psychology can address this gap by applying psychological theories and methods to help understand human behaviours and predict how stakeholders react to conservation policy and practice (St John, Keane & Milner-Gulland 2013). Anticipating behavioural responses is critical to developing robust conservation policy (Milner-Gulland 2012). For instance, Knight et al. (2010) demonstrated that conservation initiatives achieved greater support and participation by understanding and integrating stakeholder perspectives through psychological measures of willingness to participate. Recent years have seen more attention paid to
predictive approaches to improve policy and program design, but there is still much potential to further develop these approaches (Travers et al. 2019).

While pro-environmental values and connection to nature predict the likelihood of people supporting conservation decision-making and potentially engaging in behaviours that benefit biodiversity (Manfredo et al. 2017), pathways to behaviour change are not simple. Multiple factors influence behaviour, including complex structural and psychological barriers (e.g. knowledge, motivations, social norms, self-efficacy) (Stern 2000; Heberlein 2012a). In the past, behaviour change interventions have tended to focus on education as a behaviour change mechanism (Moss et al. 2017), assuming that new knowledge will lead to a shift in attitudes and behaviour (Schultz 2011). However, awareness of biodiversity loss is not a strong predictor of behavioural change, and education programs and attitudinal shifts alone are inadequate to change behaviours that impact biodiversity (McKenzie-Mohr 2011; Heberlein 2012a). Conservation behaviour change programs have started to shift their focus from changing attitudes towards changing behaviours (Nilsson et al. 2019). Multi-pronged behaviour change strategies involving incentives, regulations and messaging hold promise but often assume targeted actors behave rationally, potentially leading to perverse outcomes (Reddy et al. 2016; Rode, Gómez-Baggethun & Krause 2015).

While targeted behaviour change is needed, interventions should be vetted, ex-ante, to anticipate perverse behavioural outcomes. Additionally, more robust evaluation practices with a behavioural focus are developing contemporaneously with these advanced behaviour change approaches, as evident in conservation marketing (Veríssimo et al. 2017), zoos research (Mellish et al. 2019) and in human dimensions of natural resources management (Dayer et al. 2018).

Conservation science needs ‘bolder’ social science

A goal of conservation science is to support effective conservation decision-making (Salafsky & Margoluis 2003). Effective conservation requires an understanding of human behaviour (St John, Keane & Milner-Gulland 2013) and should ultimately seek to change behaviours (Reddy et al. 2016). Previous calls for ‘bolder thinking’ and ‘bolder science’ within conservation have focussed on rethinking approaches to traditional conservation mechanisms such as protected areas (Noss et al. 2012; Watson
et al. 2016). What conservation needs now is ‘bolder’ social science that helps embed systemic and transformative change into all aspects of society (IPBES 2019). This thesis aims to contribute towards that bolder social science.

This approach should entail integrating human behaviour into conservation science and practice in multiple ways, including by prioritising human behaviour change, predicting human behaviours, and evaluating the behavioural outcomes of conservation decision-making (Figure 1.2). Integral to a biodiversity behaviour change agenda will be methods to prioritise the actions individuals can undertake, and then select the most effective strategies to change those behaviours (Schultz 2011). Due to the nature of the complex social-ecological systems in which conservation problems arise, and the potential for unintended consequences associated with behaviour change strategies, conservation initiatives tend to have mixed success (Knight et al. 2008). As such, we should also focus on developing approaches to forecast and predict behaviours that will present future challenges to biodiversity, and conduct ex-ante policy analyses to predict potential unintended consequences of our conservation interventions and conservation behavioural interventions (Larrosa, Carrasco & Milner-Gulland 2016). Finally, evaluating all aspects of conservation interventions is important, including the biodiversity impact and social and behavioural impacts for society and individuals. Not only should this comprise of robust quantitative evaluations, but additionally in-depth qualitative research is needed to capture experiences and narratives within context (Baylis et al. 2016).

In this thesis, I aim to develop methods that will help develop a behaviour change agenda by prioritising individual behaviours that drive the greatest threats to biodiversity and more systematically considering the interventions required to change them. I will also identify predictive tools and approaches that can be used for ex-ante evaluation in conservation policy interventions and critically evaluate the use of financial incentives in behaviour change programs. More broadly this research will engage the behavioural sciences to analyse the potential for improving conservation management, directing a research agenda and developing future policy interventions.
Introduction

Figure 1.2 Stages of the conservation policy and practice cycle in which an understanding of human behaviour can improve conservation outcomes. Adapted from Verburg et al. (2016).

Thesis aims and overview

In this thesis I aim to develop approaches to more fully integrate human behaviour into conservation decision-making. I do this through four broad objectives that are addressed through research questions in each chapter. The four objectives are to:

1) Gain an understanding of methods that predict human behaviour in environmental conservation literature and explore how they could be used to aid conservation decision-making;

2) Identify and prioritise behaviours that drive biodiversity loss by their attributes (strength of impact and plasticity);

3) Identify the best behaviour change strategies for prioritised behaviours; and

4) Evaluate the effectiveness of behaviour change programs that offer financial incentives.
Introduction

Research Approach
My engagement in conservation science stems from a normative position that biodiversity has intrinsic value and therefore its conservation is important, not only for its aforementioned value but also its instrumental value to human wellbeing. In engaging in reflexivity, I recognise that my relationship with the research confined in this thesis and my past, present and future research is motivated by the goal of contributing to science that informs the effectiveness of conservation decision-making. As part of my thesis is focussed on behaviour change related to conservation, I am also conscious of the ethical implications of my research. Behaviour change can lead to empowerment but may also create inequality and injustice. The participants in my research are likely to have diverse value-sets, knowledge and understanding, but many share my passion for the natural world and are interested in generating positive change towards the conservation of biodiversity. It is my hope and intention that this thesis will contribute to our understanding of how best to achieve such change.

I use a mixed methods approach (Creswell & Clark 2017), with multiple types of methods seeking to contribute towards integrating human behaviour into biodiversity decision-making, including qualitative thematic analysis and quantitative analysis (Figure 1.3). In consideration of my philosophical position I situate my work in the epistemology of critical realism, which provides a post-positivist approach, contradictory to that of positivist and postmodernist epistemologies (Danermark, Ekstrom & Jakobsen 2005).

Outline of subsequent chapters
In Chapter Two, I investigate the uptake of psychology within conservation science by examining its prevalence and the content of articles returned in a literature review. This is followed by a discussion focussed on the challenges of integrating insights from psychology into conservation science and potential pathways forward. An edited version of Chapter Two was published in Conservation Biology.

In Chapter Three I investigate which behaviours contribute to shifting the drivers of biodiversity loss, and which behaviours have the greatest plasticity. Undertaken in collaboration with the Victorian Government in Australia, this research aims to assist
in identifying and prioritising behaviours to target for behavioural interventions in Victoria. I identify and prioritise behaviours using a structured elicitation method, the nominal group technique, during a workshop of experts and stakeholders. Chapter Three is in preparation for submission to *Conservation Science and Practice*.

**Chapter Four** addresses the question: what are the most effective behaviour change strategies for a given prioritised behaviour? I investigate this question drawing on the example of beef consumption as a behaviour prioritised in the previous chapter. I do this by conducting an online policy Delphi elicitation of experts from various disciplines who are engaged in meat-consumption research. An edited version of Chapter Four is currently undergoing a second review at *Conservation Letters*.

In **Chapter Five** I ask the question: what approaches and tools are used to predict human behaviours in environmental research and decision-making? I systematically review the environmental literature for studies that predict human behaviour to determine what methods are used, how each study interprets prediction, what types of behaviours are being predicted, and identify some general limitations of these studies. Chapter Five is in preparation for submission to *Nature Sustainability*.

**Chapter Six** investigates how financial incentives contribute towards engendering long-term stewardship in private land conservation programs. I explore this topic by drawing on three case studies; two in Australia and one in South Africa; spanning various program types – a biodiverse carbon-planting scheme, a covenanting program, and a voluntary stewardship program. I draw on these case studies to investigate the importance of financial incentives and other mechanisms from the landowner’s perspective. An edited version of this Chapter Six was published in *Ecology and Society*.

**Chapter Seven** synthesizes the results from Chapters Two to Six, and discusses the contribution of knowledge this work delivers, the limitations of the research, and future directions for more fully integrating human behaviour into biodiversity decision-making.
Figure 1.3 Schematic of PhD thesis structure, the methodological approach for each chapter, and publication status.
2 Revisiting the Promise of Conservation Psychology

A version of this chapter has been published in Conservation Biology as:

2.1 Introduction

Conservation psychology was first described as a field of research nearly 15 years ago (Saunders 2003) and such was the optimism for psychology to affect conservation that Saunders et al. (2006) published “Using Psychology to Save Biodiversity and Human Well-Being” in Conservation Biology. Conservation psychology developed as an offshoot from environmental psychology, a field that evolved from social psychology in the 1950s. Although environmental psychology is the study of people and their interactions with their environments, both built and natural, it initially did not address conservation matters. As conservation of biodiversity gained prominence, research into the psychological dimensions of conservation proliferated, and in 2003 the term conservation psychology was adopted to differentiate this field from environmental psychology. However, despite differences in scope, environmental psychology and conservation psychology are sometimes used interchangeably (Clayton and Saunders 2012).

Managing human behaviour is essential for biodiversity conservation. It is therefore timely to consider the uptake and impact of conservation psychology by examining how the publishing record in this field has changed over time and how its content relates to biodiversity. I performed a literature search via Web of Science (www.webofknowledge.com) for articles containing conservation psychology in keywords, abstracts, or titles. I found 68 articles published in peer-reviewed journals from January 2003 (the year the field was described) and December 2016. Six of these (8.8%) related to energy and water conservation—topics generally considered within the broader field of environmental psychology.

To capture further relevant papers that did not contain the term conservation psychology, I used the root terms: biodivers* AND (psycholog* OR “behavi* change”). This returned 155 relevant articles, of which 141 were unique to the additional search. Of the total relevant articles from the 2 searches (n = 203) (Figure 2.1), 18.1% (37) were published in leading conservation journals, Conservation Biology (14), Ecological Economics (8), Biological Conservation (7), Conservation Letters (4), and Society and Natural Resources (4). Over the last 13 years these 5 journals have published 12,880 articles. The results suggest that only 0.28% of those are related to psychology. Although there are likely additional terms that could be used to explore the conservation psychology literature, the results indicate that despite perceptions of growth in conservation psychology, behavioural research has not yet penetrated mainstream
conservation science. Additionally, only 5 articles from the search came from environmental psychology journals, *Environment and Behavior* and *Journal of Environmental Psychology*, which equates to just 0.36% of their output during the same period.

![Number of psychology articles per year with a biodiversity focus (n=203)](image)

My results reveal that *conservation psychology* has not become an umbrella term for interdisciplinary research that integrates biodiversity conservation and psychology; although the number of related research articles is increasing, the impact of psychology on conservation science is still relatively small; and biodiversity issues have received limited attention in environmental psychology. As with social sciences generally, structural barriers, such as past and potentially current publishing and funding biases, have hindered the uptake of conservation psychology and use of psychology in conservation science (Bennett et al. 2017). Changes to any science, of course, take time (Kuhn 1962). The rate of uptake of psychology within conservation science is comparable to transformations in economics. Recognition that cognitive and behavioural factors that influence human decision making are inconsistent with standard economic models emerged in the 1960s but took 40 years to be accepted by the
economic community (arguably culminating in the 2002 award of the Nobel Prize in economics to Daniel Kahneman) and integrated into policy and practice (a subsequent Nobel economics prize to Richard Thaler in 2017).

Similarly, despite psychology’s highly relevant, practical benefits there remains comparatively little psychology research addressing the conservation of biodiversity. Structural barriers have likely contributed to this. However, I believe there are other reasons for the lack of attention to biodiversity behaviours. To examine this claim, I explored the differences between biodiversity conservation and water and energy conservation behaviours.

2.2 Challenges of biodiversity behaviours

Biodiversity issues are often context specific (e.g., overharvesting, human-wildlife interactions) or diffuse (e.g., consumption related), and identifying threats and individuals or populations whose behaviour is driving the threat is difficult but important (Reddy et al. 2016). Typically, the major drivers of threats to biodiversity — biological resource use and agriculture (Maxwell et al. 2016) — stem from multiple behaviours by multiple actors and are generally spatially and temporally diffuse, which makes examining the link between behaviour and biodiversity impact difficult. Although biodiversity loss is global, few individual biodiversity-related problems (or solutions) are as universal as household water and electricity consumption. Owing to the globalized economy, the world’s population in both developed and developing nations has a limited perception of how their consumptive behaviours affect biodiversity. As a result, these behaviours are harder to decipher than behaviours that have direct effects or a higher degree of tangibility.

The majority of the world's people live in cities, where disconnection from nature is an increasing phenomenon (Soga et al. 2016). Urban residents struggle to link biodiversity conservation with actions undertaken at the household level. Feedback mechanisms, in which the user has a direct link between their action and the outcome, are essential for promoting pro-environmental behaviour change (Schultz 2009; Faruqui et al. 2010). Water and electricity meters and bills provide feedback that allows individuals to see the efficacy of their actions. But there are no biodiversity meters or bills, and feedback mechanisms are further complicated by the indirect way in which biodiversity is affected by people's lives.
Where water and energy conservation generally lead to personal financial efficiencies, biodiversity actions are more likely to have negative financial impact on the user. For example, biodiversity-friendly products are often more expensive, and engaging in private land conservation by placing a permanent conservation contract on farmland may reduce its financial value or incur a significant opportunity cost (Farrier 1995). Furthermore, biodiversity-conservation behaviours are not typically easy for an individual to undertake due to societal structures. Information about the actions individuals can take to reduce impacts on biodiversity can be confusing, conflicting, and unreliable, which leaves it to the individual to invest time and effort to identify effective pro-biodiversity behaviours and to source biodiversity-friendly products.

Impediments to behaviour change are likely tied to a number of social-psychological and cognitive factors and biases (Table 2.1) that potentially have a number of common underlying mechanisms. Behaviours that impact biodiversity derive from complex interactions between values, social and individual norms, attitudes, and a number of perceived and real behavioural controls that subvert behavioural intentions. Although numerous psychological measures of the relationship between individuals and nature exist (e.g., new ecological paradigm [Dunlap et al. 2000]; environmental concern [Schultz 2001]; connectedness to nature [Mayer & Frantz 2004]), it is not yet clear how and under what circumstances to apply existing psychological measures to biodiversity issues, how they relate to biodiversity behavioural change, whether they effectively predict biodiversity behaviours, and when or how to develop novel or case-specific measures (St John, Edwards-Jones, & Jones 2010; Clayton et al. 2016).

2.3 Bringing conservation psychology into the mainstream

Biodiversity conservation researchers and practitioners are aware of the importance of psychology in solving biodiversity issues, and I acknowledge there are dedicated psychology and conservation scientists working in this space. My analysis of the literature shows that these numbers are still low, which presents challenges but also highlights opportunities. Psychologists may be missing unique research opportunities for understanding human behaviour. Conservation psychology is not simply another applied psychology domain; biodiversity issues are multi-layered and generate novel psychological questions and concepts (e.g., biophilia, environmental amnesia, environmental hyperopia). The domain of conservation provides opportunities for psychologists to engage in long-term studies over which to observe significant institutional and cultural shifts.
Table 2.1 Examples of psychological dimensions of biodiversity conservation drawn from an exploratory search of the literature.

<table>
<thead>
<tr>
<th>Psychological Dimension</th>
<th>Description and potential impact to biodiversity</th>
<th>Key references</th>
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<tbody>
<tr>
<td>Environmental amnesia/ Shifting baselines</td>
<td>Ecological changes or disappearance of species can create an environmental amnesia in individuals who forget their past personal experiences of nature or generations who are unaware of what was lost previous to their understanding of their environment. This influences how people perceive the naturalness of current ecological conditions and may potentially accelerate under climate change.</td>
<td>Pauly (1995); Kahn Jr (2002); Papworth et al. (2009)</td>
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<tr>
<td>Environmental cognitive dissonance</td>
<td>People seek consistency between their beliefs and actions. When people hold beliefs and behave in a way that does not align with these beliefs, a mental discomfort occurs that could lead to an adaptation of the belief or attitude or a rationalization of behaviour. Cognitive dissonance may explain the values-action gap found in biodiversity behaviours.</td>
<td>Festinger (1957); Thøgersen (2004)</td>
</tr>
<tr>
<td>Environmental hyperopia</td>
<td>The perception that environmental issues occurring at a distance (e.g., rainforest loss in remote areas) have greater impacts than local issues and can lead to a sense of hopelessness associated with a lack of self-efficacy in the ability to positively affect biodiversity conservation.</td>
<td>Uzzell (2000); Lima and Castro (2005); MacDonald, Milfont, and Gavin (2015)</td>
</tr>
<tr>
<td>Extinction of experience</td>
<td>The loss of interaction with nature may correspond with a decrease in pro-environmental attitudes and behaviours in a bidirectional relationship, potentially creating a negative feedback within an individual and a society. Just a few engagements with nature may protect against this decline of pro-environmental attitudes.</td>
<td>Miller (2005); Soga et al. (2016)</td>
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<td>Governance trap</td>
<td>Citizens may assume the government is responsible for the conservation of the environment and threatened species. This can change if there is perceived neglect of the environment by a government.</td>
<td>Wray-Lake, Flanagan, and Osgood (2010)</td>
</tr>
<tr>
<td>Moral licensing</td>
<td>Moral licensing is a perverse behavioural outcome that may result from an individual's positive perception of their moral self. Engagement in a moral behaviour, such as a planting a tree, may diminish future pro-environmental behaviours. Although the licensing effect has been demonstrated in water and energy consumption behaviours, there has been little consideration of licensing relative to biodiversity behaviours.</td>
<td>Tiefenbeck et al. (2013)</td>
</tr>
<tr>
<td>Psychological distance</td>
<td>Psychological distance impacts an individual's thinking about an object or action. Psychological distance can be temporal, spatial, or cultural and is affected by uncertainty; events or objects that are uncertain, occur far into the future, a long way away, or to people or species that we perceive as different from ourselves will tend to be viewed more abstractly. Psychological distance affects the perceived threat of climate change.</td>
<td>Liberman and Trope (1998); Spence, Poortinga, and Pidgeon (2012)</td>
</tr>
<tr>
<td>Psychic numbing</td>
<td>Typically associated with large-scale human suffering (e.g., war, famine), psychic numbing is a psychologically protective response to great loss of life, which may be deployed in the case of continued degradation of ecosystems, loss of species, and other threats to biodiversity. If so, one can expect it to increase with greater loss of species; people will be unable to process the news of continued species loss and as a result ignore the problem and its solutions. To our knowledge, there is currently no research examining the impacts of psychic numbing and biodiversity loss.</td>
<td>Slovic (2010); Markowitz et al. (2013)</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>Self-efficacy is determined by the real or perceived barriers (cognitive, physical, financial or regulatory) controlling one’s own behaviour. An individual’s perception of self-efficacy is a strong predictor of how she or he will approach biodiversity-related behaviours.</td>
<td>Bandura (1977); Klöckner (2013); Clayton et al. (2017)</td>
</tr>
<tr>
<td>Status quo bias</td>
<td>A risk-averse strategy that prevents societal or individual adaptations to fundamentally different futures, such as large-scale sustainability measures. Status quo bias may influence resistance to policies needed for the conservation of biodiversity despite the long-term benefits that will be generated.</td>
<td>Kahneman, Knetsch, and Thaler (1991); Weber (2017)</td>
</tr>
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</table>
A deeper integration of psychology into conservation science could capitalize on these opportunities. Some recommendations for integrating conservation and psychology and social sciences exist (e.g., Schultz 2011; Pearson 2013; Clayton et al. 2016; Stenseke 2016; Bennett et al. 2017). Specific ideas include encouraging conservation scientists and psychologists to attend each other’s conferences, greater inclusion of psychologists in the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, a prioritization of behaviours that drive the greatest global biodiversity threats and are most amenable to change, and continued development of conservation psychology courses for students from both disciplines to help produce truly interdisciplinary researchers who understand both fields. Promising approaches also include the Society of Conservation Biology's Conservation Marketing Working Group's advancement of marketing and communication techniques underpinned by theory and impact evaluation (http://conbio.org/groups/working-groups/conservation-marketing-working-group), the Conservation Psychology Institute at Antioch University (https://www.antioch.edu/new-england/resources/centers-institutes/conservation-psychology-institute/), and courses in conservation psychology such as those offered by University of Adelaide (https://study.unisa.edu.au/courses/151240/2018).

As the literature search revealed, the term conservation psychology is not widely used in the context of biodiversity conservation, and when associated with issues relating to the conservation of water and energy, it may also be conflated with environmental psychology. However, behaviours affecting biodiversity are contextual and complex, and psychological theory or tools developed for other environmental issues may not be applicable. Given the urgent need to bring attention to biodiversity issues, as a starting point I encourage those who apply psychology to conservation research (e.g., conservation messaging, human dimensions of wildlife, conservation marketing, zoo engagement research, applied psychology in all conservation contexts) to use the term conservation psychology in keyword selection to highlight their work, its breadth, and importance to understanding and affecting biodiversity issues and initiatives. Although there is great potential for conservation psychology to help address current and future biodiversity challenges, this must be jointly cultivated by conservationists and psychologists to fulfil this promise.
Acknowledgements

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3 IDENTIFYING AND PRIORITISING HIGH IMPACT BIODIVERSITY BEHAVIOURS

A version of this chapter is in preparation and to be submitted to Conservation Science and Practice:

Abstract

Policy makers and other conservation practitioners are seeking effective ways to reduce societal impact on biodiversity, including through targeted behaviour change campaigns. As with any complex issue, multiple behavioural options exist, but there is currently little clarity around which behaviours to target. Behavioural prioritisation is a tool that has been used effectively to support behaviour change decision-making in other environmental disciplines and more recently for a small sub-set of biodiversity behaviour change challenges. Here, I use behavioural prioritisation to identify individual behaviours that could be modified to achieve biodiversity benefits in the state of Victoria, Australia. I use an adapted nominal group technique method to identify potential biodiversity behaviours and, for each behaviour, estimate the corresponding plasticity (or capacity for change) and impact on biodiversity outcomes. Using a mixed methods approach, including a workshop and online questionnaire, I elicited 27 behaviours that individual Victorians could undertake to reduce their impact on biodiversity. This list was then used to prioritise ten behaviours as determined by their impact, plasticity and current prevalence in Victoria. I provide a list of behaviours that can direct decision-makers towards ways to reduce societal impact on biodiversity, guide motivated individuals to reduce their own biodiversity footprint and develop a behaviour change research agenda for behaviours that benefit biodiversity.
3.1 Introduction

Human behaviour is the major driver of biodiversity loss (Lenzen et al. 2012; Maxwell et al. 2016). Altering the trajectory of this loss requires changing those behaviours that have the greatest impacts on biodiversity (Schultz 2011; Steg & Vlek 2009). Yet identifying the most important behaviours to target for change is not straightforward (Selinske et al. 2018). Prioritisation methods have been used successfully over the past two decades to advance conservation planning (Margules & Pressey 2000). Prioritisation is also a potentially useful approach for systematically evaluating and informing decisions about which conservation-relevant behaviours should be the focus of conservation efforts (Schultz 2011). Already established within community-based social marketing (McKenzie-Mohr 2011), behavioural prioritisation has the potential to identify feasible, high-impact biodiversity behaviours that could: 1) direct policymakers and other decision-makers towards policy choices that have high efficacy in reducing societal impact on biodiversity; 2) guide motivated individuals seeking effective ways to reduce their own biodiversity footprints; and 3) form the basis of a behaviour change intervention and evaluation research agenda among psychologists and behaviour change specialists.

Behavioural prioritisation is used to determine which of a range of possible behaviours should be targeted (McKenzie-Mohr 2011). Environmental behaviour prioritisation has been applied to zoos research (Smith 2009; Smith et al. 2012), energy conservation (Dietz et al. 2009), water conservation (Kneebone, Smith & Fielding 2017), and more recently to specific threats to biodiversity conservation (Linklater et al. 2019; Please et al. 2018). These prioritisations have all been executed differently, but follow a common process of: 1) identifying a candidate set of behaviours; 2) determining the impact of each behaviour; 3) assessing the plasticity (or capacity for change) of each behaviour; and 4) assessing the current prevalence of each behaviour among the target population (also known as the ‘penetration rate’; Figure 3.1). I outline the key steps to behavioural prioritisation below.

**Identifying biodiversity behaviours**

Prioritising behaviours begins by identifying and defining those behaviours that have the greatest positive or negative impact on biodiversity (Schultz 2011; Clayton, Litchfield & Geller
Identifying and prioritising high impact biodiversity behaviours

2013), a process determined in part by the objectives or scale of the behaviour change program. For instance, previous conservation research has prioritised the most impactful cat-owner behaviours (e.g. cat containment, cat collaring) in New Zealand (Linklater et al. 2019), and individual behaviours to reduce the impact of wild dogs (e.g. trapping wild dogs, abstain from feeding wild dogs) in peri-urban communities of Australia (Please et al. 2017). These studies selected a subset of behaviours that addressed a specific conservation problem (e.g. cat predation of native animals) amongst a specific audience (e.g. cat owners in New Zealand). However, because the drivers of biodiversity loss are multiple and indirect, and vary spatially, temporally and among species and ecosystems, identifying the most impactful behaviours for a general population is challenging. This challenge is further complicated by the overwhelming scale of the problem of addressing the impact of human behaviour on biodiversity, rather than focussing on a specific species or group of species of interest (Maxim, Spangenberg & O’Connor 2009).

<table>
<thead>
<tr>
<th>Process</th>
<th>Previous methods</th>
<th>Methods used in this research</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify behaviours</td>
<td>Expert structured interviews (Please et al. 2018)</td>
<td>Nominal Group Technique expert elicitation</td>
</tr>
<tr>
<td>2. Determine impact on biodiversity</td>
<td>Survey representative sample (Kneebone et al. 2016)</td>
<td>Survey Experts</td>
</tr>
<tr>
<td>3. Determine the plasticity of behaviour</td>
<td>Survey representative sample (Kneebone et al. 2016)</td>
<td>Estimates derived from published and grey literature*</td>
</tr>
<tr>
<td></td>
<td>Survey relevant segments (Please et al. 2018, Linklater et al. 2019)</td>
<td></td>
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</table>

Figure 3.1 Process of behavioural prioritisation adapted from McKenzie-Mohr (2012)
The human behaviours that influence biodiversity outcomes are multidimensional, requiring different types of engagement from a range of different audience segments (Larson et al. 2015). These different behaviours can be classified as either public or private sphere behaviours (Stern et al. 1999), and are clustered within multiple behavioural ‘domains’ (e.g. environmental activism, stewardship behaviours, donation of time and money, consumption behaviours) (Larson et al. 2015; Stern 2000). Some behaviours are undesirable and behaviour change programs encourage switching to a less undesirable behaviour (i.e. that results in less adverse biodiversity outcomes), for example switching from consuming beef to another animal protein. Other behaviours are more desirable and impact biodiversity positively, for example through environmental volunteering or donating money to a conservation campaign.

