2023

Sustaining Development Through Biodiversity Offsets

Linda Abdo
The University of Notre Dame Australia

SUSTAINING DEVELOPMENT THROUGH BIODIVERSITY OFFSETS

Linda J. Abdo

B.Sc. (Marine Science) (Hons)

Submitted in fulfilment of the requirements for the Doctor of Philosophy

The University of Notre Dame Australia

School of Arts and Sciences

Fremantle Campus

March 2023

Declaration

To the best of my knowledge, this thesis contains no material previously published by another person, except where due acknowledgement has been made.

This thesis is my own work and contains no material which has been accepted for the award of any other degree or diploma in any institution.

Signature:

Print Name: Linda Jane Abdo

Date: 16/03/2023

Abstract

Biodiversity offsets, also called “environmental offsets”, are actions used to compensate for the loss of biodiversity and social values associated with development projects. They are commonly used by governments to contribute to ecologically sustainable development (ESD); however, offsets have been criticised for inappropriate use, poor implementation, and inadequate monitoring, reporting and enforcement. Regardless, use of offsets is likely to increase due to regulatory convenience in easing community discomfort with development impacts. This thesis investigated how biodiversity offsets in Australia can be enhanced to align with ESD principles. Analyses of peer-reviewed journal articles, published reports, media articles and legislative instruments for biodiversity offsets across Australian jurisdictions was used to determine requirements, similarities, equity, effectiveness and transparency in application. These analyses were then used to develop a model for biodiversity offsets that balances the three key aspects of ESD (environmental, social, economic).

A comparison of policy and legislation in Australian jurisdictions found inconsistency and gaps in equity, transparency, measurability and effectiveness. Furthermore, Australian Commonwealth offset requirements were not improved (mature) after implementation of a biodiversity offset policy in October 2012. These learnings and further review were used to identify that cost and risk considerations, and use of strategic planning frameworks, bonds and advanced offsets, were key to improving offset use for ESD. Inclusion of conservation trust funds to deliver biodiversity offsets aligned with ESD principles, made the offsets model developed in this thesis suitable in areas with a paucity of available land. Finally, assignment of responsibilities, coupled with interchangeability of roles and a focus on collaboration, was found to be important for ensuring offsets are efficient, ethical, robust and strategic.

While this research has been developed in an Australian context, the findings have broader applicability globally, with the ability to address nature positive requirements and international commitments to protect biodiversity and minimise climate change.

Acknowledgements

As with many projects of this size, this thesis was a long process with many to thank along the way. Firstly, I would like to thank my longest standing supervisors: Annabeth Kemp and Sandy Griffin for their support since the very beginning. Grey Coupland for coming in with renewed energy, focus and expertise. Linda Davies for editorial assistance at the end to get the final thesis completed for examination. It goes without saying, but without their support and advice this thesis would not have been completed. Additional thanks go to Tim Meagher for assistance with the initial conceptualisation of the research question and thesis topics.

I have also been in the very privileged position to have benefitted from the support, experience and advice of several excellent scientists from my professional career. This has enabled me to push my thinking, supported my, sometimes quirky, ideas and encouraged me to continue through this difficult journey. Thanks for believing in me and my work, showing me it can be done, listening, supporting me through moments of self-doubt and reassuring me when I was on the right track.

A huge thanks goes to my friends and family for their practical, physical and emotional support. Like many, the juggle between work, study and family has been very difficult and without your love and support I would not have been able to complete this work. Especially to my Mum, Joan and Ali for your help with family life when work and study was too much.

The greatest thanks go to Dave, for being my true partner in all things in this life. Thank you for being a sounding board, reviewing my work and providing advice throughout this time. Your love and support are everything to me. Not only is more possible, but my life is far richer with you.

Finally to Olivia, Ava and Wesley. While this thesis may have been quicker and easier without you, it would be far less meaningful. This work is ultimately for you.

This research has been funded by an Australian Government Research Training Program Scholarship.

Publications

List of publications arising from this thesis

Thesis chapter	Status	Reference
Chapter 2	Published in Environmental Management and Sustainable development	Abdo, L., Griffin, S., & Kemp, A. (2019). Apples for Oranges: Disparities in Offset Legislation and Policy among Jurisdictions and its Implications for Environmental Protection and Sustainable Development in Australia. *Environmental Management and Sustainable Development*, 8(1). https://doi.org/10.5296/emsd.v8i1.14081
Chapter 3	Published in the Australasian Journal of Environmental Management	Abdo, L., Griffin, S., Kemp, A., & Coupland, G. (2021). Disparity in biodiversity offset regulation across Australia may impact their effectiveness. *Australasian Journal of Environmental Management, 28*(2), 81–103. https://doi.org/10.1080/14486563.2021.1919231
Chapter 4	Published in Environment, Development and Sustainability	Abdo, L. J., Griffin, S, Kemp, A., & Coupland, G. (2024). Has a dedicated biodiversity offsets policy improved the environmental and social compensation outcomes of development in Australia? *Environment, Development and Sustainability.* doi: 10.1007/s10668-024-05108-0
Chapter 5	Published in the Journal of Sustainable Development	Abdo, L., Kemp, A., Coupland, G., & Griffin, S. (2019). Biodiversity Offsets Can Be a Valuable Tool in Achieving Sustainable Development Developing a Holistic Model for Biodiversity Offsets That Incorporates Environmental, Social and Economic Aspects of Sustainable Development. *Journal of Sustainable Development, 12*(5). https://doi.org/10.5539/jsd.v12n5p65

Table of contents

List of tables

List of figures

Chapter 1

General Introduction

“The proper use of science is not to conquer nature, but to live in it.”

Barry Commoner

1.1 Research purpose

The purpose of this research was to enhance the use of biodiversity offsets in their contribution to sustainable development, using an Australian context as a model for global improvement.

Through the review and comparison of legislation and publicly available reports and peer-reviewed articles, this thesis aims to develop a model for the design, implementation and completion of offsets that also ensures the enduring management and protection of biodiversity, ecosystem function and services. This model will ultimately benefit development proponents and regulators alike, ensuring positive ecological and social outcomes for both the immediate and greater community.

The research question ‘how biodiversity offsets can be enhanced to meet the requirements of sustainable development?' was addressed through the following aims:

1. What are the requirements for biodiversity offsets in Australian Commonwealth, states and territories and are these offset requirements consistent with the principles of sustainable development?
2. Are legislative and policy requirements in Australia sufficient to ensure biodiversity offsets adequately compensate for development impacts by ensuring equity and effectiveness through measurability, enforcement and transparency?
3. Are biodiversity offsets in Australia mature[1] and / or improved in maturity since the introduction of a dedicated biodiversity offset policy?
4. Can a model for biodiversity offsets be developed that balances best practice biodiversity offset elements with the principles of sustainable development?
5. What roles and responsibilities should various parties take to ensure that offsets are aligned with best practice and capable of achieving sustainable development?

[1] For the purpose of this research, the term ‘maturity’ in this context refers to the display of greater transparency or an ability to assure improved ecological outcomes.

6. Can biodiversity offsets that support sustainable development be delivered in areas with a paucity of appropriate available land?

The global issue of biodiversity loss, compensation for biodiversity loss through biodiversity offsets, and the background to sustainable development is presented and discussed here to provide a better understanding of this study's significance. Biodiversity offsets were evaluated in an Australian context, and therefore the current use of biodiversity offsets in Australia have been summarised.

1.2 Background to research

Biological diversity (henceforth 'biodiversity') is the variety of life and is essential for our existence. Biodiversity as a collective term encompasses all aspects of life, including genetic, organismal and ecological diversity, working in a functional ecosystem. The term is formally defined by the Convention on Biological Diversity as: "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." (CBD, 2006). Estimates of biodiversity range between 3 and 100 million species worldwide (CBD, 2009).

That variability and those inter-linkages are critical in supporting ecosystem function and ecological stability (Godbold & Solan, 2009; Lefcheck et al., 2015; Lohbeck et al., 2016; Oliver et al.,2015). Biodiversity influences the functioning of ecosystems as different species can drive different functions or can vary in the functions provided under different environmental conditions (Duffy, 2009; Gamfeldt et al., 2008; Hillebrand & Matthiessen, 2009). Biodiversity is also important to the maintenance and resilience of ecosystem functions, particularly where species turnover is high (Hooper et al., 2005; Lohbeck et al., 2016) and can guard against natural disasters (CBD, 2009). Increases in biodiversity are related to greater stability and increased biomass and resource use (Duffy, 2009). High biodiversity can guard against loss of function where ecosystem services are utilised, particularly where ecosystem complexity is poorly understood (Duffy, 2009), and can improve the performance of industries that rely on environmental products such as forestry and agriculture (Johansson et al., 2013; Thrupp, 2004).

The effect of biodiversity on structure and function of ecosystems also has implications for ecosystem services (Duffy, 2009), that in turn provides essential services for human health, supports social and mental wellbeing, livelihoods and economic prosperity (Christie et al. 2012; Romanelli et al., 2015). Biodiversity is a key environmental determinant of human health (Romanelli et al., 2015) and has strong links to cultural identity (CBD, 2009). Many of those provided services are irreplaceable, and if biodiversity is impacted, permanent losses of food sources for humans and stock, environmental sources of energy and materials, genetic resources and medicines may result (Díaz et al., 2019). Loss of biodiversity has been associated with poverty and increase in vector-borne diseases (Alho, 2012). The sustainable use of the natural environment will allow future generations to meet their needs (IISD, 2017).The international Convention on Biological Diversity has been broadly accepted as providing a guidance for “the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding” (CBD, 2006). This Convention, signed by 150 different countries at the Rio Earth Summit in 1992, signifies the importance of the preservation of biodiversity on a global scale (CBD, 2009).

1.3 Biodiversity loss

Biodiversity loss, involving the loss of genetic, species and/or ecological diversity and functionality, is a global crisis that requires immediate action (Almond et al., 2020; Mace et al., 2018). Approximately one-fifth of the earth's land area is degraded (UN, 2020), negatively impacting the world’s biodiversity and contributing to both loss of biodiversity and species extinction. Decline of biodiversity is at its highest rate ever (Almond et al., 2020; Díaz et al., 2019; Mazor et al., 2018), with evidence that the globe is currently experiencing its sixth mass extinction (Cowie et al., 2022). Currently, approximately 1 million species are threatened with extinction, with many likely to be lost in the coming decades (Díaz et al., 2019). The exact loss of biodiversity to date is unknown, although estimates put this at approximately 30% (uncertainty range: 16–

50%) (Isbell et al., 2022). Loss of biodiversity can have catastrophic impacts on economic, ecological life support, recreation, cultural, scientific aspects, as well as on food security, and human health and wellbeing (Díaz et al., 2006; Marselle et al., 2021; Almond et al., 2020).

Anthropogenic influences are the greatest cause of species extinction (Almond et al., 2020; Bull & Maron, 2016). Increasing anthropogenic impacts associated with population growth, resource consumption, economic development and climate change have resulted in an unprecedented rate of biodiversity loss over the past 50 years (Bellard et al., 2012; Birkeland & Knight Lenihan, 2016; Díaz et al., 2019; Pörtner et al., 2021; Warren et al., 2013). Almost all landscapes have been negatively impacted by human drivers; 75% of global landscapes have undergone significant alteration and 85% of wetlands have been lost (Díaz et al., 2019). Significant areas of the ocean (66%) are also experiencing increasing cumulative impacts of human alteration (Díaz et al., 2019). Changes to land and sea use (expansion/intensification of use for agriculture and aquaculture) and direct exploitation (fishing, logging, hunting and wildlife trade) are the predominant drivers of biodiversity loss (Jaureguiberry et al., 2022).

Development is further contributing to these impacts; the size of urban areas around the world has doubled since 1992 and the need for associated services has resulted in direct removal of forests, wetlands and grasslands, increasing pressure on vulnerable ecosystems and species, and contributing to further biodiversity loss (Díaz et al., 2019). Without a drastic reduction in human population, greater consideration of how the use of environmental resources can both be better managed and compensated for is required, emphasising the significance of this research.

1.4 Mitigating biodiversity loss

The loss of biodiversity has been identified as a critical global issue and efforts to reverse this are viewed as critical to human survival. In recognition of this, on December 2022, the 15th Conference of Parties to the UN Convention on Biological Diversity adopted the “Kunming-Montreal Global Biodiversity Framework”, a set of targets developed to critical to address critical loss of biodiversity and the restoration of natural ecosystems (UN, 2022).

While there are many different causes of biodiversity loss, where land clearing, exploitation and development occurs, biodiversity loss can be mitigated through the application of the Mitigation Hierarchy of avoid, minimise, rehabilitate and offset (TBC, 2015). These sequential steps refer specifically to impacts on biodiversity and ecosystems caused by development (TBC, 2015). Impacts are first minimised through avoidance of impact or the use of physical, operational or abatement controls to minimise impacts to biodiversity and ecosystems (TBC, 2015). Residual impacts are then compensated for through onsite (restoration/rehabilitation) or offsite (biodiversity offsets) conservation projects (TBC, 2015).

The Mitigation and Conservation Hierarchy (MCH) builds on the Mitigation Hierarchy with the aim of reversing biodiversity loss more holistically (CH, 2023). The MCH describes four sequential steps that mitigate previous impacts and provide additional conservation potential:

1. Refrain – slows biodiversity loss through retaining and proactively protecting important species and ecosystems;
2. Reduce – slows biodiversity loss through minimising a) pressures on biodiversity, and b) further development/clearing/extraction on important species and ecosystems;
3. Restore – compensates for biodiversity loss through restoration / rehabilitation of previously impacted or degraded areas of marginal production;
4. Renew – use of biodiversity offsets to compensate for the significant residual impacts of development and additional conservation (CH, 2023).

Biodiversity offsets are key as a last stage in both the Mitigation Hierarchy and the MCH and, contrary to other stages, offsets cannot prevent biodiversity loss, but are rather used to provide compensation for biodiversity loss.

1.5 Biodiversity offsets

Biodiversity offsets, also known as ‘environmental offsets’, are a type of environmental compensatory scheme that can provide benefits for biodiversity and, consequently, improve human wellbeing (Ma, 2022). The International Business for Biodiversity Offsets Program (BBOP) defines biodiversity offsets as “measurable conservation

outcomes of actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken" (BBOP, 2019). Similarly, the International Finance Corporations (IFC) Performance Standard 6 defines biodiversity offsets as "measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development and persisting after appropriate avoidance, minimisation and restoration measures have been taken" (IFC, PS6). The most widely adopted aim of biodiversity offsets is to ensure, at a minimum, 'no net loss'; that is that overall offsets achieve a balance between environmental impacts and environmental compensation (Bigard et al., 2017; zu Ermgassen et al., 2019).

Biodiversity offsets are primarily used to provide environmental compensation in response to policy requirements, although in some cases they may be instigated voluntarily (GIBOP, 2019). The first introduction of compensatory schemes for biodiversity offsets is broadly recognised as the wetland compensation requirements in the United States of America in the 1970s (Benabou, 2014; Burgin, 2008). However, the Netherlands required forest offsets prior to this in 1960s, and biodiversity offsets were also required in France and Germany during 1970s (Bull et al., 2018; Moreno-Mateos et al., 2015). Regardless, it has only been in the last 10 to 15 years that offsets have become a popular policy instrument of governments globally, with an exponential increase in application particularly in the last five years. For example, in 2012 The Biodiversity Consultancy identified 29 countries (43 regions) with policies that either specifically required offsets or enabled their use (TBC, 2013). In 2014, the Organisation for Economic Cooperation and Development (OECD) found that there were at least 56 countries that required offsets (Levin & Olsson, 2015; Teklehaimanot, 2014), including 27 member states of the EU (Koh et al., 2014). As of 2019, the Global Inventory on Biodiversity Offset Policies (GIBOP) included over 100 countries that had or were developing biodiversity offset and other compensation policies (GIBOP, 2019). In addition to this, many financial institutions, such as the World Bank and the International Finance Corporation (IFC), have developed environmental and social guidelines that require borrowers to implement biodiversity offsets to compensate for potential or expected negative environmental impacts (Pilla, 2014).

Biodiversity offsets are required through policy following environmental impact assessment for residual significant environmental impacts that cannot be avoided or mitigated. An environmental impact assessment is a process used to identify the environmental impacts of a development (Bigard et al., 2017; CBD, 2010; Fortun, 2017). Consideration of avoidance, minimisation and then rehabilitation actions of the Mitigation Hierarchy prior to the use of offsets as compensation for residual significant impacts is recognised as best practice but is often not required by regulators (Arlidge et al., 2018; BBOP 2012; GIBOP, 2019). This thesis focusses on the examination of biodiversity offsets, which are implemented following environmental impact assessment and application of the Mitigation Hierarchy. Therefore, examination of environmental impact assessment and application of the Mitigation Hierarchy are not within the scope of this research.

Biodiversity offsets can be achieved directly through financial contribution, protection of land (averted loss), or conservation actions (restoration, rehabilitation, changes to management), or indirectly through contributions to improve knowledge of environmental matters whereby a paucity of information exists (Fallding, 2014; Maron et al., 2012). Biodiversity offsets can offer potential benefits for industry, government, and conservation groups alike (ten Kate et al., 2004), and are a way to contribute to sustainable development (Benabou, 2014; Fallding, 2014). The most recognised benefit of biodiversity offsets is their ability to address the conflict between development and conservation needs (e.g. Benabou, 2014; Clare & Krogman, 2013; Fallding, 2014; Koh et al., 2014; Lukey et al., 2017; McKenney & Kiesecker, 2010; Overton et al., 2013; Takacs, 2018; ten Kate & Jeter, 2012). However, they have the potential to offer a suite of other environmental, social, and economic benefits.

1.5.1 Benefits of offsets

Biodiversity offsets can ensure that developers are accountable for their impact by assigning economic, environmental and social value to biodiversity and ecosystem services and encouraging developers to avoid and/or mitigate environmental impacts, even in cases where offsets are not legally required (Gibbons et al., 2018; Kiesecker et al., 2009). Offsets can also provide funding and incentives for environmental conservation activities (Burgin, 2008; Fallding, 2014; Guillet & Semal, 2018; Kiesecker et al., 2009; Takacs, 2018), potentially resulting in an increase in the number and/or

coverage of protected areas and associated funding for management (Maron et al., 2015). When used strategically as part of conservation plans, there is an opportunity for biodiversity offsets to improve ecological connectivity (Rosa et al. 2022), and significantly contribute to regional conservation goals (Kiesecker et al., 2009; Takacs, 2018).

Social benefit can be derived from biodiversity offsets through the equitable provision of natural capital (Rohr et al., 2018; Walker et al., 2009), ensuring that disadvantaged communities have the same access to natural resources as more privileged communities. Further, reputational benefit can be gained by developers seeking community and regulatory support for a development, or by governments through improving community acceptance of a development project (Benabou, 2014; Burgin, 2008; Githiru et al., 2015; Kiesecker et al., 2009).

Economic outcomes of biodiversity offsets occur through the facilitation of development that might not otherwise be possible (Apostolopoulou, 2016; EDO, 2014; Fallding, 2014), increasing employment, economic stimulation, and government revenue through taxation. Biodiversity offsets can also generate economic benefits that are associated with conservation (e.g. employment, economic stimulation, ecotourism) (Fallding, 2014; Guillet & Semal, 2018) and through the lowering of costs associated with regulation and compliance (Evans, 2016; Hahn & Richards, 2013; Walker et al., 2009).

1.5.2 Criticism of offsets

Despite the potential benefits of biodiversity offsets, their implementation has been criticised for falling short in achieving these benefits. Globally, regulatory processes have been shown to inadequately consider environmental, social and economic priorities in balance (Clare & Krogman, 2013; Fallding, 2014; zu Ermgassen et al., 2019), therefore diminishing their effectiveness and equity (Clare & Krogman, 2013; Gardner et al., 2013; Grinlinton, 2017). Biodiversity offset regulation lacks clear and consistent guidelines (Fallding, 2014), enabling offsets to be open to broad interpretations and negotiation. The commodification of biodiversity, such as through biodiversity markets, can exacerbate these shortcomings as they can change the basis on which decisions are made away from environmental compensation due to the financial incentives that they create (Maron et al., 2016b). This may result in negative

environmental, social and economic outcomes, such as reductions in requirements for conservation and reduced confidence in the ability of biodiversity offsets to adequately compensate for the impacts of development.

Even where biodiversity offsets requirements are improved, the benefits of offset outcomes are often overstated (Bezombes et al., 2018; Gibbons et al., 2018; Maron et al., 2015; Nijnik & Miller, 2017). Regulators may also overestimate the background rate of loss (Evans, 2016), enabling developers to shift some of their impact to be reported as background loss. In this way, biodiversity offsets may be used to "greenwash" projects that are politically favourable by minimising perceived development impacts and allowing development to proceed despite significant environmental/social impacts (Coker et al., 2018) or without achieving real biodiversity compensation (Gelcich et al., 2017). Despite the findings of Evans (2016) and Gibbons et al. (2018) that vegetation clearing in Australia has not increased since the implementation of offsets, elsewhere, offsets have been accused of enabling projects that have not adequately considered avoidance and mitigation measures to proceed (Hahn et al., 2002; Phalan et al., 2017) or facilitating the approval of developments with significant impacts (Fallding, 2014).

1.5.2.1 Environmental disadvantages

Biodiversity offsets provide a legal loophole that allows destruction of protected species and ecosystems (Takacs, 2018), legitimising the destruction of the environment (Benabou, 2014; EDO, 2014). While the intention is that biodiversity offsets provide a commensurate environmental gain at another site, the environmental outcomes of biodiversity offsets are subject to many variables meaning that it is uncertain if adequate compensation of values lost can be achieved (Benabou, 2014). Additionally, there are ethical issues regarding both the commodification of nature, where a monetary value is assigned to threatened species and ecosystems that should be considered priceless (Gelcich et al., 2017; Takacs, 2018), and the replacement of entire ecosystems comprising of several niche habitats (Ghosh, 2015; Gibbons et al., 2018). Both these issues raise questions about the legitimacy of biodiversity offsets.

There is no evidence that biodiversity offsets can deliver on their purported gains to compensate for loss of biodiversity (Brady & Boda, 2017; Githiru et al., 2015; Koh et

al., 2014; May et al., 2017). Where offsets have been implemented, their outcomes have been shown to be ineffective and biodiversity loss has been found to continue in these areas (Fallding, 2014; Gibbons et al, 2018; May et al., 2017). For example, continued biodiversity loss in offset areas has been observed in relation to wetland mitigation programs in the United States of America (Clare & Krogman, 2013). Projects in Ohio, Massachusetts and California were reported by Taherzadeh and Howley (2018) to be unsuccessful in delivering positive environmental outcomes. May et al. (2017) also reported that at least 30% of offsets required in Western Australia over an 11-year time period were ineffective in delivering successful outcomes based on offset requirements. Even when apparently successful, gains are only measured against protected species or particular impacted species, and outcomes are unlikely to continue in perpetuity, thus, as a whole, a net loss of biodiversity may still occur (Githiru et al., 2015; Lukey et al., 2017; Maron et al., 2018; Reid & Nsoh, 2014).

1.5.2.2 Social disadvantages

Biodiversity offsets have been criticised for not adequately compensating loss of natural capital and associated resources (Rohr et al., 2018), focussing on protected species and habitats without consideration of social values, such as ecosystem services (Scholte et al., 2016) or recreational, aesthetic and cultural values (Takacs, 2018). In addition, biodiversity offsets have created an incentive for the displacement of people (Tupala et al., 2022). Traditional gender roles can mean that women are disproportionately disadvantaged by the adverse social consequences of changes to ecosystems. This was reported in Vietnam by Mabon et al. (2018) where women traditionally undertake most agricultural and household roles. In these instances, women are more impacted by ecosystem changes, yet are less likely to participate in decision making around these changes and have less access to resources that might allow them to relocate to a more favourable area.

Lack of consideration of negative impacts on communities, ignoring the cultural, spiritual and inherent values of nature and ecosystems and for allowing developments to proceed without adequately addressing related social issues are further criticisms of offsets (Bidaud et al., 2018; Githiru et al., 2015). For example, in India, governments are implementing offsets without community consultation in areas where forest tribes have rights (Narain & Maron, 2018). In China, Ali et al. (2018) reported a lack of

stakeholder participation and consideration of social rights in relation to payment for ecosystem services schemes. Lack of community participation can have several consequences, such as unemployment and poverty (Ali et al., 2018) and changes in land use (Lim et al., 2017), which can lead to resettlement, loss of access to critical resources or land dispossession (Benabou, 2014).

The commodification of nature through biodiversity offsets can cause inequities in the distribution of environmental values arising from offsets (Bidaud et al., 2018). This could be avoided through adequate community consultation. However, communities are not always consulted specifically about biodiversity offsets. Where consultation does exist, it must be representative of the whole community to ensure that societal values are appropriate and reflect a broad range of opinions (Benabou, 2014). Natural values must be distributed equitably, both spatially and temporally, to ensure development is sustainable and to prevent intergenerational inequity (Gibbons et al., 2018). However, biodiversity offsets policies rarely consider impacts on future generations (Macintosh, 2015; Nijnik & Miller, 2017) and therefore are questionable in terms of their contribution to sustainable development.

1.5.2.3 Economic disadvantages

Although replacement ratios (multipliers) have often been found to be insufficient to adequately compensate for environmental impact (Bull et al., 2017a; Laitila et al., 2014) it is also theoretically possible for the reverse to be true, where the requirement for biodiversity offsets may cause very high costs to developers that are disproportionate to the impact that eventuates from development, particularly where the offset is delivered prior to development (Fallding, 2014, Towie, 2011). These high costs could be caused by high replacement ratios based on a paucity of environmental data that do not eventuate delays from complicated approval processes and requirements to pay up front, even when impact is uncertain, rather than as impact is realised (Fallding, 2014). This can be prohibitively expensive, especially where there is a paucity of data for the ecosystem that will be impacted. For example, Lindenmayer et al. (2017) reported that adequate compensation for the loss of nesting trees would cost developers $26.9 million (Australian dollars in 2010), and Habib et al. (2013) reported that the estimated cost of effective biodiversity offsets among six different scenarios for an oil sands development in Alberta, Canada, was $25 million to $3.3

billion. If the costs of delivering the biodiversity offsets significantly outweighs the compliance costs of not delivering the offset at all, a disincentive for developers to fulfil the offset obligation can arise (Rohr et al., 2018).

While an advantage of biodiversity offsetting is that it can provide additional funding for conservation projects, a disadvantage of this approach is that it weakens the government role in conservation (Githiru et al., 2015). Biodiversity offsets create an economic burden on developers to manage areas outside of the area of the development's influence (Fallding, 2014) or to deliver projects that are in the remit of governments (Taherzadeh & Howley, 2018). While this can benefit developers through the recognition of net gain and its associated reputational benefits, where this does not occur and is instead a requirement of offsets, it essentially creates an additional environmental 'tax' on developers.

Biodiversity offsetting can cause further negative financial consequences for developers through delays for planning approvals, especially when regulators are not appropriately resourced to consider applications (Guillet & Semal, 2018). Where biodiversity offset projects are not well defined, developers can be forced to make commitments to very expensive environmental projects to secure approvals (Towie, 2011), or can pose a risk in terms of loss of investment due to the uncertainty of the outcome (Benabou, 2014).

Despite the criticisms of offsets presented here, biodiversity offsets have potential to provide significant benefits if designed and implemented in balance with the environmental, social and economic principles of sustainable development. Therefore this research intends to investigate how this can be achieved and provide recommendations for improvement.

1.6 The case for biodiversity offsets in sustainable development

Sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (IISD, 2017); WCED, 1987). The term 'sustainable development' first emerged in the 1980s as a way to capture the balance of between socio-economic needs for development and associated environmental and social concerns (Robinson, 2004).

The concept of sustainable development is underpinned by environmental, social, and economic aspects that must be considered in balance to ensure that natural values (biodiversity, ecosystem services and ecosystem function) are not compromised (Gibson, 2009; Moldan & Dahl, 2007; IISD, 2017; Macintosh, 2015). Environmental concerns include soil health, genetic diversity, ecological linkages and exchanges, ecosystem resilience and self-sustainability, loss of biodiversity, ecological pressures and threats (invasive species, destructive activities) (MEA, 2005). Social concerns include health and mental wellbeing, security, recreation and aesthetic appreciation, improved knowledge (cultural, scientific), basic material for life, and freedom of choice and action (MEA, 2005). Economic concerns include economic advantage, employment, training and capacity building, and tourism (MEA, 2005). While development can benefit economic and some social concerns, often environmental and some social concerns are negatively impacted. Therefore the purpose of sustainable development is to provide a balance between environmental, social and economic aspects, to ensure that natural values (biodiversity, ecosystem services and ecosystem function) that also provide benefits to people, are not compromised (Gibson, 2009; Moldan & Dahl, 2007; IISD, 2017; Macintosh, 2015).

The Importance of sustainable development has been recognised globally through the United Nations Agenda 21 and the Rio Declaration on Environment and Development and the subsequent development of the 2030 Agenda for Sustainable Development, which also includes the Sustainable Development Goals. These goals aspire to “recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.” (UN, 2019). However, sustainable development has several criticisms including its link to perpetuate economic growth and potential to legitimise the destruction of the environment (Robinson, 2004), as sustainable development, by definition, recognises that benefits and impacts to environmental, social and economic aspects will occur. Environmental impacts can be due to the development and related actions, while benefits are typically compensatory. Economic benefits arise from the development; however, impacts can occur from the need to compensate for environmental and social concerns. Social benefits can be related to job creation and associated economic benefits of the development; however, conversely,

environmental impacts can also cause loss of these social benefits. Regardless, 193 countries have committed to implement sustainable development as signatories to the 2030 Agenda for Sustainable Development which include the Sustainable Development Goals; a set of 17 goals and 169 targets that are “strategies that build economic growth and address a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection” (UN, 2019).

Biodiversity offsets are commonly used to contribute to sustainable development (Díaz et al., 2019; Fallding, 2014). Biodiversity offsets, also known as ‘environmental offsets’, are environmental compensatory schemes that can provide benefits for biodiversity and, consequently, improve human wellbeing (Ma, 2022; Maron et al., 2015; Rosa et al. 2022). In this way, biodiversity offsets can provide a clear contribution to the environmental and social aspects of sustainable development. Offsets can provide other indirect benefits to sustainable development such as through job creation related to the design, implementation and completion of offsets, creation of ecotourism opportunities and other new industries related to ecosystem services. Specifically, biodiversity offsets may contribute to several Sustainable Development Goals including Life on land, Life below water, and Sustainable cities and communities (Figure 1.1). Additionally, contributions to climate action, good health and wellbeing, clean water and sanitation, affordable and clean energy, industry innovation and infrastructure and responsible consumption and production may also be possible.