Different behaviours will vary in their geographic proximity to the ecological outcomes, and may directly or indirectly impact biodiversity (Stern 2000; Nilsson, Fielding & Dean 2019). For example, activist behaviours may indirectly impact biodiversity by creating a social license for governments to fund projects that support conservation actions or better regulate industries that threaten biodiversity (Kendal & Ford 2017). In contrast, volunteers planting trees or a pet owner containing their cat or dog may directly benefit the biodiversity in that location. Additionally, it might be easier to identify conservation behaviours in rural areas where landowners directly influence their natural environment (e.g. a landowner fencing off a riparian area on their land; controlling invasive species), compared to the urban populations that make up a majority of the world’s population where impacts can be less direct (Soga et al. 2016). The vast majority of impacts on biodiversity result from the societal consumption of resources which can be either direct, through e.g. overexploitation, or indirect, through e.g. agricultural or waste impacts (Kitzes et al. 2017; Chaudhary, Gustafson & Mathys 2018; Marques et al. 2019). Individuals may also have different levels of impact on biodiversity depending on their spheres of influence and also their role within an organisation or society (Amel et al. 2017). For instance, as a result of changing their own behaviour, influential individuals may influence their wider social network to act in a pro-environmental manner (Cinner 2018). Given the indirect nature of social influence, there is greater uncertainty associated with its ultimate impact on biodiversity (de Lange, Milner-Gulland & Keane 2019).
Identifying and prioritising high impact biodiversity behaviours

*Behavioural impact, plasticity, and prevalence*

Estimating the exact effects on biodiversity of specific behaviours is inherently difficult because the threats to biodiversity are diverse, contextual, often difficult to quantify, and may have obscure links to the driving behaviours (Selinske et al. 2018). High impact biodiversity behaviours are behaviours that make a large difference to the persistence or conservation status of species and biodiversity (Schultz 2011; Clayton, Litchfield & Geller 2013). In previous behaviour prioritisations, impact data has been derived from expert estimates of water reduction measures (Kneebone, Smith & Fielding 2017) and published global greenhouse gas emission reduction estimates of energy efficiency behaviours (Dietz et al. 2009). While energy and water consumption have standard units of measurement, biodiversity impacts vary spatially and temporally, and among species and ecosystems of interest. They are therefore harder to measure and contain a higher degree of uncertainty (Butchart et al. 2010; Scholes & Biggs 2005). To overcome the problem of a lack of a standard unit of measurement, Please et al. (2018) and Linklater et al. (2019) used expert estimates (measured by numerical scales) to determine the effectiveness of changing specific behaviours on targeted biodiversity outcomes.

Behaviour prioritisation is also informed by behavioural ‘plasticity’ (Dietz et al. 2009; Allen et al. 2015), that is, the probability or likelihood of a particular behaviour change eventuating within a population (McKenzie-Mohr 2011; Kneebone, Smith & Fielding 2017). While there is no universal approach to measuring the plasticity of behaviour, previous research assessed the plasticity of uptake of energy efficiency measures in US households by using uptake rates of multiple past interventions published in peer-reviewed literature or government reports (Dietz et al. 2009). Plasticity has also been measured by surveys of target communities. To generate plasticity scores, Kneebone et al. (2017) used Likert scales to estimate the perceived ease of behaviour adoption by the target audience, while Please et al. (2018) and Linklater et al. (2019) surveyed their respective populations for willingness to participate in a behaviour.

The prevalence of a behaviour within a population (i.e. the existing levels of participation) can provide insight into which behaviours will receive maximum net uptake from that population and therefore maximise benefit to biodiversity (McKenzie-Mohr 2011). For instance, if a behaviour has a large impact and high plasticity (likelihood of adoption) but is already pervasive in a population, it may be more advantageous to prioritise another high-impact, high-
plasticity behaviour with low prevalence (current participation), as there will be greater potential net uptake in response to an intervention (McKenzie-Mohr 2011). The prevalence of a behaviour can be measured by surveying the target population to obtain a self-reported measure of the selected behaviours (Kneebone, Smith & Fielding 2017; Please et al. 2018; Linklater et al. 2019) or using estimates from previous studies (Dietz et al. 2009).

Here, I identify and prioritise behaviours that have the biggest impact on biodiversity loss in the state of Victoria, Australia. I focus on multiple behaviours that any resident of Victoria (as detailed below) could undertake that would result in positive outcomes for biodiversity. I used the nominal group technique (NGT; Delbecq et al. 1975) to engage experts to develop a list of candidate target behaviours. This list was then prioritised by perceived behavioural impact on biodiversity and behavioural plasticity, through expert elicitation. Prevalence was estimated from a range of grey literature and published sources. This study represents the first prioritisation of behaviours that an individual can undertake for the benefit of biodiversity conservation.

### 3.2 Methods

**Context**

Located in south-eastern Australia, Victoria is home to nearly 6.5 million people, with the majority (4.96 million) residing in the greater metropolitan area of Melbourne, the state’s capital city (Australian Bureau of Statistics 2019). The region comprises a diverse range of terrestrial and marine ecosystems, a number of which are vulnerable and severely degraded as a result of urban expansion, farm cropping, livestock pastoralism, and forestry (Sustainability Victoria 2019). Two pieces of legislation govern threatened species listing: Victoria’s *Flora and Fauna Guarantee (FFG) Act 1988* (this was the first legislation within Australia to protect biodiversity), and the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*, which is the Australian Government's key piece of environmental legislation listing nationally threatened species and ecological communities. In total, 2577 and 276 Victorian species are listed on the FFG and EPBC Acts respectively (Australian Government Department of Environment and Energy 2018; Department of Sustainability and Environment 2009, 2013; Department of Environment and Primary Industries 2014). The International Union for
Identifying and prioritising high impact biodiversity behaviours

Conservation of Nature (IUCN) Red List of Threatened Species lists 729 assessed Victorian species (IUCN 2019).

The Victorian Government committed to environmental protection with the release of Protecting Victoria's Environment - Biodiversity 2037, a 20-year strategy for protecting the state’s biodiversity (DELWP, 2017). The plan includes the central message ‘Victorians value nature’ and outlines state-wide targets to ‘connect all Victorians with nature’ and for five million Victorians to be ‘acting to protect the natural environment’ (DELWP, 2017). The latter reflects an implicit objective to encourage pro-biodiversity behaviour changes within the Victorian general public.

I sought to identify and prioritise behaviours that any Victorian could undertake to improve outcomes for Victorian species and ecosystems. As noted above, most Victorians live in Melbourne and its surrounding suburbs, so the focus was refined to behaviours that all Victorians could undertake including those living in urban or suburban environments. A recent representative survey of Victorian residents found that most Victorians feel connected with nature and engage with various forms nature in a diversity of ways, including through gardening, visiting national parks, and outdoor activities in regional and city parks (Meis-Harris et al. 2019). Additionally, a separate survey found that residents’ cultural identities are tied to many of the ecosystems represented in Victoria (Kiley et al. 2017), but approximately half of Victoria’s residents have little or no understanding of the term ‘biodiversity’ (Kiley et al. 2019).

Participants
Candidate biodiversity behaviours were elicited in an expert workshop hosted by RMIT University and the Victorian Government Department of Environment, Land, Water and Planning (DELWP). Thirty-five conservation experts were invited to attend the workshop. These individuals were selected jointly by DELWP and RMIT University and represented a diversity of expertise and organisations. RMIT University ethics approval was granted for this research (CHEAN A 21314-01/18; Appendix D). Free, prior and informed consent was sought from participants prior to the start of workshop.
Prioritisation workshop

Of those invited, 22 people attended, representing research institutions, conservation non-governmental organisations, community groups, government departments and statutory authorities. Participants included ecologists, behavioural change specialists, psychologists, conservation scientists, threatened species specialists, social-ecological systems researchers, and science communication experts. The workshop to identify behaviours took place in November 2018, and a subsequent online questionnaire to elicit estimates of the impact and plasticity of individual behaviours was distributed to participants one week later. At the start of the workshop, prior to considering any high-impact biodiversity behaviours, candidates were presented with three key pieces of information: 1) results from a recent representative survey of Victorian residents that assessed their perceptions of nature, their values towards nature and any pro-environmental behaviours they currently participated in (Meis-Harris et al. 2019); 2) summarised information on the different types of behavioural domains (Larson et al. 2015), individual spheres of influence (Amel et al. 2017) and indirect and direct behaviours (Stern 2000); and 3) results of an analysis of the greatest threats to Australian species listed on the IUCN Red List (Selinske et al. in preparation; Table A1) and the industries driving those threats and associated threats to Victorian EPBC-listed species (Brown et al. in preparation; Figure A1). The objective of the workshop was to identify and prioritise behaviours that most Victorians could participate in. For this reason, discussions were framed around how a ‘typical’ Victorian could act for biodiversity, and the workshop participants refrained from selecting behaviours that could only be undertaken by rural landowning individuals (e.g. riparian fencing, in perpetuity protection). A typical Victorian was further defined as an individual that may or may not have pets and may rent or own the dwelling they reside in. Behaviours that only impact biodiversity through their influence on climate change were out of scope as these behaviours have been previously identified and had greater focus in terms of research and practice (Wynes & Nicholas 2017).

I used the nominal group technique (NGT) to elicit high-impact biodiversity behaviours from experts at the workshop. NGT is a group consensus method used across multiple disciplines to elicit priorities (Delbecq and Van de Ven. 1971). The NGT method involves four stages: 1) silent idea generation; 2) idea reporting; 3) clarification; and 4) a public or private ranking
(Hugé & Mukherjee 2018). To reduce facilitator bias, I divided the participants into four randomly allocated subgroups. In the subgroups, each participant privately listed five behaviours they believed that, if changed or engendered, could reduce biodiversity loss or lead to biodiversity gains. Taking turns in the subgroups, each participant read out one behaviour per turn, until all behaviours were reported and recorded. All behaviours reported by each subgroup were then collated and reported back to the broader group. The group of participants then deliberated on the merits of the behaviours in terms of their impact and plasticity, the likelihood they could be undertaken by a typical Victorian resident and whether and how they grouped into identified domains of behaviour (Stern et al. 1999; Larson et al. 2015).

Assessing impact and plasticity

Typically, the next and final step of an NGT is to survey the participants during the workshop, privately or publicly, about their preferences for behaviours by ranking them or measuring their preference with a Likert scale. As the method is flexible (Hugé & Mukherjee 2018), I adapted it to suit the objectives of the workshop. In an emailed online questionnaire one week after the workshop, I surveyed participants to assess the impact on biodiversity and plasticity of each identified behaviour using sliding scales of 0 to 10; 0 being low impact on biodiversity or plasticity and 10 being high impact or plasticity. When considering plasticity, experts were asked to consider potential barriers to engaging with the behaviour (e.g. time, cost, habits, social norms). Additionally, participants were asked to select five behaviours they would target based on their impact and plasticity. The questionnaire was hosted on Qualtrics, a web-based platform for online surveys (Qualtrics 2018; see Appendix A for questionnaire). Notes from the workshop were made available to survey participants prior to answering the questionnaire. I averaged across respondents to generate behaviour-specific impact and plasticity scores for each behaviour (McKenzie-Mohr 2011) and calculated the standard error for estimates of impact and plasticity.

Behavioural prevalence

I defined prevalence as the proportion of Victorians currently undertaking a particular behaviour. To assess the prevalence of the identified behaviours in the general population of Victoria, I collated observed, self-reported, and willingness to participate data from previously published reports, market research and peer-reviewed literature (e.g. Smith & Weiler 2011;
Essential Services Commission 2019; Malek et al. 2019; Meis-Harris et al. 2019; van Eeden et al. 2019). In cases where multiple estimates exist, I adopted the most conservative prevalence estimate. Full sources, literature search criteria, and methods of derived prevalence estimates are included in Table A2.

Prioritisation matrix and score
As demonstrated in previous literature, there are two main ways to prioritise behaviours: 1) visually through a prioritisation matrix (Kneebone, Smith & Fielding 2017); and 2) as a function of prevalence in the population, impact and behaviour plasticity (McKenzie-Mohr 2011). I plotted the impact and plasticity scores to create a prioritisation matrix to assist in visually communicating to conservation decision-makers which behaviours to target (sensu Kneebone et al. 2019; Figure 3.2). This helped us identify high-ranking behaviours that are both likely to be impactful and have high plasticity, those behaviours that might require time and/or financial effort to engage people, and those behaviours that are likely to be less impactful but relatively easy to foster and which may also lead to spillover behaviours or support new social norms (Kneebone, Smith & Fielding 2017; Thøgersen & Crompton 2009).
Identifying and prioritising high impact biodiversity behaviours

Figure 3.2 The behaviour prioritisation matrix adapted from Kneebone et al. (2017). Impact plotted on the y-axis against plasticity scores plotted on x-axis. The upper right quadrant are those high priority behaviours that are easier to change and more impactful. This assists in identifying behaviours that would be 1) impactful and also have high plasticity, easy and effective (the low hanging fruit); 2) behaviours that may require time and financial effort to engage people; 3) behaviours we should avoid spending time on as they are difficult to change and ineffective; and 4) those that might not be considered impactful but are easy to do and potentially could lead to spillover behaviours or generate social norms.

I further isolated potential priority behaviours by calculating a behaviour prioritisation score through integrating the scores of biodiversity impact, plasticity and prevalence levels. To calculate the behaviour prioritisation score I used the following equation (McKenzie-Mohr 2011):

\[
\text{Prioritisation score} = \text{Biodiversity Impact} \times \text{Likelihood of Adoption} \times (1 - \text{Current Prevalence})
\]
All analyses were completed in statistical program software R, version 3.60 (R Development Core Team 2016).

3.3 Results

Workshop results

The initial behaviour elicitation in subgroups resulted in a list of 74 target behaviours. These behaviours differed in their levels of specificity and scale; some were not behaviours at all (e.g. environmental education), and others were behaviours restricted to rural landholders. Some behaviours, such as wildlife gardening, political advocacy, and reducing beef or lamb consumption, were mentioned by all four groups. After combining each group’s suggestions and removing those that were duplicated, were not behaviours, or were not relevant to the target population, 47 behaviours remained. Further discussion amongst workshop attendees about the practicality of addressing or promoting these behaviours and the similarity or overlap between some behaviours resulted in a refined list of 27 unique specific behaviours (Table 3.1). These were grouped into a simple classification of six domains of behaviours adapted from Larson et al. (2015) and Stern et al. (1999): Consumption behaviours, Social behaviours, Stewardship behaviours, Advocacy behaviours, Donation behaviours (time and financial), and Lifestyle behaviours. Some behaviours may be further divisible, but the group decided on the level of resolution appropriate for the objectives of this prioritisation. For instance, the behaviour reduce beef/lamb consumption could be divided into more specific behaviours based on the type of meat (beef or lamb), frequency (once a week or once a month) and location of consumption (at home or restaurant).

Online survey results

When asked to list the five behaviours they perceived to have the highest plasticity and impact on biodiversity, 59% of survey participants selected responsible cat ownership (1) in their response, the highest percentage of all behaviours. Voting for candidates based on biodiversity policies (2), wildlife gardening (3), and choosing Marine Stewardship Council (MSC) certified seafood products (4) were selected by 47.0% of participants. Reducing beef and lamb consumption (5) was selected by 41.1% (see Table A3 for full results).
Behaviours that were considered to be both of high impact and high plasticity (>5 for each factor) and distributed in the top right quadrant of the prioritisation matrix (Figure 3.3) include: reduce beef/lamb consumption, choose MSC-certified seafood, choose Forest Stewardship Council (FSC) certified toilet paper, responsible cat ownership, responsible dog ownership, donate to private land conservation organisations, donate to threatened species organisations, wildlife gardening, choose green energy, and forgo pesticide/herbicide use. The lowest scoring behaviour, as measured for both impact and plasticity, was run for local government. See Figure A2 for confidence intervals of impact and plasticity estimates.

**Prioritisation score**

The current prevalence of behaviours within the population ranged from 54% of households (choosing green energy) to <1% for several behaviours such as running for local council. When the prioritisation score was calculated, three high priority behaviours featured in the prioritisation matrix (choose FSC-certified toilet paper, choose green energy, and forgo pesticide/herbicide use) were demoted from the top ten behaviours as a result of their higher existing prevalence within Victoria (42%, 54% and 43%, respectively) (Table 3.2). Conversely, several behaviours increased in priority ranking due to a low prevalence: choose biodiversity-friendly investments, vote for political candidates based on environmental policies, and advocate publicly for pest animal control.
### Identifying and prioritising high impact biodiversity behaviours

Table 3.1 List of behaviours developed during the workshop and justification for their inclusion.

<table>
<thead>
<tr>
<th>Consumption behaviours</th>
<th>Justification, considerations and supporting references</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Choose Forest Stewardship Council (FSC) toilet paper products</td>
<td>Victorian forests are partly harvested for the production of wood chips that are manufactured into paper products, including toilet paper. The state forest industry has been denied FSC certification for sustainability issues (Anderson 2018). Recycled toilet paper is readily available, with minimal cost difference and previous interventions likely have raised awareness level and increased uptake of behaviour (Smith &amp; Weiler 2011).</td>
</tr>
<tr>
<td>2. Choose organic fruit, vegetables, and grain products</td>
<td>Organic farming benefits wildlife by eliminating synthetic pesticides and fertilisers (Hole et al. 2005) Impacts likely vary depending on specific products and where grown.</td>
</tr>
<tr>
<td>5. Reduce beef and lamb consumption</td>
<td>Direct impact on biodiversity in overgrazed rangelands, wetland areas, predator conflict (Hansen, Fraser &amp; Jones 2019; van Eeden, Smith, et al. 2018; Dorrough et al. 2004). Non-meat alternatives are increasingly available, ‘reduce’ is easier than eliminate and swapping meat choices to MSC fish or chicken will also benefit biodiversity.</td>
</tr>
<tr>
<td>6. Choose local and seasonal produce</td>
<td>Globally sourced food has biodiversity and sustainability issues (Macdiarmid 2014). Local produce is usually available at markets and farmers markets but sometimes hard to identify.</td>
</tr>
<tr>
<td>Social Behaviours</td>
<td></td>
</tr>
<tr>
<td>7. Tell positive nature stories within circle of influence</td>
<td>Telling positive stories about the environment, or behaviours that benefit the environment, is a potentially powerful tool to communicate awareness and knowledge between individuals (Goldstein et al. 2015). Supports social norms building (Smith, Thomas &amp; McGarty 2015).</td>
</tr>
<tr>
<td>8. Actively support those who are making biodiversity-friendly choices</td>
<td>Positive reinforcement will encourage individuals/groups to continue with conservation behaviours (Schultz 1999). Support can be provided in real life interactions or on social media, online behaviours.</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td>9. Discuss origin of food consumed within circle of influence</td>
<td>Food choices have large impact on biodiversity (Poore &amp; Nemecek 2018) and discussions may increase knowledge of impacts, available choices, and build social norms (Culiberg &amp; Elgaied-Gambier 2016). Message framing is likely to be important for this behaviour (Kusmanoff 2017).</td>
</tr>
<tr>
<td>10. Discuss pro-environmental attitudes/behaviours within circle of influence</td>
<td>Increases knowledge of impacts and choices and may build social norms around behaviour (Smith, Thomas &amp; McGarty 2015). Potentially effective if message is framed appropriately (Kusmanoff 2017) and comes from influencers within social groups.</td>
</tr>
</tbody>
</table>

**Stewardship Behaviours**

<table>
<thead>
<tr>
<th>11. Participate in citizen science projects</th>
<th>Direct impact depends on the location and objectives of specific project (Cooper et al. 2007). Indirect impact by connecting people to nature and raising awareness (D. R. Wright et al. 2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Volunteer for activities that take care of the environment (e.g. participating in a Local Friends Group)</td>
<td>Direct on-the-ground action and fosters connection with nature (Asah &amp; Blahna 2013; McDougle et al. 2015). There are more than 100 different groups helping Parks Victoria to maintain and protect the parks network (<a href="https://parkweb.vic.gov.au/get-involved/volunteer/friends-groups">https://parkweb.vic.gov.au/get-involved/volunteer/friends-groups</a>).</td>
</tr>
<tr>
<td>13. Plant and maintain a wildlife garden</td>
<td>Australian urban environments support threatened species populations (Soanes &amp; Lentini 2019). Wildlife gardening helps address impacts of urbanization, by increasing connectivity and providing critical habitat (Belaire et al. 2011; Goddard, Dougill &amp; Benton 2010; Doody et al. 2010). Ancillary benefits include increasing connection to nature of whole neighbourhoods and potentially increasing time spent outdoors.</td>
</tr>
<tr>
<td>14. Forgo using non-natural herbicides and pesticides in domestic gardens</td>
<td>Pesticides impact pollinators, other insects and ecosystem functioning (New 2018; van der Sluijs et al. 2015) and reduce urban stream invertebrate diversity (Rippy et al. 2017).</td>
</tr>
</tbody>
</table>

**Advocacy Behaviours**

| 15. Advocate publicly for pest animal control including both native and alien species | Native and alien pest species have high impact on Victorian ecosystems. Multiple species (e.g. deer, wild horse, kangaroos) are overpopulated. Different segments of society will have various attitudes towards its management depending on the species (van Eeden et al. 2019). |
### Identifying and prioritising high impact biodiversity behaviours

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<tbody>
<tr>
<td><strong>16. Advocate for intensification (infill) of urban areas rather than urban fringe expansion</strong></td>
<td>Urban expansion threatens multiple ecosystems in Victoria (Llausàs, Buxton &amp; Beilin 2016). Advocating for this issue is not a direct behaviour but if objectives reached it will have high impact (Garrard et al. 2018; Villaseñor et al. 2017)</td>
</tr>
<tr>
<td><strong>17. Write to local members of parliament or local government about their environmental policies</strong></td>
<td>Campaign focussed on environmental issues. Tends to be issue-based but demonstrated impact in previous environmental issues in Victoria (Slattery 2002).</td>
</tr>
<tr>
<td><strong>18. Vote for political candidates based on environmental policies</strong></td>
<td>By voting in people that will support the implementation of proenvironmental policies that will benefit structural changes needed (Novacek 2008)</td>
</tr>
<tr>
<td><strong>19. Advocate for 'green' or 'biodiversity-friendly' certification</strong></td>
<td>An unknown impact. Need an appropriate labelling system, which currently does not exist. Also, this is likely to be difficult to measure (Tayleur et al. 2018; Boiral, Heras-Saizarbitoria &amp; Brotherton 2018)</td>
</tr>
<tr>
<td><strong>20. Run for local government</strong></td>
<td>Actively participate in governance processes in order to lift visibility of biodiversity issues (Mey, Diesendorf &amp; MacGill 2016). The impact is indirect, variable and context specific. Potentially increases social responsibility and citizenship.</td>
</tr>
</tbody>
</table>

#### Donation Behaviours

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<tbody>
<tr>
<td><strong>21. Donate to private land protection organisations</strong></td>
<td>Contributes to on-ground biodiversity management. Effective in protecting land in perpetuity and implementing management on private lands (Hardy et al. 2017; Selinske et al. 2019)</td>
</tr>
<tr>
<td><strong>22. Donate to organisations that focus on threatened species advocacy</strong></td>
<td>Donate to organisations that run threatened species advocacy campaigns. Organised, effective advocacy will create structural changes that benefit biodiversity (John C.Z. Woinarski et al. 2017).</td>
</tr>
<tr>
<td><strong>23. Volunteer for a biodiversity conservation organisation (including volunteering non-‘biodiversity’ skills like graphic design, accounting, IT, logistics, etc.)</strong></td>
<td>Use a job-matching framework that directs people with needed skills to the right organisation. Helps organisations prioritise the best use of their own staff’s time. Engage interested people with skills not traditionally associated with conservation while expanding their knowledge of conservation challenges and solutions (Asah &amp; Blahna 2013; Shanahan, Ledington &amp; Maseyk 2018)</td>
</tr>
</tbody>
</table>

#### Domain: Lifestyle Behaviours
| **24. Responsible dog ownership – dogs on leashes in natural areas and picking up after your dog** | Off-leash dogs disturb and predate native species (Glover et al. 2011; Stigner et al. 2016). Impact may depend on location, if there are alternatives where dog can be off leash, and knowledge of impact to wildlife (Williams et al. 2009). |
| **25. Responsible cat ownership – keep cat fully contained** | Free roaming pet cats kill millions of small mammals, birds and reptiles every year (J. C.Z. Woinarski et al. 2017; Woinarski et al. 2018; Loyd et al. 2013). |
| **26. Choose biodiversity-friendly investments (e.g. sustainable super funds)** | Biodiversity-friendly investments help support structural change (Epstein, Elkington & Leonard 2018) |
| **27. Spend regular time in nature** | Spending more time in nature influences connection to nature behaviours (Nisbet, Zelenski & Murphy 2009; Mayer & Frantz 2004). If localised may result in pro-biodiversity behaviours (Gosling & Williams 2010; Mackay & Schmitt 2019). |
Table 3.2 Behaviour biodiversity impact (1 = lowest; 10 = highest), plasticity (1 = lowest; 10 = highest), prevalence and prioritisation scores. Behaviours ranked by highest to lowest prioritisation score.

<table>
<thead>
<tr>
<th>Behaviours</th>
<th>Expert online survey</th>
<th>Prioritisation score without prevalence</th>
<th>Victorian Valuing Nature survey (Meis-Harris et al. 2019) / literature review</th>
<th>Prioritisation score with prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Impact</td>
<td>Plasticity</td>
<td>Prevalence</td>
<td></td>
</tr>
<tr>
<td>Choose Marine Stewardship Council (MSC) certified seafood products</td>
<td>7.39 ± 0.27</td>
<td>6.78 ± 0.30</td>
<td>50.1</td>
<td>0.15</td>
</tr>
<tr>
<td>Responsible dog ownership – dogs on leashes in natural areas and picking up after your dog</td>
<td>6.61 ± 0.41</td>
<td>6.00 ± 0.46</td>
<td>39.7</td>
<td>0.18</td>
</tr>
<tr>
<td>Reduce beef and lamb consumption</td>
<td>7.56 ± 0.30</td>
<td>6.89 ± 0.52</td>
<td>52.1</td>
<td>0.37</td>
</tr>
<tr>
<td>Donate to private land protection organisations</td>
<td>6.35 ± 0.39</td>
<td>5.12 ± 0.43</td>
<td>32.5</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Choose biodiversity-friendly investments (e.g. sustainable super funds)</td>
<td>6.61 ± 0.53</td>
<td>4.61 ± 0.41</td>
<td>30.5</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Donate to organisations that focus on threatened species and ecosystem advocacy</td>
<td>6.29 ± 0.39</td>
<td>5.12 ± 0.43</td>
<td>32.2</td>
<td>0.07</td>
</tr>
<tr>
<td>Plant and maintain a wildlife garden</td>
<td>6.65 ± 0.31</td>
<td>5.88 ± 0.47</td>
<td>39.1</td>
<td>0.24</td>
</tr>
<tr>
<td>Vote for political candidates based on environmental policies</td>
<td>7.25 ± 0.46</td>
<td>4.5 ± 0.50</td>
<td>32.6</td>
<td>0.1</td>
</tr>
<tr>
<td>Responsible cat ownership – keep cat fully contained</td>
<td>7.44 ± 0.44</td>
<td>5.78 ± 0.54</td>
<td>43.0</td>
<td>0.34</td>
</tr>
<tr>
<td>Advocate publicly for pest animal control including both native and alien species</td>
<td>5.53 ± 0.44</td>
<td>4.76 ± 0.50</td>
<td>26.3</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Forgo using chemical herbicides and pesticides in domestic gardens</td>
<td>5.94 ± 0.54</td>
<td>6.24 ± 0.33</td>
<td>37.1</td>
<td>0.31</td>
</tr>
<tr>
<td>Choose Forest Stewardship Council (FSC) toilet paper products</td>
<td>5.78 ± 0.51</td>
<td>7.61 ± 0.54</td>
<td>44.1</td>
<td>0.42</td>
</tr>
<tr>
<td>Spend regular time in nature</td>
<td>4.78 ± 0.50</td>
<td>5.66 ± 0.45</td>
<td>31.3</td>
<td>0.20</td>
</tr>
<tr>
<td>Volunteer for activities that take care of the environment (e.g. participating in a Local Friends Group)</td>
<td>7.06 ± 0.32</td>
<td>4.41 ± 0.39</td>
<td>31.1</td>
<td>0.20</td>
</tr>
<tr>
<td>Write to local members of parliament or local government about their environmental policies</td>
<td>4.56 ± 0.51</td>
<td>5.5 ± 0.51</td>
<td>25.1</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Participate in citizen science projects</td>
<td>5.18 ± 0.47</td>
<td>5.0 ± 0.40</td>
<td>25.9</td>
<td>0.14</td>
</tr>
<tr>
<td>Advocate for intensification (infill) of urban areas rather than urban fringe expansion</td>
<td>5.88 ± 0.49</td>
<td>3.75 ± 0.37</td>
<td>22.0</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Advocate for 'green' or 'biodiversity-friendly' certification</td>
<td>5.06 ± 0.45</td>
<td>4.35 ± 0.30</td>
<td>24.4</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Actively support those who are making biodiversity-friendly choices</td>
<td>4.17 ± 0.49</td>
<td>7.22 ± 0.54</td>
<td>30.1</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Identifying and prioritising high impact biodiversity behaviours</strong></td>
<td></td>
<td></td>
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<tr>
<td>---------------------------------------------------------------</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Choose a green energy supplier for home energy needs</strong></td>
<td>6.22 ± 0.47</td>
<td>5.89 ± 0.46</td>
<td>36.6</td>
<td>0.54</td>
</tr>
<tr>
<td><strong>Volunteer for a biodiversity conservation organisation</strong></td>
<td>5.44 ± 0.33</td>
<td>4.31 ± 0.47</td>
<td>23.4</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Discuss origin of food consumed within circle of influence</strong></td>
<td>3.11 ± 0.40</td>
<td>5.44 ± 0.51</td>
<td>16.9</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td><strong>Choose organic fruit, vegetables, and grain products</strong></td>
<td>4.17 ± 0.45</td>
<td>4.61 ± 0.39</td>
<td>19.2</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>Tell positive nature stories within circle of influence</strong></td>
<td>3.22 ± 0.49</td>
<td>7.17 ± 0.60</td>
<td>23.1</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Choose local and seasonal produce</strong></td>
<td>4.06 ± 0.55</td>
<td>4.83 ± 0.39</td>
<td>19.6</td>
<td>0.23</td>
</tr>
<tr>
<td><strong>Discuss pro-environmental attitudes/behaviours within circle of influence</strong></td>
<td>2.94 ± 0.39</td>
<td>6.12 ± 0.44</td>
<td>18.0</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Run for local government</strong></td>
<td>4.38 ± 0.61</td>
<td>1.75 ± 0.30</td>
<td>7.70</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>
Figure 3.3 Prioritisation matrix for biodiversity behaviours (abbreviated for conciseness) that a typical Victorian individual could undertake. Biodiversity impact is plotted on the y-axis against behavioural plasticity scores plotted on x-axis. The upper right quadrant are those high priority behaviours that were assessed as having both high impact and high plasticity scores. Bold lines are midpoints (5) of the x and y axes. The numbers correspond with each behaviours’ description in Table 3.3.
3.4 Discussion

Prioritisation of behaviours

Human behaviours impact biodiversity in multiple ways (Larson et al. 2015), yet it may not always be clear to individuals how to best make a positive contribution to biodiversity (Selinske et al. 2018). This is especially true for inhabitants of suburban and urban environments (Uzzell 2000). It is also unclear to conservation decision-makers which behaviours should be prioritised for behaviour change interventions. In this paper, I used an adapted nominal group technique to develop a list of behaviours that covers the breadth of activities a typical individual can undertake for biodiversity in Victoria. Despite the diversity of expertise, knowledge and perceptions of behavioural impacts on biodiversity, there were multiple behaviours that the majority of experts agreed were priorities (e.g. responsible pet ownership, voting for candidates based on biodiversity policies, wildlife gardening, reduce beef/lamb consumption, choose MSC seafood) and 10 behaviours were identified as having high impact and high likelihood of change (Figure 3.3).

Taking the additional step of including estimates of current prevalence in the population to weight individual behaviours provided information on the potential for uptake in the prioritisation matrix, and led to a slightly different prioritisation of behaviours (Table 3.2). However, while prevalence is a commonly used metric in behaviour prioritisations (McKenzie-Mohr 2011), the reliability of this approach might depend on other considerations, such as whether the behaviour has the potential to encourage a social norm or spillover into other behaviours (Thøgersen & Crompton 2009; Kashima & Margetts 2013). For example, it may be more efficient to focus on behaviours that are already prevalent within a population by pushing the behaviour towards a social norm threshold, rather than focussing on a behaviour with little current engagement (Centola et al. 2018). Additionally, if a behaviour already has a relatively high prevalence, then this potentially indicates a reasonable degree of plasticity, and a good opportunity to increase uptake through norm-based messaging. Future prioritisation efforts should consider, or attempt to account for, this behavioural nuance.
Advocacy behaviours (e.g. voting in consideration of biodiversity issues, running for council) were generally associated with high impact but low plasticity. While there may be multiple barriers to the uptake of environmental activism (Pac & Rodrigues 2016; Schmitt et al. 2019), advocacy behaviours have greater potential to generate transformational change than other categories of behaviours (Amel et al. 2017). While advocacy behaviours may not be appropriate behaviours for governmental departments to promote, NGOs or advocacy groups could drive participation in these types of behaviours (see Chapter 4). NGOs may generate activism and advocacy by producing resources for those interested in participating but who are unsure how to engage (Hasler, Walters & White 2019). Further research that examines how personal, environmental and social identity influence individual involvement in activism (Schmitt et al. 2019; Kidd et al. 2019), or identifies key barriers to advocacy (Uusi-Rauva & Heikkurinen 2013) would be useful.

All social behaviours (e.g. discussing biodiversity, supporting others) fell into the lower right quadrant of behaviours: that is, easy to undertake but not highly impactful. This is likely due to the indirect links to biodiversity conservation outcomes, subsequent difficulty in measuring this impact, and the uncertainty about any actual impact, given that these actions require other individuals to change their behaviour as a result of the social behaviour (e.g. others changing their purchasing behaviour following a discussion about the conservation value of purchasing MSC seafood) (Lange & Dewitte 2019). This does not mean that these behaviours should be ignored, as they could be effective in generating social norms, creating social expectations of behaviour, or engagement in other behaviours (i.e. spillover behaviours) that have additional biodiversity impact (Thøgersen & Ølander 2003; Maki et al. 2019; Nyborg et al. 2016). Encouraging conscious engagement in any environmental behaviour may foster larger behavioural changes in the future (Littleford, Ryley & Firth 2014). The three behaviours in the bottom left quadrant (i.e. low impact and low likelihood of change) are choose organic food, choose locally produced food, and running for local council. Experts may have perceived that the benefits for biodiversity from these behaviours have higher uncertainty as a result of contextual and efficacy issues (Hole et al. 2005).

In Victoria, some of the prioritised behaviours are already targeted by relevant programs. For example, the Gardens for Wildlife (https://gardensforwildlifevictoria.com/) program, primarily
Identifying and prioritising high impact biodiversity behaviours

funded by local governments, aims to encourage planting home gardens to benefit wildlife. Momentum in this area is something the Victorian Government could capitalise on (Shaw, Miller & Wescott 2017), as wildlife gardening generates direct benefits for biodiversity (Goddard, Dougill & Benton 2010; Belaire, Whelan & Minor 2014) and strengthens community engagement and connection to nature (Mumaw & Bekessy 2017). Given that two of the Victorian Government’s key Biodiversity 2037 targets are to increase connection to nature and the number of people acting for nature, it may make sense to prioritise behaviours that can accomplish both (e.g. wildlife gardening, citizen science). Strengthening people’s connection to nature is likely to increase the possibility of change for many of the other behaviours. Stronger connections to nature will also enhance environmental identity which is a predictor of multiple different types of conservation behaviours (Kashima, Paladino & Margetts 2014; Prévot et al. 2018; Mackay & Schmitt 2019; Whitburn, Linklater & Abrahamse 2019).

Considerations for future prioritisations

Future research could map exactly how the expected uptake of selected behaviours is likely to impact biodiversity, including the magnitude of change for specific species or ecosystems. Modelled predictions of expected impact may allow more refined prioritisation of investment and would facilitate the design of monitoring programs to evaluate the effectiveness of behaviour change interventions. The audience targeted in this study was broad; future prioritisations could be further refined to consider more specific audience segmentation for behaviour change interventions (Metcalf et al. 2019). Effective audience segmentation and targeting could involve different interventions or messaging strategies for each audience segment, or specific targeting of behavioural interventions to audience segments that are more likely to adopt the behaviour.

While I examined the likely impact, plasticity and community prevalence of each behaviour, there are additional factors to consider. For instance, prioritisation could also include the constraints of implementing the behaviour change, such as the cost of the proposed intervention, technical complexity of the behaviour, and community preference and acceptability (Michie et al. 2013). Prioritisation could potentially be used in future work to highlight effective organisational behaviours that act as leverage points for structural or
Identifying and prioritising high impact biodiversity behaviours

systems change (Clayton, Litchfield & Geller 2013; Amel et al. 2017). Given the contextual nature of biodiversity issues and the complexity of local culture, I also note that while behaviour change agendas may be guided by global or national behavioural prioritisations, to truly engage local people with local problems we need finer scale prioritisations.

Limitations

I used expert estimations in this study, but there are multiple ways to measure behavioural impact and plasticity (Kneebone, Smith & Fielding 2017; Dietz et al. 2009; Linklater et al. 2019; Please et al. 2018). While there tended to be agreement among experts with respect to scoring estimates, research has shown that laypeople may have different perceptions of behaviours compared to experts (Truelove et al. 2018). Therefore, the results may not accurately represent public perceptions of the challenges of changing a behaviour, which may influence the estimated likelihood of changing that behaviour. Future research could investigate public perceptions of these behaviours and perceived difficulty. However, it is worth noting that behavioural intention surveys of the public may also not be ideal measures for estimating plasticity and gathering this type of data from the public is challenging (Allen, Dietz & Mccright 2015; Lange & Dewitte 2019). Similarly, some prevalence estimates were based on self-report survey data, potentially inflating the current levels of participation in a behaviour.

For some of the selected behaviours the biodiversity impact may be muted in Victoria when global trade pathways are considered (Newbold et al. 2015). For instance, while cattle and sheep grazing are a driver of biodiversity loss in Victoria (Hansen, Fraser & Jones 2019) and Australia more broadly (McAlpine et al. 2009), given the global supply chains of production, a proportion of beef and lamb produced in Victoria is consumed outside of Victoria. Therefore, Victorian pastoralists will likely still have demand from markets outside Victoria to compensate for any loss from Victorian consumers. Nevertheless, if reductions in beef consumption in Victoria are substantial, this will be important for biodiversity globally and perhaps lead to increased regulation of the Victorian beef/lamb industries and increased demand for environmentally or biodiversity-friendly beef and lamb.
Identifying and prioritising high impact biodiversity behaviours

Given the exercise’s broad focus, it was necessary to engage a group of experts with diverse expertise and varying levels of understanding of the identified behaviours, potentially judging behaviours with less certainty. This uncertainty could be assessed in future expert elicitation workshops by asking participants to provide bounded scores of their estimates (sensu Hemming et al. 2018). The experts who attended the workshops largely specialised in terrestrial systems, potentially biasing the focus towards terrestrial threats and behaviours rather than threats to marine and freshwater environments. Sustainable fishing was the only identified behaviour directly related to marine biodiversity, and this behaviour is likely to be the most prominent way that the typical Victorian interacts with the marine environment. Prominent behaviours, such as those relating to the proper disposal of plastic waste, were not discussed during the workshop. Given the disposal systems available in Victoria, experts may not have linked these behaviours to specific impacts within Victoria. Future research could consider other human behaviours impacting marine biodiversity in more detail (e.g. fishing behaviours, released balloons), drawing specifically from marine science and conservation expertise.

Conclusions

Until recently there has been relatively little research into the behaviours that all individuals could adopt to benefit biodiversity (Saunders 2003; Cowling 2014b). There is an opportunity for systematic application of behavioural science to this issue, mirroring the increased sophistication and evolution of conservation planning. For greater impact, behaviour prioritisation could be implemented at multiple scales from international policy initiatives to community-based social marketing. Here I have developed a prioritisation of biodiversity behaviours within Victoria, Australia, and provide a list for policymakers, behaviour change specialists and concerned individuals, alike, to act upon. While this list of behaviours was developed for the state of Victoria, it provides a starting point that is likely to be useful in other jurisdictions as well. Given that global trends of biodiversity loss are primarily driven by human impacts, this approach for prioritising behaviours is of broad relevance.

An effective behaviour change campaign will incorporate multiple interventions (Dietz et al. 2009) and include interventions and messaging that strategically target audiences and their barriers to behaviour change, whether they be structural, psychological, technical (Heberlein 2012a) or some combination of these. The method I’ve proposed here seeks to identify key
human behaviours with the greatest potential to yield positive outcomes for biodiversity. Identifying these key behaviours provides a basis for future research and an evidence base for developing a suite of behavioural change interventions to reduce biodiversity loss and reinforce social and behavioural norms around the value of biodiversity.
Acknowledgements

Thank you to the expert participants for their time and knowledge devoted to this research and to the SWARM Expert Elicitation Platform team (https://www.swarmproject.info/) for hosting the elicitation and assistance. The manuscript benefited from the comments of three anonymous reviewers and the editors. This research was supported by S.A.B.’s ARC Future Fellowship. M.J.S., G.E.G. and A.M.K. are in part funded by the Australian Government’s National Environmental Science Program Threatened Species Recovery Hub.
4 We have a steak in it: eliciting interventions to reduce beef consumption and its impact on biodiversity

A version of this chapter has been reviewed and resubmitted to Conservation Letters:

Selinske, MJ, Fidler, F, Gordon, A, Garrard, GE, Kusmanoff, AM & Bekessy, SA, in review, ‘We have a steak in it: eliciting interventions to reduce beef consumption and its impact on biodiversity’.
Abstract

Beef production is a major driver of biodiversity loss and greenhouse gas emissions, hence multiple studies recommend reducing beef production and consumption. While interventions to reduce beef-production impacts have been developed, there has been relatively little engagement from the conservation sector in approaches for reducing beef consumption. As a first step to address this gap and identify leverage points, I conducted a policy Delphi expert elicitation. I asked 16 experts to identify drivers of beef consumption and propose interventions for reducing beef consumption in the US. Experts critiqued 20 interventions, generating a qualitative dataset that was thematically analysed to explore the feasibility and effectiveness of each intervention. Feasible, impactful interventions included changing perceived social norms, targeting food providers, and increasing the availability and quality of beef alternatives. However, a suite of inventions is likely needed to affect behaviour change. The method developed here could be applied to a range of biodiversity behaviours.
4.1 Introduction

Agriculture poses one of the greatest threats to biodiversity (Maxwell et al. 2016), and is a major contributor to greenhouse gas (GHG) emissions (Bajželj et al. 2014; IPCC 2019). Within agriculture, beef in particular is associated with global and local environmental change (Godfray et al. 2018). Beef production, including feed crops, primarily impacts biodiversity through land conversion (Machovina, Feeley & Ripple 2015), but is also a driver of human wildlife conflict (van Eeden, Crowther, et al. 2018), farmland and grassland soil erosion (Lamba et al. 2015), nitrogen and phosphorus pollution (Bouwman et al. 2013), and soil impaction, altering hydrology and ecological communities (Beschta et al. 2013). Compared to other livestock, beef has a larger footprint in terms of area, biomass, GHG emissions, and water use (Gerber et al. 2015; Hedenus, Wirsenius & Johansson 2014). Many countries already produce and consume beef above sustainable levels (Ranganathan et al. 2016), and global demand for beef is increasing with rising economic prosperity in newly industrialised countries (Tilman & Clark 2014). Without targeted interventions, beef production will increasingly impact biodiversity and ecosystem services, reducing future capacity to feed the global population (Cazalis, Loreau & Henderson 2018). By specifically targeting beef consumption, the conservation sector could help incentivise reductions in production, helping to mitigate this key driver of biodiversity loss and related GHGs emissions.

Existing conservation efforts targeting beef have focussed on reducing the impact of beef production, including through ‘sustainable feedstock’ (Nepstad et al. 2014) and incentives for reducing stocking rates (Lindenmayer et al. 2012). Both grass-fed (e.g. rockies.audubon.org/programs/audubon-conservation-ranching) and concentrated animal feeding operations (CAFO) for beef production systems have been championed (Swain et al. 2018). However, the biodiversity benefits and potential reductions in GHG emissions associated with both are disputed (Garnett et al. 2017; Beschta et al. 2013). Further, these systems each face additional challenges; the land requirements of grass-fed beef are prohibitive (Eshel et al. 2017), and CAFOs raise animal welfare issues.

Recent research has recommended targets and policies to reduce beef production and consumption in the US and globally (Bajželj et al. 2014; Eshel et al. 2018; IPCC 2019). Because heavily regulating beef production or consumption choices is politically unpalatable in many parts of the world, relying on governments to tackle consumption levels is unrealistic.
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(Dagevos & Voordouw 2013). In the absence of regulation, effective strategies to change consumer choices—for example, switching to plant-based protein sources (Harwatt et al., 2017) or to other meat products with lower biodiversity footprints (e.g. pork, chicken, and sustainably-sourced fish)—are required. Understanding how to most effectively influence individual behaviours that have the greatest impact on biodiversity has been identified as an important aspect of conservation science (Schultz 2011), yet behaviour change research is rarely connected to studies of the demand side of the drivers of biodiversity loss (Selinske et al. 2018).

While there is a growing body of research examining the factors that influence meat consumption (see Stoll-Kleemann & Schmidt (2017) for a comprehensive review), few studies explore behavioural interventions aimed at reducing meat consumption (Hartmann & Siegrist 2017). Even fewer studies specifically target or examine beef consumption (Klöckner & Ofstad 2017). The paucity of such research is likely influenced by perceptions of the limited political and social appeal of reducing meat consumption (Laestadius et al., 2014). To examine the dimensions that underpin beef consumption and determine potential interventions for reducing beef consumption, I undertook a formal elicitation using experts from multiple relevant fields. I focussed on the US because it is the largest beef producing and consuming nation, and the fifth highest per capita beef consumer, behind Uruguay, Argentina, Paraguay and Brazil (OECD, 2018).

4.2 Methods

To identify the interventions that are most likely to achieve reductions in beef consumption, I used a policy Delphi method to elicit information from experts on food choices and behaviours. The Delphi method is a structured multi-round exercise (Figure 4.1), employed to understand complex issues for which there is little background knowledge (Turoff 1970). Similar to other Delphi methods, the policy Delphi engages experts anonymously through structured interactions over multiple rounds of elicitation, allowing for revisions of opinions or estimates (Turoff 1970). It deviates from other Delphi methods in that it is not intended to lead to consensus around an issue, but rather to generate and consider a number of policy interventions, and to discuss their pros and cons in depth (de Loë, Melnychuk, Murray, & Plummer, 2016). RMIT University ethics approval was granted for this research (CHEAN A 21314-01/18; Appendix D).
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Figure 4.1 The adapted policy Delphi process followed in this study compared to the a more traditional approach (de Loë et al. 2016; Turoff 1970). The number of participating experts in this research are included for each round.

Expert participants

I identified experts using a non-probability sampling method (Teddlie & Yu 2007), by examining author lists of published literature derived from a search on Google Scholar (scholar.google.com) for “beef consumption” AND “behaviour change” in keywords, abstracts and titles of articles published from 2010-2017. I sought lead authors with multiple publications related to the topic and examined the reference lists of papers returned in the literature search to identify key literature related to changing beef consumption or meat consumption more generally (snowball sampling [Teddlie & Yu, 2007]). I also invited authors to provide introductions to other appropriate experts. As diversity is a key element of successful expert elicitations (Hemming et al. 2018), I purposefully selected experts from different disciplines and contacted several practitioners working in this area.
Expert panellists were recruited in April 2018. Thirty-one experts were contacted by email, 19 agreed to participate and 16 participated in both rounds of the elicitation. Although the research topic has a US focus, many of the leading experts on meat and beef consumption are not based in the US, hence I recruited more broadly. While meat consumption and effective interventions are likely to vary across individuals and geographical areas, it is useful to consider experiences from other contexts, which could be applicable if adapted appropriately. Participants included experts from the fields of consumer psychology, environmental psychology, public health, human geography, food psychology, mass communication, social psychology, sociology, and public policy (Table B1).

**Expert elicitation process**

The elicitation took place in two rounds. In Round 1, each expert completed an online survey (Table B2), hosted by the Qualtrics survey platform (https://www.qualtrics.com/) for five days (May 28th - June 1st, 2018). Responses to the survey, which consisted of six questions, were recorded anonymously (Table B2). The experts were asked to list what types of interventions that could be implemented to reduce beef consumption in the US. Experts were then asked to categorise their list of interventions into three time-horizon categories: short-term (0-12 months), intermediate (1-10 years), and long-term (10-40 years) (Coleman et al., 2017). Given the urgency of biodiversity loss, experts were asked to select up to three of their previously listed interventions that they believed to be most impactful and feasible within a short or intermediate time horizon and to provide a justification and description for each suggested intervention. Finally, experts were also asked to suggest fruitful ways for conservation science to contribute towards reducing beef consumption.

Round 2 took place over a three-day period (June 5th - June 7th, 2018) using SWARM (https://www.swarmproject.info/), an expert judgement and reasoning online elicitation platform. I aimed to facilitate online discussion about the interventions proposed during Round 1, with a particular focus on feasibility and effectiveness. Experts were located around the world and participated anonymously at different times over the three-day period. To maintain the expert’s original intent, the titles and descriptions of interventions were retained in the same form that they were proffered during Round 1. Where interventions suggested by different experts in Round 1 were substantially similar to one another, the responses were combined in
a way that maintained the integrity and rationale of each suggestion. The interventions were posted online and experts were invited to critique each intervention through discussion of pros and cons. All comments were visible and experts were encouraged to comment as many times as they wished, representing an innovation to the policy Delphi method, and allowing for an iterative approach to obtain more robust opinions from experts (Figure 4.1).

**Analysis**

Qualitative thematic analysis of elicitation Rounds 1 and 2 were undertaken by me and author (AK). All responses were double-coded and coding disagreements were resolved through discussion. I coded suggested interventions based on 11 *a priori* categories of factors driving meat consumption as defined by Stoll-Kleemann et al. (2017) (see Table 4.1). Critiques and other expert comments derived from Round 2 were thematically analysed to assess how the experts collectively considered the feasibility and impact of each intervention.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge and skills</td>
<td>Factual knowledge of beef’s impact on the environment and procedural knowledge of how to cook without beef</td>
</tr>
<tr>
<td>Values and attitudes</td>
<td>Principles that guide decision-making in the consumption of beef. For example, if an individual does not perceive an ethical or health issue in eating beef, they are unlikely to change their consumption habits.</td>
</tr>
<tr>
<td>Emotions and cognitive dissonance</td>
<td>Affective responses of feelings and sensory experiences of eating beef. Cognitive dissonance is a state of inconsistent attitudes and a barrier to experiencing emotions and behaviour change, e.g. holding pro-environmental attitudes yet resistant to reducing beef consumption</td>
</tr>
<tr>
<td>Habits and taste</td>
<td>Unconscious routine of buying beef at a restaurant or supermarket and taste preferences towards beef</td>
</tr>
<tr>
<td>Socio-demographic variables and personality traits</td>
<td>Gender, age, income, education, and personality may influence the consumption of beef</td>
</tr>
<tr>
<td>Perceived behaviour control</td>
<td>Lack of self-efficacy reduces the control over or the likelihood of reducing beef consumption</td>
</tr>
<tr>
<td>Culture and religion</td>
<td>Beliefs and symbolism attached to beef consumption</td>
</tr>
<tr>
<td>Social identity and lifestyles</td>
<td>Beef consumption as a signifier of social status and identity—people define themselves based on personal and social aspects</td>
</tr>
<tr>
<td>Social norms, roles and relationships</td>
<td>Perceptions of how to behave in a particular social group and the expectations of that group around beef consumption</td>
</tr>
<tr>
<td>Political and economic factors</td>
<td>Power relationships between government and agro-industry, subsidies and the costs of purchasing beef and alternative products</td>
</tr>
</tbody>
</table>
4.3 Results

Round 1: intervention generation and selection

Experts generated a list of 90 interventions to reduce beef consumption, with those addressing knowledge and skills being the most common (Figure 4.2; see Figure B1 for full results). Of the interventions identified, 41 (45.6%) were unique; the remainder overlapped with one or more of the other expert-derived interventions. Experts selected 25 interventions as feasible and effective in the short to medium-term, spanning multiple stages of the beef supply chain (Table 4.2; Figure 4.3). Of these, 20 were unique and formed the basis of the Round 2 elicitation. Summaries of experts’ thoughts of how the conservation sector can contribute towards reducing beef consumption are detailed in Appendix B and are highlighted in Figure 4.3.

![Figure 4.2](image_url)

Figure 4.2 The percentage of expert generated interventions (90 in total) classified by the category of factors addressed. The categories were identified by Stoll-Kleemann et al. (2017) as factors driving beef consumption. Two categories: Perceived Behaviour Control and Socio-Demographics/Personality identified by Stoll-Kleemann et al. (2017) were not raised by experts in this sample.
Round 2: expert critiques of interventions

The major discussion points for each intervention are summarised in Table 4.2. Experts agreed on four interventions they felt were likely to be effective in reducing beef consumption and feasible within a 10-year time frame: Manipulate perceived dynamic norms (Intervention 6); Further development of beef alternatives (Intervention 11); Beef-free meals in student, work and prison canteens (Intervention 12); and Advocate for greater proportion of plant purchases by large-scale distributors of meals (Intervention 13). Intervention 6 (relating to social norms) was generally agreed to be impactful with potential long-term implications for those individuals subjected to it, and to be highly feasible as there is a ‘lot of activity in the space’. The two structural interventions 12 and 13 were deemed to have high impact as they bypass individual decision-making, though experts cautioned that to be feasible these types of interventions need to be well-executed through corporate outreach and effective marketing and incentivised by promoting corporate social responsibility and developing a business case. Intervention 11 was thought to have high feasibility and impact, given the continued development of alternatives and market uptake, although there was concern that this would do little to shift underlying attitudes and norms about eating meat.