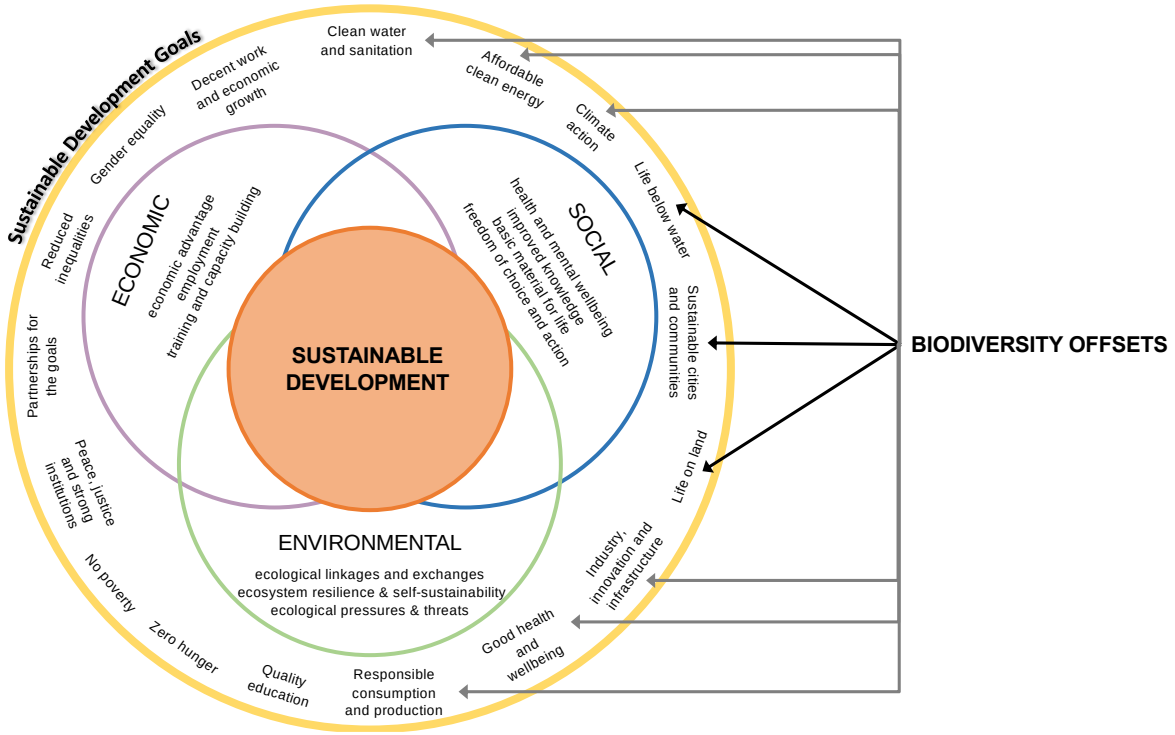

Figure 1.1: Conceptual diagram depicting the link between biodiversity offsets and sustainable development.

There are many criticisms of biodiversity offsets, yet despite their shortcomings, benefits in terms of provision of conservation funding, ability to ease community discomfit with development and regulatory convenience, as well as the lack of alternatives, mean that their use to contribute to sustainable development is likely to continue (Apostolopoulou, 2016; Foerster & McDonald, 2016). The challenge, however, is to improve the use of offsets to ensure that their contribution to sustainable development is meaningful. Despite their recognition as a mechanism to contribute to sustainable development (Díaz et al., 2019; Fallding, 2014), there is no model for biodiversity offsets that has been developed in consideration of sustainable development.

Therefore, the purpose of this research is to investigate how biodiversity offsets are designed to balance the three key aspects of sustainable development (environmental, social, economic) in an Australian context, to create a model for biodiversity offsets that contributes to the goals of sustainable development and provide recommendations for the improvement of offsets globally.

1.7 Australian legislative and governmental context for biodiversity offsets

Australian regulators have embraced the use of biodiversity offsets and its approaches to implementation have been used as models for other jurisdictions (Madsen et al., 2011; Midgley, 2015; Miller et al., 2015). However, the effectiveness of the use of biodiversity offsets in Australia to compensate for impacts to the environment and contribute to the goals of sustainable development is unknown.

Australia is a megadiverse country with a high level of species endemism (Austin et al., 2004; Broadhurst & Coates, 2017; Cresswell & Murphy, 2016; Crisp et al., 2001; Kier et al., 2009; Steffen et al., 2009). Its insect fauna, in particular, are highly endemic (Austin et al., 2004), and two of its areas, the Queensland tropical rainforests and the South West Australian Floristic Region, rank within 20 regions globally with the highest levels of vascular plant endemism richness (Kier et al., 2009). Australia is home to two biodiversity hotspots, the Forests of Eastern Australia and the Southwest of Australia (Cresswell & Murphy, 2016). Biodiversity hotspots are defined as areas with more than 1500 endemic vascular plants yet retain less than 30% of their original extent of vegetation (Cresswell and Murphy, 2016). There are also 19 World Heritage Sites of outstanding universal value for natural and/or cultural purposes in Australia (Cresswell & Murphy, 2016). However, since colonisation, Australia has lost approximately 40% of forested areas and much of the areas remaining are highly fragmented (Bradshaw, 2012). More than 10% of Australia's endemic terrestrial species have become extinct, with more 36% of those remaining listed on state and national databases as threatened. Populations of these listed species are continuing to decline (Woinarski et al., 2015). Impacts from land clearing and habitat fragmentation, changes to fire regimes, invasive species and climate change are causing high levels of loss across many landscapes (Yeates et al., 2020). According to the current Australia State of the Environment Report (Commonwealth of Australia, 2021), multiple pressures are threating Australian biodiversity and causing abrupt changes to ecological systems, which are being inadequately managed. Despite Australia's enthusiastic use biodiversity offsets (Miller et al., 2015), changes to current practices are required to protect remaining biodiversity.

Australia is a signatory to the 2030 Agenda for Sustainable Development and has voluntarily committed to undertake a review to evaluate its performance on sustainable

development (DFAT, 2018). Prior to this, Australia also committed to ensuring sustainable development as signatories to the United Nations Agenda 21 and the Rio Declaration on Environment and Development, ratifying the former through the implementation of the National Strategy for Ecologically Sustainable Development in December (ESDSC) 1992. The goal of this strategy is to ensure “development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends” (ESDSC, 1992). Biodiversity offsets are one way that Australia could contribute to sustainable development.

Biodiversity offsets in Australia are provisioned in environment-related legislation and regulations, and/or policy and applied when a statutory environmental impact assessment process identifies a residual significant biodiversity impact that cannot be mitigated. While each of the three levels of government in Australia (Commonwealth, State and Territory, and Local (Municipal)) can enforce environmental laws at some level, typically it is only the Commonwealth, and State and Territory governments that require some form of biodiversity offsets. Currently, the roles and responsibilities for the environment at each level of government in Australia are defined by the Intergovernmental Agreement on the Environment (IGAE) (CoA, 1992). Subsequently, the Council of Australian Governments further defined roles and responsibilities through development of the Heads of Agreement (HoA) on Commonwealth and State and Territory roles and responsibilities for the environment (COAG, 1997). These documents avoid overlap and potential legal conflicts between the extensive environmental powers of the Commonwealth and states and territories by ensuring that each jurisdiction only has responsibility for the environmental values on land managed by that jurisdiction (CoA, 1992), and that the Commonwealths responsibility for the environment is restricted to the protection of several key areas: Matters of National Environmental Significance and environmental assessment and approvals (COAG, 1997). While the IGAE and the HoA do not specifically mention biodiversity offsets, they do broadly denote the roles and responsibilities of the Commonwealth and the states and territories in relation to the environment. As such, these roles and responsibilities also extend to biodiversity offsets. However, the Australian Commonwealth Government is currently undertaking a reform of environmental legislation, including the development of a national standard for offsets that will be statutory (DCCEEW, 2022a).

Australia's commitments to sustainable development are not generally included as provisions in the legislation and policies of Australian jurisdictions but are rather stated in objects and mandatory consideration clauses. This means that legislation must be interpreted with an underlying lens that ensures sustainable development (Macintosh, 2015).

1.8 Research approach and thesis structure

Globally, research into the use of biodiversity offsets for sustainable development is limited. Therefore, this thesis uses reviews of legislative documents (acts, regulations, policies and associated guidelines), peer-reviewed journal articles, published reports and media articles to determine how biodiversity offsets can be enhanced to meet the requirements of sustainable development in the Australian context.

The following chapters describe research conducted to address these research questions. Figure 1.2 depicts how chapters work together to achieve the overall research aim.

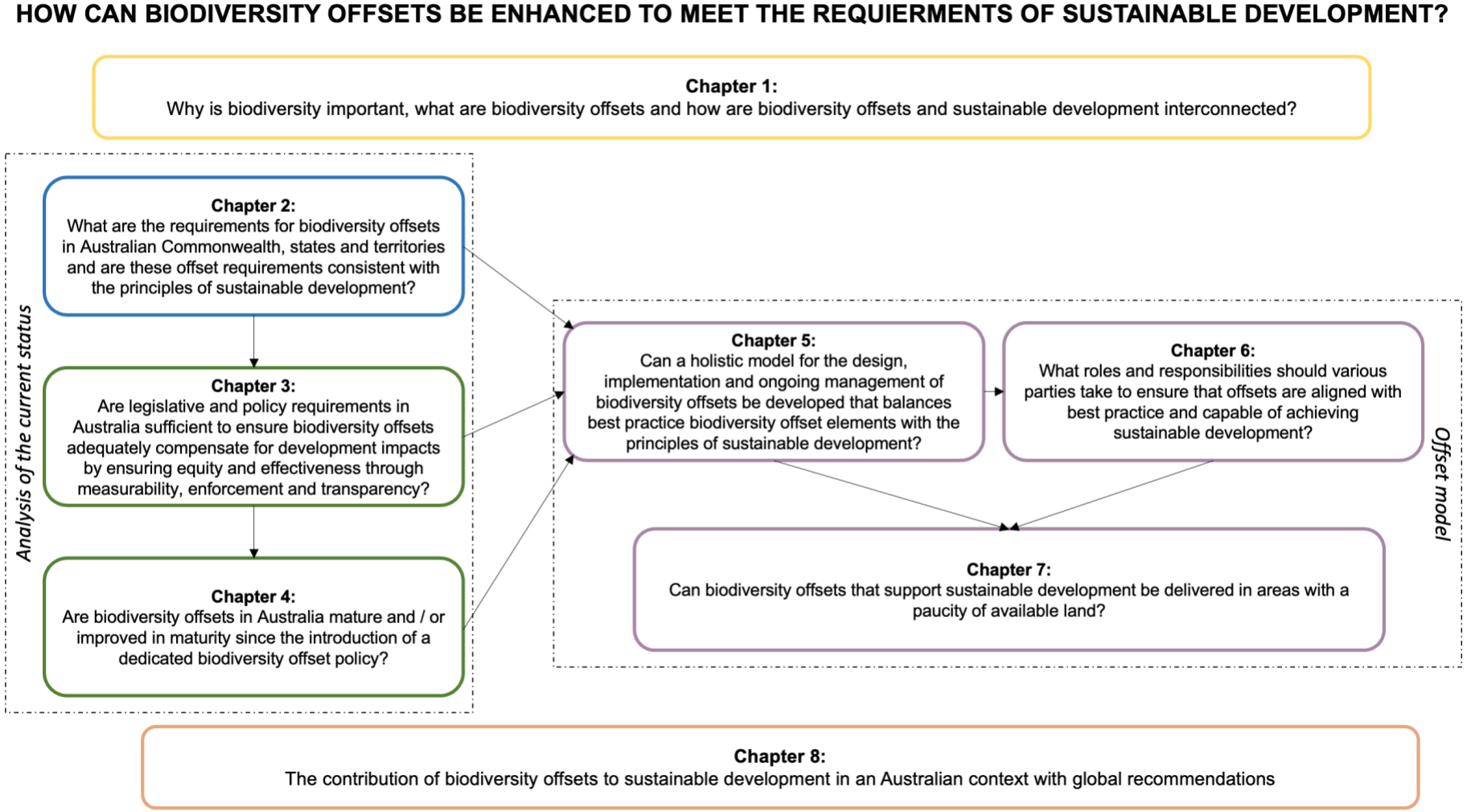

Figure 1.2: Overview of thesis structure and interconnectivity between chapters.

Chapter 2 examines biodiversity offset requirements in Australia, investigating if there are gaps in biodiversity and environmental protection, and if these offset requirements provide adequate consideration of the environmental, social and economic principles of sustainable development. To achieve this, a comparative review of Australian legislative instruments (acts, regulations, policies and associated guidelines) was conducted. Requirements for biodiversity offsets found in Australian Commonwealth, State and Territory legislation, policy and published guidelines were compared. PRIMER statistical software package (Clarke et al., 2014) was used to compare similarities across jurisdictions (Jaccard resemblance measure) and depicted using a dendrogram. Australian jurisdictions were found to be dissimilar, and gaps were found in biodiversity and environmental protection across Australia. Additionally, no jurisdiction was found to consider environmental, social and economic aspects in balance, leading to the conclusion that Australia may be negligent in meeting their commitments to sustainable development.

In **Chapter 3**, a qualitative review of Australian legislation and policy and published guidelines for biodiversity offsets requirements related to transparency, measurability and enforceability was conducted. A rating key based on the level of rigour in offset requirements reviewed was developed to determine the level of transparency, measurability and enforceability of these biodiversity offset requirements. Transparency, measurability and enforceability results were plotted separately on histograms for environmental, economic and social aspects to allow comparison between jurisdictions.

All Australian jurisdictions were found to have gaps in the use of biodiversity offsets to achieve transparency, measurability and enforceability for environmental, social and economic aspects. This leads to uncertainty in the use of offsets to ensure adequate compensation for the impacts of development. Development and implementation of dedicated biodiversity offset legislation that ensures effectiveness, equity and ethicality was identified as a way to ensure that future offsets could consistently be required under legislation to contribute to sustainable development.

In recognition of the importance of the Commonwealth to environmental protection in Australia, **Chapter 4** examines biodiversity offset conditions resulting from

Australian Commonwealth environmental approvals to determine if biodiversity offsets are mature and/or have improved in maturity since the introduction of a dedicated biodiversity offset policy. A qualitative review of development referrals submitted to the Australian Commonwealth Government before (1 year) and after (5 years) the introduction of a dedicated biodiversity offset policy was undertaken to identify if components associated with offset maturity were present. These components were then assessed and ranked in terms of the change in offset requirements over time, transparency and/or the provision of better environmental outcomes. The components included: type of offset, level of detail, requirements for commencement dates, requirements for ecological outcomes, and number of species or habitats which offset compensation was required.

Commonwealth biodiversity offset requirements were not found to be consistently maturing over the study period. Based on the results of the research, legislative amendments are recommended to improve transparency, remove uncertainty within Commonwealth offset legislation and policy, improving the likelihood that biodiversity offsets can adequately compensate for the impacts of development.

To improve the use of biodiversity offsets, **Chapter 5** uses a literature review of recommended best practice for the key elements of biodiversity offsets (scope, scale, location, timing and duration, and monitoring and measurement) and applies this to the principles of sustainable development, specifically environmental, social and economic aspects. Using the information gathered from the review, a holistic offset model that balances best practice biodiversity offsets with the environmental, social and economic principles of sustainable development for the design, implementation and ongoing management of direct biodiversity offsets is developed.

Consideration of cost and risk were found to be key to ensuring the success of offsets. The use of strategic landscape scale planning frameworks, bonds and advanced offsets were identified as having utility for the mitigation of offset failure and to enable long-term offset success.

Chapter 6 describes how regulators, developers and stakeholders contribute to biodiversity offsets and each have roles and responsibilities to facilitate the success of biodiversity offset outcomes for sustainable development, in recognition that biodiversity offset requirements both in Australia and globally need improvement to

meaningfully contribute to sustainable development (Chapters 2–5). A qualitative literature review of peer-reviewed journal articles, published reports and media articles was undertaken to identify documents that discussed roles and responsibilities for biodiversity offsets. These roles and responsibilities were then assessed against the offsets model identified in Chapter 4 to determine if roles and responsibilities for biodiversity offsets that contribute to sustainable development had been identified elsewhere. The information collected in this review was used to develop recommendations to improve the definition of roles and responsibilities related to biodiversity offsets. Clear definition of roles and responsibilities was found to be important to ensure transparency and equity, improve cost effectiveness and reduce risk. Collaborative approaches between parties were found to be particularly important, as well as the ability to interchange roles (but not responsibilities) where practicable.

Chapter 7 uses the outcomes of Chapters 4 and 6 to identify how best practice offsets that meaningfully contribute to sustainable development can be implemented in areas with a paucity of available land. Conservation Trust Funds designed specifically for biodiversity offsets were chosen as a mechanism to demonstrate this as they have the advantage over traditional offsets in that they do not require access to land. Using the Western Australian Jarrah Forest as an example, a region with competing land use but high biodiversity and important environmental value globally, a model was created for the best practice implementation of offsets in consideration of sustainable development. This model was then expanded for use globally, with particular utility for other regions with complicated regulations and/or competing priorities for land use.

Chapter 8 uses the research outcomes to determine how biodiversity offsets can meaningfully contribute to sustainable development both in Australia and globally. It discusses the main conclusions from each chapter, research limitations and identifies further research priorities for biodiversity offsets.

Each of Chapters 2 to 7 have been written as individual scientific manuscripts and therefore may contain some repetition among chapters. The publication status of each chapter (where already published) is indicated on each title page.

Chapter 2

A comparison of biodiversity offset legislation and policy among Australian jurisdictions

Australia has a complex environmental regulation system with requirements at both Commonwealth and State and Territory levels. All jurisdictions can require biodiversity offsets, but the similarity of these requirements and how they contribute to environmental protection overall is not well documented. This chapter compares Australian Commonwealth, State and Territory legislation, policy and published guidelines to determine how consistent environmental protection through biodiversity offsets is in Australia and if this provides a meaningful contribution to sustainable development. The outcomes of this chapter provide background to Chapter 3 where an examination of the transparency, measurability and enforceability of offsets in Australia is examined.

The content of this chapter has been published in the journal Environmental Management and Sustainable Development as ‘Apples for oranges: Disparities in offset legislation and policy among jurisdictions and its implications for environmental protection and sustainable development in Australia’ (doi: 10.5296/emsd.v8i1.14081). This paper was co-authored by S. Griffin and A. Kemp who provided editorial assistance.

2.1 Introduction

Since 1992, Australia has demonstrated a long-term commitment to sustainable development, as one of the more than 178 countries agreeing to the United Nations Agenda 21 and the Rio Declaration on Environment and Development. This led to Australia implementing the National Strategy for Ecologically Sustainable Development in December 1992. The goal of this strategy is to ensure "development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends" (ESDSC, 1992). In addition to this, Australia was one of more than 150 countries that agreed to adopt the 2030 Agenda for Sustainable Development, which also includes the aspirational Sustainable Development Goals (SDG). Under this Agenda, Australia has voluntarily committed to undertake a review to evaluate its performance on sustainable development. While sustainable development is not generally included as provisions in the legislation and policies of Australian jurisdictions, it is largely stated in objects and mandatory consideration clauses. This means that Australian legislation and policy must be interpreted with an underlying lens that ensures sustainable development (Macintosh, 2015). However, as the assessment of sustainability to meet the SDGs is complex and inconsistent (Allen et al., 2018; Pope et al., 2017), it is uncertain if the implementation of sustainable development in Australia is comprehensive.

The International Institute for Sustainable Development provides the most commonly used definition of sustainable development being: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (IISD, 2017). Within the scope of sustainable development, the equal consideration of environmental, social and economic aspects is required to ensure that the current level of natural capital is maintained (Gibson, 2009; Moldan & Dahl, 2007; IISD, 2017; Macintosh, 2015). This balance of aspects is also captured in the Rio Declaration on Environment and Development, along with the actions in Agenda 21 and the SDGs. Therefore, as a signatory to these international agreements, Australia has committed to ensuring sustainable development and the balance between these three aspects.

Biodiversity offsets, also known as 'Environmental offsets', are now recognised as one tool to ensure that developments are undertaken in an ecologically sustainable way (Fallding, 2014). However, if biodiversity offsets are to be used to ensure development

is sustainable, then environmental, social and economic aspects of the biodiversity offset must also be considered. Protecting biological diversity from development impacts through biodiversity offsetting was first introduced by way of wetland compensation requirements in the United States of America in the 1970s (Benabou, 2014; Burgin, 2008). Although the definition of biodiversity offsets can vary (Fallding, 2014), the International Finance Corporations (IFC) Performance Standard 6 defines biodiversity offsets as “measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development and persisting after appropriate avoidance, minimisation and restoration measures have been taken” (IFC, PS6). This IFC performance standard contributes to the assurance of sustainable development and is required for all corporations to secure and maintain ongoing funding from global banks. As these banks provide finance for the larger development projects globally, these performance standards are required of almost all large-scale projects around the world. While this provides some level of surety that developments will be sustainable, the performance standards are not prescriptive and the level of conformance to and consistency in application of these standards is unknown.

Throughout Australia, jurisdictions have agreed to developments with predicted significant impacts on the environment on the condition that they deliver biodiversity offsets (e.g. Burton et al., 2017; Coggan et al., 2013a; Kujala et al., 2015; May et al., 2017), in an attempt to ensure that the environmental principles of sustainable development are not compromised. However, the implementation of biodiversity offsets may change the use and/or function of an area, and while environmental aspects may be improved, secondary social and economic impacts may occur, such as changes in land use (Lim et al., 2017), displacement (Ghosh, 2017), and unemployment and poverty (Ali et al., 2018). Therefore, Australian requirements for biodiversity offsets need to include explicit consideration of economic and social impacts in addition to environmental impacts to ensure that their use is not compromising the principles of sustainable development. If this is not the case, then Australia may be creating social and economic inequalities, and may also be remiss in meeting their international agreements.

2.1.1 Biodiversity offset requirements in Australia

Biodiversity offsets in Australia are required through provisions in environment-related legislative acts, regulations, and/or policy as result of a statutory environmental impact assessment process. While each of the three levels of government in Australia (Commonwealth), State and Territory, and Local (Municipal)) has the ability to enforce environmental laws at some level, typically it is only the Commonwealth and State and Territory governments that require some form of biodiversity offsets.

The Australian Constitution is the primary legal document giving powers to the Commonwealth, however, without explicit reference to the environment in the Constitution, the Commonwealth has no specific environmental power, and the protection of the environment is the primary responsibility of the Australian states and territories. They may choose to legislate in order to carry out their environmental duties or to delegate responsibilities to local governments. Local governments only have responsibility for the environment if this is delegated to them by the states or territories, and can utilise biodiversity offsets to fulfil these responsibilities. Generally, this is related to local amenity or nuisance.

This omission of specific reference to the environment in the Constitution was, in combination with historical context, a recognition that the states and territories exercised power over their natural resources (Peel & Godden, 2005). Instead the Commonwealth has a responsibility towards 'external affairs' under Section 51 (xxix) of the Constitution and thus derives its ability to make laws and policies for environmental protection from Australia's signature to various international agreements, e.g. the Convention on Biological Diversity (CBD).

This allows the Commonwealth, along with the states and territories, to have extensive powers to regulate environmental matters, which has the ability to cause overlap and conflict. However, as the states and territories have historically always sought to maintain their role in regulating their own environmental matters (Peel & Godden, 2005), the Inter-governmental agreement on the environment (IGAE) was developed in 1992 to avoid potential legal conflicts and to set the roles and responsibilities in regard to the environment at each level of government (CoA, 1992).

In 1997, the roles and responsibilities for the environment were further described in the Heads of Agreement (HoA), that was developed by the Commonwealth, states

and territories through Council of Australian Governments (COAG). Specifically, the HoA limits the role of the Commonwealth to the protection of several key areas: Matters of National Environmental Significance (MNES) and environmental assessment and approvals. Additionally, it allows for the Commonwealth and the states and territories to develop bilateral agreements, whereby a State or Territory may undertake an environmental assessment and/or approval on behalf of the Commonwealth (COAG, 1997). While the IGAE and HoA do not specifically mention biodiversity offsets, they do broadly denote the roles and responsibilities of the Commonwealth, states and territories in relation to the environment. As such, these roles and responsibilities also extend to biodiversity offsets.

2.1.2 The consequence of statutory heterogeneity

There is a lack of international standards on biodiversity offsets (Benabou, 2014), meaning that each country and jurisdiction within each country develops rules around biodiversity offsets independently. This lack of consistency can result in a failure to meet conservation goals at regional, national or international scales (Bull et al., 2013b). While the IGAE mandates that the states and territories cannot cause adverse effects in another jurisdiction, if environmental legislation and policy relating to biodiversity offsets are not comprehensive in prescribed outcomes and do not adequately consider social and economic aspects, then Australia may, therefore, not be meeting its international obligations to ensure sustainable development.

With the Australian Commonwealth having overarching responsibility for sustainable development and the states and territories having responsibility for all environmental matters within their jurisdiction, theoretically the principles of sustainable development should be included and consistently applied in legislation and policy for biodiversity offsets throughout Australia. However, in the absence of a nationally integrated framework for biodiversity offsets this may not be the case. The aim of this research is to determine if the principles of sustainable development are comprehensive and integrated into biodiversity offsets in Australia. This will be assessed through:

1. Determining if environmental policy and legislation related to biodiversity offsets in Australia is sufficiently comprehensive across jurisdictions to ensure that no substantial gaps exist in biodiversity and environmental protection.

2. Determining if the use of biodiversity offsets includes adequate consideration of environmental, social and economic aspects such that Australia can meet their international obligations related to sustainable development.

Given that the legislation and policy of each jurisdiction has been developed through a democratic political process with likely different priorities, and that the Commonwealth has developed the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) to focus on Matters of National Environmental Significance (MNES), it is expected that gaps in environmental protection may be found. Furthermore, as legislation and policy has been developed to protect the environment specifically, and that consideration of the three aspects of sustainability are rarely integrated (Gibson, 2009), it is expected that social and economic aspects may have not been adequately considered and, consequently, requirements for biodiversity offsets may be compromising the achievement of sustainable development.

2.2 Methods

Legislation, policy and published guidelines (current as of December 2018) stated by the Commonwealth and each Australian State and Territory as being related to biodiversity offsets were reviewed (Table 2.1) and analysed for the inclusion of sections applicable to biodiversity offsets. As the role of local governments in environmental regulation is delegated by the states and territories, local government by-laws were not included in the analysis.

Table 2.1: List of environmental legislation and policy reviewed.

Jurisdiction	Reference	Legislation/policy reviewed
Commonwealth (Cwlth)	DCCEEW, 2022b	*Environment Protection and Biodiversity Conservation Act 1999*
		Environment Protection and Biodiversity Regulations 2000
		Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy 2012
Australian Capital Territory (ACT)	EPSDD, 2018	*Planning and Development Act 2007*
		ACT Environmental Offsets Policy
New South Wales (NSW)	OEH, 2017	*Biodiversity Conservation Act 2016*
		Local Land Services Act 2013 (as amended by the Local Land Services Amendment Act 2016)
		Biodiversity Conservation Regulation 2017
		Local Land Services Regulation 2014
		State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017
Northern Territory (NT)	NTEPA, 2013	*Environmental Assessment Act*
		Guidelines on environmental offsets and associated approval conditions
Queensland (Qld)	QG, 2018	*Environmental Offsets Act 2014*
		Environmental Offsets Regulation 2014
		Queensland Environmental Offsets Policy (Version 1.6): June 2018
South Australia (SA)	DEW, 2017	*Native Vegetation Act 1991*
		Native Vegetation Regulations 2017
		Guide for calculating a Significant Environmental Benefit under the *Native Vegetation Act 1991* and the Native Vegetation Regulations 2017
		Policy for calculating a Significant Environmental Benefit under the *Native Vegetation Act 1991* and the Native Vegetation Regulations 2017
Tasmania (Tas)	DPIWE, 2002; FPA, 2011; NCHD, 2015	*Forest Practices Act 1985*
		Nature Conservation Act 2002
		Threatened Species Protection Act 1995
		Water Management Act 1999
		Natural Resource Management Framework
		Guidelines for Natural Values Surveys - Terrestrial Development Proposals
		Policy of the Forest Practices Authority: The use of offsets
Victoria (Vic)	ELWP, 2018	*Planning and Environment Act 1987*
		Guidelines for the removal, destruction or lopping of native vegetation
		A quick comparison of first party and third party offset sites
Western Australia (WA)	EPA, 2018	*Environmental Protection Act 1986*
		WA Environmental Offsets Policy 2011
		WA Environmental Offset Guidelines
		Bilateral Agreement under section 45 of the *Environmental Protection and Biodiversity Conservation Act 1999*

From the analysis, the different biodiversity offset requirements related to sustainable development (i.e. environmental, social, economic) for the listed legislation, policies

and published guidelines were recorded (Table 2.2). The legislation, policy and published guidelines were then reanalysed against these requirements to create a presence/absence table of sustainable development considerations for biodiversity offsets for each jurisdiction. It should be noted that only aspects included in legislation, policy and published guidelines in effect as of December 2018 were included in the analysis. Historical and draft legislation, policy and published guidelines were outside the scope of this analysis, as were additional aspects that might be required by jurisdictions as conditions of approval, but not specifically stated in legislation and policy.

The presence/absence data was analysed using the PRIMER statistical software package (Clarke et al., 2014). The Jaccard resemblance measure was used to compare similarities of jurisdictions. A dendrogram was used to visualise the level of similarity among jurisdictions. The group-average was used for the dendrogram, depicting the similarity between jurisdictions as the mean closeness of two groups, averaging over all between-group pairs.

2.3 Results

The legislative acts for all Australian jurisdictions allow governments to require biodiversity offsets through some mechanism. All jurisdictions were found to require biodiversity offsets in certain circumstances with the exception being the Northern Territory, which currently cannot consider biodiversity offsets as part of an environmental impact assessment under the *Environmental Assessment Act 1982* (NTEPA, 2013). However, most jurisdictions do not have biodiversity offset specific legislation, instead requiring biodiversity offsets as a condition of an approval to compensate for residual impacts to the environment. Queensland was the only jurisdiction that has an act specifically designed to consider biodiversity offsets. New South Wales has a section of the *Biodiversity Conservation Act 2016* that is dedicated to biodiversity offsets.

All Australian jurisdictions assessed were similar in the requirement for biodiversity offsets as the final step in the application of all or most of the mitigation hierarchy of avoid, reduce, rehabilitate/restore, offset. This is consistent with the standards put forward by the Business and Biodiversity Offsets Program (BBOP; BBOP, 2018).

In terms of subsidiary legislation or policy, eight of the nine Australian jurisdictions had other legislation and/or policy that related specifically to biodiversity offsets, with a total of six statutory documents (three regulations and three policies) and a further eight non-statutory frameworks, policies and guidelines in place.

In 2007, South Australia was the first jurisdiction to implement policy that specifically refers to biodiversity offsets, although this is non-statutory. Western Australia was the first jurisdiction to implement a statutory biodiversity offsets policy in 2011 (Figure 2.1).

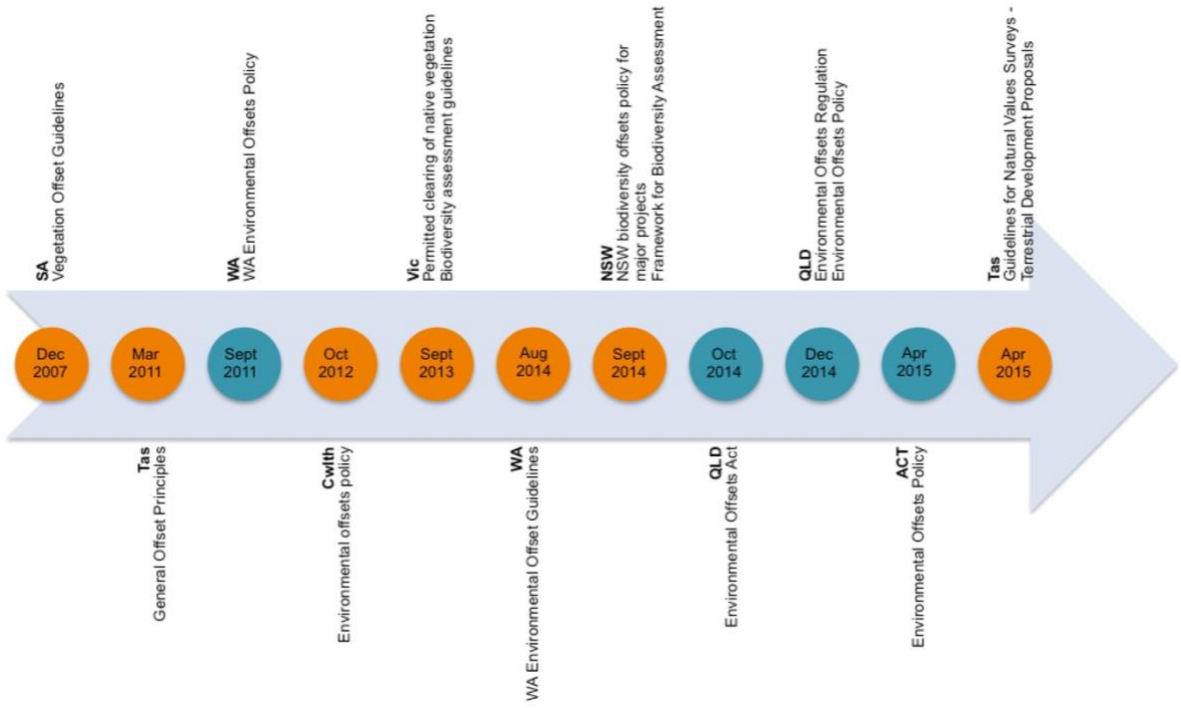

Figure 2.1: Timeline of implementation of biodiversity offset specific legislation and policies in Australia. Orange circles represent non-statutory documents, blue circles represent statutory documents. ACT – Australian Capital Territory, Cwlth – Commonwealth, NSW – New South Wales, Qld – Queensland, SA – South Australia, Tas – Tasmania, Vic – Victoria, WA – Western Australia.

While Victoria only introduced guidelines including biodiversity offsets in 2013, it should be noted that in 2002 it developed the cross-departmental strategy 'Victoria's native vegetation management: a framework for action'. This now superseded framework provided principles related to the clearing of native vegetation for use by the several Victorian departments and agencies responsible for the care of native vegetation areas, including natural resources and in catchments (DSE, 2003). This framework included provision for government to consider achievement of no net loss

through biodiversity offsets. As this framework is not currently in effect, it was not included within the scope of this analysis.

2.3.1 Biodiversity offset aspects in legislation and policy

The review of legislation, policy and published guidelines found the wording of the various requirements for biodiversity offsets was different among jurisdictions. These different requirements were, however, grouped together into themes that are explored more fully below. With this in mind, the analysis identified 11 environmental aspects, 4 social and 3 economic aspects related to biodiversity offsets (Table 2.2).

2.3.1.1 Environmental

Broad-scale biodiversity offset requirements for all removal of native vegetation (E_2) or for all impacts on species and/or communities contained in appended lists (listed matters; E_3) was included in legislation and policies of several jurisdictions. Other legislation, policies and published guidelines included specific definitions of matters that must be considered in terms of biodiversity offsets (E_1), contrasting with those that did not include these matters, whereby the requirements for matters to be offset were more discretionary.

One jurisdiction (ACT) specifies in legislation and policy timeframes in which biodiversity offsets must be delivered (E_4), while others either do not require this or may require timeframes as part of conditions placed on certain developments (outside the scope of this analysis).

The legislation, policy and published guidelines of all jurisdictions except for Tasmania and Northern Territory required biodiversity offsets to be ‘like-for-like’, meaning that the matters to be offset must be the same (species and or ecological communities) as those required to be compensated for (E_10). In addition to this, many jurisdictions required that biodiversity offsets must be designed to provide compensation that at least maintains (or improves) the viability of the species or community expected to be impacted, or to provide enhancements that match (or better) that which was lost/the scope of the adverse biodiversity impacts (no net loss or net gain; E_5).

Other considerations of various legislation, policies and published guidelines were for biodiversity offsets to be undertaken by third parties on behalf of developers

(delegated; E_7) and/or to be delivered in various stages through the construction and/or operation of a development (staged; E_11).

Some jurisdictions allowed for advanced offsets, where credit of past appropriate conservation/rehabilitation/restoration work could be credited towards a developer and used to offset future impacts of development (E_9).

Several jurisdictions also allowed for consideration of indirect biodiversity offsets, being measures that improve knowledge, understanding and management of environmental values leading to improved conservation outcomes (E_8).

A biodiversity offsets calculator was provided by several jurisdictions (Cwlth, ACT, NSW, Qld, SA, Vic) as a way of ensuring that biodiversity offsets were designed to deliver adequate compensation. An offset calculator is a type of interactive database that would calculate either levels of compensation required or provide a level of assurance that the proposed compensation would be adequate.

2.3.1.2 Social

Several jurisdictions included social considerations through inclusion of specific appeal processes for developers (S_1) and communities (S_2), or through the requirement for community consultation in relation to biodiversity offsets (S_3).

2.3.1.3 Economic

Economic considerations were included in legislation, policies and published guidelines in several ways. Land-holders can create biodiversity credits that can then be on-sold to developers. Developers can purchase and retire these credits in order to fulfil biodiversity offset conditions (tradeable permits; Ec_1).

Some jurisdictions also offer conservation funds through which developers can provide payments as an alternative to directly funding biodiversity offset programs (Ec_2). The money in these funds is then used by the government of that jurisdiction to undertake conservation projects of its discretion.

The impact of biodiversity offset requirements on the developer is an important consideration when incorporating the concept of sustainable development. Although this was not explicitly considered in any of the legislation, policies or published

guidelines reviewed, it was indirectly considered through the use of biodiversity offset calculators that incorporated financial impacts (Ec_3).

2.3.2 Legislation and policy review

2.3.2.1 Commonwealth

The Australian Commonwealth Government requires biodiversity offsets for 'significant impacts' on MNES that are described by the EPBC Act. Biodiversity offsets under the EPBC Act relate to more than 2000 protected matters, including more than 1800 threatened species and ecological communities (Miller et al., 2015). The EPBC Act is administered by the Department of Climate Change, Energy, the Environment and Water (DCCEEW). Although not statutory, DCCEEW has developed a biodiversity offset policy (DSEWPaC, 2012a), which is a guideline and accompanying biodiversity offset calculator (E_6) that assists developers in proposing biodiversity offsets that will be acceptable to accompany applications for environmental approvals. The offsets calculator, developed as an offsets assessment guide for the Commonwealth, assesses the annual probability of extinction of species/communities expected to be impacted utilising figures published by the 'Red List', a global list of threatened species that is curated by the non-government organisation 'International Union for the Conservation of Nature' (IUCN) (DSEWPaC, 2012b).

As described by the *Environment Protection and Biodiversity Conservation Act 1999* Environmental Offsets Policy 2012, the Commonwealth conditions biodiversity offsets for significant impact to any EPBC Act listed matter (MNES) (E_1, E_3). These biodiversity offsets should be 'like-for-like' (E_10) and ensure there is no net loss of biodiversity (E_5). The Commonwealth allows for biodiversity offsets to be delegated (E_7) and staged (E_11), and also allows for advanced (E_9) and indirect (E_8; termed 'other compensatory measures') biodiversity offsets.

While social aspects are considered as part of the environmental impact assessment process, and by default any biodiversity offsets that might have been proposed in an environmental impact statement, consideration of social aspects were not required specifically for biodiversity offsets. As such, no social aspects of biodiversity offsets were noted as required.

Economic aspects were not specifically required for Commonwealth biodiversity offsets either. The financial impact on the developer was, however, included as a requirement as this is considered as part of the offsets calculator (Ec_3). While there is not a formal appeals process for developers and concerned stakeholders, the EPBC Act allows for interested persons to seek injunctive relief or to initiate judicial review of decisions of the Minister, meaning that developers and/or community members can appeal biodiversity offset conditions through court. However, as this is not a dedicated appeal process, this has been omitted from the analysis.

2.3.2.2 Australian Capital Territory

The legislative framework in the Australian Capital Territory requires biodiversity offsets under the *Planning and Development Act 2007* for Australian Capital Territory -protected matters, as well as MNES listed under the EPBC Act (E_1, E_3), as conditions of development approvals. Within the Australian Capital Territory, the statutory 'ACT Environmental Offsets Policy' (ACT GEP, 2015) provides further detail as to specific biodiversity offset requirements.

The Australian Capital Territory legislation and policy requires biodiversity offsets to be 'like-for-like' (E_10) and to ensure no net loss (E_5). Biodiversity offsets can be delegated (E_7) and proposals for advanced (E_9) and indirect (E_8) biodiversity offsets may be accepted. The Australian Capital Territory also considers appeals from developers (S_1) and concerned stakeholders (S_2). While community consultation is required for prescribed development proposals, it is not comprehensive and consequently has not been included in the analysis.

2.3.2.3 New South Wales

In New South Wales, biodiversity offsets are required under the *Biodiversity Conservation Act 2016, the Local Land Services Act 2013* (as amended by the *Local Land Services Amendment Act 2016*) and the State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017, which are administered by the Office of Environment and Heritage. Biodiversity offsets are required for most impacts on biodiversity caused by major projects and are established through either retiring biodiversity credits (only where credits are available for the listed matters impacted (i.e. like-for-like)), undertaking biodiversity conservation actions or mine-site rehabilitation (where applicable), or through payment into the Biodiversity

Conservation Fund, where the payment required is calculated using the Offset Payments Calculator and is commensurate with the value of biodiversity credits that would have been purchased.

The New South Wales *Biodiversity Conservation Act 2016* requires biodiversity offsets for residual impacts on listed species and ecological communities, that are listed within Schedules 1 and 2. It also requires biodiversity offsets for areas of 'outstanding biodiversity value' that are declared through publication on the New South Wales legislation website (E_1 and E_3). This includes areas that had been previously declared as critical habitat under the *Threatened Species Conservation Act 1995.*

Retiring of biodiversity credits must be undertaken prior to the commencement of actions that would impact on listed matters (E_4), although these may be staged throughout development (E_11). The New South Wales legislation and policy requires biodiversity offsets to be 'like-for-like', except where an approved variation is in place. It also allows for biodiversity offset requirements to be delegated to third parties (E_7), for indirect biodiversity offsets to be implemented (E_8), and for developers to provide a financial contribution to the government in lieu of a biodiversity offset (Ec_2). The New South Wales legislation and policy allows for appeals in relation to enforcement matters, but not the setting of biodiversity offset conditions, and as such has not been included in the analysis.

2.3.2.4 Northern Territory

As at December 2018 the Northern Territory government did not have in place specific biodiversity offset legislation or policy and could not consider biodiversity offsets (NTEPA, 2013).

The Northern Territory government had previously drafted biodiversity offset guidelines, but these were withdrawn prior to formalisation after a change of governing party in 2012. Even though the Northern Territory could not legally require biodiversity offsets, they had developed voluntary biodiversity offset projects with some developers of larger scale developments (e.g. INPEX, 2012). However, as these were not required, these were excluded from the analysis.

2.3.2.5 Queensland

Queensland is the only state to have developed specific biodiversity offset legislation. Queensland biodiversity offsets are required for significant residual impacts on prescribed environmental matters under its biodiversity offset legislation, which includes the *Environmental Offsets Act 2014*, the Environmental Offsets Regulations 2014, and the statutory Queensland Environmental Offsets Policy (Version 1.6): June 2018 (DES, 2018). The Department of Environment and Science (DES) administers this legislation.

Queensland legislation and policy require biodiversity offsets to be 'like-for-like' (E_10) and to be focused only on listed matters (termed as prescribed environmental matters) (E_1, E_3). This legislative framework requires no net loss (E_5) as part of the described biodiversity offset principles, and allows for staged (E_11), advanced (E_9) and delegated (E_7) biodiversity offsets. It includes an appeal process for developers (S_1) and for communities (S_2) through an application for an internal review. DES provide three calculators to assist in the development of suitable biodiversity offsets as required by the Queensland legislation and policy: the Financial Settlement Calculator for financial settlement offsets, and the Impact Matters and Offset Matters calculators to assist in site assessment (E_6). The financial impact on developers is considered through the Financial Settlement Calculator (Ec_3) and allowance is made for financial contributions in lieu of biodiversity offsets (Ec_2).

2.3.2.6 South Australia

Biodiversity offsets in South Australia are required to compensate for the clearing of terrestrial native vegetation. This is administered by the Native Vegetation Council under the *Native Vegetation Act 1991* and the Native Vegetation Regulations 2017. Under these legislative instruments, developers are required to ensure a significant environmental benefit to counterbalance vegetation loss (E_2). Further guidance is provided to developers removing scattered trees under the non-statutory 'Policy for calculating a Significant Environmental Benefit under the *Native Vegetation Act 1991* and the Native Vegetation Regulations 2017' (DEWNR, 2017a), and the 'Guide for calculating a Significant Environmental Benefit under the *Native Vegetation Act 1991* and the Native Vegetation Regulations 2017' (DEWNR, 2017b).

The South Australia policy requires biodiversity offsets for the removal of native vegetation, that these biodiversity offsets are ‘like-for-like’ (E_10) and ensure no net loss (E_5). The guidelines include biodiversity offsets calculations (E_6) and allow for biodiversity offsets to be delegated (E_7), as well as for developers to provide financial contributions in lieu of biodiversity offsets (Ec_2). The financial impact on the developer is considered as part of the calculations for financial contributions provided in the guide. However, as this has not been considered for other types of biodiversity offsets allowed by South Australia, this has not been included in the analysis.

2.3.2.7 Tasmania

Biodiversity offsets in Tasmania are complex in that they are required through four different mechanisms:

1. The Department of Primary Industries, Parks, Water and Environment (DPIPWE) requires biodiversity offsets within the dam assessment framework under the Water Management Act 1999.
2. DPIPWE also applies biodiversity offsets under the Resource Management and Planning System, which is described in the Tasmanian Natural Resource Management Framework (DPIWE, 2002), and provides guidance under the Guidelines for Natural Values Surveys - Terrestrial Development Proposals (NCHD, 2015).
3. The Forest Practices Authority (FPA) requires biodiversity offsets to compensate for the loss of significant biodiversity values within forest practices plans in accordance with the Forest Practices Act 1985, the Threatened Species Protection Act 1995 and the Nature Conservation Act 2002. The FPA has produced the non-statutory Policy of the Forest Practices Authority: The use of offsets (Forest Practices Authority, 2011) to compensate for the loss of significant biodiversity values within forest practices plans. This includes the DPIPWE General Offset Principles as an attachment; however the DPIPWE guideline is no longer directly available from the DPIPWE website. Despite this confusion, this text was analysed.
4. In addition to this, biodiversity offsets are also required by some local planning authorities. These have not, however, been included in the analysis.

Tasmania allows for flexibility in the application of biodiversity offsets and does not describe which matters are required to be offset. Indirect biodiversity offsets (E_8), as well as staging (E_1) and delegation (E_7) of biodiversity offsets, are permitted. The DPIPWE offset principles state that biodiversity offsets should be like-for-like and ensure no net loss, but this is not required, and as such has not been included in the analysis.

2.3.2.8 Victoria

In Victoria biodiversity offsets are required to compensate for the clearing of native vegetation under the *Planning and Environment Act 1987*, which is administered by the Department of Environment, Land, Water and Planning (DELWP). In the Biodiversity information explanatory document: Measuring value when removing or offsetting native vegetation (DELWP, 2017a), DELWP have provided maps classifying areas of native vegetation to provide further guidance as to the biodiversity offsets required (E_1).

DELWP has also developed the documents 'Guidelines for the removal, destruction or lopping of native vegetation' (DELWP, 2017b) and 'A quick comparison of first party and third party offset sites', which further describes biodiversity offset requirements (DELWP, 2017c). Victoria requires two types of biodiversity offsets; species offsets, that require a like-for-like offset, and general offsets, that must be within the same area as the vegetation removed (E_10). Under these documents, biodiversity offsets ensure no net loss of biodiversity through the use of multipliers for species (x2) and general (x1.5) offsets (E_5). However, biodiversity offsets may be delegated (E_7) and developers may trade permits (Ec_1) through the Native Vegetation Credit Register. The guideline provides definitions for matters to be a biodiversity offset (E_1), as well as biodiversity offset calculations (E_6).

2.3.2.9 Western Australian

The Western Australian Environmental Protection Authority (WA EPA) has also developed a non-statutory guideline for biodiversity offsets, the Western Australian Environmental Offset Guidelines: August 2014 (EPA, 2014). The guideline provides further guidance to developers that are required to implement biodiversity offsets under the Western Australian Environmental Offsets Policy 2011 (GWA, 2011), which has been made statutory under the *Environmental Protection Act 1986* (the EP Act).

Biodiversity offsets primarily arise under this legislative framework either through the assessment of significant development proposals, such as extractive industries by the WA EPA, or through the consideration of vegetation clearing permits by the Department of Water and Environmental Regulation (Foster, 2013).

Biodiversity offsets are required for significant residual impacts on environmental matters, such as rare and endangered plants and animals, areas within the formal conservation reserve system, important environmental systems and species that are protected under international agreements, and areas that are already defined as being critically impacted in a cumulative context (EPA, 2014).

The Western Australian policy and guideline require that biodiversity offsets ensure no net loss of biodiversity (E_5) and to be 'like-for-like' (E_10). Delegation (E_7) and staging (E_11) of biodiversity offsets is allowed, as are advanced (E_9) and indirect (E_8; termed 'Research projects') biodiversity offsets. Western Australia has an appeal process for both developers (S_1) and communities (S_2) and requires that community consultation (S_3) be undertaken by developers. Financial payments in lieu of biodiversity offsets are also permitted (Ec_2).

2.3.3 Aspects of policy and legislation

Eleven environmental, three social and three economic considerations were present in the legislation, policies and published guidelines for the various Australian jurisdictions (Table 2). Specifically, the environmental considerations included definitions of matters to be offset and provision of a biodiversity offsets calculator(s) that developers may use to assist in the planning of acceptable biodiversity offsets. Environmental requirements were found for matters specifically listed under legislation (Cwlth, ACT, NSW, Qld, Vic), and/or only for the clearing of native vegetation (SA, Vic), delivery of biodiversity offsets within specific timeframes (ACT), overall no net loss of biodiversity (Cwlth, ACT, Qld, SA, Vic), and that biodiversity offsets must be 'like-for-like' (Cwlth, ACT, NSW, Qld, SA, Vic, WA). Delegation of biodiversity offsets to third parties by developers was allowed by all jurisdictions requiring biodiversity offsets, and staging of biodiversity offsets are allowed by some jurisdictions (Cwlth, ACT, NSW, Qld, Tas, WA). In addition, some jurisdictions (Cwlth, ACT, Qld, WA) also allowed for advanced biodiversity offsets, in which projects that have been previously undertaken by a developer and determined in some way to be beneficial to biodiversity

are used to offset impacts that are occurring or will occur in the future. Indirect biodiversity offsets were also allowed by some jurisdictions (Cwlth, ACT, NSW, Tas, WA), in the form of projects that contribute to the overall knowledge of a matter without directly providing protection.

Social considerations included requirements for developers to consult with the community (ACT, WA) and allow appeal processes for developers and/or members of affected communities (Qld, WA).

Economic considerations such as the financial impact of the biodiversity offset on developers (Cwlth, NSW, Qld), allowing developers to trade permits (NSW, Vic), and allowing developers to provide a financial contribution to the government for conservation in lieu of providing biodiversity offsets (NSW, Qld, SA, WA) were included by some jurisdictions.

Legislative inclusions varied among jurisdictions (Table 2). The delegation of biodiversity offsets to third party providers (E_7) and the requirement for biodiversity offsets to be 'like-for-like' (E_10) were the most commonly included considerations with eight and seven jurisdictions requiring these respectively (Table 2). The consideration that was least frequently required for biodiversity offsets was for delivery within specified timeframes (E_4); with only one jurisdiction including this component. Inclusion of appeal processes for developers (S_1) and communities (S_2), as well as the requirement for biodiversity offsets for the removal of all native vegetation (E_2) and the allowance of tradeable permits (Ec_1) were also poorly considered, with these only occurring in two jurisdictions each (Table 2).

The legislation and policies for Queensland were the most comprehensive, including 12 considerations across environmental and economic aspects. The Australian Capital Territory and New South Wales had the second most considerations with 11. The Northern Territory included no considerations and Tasmania had the second least with three, despite having biodiversity offset requirements spread across several different legislative instruments.

Australian Capital Territory and Commonwealth included the largest number of environmental considerations, with 10 and 9 respectively, while Tasmania included the least with three. Western Australia included the most social considerations with three, while Commonwealth, New South Wales, South Australia, Tasmania and

Victoria did not include social considerations. New South Wales included three economic considerations; Tasmania and Australian Capital Territory did not have any economic considerations.

Table 2.2: Environmental, social and economic considerations identified in the legislation and /or policy of each jurisdiction. ACT – Australian Capital Territory, Cwlth – Commonwealth, NSW – New South Wales, Qld – Queensland, SA – South Australia, Tas – Tasmania, Vic – Victoria, WA – Western Australia.

	Code	Consideration	Cwlth	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	*Total*
Environmental	E_1	Includes definitions of matters to be offset	1	1	1	0	1	0	0	1	0	*4*
	E_2	Required for all native vegetation removal	0	0	0	0	0	1	0	1	0	*2*
	E_3	Required for listed matters	1	1	1	0	1	0	0	0	0	*4*
	E_4	Requires delivery within specified timeframes	0	1	1	0	0	0	0	0	0	*2*
	E_5	Requires no net loss of biodiversity	1	1	0	0	1	1	0	1	0	*5*
	E_6	Includes an offsets calculator	1	1	1	0	1	1	0	1	0	*6*
	E_7	Allows offsets to be delegated	1	1	1	0	1	1	1	1	1	*8*
	E_8	Allows indirect offsets	1	1	1	0	0	0	1	0	1	*5*
	E_9	Allows advanced offsets	1	1	0	0	1	0	0	0	1	*4*
	E_10	Requires ‘like-for-like’ offsets	1	1	1	0	1	1	0	1	1	*7*
	E_11	Allows offsets to be staged	1	1	1	0	1	0	1	0	1	*6*
Social	S_1	Includes an appeal process for developers	0	0	0	0	1	0	0	0	1	*2*
	S_2	Includes an appeal process for community members	0	0	0	0	1	0	0	0	1	*2*
	S_3	Requires community consultation	0	1	0	0	0	0	0	0	1	*2*
Economic	Ec_1	Allows tradeable permits	0	0	1	0	0	0	0	1	0	*2*
	Ec_2	Allows for a financial contribution in lieu of an offset	0	0	1	0	1	1	0	0	1	*4*
	Ec_3	The financial impact of offset on developer is taken into account	1	0	1	0	1	0	0	0	0	*3*
Total			*10*	*11*	*11*	*0*	*12*	*6*	*3*	*7*	*9*	

2.3.4 Similarity analysis

According to the statistical analysis, Australian Capital Territory and Commonwealth were the most similar in offsetting capability, with a similarity of 75% (Table 2.3, Figure 2.2). However QLD and New South Wales were also moderately similar to both Australian Capital Territory (>50% similarity) and Commonwealth (>60% similarity). Victoria and South Australia were also moderately similar, with similarities greater than 60%.

The Northern Territory was the least similar to the other jurisdictions with a similarity of 0% due to the fact that the Northern Territory does not have biodiversity offsets policy or legislation in place and cannot require biodiversity offsets. To prevent skewing of results, the Northern Territory was removed from further analysis (Table 2.3, Figure 2.2).

Of the other jurisdictions, Victoria and Tasmania were the least similar with less than 11% similarity (Table 2.3, Figure 2.2). In fact, Tasmania had a low similarity to all jurisdictions, consistently demonstrating the least similarity (Table 2.3, Figure 2.2).

Table 2.3: Similarity matrix showing the percentage similarity between the biodiversity offsets policy and legislation of each jurisdiction based on the aspects analysed. ACT – Australian Capital Territory, Cwlth – Commonwealth, NSW – New South Wales, Qld – Queensland, SA – South Australia, Tas – Tasmania, Vic – Victoria, WA – Western Australia.

	Cwlth	ACT	NSW	Qld	SA	Tas	Vic	WA
Cwlth	100.00	75.00	61.54	69.23	33.33	30.00	41.67	35.71
ACT	75.00	100.00	57.14	53.33	30.77	27.27	38.46	42.86
NSW	61.54	57.14	100.00	53.33	30.77	27.27	38.46	33.33
Qld	69.23	53.33	53.33	100.00	38.46	15.38	35.71	50.00
SA	33.33	30.77	30.77	38.46	100.00	12.50	62.50	25.00
Tas	30.00	27.27	27.27	15.38	12.50	100.00	11.11	33.33
Vic	41.67	38.46	38.46	35.71	62.50	11.11	100.00	14.29
WA	35.71	42.86	33.33	50.00	25.00	33.33	14.29	100.00

	Cwlth	ACT	NSW	Qld	SA	Tas	Vic	WA
Cwlth	100.00	75.00	61.54	69.23	33.33	30.00	41.67	35.71
ACT	75.00	100.00	57.14	53.33	30.77	27.27	38.46	42.86
NSW	61.54	57.14	100.00	53.33	30.77	27.27	38.46	33.33
Qld	69.23	53.33	53.33	100.00	38.46	15.38	35.71	50.00
SA	33.33	30.77	30.77	38.46	100.00	12.50	62.50	25.00
Tas	30.00	27.27	27.27	15.38	12.50	100.00	11.11	33.33
Vic	41.67	38.46	38.46	35.71	62.50	11.11	100.00	14.29
WA	35.71	42.86	33.33	50.00	25.00	33.33	14.29	100.00

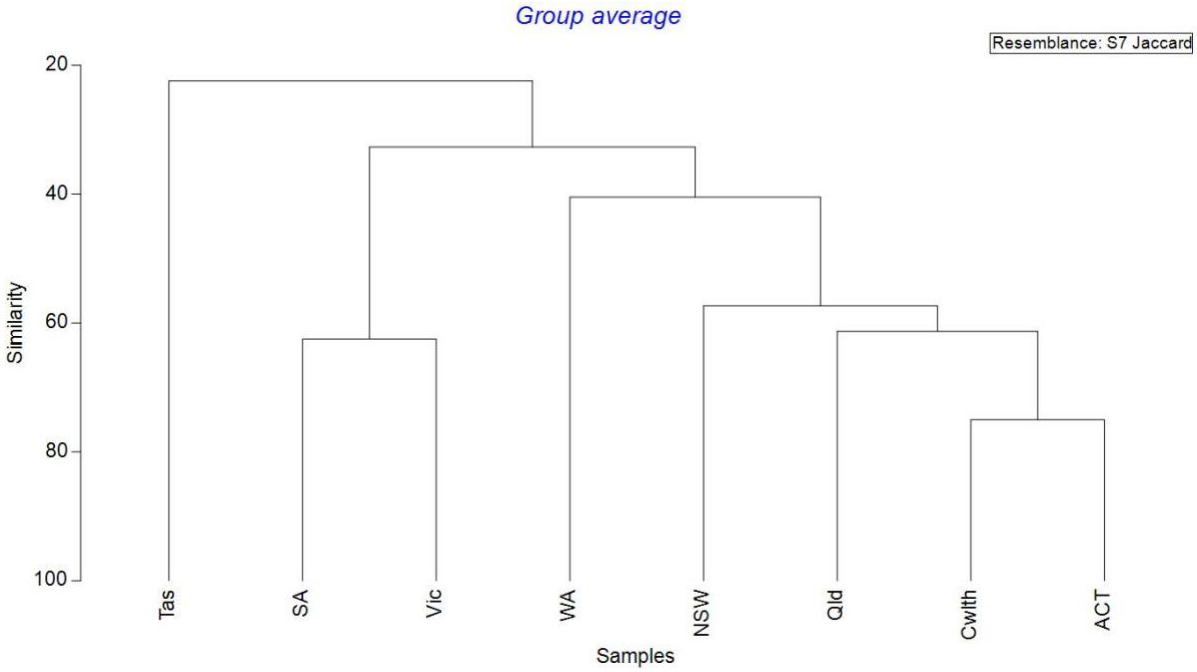

Figure 2.2: Cluster analysis dendrogram depicting similarities between all jurisdictions except for NT. ACT – Australian Capital Territory, Cwlth – Commonwealth, NSW – New South Wales, Qld – Queensland, SA – South Australia, Tas – Tasmania, Vic – Victoria, WA – Western Australia.