The interventions targeted different leverage points within the beef supply chain (Figure 4.3). While some leverage points were thought to have higher impact than others, experts made the point that multiple interventions across the supply chain were required to successfully reduce beef consumption, with different interventions potentially reinforcing others. In general, interventions that focussed on psychological behaviour changes (changes to knowledge, skills, attitudes, values) were perceived by experts as having high feasibility but low impact. Conversely, structural interventions (changes to food environment, political or economic factors), particularly policy changes, were generally thought to have high impact but low feasibility. Some experts emphasised that outright banning of beef will have low feasibility and could result in strong pushback from consumers and special interest groups.
Figure 4.3 Graphical representation depicting the suggested interventions in the beef supply chain and related points of leverage. Intervention numbers correspond with those in Table 4.2. Dashed lines represent indirect influence from government, NGOs and production/consumption. Green boxes are roles for conservation science and practice, as suggested by experts (Appendix B).
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Table 4.2 Interventions selected by experts to be both feasible and effective within a 10-year time horizon, including intervention description, target audience, and a summary of expert comments. Comments pertaining to impact and feasibility are highlighted in **red if considered low**, **green if considered high**, and **orange if expert opinions were mixed**. Three interventions elicited little discussion and are not included; *Strategic communication campaign*, *Encourage consumers to eat more plant-based meals rather than other meats*, and *Promoting greater reflexivity as to the complex drivers behind industrial meat consumption*. In each case, experts expressed that the intervention lacked sufficient description or reasoning to enable meaningful discussion.

<table>
<thead>
<tr>
<th>Intervention*</th>
<th>Description</th>
<th>Target audience</th>
<th>Summations of expert critiques and comments</th>
</tr>
</thead>
</table>
| 1. Health messaging/social marketing campaign | Provide individuals with information about health impacts of consuming too much beef, benefits of eating alternatives, and how to implement changes. Health related arguments often resonate better with larger groups of the public than environmental arguments | General public | • Interventions would have **low impact** and **high feasibility**  
• Based on the assumption of knowledge deficit model which is less effective  
• Public views on the health benefits of beef consumption could be contradictory challenging the interventions’ efficacy |
| 2. Challenge misrepresentations and misunderstandings of plant-based diets | Directly counter negative and inaccurate conceptions of plant-based diets using science-based evidence. Increase understanding of production methods economics, nutrition, and what happens to 'the animals' during production. | General public | • Interventions would have **low impact** and **high feasibility**  
• Based on the assumption of knowledge deficit model which is less effective  
• Potentially appeal to limited numbers of the public |
| 3. Cooking classes without beef in schools to promote and form early cooking habits that exclude beef | Preparing meals with beef can be habit forming and habits are formed early, it is important to form cooking habits that exclude beef. Cooking skills can be taught at schools, also to promote healthy eating. | Schools and their students | • Experts perceived that the **feasibility would be high** for implementation but **impact low**  
• May not have uptake as there is a gap between learning and practice  
• Implementation dependent on uptake of schools and teachers |
| 4. Better nutrition education for physicians in medical school as they currently receive little training on nutrition, and even less on the environment impacts of diet choices. | Currently physicians receive little training on nutrition, and even less on the environment impacts of diet choices. With rational physicians could counsel their patients to make improved dietary choices. Might compel groups like the American Medical Association to support policy change around beef. | Physicians in medical school | • Experts perceived that the **feasibility may be high** for implementation but **impact low** as it is a niche strategy  
• People don’t always listen to health professionals’ diet advice and this would likely extend to the environment  
• Health marketing might be more effective than a physician’s advice |
5. Challenge the normalisation of ‘food’ animals', by highlighting and questioning the conceptions of food animal farming as natural, and understandings of meat as natural and necessary

| Change the normalised language used to talk and write about ‘meat’ ‘food’ animals and farming to start to counter and unsettle normalised constructs. Introduces the opportunity to think, talk and act differently with regards to ‘meat’, ‘beef’ and ‘food’ animals. | General public | • Experts **questioned feasibility** in the short-term  
• Questioned how to deliver or scale-up the interventions due to their abstract nature  
• Would receive significant pushback from segments of the public and special interests  
• **Potentially effective** if led by high profile members of society |

6. Manipulate perceived dynamic norms by framing information of plant-based consumption

| Frame plant-based meals as increasingly popular and mainstream. Providing information about how behaviour is changing can cause people to ‘pre-conform’ with environmentally friendly behaviours that contradict the status quo before they become mainstream. | General public | • **General agreement of high feasibility and high impact**  
• Potential long-term implications for those individuals exposed  
• Changing norms works well in conjunction with other interventions  
• Potential perverse outcome for those who like to be different from the majority |

7. Meat/Beef Free Days campaign to agree to go meat/beef free at least one day per week

| Information and a campaign to agree to go meat/beef free at least one day per week. A small amount of funds required setting up the initiative and maintaining momentum, providing how-to’s etc. Generally, involves the main evening meal. | General public | • **General agreement of high feasibility**, mixed feelings on its impact  
• Meat/Beef free days intervention could also be impactful if broad and catches on  
• Criticism that it is currently undertaken by people who are already contributing |

8. Online tailored behavioural interventions delivering targeted information designed to answer consumers questions and challenges they have at the moment

| This intervention starts with detecting where in the process of change people are. Then - for example with an app or online platform - people receive targeted information designed to answer the questions and challenges they have at the moment. | General public especially those engaged in reducing their beef consumption | • **Mixed beliefs if this would be an impactful and feasible intervention**  
• Addresses multiple factors including knowledge, skills, attitudes, social norms  
• Experts challenged the conceptualisation of behaviour change as a ‘linear process’  
• Other experts liked the interventions framework - useful in conjunction with other types of interventions |

9. Include reduced beef consumption in 2020 US dietary guidelines to influence school lunch

| Ensure that scientific recommendations of reduced beef consumption are included in 2020 U.S. Dietary Guidelines. These guidelines form the bases of school lunch programs and are a major educational tool for the public at large. | US government | • Consensus among experts these interventions will have **high impact** and broad reach because of its impact on school lunch programs  
• Special interests and potentially parents may **dampen feasibility** and challenge implementation  
• Little impact on public as they pay less attention to health guidelines |
### 10. Include environmental considerations in 2020 US dietary guidelines

| Consideration of environmental health as well as nutrition in the guidelines would lead to a recommendation for reduced beef consumption, which would filter down to schools and nutrition programs. Nearly achieved in previous US Congress. |
| US government | • Similarly, to Intervention 9 the consensus among experts these interventions will have high efficacy and broad reach because of its impact on school lunch programs |
| | • Special interests and potentially parents may dampen feasibility and challenge implementation |
| | • Future research could focus on how consumers engage with sustainability ratings |

### 11. Further development of beef alternatives that look, taste, and smell like beef without the same negative impacts on the environment and animal welfare

| Continue making advances in food science so that people can eat things that look, taste, and smell like beef without the same negative impacts on the environment and animal welfare. Create affordable plant-based or cultured meat alternatives that are viable alternatives to beef. |
| Meat substitute industry and companies | • Has high feasibility as there is continued investment and high impact given uptake from food retailers, media |
| | • Likely achievable in 10 years’ time, with existing products in the market and continued development |
| | • There was concern that people may resist imitation meats as undesirable and there may also be environmental impacts from the alternative products |
| | • Potentially does little to shift the underlying attitudes and norms towards eating meat but a key step in overall reduction despite drawbacks |

### 12. Advocate for major food service companies to commit to cutting purchases of beef and increasing purchases of beef alternatives

| Ask major food service companies to commit to cutting purchases of beef and increasing purchases of produce. The business models of large-scale sellers of meals, like the major food service companies in the US, require them to more responsive to increasing demand for plant-based meals |
| Large food distributors that sell pre-packaged meals, and meals to large food | • High impact as it bypasses individual decision-making and broad reach |
| | • Feasible but difficult, needs to be well executed |
| | • To increase feasibility, incentivise participation by promoting the corporate social responsibility and developing a business case |

### 13. Institutional Reform to include beef-free meals in student, work and prison canteens

| Convince large institutions, such as cafeterias, prisons, and schools, to reduce their meat consumption by 10-20%. This intervention may go unnoticed to many consumers. Institutional reform already has a proven track record in the US and could be significantly scaled up and intensified. |
| Large food providers such as school cafeterias | • Like Intervention 12 high impact as it bypasses individual decision-making; feasible but difficult |
| | • Experts suggested focussing on reduction of meat-based meals rather than a ban |
| | • Potential for backlash and unintended consequence- increased beef consumption elsewhere |
14. **Internalise the environmental cost of beef to ensure the societal cost is included in the consumers price**

<table>
<thead>
<tr>
<th>Polluter pays principle to ensure the societal cost is included in consumers price.</th>
<th>Cattle farmers, food providers</th>
</tr>
</thead>
</table>
| • Likely will have **broad impact** as a result of increased price for beef but low feasibility as a result of the resistance to increasing the cost of beef  
• Would be a polarising policy  
• Experts **questioned the feasibility** of fully accounting for and robustly monetising the GHG emissions and indirect costs of land clearing associated with beef production  
• An expert suggested alternative intervention – apply these metrics to a marketing campaign, raising the profile of beef’s environmental costs |  |

15. **End the Beef Check-off Program to terminate the marketing of beef in the US as a product in itself** ([https://www.beefboard.org/about/faq_aboutcheckoff.asp](https://www.beefboard.org/about/faq_aboutcheckoff.asp))

<table>
<thead>
<tr>
<th>Commodity check-off programs such as the beef check off program (<a href="https://www.beefboard.org/about/faq_aboutcheckoff.asp">https://www.beefboard.org/about/faq_aboutcheckoff.asp</a>) require producers to support generic advertising campaigns for their products. Ending this would end marketing for beef as a product in of itself.</th>
<th>US government</th>
</tr>
</thead>
</table>
| • All responses **questioned the feasibility** due to political power of beef industry but it would reduce the marketing power of the beef industry so it would **have high impact**  
• Alternative proposal suggested to create a “tofu check-off” program funding advertising for plant-based meals |  |

16. **Change and reduce the availability of beef in restaurants, supermarkets, and menus**

<table>
<thead>
<tr>
<th>Reduce the availability of beef and increasing the availability of alternatives by presenting them earlier in buffets, place beef further down on menu.</th>
<th>Restaurants, supermarkets</th>
</tr>
</thead>
</table>
| • Any reduction of availability through costs, menu structure, or availability and visibility of beef alternatives would **have an impact**  
• Outright bans will be difficult and met with pushback  
• Debate might create awareness about the importance of reducing beef consumption  
• Noted that this was less a single intervention but multiple interventions |  |

17. **Foster better conditions and training for small-scale cow/calf operators through policy and research efforts**

<table>
<thead>
<tr>
<th>Policy and research efforts should be directed towards improving the livelihoods and security of rural communities and finding ways to foster environmental sustainability therein- including cow/calf operators. Market pressures often drive farmers out of business or into bigger operations. Find ways to relieve these pressures and encourage multiple land use practices that are more sustainable</th>
<th>Cattle farmers</th>
</tr>
</thead>
</table>
| • The intervention was seen as a **low disruption so easily feasible**  
• Will help husbandry for small growers and a shift to more sustainable agriculture  
• For some experts was seen as providing a license for beef consumption  
• It was noted that this intervention doesn’t shift consumption |  |

*An unedited and full description of each intervention is available in the Table B3*
4.4 Discussion
The policy Delphi expert elicitation provided insights into potential interventions to address key factors driving beef consumption in the US and the challenges that reduction efforts will face. During the initial elicitation, the experts contributed a comprehensive and diverse list of interventions, many of which addressed knowledge and skills-based drivers of consumption. While there is a need to raise public awareness of the link between beef consumption and environmental issues (Neff et al. 2018), the limitations of the knowledge-deficit model for creating behaviour change are well known (Heberlein 2012b). In the second round, experts disagreed about which interventions would be most appropriate within a 10-year timeline, and whether some interventions should be pursued at all. For instance, the development of meat alternatives, despite being recognised by experts as an intervention that will likely have a high impact on reducing beef consumption, drew criticism from some experts who felt that it might reinforce a view that meat consumption is appropriate. A flexitarian diet (meat consumption in moderation) is unlikely to be satisfactory for those that are focussed on the ethical implications of animal consumption but has great potential to reduce the biodiversity and climatic impacts.

There was general agreement that structural interventions such as influencing the practices of major food suppliers and service providers could have a large effect in reducing beef consumption. Given the political and economic factors that drive beef consumption, structural approaches that engage business directly to attempt to change consumer decision-making environments may be preferable to attempting to change governmental policy (Dagevos & Voordouw 2013). However, interventions such as sustainability ratings and dietary guidelines for reduced beef consumption have been possible under previous US leadership and may be again in the future (Merrigan et al., 2015). Experts also agreed that dynamic norm-messaging targeting changes in beef consumption would likely be effective (e.g. Sparkman & Walton, 2017), and comparatively easy to rollout. Other ‘nudges’, for example making non-beef options a default choice, or re-arranging menus, cafeterias etc. to alter consumer choices may also be useful in to reducing beef consumption. However, these kinds of interventions will likely require multiple strategies and will be dependent on context (Hartmann & Siegrist 2017; Arbit et al. 2017). As demonstrated in a recent review of pro-environmental meat consumption studies, more research including experimental studies, is required for greater understanding of best ways of changing consumption behaviours (Hartmann & Siegrist 2017).
There are a number of challenges associated with some of the interventions aimed at reducing beef consumption, including pushback from segments of the public and special interest groups, poor engagement and dependence on individual rationality (Stoll-Kleemann & Schmidt, 2017). At a minimum, messaging and marketing efforts targeted at specific audience segments will be necessary to address these challenges (Klöckner & Ofstad 2017) and more research is needed to understand pathways to pro-environmental-motivated consumption (Arbit et al. 2017; Stoll-Kleemann & Schmidt 2017).

Socio-economic and geographic factors may play an important role in consideration of meat substitutes and more sustainable consumption (Stoll-Kleemann & Schmidt 2017). The per capita rate of beef consumption in the US is fairly stable (Neff et al. 2018), but increasing population and changing dietary norms in urban areas presents opportunities to increase the impact of interventions (Stoll-Kleemann & Schmidt 2017). While urban populations may be more open to reducing beef consumption, recent research suggests that within the US, there is little regional variation in trends of meat consumption (Neff et al. 2018). Additionally, making sustainable consumption available to all socio-economic groups, through reducing cost barriers to meat substitutes, could be key in promoting both sustainable and healthy lifestyles (Arbit et al. 2017).

*Establishing a conservation research and practice agenda to reduce beef consumption*

The intention of this elicitation was not to single out one intervention to target for better biodiversity outcomes; there is no silver bullet in reducing beef consumption (Ranganathan et al. 2016). Instead, I aimed to stimulate thinking about this as an interdisciplinary conservation issue. Behaviour change is increasingly recognised as an important component of biodiversity conservation and there is a role for experimental testing of candidate interventions to inform conservation practice (Hartmann & Siegrist, 2017). For instance, research investigating links between awareness of the biodiversity impact of beef and reduced beef consumption, including how increased biodiversity awareness influences or displaces other (e.g. climate and health) motivations for reducing beef consumption, could make an important contribution to biodiversity conservation (de Boer, de Witt & Aiking 2016). There is also a meaningful role for conservation NGOs, who can utilise their previous experience in campaign implementation to engage and/or pressure large food-suppliers, encourage supporters to reduce their own beef consumption, and actively lobby governments to support policies that reduce beef consumption.
and engender farmer stewardship. There is an opportunity to collaborate with and learn from organisations like the World Resources Institute (www.wri.org/our-work/project/better-buying-lab), that are already engaged in research and practice on both the production and consumer end of beef supply chains. As evident in the discussions by the experts, I note that engaging in this space will require careful and strategic consideration including the balancing of competing goals. However, if the conservation sector is to truly make inroads in achieving outcomes, then this is the kind of problem that the research community must engage in, notwithstanding that it is a difficult and contested space.

Limitations
This study focussed on beef consumption in the USA. While it is likely that these interventions can be applied to other contexts, some may be inappropriate for other nations with high beef consumption and thus should be considered and tested in multiple contexts (Graça 2016). It’s also likely that some interventions may have been overlooked, so the study should not be viewed as a complete list. Repeating this process with different experts may uncover additional interventions. While I found the policy Delphi to be an effective tool for rapidly generating a list of potential interventions and understanding the challenges in implementing them, experts tended not to engage with interventions for which only minimal background information was provided, thereby potentially favouring interventions that were described in greater detail. Additionally, the suggested interventions differed in specificity and scale and as a result received different types of criticism, potentially resulting in inconsistent comparisons of interventions.

Conclusions
Even with production efficiency gains there are no scenarios under which the world’s population can live within our planetary boundaries on a US-level of beef consumption (Bowles, Alexander & Hadjikakou 2019). Understanding and reducing the drivers of beef consumption potentially offers a more effective, longer-term strategy (Poore & Nemecek 2018). I have demonstrated a method for eliciting a diversity of potentially impactful and feasible behaviour change strategies for reducing beef consumption, a behaviour prioritised for change because of its significant impact on biodiversity and global GHG emissions. The policy Delphi employed here revealed a diverse range of interventions required for tackling an
entrenched behaviour like beef consumption. For the foreseeable future, beef consumption will not be eliminated, but there are solutions available to bring it to levels that will effectively reduce our impact on biodiversity and the climate.
Acknowledgements

Thank you to the expert participants for their time and knowledge devoted to this research and to the SWARM Expert Elicitation Platform team (https://www.swarmproject.info/) for hosting the elicitation and assistance. The manuscript benefited from the comments of three anonymous reviewers and the editors. This research was supported by S.A.B.’s ARC Future Fellowship. M.J.S., G.E.G. and A.M.K. are in part funded by the Australian Government’s National Environmental Science Program Threatened Species Recovery Hub.
The work presented in Chapter 5 is an edited version of a paper in preparation:

Abstract
Recently, there have been calls for greater use of prediction in ecological and other environmental sciences. These calls have generally neglected predicting human behaviour, which is arguably the greatest source of uncertainty in these systems. Predicting human behaviours can increase understanding of environmental systems, foresee future challenges and assist in ex-ante evaluation of policy and practice interventions. While predicting human behaviour is challenging, I demonstrate in a systematic review of the environmental literature, that it is increasingly undertaken. I reviewed 253 papers that purported to predict, forecast, project or simulate human behaviours. I find that a large number of methods are being used, but they rely on quite different interpretations of prediction itself, with less than half of studies reviewed including an anticipatory prediction. Psychological theories and measures (30.8%) and agent-based modelling (22.1%) were the most commonly used methods in the reviewed studies. Papers that set out clear policy and practice implications of the research made up only 17.0% of studies reviewed. Predictions of human behaviour were undertaken at a variety of social scales, with most focussing on individual, rather than collective behaviours. While the uncertainty in such predictions is likely to be substantial, it is not always taken into account and there is a general lack of evaluation of the predictions. Most studies did not evaluate their predictions yet provided recommendations for policy and practice. Standardising reporting and transparency practices across research predicting human behaviour in the environmental disciplines could increase the accessibility of these predictions to stakeholders, generating trust among those using the models or predictions in decision-making. I call for substantial research effort to build the capacity to make robust, defensible recommendations about human behaviour in environmental systems that are relevant to policy and practice.
5.1 Introduction

Improving predictions of human behaviour is critical for environmental and conservation management for two reasons. First, many of the processes that drive environmental change are fundamentally human induced, and a predominant source of uncertainty in environmental systems comes from people (Fulton et al. 2011). Reducing this uncertainty would itself facilitate better environmental decision-making (Maris et al. 2018). Second, being able to predict how people are likely to respond to different interventions—e.g., campaigns to reduce energy and water use, improve waste management, climate change mitigation, and the conservation of biodiversity and ecosystem services (Ludwig, Hilborn & Walters 1993; Steg & Vlek 2009; Selinske et al. 2018)—would facilitate more targeted and efficient use of limited resources (Liu et al. 2007; Travers et al. 2019; Liu 2001; Milner-Gulland 2011).

In other disciplines outside social-environmental research, a broad spectrum of tools and approaches are applied to predict human behaviour, including both quantitative models (e.g. agent-based modelling; choice modelling), and qualitative predictions (such as stakeholder elicited scenario analyses and conceptual models). The increasing power of these predictive methods and tools is a result of increased data availability, greater sophistication of tools and computational ability (Hofman, Sharma & Watts 2017). For instance, agent-based modelling is now commonly used to predict patterns of movement in and out of buildings or cities and informing policies such as fire evacuation (Singh & Padgham 2017). Furthermore sentiment analysis of social media can predict changes in the stock market (Bollen, Mao & Zeng 2011) and prediction of daily travel, emailing, and phone patterns are found to be reliable based on big data analyses (Barabási 2005; González, Hidalgo & Barabási 2008; Kosinski, Stillwell & Graepel 2013). Additionally, predictive analytics are employed in marketing, crime policing and, as recently seen in the 2016 US elections and Brexit Vote, by campaigns to engage voters and drive turnout (Hall, Tinati & Jennings 2018).

Given increased use in other research fields, it is useful to know how methods that predict human behaviour are being used in the social-environmental disciplines and for what purposes, and to examine how this line of research could be further developed to benefit environmental decision-making. In this review, I document a) existing use of predictive tools for modelling the social and behavioural components of social-environmental systems, b) highlight disciplinary differences in the use of tools, and more generally in their understanding of the
role of prediction and uncertainty, and c) discuss the strengths and limitations of different tools in the context of predicting human behaviour for environmental decision making. Previous reviews of different tools for predicting human behaviour exist. Some reviews focus on a specific subset of tools such as agent-based modelling (e.g. An 2012; Müller-Hansen et al. 2017). Verburg et al. (2016) reviewed types of models used to represent complex social-environmental conditions of the Anthropocene, but did not employ a systematic approach to curating the literature. In this review, I take a systematic approach to the search, summary and analysis of the predictive tools currently being used to incorporate human behaviour in environmental decision-making, not only across categories of tools, but also across disciplines and across different conceptual understandings of prediction.

The role of prediction in social-environmental decision making

Predictive modelling tools are often applied to the environmental components of social-environmental systems (e.g. hydrological [Quinn et al. 1991; Maier et al. 2010], climate [IPCC 2018], agriculture [Paini et al. 2016], ecological [Guisan & Zimmermann 2000; Haddon 2010]) and policymakers are now generally familiar and accepting of such predictive tools (Schmolke et al. 2010; Verburg et al. 2016; Dietze & Lynch 2019). However, the use of equivalent tools for predicting the social and behavioural components of social-environmental systems is much less widespread (Milner-Gulland 2011; Travers et al. 2019). One exception to this is land-use-change (LUC) and coupled human and natural systems (CHANS) research, where human behaviour is incorporated into coupled models approaches such as bioeconomic modelling, agent-based modelling or systems dynamic models (Liu et al. 2007; Anderies 2014; Janssen & Ostrom 2006). Such research predominantly investigates the consequences of policy interventions or other exogenous changes, such as climate change, by examining the behavioural responses to system disturbances, the impact on managed natural resources and subsequent feedback to human behaviours (Schlüter et al. 2012). These cases represent only a subset of the literature as there are other disciplines whose main purpose is to develop theory and understanding of how human behaviour impacts the environment.

Environmental psychology is one such field (Stedman 2002); behavioural economics is another. Many disciplines contribute both to our understanding of human behaviour and to evidence-based decision-making and policy (Game et al. 2018). This review spans all relevant disciplines. Adding further complexity is the fact that the use of the term ‘prediction’, and the
scope of the underlying concept is itself different across disciplines. The multiple disciplinary approach used in this review highlights both the range and diversity of predictive tools in use, and fundamentally challenges how we think about prediction and uncertainty (Ascough et al. 2008)

What is prediction? Multidisciplinary interpretations
Prediction as a term that encompasses multiple interpretations, is sometimes used interchangeably or without clarity in research and practice, creating ambiguity among the types of predictions made (Sarewitz & Pielke 1999; Shmueli 2010). While some interpret prediction to be a prospective investigation of a past, present, or future occurrence, with some associated certainty (Hyndman & Athanasopoulos 2018), others view prediction as a definite statement of a future event (Silver 2012). Prediction is also used to describe hypothesis testing of causal mechanisms (Douglas 2009) and scientific explanation (Yarkoni & Westfall 2013; Shmueli 2010). The differentiation between explanation and prediction may depend on the disciplinary and epistemological identity of the researcher (Douglas 2009; Maris et al. 2018).

Recently, calls for greater use of prediction in the environmental sciences (Mouquet et al. 2015; Brudvig 2017; Houlahan et al. 2017; Wood, Stillman & Hilton 2018; Lindenmayer 2018; Dietze 2017), have also led to appeals to be more explicit in what types of predictions are being made (Maris et al. 2018). Mouquet et al. (2015) and Maris et al. (2018) categorised prediction into two groupings: 1) anticipatory predictions which explore possible futures and are temporally unconstrained; and 2) explanatory predictions that contribute to causal or mechanistic understandings of the world.

Anticipatory predictions use methods that focus on predicting future events such as projections, forecasts and foresight tools (scenario analysis, horizon scanning) are underpinned by different assumptions and certainty. Projections have been defined as estimates of the future based on business-as-usual trends, whereas a forecast is a probabilistic depiction of the future aimed at accurate prediction (IPCC 2018). Foresight tools and scenario analyses offer quantitative and qualitative estimations of future values based on knowledge of an existing system (Kelly et al. 2013). Additionally, there are multiple types of methods and data sources that contribute to specific types of predictions. For instance, methods that
contribute to forecasting include predictions based on expert judgments, time series regression models and machine learning algorithms (Hyndman & Athanasopoulos 2018).

Historically, social sciences have tended to focus on *explanatory predictions* such as behavioural causal mechanisms, rather than prediction of future events (Hofman, Sharma & Watts 2017). While this may not necessarily predict a future event, it can be used to test a causal mechanism, provide mechanistic understanding of a behaviour, or infer the prevalence of a behaviour in a population. Recently, Yarkoni & Westfall (2013) and Hofman et al. (2017) have called for an increased focus on anticipatory prediction and less reliance on explanatory prediction in the social sciences, arguing that high explanatory power does not necessarily influence predictive ability.

Below I present the methods used to undertake the systematic search and analysis. In the results I describe the existing use of predictive tools for modelling the social and behavioural components of social-environmental systems, highlight disciplinary differences in the use of such tools, and more generally in their understanding of the role of prediction and uncertainty, including predispositions towards either anticipatory or explanatory prediction. I point to specific limitations in some areas and recommend the integration of tools and approaches and the evaluation of predictions for improving environmental decision-making relevancy.

**5.2 Methods**

I carried out a systematic review of literature published from 2005 to 2017. I developed a review protocol in accordance with published systematic literature review guidelines to ensure comprehensive coverage of predictive approaches in journal articles (Moher et al. 2009; Figure C1). The Web of Science literature database (http://www.webofknowledge.com/) was searched for the following terms:

- TOPIC: (conservation OR environment* OR "natural resource*"") AND
- TOPIC: (predict* OR forecast* OR model* OR project* OR simulat*) AND
- TOPIC: ("human behavio*" OR "behavio* change" OR "human decision making" OR "soci*-economic system*" OR "soci*-ecological system*"")

The literature search returned 3426 articles. Through a title and abstract review 572 were determined to be potentially relevant to the review subject, that is they made attempts to
predict behaviour relevant to a social-environmental system or decision. Criteria for inclusions included: 1) the article was related to an environmental issue, 2) the article incorporated a predictive approach and 3) the article was empirical peer-reviewed research with a quantitative or qualitative data set. I documented published research reviews but did not include them in the analysis. As a result, I reviewed 253 published research articles across 112 journal titles, in 44 disciplines.

Each paper was analysed according to predetermined questions (Table C1) and information collected from each paper was coded into a spreadsheet. Double coding was used to calibrate answers and arrive at consensus among the three authors for the first 20 papers reviewed. Points of disagreement were discussed and resolved among the three authors and clear instructions were set for the remaining papers, which were reviewed by one author (MJS).