2.4 Discussion

This study highlights the considerable inconsistencies and incompleteness in biodiversity offsets policy and legislation across Australian jurisdictions, with no jurisdiction including all environmental, social and economic considerations found. The consequence of this variation is that some states/territories have the capacity to elicit clear requirements for biodiversity offsets, whilst others do not. In addition, it was apparent that there is insufficient consideration of social and economic aspects of sustainability in relation to biodiversity offsets, with few considerations recorded and few jurisdictions including the considerations found. Clearly there is need for consolidation of legislation and policies across Australian in order to ensure that the application of biodiversity offsets is not contradictory to the goals of sustainable development.

2.4.1 Similarity among jurisdictions

Australian jurisdictions, other than the Northern Territory, included the environmental aspect of sustainability in their legislation, policies and published guidelines. All jurisdictions, other than Tasmania, also considered at least one other aspect (social

or economic). The consideration of these aspects varied with the jurisdictions broadly organised into four clusters: 1) Commonwealth, Australian Capital Territory, New South Wales and Queensland, 2) South Australia and Victoria, 3) Western Australia and 4) Tasmania. The variability in Australia's biodiversity offset requirements is primarily because there are not nationally or internationally recognised standards for biodiversity offsets (Benabou, 2014). Further, the Commonwealth has restricted its responsibility for MNES under the HoA (Macintosh, 2015). While the states and territories have responsibility for the whole of the environment within their respective regions, how this is achieved is discretionary (Macintosh, 2015). Due to the democratic nature of the political process in Australia, the way this responsibility is actioned is almost certainly reflective of the political climate of each jurisdiction. This has further implications in terms of equity between developers and communities. The Commonwealth allows state and territory imposed biodiversity offsets to contribute towards the EPBC Act required offsets package if it also offsets impacts to MNES (DSEWPaC, 2012a). As such, with states and territories having different biodiversity offset requirements in place, the Commonwealth may be applying offsets inconsistently, potentially causing environmental, social and economic inequities.

The objectives between State and Territory environmental legislation and policy also differed between jurisdictions, requiring biodiversity offsets for different matters. South Australia and Victoria require biodiversity offsets only for removal of native vegetation, while Commonwealth, Australian Capital Territory and Queensland require biodiversity offsets for impacts on listed species. The remaining states (NSW, Tas, WA) require biodiversity offsets for the protection of the environment more broadly. This is likely a reflection of politics, as legislation is driven by the needs of political parties to represent the concerns of their constituents. However, the evident disparity among states and territories regarding matters that are protected is of concern as it has the potential to enable biodiversity loss. This may be particularly important for species that have broad home ranges crossing jurisdictional boundaries and for migratory species. In addition, having jurisdictions with different biodiversity offset requirements could result in inequitable outcomes (Bull et al., 2013b). While it might be argued that the Commonwealth has a responsibility to fill gaps in environmental protection, the EPBC Act does not achieve this. MNES includes listed species, which must already have been assessed as having a threatened conservation status (e.g.

vulnerable), and migratory species. The conservation status of a species is, however, based on available research, and as such many species, particularly those with a paucity of current information on life history, ecology and/or population status, may be missed. This focus on listed species may also miss provisioning species that support these listed species, allowing indirect threats on listed species to occur.

An indirect source of inconsistency in approach relates to how biodiversity offsets are required under legislation. Excluding Queensland, which has specific biodiversity offset legislation, and Northern Territory, with no biodiversity offset legislation or policies, all biodiversity offset requirements of Australian jurisdictions are described in policies. While for the Australian Capital Territory and Western Australia these policies are statutory, for the remainder of the states and territories these are non-statutory documents. This means that biodiversity offset requirements are guidelines only, and instead are required at the discretion of the governing jurisdiction.

Even where policies are statutory, there is now a legal precedent where these have been found to be discretionary. The Roe 8 development (a road extension project proposed for the use by heavy transportation, primarily trucks, in order to bypass inner suburban streets when transporting freight to and from Fremantle Port in Western Australia) was granted conditional environmental approval to clear approximately 97.8 hectares of native vegetation within a 167 hectares development envelope by the Western Australian Minister for the Environment, Hon Albert Jacob MP, 5 July 2015. This highly controversial project was the subject of several appeals, most notably that the WA EPA had been legally unreasonable in ignoring its own policies when approving the project (Save Beeliar Wetlands (Inc) -v- Jacob [2015] WASC 482). Ultimately, however, the high court found that the WA EPA was under no legal obligation to consider its policies and was therefore free to grant approvals on other considerations (Jacob-v-Save Beeliar Wetlands (Inc) [2016] WASCA 126). This sets an important legal precedent in Australian environmental regulation, and in particular has potential implications for biodiversity offsets which are primarily described under policies.

Another source of dissimilarity in biodiversity offsets between the jurisdictions may be in the application of biodiversity offsets by regulators. Although this concept was not assessed in this study, it is foreseeable that discretion used in the application of

biodiversity offset requirements could cause further dissimilarity not only between jurisdictions, but perhaps even within a jurisdiction.

2.4.2 Consistency in biodiversity offsets

Greater consistency in the requirements for biodiversity offsets would address gaps in protection and equity between developers/communities. Furthermore it may create greater benefits for the environment by allowing developers to build complementary biodiversity offset programs across jurisdictions to provide better outcomes. Martin et al. (2016) found this to be a key priority when interviewing relevant stakeholders from various sectors including governments, business, NGOs and individuals.

Globally, there is also a case for a consistent approach to biodiversity offsets. It may be argued that this is evidenced by the success of BBOP, an organisation with more than 80 members, including developers, service providers, governments, conservation groups and individuals. BBOP shares information on a best practice approach to biodiversity offsets that, in effect, would achieve consistency between those using the BBOP approach. While developers may strive for best practice and to follow a consistent approach to biodiversity offsets, they must also meet the requirements that are imposed by jurisdictions relevant to their developments. As such, it is unlikely that a consistent approach to biodiversity offsets will be broadly adopted without a consistent approach being required within legislation and policies between jurisdictions.

Although legislation and impetus differs among countries, countries developing biodiversity offset requirements generally look to others to find out how to develop and implement them. Reviews have been published comparing the environmental regulation and market based instruments for biodiversity offsets that are used in Australia to countries such as Uzbekistan and South Africa (Bull & Brownlie, 2015; Midgley, 2015). Additionally, countries such as the United Kingdom have based their biodiversity offset requirements on examples from Australia (Carver, 2015). In this way, Australia may have the ability to influence the concept of biodiversity offsets globally and to drive biodiversity offsets policy to better ensure sustainability of development.

In recent times, there has been a move to improve consistency in biodiversity offsets policy and legislation across Australian jurisdictions. In 2012, the Council of Australian

Governments (COAG) agreed to reform regulation to reduce the duplication of environmental requirements (including biodiversity offsets) and double-handling of environmental assessments of development applications (DSEWPaC, 2012c). This agreement resulted in a commitment for the Commonwealth to delegate its environmental assessments and approvals to the states and territories by way of bilateral agreements (DSEWPaC, 2012d). While this is a step in the right direction towards improving the consistency of biodiversity offsets, these agreements only apply to matters protected by the EPBC Act. Consequently, this move will not address the disparity in the protection of environmental matters using biodiversity offsets between states and territories. Further, with a paucity of appropriate social and economic considerations in the EPBC Act, it will not appropriately address the other aspects of sustainable development in relation to biodiversity offsets. Additionally, uptake to date has been poor, with bilateral agreements in effect for the assessment of MNES in place for all states and territories, but not for the approval of MNES. In practice, this means that states and territories have the delegated ability to assess MNES on behalf of the Commonwealth, but approval and the requirements for conditions, including biodiversity offsets, remains at the discretion of the Commonwealth.

2.4.3 Biodiversity offset and sustainability

Ideally, jurisdictions that use biodiversity offsets to allow developments to go ahead should ensure sustainability by including biodiversity offset requirements that appropriately encompass environmental, social and economic aspects. In fact, as environmental legislation in Australia requires consideration of sustainable development through interpretation (Macintosh, 2015), consideration of the environmental, social and economic aspects of sustainability is required relation to biodiversity offsets. However, biodiversity offsets policy and legislation in Australia was found to be heavily weighted towards environmental components, with 11 of the total of 18 components analysed being environmental. This is likely a reflection of the requirement for biodiversity offsets to compensate for environmental impacts under environmentally focussed legislation. Although social and economic aspects must be considered in the assessment process, without explicit mention of these aspects in legislation and policy, this will be discretionary and is not reflective of a balanced approach to sustainable development. To ensure that biodiversity offsets are applied fairly and consistently, legislation and policies should comprehensively include

environmental, social and economic considerations and ensure that the definition and application of significance criteria for each consideration is applied consistently. Without this, the potential to unfairly impact developers and communities, as well as the introduction of unnecessary risks to the environment, will continue.

Both developments and biodiversity offsets can pose substantial social and economic risks if not appropriately considered. The change of use of an area from one purpose (such as a public open space) to be set aside for a development can have societal impacts through restrictions to recreational services (e.g. fishing, hiking, etc.), visual amenity, pollution concerns and removal of ecosystem services. Consequently, there may be loss of income from ecosystem services impacted by a development, thereby introducing economic concerns to communities. In addition to this, the placement of the biodiversity offset could cause similar negative impacts to society and the economy, for example by 'locking-away' for conservation certain ecological resources that were used by a community (Ghosh, 2017).

Additionally, economic components regarding the cost/benefit of the biodiversity offset approach should be considered to ensure that developers are not unfairly disadvantaged and/or the benefits to communities of development (economically or through the access to further services) are not inequitable. As such, not only should environmental, social and economic components be considered for developments, all three aspects should also be considered for biodiversity offsets.

Theoretically, a consistent approach to biodiversity offsets could allow developers more flexibility to achieve 'like-for-like' by permitting biodiversity offsets in one area to be compensated for in another jurisdiction. Care would need to be taken, however, to ensure that this did not create social and economic inequity by the displacement of ecosystems services or other associated benefits (jobs, employment, visual aesthetic etc.) that could come from biodiversity offsets, bearing in mind that for practical purposes (cost, zoning/land tenure, boundary effects etc.) biodiversity offsets are often not in the direct vicinity of the development. Further research into which environmental, social and economic considerations should be applied and incorporated into biodiversity offset regulation would ensure that biodiversity offsets are effective, fair and equitable across jurisdictions.

2.4.4 The role of the Commonwealth

The Commonwealth has the overarching responsibility under the external affairs provision of the Constitution and Australia's ratification of the CBD to ensure sustainable use of all species. This allows the Commonwealth the ability to override the states and territories in regard to the protection of the environment (Peel & Godden, 2005). The EPBC Act also requires the Commonwealth to ensure sustainable development and that the principles of sustainable development must be considered in regard to determinations under the EPBC Act (Fallding, 2014; Macintosh, 2015; Peel & Godden, 2005). However, currently this is open to much interpretation as the EPBC Act refers to 'likely significant impacts', which are not defined, reducing transparency of matters assessed and compensation required (Macintosh, 2015; Peel & Godden, 2005). The analysis conducted in this study found that the Commonwealth included environmental components to ensure sustainable use, such as requirements for no net loss of biodiversity and for biodiversity offsets to be like-for-like. However, the EPBC Act restricts the role of the Commonwealth to protection of MNES, as agreed in the HoA, which has been criticised as being unnecessarily restrictive (Peel & Godden, 2005).

While the EPBC Act restricts the role of the Commonwealth, this could be changed as the Commonwealth has the power to enact a much broader role in terms of the environment (Peel & Godden, 2005) and because the HoA is an agreement, meaning that it is non-legally binding. Consequently the Commonwealth could extend its regulation to ensure that there are no gaps in the protection of species. This could, however, create conflict with the states and territories. The impetus behind the HoA is not for comprehensive environmental protection, but rather to avoid conflict between the Commonwealth and the states and territories on environmental matters. The states and territories have a long history of resisting any interference of the Commonwealth in their affairs in relation to the environment. This is best exemplified by the Tasmanian Dam Case in 1983, where the then Premier of Tasmania Robin Gray, very publicly defied an order of the Commonwealth to halt construction of a dam on the Gordon River, which is situated within a World Heritage Area. In relation to biodiversity offsets legislation, development of a specific COAG council dedicated to the environment could be a solution that would allow consistency between jurisdictions to be obtained.

The analysis conducted in this study found that the Commonwealth only included one social component and no economic components. The Commonwealth approves developments under the EPBC Act on the basis that biodiversity offsets are undertaken and has a commitment to ensure Australia meets its obligations to sustainable development as a signatory to the CBD, as well as Agenda 21, the Rio Declaration on Environmental Development and the 2030 Agenda for Sustainable Development. Therefore in addition to the environment, the Commonwealth should include social and economic aspects for biodiversity offsets regulation. Currently, all determinations under the EPBC Act require consideration of the principles of sustainable development, meaning that the Minister must have regard to all social and economic issues. However, with the scope of the EPBC Act restricted to direct or indirect impacts on MNES, the Minister can only consider certain environmental issues (Macintosh, 2015; Peel & Godden, 2005). As the requirement for sustainable development is not encapsulated in legislation specifically, further research would need to be undertaken as to how this is applied. With this legal ambiguity, however, it is likely that the application the EPBC Act is inconsistent. The restriction of the EPBC Act to consider only listed species and communities and not all of biodiversity is contrary to the principles of sustainable development and means that the EPBC Act in its current state is contradictory and cannot be fully implemented (Macintosh, 2015). The EPBC Act should be revised or replaced with new legislation that incorporates these requirements to ensure that the principles of sustainable development are adequately considered for all developments with significant impacts, and to ensure that all of the environment is protected. Further, a comprehensive framework for biodiversity is needed with clarity of roles and responsibilities at all three levels of government (Fallding, 2014).

2.5 Conclusion

Approval of developments is often contingent upon the implementation of appropriate biodiversity offsets. As such, biodiversity offsets should consider environmental, social and economic aspects to ensure that the developments approved by regulators are consistent with Australia's obligations to sustainable development. Currently inconsistencies in biodiversity offsets policy and legislation mean that species may be

vulnerable to loss and environmental degradation may occur. In addition, social aspects, such as ecosystem services, are not being considered and financial cost for developers and communities may not be applied equitably. The focus of legislation and policy on environmental aspects, without adequately considering economic and social aspects of biodiversity offsets, means that Australia may be remiss in their international obligations related to sustainable development.

Australia could improve its use of biodiversity offsets to assist in the achievement of sustainable development by ensuring that environmental, social and economic aspects of sustainability are considered in a balanced way across all jurisdictions. As the Commonwealth has the responsibility for implementing the CBD and ensuring the sustainable use of species, consistency in the approach to biodiversity offsets that ensures sustainable development will need to be driven by the Commonwealth. With appropriate support through COAG, Australia could use biodiversity offsets to ensure effective sustainable development, a notable achievement that could be adopted by other countries globally.

Addendum 2.1

Amendments to Chapter 2 following publication

Amendment	Location
The review of legislation, policy and published guidelines was undertaken by the same person over time to ensure consistency of results. Other authors reviewed the data, conclusions and presentation of the data but not were not involved in the analysis	Section 2.2
The Jaccard resemblance measure calculates the similarity between two sets of binary (i.e. presence/absence) data, and is calculated by dividing the intersection by the union of two sets of data (Chung et al., 2019). In this case, the Jaccard resemblance measure was used to compare the similarity between two jurisdictions at a time and this was then repeated until comparisons between all jurisdictions had been made.	Section 2.2
Subsequent to the publication of Chapter 2, the Northern Territory's *Environmental Assessment Act 1982* was repealed and replaced with the *Environmental Protection Act 2019* which commenced on 28 June 2020.	Section 2.3
Subsequent to publication of this paper, the NT published its Offsets Framework, which consists of the Northern Territory Offsets Principles, Offsets Policies, Technical Guidelines and Administrative Guidelines. In addition, a draft Northern Territory Biodiversity Offsets Policy was published for public consultation, with a view to finalising in 2023. As the Policy is still in draft, and subject to amendment resulting from public consultation, it has not been further considered.	Section 2.3.2.4

Chapter 3

The equity and effectiveness of biodiversity offset regulation in Australia

Biodiversity offsets are regularly used in Australia to enable development as demonstrated by Chapter 2. However, the ethicality of the use of biodiversity offsets to contribute to sustainable development and the effectiveness of offset requirements in Australia has not been assessed in detail. This chapter provides a review of Australian legislation, policies and published guidelines to rate biodiversity offset requirements in terms of the level of transparency, measurability and enforceability to identify offset ethicality and effectiveness. The results of this chapter provide necessary background and contribute to the development of the holistic best practice model detailed in Chapter 5.

The content of this chapter has been published in the Australasian Journal of Environmental Management as ‘Disparity in biodiversity offset regulation across Australia may reduce effectiveness’ (https://doi.org/10.1080/14486563.2021.1919231). This paper was co-authored by S. Griffin, A. Kemp and G. Coupland who provided editorial assistance.

3.1 Introduction

At a global level, governments need to promote economic development but without causing significant negative impacts on communities or the environment (Mandle et al., 2016). Economic, environmental and social priorities can often, however, be in conflict (Oettle, 2008). Biodiversity offsets are a way of attempting to achieve balance between the economy, environment and social priorities by resolving and/or easing community discomfort with the contradiction between economic growth and environmental protection (Apostolopoulou, 2016; Foerster & McDonald, 2016). Several studies exist on the effectiveness of environmental (e.g. Clare & Krogman, 2013; Fallding, 2014; May et al., 2017; Taherzadeh & Howley, 2018; zu Ermgassen et al., 2019), social (e.g. Ali et al., 2018; Bidaud et al., 2018; Ghosh, 2015; Mabon et al., 2018; Narain & Maron, 2018) and economic (e.g. Githiru et al., 2015; Habib et al., 2013; Lindenmayer et al., 2017) aspects of biodiversity offsets in isolation. However, there is a paucity of information on the effectiveness of implementation of all three aspects in combination and on the implications of this in terms of equity for both developers[2] and communities[3].

3.1.1 Effectiveness and equity of biodiversity offsets

The ability of biodiversity offsets to compensate adequately for development impacts on the environment has been questioned largely due to governance and administrative failures. Inadequacies include: deficiencies in legislation and administrative governance; insufficient description of matters to be offset; poor measurability and timeliness of implementation; a narrow focus only considering protected habitats and species rather than the whole of environment; and poorly considered social issues, such as the creation of social and spatial inequities or lack of consideration of ecosystem services (Apostolopoulou, 2016; Bidaud et al., 2018; Bigard et al., 2017; Burgin, 2008; Fallding, 2014; Foerster & McDonald, 2016; Griffiths et al., 2019; Jacob et al., 2016; Mandle et al., 2016; Maron et al., 2016b; Scholte et al., 2016; zu Ermgassen et al., 2019). The use of biodiversity offsets as compensatory measures

[2] The term ‘developers’ refers to those private and/or public companies, government and other organisations that seek to undertake an action that will have, or has the potential to have, a significant negative impact on the environment.

[3] The term ‘communities’ refers here to those persons, collective or individual, that will be physically, socially, culturally or otherwise affected by an action that will have, or has the potential to have, a significant negative impact on the environment.

for development may even cause an ethical shift in community expectations related to conservation (Maron et al., 2016b).

The failure of policy and legislation to deliver effective offsets has been questioned over time (Clare & Krogman, 2013; Fallding, 2014; zu Ermgassen et al., 2019). Offsets were found to be ineffective and have poor success rates if three practical challenges were not adequately addressed (Bull et al., 2013a): i) compliance/enforceability, ii) measuring environmental outcomes and iii) uncertainty/transparency (Bull et al., 2013b; Carreras Gamarra & Toombs, 2017; Clare & Krogman, 2013; Grinlinton, 2017). Failure to address these challenges may also cause inequities between communities affected by either development and/or the placement of biodiversity offsets.

3.1.1.1 Enforceability

One key factor affecting the effectiveness of biodiversity offsets is adequate enforceability (Gibbons & Lindenmayer, 2007), as poor compliance can result in offsets not meeting their intended outcomes and thus causing a loss of biodiversity (Lindenmayer et al., 2017; Moilanen et al., 2009; Norton, 2009). In order to be effective, biodiversity offset projects should be legally enforceable and audited (Lodhia et al., 2018; Norton, 2009). To achieve this, regulators must have the ability to ensure that offsets are achieving their goals against well-defined and appropriate measurable outcomes.

3.1.1.2 Measurability

A major concern is that the effectiveness of biodiversity offsets is rarely measured during and after implementation (Lindenmayer et al., 2017). Monitoring, reporting and auditing of offset activities is needed to ensure that biodiversity offsets are either meeting their intended outcomes, or to identify ongoing improvements (Koh et al., 2014; Kujala et al., 2015; Maron et al., 2010; Maron et al., 2012; Maron et al., 2016b). Even where the monitoring of offsets is required, this is often rendered ineffective through a lack of requirements for reporting (Gibbons et al., 2018), appropriate targets (Brady & Boda, 2017; Grinlinton, 2017; Takacs, 2018) or completion criteria (May et al., 2017). Requirements for measurability of biodiversity offsets, including regular reporting on appropriate offset targets and criteria, would provide regulators and relevant stakeholders (e.g. affected communities) with evidence that a given biodiversity offset is delivering its intended environmental outcomes.

3.1.1.3 Transparency

Transparency in biodiversity offset requirements, including stakeholder consultation, can reduce uncertainty of biodiversity offset outcomes (Bull et al., 2013b) or the unwitting loss of biodiversity (Maron et al., 2015), and has been recognised as best practice for biodiversity offsets (Bull et al., 2018). Transparency can also ensure that relevant stakeholders (e.g. affected communities) have realistic expectations in relation to biodiversity offsets (Maron et al., 2015). Transparency in a regulatory sense would mean the inclusion of clear definitions of matters to be offset and the inclusion of appeals processes for both developers and communities. A lack of transparency and clear objectives for biodiversity offsets hamper efforts to both monitor the effectiveness of offsets and to ensure that biodiversity offsets comply with legislative regulations and conditions. Compliance is more likely if clear standards are set for biodiversity offset requirements in legislation and policy (Bull et al., 2018; Carreras Gamarra & Toombs, 2017). Measuring the effectiveness of biodiversity offsets against these clear standards and reporting on this can provide regulators with assurance that the biodiversity offset is delivering its intended outcomes. Further, if standards in legislation and policy are clear, it improves the ability of regulators to act should the biodiversity offset fail to provide its intended outcomes.

3.1.1.4 Effectiveness

Often the effectiveness of biodiversity offsets is assessed by measuring their biodiversity outcomes against their intended compensatory measures, such as the capacity to achieve no net loss of biodiversity (zu Ermgassen et al., 2019). However, the outcomes of biodiversity offsets are often not publicly available or can be difficult to ascertain due to the long-time frames for environmental values to be realised and/or a lack of completion criteria (May et al., 2017). Given that biodiversity offsets must be measured against predetermined outcomes, the effectiveness of the biodiversity offset can be indicated by the level of detail provided in the offset requirements.

Biodiversity offsets often involve the delivery of conservation projects, either for research, rehabilitation/restoration or averted loss/protection (Jacob et al., 2018; Maron et al., 2015; Moilanen & Kotiaho, 2018). To ensure that these conservation projects are effective, aspects of conservation and measures of success or failure, including key milestones, need to be defined rigorously and transparent reporting

should occur at key intervals (Brady & Boda, 2017). The ability of governments to implement biodiversity offsets effectively and equitably may be severely reduced (McKenney & Kiesecker, 2010) if there is no transparency regarding the ecological, social, political, and cultural impacts of biodiversity offsets (Mann, 2015). Transparency and measurability in particular, but also enforceability, must be included in biodiversity offset conditions to enable assessment of effectiveness of the offset to meet key milestones and completion criteria, or, conversely, the need to implement remediation measures.

3.1.1.5 Equity

Transparency, measurability and enforceability are important to ensure not only the effectiveness of biodiversity offsets, but also their equity. If biodiversity offsets are not effective in achieving their intended outcomes, then communities and relevant stakeholders could be disadvantaged by a loss of biodiversity and/or ecosystem services. Additionally, developers investing significant resources to effectively achieve positive outcomes for biodiversity offsets could be disadvantaged compared to those not achieving positive outcomes due to more lax requirements and a lower resource burden.

3.1.2 Offset requirements in Australia

In Australia, there are three levels of government: the Commonwealth (federal) government; the governments of the eight states and territories; and the local (municipal) governments. Each level of government has the ability to regulate the environment and may consider biodiversity offsets as a form of environmental compensation for development (Abdo et al., 2019a). The states and territories have the ability to regulate environmental matters within their boundaries. Local governments' capacity for environmental regulation is nested within the relevant states and territories as this is where they gain their legislative power. The Australian Constitution does not include consideration of the environment, meaning the Commonwealth does not have explicit powers of environmental regulation (Abdo et al., 2019a). However, the Commonwealth does have the legal power to ensure that Australia meets its international commitments under its external affairs powers and therefore gains powers to regulate the environment as a signatory to various international conventions related to environmental matters (Abdo et al., 2019a). In the

case of biodiversity offsets, Australia is a signatory to the Convention on Biological Diversity, which is dedicated to the conservation of biodiversity (CBD, 2017a). As a signatory to the Convention on Biological Diversity, Australia is obliged to achieve the Aichi Targets (a set of 20 ambitious, yet achievable, biodiversity goals to be attained by the year 2020) under the Convention on Biological Diversity 2011-2020 strategic plan (CBD, 2011). The overall aim of the Aichi Targets is to ensure "pressures on biodiversity are reduced, ecosystems are restored, biological resources are sustainably used and benefits arising out of utilization of genetic resources are shared in a fair and equitable manner; adequate financial resources are provided, capacities are enhanced, biodiversity issues and values mainstreamed, appropriate policies are effectively implemented, and decision-making is based on sound science and the precautionary approach" (CBD, 2011). The Aichi Targets expired in 2020 and are expected to be superseded by the Global Biodiversity Framework, which has been drafted and is currently (as of 2021) being finalised by the Convention on Biological Diversity. The Global Biodiversity Framework identifies five long-term goals for 2050 that meet its 2050 vision to ensure "biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people" (CBD, 2020). Further, its goal to ensure "No net loss by 2030 in the area and integrity of freshwater, marine and terrestrial ecosystems, and increases of at least (20%) by 2050, ensuring ecosystem resilience" will have significant bearing on Convention on Biological Diversity signatories' approach to biodiversity offsets.

If biodiversity offsets are not effective and equitable, then Australia may not be able to meet the Aichi Targets/Global Biodiversity Framework or any other obligations as a signatory to the Convention on Biological Diversity. While the actual repercussions for Australia in not meeting these obligations are merely reputational in nature, failure to meet these obligations can result in further decline in the extent and condition of biodiversity and ecosystem services, and may even result in further extinction of vulnerable species. Given that Australia has a very high biodiversity and proportion of endemic species coupled with extensive loss of natural vegetation and the greatest current rate of terrestrial species extinction in the world (Bradshaw, 2012; Woinarski et al., 2015), continuing decline is of particular concern.

3.2 Aims

Our study aims to determine if the Australian Commonwealth's, and states' and territories' legislative and policy requirements are sufficient to ensure biodiversity offsets compensate adequately for development impacts by ensuring equity and effectiveness through measurability, enforcement and transparency. As biodiversity offsets should balance environmental, social and economic aspects, measurability, enforcement and transparency have been assessed separately in relation to these aspects.

Previously the requirements for biodiversity offset in relation to environmental, social and economic aspects in Australia have been found to be variable (Abdo et al., 2019a). Based on this, it is expected that the Commonwealth and the states and territories will vary in their ability to ensure transparency, measurability and enforceability across these three aspects. Given that the Commonwealth has the responsibility to ensure that Australia meets its commitments to the Convention on Biological Diversity, it is expected that any gaps found in the transparency, measurability and enforceability of biodiversity offsets between the states and territories will be filled by Commonwealth biodiversity offset requirements.

3.3 Methods

The websites for the Commonwealth, state and territory government departments with responsibility for the approving environmental impact assessments were examined for legislative instruments (legislation, policies, published guidelines) relating to environmental impact assessment and/or biodiversity offsets (see Table 3.1, column 2). Public availability of such documents would reflect the transparency of documentation readily available to both developers and communities affected by biodiversity offsets, regardless how narrow the scope. The documentation attained though this method was reviewed (Table 3.1, column 3) and analysed for inclusion of sections applicable to biodiversity offsets. As the Northern Territory does not have in place specific biodiversity offset legislation or policy and cannot consider biodiversity offsets (NTEPA, 2013), it was excluded from further analysis.

It should be noted that only aspects included in legislation, policy and published guidelines in effect as of September 2019 were included in the analysis. Historical

legislation and policy were outside the scope of this analysis, as were additional aspects that might be required by jurisdictions as conditions of approval, but not specifically stated in legislation, policy and published guidelines.

Table 3.1: List of environmental legislation and policy reviewed for comparison of Commonwealth and state and territories biodiversity offset inclusions and requirements.

Jurisdiction	Authority responsible	Legislation/policy reviewed
Commonwealth	DCCEEW, 2022b	*Environment Protection and Biodiversity Conservation Act* 1999
		Environment Protection and Biodiversity Regulations 2000
		Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy 2012
Australian Capital Territory	EPSDD, 2018	*Planning and Development Act 2007*
		ACT Environmental Offsets Policy
New South Wales	OEH, 2017	*Biodiversity Conservation Act 2016*
		Local Land Services Act 2013 (as amended by the Local Land Services Amendment Act 2016)
		Biodiversity Conservation Regulation 2017
		Local Land Services Regulation 2014
		State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017
Northern Territory	NTEPA, 2013	*Environmental Assessment Act*
		Guidelines on environmental offsets and associated approval conditions
Queensland	QG, 2018	*Environmental Offsets Act 2014*
		Environmental Offsets Regulation 2014
		Queensland Environmental Offsets Policy (Version 1.6): June 2018
South Australia	DEW, 2017	*Native Vegetation Act 1991*
		Native Vegetation Regulations 2017
		Guide for calculating a Significant Environmental Benefit under the *Native Vegetation Act 1991* and the Native Vegetation Regulations 2017
		Policy for calculating a Significant Environmental Benefit under the *Native Vegetation Act 1991* and the Native Vegetation Regulations 2017
Tasmania	DPIWE, 2002; FPA, 2011; NCHD, 2015	*Forest Practices Act 1985*
		Nature Conservation Act 2002
		Threatened Species Protection Act 1995
		Water Management Act 1999
		Natural Resource Management Framework
		Guidelines for Natural Values Surveys - Terrestrial Development Proposals
		Policy of the Forest Practices Authority: The use of offsets
Victoria	ELWP, 2018	*Planning and Environment Act 1987*
		Guidelines for the removal, destruction or lopping of native vegetation
		A quick comparison of first party and third party offset sites
Western Australia	EPA, 2018	*Environmental Protection Act 1986*
		WA Environmental Offsets Policy 2011
		WA Environmental Offset Guidelines
		Bilateral Agreement under section 45 of the Environmental Protection and Biodiversity Conservation Act 1999

A rating key (Table 3.2), based on the review of legislation, policy and published guidelines, was developed for the level of transparency, measurability and enforceability of biodiversity offset requirements in relation to environmental, social and economic aspects of biodiversity offsets. Definitions of the terms ‘transparency’, ‘measurability’ and ‘enforceability’ used for the purposes of this study are also provided in Table 3.3. Transparency, measurability and enforceability indicators were recorded for environmental, social and economic aspects.

Table 3.2: Key to ratings used to determine the transparency, measurability and enforceability of biodiversity offset inclusions and requirements of Commonwealth, and state and territories governments.

Rating	Transparency	Measurability	Enforceability
0	complete absence of this aspect in legislation - not considered at all		
1	Partially defined biodiversity offset inclusions and processes	Reporting on achievements of the biodiversity offset is required at regular set intervals	Aspects of biodiversity offsets are included in guidelines but are not included in legislation (non-statutory) and therefore cannot be enforced
2	Clearly and comprehensively defined biodiversity offset inclusions and processes	Reporting on achievements of biodiversity offset is required at regular set intervals **and** key milestones/indicators of success/failure are defined	Aspects for biodiversity offsets are clearly stated in the legislation
3	Clearly and comprehensively defined biodiversity offset inclusions **and** a dedicated appeal process in place for developers and/or community	Reporting on achievements of biodiversity offset is required at regular set intervals **and** key milestones/indicators of success/failure are defined **and** mechanisms for 'non-compliance'/failure of biodiversity offset to achieve its stated milestones are included	Aspects for biodiversity offsets are clearly stated in the legislation **and** onsite audits are conducted at regular intervals

Table 3.3: Definition of terms and indicators used for the purposes of this study.

Terminology	Study definition	Indicators	Examples of aspects
Transparency	How well prescribed offset requirements and processes are to ensure equity and effectiveness	• clear definitions of matters to be offset and associated processes • appeal provisions for both developers and communities	• threatened species and communities
Measurability	The transparency of how compliance with biodiversity offset conditions were measured	• requirements for reporting at defined intervals • definitions of key indicators and non-compliance	• social engagement • consideration of ecosystem services
Enforceability	The ability of regulators to take action should biodiversity offsets fail to deliver in their objectives[4]	• aspects of biodiversity offsets being captured in statutory documents, • the ability of regulators to audit biodiversity offset implementation and outcomes	• financial requirements related to biodiversity offsets • economic cost to developers

The documents were then rated according to transparency, measurability and enforceability. The ratings are cumulative: the provisions that were least rigorous (and commonly found in legislation and policy) were given low ratings, and provisions that went beyond these to demonstrate increased rigour were given higher ratings. No measures of transparency, measurability and enforceability that were at higher ratings (2 or 3) were found in the legislation, policy or published guidelines in the absence of any of the lower rated (1) measures.

Local government by-laws were not included in the analysis as the role of local governments in environmental regulation is delegated by the states and territories.

The assessment of Commonwealth, state and territory biodiversity offsets-related legislation, policy and published guidelines against the rating key was conducted nine times, incorporating: environmental transparency, social transparency, economic transparency, environmental measurability, social measurability, economic

[4] Although legislation provides government officers power to take action if it is suspected a provision of legislation has not been complied with, enforceability in this manuscript is defined as the transparency of how compliance with biodiversity offsets is determined

measurability, environmental enforceability, social enforceability, economic enforceability.

3.4 Results

3.4.1 Transparency

All jurisdictions reviewed had legislation or policy that ensured some level of environmental transparency (Figure 3.1). Western Australia and Queensland had the greatest level of transparency, with matters related to biodiversity offsets clearly defined, as was an appeal process for developers and/or community. New South Wales, South Australia, Victoria and the Commonwealth had clearly defined environmental biodiversity offset inclusions and processes. Tasmania and the Australian Capital Territory had the lowest environmental transparency ratings as environmental biodiversity offset inclusions and processes were only partially defined.

The Australian Capital Territory and Queensland were the only jurisdictions with social transparency ratings, each with a score of one. Both jurisdictions have partially defined processes for social (community) engagement.

Queensland, Victoria, South Australia and the Commonwealth were the only jurisdictions given ratings for economic transparency, with all scoring two. Queensland and the Commonwealth have biodiversity offset calculators that enable determination of the cost of biodiversity offsets, whereas Victoria and South Australia have economic calculations embedded within their biodiversity offset guidelines.

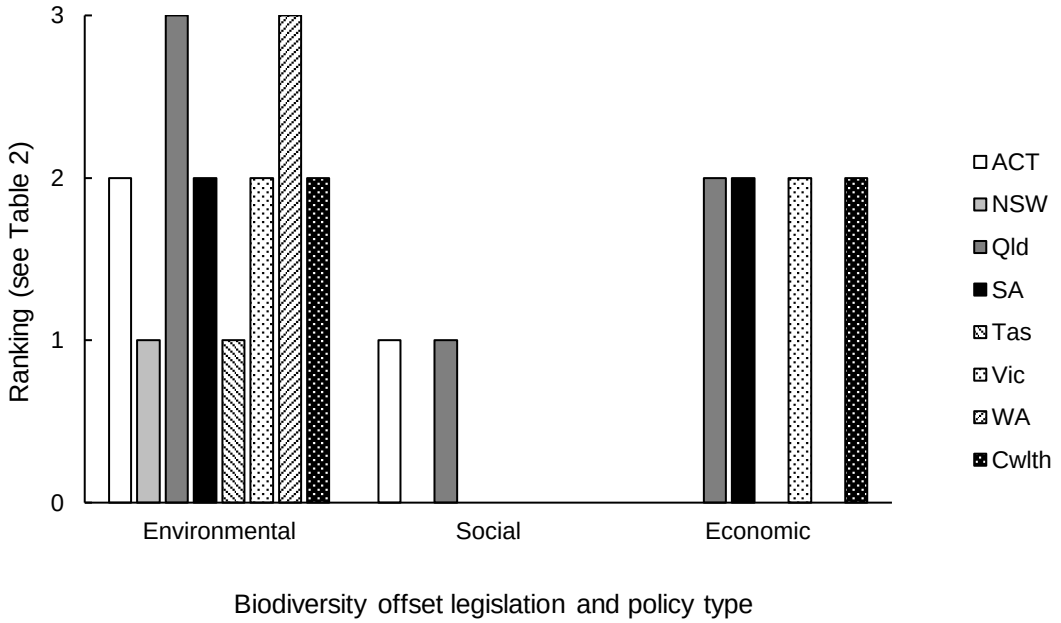

Figure 3.1: Ratings of transparency (out of 3 - as defined in Table 3.2) for the Australian Commonwealth, states and territories based on a review of biodiversity offsets related legislation and policy (see Table 3.1). ACT – Australian Capital Territory, Cwlth – Commonwealth, NSW – New South Wales, Qld – Queensland, SA – South Australia, Tas – Tasmania, Vic – Victoria, WA – Western Australia.

3.4.2 Measurability

The Commonwealth and New South Wales were the only jurisdictions with ratings of one for environmental measurability with requirements for reporting at regular intervals (Figure 3.2). The Commonwealth was also rated one for economic measurability. Social measurability was not included in legislation or policy for any jurisdiction.

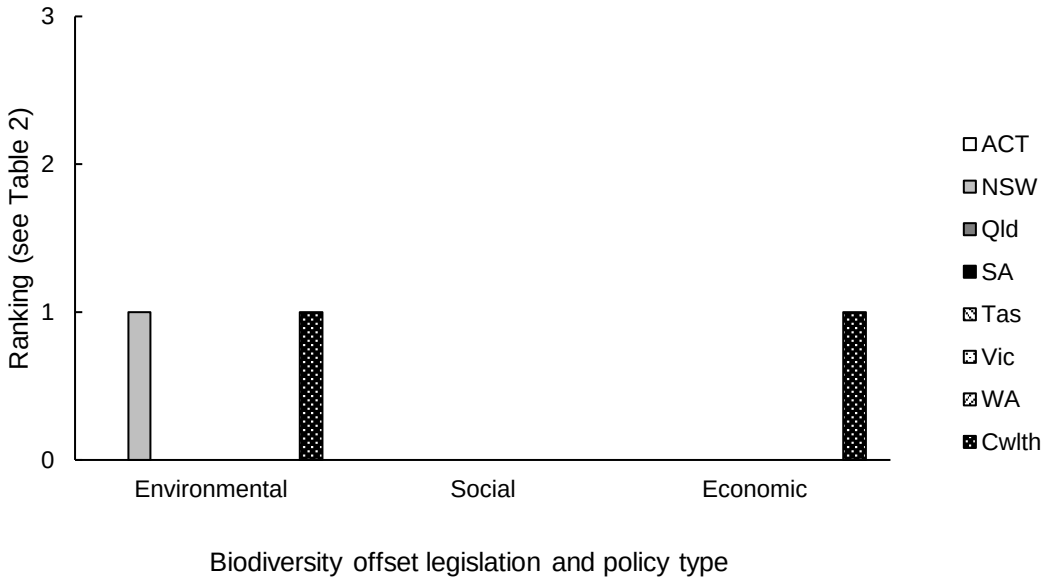

Figure 3.2: ratings of measurability (out of 3 – as defined in Table 3.2) for the Australian Commonwealth, states and territories based on a review of biodiversity offsets related legislation and policy (see Table 3.1). ACT – Australian Capital Territory, Cwlth – Commonwealth, NSW – New South Wales, Qld – Queensland, SA – South Australia, Tas – Tasmania, Vic – Victoria, WA – Western Australia.

3.4.3 Enforceability

Australian Capital Territory, New South Wales and Queensland had the highest rating (2) for environmental enforceability, with environmental aspects for biodiversity offsets clearly stated in legislation (Figure 3.3). All other jurisdictions had a rating of one, as environmental aspects of biodiversity offsets were in non-statutory guidelines.

Australian Capital Territory and Queensland also had a rating of two for social enforceability, with social aspects for biodiversity offsets clearly stated in legislation. Western Australia was the only other jurisdiction to consider social enforceability, although this was found in non-statutory guidelines, so was given a rating of one.

Queensland and South Australia both had economic ratings of two for enforceability, with both clearly stating economic biodiversity offset requirements in legislation. Victoria and the Commonwealth were the only other jurisdictions that had ratings for economic enforceability, with each having a rating of one, as economic biodiversity offset requirements were stated in non-statutory guidelines.

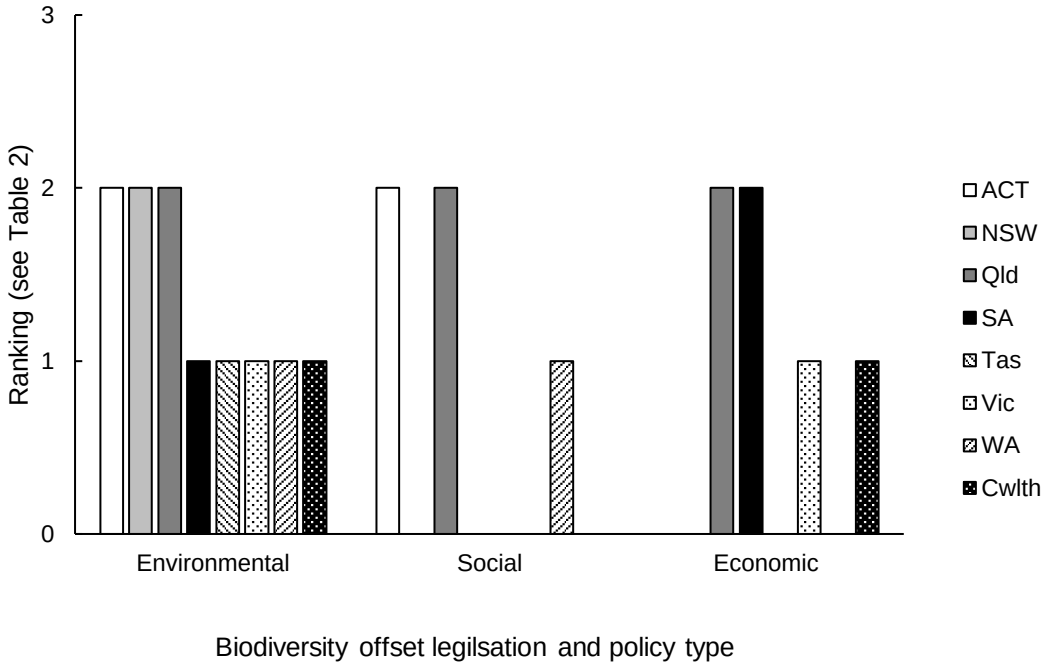

Figure 3.3: Ratings of enforceability (out of 3 – as defined in Table 3.2) for the Commonwealth, states and territories based on a review of biodiversity offsets related legislation and policy (see Table 3.1). ACT – Australian Capital Territory, Cwlth – Commonwealth, NSW – New South Wales, Qld – Queensland, SA – South Australia, Tas – Tasmania, Vic – Victoria, WA – Western Australia.

3.5 Discussion

All jurisdictions were found to have gaps in their ability to ensure transparency, measurability and enforceability for environmental, social and economic aspects of biodiversity offsets. This indicates that there is uncertainty with regard to biodiversity offsets in Australia being effective compensation measures for the impacts of development. Queensland had the best ratings for transparency and enforceability, being the only jurisdiction with dedicated biodiversity offset legislation. Other jurisdictions rely on conditions of approval following some form of environmental impact assessment (EIA) to impose offsets. An EIA is used to identify the likely environmental impacts of a development, and typically includes environmental studies as well as some form of stakeholder engagement (Bigard et al., 2017). In this way the environmental and social impacts of a development are considered. In Australia, biodiversity offsets are then triggered when the EIA identifies that the development will have, or has the potential to have, a substantial negative impact on a particular species or habitat of concern despite mitigations (DSEWPaC, 2012a).

The use of EIA as a regulatory means to require biodiversity offsets may be inappropriate as EIA and biodiversity offsets have different purposes; EIA is used to assess the suitability of a development proposal, whereas biodiversity offsets are a form of environmental compensation (Bull et al., 2013b; IAIA, 2009). Regulation for EIA only needs to assess the impact in the context of sustainable development, where regulation for biodiversity offsets should ensure that compensation is adequate and that environmental, social and economic aspects are also considered. This will ensure that biodiversity offsets are effective as compensatory measures for the impacts of development. Without regulation designed specifically for biodiversity offsets, development in Australia may not be adequately compensated for, which could lead to environmental degradation, social inequity or economic instability.

Regulation specifically designed for biodiversity offsets could also improve the success of implementation and assurance of adequate environmental compensation. Bidaud et al. (2018) found that this was a failing of biodiversity offsets implemented in Madagascar; where despite comprehensive environmental legislation, offsets rarely provided adequate compensation for environmental impacts, in part, due to the complexity of legislative requirements, with provisions being 'hidden' within guidelines and other documentation rather than consolidated into a single repository.

3.5.1 Transparency

The best assurance of equity in requirements for biodiversity offsets is transparency. Transparency ensures that matters to be offset are captured within legislation and appeal processes are available to relevant stakeholders. Transparency of requirements can also assist in effective offset implementation and compliance (Bidaud et al., 2018; Bull et al., 2018, Theis et al., 2020). Regulations should provide sufficient detail to ensure that the assessment of any development is consistent in terms of its environmental, social and economic impact. Although Western Australia and Queensland had transparent process for environmental aspects, transparency was lacking for social and economic aspects. All other jurisdictions were found to be lacking in every aspect of transparency. This could lead to a large degree of interpretation and discretion in decision-making. Inequities between the approvals for different developments could also be created, potentially resulting in inadequate environmental protection or inequitable impacts on communities and/or developers.

This inadequate protection could in turn have negative economic outcomes, including loss of jobs or changes to share prices. It can also create unnecessary economic burden. For example, Coggan et al. (2013a) found that in Mission Beach, Queensland, a lack of clarity in biodiversity offset requirements resulted in protracted negotiations and development delays of six to 12 months, with every week of negotiation costing developers approximately AUD10,000 in holding and interest costs, as well as additional costs incurred by the regulator.

Where transparency of requirements is lacking, biodiversity offset requirements may be influenced by negotiations between regulators and developers, resulting in inequities between the requirements for environmental outcomes between developers (Clare & Krogman, 2013). Due to a lack of transparency, flexibility is allowed, with the implication that assessors may be using discretion in environmental approval processes. This may result in inconsistently applied requirements and even deviation, or contradiction, in the interpretation of legislation and policy compared to its original goal (Clare & Krogman, 2013). For example, the Ichthys LNG Development Project was approved with biodiversity offset conditions for the Commonwealth in 2012 (EPBC 2008/4208). These conditions require the development of a biodiversity offset for a small area of cleared mangroves in the Northern Territory. The requirement is based on the precautionary principle that the affected area may be habitat for certain listed species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), even though they have not previously been detected in the project development area. In contrast, the Gulf Alumina Skardon River Bauxite Mining Project in Queensland, which was approved by the Commonwealth in 2014, only requires biodiversity offsets for similar listed species if those species (or signs of their habitat such as breeding, roosting, nesting or prey) are found within the project development area (EPBC 2014/7305). It could be argued that this is related to the maturation of biodiversity offsets within the two years separating these approvals. There were, however, no material changes to the EPBC Act in relation to biodiversity offsets between these times. Therefore, the discrepancies between these offset conditions are likely to be more reflective of gaps in the transparency of Commonwealth requirements for biodiversity offsets.

3.5.1.1 Appeal processes

Transparency of regulation of appeal processes is a further assurance of equity. Only Queensland and Western Australia had formal appeal processes in place for environmental aspects of biodiversity offsets. Without the possibility of appeal, disputed biodiversity offset conditions are only contestable in court. In the case of a community contest in court, the process is lengthy, costly and often subject to multiple appeals, which can deter or deny access to community groups. For developers, this has the potential to cause delays in development commencing with the associated economic repercussions. Consequently, biodiversity offset conditions are rarely contested, regardless of actual and/or perceived inequalities.

3.5.1.2 Considerations of biodiversity offset approval

Transparency of matters to be offset also requires adequate consideration of the feasibility of siting offsets, especially when like-for-like biodiversity offsets are required. For example, a search of the Northern Territory's Natural Resources Maps online application (DENR, 2018) finds there are very few areas available for biodiversity offset development in the Northern Territory due to land tenure. This situation has arisen because the Northern Territory's *Territory Parks and Wildlife Conservation Act 2014* does not have the legal power to supersede legal determinations made in relation to land tenure made by other acts, including the Commonwealth *Native Title Act 1993*, the Northern Territory's *Mineral Titles Act 2010, Petroleum Act 2009* or *Petroleum (Submerged Lands) Act 1967*. These acts prevail over environmental legislation, meaning that if biodiversity offsets are created on land designated under these acts, then the biodiversity offset may be subject to development at any time in the future, reducing the potential for offsets to achieve adequate environmental outcomes. This leaves very few areas within the Northern Territory where biodiversity offsets could be sited. Accordingly, like-for-like biodiversity offsets on a large scale are unlikely to be possible in the Northern Territory, which should be factored into Commonwealth considerations of development applications in the Northern Territory. Land tenure issues are also likely to exist in other states and territories because the Commonwealth *Native Title Act 1993* cannot be superseded anywhere in Australia, and mining and exploration legislation may also permit leases on land in which biodiversity offsets have been established. This has not been factored into biodiversity

offsets legislation and policy in a transparent way, potentially resulting in developers being granted biodiversity offset conditions for developments that cannot be practically implemented. This issue might not be discovered until after environmental impacts have occurred, meaning that loss of biodiversity will occur (Bigard et al., 2017; Bull et al., 2013b; Burgin, 2008; Maron et al., 2010; Maron et al., 2012). Availability of land for biodiversity offset measures should therefore be a component of biodiversity offset design and should be considered by regulators when setting biodiversity offset conditions.

3.5.1.3 Issues of equity

Lack of transparency of biodiversity offset requirements may allow developers to 'buy' favour with regulators and/or communities (ten Kate et al., 2004), allowing developments to proceed that cannot be compensated for adequately. Conversely, a lack of transparency could allow regulators to unfairly require developers to pay large sums of money for environmental benefits that are unrelated to the matters to be offset. While this could have benefits in terms of providing a solution where land is not available, there is a risk that this will cause loss of biodiversity and/or ecosystem services. This payment for environmental compensation is especially prevalent where regulators allow either indirect biodiversity offsets (also known as 'other compensatory measures') and/or the 'trading up' of biodiversity offsets. Indirect biodiversity offsets are those that provide a benefit for an environmental matter, such as improvement in the knowledge of that matter, as opposed to the direct conservation of that species and/or ecosystem (Fallding, 2014). The term 'trading up' means that instead of requiring developers to ensure no net loss of biodiversity (as required by the Convention on Biological Diversity), regulators allow developers to create biodiversity offsets for areas with higher ecological values, or a greater need for conservation (Habib et al., 2013). While both of these practices may be desirable for various reasons, both can create issues of ethicality, particularly in association with environmental responsibility. For example, the Commonwealth has a restricted responsibility to make determinations only for Matters of National Environmental Significance (MNES) listed under the EPBC Act. As listing of these species and ecosystems relies on available scientific information on their conservation status, it is feasible that other threatened species and ecosystems may not be included on this list. The allowance of trading-up under the EPBC Act may therefore permit significant

impacts on non-listed threatened species or ecosystems in one area in exchange for environmental compensation for other listed species or ecosystems, inadvertently resulting in loss of biodiversity and ecosystem function.

The EPBC Act allows for trading-up to occur despite the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* Environmental Offsets Policy 2012 (non-statutory) requiring that offsets must relate to the same MNES that is impacted by the development. Section 134 (1) – (2) of the EPBC Act allows the Minister to set conditions of approval for the protection of MNES, or for repairing or mitigating damage to MNES. While the expectation, and reasonable belief is that this provision would relate to MNES actually impacted, or expected to be impacted by development, this is not the case, with Section 143 including qualifiers describing how conditions may include requirements to protect, repair or mitigate impacts to MNES other than those caused by the development. This has the potential to cause further inequities and brings into question the ethicality of requiring developers to undertake environmental protection/conservation that is in the remit of the Commonwealth and/or the states and territories. It is difficult to determine if this is occurring as the implementation of biodiversity offsets is not always publicly available. However, in order to ensure that this does not occur, the EPBC Act should be updated to better reflect this intention.

The Commonwealth has the responsibility for the whole of the environment under the Convention on Biological Diversity and therefore must ensure that conservation, restoration and protection measures are adequate if not addressed by another jurisdiction (e.g. states and territories). Biodiversity offsets by definition are only applicable if they compensate for commitments under the Convention on Biological Diversity that would otherwise not be met (Maron et al., 2016a). The Convention on Biological Diversity requires the protection of biodiversity and does not provide a prioritisation of biodiversity benefits (CBD, 2020). Therefore, the Commonwealth should be managing biodiversity as a whole, and avoid delegating responsibilities to developers, which has the potential to result in either indirect offsets or trading up of offsets. Instead, developments should be measured on their environmental impact and should only compensate for the unavoidable impacts that they have on a particular species, ecosystem or ecosystem service. Otherwise biodiversity offsets may be viewed as corrupt and/or a tax on developers as has been previously described in Western Australia (Towie, 2011).

This negative view of biodiversity offsets can be further exacerbated if the developer is another government department undertaking a development funded by taxes. The Roe 8 development (Section 1 of the Perth Freight Link proposal) in Western Australia, in which Main Roads Western Australia proposed extending an existing highway to enable a greater volume of freight trucks to access Fremantle Port, is an example of this. Before the development was cancelled, it was required to meet an approval condition of obtaining at least 523 ha of land with similar or better environmental attributes than the 97.8 ha of the Roe 8 site being cleared or disturbed. A 980 ha property close to Lake Clifton, south of Mandurah and a 101 ha site located in Nirimba were purchased with public funds with the view that they contained 624 ha of suitable offset land for Roe 8. There was, however, criticism that these areas did not compensate for the environmental loss at the Roe 8 site (MacLaren, 2017). Consequently, the community not only lost environmental and social values, but also public funding that could have been better targeted to meaningful outcomes.

3.5.1.4 Aspects of sustainability

In environmental terms, if matters of biodiversity are not protected uniformly there could be a negative impact on the conservation status of species and ecological communities leading to loss of biodiversity. This is particularly the case for migratory species, marine species and species with large home ranges that cross-jurisdictional boundaries (Bull et al., 2013b).

Transparency of requirements for social aspects of biodiversity offsets is important to ensure adequate community consultation and consideration of ecosystem services. Ecosystem services are the benefits provided to humans through the transformations of resources (or environmental assets, including land, water, vegetation and atmosphere) into a flow of essential goods and services, such as clean air, water, and food (DEWHA, 2009). Almost a decade ago, Pittock et al. (2012) reported that although ecosystem services were referenced widely in several public documents, no further guidance or framework was provided by regulators in Australia. Our study found that little has since changed as only three states considered social transparency, with all achieving a low rating, of one.

Only four of eight jurisdictions considered economic transparency, with these four jurisdictions rated two for this criterion. In these four instances, economic transparency

was delivered in two different ways: as a calculator (external to legislation, policy and guidelines) that can enable the determination of the cost of biodiversity offsets or as economic calculations embedded in legislation. A lack of economic transparency may result in non-economically viable developments, or biodiversity offsets that can have further social and environmental impacts. From a social perspective, a lack of transparency of economic considerations could result in financial inequity between developers and consequently may make a development and/or biodiversity offset program not economically viable. This could create social issues in terms of loss of jobs and/or services and amenities. For example, Narain and Maron (2018) reported that lack of community consultation on compensatory afforestation projects led to displacement and associated negative outcomes for forest tribes in India.

In environmental terms, it may not be possible for developers to deliver on pre-agreed environmental outcomes if a significant environmental impact occurs as a consequence of a development, but the biodiversity offset becomes unviable economically. For example, Habib et al. (2013) found that the estimated cost of effective biodiversity offsets among six different scenarios for an oil sands development in Alberta, Canada was $25 million to $3.3 billion, which would negate the cost/benefit of a development in many cases. Further, if the costs of delivering the biodiversity offset significantly outweigh the compliance costs of not delivering the offset at all, this can create a disincentive for developers to fulfil the offset obligation (Rohr et al., 2018), resulting in the loss of biodiversity and/or ecosystem services.

3.5.2 Measurability

Measurability is rarely considered in Australian jurisdictions, as most legislation and policy in relation to biodiversity offsets is focused on the development stage of the offset (Fallding, 2014). Commonwealth and New South Wales were the only jurisdictions that considered measurability in legislation. In the case of the Commonwealth, however, measurability was inadequate as the description of measurability was provided in non-statutory policy. A lack of measurability seems to be a failing of biodiversity offset regulation globally. For example, Bull, et al. (2013b) reported that fish habitat compensation in Canada and conservation banking in the USA were only monitored for short periods after implementation. Bigard et al. (2017) reported that most environmental impact assessments in France (including those with

biodiversity offset requirements) lacked provisions for monitoring and evaluation, despite many including requirements for implementation schedules. A lack of measurability of biodiversity offsets means that regulators cannot be sure that biodiversity offsets are adequate measures of compensation and may have repercussions in environmental, social and economic aspects.

Australian jurisdictions may rely on conditions that require biodiversity offset strategies or plans to be developed inclusive of reporting requirements, rather than incorporating the requirement for reporting into legislation. Koh et al. (2014) reported a similar situation in countries including Germany, England and South Africa, which only require biodiversity offset monitoring and reporting on an ad hoc basis. While this would be better than a complete lack of consideration of measurability, this could result in biodiversity offsets not achieving expected outcomes, as well as inequality of financial and resourcing burdens associated with reporting, auditing and other mechanisms that ensure that biodiversity offsets are measurable. Considerations of measurability, such as monitoring, reporting and auditing, should be clearly defined in legislation and policy (Koh et al., 2014; Maron et al., 2016b) to ensure that measurability requirements are equal and that biodiversity offsets are meeting their objectives.

The Commonwealth only considered environmental and economic aspects of measurability, meaning that social impacts and ecosystem services are not measured at all in Commonwealth biodiversity offsets policy and legislation. To remedy this, the Commonwealth should include requirements in legislation for the development of robust and appropriate measurable indicators and/or key milestones in relation to social impacts and ecosystem services as well as requirements for monitoring, reporting and auditing against these indicators and/or milestones. Furthermore, the Commonwealth should detail penalties for lack of compliance in this regard.

Historically, biodiversity offsets have focused on environmental concerns without linking to social impacts, even if initial social concerns are considered (Mandle et al., 2016). This may mean that Australia is not meeting its obligations in terms of the Convention on Biological Diversity requirement to ensure consideration of ecosystem services. This can create inequalities for communities impacted by a development, as well as those that have been impacted by the location of a biodiversity offset. For example, Ali et al. (2018) reported on a lack of stakeholder participation and consideration of social rights for payment for ecosystem services schemes in China,

which led to increased financial burden on local governments and unemployment and poverty for members of impacted communities.

3.5.3 Enforceability

Globally, poor compliance has been identified as a major issue in the implementation of biodiversity offsets (Bull et al., 2013b; Burgin, 2008; Ghosh, 2015; Gibbons & Lindenmayer, 2007; Roberts, 2013; Turner et al., 2001; zu Ermgassen et al., 2019). Poor compliance has also been identified as causing loss of biodiversity and ecosystem services, in several cases without repercussions or requirements for further compensatory measures to be undertaken. For example, Ghosh (2015) reported that compensatory afforestation projects in India were found not to comply with requirements; Brown and Penelope (2016) reported poor compliance in relation to offset projects in New Zealand; May et al. (2017) found 19% of biodiversity offsets in Western Australia had not been implemented and a further 18% were thought to be implemented but had unknown outcomes; Norton (2009) reported 86% of offset conditions in Canada had not been complied with; and in the USA, Turner et al. (2001) found that of eight programs that had permit requirements for wetland compensatory mitigation, seven did not complete the required on-ground mitigation activities. It is important that regulators ensure that they can enforce conditions to prevent biodiversity loss and that, in the event that a biodiversity offset does not achieve its goals, further conditions can be imposed to ensure that adequate compensation is achieved.