**Coding environmental systems and decisions**

I used the International Union for Conservation of Nature threat typology (Salafsky et al. 2008) to categorise environmental threats the journal articles were addressing, with additional categories accounting for studies predicting general environmental behaviours, green consumer behaviour, energy consumption, and environmental activism.

**Coding prediction categories**

Articles were classified as making ‘explanatory predictions’ if they were a) testing hypotheses with inferential statistics, b) examining the influence of predictors on behavioural outcomes or c) isolating a causal mechanism of a behavioural outcome. Separating these from descriptive papers required subjective judgement, but there were few purely descriptive papers in this literature. Articles were classified as including ‘anticipatory predictions’ if they a) explicitly discussed predicting a future outcome, b) reported cross-validation for their prediction, or c) relied on longitudinal data and used time steps. Again, separating these papers from explanatory prediction articles required subjective judgement. I also classified papers by their treatment of uncertainty, that is, whether they employed sensitivity analyses, multiple scenarios, multiple models, Monte Carlo simulations or others. Here my judgements were informed by Polasky et al. (2011); Refsgaard et al. (2007) which have previously examined uncertainty in the context of environmental decision-making. Additionally, I coded whether or not an article was attempting to explicitly influence policy and practice, which might be viewed
as entailing a predictive inference. If a paper listed recommendations or devoted a section of discussion to policy or decision implications of the results, it was classified as entailing a predictive inference designed to impact on policy.

5.3 Results

Types of predictive tools, and their role in explaining and anticipating human behaviour

I found 13 broad categories of predictive tools (see Table 5.1; Figure 5.1). I also found an increase in the use of predictive tools over time (Figure 5.2), with 76% of cases occurring in the final 4 years of my 12-year sample (i.e., 2013-2017). Psychological theories (including the theory of planned behaviour [Ajzen 1991]) were the most commonly used predictive tool (employed in 31% of the sample articles). Agent-based models were the second most common method, used in 20% of the sample. Almost half of all articles (49%) combined two or more types of predictive methods. Agent-based models in particular were often paired with other tools. For example, the theory of planned behaviour to understand diffusion of energy reduction behaviours (Berglund 2015), and decision trees used to predict membership of a conservation program (Sengupta et al. 2005).

![Figure 5.1 The percentage of reviewed articles per predictive method category (n = 253).](image)

Articles were roughly evenly split between explanatory (45%) and anticipatory prediction (48%). The remaining 7% of articles appeared to include both explanatory and anticipatory predictive methods. The vast majority (73%) of explanatory articles came from the
psychology literature, where researchers rely on established psychological theories (e.g. theory of planned behaviour) for prediction. Others employed choice modelling, fuzzy cognitive models and controlled experimental designs to study behavioural outcomes. Anticipatory methods generally included agent-based modelling and scenario analysis. There are sharp disciplinary divides here—for example, nearly three quarters of explanatory articles were found in the psychology literature—hinting at very different disciplinary uses of the term, if not different understandings of the concept of prediction.

Figure 5.2 The frequency of predictive studies per year from 2005 to 2017 (n = 253).

Predicting: which behaviours, in what context?
Most studies were focussed on predicting human behaviours in contexts related to either biological resource use (24.4%), agriculture and aquaculture (21.4%) or energy consumption (10.5%) (Figure 5.3). The predicted behaviours in the reviewed literature span diverse types of environmental behaviours and multiple scales. These were most commonly the antecedents of behaviours or behavioural intentions such as psychological or socio-economic predictors (Nelson, McHale & Peterson 2012; Qin & Flint 2010; Werner et al. 2017). Many of the agent-based modelling papers predicted changes in human behaviour as a result of policy scenarios (incentives or regulation) (Chen et al. 2012), exogenous disturbances such as climatic changes (Pérez, Janssen & Anderies 2016; Rebaudo & Dangles 2013) or both (Murray-Rust et al. 2014). Some papers did not specifically predict human behaviour but the processes of collective human behaviour such as land use changes. For example, Sharma et al. (2006) used cellular automata in combination with multiple stakeholder-developed sustainable agriculture
scenarios to spatially project future land uses. Other studies predicted adaptive behaviours, like agricultural shifts as a result of climate change, by integrating an agricultural utility model with climate change projections (Estes et al. 2014), or using a gravity model to predict climate change induced migration of people (Mastrorillo et al. 2016).

![Figure 5.3 Percentage of articles addressing categories of environmental issues. Categorisation followed Salafsky et al. (2008), with additional categories of civic engagement, general behaviours (as typified in the general pro-environment behaviour scale [Schultz & Zelezny, 1999]), green consumerism, and pay for conservation (n = 253).](image)

**Scale of prediction**

I found that the scales of predictions varied temporally and socially (Figure 5.4). Studies that predicted individual behaviours were the most common (44.7%), while those predicting household or business behaviours accounted for 7.8% of behaviours. Aggregated, higher-level social scale models accounted for 32.7% of papers. Of those papers, community behaviours accounted for 12.7%, and 20.0% modelled regional or societal-level behaviour. Some studies spanned multiple social scales (14.8%), with feedbacks between local-scale social dynamics and societal changes. Of those that spanned two or more social scales, 33.3% included systems dynamics modelling, a modelling technique adept at simulating feedback between different scales. For example, Sigdel et al. (2017) used a behavioural model consisting of an opinion dynamics model situated in a systems dynamics model of an agri-environmental system to demonstrate responses to a series of potential policies.
Of the papers using anticipatory approaches, predictions spanned multiple time scales. Many anticipatory studies did not explicitly state the length of the temporal predictions. Multiple studies incorporating scenarios focused on 20-40 year timelines which, given the dynamism of social systems, is likely the outer limit of what is reasonable (Hawkins & Sutton 2009; Mullon et al. 2016). One study predicting global flight demand through the use of a choice model, time series data and a CGE model, made predictions 100 years into the future (Mittal et al. 2017).

Figure 5.4 The percentage of articles undertaking analyses focused on different social scales, from individual to societal/regional levels.

Uncertainty related to predicting human behaviour

Uncertainty was described and measured differently depending on the approach or tool used. A surprisingly high proportion of articles (15.4%) neglected to report any uncertainty measures. Many of these were reporting qualitative conceptual models (Ajit Prabhu et al. 2013; Mosimane et al. 2014) with few standard practices to account for uncertainty. As is convention, standard error and/or confidence intervals were reported in studies using psychological theory and measures, experimental controlled research and those studies running socio-economic data correlations (43.1%). I found that 39.2% of all studies used multiple scenarios to incorporate uncertainty, and 29.2% used sensitivity analysis (Figure 5.5). Of those that used probabilistic methods, 6.4% employed a Monte Carlo simulation approach and 3.5% used a Bayesian approach. Studies that treated uncertainty with multiple
methods made up 5.8% studies reviewed. Of agent-based modelling and cellular automata studies, 9.3% incorporated average runs. One study used likelihood statements from stakeholders as an uncertainty treatment (Capitani et al. 2016).

Figure 5.5 Percentage of articles treating uncertainty by method category (n = 214)

How were predictions evaluated?
Like methods of accounting for uncertainty, the way predictions were evaluated also varied with prediction tool type. Tools such as regression models and machine learning algorithms use cross-validation methods, testing the model’s generalisability to new data, to determine predictive ability. In this review only four studies reported using cross-validation by partitioning datasets or testing models on out of sample data; two were psychological studies that used regression models to examine predictors of environmental behaviours and two were analyses that incorporated a machine learning tool (e.g. decision trees and artificial neural networks) (Peterson, Chen & Liu 2008; Poortinga & Darnton 2016; Stephen et al. 2017). In anticipatory methods, particularly in agent-based modelling, a somewhat broader range of evaluation tools were employed, such as stakeholder validation and expert evaluation.

Prediction for decision and policy making
Papers that set out clear policy and practice implications of the research made up only 17.0% of studies reviewed. A further 50.8% of papers provided what might be considered general recommendations, with the remaining 32.2% papers failing to include any recommendations. Amongst those that did not include explicit policy or practice recommendations, the majority
were focussed on methods development and/or demonstrating a proof of concept for future research. Of the 17% with explicit recommendations, 55.8% accounted for uncertainty in their study and 34.3% evaluated their predictions. This was slightly lower as those making general recommendations (46.5% of 129 articles).
Table 5.1 Predictive methods used in environmental research from 2005-2017, the percentage of the total they represent, their description, and key references derived from review

<table>
<thead>
<tr>
<th>Category of approach or tool</th>
<th>Description</th>
<th>Key References</th>
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<tbody>
<tr>
<td>Psychological models and measures</td>
<td>These methods include psychological behavioural models (e.g. Theory of Planned Behaviour, Value-Belief-Norms Model, models of bounded rationality, predictors of behaviours such as values, attitudes or socio-demographic characteristics, and psychographic market segmentation.)</td>
<td>Macovei (2015); Oreg &amp; Katz-Gerro (2006); Arnocky, Stroink &amp; Decicco (2007); Marchini &amp; Macdonald (2012); Drake et al. (2014)</td>
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<tr>
<td>Agent-based models</td>
<td>Agent-based models (individual-based models in ecology) are computational model in which simulated agents learn from their environment and interactions with other agents. Used in a variety of environmental challenges including land-use change, recycling programs and socio-hydrological systems. Generally underpinned by behavioural models that are utility-, cognitive- or rule-based based on bounded rationality.</td>
<td>An (2012); Schlüter et al. (2017); Schulze et al. (2017); D. Murray-Rust et al. (2014)</td>
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<tr>
<td>Foresight methods</td>
<td>Foresight methods include horizon scanning, projections, scenario analysis and backcasting. A structured method for identifying trends or exploring trade-offs in achieving desirable futures in the face of uncertainty. Generally qualitative. Anticipatory, but more exploratory and not necessarily predictive. Often informed by multiple tools such as quantitative modelling to examine a range of plausible futures.</td>
<td>Bengston, Kubik &amp; Bishop (2012); Cook et al. (2014); Davies, Mees &amp; Milner-Gulland (2015)</td>
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<tr>
<td>Systems dynamics</td>
<td>Systems dynamics methods include causal loop diagrams, stock and flow diagrams and system dynamics/simulation models. Model causal relationships based on feedback between system components and subsystems. Methods related to graph theory tools (see below).</td>
<td>Cumming et al. (2005); Nancarrow, Bates &amp; Bishop (2007); Lafuite, de Mazancourt &amp; Loreau (2017)</td>
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<tr>
<td>Models of Rational Choice</td>
<td>Rational choice models include utility maximisation model, optimal foraging model, and game theoretical modelling. Provides rules of logic in which to understand self-interested decision-making. Used to model common pool resource dilemmas such as land use or carbon trading.</td>
<td>Taher, Dinar &amp; Albiac (2016); Lennox et al. (2013); Bertrand et al. (2007)</td>
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<td>Category</td>
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<td><strong>Graph theory</strong></td>
<td>Graph theory methods include network analysis and fuzzy cognitive mapping. These tools visualise how different variables in a system are interrelated. Nodes represent the variables and edges are the links that represent a connection or a relation between the two variables. Determine causal relationships, mainly explanatory. Some representations allow for feedback.</td>
<td>Huber et al. (2013); Gray et al. (2012); Nyaki et al. (2014); Murungweni et al. (2011)</td>
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<tr>
<td><strong>Psychological and economic behavioural experiments</strong></td>
<td>Includes both experimental and quasi-experimental methods to test and measure behavioural responses to an intervention or predict behaviour based on theory.</td>
<td>Bolsen, Ferraro &amp; Miranda (2014); Gaker et al. (2011); McAllister et al. (2011)</td>
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<tr>
<td><strong>Social-ecological structured decision-making frameworks</strong></td>
<td>Social-ecological frameworks such as resilience theory, management strategy evaluation, adaptive management, and Press-Pulse Dynamics, used to develop conceptual models of the dynamics within environmental systems. Applied in conjunction with predictive tools to understand influences on behavioural outcomes within these systems.</td>
<td>Langmead et al. (2009); Bunnefeld, Hoshino &amp; Milner-Gulland (2011); Dawson et al. (2010)</td>
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<tr>
<td><strong>Social-economic predictors</strong></td>
<td>Used to test influences of management decisions, drivers of environmental change on behaviours. Generally characterised by large datasets of socio-economic including cultural variables, modelled by regression analyses.</td>
<td>Nautiyal &amp; Kaechele (2008); de Lange et al. (2010)</td>
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<tr>
<td><strong>Qualitative models</strong></td>
<td>Cognitive mapping, mental models, conceptual models. Mental frameworks to interpret individual and groups of stakeholder’s knowledge, thinking, and understanding of the world.</td>
<td>Mosimane et al. (2014); Gray et al. (2012); Elsawah et al. (2015)</td>
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<tr>
<td><strong>Expert and stakeholder elicitation</strong></td>
<td>Structured elicitation methods including Delphi process seeking consensus and Bayesian methods to capture the uncertainty between individual expert opinions. These methods derive qualitative or probabilistic judgements of future events or states.</td>
<td>Kohler et al. (2017); Capitani et al. (2016); Dave Murray-Rust et al. (2014); Schmitt &amp; Brugere (2013)</td>
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<tr>
<td><strong>Bayesian Belief Networks</strong></td>
<td>Probabilistic modelling approach that uses multiple types of data (quantitative and qualitative) to create a network of linked nodes and demonstrate causal relationships. Each node represents a key process and links provide a graphical representation of causal relationships between nodes.</td>
<td>Carmona, Varela-Ortega &amp; Bromley (2013; Ticehurst, Curtis &amp; Merritt (2011); Keshavarz &amp; Karami (2016)</td>
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<tr>
<td>Method</td>
<td>Number of papers</td>
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<tr>
<td><strong>Machine learning</strong></td>
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<td><strong>Choice models</strong></td>
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<td>3.2%</td>
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<td><strong>Behavioural games</strong></td>
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<td>3.2%</td>
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<tr>
<td><strong>Monte Carlo simulations</strong></td>
<td>7</td>
<td>2.8%</td>
</tr>
<tr>
<td><strong>Bioeconomic modelling</strong></td>
<td>7</td>
<td>2.8%</td>
</tr>
<tr>
<td><strong>Cellular automata</strong></td>
<td>2</td>
<td>0.8%</td>
</tr>
</tbody>
</table>
5.4 Discussion

The systematic review presented here demonstrates that a diverse set of predictive tools are used to aid environmental decision-making. I documented a broad range of environmental and sustainability concerns that predictive tools are currently employed to address, across diverse social and temporal scales. I found the use of both anticipatory and explanatory prediction methods increasing in recent years (Figures 5.1, 5.2).

Less than half of all studies reviewed included an anticipatory prediction. Whilst there are certainly research questions where explanatory approaches alone are fit for purpose, for many applied problems aiming to influence policy and management practice, this is very unlikely to be the case. Such cases do indeed constitute a non-trivial proportion of this literature (17.0% of reviewed papers made explicit policy and practice recommendations, and a further 50.8% made general recommendations). Hence, anticipatory prediction should be a focus of future research effort.

There have been strong arguments for integrated approaches—that is, the combined and complementary use of explanatory and anticipatory prediction—made elsewhere in the literature (Schoemaker 1991; IPBES 2016). Increasing interdisciplinary collaborations between psychology, artificial intelligence including both machine learning and agent-based models, and environmental science researchers would be one pathway to achieving a more integrated approach. This is also likely to improve the ecological validity and policy relevance of research outcomes from the environmental sciences.

Systematically accounting for the different types of uncertainty and evaluating predictions is critical (Milner-Gulland & Shea 2017; Schmolke et al. 2010) but many of the reviewed studies were limited by their lack of evaluation and, for some, accounting for uncertainty. It is surprising that so many of the papers provided either in-depth or general recommendations for policy and practice yet did not evaluate their prediction. It was particularly surprising that two of the four machine learning methods did not report evaluations of their predictions through cross-validation, a standard approach for assessing predictive power in machine learning and in regression analyses (Bennett et al. 2013). Implementing evaluation methods for models and scenarios can be challenging, but this is a necessary element to increase relevancy to decision-making. Mainstreaming evaluation approaches should therefore be a key priority.
Methods developed in the anticipatory space expand the scope of evaluation or validation techniques beyond those typically used in the explanatory space. For example, agent-based modellers often explore uncertainty and evaluate predictions using probabilistic approaches, multiple scenarios, and stakeholder validation (e.g. Overview Design and Development protocol [ODD] [Grimm et al. 2006]; ODD+ [Müller et al. 2013]; transparent and comprehensive model evaluation [TRACE] [Grimm et al. 2014]). This generates a transparent research process by outlining the subjective decisions made during the modelling process, the type of behavioural model used (e.g. bounded rationality, rules-based, or psychological), how uncertainty is treated, and the evaluation techniques used. It also provides benchmarks for non-experts to evaluate this research (Schulze et al. 2017).

Standardising reporting and transparency practices across research predicting human behaviour in the environmental disciplines could increase the accessibility of these predictions to stakeholders, generating trust among those using the models or predictions in decision-making (Schmolke et al. 2010; Cartwright et al. 2016). A further step towards transparency and evaluation would be to design metrics to compare across studies and over time, allowing for a more iterative approach testing the predictions with out of sample data sets and evaluating their performance (Dietze & Lynch 2019; Schulze et al. 2017; Hofman, Sharma & Watts 2017). This could be an important development in this field and reiterates previous suggestions that behavioural predictions be preregistered with sites such as the Open Science Framework (https://osf.io/) (Hofman, Sharma & Watts 2017).

Two key approaches to prediction were absent in the sample: sentiment analysis and crowd sourcing. Environmental disciplines are only beginning to engage with sentiment analysis (Ladle et al. 2016) but it has potential to predict behavioural outcomes for awareness campaigns or foresee emerging behavioural challenges. With large data sets of behavioural and demographic information now available, the absence of its use was somewhat surprising. As social systems become further entwined, the uses of social media data, large data sets and predictive analytics to predict online and behaviour in real life will likely become more prevalent in the field. Crowd sourcing (or crowd intelligence/elicitation) is another approach that has demonstrated its value to prediction of events and to explore potential futures, but has not as yet been utilised in the environmental sciences (Malone & Klein 2007).
Ethical implications of prediction

While predicting human behaviour is critical for robust environmental decision-making, ethical dilemmas relating to the implementation of this practice abound. Capitalising on insights about human behaviour to inform policies and decisions will become increasingly important, but it doesn’t take much to imagine ethically dubious extensions, such as predictive policing to identify ‘potential’ criminal activity (Perry 2013). The use of predictive policing that analytically identifies likely individuals or locations of high crime-risk has been shown to be effective at controlling crime, yet it can be perceived as profiling, or justice without due process, and potentially hardwiring the previous biases of the system (Zwitter 2014). Additionally, there is growing focus on using cognitive biases to predict behaviours and design interventions. Navigating the ethics of ‘nudging’ is potentially challenging (see for example Raihani, (2013). Sunstein (2015) recommends awareness of welfare, autonomy and dignity to avoid the risk of unethical manipulation, but also reason that it’s pointless to completely object to these approaches; policies and interventions influence people’s decisions whether explicitly designed to or not. I argue here that it’s better to anticipate the human behaviours likely to impact on the success or failure of environmental interventions and be adequately transparent about those predictions to allow public scrutiny as an important safeguard.

Conclusions

While there are many calls for increased use of prediction in understanding and managing social-behavioural systems (Mouquet et al. 2015; Brudvig 2017; Houlahan et al. 2017; Wood, Stillman & Hilton 2018; Lindenmayer 2018), few have focussed on the application of those tools in predicting the behavioural components of those systems (Travers et al. 2019). If we are to meet the challenges and properly account for human behaviour in these systems, we need to build capacity and collaborations that integrate predictions into environmental management and decision-making (IPBES 2016). This review has been a first step in taking stock of where the environmental disciplines are situated in terms of meeting this challenge and highlighting the gaps in current practice to guide our next steps. Based on the results of the review it seems the field still has a long way to go with respect to building the capacity to make robust recommendations that are relevant to policy and practice.
6 Locating financial incentives among diverse motivations for long-term private land conservation

A version of this chapter has been published in Ecology and Society as:
Abstract

A variety of policy instruments are used to promote the conservation of biodiversity on private land. These instruments are often employed in unison to encourage land stewardship beneficial for biodiversity across a broad range of program types, but questions remain about which instruments are the appropriate tools when seeking long-term change to land-management practice. Drawing on three case studies, two in Australia and one in South Africa, spanning various program types—a biodiverse carbon planting scheme, a covenanting program, and a voluntary stewardship program—I investigate the importance of financial incentives and other mechanisms from the landholder’s perspective. From participant interviews I find that landholders have preconceived notions of stewardship ethics. Motivations to enrol into a private land conservation program are not necessarily what drives ongoing participation, and continued delivery of multiple mechanisms will likely ensure long-term landholder engagement. Financial incentives are beneficial in lowering uptake costs to landholders but building landholder capacity, management assistance, linking participants to a network of conservation landholders, and recognition of conservation efforts may be more successful in fostering long-term biodiversity stewardship. Furthermore, I argue that diverse, multiple instrument approaches are needed to provide the flexibility required for dynamic, adaptive policy responses. I raise a number of key considerations for conservation organisations regarding the appropriate mix of financial and nonfinancial components of their programs to address long-term conservation objectives.
6.1 Introduction

A primary aim of private land conservation (PLC) programs is to motivate landholders toward preservation, active management, restoration, and sustainable utilisation of private lands to support biodiversity and landscape conservation (Stern 2006). Conserving biodiversity on private lands depends not only on protection but also long-term management (Naidoo et al. 2006). As such PLC programs must not only consider initial landholder uptake but also how the program fosters and sustains landholder stewardship through time (Greiner & Gregg 2011). Land stewardship, which has been documented among rural landholders for decades (Leopold 1949), is the set of ideas and practices that landholders use to manage their properties for long-term public and private benefits (Worrell & Appleby 2000), capturing the desire to conserve biodiversity as well as to act as custodian of production landscapes (Gill et al. 2010). Encapsulated within stewardship is the notion of legacy: an aspiration to improve or maintain the condition of the land for the benefit of future landholders. The long-term stewardship motives of landholders align with a range of different instruments for PLC, including management assistance, permanent protection, recognition, social learning, and financial incentives (Gunningham & Young 1997).

The instruments supporting PLC are often used in conjunction, providing different mechanisms to increase program participation among landholders, while meeting multiple objectives. Optimally, a mix of instruments will be implemented by different organisations at multiple governance levels within the same conservation and geographic space, acting in concert to protect biodiversity on private lands (Young and Gunningham 1996). Because the social-ecological settings of private lands are complex, programs must accommodate their inherent dynamism by carefully selecting and employing a complementary mix of instruments (Stirling 2010).

Financial incentives compensate landholders for the costs associated with land management or opportunity costs, reducing impediments to program uptake (Pannell & Wilkinson 2009). In a variety of economic contexts, the use of financial incentives operates under the assumption that people will shift more readily and effectively toward pro-environmental behaviour when a fiscal inducement is offered (Farrier 1995). However, while financial incentives are at times instrumental to securing a PLC agreement (Moon & Cocklin 2011) and short-term shifts in land management have been documented (Kay et al. 2013), it remains unclear what specific
role financial incentives play in engendering a long-term stewardship perspective, given the complex array of nonfinancial motivations that constitute stewardship (Reimer et al. 2012).

Currently, financial incentives are applied in various ways to promote proconservation land management. These include direct and indirect payments or reimbursements, aimed at inducing positive, or preventing negative, behaviour (Pannell 2008). Financial incentives are commonly used to remove perceived barriers to landholder participation, leveraging conservation action from individuals or communities lacking the interest or financial means to conserve or restore their land (Putten et al. 2011; Race & Curtis 2013).

Using insights from three PLC programs in Australia and South Africa that represent different types of financial incentives, i.e., carbon offset, reverse auction, and rates rebates (Table 6.1), I sought to explore how different types of financial incentives interact with the diversity of landholder’s motivations to participate in PLC and how they contribute to sustaining long-term commitment to PLC. Through investigation I highlight three key issues requiring critical attention if financial incentives are to be explicitly designed to improve PLC program effectiveness: (1) engaging landholders’ existing notions of stewardship, (2) applying financial incentives in a way that is attentive to securing long-term benefits, and (3) decentring financial incentives as the core mechanism in a broader mix of instruments. I then draw from these insights to argue that uncritical use of financial incentives risks disregarding the complexity of social-ecological systems (Li & Li 2012) including the diversity of participant motivations, expectations, and experiences (Moon & Cocklin 2011; Selinske et al. 2015). I also suggest that the positioning of financial incentives as the dominant approach potentially compromises the effectiveness of PLC programs, particularly through their lack of capacity to respond to the complexity, diversity, and dynamism of social-ecological systems (Muradian et al. 2013).

Reviewing the challenges for implementing financial incentives

Financial incentives have proven to be an attractive proposition for conservation organisations because they (a) increase participation rates (Ernst and Wallace 2008); (b) allocate funding in a quantifiable and verifiable way (Robins and Kanowski 2011); and (c) have the potential to deliver immediate outcomes, e.g., prevention of vegetation clearing (Binney et al. 2010). The use of financial incentives accords with the view that landholders should be compensated for the lost opportunities to pursue land uses that compromise nature,
in their provision of ecological benefits for the public good (Morrisette 2001). Perhaps most significantly, the advertised benefits of financial incentives are frequently set against the perceived failure or limitations of other approaches to PLC, namely regulatory instruments and persuasion efforts (Cocklin et al. 2007, Whitten et al. 2013). In this sense, the rise of financial incentives fits within a neoliberal framework for PLC and environmental policy more generally (e.g., Robertson 2004, Higgins et al. 2014).