Queensland was the only jurisdiction that included environmental, social and economic aspects of biodiversity offsets in legislation. The Australian Capital Territory included environmental and social aspects of biodiversity offsets in statutory policy, and South Australia included economic aspects of biodiversity offsets in legislation. Otherwise, jurisdictions' legislation and policy either did not specify aspects of biodiversity offsets, or it was included in non-statutory policies. This is a concern as there is now a legal precedent that Australian jurisdictions are not bound to implement non-statutory policies. In Western Australia, the Roe 8 development was announced in 2014, and in 2015 the 'Save Beeliar Wetlands' community group took legal action against the government claiming that it did not follow its own environmental policies when approving this development (*Save Beeliar Wetlands (Inc) v Jacob* [2015] WASC

482). This legal action was initially successful in December 2015 but was unanimously overturned on appeal in July 2016 on the grounds that the EPAs policies were not "mandatory relevant considerations" (*Jacob v Save Beeliar Wetlands Inc* [2016] WASCA 126). Despite this, if matters to be offset are not captured in statutory documents, the ability of regulators to enforce biodiversity offsets is unlikely to be restricted, as requirements may be enforced through obligation to meet conditions and many jurisdictions have legislation that enables their officers to take action should a condition not be complied with. It does mean, however, that there may again be an issue in terms of transparency and equity. This suggests that Australia is not consistently meeting its requirements under its commitment to the Convention on Biological Diversity.

3.5.4 Commonwealth

The Commonwealth is required to ensure that Australia meets its obligations for protection of biodiversity as a signatory to the Convention on Biological Diversity (Abdo et al., 2019a). The Commonwealth should thus fill any gaps in biodiversity offset legislation and policy left by the states and territories. However, the Commonwealth did not achieve a rating of three for any aspect of biodiversity offsets, indicating it is likely that there are gaps in the biodiversity offset policy and legislation. This suggests that biodiversity offsets in Australia are not adequate compensatory measures for development. The EPBC Act must therefore be updated or replaced with adequate legislation, or alternately new legislation must be created that meets the requirements of the Convention on Biological Diversity and ensures that development in Australia is adequately compensated for.

The EPBC Act has recently been under scrutiny, with the recommendation that it should be updated to better reflect transparency, measurability and enforceability (ANAO, 2020; Samuel, 2020). There is a requirement for the EPBC Act to be subject to independent review at least every 10 years to determine if the act fulfils its role in protecting and conserving environmental matters (Independent review of the EPBC Act, 2020; Samuel, 2020). The interim report for the second 10-year review was released in June 2020 and found that the EPBC Act was ineffective and that a fundamental reform of national environmental law is required (Samuel, 2020). Further, it recommends that biodiversity offsets need to be enshrined in law (Samuel, 2020).

In addition to this, in June 2020 the Australian National Audit Office published an audit of the referrals, assessments, and approvals of controlled actions under the EPBC Act (ANAO, 2020). The purpose of this audit was to determine if the EPBC Act has been applied appropriately. This audit reported the EPBC Act similarly lacked in its protection of ecosystems and biodiversity in Australia. All recommendations were accepted by the Commonwealth (ANAO, 2020). Of the eight recommendations provided, five related to approvals, timeliness and compliance which are also important factors for biodiversity offset conditions (recommendations 2, 4, 5, 7, and 8; ANAO, 2020). The implementation of these recommendations will not necessarily address the gaps in biodiversity protection within the EPBC Act, however, they will go a long way to ensuring that the application of the EPBC Act is more transparent and ensures greater transparency, measurability and enforceability.

While the purpose of the review and audit of the EPBC Act are different, the recommendations are similar: the EPBC Act must incorporate greater transparency, measurability and enforceability and it must be applied in a way that ensures that biodiversity offsets are transparent, measurable and enforceable.

The Convention on Biological Diversity requires signatories to commit to the conservation of biological diversity, the sustainable use of the components of biological diversity and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources (CBD, 2017b). While this is a broad aspiration, the Convention on Biological Diversity has developed targets (the Aichi Targets) for biodiversity to be delivered by 2020. Although these targets have now expired, the draft Global Biodiversity Framework similarly focuses on reducing threats to biodiversity and meeting people's needs through sustainable use and benefit-sharing. Inclusion of provisions in the EPBC act that would (as a minimum) meet the Aichi Targets/Global Biodiversity Framework, would better ensure that ecosystem services and the concerns of stakeholders are appropriately addressed in regard to biodiversity offsets.

3.6 Conclusion

Biodiversity offset legislation in Australia was found to be lacking in terms of transparency, measurability and enforceability. Effective biodiversity offsets are those

that consider the environment, social concerns and are economically viable (or non-prohibitive) to ensure that development can continue sustainably and that the risk of failure is minimised. Biodiversity offsets should also be transparent and enforceable to ensure equity for developers and stakeholders alike.

There is a need for dedicated biodiversity offset legislation that is transparent and equitable, and also addresses the effectiveness of biodiversity offsets beyond design. Furthermore, this dedicated legislation should be designed to compensate for biodiversity that is impacted by a particular development to ensure effectiveness, equity and ethicality. Although the aspirations of the Convention on Biological Diversity that encourage countries to protect all biodiversity may be practicably unattainable, inclusion of requirements that meet the Aichi Targets/Global Biodiversity Framework, as a minimum, would increase the capacity for more sustainable use of biodiversity in Australia.

Addendum 3.1

Amendments to Chapter 3 following publication

Amendment	Location
To clarify the intent of the examples of aspects and indicators provided in Table 3.3, the following worked example has been provided. Western Australia was rated 3 for environmental transparency. In Western Australia's environmental offsets guideline, it clearly defines when offsets are required - for significant residual impacts on "rare and endangered plants and animals (such as declared rare flora and threatened species that are protected by statute), areas within the formal conservation reserve system, important environmental systems and species that are protected under international agreements (such as Ramsar listed wetlands) and areas that are already defined as being critically impacted in a cumulative context."	Table 3.3
While EIA and biodiversity offsets are linked, legislative instruments for EIA are too broad to adequately consider the intricacies of offsets and, therefore, offsets should be assessed under their own specific legislative instruments that are pursued and accounted for separately (BBOP, 2009) to ensure adequate compensation and contribution to sustainable development.	Section 3.5

Chapter 4

Has a dedicated biodiversity offsets policy improved biodiversity offsets in Australia?

Chapter 4 builds on Chapters 2 and 3, where it was identified that the Australian Commonwealth has overarching responsibility for the environment and should fill any gaps in environmental protection. This chapter further analyses referrals made by developers to the Australian Commonwealth Government that have actions approved with conditions for biodiversity offsets by examining their capacity to ensure biodiversity offsets contribute to sustainable development. The maturation of offsets over the study period to meet best practice is also investigated.

The content of this chapter has been published in the journal Environment, Development and Sustainability, as ‘Has a dedicated biodiversity offsets policy improved biodiversity offsets in Australia?’ This paper was co-authored by S. Griffin, A. Kemp and G. Coupland who provided editorial assistance. L. Davies provided further editorial assistance.

4.1 Introduction

Biodiversity offsets aim to balance the benefits of development with associated environmental, and, in some cases, social impacts, such as the displacement of people or the loss of ecosystem functions and services (Burton et al., 2017; Coggan et al., 2013b; May et al., 2017; Pope et al., 2021). Compensation programs to balance the impacts of development, including biodiversity offsets, are legally required in many countries globally (GIBOP, 2019) and are increasing in use (Damiens et al., 2021; Josefsson et al., 2021). There are currently 42 countries that have a regulatory requirement for offsets "for some project in some circumstances" (GIBOP, 2019). There are 66 countries that have legislative provisions in place to "enable and facilitate voluntary offsetting", and a further 28 countries are in the process of exploring options for biodiversity offsets (GIBOP, 2019). In addition, global financial institutions often require biodiversity offsets as a condition of finance to ensure developers compensate for the adverse environmental and social impacts of large-scale developments (Pilla, 2014).

Australia has embraced the use of offsets, having implemented offsets for longer, in more jurisdictions, and for more species, habitats or vegetation types than most other jurisdictions (Madsen et al., 2011). Additionally, Australia's offset methodologies have been, and may continue to be, used as models for other jurisdictions (Midgley, 2015; Miller et al., 2015). It is therefore important to understand whether offset requirements under Australian offset policies and legislation are mature, i.e. at an advanced stage, whereby the requirements for biodiversity offsets are transparent and capable of ensuring at least adequate compensation for the impacts of development.

4.1.1 Biodiversity offsets in Australia

Biodiversity offsets have been applied in Australia since at least the 1990s but since 2011 they have become more intentionally used to contribute to sustainable development (Foster, 2013). Despite the widespread use of biodiversity offsets in

Australia, at the national level and in most jurisdictions, there is no specific offset legislation to formalise offset implementation and use (Abdo et al., 2019a). At the Australian national level, the Commonwealth does not have specific biodiversity offset legislation and relies on biodiversity offsets being included as conditions of environmental approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Commonwealth's biodiversity offset policy, the "Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy" (EPBC Offset Policy), has been in place since October 2012 (DSEWPaC, 2012) and should be used to contribute to sustainable development (Fallding, 2014). Consistency and transparency in the application of biodiversity offsets is the first step in ensuring adequate environmental protection and sustainable development in Australia.

While the Australian Commonwealth does not have specific responsibilities for the environment under the Australian Constitution, it does have responsibility for external affairs. As part of this responsibility, Australia has become a signatory to various international conventions requiring environmental protection, conservation of biodiversity and ecologically sustainable development. These responsibilities require the Commonwealth to ensure that the intentions of these agreements are implemented throughout Australia (Abdo et al., 2019a). Biodiversity offsets are one mechanism that the Australian Commonwealth has used to ensure this.

The use of biodiversity offsets in Australia is increasing; a 2019 audit of the environmental approvals (ANAO, 2020) found that the proportion of approved developments with conditions for biodiversity offsets increased from less than 30% in 2007 to more than 80% in 2017. Although this audit investigated the number of approvals with conditions for offsets, the audit did not assess the complexity of offset requirements or how these requirements matured over time.

4.1.2 Outcomes of biodiversity offsets

The intention of biodiversity offsets is to ensure no net loss of biodiversity (Noga, 2014; Rosa et al., 2016; Sonter et al., 2020). However, biodiversity offsets may not always achieve no net loss. Gaps in legislation and the assessment metrics used often result in the inequitable application of offset requirements (Bull et al., 2014; Coggan et al., 2013b; Theis et al., 2020; zu Ermgassen et al., 2019).

There are limited studies reporting on the implementation of offset programs undertaken by developers, and of these, only a few report on the environmental outcomes of these programs (Brady & Boda, 2017; May et al., 2017; Theis et al., 2020). For example, zu Ermgassen et al. (2019) found only 32 articles that reported on the ecological outcomes of biodiversity offsets from an analysis of 15,715 articles overall. Similarly, Bull et al. (2018) found a lack of data on the implementation of offsets in France, Germany, the Netherlands and Sweden, and a broad review undertaken by Josefsson et al. (2021) found only 40 of 1,415 programs globally that reported on offset outcomes. This paucity of information means that desktop assessment of no net loss is difficult (Theis et al., 2020; zu Ermgassen et al., 2019). The ability to undertake desktop assessments of biodiversity offsets is crucial as offsets are commonly located in remote areas and are often on private property, making physical assessment difficult.

Of the studies that have reported on the outcomes of biodiversity offsets, most have found that in practice offsets do not truly achieve no net loss (Brown & Lant, 1999; zu Ermgassen et al., 2019). For example, of the studies that Josefsson et al. (2021) analysed, those that reported offset outcomes did not estimate biodiversity losses from development and therefore achievement of no net loss/net gain could not be ascertained. Sudol and Ambrose (2002) reported a 16% success rate of offsets in California. Harper and Quigley (2005) reported a success rate of 64% in Canada, but half of the projects had a low (less than 1:1) compensation ratio and many projects were not evaluated for performance. Brady and Boda (2017) reported that “Managed

Realignment" projects in England did not adequately compensate for the loss of habitat.

If biodiversity offsets are not implemented appropriately to achieve no net loss they will result in an overall loss of natural values and/or adverse social outcomes (Bidaud et al., 2018; Gibbons et al., 2018; Githiru et al., 2015; Jacob et al., 2018; Lindenmayer et al., 2017; Macintosh, 2015; Maron et al., 2015; May et al., 2017; Nijnik & Miller, 2017). However, the degree of compensation provided by biodiversity offsets is difficult to quantify without a detailed assessment of environmental/social outcomes. Sonter et al. (2020) reported that offsets policy had a strong influence on whether no net loss was achieved. Therefore, analysis of the application of biodiversity offset requirements in legislation and policy can determine if biodiversity offsets are able to ensure adequate environmental protection.

This research examines Australian biodiversity offset requirements as conditions of environmental approval under the EPBC Act to determine if biodiversity offsets are mature and/or have improved in maturity since the introduction of the EPBC Offset Policy in 2012. If biodiversity offset requirements are mature, then indicators will display greater transparency or assure improved ecological outcomes. Similarly, if biodiversity offset requirements are maturing due to the introduction of the EPBC Offset Policy, then it is expected that there will be a trend of increasing transparency or incorporation of indicators displaying improved ecological outcomes following the introduction of the EPBC Offset Policy.

To investigate maturity and maturation, a proxy – Australian Commonwealth environmental approval conditions for biodiversity offsets – was used to overcome the limited data on outcomes of biodiversity offsets. Results of this research are used to determine if improvements in biodiversity offsets requirements are needed before offsets can ensure adequate environmental protection in Australia, and whether the Australian approach to biodiversity offsets is suitable for emulating in other jurisdictions.

4.2 Methods

This research undertook a qualitative thematic synthesis (Macura et al., 2019) of development referrals under the Australian Commonwealth EPBC Act that were submitted to the Commonwealth Minister for the Environment[5], between 1 October 2011 and 30 September 2017. For the purposes of this research, the term "development" has been used to describe any action that has been deemed by the Australian Commonwealth to require approval under the EPBC Act as controlled actions. These referrals are publicly available through the EPBC Notices Referrals list, available from http://epbcnotices.environment.gov.au/referralslist/. The referral review period from 2011 to 2017 reflects one year prior to the commencement, and five years following the implementation, of the Commonwealth's EPBC Offset Policy in October 2012. This period was selected to define a baseline (i.e. 1-year prior to implementation) and determine if biodiversity offsets displayed a trend of improvement over time (maturing) due to the implementation of the EPBC Offset Policy (i.e. 5-years post-implementation).

All referrals available for the study period through the EPBC Notices Referrals list were reviewed and those that had been approved with Commonwealth biodiversity offset (termed 'environmental offsets)conditions were retrieved (eligible data). Conditions for biodiversity offsets included all compensatory measures required for residual significant impacts to listed species or ecological communities, regardless of whether the terminology of 'offset' was used. Referrals that were approved with conditions for biodiversity offsets (henceforth "offset approvals") were partitioned into separate time classes (years), with a "year" defined as being the period between 1 October – 30 September, to align with the implementation of the EPBC Offset Policy in October 2012.

[5] Referrals submitted to the Australian Commonwealth Minister for the Environment are currently provided through the Commonwealth Department of Climate Change, Energy, the Environment and Water. Note that the name of this government department is current as of July 2022. During the study period this Department has changed names several times.

Maturation was assessed in referral requirements by examining the change in offset requirements over time in terms of transparency and/or requirements for environmental outcomes using the following qualitative maturation indicators:

1. Offset type
2. Offset detail
3. Implementation
4. Ecological outcomes
5. Species & habitats.

4.2.1 Indicator 1: Offset type

Offset types were categorised as being increasingly mature based on likelihood of greater environmental benefits. There were six offset types defined:

- Unspecified – no offset type was specified.
- Indirect – other compensatory measures (e.g. research projects) were specified.
- Financial contribution – payments, biobanking credits and/or ceding of land already owned by proponent was required.
- Averted loss – protection of existing parcel(s) of land was required.
- Management – a management plan, strategy etc. including activities to manage an area of land for environmental benefit was required to be developed.
- Rehabilitation/restoration – degraded land was to be revegetated/restored to reflect a representative ecosystem.

Offset approvals with unspecified or indirect offset requirements were deemed to be less mature as the link between these offset types and environmental benefits is unclear (Niner et al., 2017). Management and rehabilitation/restoration offset types were deemed to display high maturity as, if conducted appropriately, this is the sole

offset type able to provide full environmental compensation for the environmental impacts of development (i.e. no net loss) (Maron & Louis, 2018). Averted loss offsets were deemed to be moderately mature as these halt decline but cannot provide further environmental benefit (Gibbons et al., 2018; Maron, 2015; zu Ermgassen et al., 2019). . Financial contributions were also deemed moderately mature as these offset types provide a financial mechanism to deliver averted loss, management or rehabilitation/restoration offsets; having less transparency and potentially greater time lags than the aforementioned offset types. Weightings used to determine the rank per year for this indicator are provided in Table 4.1.

Table 4.1: Weightings applied to assess the maturity of the offset type indicator, with 1 representing the least maturity and 6 representing the greatest maturity.

Offset Type	Weighting
Unspecified	1
Indirect	2
Financial contribution	3
Averted loss	4
Management	5
Rehabilitation/restoration	6

The yearly weighted score for the Offset type indicator ($Maturity_{type}$) was determined for each year according to the following equation:

$$Maturity_{type} = \Sigma(Weighting_{type} \times n_{type}) / Total\ yearly\ offset\ approvals$$

Where $Weighting_{type}$ is the weighting for a category of Offset type (Table 4.1), and n_{type} is the number of offset approvals for the same offset type category. ($Weighting_{type} \times n_{type}$) was divided by total yearly offset approvals to enable comparison between years

by preventing variability in number of approvals per year from confounding yearly weighted scores.

4.2.2 Indicator 2: Offset detail

The level of detail within the offset approval was categorised using the following qualitative descriptors:

- Prescriptive - there was an explicit description of what was required to fulfil the offset condition(s), enabling an inference about completion criteria to be made. For example, the offset condition stated species/habitat required and/or actions required to be taken.
- Ambiguous – the offset approval did not elaborate on what offsets were required or offset requirements were ambiguous, meaning that no inference about completion criteria could be made. For example, an offset condition that stated compensation for residual significant impacts were required but did not provide any requirement stating how this might be achieved was considered ambiguous.
- Refers to other plans/conditions – the offset approval did not provide specific requirements regarding offset types and/or matters in their conditions, but instead referred to other plans or state/territory conditions for environmental approval.

Offset approvals with ambiguous requirements were identified as having low maturity as this indicated low transparency. Low transparency of offsets can result in uncertainty in offset outcomes, low compliance with offset requirements and may result in the overall loss of biodiversity (Bull et al., 2013a; Bull et al., 2018; Carreras Gamarra & Toombs, 2017; Maron et al., 2015). Approvals that referred to other plans/conditions were identified as having moderate maturity due to the possibility that specific requirements may have been included but lacked transparency/availability of plans and conditions. Offset approvals with prescriptive conditions were identified as being the

most mature for this indicator. Weightings used to determine the rank per year for this indicator are provided in Table 4.2.

Table 4.2: Weightings applied to assess the maturity of the level of detail indicator, with 1 representing the least maturity and 3 representing the greatest maturity.

Level of detail	Weighting
Ambiguous	1
Refers to plan/conditions	2
Prescriptive	3

The yearly weighted score for Offset detail ($Maturity_{detail}$) was calculated using following equation:

$$Maturity_{detail} = \Sigma(Weighting_{detail} \times n_{detail}) / Total\ yearly\ offset\ approvals$$

Where, $Weighting_{detail}$ is the weighting for a category of Offset detail (Table 4.2), and n_{detail} is the number of offset approvals for the same Offset detail category. ($Weighting_{detail} \times n_{detail}$) was divided by total yearly offset approvals to enable comparison between years by preventing variability in number of approvals per year from confounding yearly weighted scores.

4.2.3 Indicator 3: Implementation

Offset approvals that required a commencement date for the offset to be undertaken were deemed to be more mature than those that did not, as this requirement provides more certainty in delivery and minimisation of time lags preventing further loss and/or threat to biodiversity (Gardner et al., 2013; Maron et al., 2010). Offset approvals without a required commencement date had a score of 1 applied for the assessment of maturity; while offset approvals with a required commencement date had a score of 2 applied. The yearly weighted score for offset implementation ($Maturity_{implementation}$) was determined according to the following equation:

$$Maturity_{implementation} = \Sigma(Weighting_{implementation} \times n_{implementation}) / Total\ yearly\ offset\ approvals$$

Where, $Weighting_{implementation}$ is the weighting for based on whether a commencement date was required or not, and $n_{implementation}$ is the number of offset approvals for those with a commencement date or not. ($Weighting_{implementation} \times n_{implementation}$) was divided by total yearly offset approvals to enable comparison between years by preventing variability in number of approvals per year from confounding yearly weighted scores.

4.2.4 Indicator 4: Ecological outcomes

For the purpose of this chapter, the term “ecological outcomes” refers to requirements that have a particular environmental benefit, such as the installation of nesting habitat or the requirement for a prescribed extent of vegetation canopy cover. Offset approvals that did not provide a requirement for specific ecological outcomes were also identified as having a low maturity. Similarly, approvals with requirements for ecological outcomes that referred to plans/conditions without mention of specific environmental outcomes were identified as having a low maturity due to the lack of transparency regarding outcomes. Offset approvals that referred to ecological outcomes in plans were identified as having a moderate maturity. Approvals that included ecological outcomes in the offset approval were identified as being most mature. Weightings used to determine the rank per year for this indicator are provided in Table 4.3.

Table 4.3: Weightings applied to assess the maturity of the requirement for ecological outcomes indicator, with 1 representing the lowest maturity and 4 representing the greatest maturity.

Ecological outcomes	Weighting
Ecological outcomes not included	1
Requires plan to be developed	2
Refers to plan/conditions	3
Ecological outcomes required	4

The yearly weighted score for the ecological outcomes indicator ($Maturity_{outcome}$) was determined according to the following equation:

$$Maturity_{outcome} = \Sigma(Weighting_{outcome} \times n_{outcome}) / Total\ yearly\ offset\ approvals$$

Where, $Weighting_{outcome}$ is the weighting for a category of ecological outcomes (Table 3), and $n_{outcome}$ is the number of offset approvals for the same ecological outcome category. ($Weighting_{outcome} \times n_{outcome}$) was divided by total yearly offset approvals to enable comparison between years by preventing variability in number of approvals per year from confounding yearly weighted scores.

4.2.5 Indicator 5: Species & habitats

Offset approvals that included a higher number of species and/or ecological habitats were identified as displaying greater maturity than those with a lower number, as this was assumed to indicate more detailed consideration of the environment as a whole, leading to better environmental compensation.

The number of species or habitats included in offset approvals were used to score this indicator for each year ($Maturity_{species}$) according to the following formula:

$$Maturity_{species} = \Sigma(n_{species} \times n_{approvals}) / Total\ yearly\ offset\ approvals$$

Where, $n_{species}$ is the total number of species included in offset approvals and $n_{approvals}$ is the number of offset approvals. ($n_{species} \times n_{approvals}$) was divided by total yearly offset approvals to enable comparison between years by preventing variability in number of approvals per year from confounding yearly weighted scores.

Maturity of an offset may be defined in different ways; for example, one measure could be the number of surrogates used to characterise the ecological features of the impacted location. However, for simplicity, and to account for the implicit variation in the number of species and/or ecological habitats that will be present at each development location, and the effect variations of scale and scope of developments

will have on impacts, it was assumed developments will have a similar impact on species overall each year, in order to provide an insight into the change in maturity of offsets.

4.2.6 Overall maturation

Yearly weighted score for each indicator were ranked (1–7), as indicated by the term 'Rank', and then summed according to the following equation:

$$Maturity_{overall} =$$

$$Rank(Maturity_{type}) + Rank(Maturity_{detail}) +$$

$$Rank(Maturity_{implementation}) + Rank(Maturity_{outcome}) + Rank(Maturity_{species})$$

$Maturity_{overall}$ was then ranked to gain an insight into the overall change in maturity over time. Larger numbers for $Maturity_{overall}$ represent greater maturity and were ranked higher. Conversely, lower ranks are associated with less maturity.

Referrals that were changed following receipt of approval subject to offset requirements (variations), and referrals that were submitted but later withdrawn, were omitted from the analysis. During the review period 2011 to 2017, there were 37 approvals that were approved by other jurisdictions (states, territories) on behalf of the Commonwealth through the existing bilateral agreement process. While these approvals may have included requirements for biodiversity offsets at the state or territory level, documentation (if any) relating to these approvals was not available in the Commonwealth repository. Therefore, these offset approvals were excluded from the scope of this analysis.

Offset approvals assessed in this study with the fields "none" or "ambiguous" refer to the availability of offset information and do not reflect whether the required actions occurred. These fields indicate that further information is not publicly available and/or is beyond the scope of this analysis.

The inclusion of any of the five indicators listed above in an offset approval condition was used as an indicator of maturity. The study did not extend to assessing the suitability of each of these factors. For example, if an approval offset condition included a requirement to commence implementation of the offset by a certain date, this was deemed as having a high level of maturity, but an analysis of whether the stated commencement date was suitable for the specific impacts to be offset was outside the scope of this research.

4.3 Results

A total of 1,907 environmental referrals submitted between 1 October 2011 and 30 September 2017 under the EPBC Act were assessed. However, 171 were withdrawn by the developer and a further 26 lapsed in that the Commonwealth determined that environmental approval was not required under the EPBC Act. Of those approved (n = 1,710), 167 contained Commonwealth conditions that required compensation for residual significant impacts on listed species and ecological communities (offset approvals).

A mean of 24 offset approvals were submitted per year based on the date they were submitted as a referral. Based on the date of approval, a mean of 21 offset approvals with conditions requiring offsets were granted per annum. The year with the greatest number of referral submissions resulting in offset approvals was 2011-12 (n = 63), and most of the approvals with conditions for offsets occurred in 2015-16 (n = 32) (Figure 4.1).

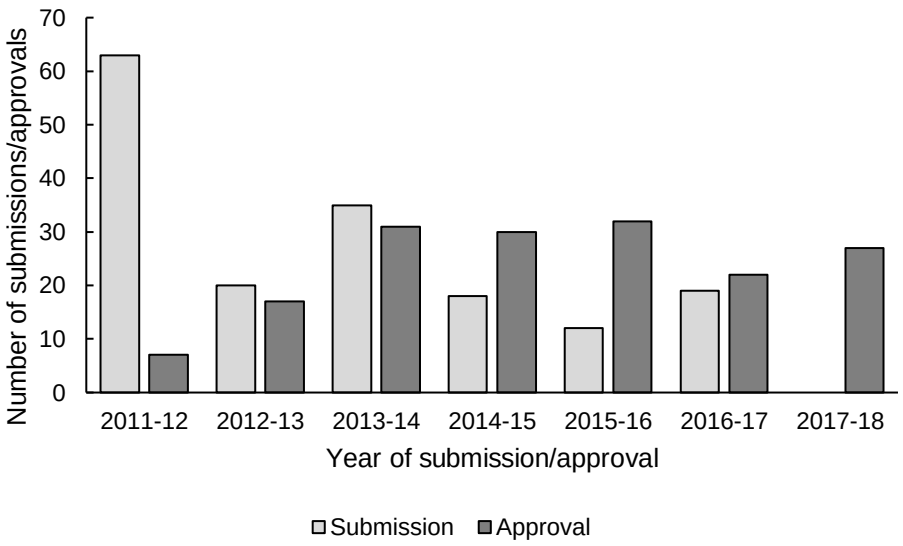

Figure 4.1: Number of offset approvals submitted to the Commonwealth Minister for the Environment. (n=167 development referrals (DAWE, 2022)).

Averted loss offsets were the most commonly required offset type (71 approvals) (Figure 4.2). Offsets with requirements for ecological management (n = 61) and financial contribution (n = 47) were similarly high. Ecological management was required for 39 approvals that also required averted loss offsets and 19 that also required rehabilitation/restoration. Requirements for rehabilitation/restoration (n = 25) and indirect offsets (n = 3) were low. All years, except for 2015-16 and 2017-18, had offset approvals that did not specify an offset type (unspecified), with 27 found in total across all years.

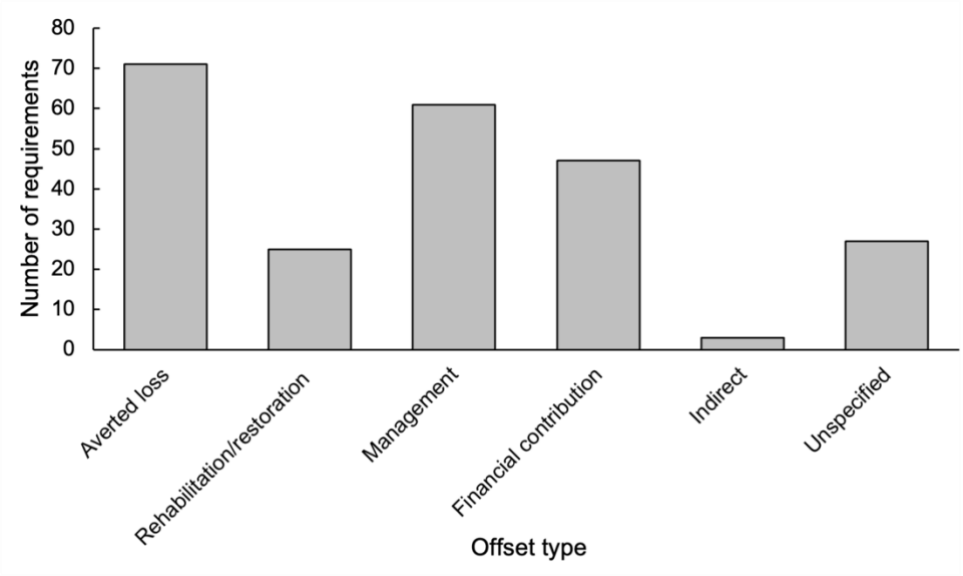

Figure 4.2: Offset types required by referrals submitted between October 2011 and September 2017 that resulted in approval with conditions for biodiversity offsets (n=167 development referrals (DAWE, 2022)).

The proportion of rehabilitation/restoration offset approvals generally decreased over the study period (14%–4%), as did the proportion of management offset approvals (27%–10%) (Figure 4.3). Conversely, the proportion of offset approvals requiring averted loss offsets increased (25%–50%). The proportion of unspecified and financial contribution offset approvals varied among the years. Indirect offsets were only recorded in 2012-13, 2013-14 and 2015-16, with only one offset approval requiring indirect offsets in each year.