To date, the development and evolution of financial incentives has centred on the “needs of the [funding] provider” (Sorice and Donlan 2015:788), with particular emphasis on reducing the implementation and transaction costs of PLC programs. This approach risks utilising financial incentives because of their perceived alignment with existing governance structures or mentalities, rather than their suitability to a specific on the ground context (Higgins et al. 2012, Cooke and Moon 2015). Accounting for context in program design is vital (Young et al. 1996); if financial incentives are applied without careful consideration, it is possible that the investment by conservation organisations in fostering stewardship may be jeopardised.
Table 6.1 Program attributes and study methods

<table>
<thead>
<tr>
<th>Location</th>
<th>Greenfleet Biodiverse carbon plantings</th>
<th>EcoTender</th>
<th>Biodiversity Stewardship Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Victoria, Australia</td>
<td>Victoria, Australia</td>
<td>Western Cape, South Africa</td>
</tr>
<tr>
<td>Landscape</td>
<td>Rural</td>
<td>Rural and peri-urban</td>
<td>Rural and peri-urban</td>
</tr>
<tr>
<td>Program Objectives</td>
<td>Encourage individuals and businesses to offset carbon emissions Plant native trees that contribute to biodiversity and carbon sequestration Provide habitat for native wildlife and enhance water quality, manage salinity and protect soils Supply trees at no cost to landowners</td>
<td>To provide opportunities by which private landholders are supported and rewarded as the suppliers of public environmental benefits To maximise the cost-efficiency of government investment in ecological services through a process of competitive bidding for environmental management funding between interested landholders To offer a financial incentive to participate in environmental management practices as a means for attracting a wider cross-section of landholders than persuasion/education-based voluntary environmental management programs</td>
<td>To ensure that privately owned areas with high biodiversity value receive secure conservation status and are linked to a network of other conservation areas in the landscape. To ensure that landowners who commit their property to a stewardship option, will enjoy tangible benefits for their conservation actions. To expand biodiversity conservation by encouraging commitment to, and implementation of, good biodiversity management practice, on privately owned land, in such a way that the private landowner becomes an empowered decision maker</td>
</tr>
<tr>
<td>Land use</td>
<td>Commercial, semi-commercial, and lifestyle farming</td>
<td>Rural-residential, lifestyle farming, bush block for conservation</td>
<td>Commercial, semi-commercial, lifestyle farming and rural residential</td>
</tr>
<tr>
<td>Program characteristics</td>
<td>100-year contracts, no direct payments, trees and labour paid for</td>
<td>Payments for ecosystem services and permanent conservation covenant</td>
<td>Short-term (5-10 year) voluntary agreements and long-term (30 – in perpetuity) legally binding contracts Reduced land tax incentive Partial reimbursement for management Stewardship officer visits</td>
</tr>
<tr>
<td>Research Methods</td>
<td>Qualitative 17 participants (37% of program total in Victoria) Semi-structured interviews Random sample of landholders Victoria</td>
<td>Qualitative 21 participants (~20% of program total) Semi-structured interviews Random sample of landholders Victoria</td>
<td>Qualitative 75 participants (85% of program total) Semi-structured interviews and online/mail survey</td>
</tr>
</tbody>
</table>
The fixed-term nature of some financial incentives highlights the danger of a mismatch between the length of time the PLC program runs and the time required to achieve on-ground conservation outcomes. Financial incentives can fundamentally change a landholder’s willingness to contribute to conservation activities, arguably a main benefit for governments implementing PLC programs (Rode et al. 2015). Direct payments can potentially increase the cost of conservation over time as landholders come to expect payments, seeing them as an entitlement, or creating dependencies, leading to questions over what happens if or when the incentives cease (Elmendorf 2003). Organisations must also account for both the immediate expenditure associated with financial incentives and the subsequent uncertainty of their investment for producing lasting biodiversity outcomes where political, economic, and climatic conditions may change, potentially compromising a program’s ecological, social, and/or cost-effectiveness (Rissman 2011, Mendham et al. 2012). Moreover, market-based instruments (MBI) and similar direct financial incentives that prominently feature in the financial aspect of the program may lack the dynamism required to cover rising opportunity costs, the need for social learning and knowledge sharing in a changeable social-ecological setting, or guaranteed funding for the long timelines suitable to landscape scale restoration and protection (Swart et al. 2003). In the face of these issues, clear questions remain about whether financial incentives are the appropriate tool when seeking long-term change to land-management practice.

6.2 Methods

Introduction to empirical case studies from Australia and South Africa

To illustrate the complex social-ecological interactions around PLC into which financial incentives are being introduced, I draw from empirical research in Australia and South Africa. The qualitative research from each case offers deep insights that clearly expose the need for diverse approaches to PLC. Exploring the detail and nuance of conservation efforts as they play out on the ground through interviews and participant observation provides a counterbalance to existing assumptions and predictions for how financial incentives and other instruments might operate. The studies from which I draw on all received ethics approval at the time the research took place.

Each case is defined by the implementation of a financial incentive program in a given geographical area. Case study research was pursued in all three instances because it encourages
an in-depth exploration and analysis of phenomena in a real-life context (Stake 1995). The commonality between cases in the way they are defined makes a combined approach to analysis appropriate in this instance. Additionally, questions asked by researchers of each case study were similar in nature (Table 6.2). During a one-day workshop the participants discussed each case study in detail identifying similar objectives of the research and common themes discovered in the results (George and Bennett 2005).

A key limitation of this research is that it is based on three case studies sharing similar private property rights characteristics, which may constrain its applicability beyond similar contexts. I am not seeking to generalise from the case studies, but to provide examples that illustrate the range and complexity of stewardship motivations to which financial incentives must be attentive.

Table 6.2 Case Study Questions

<table>
<thead>
<tr>
<th>EcoTender</th>
<th>Greenfleet</th>
<th>Biodiversity Stewardship Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>How did you come to decide that</td>
<td>What were your motivations for</td>
<td>Can you please list your reasons for entering the biodiversity</td>
</tr>
<tr>
<td>EcoTender would fit with your</td>
<td>participating?</td>
<td>stewardship programme?</td>
</tr>
<tr>
<td>conservation efforts?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What do you see as the major</td>
<td>How do you describe the benefits</td>
<td>How do you feel you benefit from being involved in the biodiversity</td>
</tr>
<tr>
<td>benefits of the EcoTender program?</td>
<td>of participating in Greenfleet?</td>
<td>stewardship programme?</td>
</tr>
<tr>
<td>What is one aspect of the</td>
<td>Are you satisfied with your current</td>
<td>Do you have any suggestions on how to improve the biodiversity</td>
</tr>
<tr>
<td>program you would change if you</td>
<td>agreement with Greenfleet?</td>
<td>stewardship programme?</td>
</tr>
<tr>
<td>could that you think would have</td>
<td></td>
<td></td>
</tr>
<tr>
<td>enhanced your experience of it?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What activities do you think you</td>
<td>How did you find managing/integrating new plantings with your usual</td>
<td></td>
</tr>
<tr>
<td>will continue when the program</td>
<td></td>
<td>business?</td>
</tr>
<tr>
<td>concludes?</td>
<td></td>
<td></td>
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</table>
Case studies

Greenfleet
Greenfleet is a not-for-profit organisation collaborating with landholders to plant multiple species of native trees on private lands throughout Australia to offset the greenhouse gas emissions of businesses and individuals. Although landholders do not receive direct financial incentives for participating, Greenfleet agrees to cover the costs of restoration, with landholders then obliged to manage the revegetated land for 100 years. Landholders were recruited through a posted invitation facilitated by Greenfleet. Interviews took place between January and September 2013 with 17 private landholders. In-depth, semi-structured interviews were used to obtain comprehensive data about peoples’ experiences, perceptions, and opinions. Interviews took one to two hours and included walking or driving around participants’ properties with them as the interview progressed. This enabled the interviewers to gain a grounded understanding of the landholder’s experiences with their carbon plantings. The interview questions asked pertained to landholder drivers to participate in a carbon offset, land management challenges, and critiques of the program.

Interviews were tape-recorded and transcribed verbatim. Data analysis was informed by a thematic approach that helps to discover and present the patterns found in the interviews (Braun and Clarke 2006, Saldaña 2009). Interview materials were coded line-by-line using an open coding technique in NVivo 10 qualitative analysis software (QSR International 2012, http://www.qsrinternational.com).

EcoTender
In this study, participants in the Victorian EcoTender Program (from eastern Victoria) were interviewed on their properties. EcoTender is a reverse auction tender program, run by the State of Victoria, requiring landholders to bid for funds to complete agreed conservation works on their land. The conservation agency then allocates funds to the bids that represent the best return on investment. Once landholders are selected to participate, the program contract runs for five years.

Landholders were recruited by an e-mail sent to all landholders in the case study region who had been successful with their EcoTender bid. The e-mail contained a summary of the research
Locating financial incentives among diverse motivations for long-term private land conservation

objectives and central research questions of interest (captured in Table 6.2), with interested landholders contacting the researcher to participate. Property visits took place in 2010 (seven interviews) and 2016 (15 interviews) as part of an ongoing study of PLC program participation in Victoria. In-depth, semi-structured interviews were held with landholders, followed by the interviewer walking the participants’ property with them (in a similar manner to the Greenfleet study). The intention of the interviewer was to acknowledge that the landscape serves as a repository of memory when people have a strong attachment to place, which allowed participant perspectives on program participation to be linked closely with on-ground activities (Strang 2010). Research questions focussed on how landholders’ environmental management practices emerged and developed over time, and the way PLC programs shaped, or were shaped by, landholder conservation motivations and practice. Interviews and notes from the property walks were transcribed and coded using an open thematic coding approach, which groups together passages with common ideas and perspectives to build a substantive thematic structure around a shared idea (Saldaña 2009). The NVivo software package was used to facilitate the coding. Emergent themes were discussed in detail and presented to colleagues for critical reflection and discussion as the research progressed.

Biodiversity Stewardship Program

Since 2003, South Africa has worked toward meeting national protected area and critical biodiversity targets through the Biodiversity Stewardship Program (BSP), a PLC initiative. Although coordinated at the national level, the BSP is implemented at the provincial level. This research, conducted over nine months from July 2013 through to March 2014, assessed the motivations of landholders participating in the Western Cape province’s BSP, how these motivations and program implementation generated satisfaction or dissatisfaction with the program, and predicted the likelihood the landholder would remain in the BSP after a contract ended. These three factors were measured qualitatively through semi-structured interviews and by online or mailed surveys.

CapeNature, the Western Cape’s parastatal conservation agency, provided a list of all BSP landholders (88 households) who were then contacted by e-mail or phone. Initially, all landholders were sent an email or a mailed survey (Dillman et al. 2009) of which 35 landholders responded. An additional 40 were interviewed in person using the same protocol as the mailed surveys. On average, interviews took one to two hours to complete. If convenient
for the landholder, interviews took place while touring their land enrolled in the BSP. Questions focussed on the landholder’s relationship with the land and the BSP, motivations to participate in PLC, how the BSP could be improved, and land management goals. Responses were coded based on themes identified by a priori understanding of the program or those that emerged during analysis (Kitchin and Tate 2000, Braun and Clarke 2006). Coding themes centred on identifying landholder motivations to participate in the BSP, satisfaction with the program, and commitment to management objectives and remaining in the program. Recurrent themes were identified and interrogated with two coresearchers as part of the coding process. Additional insights into the BSP based on quantitative methodology were reported in Selinske et al. 2015.

Table 6.3 Socio-demographics of program participants.

<table>
<thead>
<tr>
<th>Age</th>
<th>Term of ownership</th>
<th>Majority of income generated from property (productive land use)</th>
<th>Livelihoods/land use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Green Fleet</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-39</td>
<td>18.0%</td>
<td>&lt; 5 years</td>
<td>49% of participants generated majority of income from property</td>
</tr>
<tr>
<td>40-54</td>
<td>41.0%</td>
<td>5-20 years</td>
<td>53.0%</td>
</tr>
<tr>
<td>55-69</td>
<td>29.0%</td>
<td>&gt;20 years</td>
<td>35.0%</td>
</tr>
<tr>
<td>70-99</td>
<td>12.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Biodiversity Stewardship Program</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-39</td>
<td>5.70%</td>
<td>&lt; 5 years</td>
<td>6.30%</td>
</tr>
<tr>
<td>40-49</td>
<td>17.1%</td>
<td>5-20 years</td>
<td>62.5%</td>
</tr>
<tr>
<td>50-59</td>
<td>20.0%</td>
<td>&gt;20 years</td>
<td>12.5%</td>
</tr>
<tr>
<td>60-69</td>
<td>40.0%</td>
<td>2 or more generations</td>
<td>18.6%</td>
</tr>
<tr>
<td>70-99</td>
<td>17.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EcoTender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-39</td>
<td>10.0%</td>
<td>&lt; 5 years</td>
<td>10.0%</td>
</tr>
<tr>
<td>40-49</td>
<td>25.0%</td>
<td>5-15 years</td>
<td>69.0%</td>
</tr>
<tr>
<td>50-59</td>
<td>35.0%</td>
<td>&gt;15 years</td>
<td>21.0%</td>
</tr>
<tr>
<td>60-69</td>
<td>21.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70-79</td>
<td>10.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.3 Results and Discussion

I synthesise the findings from the individual case studies, including demographics (Table 6.3), and draw out three themes in the data that relate to the use of financial incentives in PLC.

The need to engage with existing stewardship ethic

Although the reverse auction EcoTender program seeks to attract landholders by offering payments for the delivery of ecosystem services, some participants used the program as a means for placing an in perpetuity conservation covenant on their land, a motivation that aligns with legacy preservation that extends beyond the duration of their own land tenure. For example, 38% of the Victorian landholders surveyed submitted EcoTender bids upon discovering the program offered a permanent protection agreement. These landholders were previously unsuccessful in securing a covenant through other conservation organisations, having been told that their patches of mixed remnant and revegetated forest were not considered of significant ecological value. As a result, 20% of landholders who did not have existing covenants deliberately placed a low bid to increase their likelihood of getting the covenant, even though that meant the money they received only covered between a third and half of their land management costs:

Because [the restoration is] something I would have done anyway but I think the real bait for me was the covenant. If I did all this [work] and after I’ve gone somebody buys the land and knocks it all over, what’s the point [of restoration]?

One landholder saw EcoTender as an alternative way to realise an existing desire to protect the landscape from encroaching local development. The attraction of the scheme was that it “had teeth” in terms of regulatory controls that helped to see “all this [work]” preserved. Although landholders implemented this program creatively to align with their stewardship objectives, the hybridity of the program, where multiple mechanisms are combined into the one initiative, appealed to a diversity of landholder stewardship aspirations (Gunningham and Young 1997).

Another landholder was enthusiastic about the EcoTender scheme for similar reasons: “I wanted to protect it into the future for the environments who can’t protect themselves and for all the many people who have come and helped [with the restoration effort].” Here, the motivation was to protect restoration efforts for their habitat value, but also because the vegetation embodied the efforts of friends and neighbours who had assisted. Ensuring a future
Locating financial incentives among diverse motivations for long-term private land conservation

owner could not undo these efforts was critical, suggesting the importance on securing long-term conservation benefits as part of landholders’ motivations. These sentiments are commonly expressed by landholders who have sought out covenants or easements to protect their land and/or conservation efforts (Harrington et al. 2006, Lai and Kreuter 2012). These examples reveal that financial incentives were often secondary considerations for landholders compared with other aspects of the program, despite being the centrepiece of EcoTender program design.

The creative interpretation of incentive-based programs offers insights into the complex, diverse, and unanticipated ways in which an existing stewardship ethic can interact with a financial incentive. Although landholders generally found ways to accommodate their conservation motives, the EcoTender example suggests that the financial incentives in question could focus more intently on connecting with existing and ongoing landholder stewardship efforts, rather than a finite policy intervention that is detached from a social and ecological context. By doing more to recognise existing stewardship, financial incentives can be designed and implemented in ways that better accommodate nonfinancial motives for conservation, rather than some landholders having to co-opt programs to meet their needs.

In the Greenfleet case study, land restoration was a strong driver for landholders to consider participation in the scheme. Reflecting a stewardship ethic, 89% of landholders were motivated by the idea of restoring land to provide more suitable habitat for native fauna. As one participant noted: “We just...wanted to rehabilitate the land I suppose, so we wanted to bring back what would have been here with the habitat to the local fauna.” Additionally, landholders tended to take an eco-centric approach toward their land: as one landholder expressed “So it’s just we kind of feel like that we’re doing something for the health of the land and giving something back instead of just taking stuff away from it.”

Similarly, with BSP participants, although a few landholders were previously uninterested in conservation prior to learning about the program, for many an existing stewardship ethic was already in place. The protection of land in perpetuity was used to describe 45% of landholder’s motivations often in conjunction with “safeguarding nature for future generations.” Others (22%) discussed a moral obligation to protect nature or for one “divine purpose.” Landholders in all three case studies expressed a belief that they were part of the biotic community that exists on their property, a view very much in line with Leopold’s stewardship ethic (Leopold 1949). Moral aspects of caring for land through stewardship can be powerful drivers of
program participation, irrespective of what the main objective and intention of the program might be.

**Securing participation and long-term collaboration**

A challenge to PLC programs and their long-term effectiveness is the interplay between different types of incentives and how they work to retain landholders. Effective PLC programs cater for the multiple, diverse motivations held by individuals and groups of landholders across a landscape (Young et al. 1996, Knight et al. 2010, Armsworth et al. 2012). However, programs often must continue to incentivise landholders post enrolment to ensure they remain in a program, manage their property for biodiversity gains, and comply with agreed management practices (Sorice et al. 2013). As in other environmental programming, this can be a secondary consideration; once knowledge is gained, attitudes are shifted, or adoption and uptake is in place, it is measured as an output or outcome with little consideration toward longer-term impact (Wilson and Hart 2001).

Research in conservation volunteerism suggests that the initial motivations for volunteering are unrelated to the attributes of the program that drive continued participation (Ryan et al. 2001, Asah and Blahna 2013). The evolution of motivations reflects a similar process of participation and engagement among PLC landholders. Within the BSP the motivations that landholders stated for initially enrolling in the program were often not the same motivations that contributed to their overall program satisfaction or that engendered long-term commitment to the program. Landholders were motivated by their own conservation goals to adopt the program; 98% of landholders expressed that the impetus to participate in the BSP was to protect and properly manage the landscape and protect the species on their land. Enrolment for nearly 30% of participants was facilitated by a land tax rate reduction, although it was clearly expressed that this was not central to participating, just “a sweetener.” In contrast, continued participation in the BSP was linked by 74% of landholders to the efficacy of land management assistance and training, the quality of the landholder’s relationship with the management agency, and the frequency of visits by a stewardship officer. Of those responding negatively the landholders felt they “had kept up their end of the bargain” but were neglected by the BSP. These results are supported by previous BSP work (Cumming 2007, Pasquini et al. 2010), conservation psychology research into motivations (De Young 2000), and factors driving satisfaction (Stroman and Kreuter 2015).
Similarly, participants in the Greenfleet scheme were initially drawn to the program by access to low-cost tree planting and assistance in land restoration. Sometimes this linked to underlying motivations, as one participant noted, “Our dream was always not to farm the land but to plant it back up as bush.” However, through interviews it became clear that motivation had shifted with participation, and the partnership with Greenfleet staff and associated capacity building was an important component of ongoing program satisfaction. Landholders’ capitalised on Greenfleet’s regular monitoring of trees to engage foresters for management guidance and support. Of the landholders in this study, 94% emphasised the role of the extension officer (foresters) in facilitating landholders’ access to information and linked this continued engagement to the increased likelihood of long-term sustained outcomes. As a landholder noted “It’s the knowledge and the connections that Greenfleet have got that I don’t have to worry about.”

In the case of EcoTender, part of ongoing participant satisfaction appeared to be linked not with the initial interaction with program staff or the securement of a covenant, but rather with other participants. The desire for social networking opportunities through EcoTender was notable, with 60% of EcoTender participants wanting some form of engagement with other landholders. However, because of the competitive design of the auction bidding process, there was no formal way to interact with one another. As has been noted with MBIs designed in this fashion, the use of a competitive funding instrument can constrain collaboration on land management between landholders (Cooke and Moon 2015). As one participant noted, “it would be great if we did have...some sort of networking opportunity. It would be nice to see how successful other participants have been, whether they ran into problems....” Being able to discuss the program with fellow participants can help with knowledge sharing and with advice on implementing the scheme effectively (Riley 2006).

There is a risk that management organisations can prioritise PLC program outputs over long-term conservation outcomes that are beyond the life of any given program (Wilson and Hart 2001). The diversity and dynamism of landholder motivations and satisfaction demands that financial incentives complement and augment, other instruments such as capacity building, stewardship officer visits, establishment of social networks, and recognition of landholder efforts that support nonfinancial motivations and engender long-term commitment. Financial incentives facilitate a landholder’s intention by removing barriers and providing opportunities
for participation. However, effective ongoing conservation management requires more than increasing program participation or removing barriers to participation.

Sustaining landholder involvement necessitates continued behavioural reinforcement (Stern 2006). This can be achieved by building collaborative partnerships between landholders and conservation organisations (Wondolleck and Yaffee 2000, Cooke et al. 2012), development of landholder networks, continued visibility through auditing, and efforts toward comanagement through land management assistance. For example, a collaborative conservation ethic may mean rethinking the design of MBIs like EcoTender, to enable formal landholder networks than can extend beyond a conservation payment contract. This collaborative process reinforces both landholders’ self-efficacy (Bandura 1977) and pro-environmental social norms among participating landholders (Knight et al. 2010).

**Long-term stewardship is best supported by a diverse offering of mechanisms**

The case studies highlight that the relationship between financial incentives and on-ground conservation outcomes is likely to be complex, and could be nonlinear, especially given the uncertainty over ongoing management post-contract. There is little doubt that financial incentives support transitions into PLC programs by covering opportunity costs and investments, particularly for landholders financially dependent on their land (Burns et al. 2016). However, I contend they are not suitable as the backbone of a PLC strategy, particularly for organisations seeking long-term outcomes. Indeed, there are substantial risks in relying too heavily on PLC programs that are designed with a financial incentive as their centrepiece. Here I detail how a diverse offering of mechanisms can best develop and enhance stewardship, in particular stewardship extension support.

The BSP illustrates a balanced mix of mechanisms that successfully entices landholders by providing multiple pathways into the program, and engages them in the long term with continued stewardship support. The program can secure valued nature across four tiers of increasing protection, supported by increasing degrees of financial and management support, each offering commitment options to match landholder needs. Landholders enrolled in the BSP receive nonfinancial incentives from government organisations including land management advice, invasive plant species management support, and fire management assistance delivered through an extension officer. Landholder buy-in of these activities is compulsory, increasing co-ownership of land restoration and materials, e.g., fencing or herbicide. Landholder
achievements are also recognised through an annual landholder awards night, and signage designating the land as part of the BSP. Landholders use the status of their stewardship lands as a form of accreditation to market ecotourism business and “green” products, e.g., wine, fruit, flowers. Increasing landholder commitment through the BSP by increasing the term and conditions of the contract is matched by an increasing amount of support from the conservation authority.

Lands with the highest conservation value and those with title-deed restrictions of 30 years or higher receive property tax exemption (Cumming et al. 2015). This indirect financial incentive is intended to mitigate the effect of removing land from agricultural status, which in South Africa is taxed at a lower rate than that of conservation status. Audits of the participants are conducted yearly, complementing the mix of incentives with an enforcement instrument. The BSP generated a sense of partnership by comanaging lands with landholders. Over a third of BSP participants offered similar sentiments to the landholder who expected “collaboration on joint projects [on the stewardship land]…there is much we [the BSP and the landholder] can do together.”

By providing a variety of mechanisms, i.e., tax incentive, information, property-rights instrument, enforcement, accreditation, and awards, the BSP achieves a standard that other programs in both developing and developed countries could emulate to increase uptake in a heterogeneous population of landholders and maintain long-term stewardship among participants. During the interviews the full range of instruments offered by BSP were described as beneficial, but some such as land and invasive plant management assistance came up more frequently with 63% of participants remarking on their importance. As a landholder remarked, “The benefits that I have enjoyed so far, funding [for invasive clearing], technical assistance, managing, as well as labour for clearing, have been invaluable to our farm.” My analysis demonstrated that stewardship extension officer support in particular had an outsized influence on BSP satisfaction with 74% of program landholders discussing the importance of interaction with a stewardship officer. This is similar to findings from the other case studies, which were not established with the intention of providing landholders with support from a stewardship officer.

Of the surveyed EcoTender participants, 35% reported that the site visit by an extension officer to assess their reverse auction tender bid as one of the highlights of the program. Given the
paucity of extension opportunities available to landholders, participants used this visit as a chance to ask important questions about land management, species identification, and landscape change. Knowledge-sharing and social interaction with an extension officer or a social network of landholders can motivate landholders to sustain long-term conservation efforts.

Additionally, landholders in the Greenfleet program stated that having foresters visiting their properties to monitor carbon is an important element of the program: “they [Greenfleet’s foresters] know their stuff, they know when to plant, they’ve been fantastic.” In both of the Australian examples, the advice and assistance provided to landholders through property visits from extension officers were important, but happened informally. Integrating these opportunities for enhancing landholder knowledge and capacity more formally as a program instrument may assist in the continuation of land management practices after a program concludes (EcoTender) or when property visits are infrequent (Greenfleet). This is especially important when program involvement presents new land management challenges that participants have not previously encountered.

Conclusions

If PLC programs are to deliver conservation benefits on private land that are sustained and supported by landholders, the instruments utilised need to be positioned within an overarching strategy that recognises a dynamic social-ecological context (Gunningham and Young 1997). Financially incentivising enrolment can be a useful tool to draw landholders into a PLC program, but landholders’ ongoing participation in programs is driven by a variety of factors that are not necessarily related to economic considerations (Selinske et al. 2015).

The case study results reinforce the need for flexible and diverse approaches to conservation policy that emphasise a suite of policy mechanisms. There is substantial evidence from the case studies and existing research that financial incentives are not well suited to being the foundation upon which PLC policy and programs should be built. Policy makers need to be open to the ways in which landholders’ “practical and emotional attachments” (Trigger et al. 2010:1070) to their landscapes manifest through their stewardship ethic and connect with, reinterpret, or resist program objectives. Ideally, to secure conservation benefits on private land, program design would consider what is required to foster stewardship over the long term.
I suggest that recognising social-ecological complexity and responding to the dynamism and uncertainty that this entails (which makes the rigidity of some financial incentive programs less attractive) needs to be considered upfront when designing PLC policy. To enhance a landholder’s ability to respond to change, we need cooperation and critical reflection among and between the different actors in PLC program design and implementation. Financial incentives that do not foster collaboration and ongoing stewardship may be problematic in the long-term, especially in the face of indefinite political support for conservation initiatives. As I have argued, an approach to PLC that centres on the context of implementation and responds to a diverse range of landholder stewardship motivations benefits both landholders and conservation organisations, enhancing the potential for long-term ecological benefits.
Reducing the continued loss of biodiversity requires greater sophistication in conservation science, particularly through the integration and development of conservation social sciences (St John, Keane & Milner-Gulland 2013; Bennett et al. 2017). Understanding and changing human behaviour is a fundamental part of the contribution of social science (Clayton & Myers 2009; Saunders, Brook & Eugene Myers 2006; Schultz 2011). Research in conservation psychology is well placed to assist in this endeavour, as it is specifically focussed on understanding and changing conservation behaviours. Given the immediacy of the biodiversity crisis, the conservation sector must also think strategically and systematically about how we use conservation resources to implement conservation actions (Salafsky et al. 2002). This includes how we consider and change human behaviour. But unlike conservation planning where there was and potentially still is a gap between ‘knowing’ and ‘doing’ (Knight et al. 2008), for the integration of human behaviour we need to improve both knowing and doing. To push the conservation planning analogy a step further, similar to advances in the science of conservation planning, conservation behaviour change should be prioritised, to ensure an efficient and systematic approach to the way in which we understand and target behaviour change for biodiversity benefits. Parallel to the development of ecological models, conservation decision-making will benefit from focussing on the prediction of behaviours in conservation contexts, both in understanding their mechanisms and predicting future behaviours (Milner-Gulland 2012; Travers et al. 2019). Additionally, improvements are needed in evaluating behaviours in response to conservation interventions. This should be undertaken both quantitatively and qualitatively.

In this thesis I examined ways to better advance the integration of human behaviour into conservation decision-making as it relates to conservation science and practice, specifically through prioritising, predicting and evaluating conservation behaviours.
This thesis contributes to building knowledge and furthering the integration of human behaviour in conservation decision-making by:

- contributing ideas of how to further develop and integrate the field of conservation psychology;
- prioritising behaviours based on their impact on biodiversity and plasticity;
- using a structured method to consider the most effective interventions to change a behaviour with high impact on biodiversity;
- identifying methods to predict human behaviour in conservation contexts; and
- critically evaluating the use of financial incentives in private land conservation programs.

In Chapter 2 I demonstrated through a literature search that there has been insufficient uptake of psychological research within conservation science. Although this is likely a result of current and historical impediments, such as publication and funding barriers, I hypothesise that the characteristics underpinning behaviours that impact biodiversity are more entrenched and difficult to change than other focal environmental behaviours such as energy or water-use reduction or waste management. Behaviours that impact upon biodiversity are generally context specific, indirect, diffuse in nature, costly, lack feedback mechanisms, and are difficult to quantify. Given this complexity, the psychological theory or tools developed for other environmental issues may not be applicable. I go on to argue that this degree of difficulty makes biodiversity behaviours more difficult to study and may deter psychologists from engaging with conservation science, hampering the growth of the conservation psychology discipline. I develop a number of suggestions to better integrate the fields of psychology including hosting biodiversity-specific symposia at psychology conferences, continued development and expansion of undergraduate and master’s degree conservation psychology programs, and prioritising human behaviours driving the greatest biodiversity threats, so as to develop a behaviour change research agenda for conservation.

When conservation psychology was introduced in 2003, proponents held high hopes for this new discipline to help solve the global challenge of slowing or halting biodiversity loss (Saunders, Brook & Eugene Myers 2006; Saunders 2003). My research has revealed that despite its enormous and ongoing promise, conservation
psychology has not yet fulfilled its potential. However, there is growing interest in this field, as is seen by the popularity of Conservation Optimism (conservationoptimism.org) and the emergence of conservation marketing (Wright et al. 2015) which at their very core are concerned with the relationship between human emotion and conservation decision-making. Perhaps these recent advances indicate that the tide is turning.

In Chapter 3 I identified and prioritised human behaviours that have positively and negatively impacted biodiversity in Victoria, Australia. I demonstrated a method of behavioural prioritisation using an adapted nominal group technique during an expert workshop and through an online survey. Through this structured elicitation I identified 27 behaviours that people living in Victoria, Australia, could engage in to reduce their impact on local biodiversity. For each behaviour I elicited estimates of its behavioural plasticity and impact on biodiversity. Additionally, I sought previously published literature to derive estimates of prevalence of these prioritised behaviours among the Victorian population. These 27 behaviours fell into multiple behavioural domains including advocacy, donating, stewardship, lifestyle, social and consumption behaviours.

To my knowledge, this is the first prioritisation of behaviours that impact biodiversity gauged for the general public. I found that the prioritisation was not only an effective tool for developing a list of behaviours to target, but also an effective method to engage stakeholders, including government, in the process of developing behaviour change strategies. While this list was specific to Victoria, it is likely that many of these behaviours, and certainly the methods developed, are relevant in other contexts.

In Chapter 4 I selected one behaviour from the prioritised list developed in Chapter 3, namely beef consumption, and investigated the most effective strategies for changing that behaviour. I specifically focussed on the context of the United States (US) rather than Victoria or Australia, as the US has a higher per capita and overall consumption rate of beef. I employed a structured expert elicitation technique different to that used in Chapter 3, a policy Delphi, to derive a list of potential behaviour change interventions and to consider their pros and cons. I elicited a list of 20 interventions that were viewed as impactful and generated a qualitative dataset critiquing those interventions that was
thematically analysed to explore their feasibility and effectiveness. Interventions that
were broadly deemed feasible and impactful by the experts included: changing social
norms, targeting food providers to reduce beef-based meals, and increasing the
availability and quality of beef alternatives.

In addition to contributing knowledge about what types of interventions are most
effective to reduce beef consumption, I also innovated the policy Delphi elicitation
method by hosting the second and third rounds of the elicitation on a new online crowd
elicitation platform (https://www.swarmproject.info/). This allowed for experts’
responses to be visible immediately to other experts, who could then respond in real
time rather than waiting for data collation and reporting back, as is the standard method.

In Chapter 5 I investigated the types of tools being used to predict human behaviours
and how they can be applied to environmental decision-making. I systematically
examined the peer-reviewed published environmental science literature to identify
methods that incorporate some component of predicting human behaviour. I found in
the literature that the term ‘prediction’ is interpreted differently depending on the
discipline and epistemology of the researcher. Both explanatory and anticipatory
prediction are used without distinction, which can potentially lead to confusion given
the interdisciplinary nature of conservation science.

Multiple methods are used to predict a variety of human behaviours for many different
environmental issues and contexts. Many of the papers I reviewed used these tools in
conjunction, for example, using psychological theory to underpin decision-making in
agent-based models. This chapter demonstrates that predicting human behaviours is a
powerful tool for foreseeing future threats and for ex-ante evaluation and is likely to be
used increasingly to better integrate behaviours into biodiversity decision-making. I
argue that the integration of tools, better evaluation techniques and accounting for
uncertainty will increase the policy relevancy of these predictive methods. Agent-based
models have long established protocols for model development and specifically
detailing uncertainty and evaluation. Learning from this area could benefit all methods
predicting human behaviours in conservation decision-making.
Another complexity to human behaviour research is understanding how interventions can potentially create perverse outcomes (Stevens 2002). In Chapter 6 I qualitatively evaluated the outcomes of incentives on pro-environmental behaviour change in private land conservation programs. Through examining three independent case studies of private land conservation, two in Australia and one in South Africa, I found that financial incentives were seen as beneficial to landowners but did not necessarily drive participation. Capacity building, management assistance and social networks were seen as equally, if not more important than financial incentives at generating participation and importantly may contribute more to long-term land stewardship.

Future work

This thesis has drawn attention to the various ways we can integrate human behaviour into conservation decision-making. I envisage multiple directions for future work to build on the research presented in this thesis. Firstly, behavioural prioritisation should be undertaken at multiple levels, including global and local scales. While in Chapter 3 I demonstrated a behavioural prioritisation for the population of Victoria, Australia, a prioritisation of the highest impacting behaviours globally would also be valuable, creating a focal point for the conservation scientists, behavioural change specialists, and psychologists to systematically investigate interventions to target prioritised behaviours. Methods such as input-output analysis (Lenzen et al. 2012; Marques et al. 2019) and biophysical modelling of trade paths (Chaudhary & Kastner 2016) provide a good basis on which to build these global prioritisations; however, additional research is required to expand the suite of potential behaviours beyond consumptive behaviours.

In addition to prioritising behaviours based on their impact and plasticity, behaviours could be prioritised based on the economic costs of specific behaviour change programs, as well as including other attributes such as political feasibility. By including costs and feasibility, the priority rankings of behaviours elicited in Chapter 3 could potentially shift, allowing us to understand the trade-offs between the impact of the behaviour change, the cost of intervention implementation and its feasibility. In some cases, behaviour changes that have a lower impact might become highest priorities because they are cheap and effective. Additionally, engaging policy and practice specialists in this process could result in a comprehensive and realistic measure of
feasibility. In so doing, this field of research will hopefully avoid the knowledge-implementation gap that has characterised much conservation research (Toomey, Knight & Barlow 2016).

It’s possible that there would be greater uptake and recognition of the importance of behaviour change for biodiversity by conservation science and decision-makers if we were better able to predict the effect that individual behaviour changes would have on biodiversity. At the moment there is little consideration of demonstrating this beyond ex-post analyses (e.g. Veríssimo et al. 2017). For many behaviours (for example, those that are indirectly impacting biodiversity or those that are but one of many impacting drivers), it’s difficult to know what the actual effect of changing a behaviour will be. I see future research investigating behaviour change impact projection and prediction as an important part of mainstreaming behaviour change into conservation decision-making.

Finally, a deeper consideration of the ethics of specifically targeting people’s behaviours is required. Given that we are using instruments of influence such as tools from behavioural economics and marketing techniques, future work should focus on designing protocols for systematically working though ethical considerations of conservation science and practice focussed on human behaviour change. The ethics of behaviour change currently receives little consideration and it is often assumed, because in our minds we are doing work for nature’s benefit, that we are right in doing so. This mindset presents the conservation field with ethical dilemmas as much of conservation work occurs in emerging economies, where individuals and communities may not have the same agency as those in developed economies.

*Closing remarks*

Like much of the conservation social sciences, consideration of human behaviour is just beginning to be examined in the context of conservation decision-making. This thesis has offered a number of insights for the integration of human behaviour in relation to its uptake within conservation and has advanced a number of potential research areas that could be fruitfully explored. The continued exploration of this line of inquiry is key to developing the ‘bolder’ conservation science needed to address the
Conclusions

conservation crisis. We are currently at a crossroads, with a range of potential futures dependent on how our society evolves over the coming decade. This presents a real opportunity for new advances in conservation psychology and conservation behaviour change to inform our path forward and strengthen conservation decision-making.
REFERENCES


References


References


Berglund, EZ 2015, ‘Using Agent-Based Modeling for Water Resources Planning and Management’, *Journal of Water Resources Planning and Management*, vol. 141, no. 11, p. 04015025.


Bouwman, L, Goldewijk, KK, Van Der Hoek, KW, Beusen, AHW, Van Vuuren, DP, Willems, J, Rufino, MC & Stehfest, E 2013, ‘Exploring global changes in nitrogen and phosphorus cycles in agriculture induced by livestock production over the 1900-2050 period’,
References


Broch, SW, Strange, N, Jacobsen, JB & Wilson, K a. 2013, ‘Farmers’ willingness to provide ecosystem services and effects of their spatial distribution’, Ecological Economics, vol. 92, pp. 78–86.


References

144–157.


Clayton, S & Myers, EO 2009, Conservation psychology: Understanding and promoting
References

human care for nature. 1st edn, Wiley-Blackwell, Hoboken, NJ.


Creswell, JW & Clark, VLP 2017, Designing and conducting mixed methods research, Sage publications.


References


Delbecq, AL, Van de Ven, AH & Gustafson, DH 1975, *Group techniques for program planning: A guide to nominal group and Delphi processes*, Scott Foresman.

Department of Environment and Primary Industries 2014, ‘Advisory list of rare or threatened plants in Victoria - 2014.’

Department of Sustainability and Environment 2009, ‘Advisory list of threatened invertebrate fauna in Victoria’.


References


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Evans, MC & Cvitanovic, C 2018, ‘career researchers’, *Palgrave Communications*.


policy’, *Nature Sustainability*, vol. 1, no. 9, p. 452.


Gowdy, J, Hall, C, Klitgaard, K & Krall, L 2010, ‘What every conservation biologist should
know about economic theory’, *Conservation Biology*, vol. 24, no. 6, pp. 1440–1447.


Hartmann, C & Siegrist, M 2017, ‘Consumer perception and behaviour regarding sustainable protein consumption: A systematic review’, *Trends in Food Science and Technology*, vol. 61, pp. 11–25.

References

261–270.
Heberlein, TA 2012b, Navigating environmental attitudes, Oxford University Press, New York, NY.
References


IPBES 2016, The methodological assessment report on scenarios and models of biodiversity and ecosystem services, Bonn, Germany.

IPBES 2019, Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany.


IPCC 2019, IPCC, 2019: Climate Change and Land, Geneva, Switzerland.


Kosinski, M, Stillwell, D & Graepel, T 2013, ‘Private traits and attributes are predictable from digital records of human behavior.’, *Proceedings of the National Academy of Sciences of the United States of America*, vol. 110, no. 15, pp. 5802–5.


Kusmanoff, AM 2017, ‘Framing the conservation conversation: an investigation into framing techniques for communicating biodiversity conservation’.


Lamba, J, Thompson, AM, Karthikeyan, KG & Fitzpatrick, FA 2015, ‘Sources of fine sediment stored in agricultural lowland streams, Midwest, USA’, *Geomorphology*, vol. 236, pp. 44–53.


Larson, LR, Stedman, RC, Cooper, CB & Decker, DJ 2015, ‘Understanding the multidimensional structure of pro-environmental behavior’, *Journal of Environmental Psychology*, vol. 43, pp. 112–124.


Lennox, GD, Gaston, KJ, Acs, S, Dallimer, M, Hanley, N & Armsworth, PR 2013,
‘Conservation when landowners have bargaining power: Continuous conservation investments and cost uncertainty’, *Ecological Economics*, vol. 93, pp. 69–78.


Macdiarmid, JI 2014, ‘Seasonality and dietary requirements: will eating seasonal food contribute to health and environmental sustainability?’, *Proceedings of the Nutrition Society*, vol. 73, no. 3, pp. 368–375.


Mackay, CML & Schmitt, MT 2019, ‘Do people who feel connected to nature do more to protect it? A meta-analysis’, *Journal of Environmental Psychology*, vol. 65, p. 101323.


changed for the sake of conservation’, *Conservation Biology*, vol. 31, no. 4, pp. 772–780.


Markowitz, EM, Slovic, P, Västfjäll, D & Hodges, SD 2013, ‘Compassion fade and the challenge of environmental conservation’, *Judgment and Decision Making*, vol. 8, no. 4, pp. 397–406.


Perry, WL 2013, Predictive policing: The role of crime forecasting in law enforcement operations., Rand Corporation, Santa Monica, CA.


Polasky, S, Carpenter, SR, Folke, C & Keeler, B 2011, ‘Decision-making under great


Qualtrics 2018, ‘Qualtrics’.


R Development Core Team 2016, ‘R: A Language and Environment for Statistical Computing’.

Race, D & Curtis, A 2013, ‘Reflections on the Effectiveness of Market-Based Instruments to


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Smith, LGE, Thomas, EF & McGarty, C 2015, ““We Must Be the Change We Want to See in the World”: Integrating Norms and Identities through Social Interaction’, *Political Psychology*, vol. 36, no. 5, pp. 543–557.


Ticehurst, JL, Curtis, A & Merritt, WS 2011, ‘Using Bayesian Networks to complement conventional analyses to explore landholder management of native vegetation’,
References


Tran, M, Banister, D, Bishop, JDK & McCulloch, MD 2013, ‘Simulating early adoption of alternative fuel vehicles for sustainability’, *Technological Forecasting and Social Change*, vol. 80, no. 5, pp. 865–875.


References


environmental attitudes, beliefs, and behaviors across three decades’, *Environment and behavior*, vol. 42, no. 1, pp. 61–85.


Wright, DR, Underhill, LG, Keene, M & Knight, AT 2015, ‘Understanding the Motivations and Satisfactions of Volunteers to Improve the Effectiveness of Citizen Science Programs’, *Society & Natural Resources*, vol. 28, no. 9, pp. 1013–1029.


APPENDICES
Table A1 Australia’s top biodiversity threats as derived from a multi-regional input-output analysis (for methods and specific results see Lenzen et al. 2012; Peterson et al. in preparation; Selinske et al. in preparation).

<table>
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<th>Australia ranked sectors</th>
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<td>1 Residential building</td>
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<tr>
<td>2 Non-residential building</td>
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<tr>
<td>3 Non-building construction</td>
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<td>4 Fishing</td>
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<td>5 Aquaculture</td>
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<td>6 Petrol and diesel drilling</td>
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<td>7 Beef Production</td>
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<td>8 Vegetable farming</td>
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<td>9 Fruit farming</td>
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<td>10 Coal mining</td>
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<td>11 Natural gas exploration</td>
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<tr>
<td>12 Residential building- softwoods</td>
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<td>13 Wheat</td>
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<td>14 Cotton</td>
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<td>15 Dairy</td>
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<tr>
<td>16 Sheep/lamb</td>
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<tr>
<td>17 Residential building- hardwoods</td>
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<tr>
<td>18 Forestry</td>
</tr>
<tr>
<td>19 Furniture- softwoods</td>
</tr>
<tr>
<td>20 LPG, LNG drilling</td>
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</table>
Figure A1 Number EPBC-listed species impacted by IUCN Red-List threat category. Threats extracted from EPBC listed species recovery plans and classified according to Salafsky et al. (2008) threat classification of EPBC listed species. For methods see (Brown et al. in preparation).
Figure A2 Confidence intervals for estimates of biodiversity impact (titled Impact on the y-axis) and behavioural Plasticity (titled Feasibility on x-axis). Numbers correspond to Table 3.1.
<table>
<thead>
<tr>
<th>Behaviours</th>
<th>Description of source and calculation</th>
<th>Penetration</th>
<th>Refs</th>
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<tbody>
<tr>
<td>1. Choose Forest Stewardship Council (FSC) toilet paper products</td>
<td>Self-report from campaign evaluation Smith et al. (2009)</td>
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<td>Smith et al. (2009)</td>
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<td></td>
<td>Corroborated with 2011 representative study from Sun Coast, Queensland</td>
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<tr>
<td>2. Choose organic fruit, vegetables, and grain products</td>
<td>14% of Australian households spend 40% or more of their food budget on organic food 71% of Victorian consumers are open to buying more organic depending on price and convenience</td>
<td>.14</td>
<td>Australian Organics (2015) Lobo et al. (2014)</td>
</tr>
</tbody>
</table>
| 4. Choose a green energy supplier for home energy needs                   | Green rating (highest) by Green Electricity Guide  
VIC households servicing per company:  
Diamond 3941  
Powershop 57471  
AGL 550904  
Origin 456467  
Momentum 69933  
https://www.greenelectricityguide.org.au/#ratings-container  
<p>| 5. Reduce beef and lamb consumption | Published work based on Victorian consumption | .37 | Victorian Energy report (2017) |
| 6. Choose local and seasonal produce | Published work based on Victorian consumption and Australian consumption | &lt; .01 | Mann et al. (2018) |
| 7. Tell positive nature stories within circle of influence | Based on subjective assumptions and group discussion | &lt; .01 | |
| 8. Actively support those who are making biodiversity-friendly choices | Based on subjective assumptions and group discussion | &lt; .01 | |
| 9. Discuss origin of food consumed within circle of influence | Based on subjective assumptions and group discussion | &lt; .01 | |
| 10. Discuss pro-environmental attitudes/behaviours within circle of influence | Environmental identity predicts Green talk-discussion of environmental issues. Environmental identity is a major component of connection to nature scale | &lt; .01 | Meis et al. (2019); Margetts and Kashima (2016) |
| 12. Volunteer to activities that take care of the environment (e.g. participating in a Local Friends Group) | Victorians Valuing Nature (VVN) survey conservative self-report | .20 | Meis-Harris et al. (2019) |
| 14. Forgo using chemical herbicides and pesticides in domestic gardens | Based on conservative estimates from Adelaide South Australia | .31 | Pollard et al. 2018 |
| 15. Advocate publicly for pest animal control including both native and alien species | Based on subjective assumptions and group discussion | &lt; .01 | van Eeden et al. (2019) |
| 16. Advocate for intensification (infill) of urban areas rather than urban fringe expansion | Based on subjective assumptions and group discussion | &lt; .01 | |
| 17. Write to local members of parliament or local government about their environmental policies | Based on subjective assumptions and group discussion | &lt; .01 | |</p>
<table>
<thead>
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<th></th>
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</thead>
<tbody>
<tr>
<td><strong>19. Advocate for 'green' or 'biodiversity-friendly' certification</strong></td>
<td>Based on subjective assumptions and group discussion</td>
<td>&lt; .01</td>
</tr>
<tr>
<td><strong>20. Run for local council at least once</strong></td>
<td>Based on subjective assumptions and group discussion</td>
<td>&lt; .01</td>
</tr>
<tr>
<td><strong>21. Donate to private land protection organisations</strong></td>
<td>Discussions with PLC organisations based in VIC</td>
<td>&lt; .01</td>
</tr>
<tr>
<td><strong>22. Donate to organisations that focus on threatened species and ecosystem advocacy</strong></td>
<td>Victorians Valuing Nature (VVN) survey conservative self-report and discussion with environmental organisation</td>
<td>.07</td>
</tr>
<tr>
<td><strong>24. Responsible dog ownership – dogs on leashes in natural areas and picking up after your dog</strong></td>
<td>Self-reports data</td>
<td>.18</td>
</tr>
<tr>
<td><strong>25. Responsible cat ownership – keep cat fully contained</strong></td>
<td>Self-report, Victorians Valuing Nature (VVN) survey conservative self-report</td>
<td>.34</td>
</tr>
<tr>
<td><strong>26. Choose biodiversity-friendly investments (e.g. sustainable super funds)</strong></td>
<td>Ethical Super data; ACSRF Socially Responsible Balance Market data</td>
<td>&lt; .01</td>
</tr>
<tr>
<td><strong>27. Spend regular time in nature</strong></td>
<td>Victorians Valuing Nature (VVN) survey conservative self-report</td>
<td>.20</td>
</tr>
</tbody>
</table>
Table A3 Survey respondents selection of what they perceived to be the top 5 most feasible and impactful behaviours out of the 27 listed

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsible cat ownership</td>
<td>58.8%</td>
</tr>
<tr>
<td>Voting for people based on biodiversity policies</td>
<td>47.1%</td>
</tr>
<tr>
<td>Purchase Marine Stewardship Council (MSC) certified seafood products</td>
<td>47.1%</td>
</tr>
<tr>
<td>Wildlife gardening</td>
<td>47.1%</td>
</tr>
<tr>
<td>Reducing Beef and lamb consumption</td>
<td>41.2%</td>
</tr>
<tr>
<td>Donate to land protection organisations</td>
<td>29.4%</td>
</tr>
<tr>
<td>Donate to orgs threatened species</td>
<td>23.5%</td>
</tr>
<tr>
<td>Join Local friends group (including volunteering)</td>
<td>23.5%</td>
</tr>
<tr>
<td>Spending regular time in nature</td>
<td>23.5%</td>
</tr>
<tr>
<td>Purchase FSC toilet paper products</td>
<td>23.5%</td>
</tr>
<tr>
<td>Biodiversity friendly investments (e.g. Super funds)</td>
<td>17.6%</td>
</tr>
<tr>
<td>Advocate publicly for pest animal control</td>
<td>17.6%</td>
</tr>
<tr>
<td>Purchase green energy</td>
<td>11.8%</td>
</tr>
<tr>
<td>Consume local and seasonal produce</td>
<td>11.8%</td>
</tr>
<tr>
<td>Responsible dog ownership- dogs on leashes in natural areas</td>
<td>11.8%</td>
</tr>
<tr>
<td>Participate in citizen science projects</td>
<td>11.8%</td>
</tr>
<tr>
<td>Actively support those that are making biodiversity-friendly choices</td>
<td>11.8%</td>
</tr>
<tr>
<td>Volunteer for a biodiversity conservation organisation</td>
<td>5.9%</td>
</tr>
<tr>
<td>Advocate for 'green' or 'biodiversity-friendly' certification</td>
<td>5.9%</td>
</tr>
<tr>
<td>Discussing pro-environmental attitudes/behaviours within social groups</td>
<td>5.9%</td>
</tr>
<tr>
<td>Purchasing organic fruit, grain</td>
<td>5.9%</td>
</tr>
<tr>
<td>Write to local members</td>
<td>5.9%</td>
</tr>
<tr>
<td>Stop using non-natural herbicides and pesticides in domestic gardens</td>
<td>5.9%</td>
</tr>
<tr>
<td>Discuss origin of food consumed to family/friends</td>
<td>5.9%</td>
</tr>
</tbody>
</table>
Workshop Participant Survey

Thank you again for your participation and contributions made during the Victorian Biodiversity Behaviours workshop.

As discussed, the exercise of prioritising behaviours requires a final step of completing a short survey.

The following survey contains the ideas developed in the workshop as potential behaviours to target. In consideration of the aims of the workshop, and to keep the survey short, we've decided to focus only on those behaviours that a 'typical' Victorian can participate in. While organisational behaviours and rural landholder behaviours are very important in protecting threatened species and biodiversity, these suggestions have been set aside, to unpack in future work.

Some of these behaviours are likely to be further divisible but if this is the case please do your best to assess the behaviour as a group or class of behaviours.

After the survey, a literature search will be undertaken for those highly prioritised behaviours to further assess impact and plasticity. The results from this survey and reporting from the workshop will provided in the new year.

Instructions
The survey will take approximately 10 minutes to complete.
The behaviours are divided up into 6 domains: Consumption, Social, Stewardship, Advocacy, Lifestyle, and Donation.

Please consider the behaviours 'impact' on Victorian biodiversity and 'plasticity' or likelihood of an individual to engage in the behaviour.
When assessing plasticity, please think of potential barriers (e.g. time, money, social norms, etc.) of the behaviour. Notes from the workshop have been included for each behaviour. Using the sliding scales provided, please individually indicate on a scale of 0-10 the impact and plasticity of the behaviour.

After each behaviour, if you wish, please feel free to include any additional comments in the space provided.

If you have any queries please contact Matthew by phone: 0420263377 or email: matthew.selinske@rmit.edu.au.

Thank you again for your time and we look forward to your participation.

**Survey Questions**

**Domain: Consumption behaviours**

1. Purchase Forest Stewardship Council toilet paper products

Using the sliding scales provided, please indicate on a scale of 0-10 the positive impact of the behaviour (0 being the lowest and 10 the highest). Please feel free to include any additional comments in the space provided.

**Sliding Scale 0-10**

Using the sliding scales provided, please indicate on a scale of 0-10 the plasticity of the behaviour (0 being the lowest and 10 the highest). Base your decision on your own knowledge and the information provided above. Please feel free to include any additional comments in the space provided.

**Sliding Scale 0-10**
Please include any additional comments you may have regarding 'Purchasing FSC toilet paper products' below.

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Same format all 27 behaviours

2. Purchase organic fruit and grain products

3. Purchase Marine Stewardship Council (MSC) certified seafood products

4. Purchase green energy

5. Reduce beef and lamb consumption

6. Consume local and seasonal produce

Domain: Social Behaviours

7. Tell positive nature stories within your circle of influence

8. Actively support those who are making biodiversity-friendly choices

9. Discuss origin of food consumed to family/friends

10. Discuss pro-environmental attitudes/behaviours within social groups
Domain: Stewardship Behaviours

11. Participate in citizen science projects
12. Join a local friends group (including volunteering)
13. Plant a wildlife garden
14. Forgo using non-natural herbicides and pesticides in domestic gardens

Domain: Advocacy Behaviours

15. Advocate publicly for pest animal control including both native and pest species
16. Advocate for intensification (infill) of urban areas rather than urban fringe expansion
17. Write to local members about their biodiversity policies
18. Voting for political candidates based on biodiversity policies
19. Advocate for 'green' or 'biodiversity-friendly' certification
20. Run for local council at least once

Domain: Donating Behaviours

21. Donate to private land protection organisations
22. Donate to organisations that focus on threatened species
23. Volunteer for a biodiversity conservation organisation (including people with non-traditional skills like graphic design)
Domain: Lifestyle Behaviours

24. Responsible dog ownership – dogs on leashes in natural areas and picking up after your dog

25. Responsible cat ownership – keep cat fully contained

26. Biodiversity friendly investments (e.g. Super funds)

27. Spending regular time in nature, active engagement

<Page Break>

Finally, of the 27 behaviours listed, please drag the five you would prioritise, based on being the most feasible and impactful or potentially another attribute, into the box below.