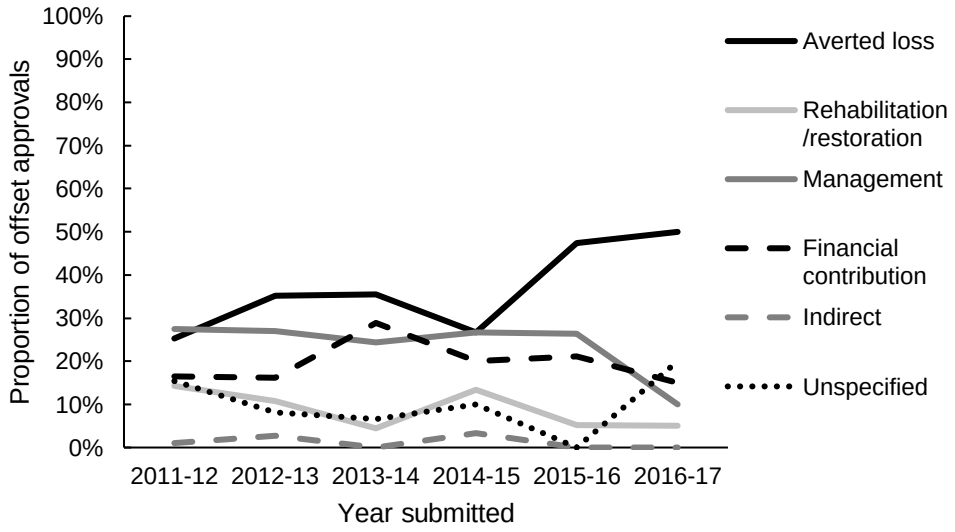

Figure 4.3: Change over time (%) in offset types required by referrals submitted between October 2011 and September 2017 that resulted in approval with conditions for biodiversity offsets (n=167 development referrals (DAWE, 2022)). A year represents the period 1 October – 30 September.

Most offset approvals (n = 119) analysed were categorised as prescriptive in that requirements were explicitly described in a way that completion criteria could be ascertained. A substantial number referred to other plans or state/territory conditions for environmental approval (n = 43). There were some that did not elaborate on what offsets were required (n = 1) or were ambiguous (n = 5).

The level of detail included in offset approvals varied among years but was relatively consistent overall (Figure 4.4). Prescriptive offset approvals made up the greatest proportion, varying from 47%–70%. Ambiguous offset approvals, with non-explicit requirements, were only observed in four years, with 2012-13 having the highest proportion (11%) and 2013-14, 2015-16 and 2017-18 all with 5% or less.

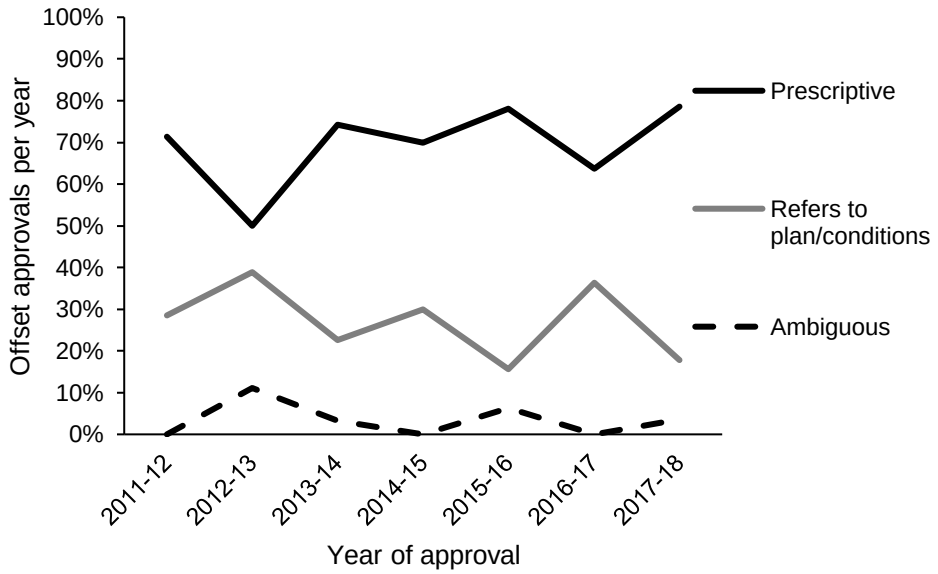

Figure 4.4: Proportion of offset approvals per year (1 October – 30 September) with differing levels of detail. “Prescriptive” means that what is required is explicitly stated within the offset approval (n= 119). “Ambiguous” means that offset requirements are not explicit (n=48) (development referrals sourced from (DAWE, 2022).

More offset approvals required the offset to commence by a specified date (n = 93) than those that did not stipulate a specific commencement date (n =73). It is noted, however, that 29 offset approvals (17%) required an offset plan/strategy. While it is unknown if these plans or strategies included requirements for commencement dates, it is possible. However, as this was not recorded within offset approvals and therefore transparency on this aspect was lacking, these offset approvals were recorded as not having a requirement for a commencement date.

The proportion of offset approvals requiring a commencement date varied between 41% (2012-13) and 66% (2015-16) (Figure 4.5).

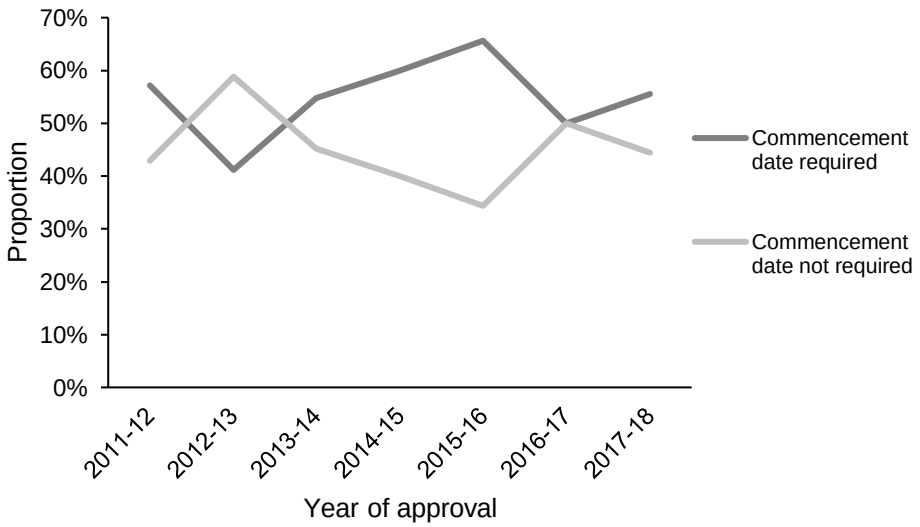

Figure 4.5: Proportion of offset approvals that contained a requirement for offsets to commence by a certain date (commencement date). (n=167 development referrals (DAWE, 2022)). A year represents the period 1 October – 30 September.

Of the 167 offset approvals between October 2011 and September 2017, only 18 of the biodiversity offset conditions analysed included requirements for measurable ecological outcomes (Figure 4.6). Most offset approvals analysed did not include specific mention of ecological outcomes (n = 81). The absence of ecological outcomes was consistently observed across all years. Many offset approvals did include a general requirement for ecological outcomes to be stated in yet to be developed biodiversity offset plans (n = 63). References to other plans/conditions (n = 5) were observed in 2014-15, 2015-16 and 2017-18. These plans and conditions were outside the scope of analysis, but it is recognised that they may have included requirements for ecological outcomes. Although variable, the omission of ecological outcomes increased over time.

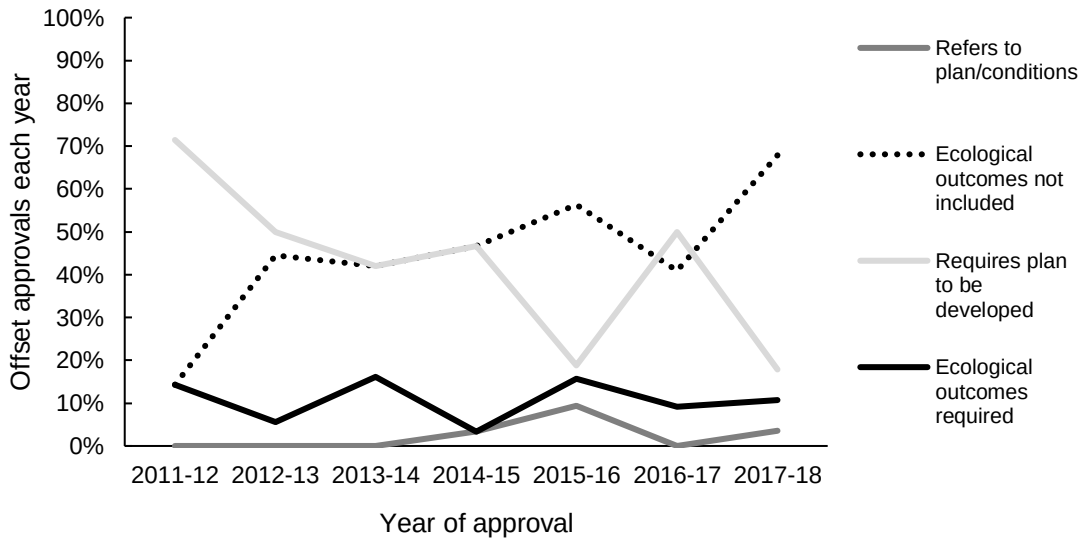

Figure 4.6: Proportion of offset approvals per year (1 October – 30 September) that included or excluded requirements for ecological outcomes (n=167 development referrals (DAWE, 2022)).

Of the 167 offset approvals analysed, 42 did not include reference to a species or ecosystem required to be offset (Figure 4.7). These approvals instead referred to offsets for EPBC listed species or ecological communities (generically), or to conditions required by another jurisdiction (state or territory government). Four offset approvals required offsets for both aquatic and terrestrial species.

The remaining 128 offset approvals referred to offset requirements for one or more species/habitats. Within this subsample, offsets were required for 357 terrestrial species, and 32 aquatic species. Offsets were required predominantly for fauna species (258), while far fewer offset approvals included requirements for vegetation (115) and habitat (16) (Figure 4.8).

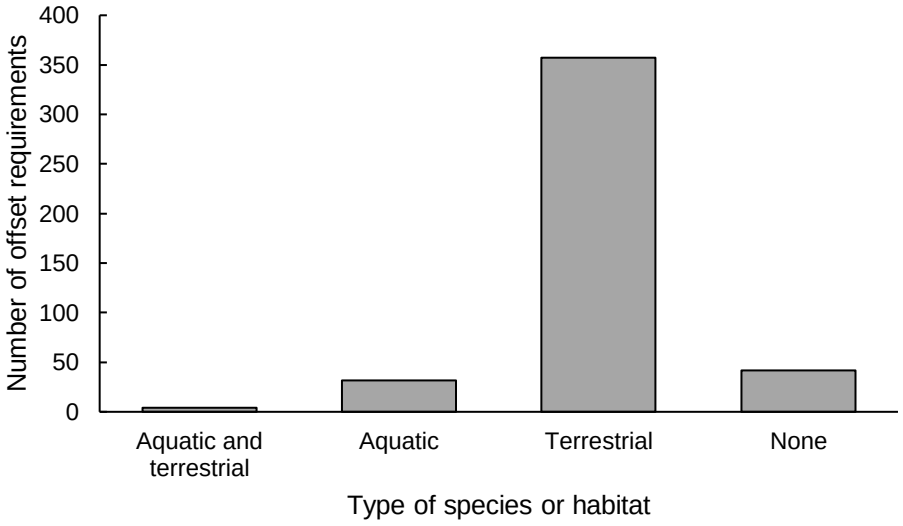

Figure 4.7: Type of species or habitats for which biodiversity offsets were required within offset approvals between October 2011 and September 2017 (n=167 development referrals (DAWE, 2022)).

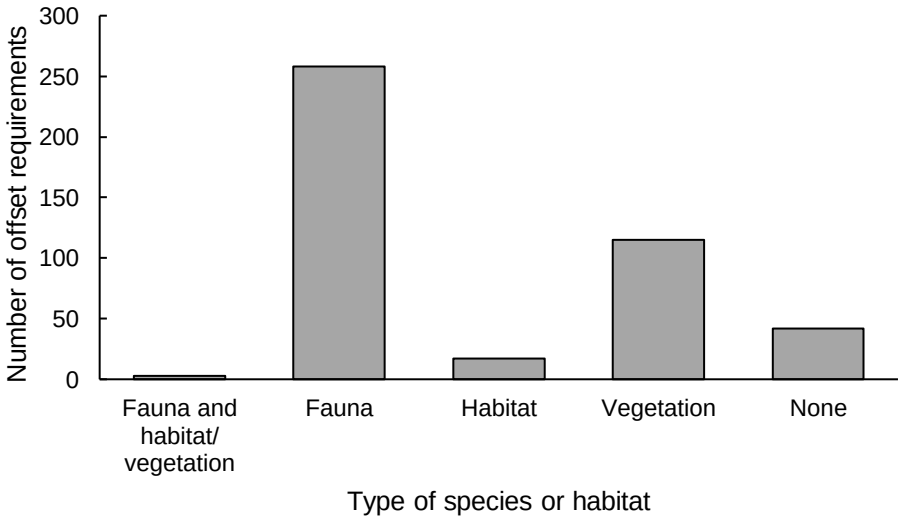

Figure 4.8: Species or habitats for which biodiversity offsets were required within offset approvals between October 2011 and September 2017 (n=167 development referrals (DAWE, 2022)).

The number of types of species or ecosystems contained within offset approvals varied each year, but with majority of offset approvals only considering one type (Figure 4.9). Three types were included in offset approvals in 2011-12 only. No explicit mention of types of matters were found in offset approvals in 2015-16 (13%) and 2017-18 (4%).

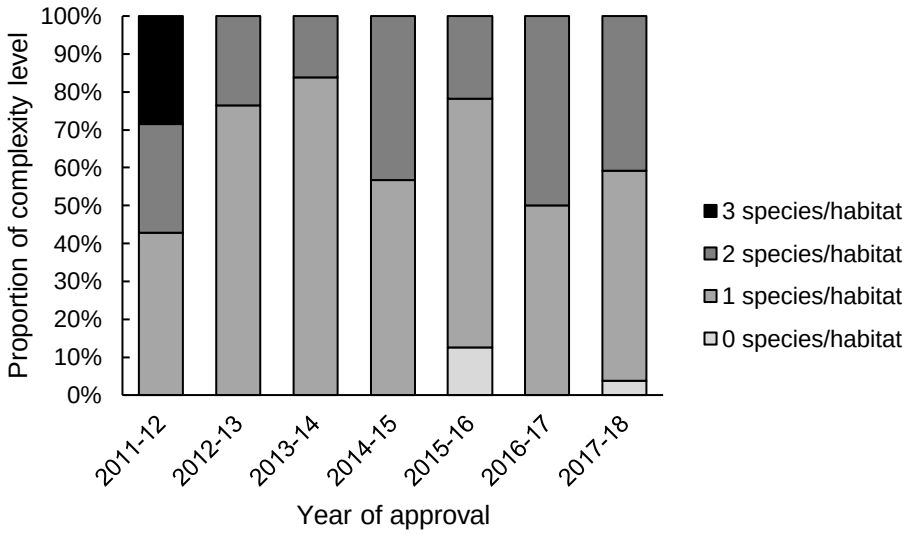

Figure 4.9: Proportion of species or habitats for which biodiversity offsets were required (fauna, habitat, vegetation, none) in offset approvals found among years (1 October – 30 September) (n=167 development referrals (DAWE, 2022)).

Overall maturity was variable with no consistently increasing trend (Table 4.4). The greatest level of maturity was demonstrated in 2011-12, while 2012-13 was the least mature. Although an increase in maturity was observed between 2013-14 and 2015-16, this then decreased to the end of the study period. Overall, the change in indicators over time was variable, with offset type indicating a trend of decline.

Table 4.4: Ranks applied for each indicator per year (1 October – 30 September) to assess overall change in maturity. Repeated ranks for an indicator represent years where scores were equal.

	2011-12	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**
Rank($Maturity_{type}$)	7	6	5	4	3	2	1
Rank($Maturity_{detail}$)	4	1	4	3	6	2	7
Rank($Maturity_{implementation}$)	5	1	4	6	7	2	2
Rank($Maturity_{outcome}$)	7	3	6	2	5	4	1
Rank($Maturity_{species}$)	7	3	2	5	1	6	4
$Maturity_{overall}$	30	14	21	20	22	16	15
Rank ($Maturity_{overall}$)	7	1	5	4	6	3	2

4.4 Discussion

Based on the indicators assessed, there was no indication of increasing transparency or assurance of improved environmental outcomes for biodiversity offsets over the study period. This outcome indicates that offset requirements were not consistently maturing over time. In particular, maturity was found to be highest prior to the implementation of the EPBC Offset Policy and no sustained trend of increasing maturity was found following the introduction of the EPBC Offset Policy in September 2012, despite periods of maturation in some indicators from 2013-2016. This suggests the policy is inadequate, or that it is not being implemented to ensure robust and mature offsets.

Overall, there was a low proportion of biodiversity offset approvals that displayed high levels of maturity in relation to the provision of detailed offset requirements, detail for the timing of biodiversity offsets (commencement date) and explicit requirements for ecological outcomes. Requirements for species and habitats to be offset were also lacking in transparency as indicated by the number of approvals that did not refer to the species or habitat to be offset. The EPBC Offset Policy requires offsets to be

“efficient, effective and transparent”, however does not provide further guidance on how to achieve this other than a broad reference to timeliness (DSEWPaC, 2012). Regardless, the lack of detail provided in offset requirements and ecological outcomes, and omission of species or habitats to be offset is not consistent with transparency. Similarly, the omission of requirements for offset commencement dates is not consistent with timeliness. This lack of transparency and measurability can result in uncertainty, poor compliance and inadequacy of compensation (Abdo et al., 2021; Bidaud et al., 2018; Bull et al., 2013a; Koh et al., 2014; Kujala et al., 2015; Maron et al., 2010; Maron et al., 2016b; Theis et al., 2020).

4.4.1 Approval duration

Overall there was a low proportion (10%) of development referrals that resulted in approval with conditions for biodiversity offsets under the EPBC Act between 1 October 2011 and 30 September 2017. This is likely reflective of a low number of referrals achieving approval, as the Australian National Audit Office (ANAO, 2020) found that, from a sample of 246 EPBC Act referrals submitted between 1 July 2015 and 30 June 2019, 43 (17%) resulted in approval with conditions (ANAO, 2020). However, the Australian National Audit Office also reported that the proportion of approvals with conditions that also included conditions for offsets increased over a period of 18 years, from >10% in 2001-02, to <75% in 2018-19 (ANAO, 2020). Therefore, biodiversity offsets can still be considered the primary mechanism used by the Australian Commonwealth Government to ensure protection of natural values. It is unknown how this proportion relates to other countries, but it is likely to be relatively high as Australia requires offsets for a much broader range of environmental impacts than most other countries (Abdo et al., 2019a; Madsen et al., 2011; Miller et al., 2015).

4.4.2 Offset type

Although over time offset types were variable, there were overall more averted loss offset approvals (33%) than rehabilitation/restoration offsets (10%), with a general

trend of averted loss offsets increasing and rehabilitation/restoration offsets decreasing. Implementation of averted loss offsets without broader consideration (e.g. through planning frameworks) results in less connected and effective conservation areas due to edge effects and the absence of wildlife corridors (Bull et al., 2017a; Bull et al., 2013b; Lukey et al., 2017). However, there is no requirement for this in the EPBC Act and strategic landscape scale planning frameworks do not exist for most areas of Australia. While averted loss offsets are easier to implement, provide greater certainty of outcomes and are more cost-effective, it has been found that these types of offsets cannot ensure no net loss of biodiversity (Gibbons et al., 2018; zu Ermgassen et al., 2019). Furthermore, the implementation of averted loss offsets requires protection of land under imminent threat, however, often they are incorrectly applied on land not under threat, which can result in loss of biodiversity (Maron et al., 2015). This loss can be somewhat mitigated through the inclusion of ecological management measures that improve the ecological condition and/or functionality of the area protected. Just over half of the averted loss offset conditions also included requirements for management. The inclusion of ongoing management requirements by regulators for all averted loss offsets could vastly improve both ecological and social outcomes.

Financial contributions are usually provided for rehabilitation/restoration or averted loss offsets to be undertaken by a third party, typically a government agency. There were 18% of offset approvals that required financial compensation in lieu of offsets, although this is not considered under the EPBC Offset Assessment Guideline. Further, the EPBC Offset Policy does not refer to financial compensation per se; instead it describes how offsets can be undertaken by third parties, including “rural landholders, private conservation organisations, and Indigenous corporations” (DSEWPaC, 2012). Financial contributions, while convenient for developers that may not have the expertise to undertake offsets directly, are not viewed favourably as a type of offset. They have been criticised as a potential source of inequity for communities or developers and could contribute to the misuse of offsets for political and/or economic gain (Abdo et al., 2021; Maron et al., 2016b; Taherzadeh & Howley, 2018). Additionally,

it is not always clear how projects funded by financial contributions relate to the initial environmental impacts of development. If financial contributions should be permitted in lieu of biodiversity offsets, then they should not only be included explicitly in biodiversity offset policy and legislation to better advise developers and ensure consistent use by regulators, but also be linked to the impacts of development to prevent loss of natural values.

The change in different offset types was not consistent with maturation. To demonstrate maturity, it would be expected that averted loss offsets would decrease over time, while management and rehabilitation/restoration offsets would display a corresponding increase over time. This was not found, and the reverse was true with the proportion of averted loss offsets increasing and the proportion of rehabilitation/restoration offsets decreasing. Rehabilitation/restoration and management offsets, while higher in risk due to higher uncertainty of outcomes, have the benefit of providing direct environmental benefits for impacted species and habitats, while averted loss offsets can only avoid further damage (Gibbons et al., 2018; Maron et al., 2015; zu Ermgassen, 2019). Additionally, rehabilitation/restoration and management offsets may also be able to provide greater socio-economic benefits such as through the hiring of local companies to undertake works. Therefore these offset types should be preferentially required wherever appropriate as they are more likely to be consistent with the values of sustainable development.

4.4.3 Offset detail

The level of detail in offsets was variable over time, although prescriptive offsets, with an explicit description of what was required to fulfil the offset condition(s), made up the greatest proportion consistently each year. Although many of these prescriptive offset approvals had a low level of detail associated with offset delivery and expected ecological outcomes, leading to greater scope for different interpretations of requirements. Consequently, there may not be adequate compensation for environmental damage caused by development despite being compliant with offset

requirements. Offset requirements can be very prescriptive, but if they do not include ecological benefits, matters to be offset at a landscape level, social concerns and ecosystem services, in association with transparency, measurability and enforceability, then they are unlikely to achieve effective compensation for the impacts of development (Abdo et al., 2021; Apostolopoulou, 2016; Bidaud et al., 2018; Bigard et al., 2017; Burgin, 2008; Fallding, 2014; Foerster & McDonald, 2016; Griffiths et al., 2019; Jacob et al., 2016; Mandle et al., 2016; Maron et al., 2016b; Scholte et al., 2016; zu Ermgassen et al., 2019).

Plans and strategies would likely contain greater detail around offset commitments, however, as plans and strategies are often not publicly available, it is difficult to ascertain how offsets are implemented in this way. While it may be appropriate for regulators to link biodiversity offsets to plans/strategies developed for other jurisdictions, the plans and strategies should either be made publicly available or mirrored within Commonwealth imposed offset conditions. This would ensure greater transparency of offset requirements, providing greater assurance of offset outcomes and preventing the involuntary loss of natural values (Abdo et al. 2021; Bull, et al. 2013a; Maron et al. 2015).

The level of detail in offset approvals varied over the study period, but with no discernible pattern. This is expected as there has been no change to offset legislation or policy by the Australian Commonwealth Government since the introduction of the EPBC Offset Policy in 2012. This is despite an inquiry into biodiversity offsets conducted in 2014 by the Australian Senate (The Senate, 2014) that found offsets were lacking in transparency among other flaws. While the Australian Commonwealth Government accepted nine (five in principle) of the 21 recommendations made by the Senate (The Senate, 2014), it is yet to implement these in policy or legislation, indicating that it is unlikely that there is a focus on the improvement or maturation of offsets.

4.4.4 Implementation

Most offset approvals did not ensure the minimisation of time lags; approximately 45% of offset approvals did not require biodiversity offsets to commence by a particular date. Additionally, the proportion of offset approvals requiring a commencement date did not consistently increase over time.

Time lags can lead to loss of biodiversity, ecosystem services, intergenerational inequity and inequalities from political changes over time (Gardner et al., 2013; King & Wilson, 2015; Maron et al., 2010; Overton et al., 2013; Taherzadeh & Howley, 2018). The timing of the approval of plans and strategies can further exacerbate the effect of time lags. Plans created long after the commencement of a development could be open to different interpretation due to changes in the political and social landscape and/or lobbying from the developer/industry groups. Once a development commences, it is difficult, expensive and politically/socially unfavourable to pause the development, even if offset requirements are yet to be met. Lobbying from the developer could potentially result in requirements being weakened and thus offset requirements may be rendered ineffective and inequitable. Conversely, lobbying from communities could result in requirements increasing, causing inequities and negative economic outcomes for developers. Where possible, regulators should ensure that biodiversity offsets are implemented as soon as possible after commencement of the development, if they cannot be implemented prior to development.

4.4.5 Ecological outcomes

There was a lack in the requirement for ecological outcomes of biodiversity offsets; only 10% required specific ecological outcomes. Inclusion of environmental outcomes demonstrates maturity as these provide transparency, measurability and enforceability through the setting of milestones, key performance indicators and completion criteria. This level of detail can mitigate the risks and costs associated with biodiversity offsets, which is beneficial for regulators, developers and communities (Miller et al., 2015).

The proportion of offset approvals requiring ecological outcomes did not increase over time, further indicating that Commonwealth offset requirements are not maturing. Conversely, the number of offset approvals that referred to other plans or conditions did increase over time. While it is possible that these plans/conditions could include requirements for specific outcomes, the omission of these requirements within offset approvals displays a lack of transparency.

4.4.6 Species & habitats

The species and habitats to be offset is related to the type of environmental impact from the proposed development; however, approvals with a low number of species and/or habitats to be offset could also be indicative of poor consideration of natural values during environmental impact assessment. There were 42 approvals that did not mention which species or habitat were to be offset, so it is unknown what these offset approvals were designed to protect, exemplifying a lack of transparency.

The species and habitats to be offset were mostly focussed on terrestrial species with little mention of aquatic species or associated habitats. There were few (8%) offset approvals that included requirements for aquatic or amphibious species. This may be due to few referrals having significant impacts on aquatic environments and is likely reflective of the industries for which offsets were predominantly required (mining, residential development, transport), which are not expected to have significant aquatic impacts. However, the low representation of offset requirements for aquatic environments could indicate that direct impacts of development, and/or indirect effects (e.g. runoff and changes to hydrology from water use), on aquatic environments have been poorly considered. For example, the approval of the Skardon River Bauxite Mine expansion in northern Queensland in 2016 (EPBC 2014/7305), required offsets for three terrestrial species (the red goshawk (*Erythrotriorchis radiatus*), masked owl (*Tyto novaehollandiae*) and the bare-rumped sheathtail bat (*Saccolaimus saccolaimus nudicluniatus*)) despite being located coastally on the Gulf of Carpentaria, a marine area high in primary productivity that is thought to be one of the few remaining near-

pristine marine ecosystems in the world (DAWE, 2021). Poor consideration of aquatic species has also been observed elsewhere globally and leads not only to biodiversity loss and loss of ecosystem services but can have implications for carbon sequestration (Coker et al., 2018; Shutler & Watson, 2020).

Most of the species and habitats to be offset were for fauna species (60%), with a further 27% for floral species. None of the offset approvals analysed included requirements for other ecological aspects beyond species or habitats. To ensure biodiversity offsets fully compensate for the impacts of development, they should also include consideration of ecological processes and functions, genetic variation, and the impacts of climate change (Bigard et al., 2017; Bull et al., 2013a; Gardner et al., 2013; Gonçalves et al., 2015; Kiesecker et al., 2009; McDonald et al., 2016; Moreno-Mateos et al., 2015; Pilgrim et al., 2013). While it could be inferred that these aspects would be passively offset through the actions taken for species, to ensure transparency and prevent loss, regulators should ensure that all aspects (or surrogates for these aspects) should be explicitly included within offset conditions. This would ensure that a balanced approach to the compensation of natural values is achieved, improving ecosystem resilience and offset success (Duelli & Obrist, 2003; Rohr et al., 2018; Ruppert et al., 2018).

The number of types of species and habitats for which offsets were required was variable and did not consistently increase over time. This may reflect the types of development referrals that were approved but could also indicate a lack of maturation as the number of approvals that did not include a type of species or habitat did not decrease over time. Additionally, consideration of the suite of natural values was lacking as there were no offset approvals with requirements for compensation for impacts on ecosystem functions or services.

The proportion of offset approvals requiring a commencement date and those requiring ecological outcomes did not consistently increase over time, further indicating that Commonwealth offset requirements are not maturing. Conversely, the number of offset

approvals that referred to other plans or conditions did increase over time. While it is possible that these plans/conditions could include requirements for specific outcomes, the omission of these requirements within offset approvals displays a lack of transparency.

4.4.7 Recommendations

4.4.7.1 Recommendations to improve offset requirements in Australia

There was no indication of consistently increasing maturity in terms of transparency or assurance of improved environmental outcomes for biodiversity offsets over the study period. If offsets are not mature, then it is unlikely that they will adequately compensate for the impacts associated with development and consequently will result in the loss of natural values (biodiversity, ecosystem services, ecosystem function) and/or negative social consequences (Bidaud et al., 2018; Gibbons et al., 2018; Githiru et al., 2015; Jacob et al., 2018; Lindenmayer et al., 2017; Macintosh, 2015; Maron et al., 2015; May et al., 2017; Nijnik & Miller, 2017). In order to address the potential shortcomings in offsets found by this study, it is recommended that Australian regulators amend the EPBC Act and its associated EPBC Offset Policy to ensure greater transparency in offset requirements with:

- offset type, matters to be offset, timeframes for offsets and required ecological outcomes (including milestones, key performance indicators and completion criteria) to be all be explicitly stated;
- social concerns and impacts on ecosystem services from offsets included as explicit considerations of all environmental approvals; and
- approval of offsets only in consideration of a strategic landscape-scale planning framework.