Top 5 behaviours

______ Purchase FSC toilet paper products (1)
______ Purchasing organic fruit, grain (2)
______ Purchase Marine Stewardship Council (MSC) certified seafood products (3)
______ Purchase green energy (5)
______ Reducing Beef and lamb consumption (6)
______ Consume local and seasonal produce (7)
______ Tell positive nature stories within your circle of influence (8)
______ Actively support those that are making biodiversity-friendly choices (9)
______ Discuss origin of food consumed to family/friends (10)
______ Discussing pro-environmental attitudes/behaviours within social groups (11)
______ Participate in citizen science projects (12)
______ Join Local friends group (including volunteering) (13)
______ Wildlife gardening (14)
______ Stop using non-natural herbicides and pesticides in domestic gardens (15)
______ Advocate publicly for pest animal control (16)
______ Advocate for intensification (infill) of urban areas (17)
______ Write to local members about their biodiversity policies (18)
<table>
<thead>
<tr>
<th>Number</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Voting for people based on biodiversity policies</td>
</tr>
<tr>
<td>20</td>
<td>Advocate for 'green' or 'biodiversity-friendly' certification</td>
</tr>
<tr>
<td>21</td>
<td>Run for local council at least once</td>
</tr>
<tr>
<td>22</td>
<td>Donate to land protection organisations</td>
</tr>
<tr>
<td>23</td>
<td>Donate to orgs threatened species</td>
</tr>
<tr>
<td>24</td>
<td>Volunteer for a biodiversity conservation organisation</td>
</tr>
<tr>
<td>25</td>
<td>Responsible dog ownership- dogs on leashes in natural areas</td>
</tr>
<tr>
<td>26</td>
<td>Responsible cat ownership- keep cat fully contained</td>
</tr>
<tr>
<td>27</td>
<td>Biodiversity friendly investments (e.g. Super funds)</td>
</tr>
<tr>
<td>28</td>
<td>Spending regular time in nature, active engagement</td>
</tr>
</tbody>
</table>
Table B2 Experts disciplines. Answers to *Q1. How would you describe your disciplinary expertise* (*e.g. environmental psychology, food psychology)*?

<table>
<thead>
<tr>
<th>Disciplinary Expertise</th>
<th>Number of Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental psychology (3 experts)</td>
<td></td>
</tr>
<tr>
<td>Transformation science</td>
<td></td>
</tr>
<tr>
<td>Consumer behaviour (2 experts)</td>
<td></td>
</tr>
<tr>
<td>Mass communication and public opinion research</td>
<td></td>
</tr>
<tr>
<td>Human geography / cultural studies</td>
<td></td>
</tr>
<tr>
<td>Social psychology (2 experts)</td>
<td></td>
</tr>
<tr>
<td>Public health (2 experts)</td>
<td></td>
</tr>
<tr>
<td>Food psychology, cultural psychology</td>
<td></td>
</tr>
<tr>
<td>Environmental sociology/human geography</td>
<td></td>
</tr>
<tr>
<td>Food and environmental sustainability</td>
<td></td>
</tr>
<tr>
<td>Climate and environmental science, sociology, human geography, cultural studies</td>
<td></td>
</tr>
<tr>
<td>Food and public health nutrition policy</td>
<td></td>
</tr>
<tr>
<td>Consumption psychology (2 experts)</td>
<td></td>
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<tr>
<td>Question</td>
<td></td>
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<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Q1. How would you describe your disciplinary expertise (e.g. environmental psychology, food psychology)?</td>
<td></td>
</tr>
<tr>
<td>Q2. What are the most significant behavioural or societal factors/practices that drive beef consumption?</td>
<td></td>
</tr>
<tr>
<td>Q3. Based on your knowledge and understanding of the dimensions that underpin beef consumption what interventions do you think will be effective in reducing beef consumption in the US?</td>
<td></td>
</tr>
<tr>
<td>Additionally, please include any campaigns with which you have been involved or know of through reports or publications, that are effective in reducing meat consumption and germane to reducing beef consumption.</td>
<td></td>
</tr>
<tr>
<td>Q4. Please categorize the interventions you listed in the previous question by identifying an appropriate time horizon in which the proposed intervention could likely take place. To do this, please click and drag the intervention into the appropriate box.</td>
<td></td>
</tr>
<tr>
<td>Short-term operational (0-12 months): behavioural interventions that can take place in the next year given the socio-political context of the US to make an immediate impact</td>
<td></td>
</tr>
<tr>
<td>Intermediate tactical (1-10 years): behavioural interventions that can be taken over the next decade potentially based on incremental changes in policy and/or societal preferences in the US</td>
<td></td>
</tr>
<tr>
<td>Long-term strategic (10-40 years): behavioural interventions that require time and planning and potentially major policy shifts in the US</td>
<td></td>
</tr>
<tr>
<td>Q5 Of the interventions that you categorised as either short-term or intermediate please list up to a maximum of five that you think would be most effective and feasible (costs, political environment, logistics). Please include a description of the intervention including the factors/practices the intervention addresses and your rationale below.</td>
<td></td>
</tr>
<tr>
<td>Q6 Up to now, conservation research and practice has had little focus on changing beef consumption behaviors. How do you suggest the conservation sector involve itself in reducing beef consumption? Where is resourcing needed and what actors are best placed to tackle this issue?</td>
<td></td>
</tr>
</tbody>
</table>
Figure B1 Number of mentions (% of overall comments) of each category of behaviors in expert discussion of a) factors driving beef consumption and b) suggested interventions to reduce beef consumption. Y-axis categories were identified by Stoll-Kleemann et al. (2017) as factors driving beef consumption. Two categories: Perceived Behavior Control and Socio-Demographics/Personality identified by Stoll-Kleemann et al. (2017) were not raised by experts in this sample.
### Table B3 Expert selected interventions during Round 1

**Intervention 1:** Change U.S. Dietary Guidelines to reflect latest nutrition science

**Description:**
Ensure that scientific recommendations to recommend reduced beef consumption are included in 2020 U.S. Dietary Guidelines, and are not removed as a result of Congressional or special interest pressure.

**Rationale:**
These guidelines form the bases of school lunch programs and are a major educational tool for the public at large.

---

**Intervention 2:** Beef-free meals in student, work and prison canteens (Institutional Reform)

**Description:**
Convincing large institutions, such as cafeterias, prisons, and schools, to reduce their meat consumption by 10-20% could significantly reduce the amount of meat consumed. Convincing a large company like Aramark would have large scale implications across the US. Alternatively, one could introduce beef-free days of the week, if opposition is expected to ban out beef completely.

**Rationale:**
If the catering service is willing to cooperate, this intervention is relatively easy to implement and highly effective. Provide training and create materials (e.g., toolkits) to caterers and service providers in university and school meals’ systems to develop and provide appetizing plant-based meals to students. Encouraging and empowering institutional change has the potential to reach a large number of consumers at relatively low cost. Providing positive experiences with plant-based meals has the potential to shape attitudes and future behaviors of consumers. If beef is no longer on the menu, people cannot choose to eat it. Consequently, beef consumption reduces. This intervention may even go unnoticed to many consumers. Institutional reform already has a proven track record in the US (and Brazil) and could be significantly scaled up and intensified.
### Intervention 3: Further Development of Beef Alternatives

**Description:**
Continue making advances in food science so that people can eat things that look, taste, and smell like beef without the same negative impacts on the environment and animal welfare. Create affordable plant-based or cultured meat alternatives that are viable alternatives to beef.

**Rationale:**
People are creatures of habit, and food choice is highly driven by taste and availability. If you make it easy for them to eat tasty, cruelty-free (and eventually more affordable) alternatives, they likely will. Decent plant-based products already exist (Beyond Burger, Impossible Burger). If we can significantly increase the amount of time and resources we put into created better products and scaling them, I believe many products currently containing beef could be replaced with a plant-based alternative (both at institutions and individually). Cultured meat is also a promising option, but the timeline is less clear.

### Intervention 4: Advocate for greater proportion of plant purchases by large scale sellers of meals

**Description:**
Ask major food service companies like Aramark and Sodexo to commit to cutting purchases of beef and increasing purchases of produce.

**Rationale:**
The business models of large-scale sellers of meals - like the major food service companies in the U.S. - require them to more responsive to increasing demand for plant-forward menus.
**Intervention 5: Tailored behavioural interventions**

Description:
This intervention starts with detecting where in the process of change people are. Then - for example with an app or online platform - people receive targeted information designed to answer the questions and challenges they have at the moment. According to theory, the stages are as follows:

1) Predecision Stage = people are unaware of the problems connected to beef consumption and not willing to change = main question: Why should I do something? = information about the why is important (Norms, Values, awareness of need, awareness of consequences, emotional reactions, ...)

2) Preaction Stage = people want to act but do not know how = main question: What can I do? What are the alternatives? = information about alternatives and their implementation is important (attitudes, PBC)

3) Action Stage = people have decided what to do and need to implement it / try it = main question: How do I implement this in my everyday life? How do I overcome obstacles? = practical information (shops where alternatives can be bought, recipes, ...) is important (procedural knowledge)

4) Postaction stage = people have tried and need to stabilize new behavior = main question: how do I make this a habit? What do I do, if I "failed" (I had such a tasty burger the other day, am I a failure now?) = social support, information on less beef in everyday life, information on strategies against "relapse" are necessary.

Rationale:
According to stage models of behavior change (e.g., Bamberg), people need to go through different steps in changing habitual behavior and providing them with information that is not adapted to their stage of change will reduce the effectiveness, maybe even cause resistance. Thus, detecting stage of change and then targeting information provided is considered important to reduce the information people get to something that they can handle in everyday life.
**Intervention 6:** Challenge the normalisation of 'food' animals', conceptions of 'food animal farming as natural, and understandings of meat as natural and necessary. Unsettle and uncouple associations of 'meat' or 'beef'  

**Description:**  
Highlight and question normalised representations of 'food' animals, 'meat' and animal farming. Change the normalised language used to talk and write about 'meat' 'food' animals and farming to start to counter and unsettle normalised constructs.  

**Rationale:**  
Foregrounds that understandings of 'meat', 'food' animals and animal agriculture as natural and necessary are entirely socialised human constructs. Introduces the opportunity to think, talk and act differently with regards to 'meat', 'beef' and 'food' animals.
## Intervention 7: Challenge misrepresentations and misunderstandings of plant-based diets

**Description:**
Directly counter negative and inaccurate conceptions of plant-based diets using science-based evidence.
Encompassing production methods (organic non-animal manures, fertilizers etc.), GHGs and other environmental impacts, economics (trade, revenue, jobs etc.), nutrition (protein, B12, iron), and what happens to 'the animals'.

**Rationale:**
Addresses the role that negative constitutions of plant-based diets, and the practices and people they involve, play in reinforcing and further stabilising commitments to 'meat' - through fear or being associated with or becoming the transgressive, subversive 'other'.

## Intervention 8: Health messaging/campaign

In my research (environmental communication / environmental psychology), it is a common finding that health related arguments often resonate better with larger groups of the public than environmental arguments.

This makes campaigns focussing on the health effects of reducing beef consumption potentially more effective than campaigns focussing on other benefits.

Important is, to provide people with information about health threats of consuming too much beef AND to provide people with information about health threats of consuming too much beef AND benefits of eating alternatives AND information about how to implement that in everyday life. Social marketing campaigns, supported by other means (e.g. GPs/Medics advice to patients, skills and training in how to cook without beef/meat, availability of alternatives) about reducing beef for health reasons.
**Intervention 9: Strategic communication campaign**

**Description:**
Strategically planned dissemination

**Rationale:**
A consistent and continuous communication of the main facts at stake will reach the public best overtime. However, changing political directions might hinder such a programme.

**Intervention 10: Encourage consumers to eat more plant-based meals rather than other meats**

**Description:**
Avoid endorsing other meats as alternatives to beef consumption, and focus on promoting more plant-based eating instead

**Rationale:**
There is evidence that some groups of consumers may find it difficult to interpret guidelines and information on different types of meat. Encouraging transitions from beef to more plant-based meals conveys a clear message and boosts additional health and environmental co-benefits.
**Intervention 11:** Internalise the environmental cost of beef

Description:
Polluter pays principle to ensure the societal cost is included in consumers price

Rationale:
Difficult to calculate, large opposition

**Intervention 12:** Better nutrition education for physicians in med school

Description:
Currently physicians get almost no training on nutrition, and even less on the environment.

Rationale:
If physicians understood the rationale for cutting out beef consumption, they could better counsel their patients to make improved dietary choices. Additionally, it might eventually compel groups like the AMA to support policy change around beef.
| Intervention 13: Cooking classes without beef in cooking schools |
| Description: |
| Since preparing meals with beef can be a habit and habits are formed early, it is important to form cooking habits that exclude beef. Cooking skills can be taught at schools, also to promote healthy eating. |
| Rationale: |
| The feasibility of this intervention depends on the facilities at school and the willingness of teachers to adapt their teaching materials. |

| Intervention 14: Foster better conditions and training for small-scale cow/calf operators |
| Description: |
| Policy and research efforts should be directed towards improving the livelihoods and security of rural communities and finding ways to foster environmental sustainability therein- including cow/calf operators - rather than on efforts to encourage people to eat less beef. Market pressures often drive farmers out of business or into bigger operations - where cattle are turned into mass commodities. Finding ways to relieve these pressures and encourage multiple land use practices that are more sustainable - are significant. |
| Rationale: |
| In the long run, improving the livelihoods and security of rural communities is important. Health and environmental policy disproportionately focus on fixing consumption and not addressing production – this institutional bias is a bit part of the problems we currently face. |
### Intervention 15: Manipulate perceived dynamic norms

Description: Frame plant-based meals as increasingly popular and mainstream

Rationale:
Providing information about how behavior is changing can cause people to ‘pre-conform’ with environmentally friendly behaviors that contradict the status quo before they become mainstream.

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### Intervention 16: End the Beef Checkoff Program

Description:
Commodity check-off programs such as the beef check off program (https://www.beefboard.org/about/faq_aboutcheckoff.asp) require producers to support generic advertising campaigns for their products. The well known "Beef. It's what for dinner" campaign was funded by check off programs.

Rationale:
Ending this would end marketing for beef as a product in of itself.


**Intervention 17:** Change the availability

**Description:**
This intervention is about reducing the availability of beef and increasing the availability of alternatives. Buffets for example often present meat/beef alternatives as the first thing you encounter, so you put it on your plate right away. On menus, beef is often presented first, so you read about it and choose before you read about alternatives. In addition, alternatives are often not presented in the same "tasty" language. This intervention would rearrange the availability of options. Alternatives to beef would be highlighted, beef alternatives would be "hidden" more in the background. It could even be on a buffet that you can have beef, but need to ask for it. Or go to another room to get it, or have to search more, or bend down. Another component would be to reduce the size of beef portions, meaning that people still get their steak but it is not the size of a smaller US state. In supermarkets, the beef would be available, but less highlighted than alternatives.

**Rationale:**
The rationale behind this intervention package would be to keep people's freedom of choice (important, especially in the US), but making beef less attractive by making it less visible, less easy to pick. In addition, does this communicate also norms about that is "accepted" to choose.

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**Intervention 18:** Inclusion of environmental considerations in dietary guidelines

**Description:**
This was almost achieved in the prior set of guidelines, but was removed after push back from Republican Congress people and the USDA.

**Rationale:**
Consideration of environmental health as well as nutrition in the guidelines would lead to a recommendation for reduced beef consumption, which would filter down to schools and nutrition programs.
### Intervention 19: Promote greater reflexivity as to the complex drivers behind Industrial meat production

**Description:**
Rather than focus on consumption, more policy and research efforts need to address systems of beef production. I suspect that beef consumption - on a global scale - is the problem and is driven by industrial practices.

**Rationale:**
Beef production - including slaughtering, processing, and marketing - is a global enterprise that is driven by export-oriented trade regimes. A national focus on increasing global trade can lead to marketing efforts to increase global beef consumption and 'beggar thy neighbor' practices where small-scale beef producers from one country are pitted against beef producers from another.

### Intervention 20: Meat/Beef Free Days

**Description:**
Information and a campaign to agree to go meat/beef free at least one day per week. A small amount of funds required setting up the initiative and maintaining momentum, providing how-to’s etc. Generally involves the main evening meal.

**Rationale:**
Shown to be effective in Australia - becomes more than a campaign as can result in practice change; one day per week appears reasonable to most people; can have a significant impact if enough people do it (all else remaining equal); can be a first step in the right direction.
Experts thoughts on a role for conservation science and practice

In response to the survey question about the potential contribution that conservation science and practice could have in reducing beef consumption, experts provided a variety of responses, including some conflicting recommendations. Multiple experts suggested that engaging in research and interventions targeting beef consumption will require work in transdisciplinary teams to examine ‘different perspectives of stakeholder groups on meat purchasing and consumption behaviors.’ Experts were concerned about ‘condemning beef’, adding that conservation scientists should be engaging in research that will assist ‘transitions from beef production to other livelihoods’ (Figure 4.3). Some experts recommended ‘incremental approaches’ to reducing beef consumption, including promoting flexitarianism (meat consumption in moderation), while others advised against this as it could entrench the belief that meat consumption is morally acceptable.

Experts recommended engaging conservation NGOs, in order to leverage their experience and capacity for advocacy and research translation, to help secure adequate resources, and drive a ‘research-informed agenda’. This could manifest in multiple ways including public campaigns to ‘connect beef to biodiversity issues’, developing sustainability criteria for businesses related to beef and biodiversity issues, and targeting businesses and governments to change policies related to beef consumption and production (Figure 4.3). Some experts also suggested that NGOs should ‘take a more strident stance publicly and incorporate meatless meal policies into their organizations’. Reiterating this, an expert stated that conservationists should be role models and ‘need to be seen [in our own behavior] to be reducing beef consumption’.
APPENDIX C

Figure C1. Flow diagram of review process

```
Identify

Records identified through Web of Science (n = 3426)

Screen

Records screened (n=3426) → Records excluded (n=2668)

Assess Eligibility

Abstracts assessed for eligibility (n=758) → Abstracts excluded, with reasons (n=186)

Full-text articles assessed for eligibility (n=572) → Full-text articles excluded, with reasons (n=319)

Include

Studies included in qualitative and quantitative synthesis (n =253)
```
Review protocol questions

Table C1. Predictive review protocol questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter</td>
<td></td>
</tr>
<tr>
<td>1. Is the paper environmentally focussed?</td>
<td>Yes;</td>
</tr>
<tr>
<td></td>
<td>No, it is not about a human induced environmental issue</td>
</tr>
<tr>
<td>2. Does the paper seek to forecast or predict human behaviour?</td>
<td>Yes;</td>
</tr>
<tr>
<td></td>
<td>No, it is a review;</td>
</tr>
<tr>
<td></td>
<td>No, it is not predictive;</td>
</tr>
<tr>
<td></td>
<td>No, it reports a conceptual framework for a predictive tool;</td>
</tr>
<tr>
<td></td>
<td>No, it is predictive but not of a human behaviour</td>
</tr>
</tbody>
</table>

| Environmental issue                                                      |                                                                         |
| 3. What type(s) of environmental threat or action (IUCN categories) does the paper address? | Residential and commercial development;                                  |
|                                                                           | Agriculture and aquaculture;                                           |
|                                                                           | Energy production and mining;                                          |
|                                                                           | Transportation and service corridors;                                  |
|                                                                           | Biological resource use;                                              |
|                                                                           | Human intrusion and disturbance;                                       |
|                                                                           | Invasive species;                                                     |
|                                                                           | Pollution;                                                             |
|                                                                           | Climate change (not energy consumption);                              |
|                                                                           | Water Use;                                                            |
|                                                                           | General;                                                              |
|                                                                           | Energy consumption;                                                   |
|                                                                           | Pay for conservation;                                                 |
|                                                                           | Green Consumerism;                                                    |
|                                                                           | Civic Engagement (voting, activism)                                    |

4. Please specify the issue.

5. Where is the geographic location of the research?

6. Is it a specific or general environmental behaviour? Specific behaviour; Behaviour is measured by a general behavioural intentions scale or a general self-report list (i.e., Schultz (2002) proenvironmental behaviour self-report measure)

7. What is the social scale of the predicted behaviour? Individual; Household; Community; Societal; Multiple scales

8. What types of predictive tools are used? Psychological theories and measures (e.g., Theory of Planned Behaviour, Values-Beliefs-Norms, psychographic market segmentation); Behavioural experiments (psychological and economic) Choice models (discrete choice experiments, contingent valuation); Models of rational choice (game theory, utility maximisation); Agent-based models; Bayesian Belief Networks;
<table>
<thead>
<tr>
<th>Appendix C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular automata;</td>
</tr>
<tr>
<td>Machine learning (cluster analysis, self-organising maps, artificial neural networks, decision trees);</td>
</tr>
<tr>
<td>Markov Chain Monte Carlo distributions;</td>
</tr>
<tr>
<td>Qualitative models (cognitive maps, mental models, conceptual models);</td>
</tr>
<tr>
<td>Graph theory tools (network analysis, causal loop diagram, fuzzy cognitive mapping);</td>
</tr>
<tr>
<td>Systems dynamic models;</td>
</tr>
<tr>
<td>Expert elicitation;</td>
</tr>
<tr>
<td>Foresight tools (horizon scanning, projections, back-casting, forecasting);</td>
</tr>
<tr>
<td>Role playing games;</td>
</tr>
<tr>
<td>Bio-economic modelling;</td>
</tr>
<tr>
<td>Socio-economic data correlations;</td>
</tr>
<tr>
<td>Social-ecological decision-making frameworks;</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9. What type(s) data is used?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualitative</td>
</tr>
<tr>
<td>Quantitative</td>
</tr>
<tr>
<td>Both</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10. What type of method(s) is used?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empirical</td>
</tr>
<tr>
<td>Conceptual</td>
</tr>
<tr>
<td>Both</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11. Is it an explanatory or anticipatory prediction?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticipatory</td>
</tr>
<tr>
<td>Both</td>
</tr>
<tr>
<td>Unsure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12. Does the tool allow for feedback?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Unsure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>13. If it is an anticipatory prediction, how far into the future is it predicted?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide number of years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>14. Was uncertainty considered?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes;</td>
</tr>
<tr>
<td>Yes, it acknowledges it but no specifics;</td>
</tr>
<tr>
<td>No, the paper neglected to mention uncertainty;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>15. What methods were used to incorporate uncertainty into the prediction?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario analysis (comparison of different, internally consistent, sets of assumptions about the future);</td>
</tr>
<tr>
<td>Multiple models (assessment is carried out using different models of the same system);</td>
</tr>
<tr>
<td>Averaging of multiple runs (Agent-based models; Cellular automata);</td>
</tr>
<tr>
<td>Sensitivity analysis (varying parameters of the analysis);</td>
</tr>
<tr>
<td>Probabilistic - Monte Carlo analysis (statistical technique for stochastic model calculations);</td>
</tr>
<tr>
<td>Probabilistic - Bayesian (a graphical model that represents a set of variables and their conditional dependencies);</td>
</tr>
<tr>
<td>Other (please describe)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>16. Is the prediction evaluated?</th>
</tr>
</thead>
<tbody>
<tr>
<td>No;</td>
</tr>
<tr>
<td>Yes, by cross validation;</td>
</tr>
<tr>
<td>Yes by validation;</td>
</tr>
<tr>
<td>Yes, by controlled experiment;</td>
</tr>
<tr>
<td>Yes, by before-after-control-intervention (counterfactual);</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>
17. Does the research provide decision-making guidance?

No;
Yes, offers general guidance;
Yes, provides a section devoted to discussing recommendations or a list of recommendations.
APPENDIX D

1. Ethics approval

2. Ethics amendment approval
Notice of Approval

Date: 26 February 2018
Project number: CHEAN A 21314-01/18
Project title: ‘Prioritising Human Behaviors for Better Environmental Policy Decision-making’
Risk classification: Negligible risk
Chief investigator: Professor Sarah Bekessy
Status: Approved
Approval period: From: 26 February 2018 To: 26 February 2021

The following documents have been reviewed and approved:

<table>
<thead>
<tr>
<th>Title</th>
<th>Version</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Assessment and Application Form</td>
<td>2</td>
<td>8 February 2018</td>
</tr>
<tr>
<td>Participant Information Sheet and Consent Form</td>
<td>3</td>
<td>23 February 2018</td>
</tr>
<tr>
<td>Sample Email Invitation</td>
<td>2</td>
<td>23 February 2018</td>
</tr>
<tr>
<td>Sample Recruitment Advertisement</td>
<td>1</td>
<td>8 February 2018</td>
</tr>
<tr>
<td>Permission to use SWARM Platform</td>
<td>1</td>
<td>8 February 2018</td>
</tr>
<tr>
<td>Screenshot of SWARM Platform</td>
<td>1</td>
<td>8 February 2018</td>
</tr>
<tr>
<td>Response to CHEAN</td>
<td>1</td>
<td>23 February 2018</td>
</tr>
</tbody>
</table>

The above application has been approved by the RMIT University CHEAN as it meets the requirements of the National Statement on Ethical Conduct in Human Research (NH&MRC, 2007).

Terms of approval:

1. Responsibilities of chief investigator
   It is the responsibility of the above chief investigator to ensure that all other investigators and staff on a project are aware of the terms of approval and to ensure that the project is conducted as approved by CHEAN. Approval is valid only whilst the chief investigator holds a position at RMIT University.

2. Amendments
   Approval must be sought from CHEAN to amend any aspect of a project. To apply for an amendment use the request for amendment form, which is available on the HREC website and submitted to the CHEAN secretary. Amendments must not be implemented without first gaining approval from CHEAN.

3. Adverse events
   You should notify the CHEAN immediately (within 24 hours) of any serious or unanticipated adverse effects of their research on participants, and unforeseen events that might affect the ethical acceptability of the project.

4. Annual reports
   Continued approval of this project is dependent on the submission of an annual report. Annual reports must be submitted by the anniversary of approval of the project for each full year of the project. If the project is of less than 12 months duration then a final report only is required.

5. Final report
   A final report must be provided within six months of the end of the project. CHEAN must be notified if the project is discontinued before the expected date of completion.

6. Monitoring
   Projects may be subject to an audit or any other form of monitoring by the CHEAN at any time.
Appendix D

Design and Social Context College Human Ethics Advisory Network (CHEAN)
Sub-committee of the RMIT Human Research Ethics Committee (HREC)

Notice of Approval

Date: 21 November 2018
Project number: CHEAN A 21314-01/18
Project title: ‘Prioritising Human Behaviors for Better Environmental Policy Decision-making’
Risk classification: Negligible Risk
Investigator: Professor Sarah Bekessy, Mr Matthew Selinske
Approved: From: 21 November 2018 To: 26 February 2021

I am pleased to advise that your amendment request has been granted ethics approval by the Design and Social Context College Human Ethics Advisory Network (CHEAN), as a sub-committee of the RMIT Human Research Ethics Committee (HREC). The CHEAN approves the addition of an online expert elicitation workshop and a nominal group techniques workshop. The CHEAN notes the revised recruitment email, participant information sheets, and consent form.

Terms of approval:

1. Responsibilities of investigator
   It is the responsibility of the above investigator/s to ensure that all other investigators and staff on a project are aware of the terms of approval and to ensure that the project is conducted as approved by the CHEAN. Approval is only valid whilst the investigator/s holds a position at RMIT University.

2. Amendments
   Approval must be sought from the CHEAN to amend any aspect of a project including approved documents. To apply for an amendment please use the ‘Request for Amendment Form’ that is available on the RMIT website. Amendments must not be implemented without first gaining approval from CHEAN.

3. Adverse events
   You should notify HREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.

4. Participant Information Sheet and Consent Form (PISC)
   The PISC and any other material used to recruit and inform participants of the project must include the RMIT university logo. The PISC must contain a complaints clause.

5. Annual reports
   Continued approval of this project is dependent on the submission of an annual report. This form can be located online on the human research ethics web page on the RMIT website.

6. Final report
   A final report must be provided at the conclusion of the project. CHEAN must be notified if the project is discontinued before the expected date of completion.

7. Monitoring
   Projects may be subject to an audit or any other form of monitoring by HREC at any time.

8. Retention and storage of data
   The investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

Please quote the project number and project title in any future correspondence.

On behalf of the DSC College Human Ethics Advisory Network, I wish you well in your research.

Dr David Blades
DSC CHEAN Secretary
RMIT University
E: dscethics@rmit.edu.au
APPENDIX E

Published versions of Chapters 2 and 6.