The EPBC Act is currently being reformed as are the Australian Commonwealth Governments' approach to offsets (DCCEEW, 2022). Specifically the Commonwealth is currently developing a national standard for offsets that will "be made under law to

provide certainty and confidence in its application." (DCCEEW, 2022). Therefore the recommendations of this research are time critical; if these aspects are not incorporated into reform now, offsets in Australia may still be unable to provide adequate environmental compensation. Further, if the national standard on offsets is enshrined in law and does not ensure adequate environmental compensation, then the effectiveness of offsets in other Australian jurisdictions may decrease.

4.4.7.2 Global context

The recommendations of this research have applicability to other jurisdictions globally, despite being focussed on Australia. Less than 20% of countries have legal requirements for offsets (GIBOP, 2019) and many of these countries also have documented shortcomings in their application of biodiversity offsets. For example, Prévost and Rivaud (2019) described how changes to environmental policy in France to include enforcement of Avoid–Reduce–Offset principles did not improve offsets in France. Carreras Gamarra and Toombs (2017) concluded that offset policies in the USA were lacking in transparency and the description of standards leading to net loss of biodiversity. Ghosh (2017) and Narain and Maron (2018) reported that offsetting in India led to perverse outcomes such as loss in biodiversity and negative social outcomes, and Kylin (2017) found inconsistencies in the application and outcomes of environmental compensation programs in Sweden. These shortcomings could be overcome by improvement of transparency in legislation/policy related to offsets as recommended by this study. It is therefore recommended that regulators in other countries consider the inclusion of the recommendations of this study for their own offset requirements.

Further, while not specifically related to offsets, recent legislation introduced by the United Kingdom, to be phased in through to 2025, requires developers to deliver a 10% biodiversity gain (over a 30-year period) for all developments regardless of size or impact to the environment (DEFR, 2023). The recommendations of this study have

further applicability to the delivery of these biodiversity benefits to ensure transparency and strategic application to ensure benefits are optimised across the landscape-scale.

The recommendations of this research also have relevance to developers and organisations that provide finance for developers. Global banks provide funding for large developments around the world. The International Bank for Reconstruction and Development and the International Development Association, that together are the largest funder of infrastructure construction, require their lendees to adhere to a set of environmental and social offsets standards termed the Environmental and Social Framework (The World Bank, 2017). However, new changes to this framework around biodiversity offsets offers greater flexibility that may result in declines in biodiversity (Morley et al. 2020). The incorporation of the recommendations of this research into the Environmental and Social Framework (or other similar global bank policies) could ensure that developments supported by funding from global banks contribute to sustainable development and the preservation of natural values.

4.4.7.3 Recommendations for future research

This research aimed to determine if the Australian Commonwealth offset requirements were mature or have matured since the introduction of the EPBC Offset Policy in September 2012. However, the assessment of actual offset outcomes against offset requirements was out of scope for this research. Therefore, it is recommended that future research be directed into testing actual offset outcomes against offset requirements.

The study period was chosen to reflect one year prior to the implementation of the EPBC Offset Policy and five years post implementation of the policy in order to ascertain if the policy had any tangible effect on the maturation of offset conditions required by the Commonwealth. However, it is possible that this time period was insufficient to adequately detect change. The year analysed prior to implementation of the policy may not be representative of years prior to the introduction of the policy. Further, the five years analysed after the implementation of the policy may have been

inadequate to detect a change towards maturity. Analysis of results over a longer time frame, including a longer period prior to implementation of the EPBC Offset Policy, is recommended to verify the results of this research.

The omission of information in plans and conditions required by other (i.e. non-Commonwealth) jurisdictions were not analysed as the study focussed on requirements by one jurisdiction, the Australian Commonwealth, to observe if offset requirements were suitable to ensure a meaningful contribution to sustainable development. However, it is recognised that further information from other offset requirements could provide further intention around offset projects and could provide further information about their suitability in terms of sustainable development. While this information should be duplicated/included in the requirements for each jurisdiction to ensure transparency and consistency of approach, in the absence of this, it is recommended that further research in this area incorporate information from other plans and conditions.

4.5 Conclusion

This study reports that offset approvals in Australia lacked transparency, and were not consistently maturing in terms of increasing transparency or assurance of improved environmental outcomes over the study period, despite the introduction of a dedicated offset policy. This indicates that the current impetus for biodiversity offsets in Australia is not related to the assurance of sustainable development, but rather other factors such as political will and the appeasement of community concern. Worryingly, despite these short-comings, Australia is still heralded as a global leader in the use of biodiversity offsets. Legislative amendment by regulators to implement the recommendations of this study is required to improve transparency, remove uncertainty within the EPBC Act and improve the likelihood that biodiversity offsets can adequately compensate for the impacts of development.

While this research has focussed on the application of biodiversity offsets under the EPBC Act in Australia, similar deficiencies in the application of biodiversity offsets are likely to be found in other jurisdictions that do not specifically legislate for biodiversity offsets in a transparent and equitable way. Inclusion of the outcomes of this research can ensure that offset requirements meaningfully contribute to the protection of the environment and conservation of biodiversity. This research serves as an indication of where deficiencies in the application of biodiversity offsets lie and provides some suggestions on how changes could be made to fill these gaps in environmental protection and equity. While the outcomes of this research have obvious benefits for the improvement of the use of biodiversity offsets to contribute to sustainable development, further research into the incorporation of offset requirements from other jurisdictions and assessment of offset requirements against actual offset outcomes is recommended.

Chapter 5

A holistic model for biodiversity offsets incorporating environmental, social and economic aspects of sustainable development

This chapter uses the deficiencies of biodiversity offsets to contribute to sustainable development identified in Chapters 2 and 3 to develop a model for offsets that ensures ethicality and effectiveness. A review of publicly available literature was conducted for this analysis. Best practice elements for aspects of sustainable development (environmental, social, economic) were identified for offset design, implementation and completion. These best practice elements included scope, scale, location, timing, duration and measurement. In addition, the analysis also identified cost/risk mitigation factors. A holistic model was developed on the basis of these best practice elements and was used as the basis for analyses conducted in Chapters 6 and 7.

The content of this chapter has been published in the Journal of Sustainable Development as 'Biodiversity offsets can be a valuable tool in achieving sustainable development: Developing a holistic model for biodiversity offsets that incorporates environmental, social and economic aspects of sustainable development' (doi: 10.5539/jsd.v12n5p65). This paper was co-authored by A. Kemp, G. Coupland and S. Griffin who provided editorial assistance.

5.1 Introduction

Biodiversity offsets are defined by the Business and Biodiversity Offsets Programme (BBOP) as “measurable conservation outcomes of actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken” (BBOP, 2019). To implement, the BBOP (2012) categorises the elements that biodiversity offsets should contain, which include scope (including type of compensatory activities), landscape interaction (scale), location, and implementation (including monitoring, management and reporting). However, as biodiversity offsets are often used to balance the loss from development with conservation gains (Fallding, 2014; Maron et al., 2016b), they should also be aligned with the principles of sustainable development, and include not only the environmental, but the social and economic aspects of the ecological community as well (Abdo et al., 2019a). Here sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (IISD, 2017). There are three key aspects to sustainable development that must be considered in balance to ensure that natural values (biodiversity, ecosystem services and ecosystem function) are not compromised: environmental, social and economic (Gibson, 2009; Moldan & Dahl, 2007; IISD, 2017; Macintosh, 2015).

Biodiversity offsets are intended to be implemented with consideration to all three aspects of sustainable development (Abdo et al., 2021; BBOP, 2012; MacIntosh, 2015). While much has been written on the design of biodiversity offsets (Bull et al., 2013a; Carreras Gamarra et al., 2018; Gardner et al., 2013; Quétier & Lavorel, 2011), this previous work has predominantly focussed on the environment, excluding the social (Bidaud et al., 2018; Gibbons et al., 2018; Githiru et al., 2015; Jacob et al., 2018; Macintosh, 2015; Nijnik & Miller, 2017; Scholte et al., 2016; Takacs, 2018) and/or economic (Benabou, 2014; Fallding, 2014; Jacob et al., 2018) aspects of sustainability, leading to inequalities and an inconsistent approach (Abdo et al., 2019a; Jacob et al.,

2018). Therefore, to ensure biodiversity offset requirements compensate for all aspects of sustainable development, a holistic model, incorporating natural values for design, implementation and 'end-of-life' phases, is needed. In particular, biodiversity offsets should address the Sustainable Development Goals that provide "strategies that build economic growth and address a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection" (United Nations, 2019).

This chapter will seek to address this imbalance by: i) firstly providing a review of recommended best practice for the key elements of biodiversity offsets - scope, scale, location, timing and duration, and monitoring and measurement; ii) secondly, applying these aspects to the considerations of sustainable development; before iii) finally developing a holistic model for biodiversity offsets that balances all aspects of sustainable development. Note that the scope of this chapter is restricted to aspects of biodiversity offsets that are chosen as part of offset design, implementation and ongoing management. Other considerations, such as counterfactual scenarios and environmental economics/metrics, that are chosen prior to this and generally as part of the assessment of impact from a development have not been explored.

5.2 Scope of biodiversity offsets

The scope of biodiversity offsets defines the aspects that will be offset and dictates the conservation gains that are to be achieved within a defined timeframe, thus identifying the expected ecological equivalence/no net loss (Bull & Brownlie, 2015; Carreras Gamarra et al., 2018; Gardner et al., 2013; Quétier & Lavorel, 2011). It is important that inclusions within the scope are broad enough to not only ensure that all key attributes required to secure adequate compensation are captured, but that the conservation gains and timeframe are also achievable. However, the scope of biodiversity offsets is often too narrow to effectively capture all environmental, social and economic concerns (Abdo et al., 2019a; Fallding, 2014; Ghosh, 2015; Gibbons et

al., 2018; Reyers et al. 2013; Takacs, 2018). For example, Gibbons et al. (2018) 10-year review of biodiversity offsets in New South Wales, Australia, found offset programs insufficiently considered the social aspects of intergenerational equity and the inherent value of different habitat types. Ghosh (2017) reported that the compensatory afforestation program in India was narrow in scope, focusing only on numerical valuations of forest type and region, ignoring inherent biological, spatial and social values of the ecosystems impacted. Similarly, Birkeland and Knight-Lenihan (2016) found that the scope of a biodiversity offset in New Zealand focused on compensation for species removed or directly impacted at the development site, without consideration of the impact from other stages (such as transportation, storage or construction) of the development life-cycle; which could result in further environmental and social impacts that remained unaccounted for.

The scope of biodiversity offsets should include assessment of not just species and habitats, but also ecological processes (Bigard et al., 2017; Gardner et al., 2013; Pilgrim et al., 2013), ecological function (Bigard et al., 2017; Bull et al., 2013a; Gardner et al., 2013; Gonçalves et al., 2015; Kiesecker et al., 2009; Moreno-Mateos et al., 2015; Pilgrim et al.; 2013) and genetic variation (Bigard et al., 2017; Bull et al., 2013a; Gonçalves et al., 2015; Moreno-Mateos et al., 2015), to ensure it is broad enough to provide adequate compensation. In addition, the scope should also include the potential impacts of climate change, both in terms of site selection and the potential effect of climate change on conservation measures (McDonald et al., 2016). However, the choice of ecological functions used for biodiversity offsets can be controversial from a social perspective, as some services (e.g. wetlands) are beneficial for some members of the community, while other aspects (e.g. wetlands harbouring mosquitoes) can have a negative impact on other community members (Moreno-Mateos et al., 2015). The type of compensatory measure, method of determining ecological equivalence, and the choice of biological indicators must be adequately considered for all aspects of sustainable development, in order to resolve these conflicts and ensure

that the scope of biodiversity offsets is effective to compensate for the natural values (biodiversity and ecological processes, functions and services) impacted.

5.2.1 Type of compensatory measure

There are several types of activities that are considered appropriate as compensatory measures for biodiversity offsets. These are typically categorised as either indirect or direct offsets. Indirect offsets (also known as 'other compensatory measures') are "actions that do not directly offset the impacts on the protected matter but are anticipated to lead to benefits for the impacted protected matter" (DSEWPaC, 2012) and include knowledge acquisition and scientific research programs, as well as compensatory packages (Fallding, 2014; Jacob et al., 2018). In order to be considered appropriate, indirect offsets need to provide measurable biodiversity gains (Gardner et al., 2013). As the link between indirect offset activities and measurable biodiversity outcomes is not always clear, regulators usually require direct offsets over indirect offsets (Niner et al., 2017). Therefore, this review will focus on direct biodiversity offsets.

Direct offsets are defined as "those actions that provide a measurable conservation gain for an impacted protected matter" (DSEWPaC, 2012), and include habitat restoration (Gardner et al., 2013; Maron et al., 2012; McDonald et al., 2016) and management interventions to prevent loss (termed averted loss) (Fallding, 2014; Gardner et al., 2013; Jacob et al., 2018; Maron & Louis, 2018; Moilanen & Kotiaho, 2018). Biodiversity offset markets (including payments for ecosystem services) are also often considered direct offsets, as, although compensatory conservation activities are undertaken by third parties on behalf of a developer, they usually result in habitat restoration.

Habitat restoration biodiversity offsets rely on conservation activities that improve habitat quality and/or extent as a compensatory measure (Maron, 2012; McDonald et al., 2016). Habitat restoration biodiversity offsets should only be implemented where natural values can be explicitly defined, there is sound scientific evidence that

restoration will be successful, and time lags and uncertainties are effectively accounted for (Maron et al., 2012). Habitat restoration offsets can ensure no net loss (Maron & Louis, 2018) but have been shown to have unpredictable costs and a lower likelihood of success. For example, Bekessy et al. (2010) reported that restoration projects are usually associated with time lags and uncertain outcomes, which often leads to loss of biodiversity. Maron et al. (2012) reported low success for restoration projects and, when revegetation occurred in a highly degraded area, the resulting restored ecosystem rarely reflected what was intended. Similarly, Bullock et al. (2011) meta-analysis of 89 restoration projects across a range of different ecosystems found that restored areas only provided on average 86% of the biodiversity and 80% of the services associated with reference ecosystems.

Averted loss biodiversity offsets are those that involve the maintenance and/or protection of sites that would otherwise be under threat (Maron, 2012; McDonald et al., 2016; Moilanen & Laitila, 2015). Averted loss biodiversity offsets are only able to halt decline and cannot offer no net loss or net gain, despite being lower in cost and easier to implement than habitat restoration offsets (Gibbons et al., 2018; Maron, 2015; zu Ermgassen, 2019). While habitat restoration biodiversity offsets are often preferred over averted loss biodiversity offsets (Githiru et al., 2015; Moilanen & Kotiaho, 2018), averted loss biodiversity offsets have the advantage in that they are lower cost, easier to implement (Maron, 2015), and can mitigate uncertainty (Maron et al., 2012). However, as averted loss biodiversity offsets aim to halt decline, rather than providing explicit biodiversity benefits, they are only appropriate where there is a substantial and certain ongoing or imminent threat to the biodiversity (Bidaud et al., 2018; Gardner et al., 2013; zu Ermgassen, 2019), the predicted loss of biodiversity is low and it is not critical that biodiversity offsets achieve their intended outcomes within a short period of time (Gibbons et al., 2018). Both habitat restoration and averted loss biodiversity offsets should ensure that compensatory activities provide equivalent ecological benefits for the natural values impacted to ensure that the principles of sustainable development are not compromised.

Biodiversity offset markets are a cost-effective solution (Benabou, 2014; Simpson et al., 2017) that can ensure no net loss/net gain of natural values. They provide a market for conservation activities undertaken by third parties, such as landholders (Bull et al., 2013a; van Teeffelen et al., 2014). These activities generate credits that are then purchased by developers as compensation. Credits created by biodiversity offset markets have a value that is determined by future supply (Ozdemiroglu et al., 2009) and the design of the offset itself (Coggan et al., 2013a). This supply is in turn influenced by regulatory requirements, meaning that governments have a large, although often indirect, role in the development and maintenance of biodiversity offset markets (Coggan et al., 2013a). To develop functional markets, biodiversity offsets need to have clear, transparent and specific requirements, stated compensatory activities and clear definitions around duration of impact, in addition to adequate numbers of buyers and sellers (Godden & Vernon, 2003).

Biodiversity offset markets provide an incentive for conservation, and thus may be influential in changing the behaviour of landholders (Filoche, 2017) and enabling governments to achieve conservation goals at a lower cost (Kleining, 2017). Biodiversity offset markets can also allow biodiversity offset gains to be achieved in advance of development impacts (Bull et al., 2015; Ozdemiroglu et al., 2009; van Teeffelen et al., 2014), can consolidate small offset projects into a larger project with value greater than the sum of smaller offsets (Benabou, 2014), while simultaneously enabling savings and efficiencies for regulators (Kormos et al., 2015). Biodiversity offset markets are valuable for developers as offset related costs are predictable and therefore the responsibility for managing an offset site can be delegated. Biodiversity offset markets can also provide an opportunity for communities to become more vested in the decisions around developments and their associated offsets, as well as potentially providing opportunities for the community to become offset providers and for the financial incentives of offsets to flow back into the community.

There is a risk, however, that biodiversity offset markets may result in further simplification of ecosystem measures, ultimately resulting in inadequate compensation of biodiversity, ecosystem function and/or ecosystem services. While complex banking schemes may ensure better ecological equivalency, the higher transaction costs of such schemes are likely to lower the potential financial gains from the trade (Simpson et al., 2017), which could impact on provider participation and ultimately affect the usefulness of the banking scheme overall. As with habitat restoration and averted loss offsets, biodiversity markets should only be implemented where the costs and risks associated with ecological equivalency can be adequately balanced.

5.2.2 Ecological equivalency

The planning of biodiversity offsets should be based on equivalence, with biodiversity losses comparable to biodiversity gains, thus ensuring no net loss (Noga, 2014; Rosa et al., 2016). Yet a key component of biodiversity offsets is the fact that some of biodiversity will be lost (Gardner et al., 2013; Maron et al., 2016b; Noga, 2014; Rosa et al., 2016). As such, a particular challenge for designing biodiversity offsets is ensuring that the expected loss is acceptable.

In terms of ecological equivalence, while “like-for-like” represents exact, or as near to, equivalence, trading up can be advantageous in some circumstances (Gardner et al., 2013). Trading up occurs where biodiversity offsets are steered to priority areas for both ecological and socio-economic investment in contrast to the requirement for the replacement of impacted resources in similar sites and in close proximity to the impacts (Tallis et al., 2015). Trading up can provide environmental benefits that are more valuable to developers, regulators and/or communities (Bull et al., 2016; Takacs, 2018), and results in significant cost savings (Habib et al., 2013). Requirements for equivalent vegetation to be protected are up to two orders of magnitude greater in terms of area (Habib et al., 2013), requiring a significant burden not only on developers, but also on governments in regard to monitoring and assessment for compliance. Trading up can allow conservation to be focused on regional priorities (Habib et al.,

2013). For example, Kujala et al. (2015) reported that biodiversity offsets that were developed to address strategic priorities led to a 10% increase in biodiversity, while like-for-like biodiversity offsets led to a 10% decrease in biodiversity. Trading up can provide additional compensation to areas that have experienced cumulative impacts. It is also valuable for practical purposes, as it can allow a broader range of offset locations (Habib et al., 2013), which is particularly important in areas where availability of land for biodiversity offsets is difficult due to tenure issues (Abdo et al., 2021). In areas where there are biodiversity offsets markets, trading up can also facilitate market activity (Habib et al., 2013).

Trading up, unlike 'like-for-like' biodiversity offsets, can, however, remove visibility of the links between losses at the development site and gains at the offset site (Bull et al., 2016). As with other types of biodiversity offsets, whilst considering trading up it is important to ensure that loss at the development site and gains derived from conservation activities at the offset site are equivalent (Habib et al., 2013). It is also important to ensure that ecosystems with attributes that are less socially/politically desirable, but that provide a supportive or functional advantage for desirable ecosystems/species (e.g. areas that support key life stages of desirable species), are not excluded.

Non-equivalent biodiversity offsets should not be permitted unless in combination with trading up (Villarroya et al., 2014). The determination of ecological equivalence should incorporate natural values, including consideration of biodiversity representation and species persistence (Andrello, et al., 2015). Species persistence is strongly related to dispersal through population persistence, mean time to extinction, number of occupied habitat patches and metapopulation capacity (Andrello et al., 2015). Consideration of ecosystem components that will not be measured (e.g. habitat structure) and those aspects of biodiversity that are important to communities but that do not necessarily provide a substantial conservation outcome (e.g. cultural values) (Gardner et al., 2013) are also important to ensure that biodiversity offsets do not create or deepen social

inequities (Mandle et al., 2016; Rosa et al., 2016; Tallis et al., 2015) and can balance the principles of sustainable development.

5.2.3 Biodiversity indicators as representatives of biodiversity

Ecological communities are unique, so it is impossible to exactly replace the biodiversity of one area in another, which from a practical sense, would be prohibitively costly and time consuming. As such, surrogates, proxies or indicators are chosen to represent aspects of biodiversity (Bezombes et al., 2018; Duelli & Obrist, 2003; Kiesecker et al., 2009; Macintosh, 2015), particularly where there is a paucity of data available regarding the components, structure and/or function of the affected ecosystem (McElwee, 2017). Indicators are important basis of biodiversity offset markets as they contribute to the 'currency' that can be traded (Benabou, 2014).

Indicators are typically chosen to represent those aspects of an ecosystem that are the most important to communities, governments, developers and other relevant stakeholders (Coralie et al., 2015). As different components of ecosystems are valued by different stakeholders (Gardner et al., 2013), the choice of indicators should include stakeholder input and consideration of equity (Noga, 2014). This requires prioritisation of rules and natural values (Macintosh, 2015). In practice, however, this can be difficult to define (Maseyk et al., 2016), as stakeholders can have competing priorities.

Several biodiversity indicators are required to ensure that desirable natural values are adequately represented. While directing conservation activities at a single indicator species would enable biodiversity offset gain calculations to be simplistic and cost effective, this approach to biodiversity offset would result in misrepresentation of natural values, increased variability in offset outcomes and lower resilience in the resultant ecosystem, potentially limiting the offset success (Duelli & Obrist, 2003; Ruppert et al., 2018). For example, despite undertaking conservation activities, indicator species may fail to thrive if conservation activities do not encompass other species the indicator species is clearly linked to. Additionally, the use of a single indicator species could create a false positive of success if the indicator species used

responds positively to conservation actions, whilst other aspects of the impacted ecosystem either do not exist within in the designated biodiversity offset area or fail to thrive.

Each aspect of the ecosystem (or each aspect to be offset) requires a corresponding indicator (Duelli & Obrist, 2003; Quétier & Lavorel, 2011). Indicators should consider threatened and priority species, key species that are very specific to particular habitats, species with restrictive life histories, those that have lost significant habitat due to cumulative effects, and species that are particularly sensitive to human influence (Kiesecker et al., 2009). In addition to carefully selected indicator species, carbon, water and other indicators of condition (soil, vegetation) should also be included (King & Wilson, 2015). Genetic diversity is another important attribute, as sites may appear similar but have a different genetic composition, particularly in terms of less obvious components (e.g. microbes), that are essential to ecosystem success (Tierney et al., 2017). While habitat type needs should be equivalent, greater gains in species richness may be achieved in areas with less remnant vegetation (Gibbons et al., 2018). As such, consideration of indicators should not rely solely on vegetation type and condition (Kujala et al., 2015) and should also incorporate structural, compositional and functional attributes (Rohr et al., 2018). The biodiversity aspects of ecosystems and landscapes should be captured, as these in turn contribute to ecosystem function, and have societal benefits (Walz, 2015). A balance between rare and threatened species, and ecosystem functions and services is also required (Rohr et al., 2018). Biodiversity offsets also need to take into account external threats, such as natural disasters and climate change (May et al., 2017), as these threats have the ability to prevent the offset from reaching its' objectives.

Determining appropriate indicators is extremely important, as in their absence, concealed trades may occur. Concealed trades are exchanges of biodiversity elements that are not explicitly accounted for and which are either offset implicitly or lost in the exchange (e.g. different canopy tree species within the same vegetation type, or genes

within species) (Maseyk et al., 2016). In order to avoid concealed trades, rigorous science must be applied to ensure that all natural values are known and that appropriate indicators for each natural value are included (Duelli & Obrist, 2003).

Indicators provide practical and cost advantages over attempts at compensation for all natural values of an ecosystem (Bennun, 2014); however, in order to be effective, indicators must be based on a grounding of robust science that has established links to the natural values of the ecosystem. Appropriate indicators that are both representative and sensitive to changes from impact and conservation actions may overcome deficiencies in metrics used to determine no net loss (Bezombes et al., 2018). However, the assessment and monitoring of indicators must occur at a scale that is appropriate to each indicator, as scales such as those used by planning frameworks are often too broad to address the needs of individual species (Kormos et al., 2015).

5.3 Scale of offset

Determining the size of biodiversity offsets relies on five key features: 1) definition of key species/ecosystems, 2) appropriate indicators, 3) calculation of the loss/gain, 4) understanding of time-lags, and 5) understanding of uncertainties and risks (Jacob et al., 2016). The size and the extent of the biodiversity offset must be adequate to compensate for relevant natural values, in order to ensure that biodiversity offsets adequately consider all aspects of sustainable development.

5.3.1 Size of offset

The size of the biodiversity offset should be proportional to the size and scale of the environmental and social impact, and should incorporate the risk of failure (Fallding, 2014; Quétier & Lavorel, 2011; ten Kate et al., 2004). Biodiversity offsets are often scaled in order to ensure adequate compensation for losses of type of compensatory measure, degree of ecosystem impact, time and space (Benabou, 2014). In terms of

biodiversity offsets, the ratios used for this scaling is termed as “multipliers”. While multipliers represent the ratio between the offset area and the impacted area, they are usually much greater than one as they are used to compensate for deficiencies in offsetting (Moilanen & Laitila, 2015). Multipliers are often used to account for uncertainties in project design and implementation (Bull & Brownlie, 2015; Bull et al., 2016; Bull et al., 2017b; Moilanen et al., 2009). Multipliers can also contribute to conservation objectives (Bull et al., 2017b) and reduce the risk of offset failure (Clarke & Bradford, 2014; McKenney, 2005; Quétier & Lavorel, 2011) by compensating for lack of information, imperfect exchanges or risk of failure (Bull et al., 2017b). They can also account for time lags (Bull et al., 2016; Gardner et al., 2013; Moilanen & Laitila, 2015; Moilanen et al., 2009) and conservation actions of a shorter duration than the environmental impact from development (Moilanen & Laitila, 2015). Requirements for multipliers can influence developers to provide impetus to avoid ecologically and/or socially important habitat (McKenney, 2005) through higher costs to both developers and regulators.

Multipliers should be developed to address residual risk after mitigation measures (Gardner et al., 2013) and include consideration of additionality, risk of failure and timeframes for achievement of milestones (McKenney & Kiesecker, 2010). Generally, however, biodiversity offset ratios either do not consider the ecosystem as a whole, climatic conditions or ongoing threats to the offset area (May et al., 2017), or are too small to adequately account for these attributes (Bell, 2016; Bull et al., 2017b). While multipliers are rarely required to be greater than a ratio of 1:10, they would often need to be in the tens to hundreds to truly achieve no net loss (Bull et al., 2017a). For example, Fallding (2014) reported that offset multipliers used in Australia ranged from 2:1 for key fish habitat offsets in NSW and certain vegetation offsets in Queensland, to 10:1 for wetland offsets in NSW and certain Commonwealth biodiversity offsets. Additionally, social considerations, such as social, ethical and governance concerns, are rarely addressed, which could result in the need for even larger multipliers (Bull et al., 2017a; Bull et al., 2017b). In order to be effective and to minimise these impacts,

multipliers should be linked to risk and cost/benefit. They should ensure appropriate consideration of all aspects of sustainable development by incorporating biodiversity and socio-economic aspects, as well as future considerations (e.g. climate and ongoing threats).

While the size of the biodiversity offset will be proportional to the cost and risk of the offset, the definition of ecosystem extent (including land cover, land use, habitat) is also a key factor in determining the size of the offset. While this can be difficult and costly to identify, technology, such as satellite remote sensing, can be used to provide efficiencies (King & Wilson, 2015).

5.3.2 Consideration of offset extent

Policy objectives for biodiversity offsets and no net loss are typically at the site level (Bull et al., 2013a; Burgin, 2008); however, this could lead to the uneven distribution of natural values (Budiharta et al., 2018). While it is generally accepted that biodiversity offsets should be selected at the smallest size at which conservation goals can be met (i.e. where no net loss is achieved) (Kiesecker et al., 2009), studies such as that by Di Minin et al. (2017) reported that small increases in targets at no additional costs can improve the representation of biodiversity and ecosystem services. As many biodiversity processes operate over larger scales (Fallding, 2014) and outside factors have the ability to impact on the success of the offset area (e.g. invasive species), biodiversity offsets should be considered at the landscape level (McKenney & Kiesecker, 2010; Noga, 2014). Consideration of biodiversity offsets at a landscape level provides assurance of a number of key factors: that the environmental, social and economic significance of the area is accounted for; that no go areas and the most appropriate location(s) and suite of offset activities have been determined; and that future risks to the successful achievement of biodiversity offset goals have been identified (Gardner et al., 2013). These factors do not necessarily have to be addressed on an individual project basis, rather much of this information could be available

through a strategic landscape-scale planning framework (henceforth ‘planning framework’).

Consideration of offsets at a landscape scale can create social issues because considering biodiversity offsets over a broader area involves a greater range of stakeholders, which may have differing views (Budiharta et al., 2018). Additionally, while increased connectivity has obvious ecosystem advantages (e.g. dispersal, migration), connectivity could create disadvantages, especially in areas where there is increased risk of disease outbreaks (Kormos et al., 2015), fire or susceptibility to climate change. As such, social considerations and risk mitigation are also important considerations for planning frameworks, particularly if used in conjunction with biodiversity offsets.

5.4 Location of offset

The determination of an appropriate distance between the biodiversity offset and site of impact is subjective and depends on connectivity of landscape, range and dispersal of key species, supply/redundancy of ecosystem functions and services, availability of land, external pressures and maximum benefit of desirable features for both communities and regulators. The biodiversity offset should be located such that it provides the same desirable features as the development site (Quétier & Lavorel, 2011) and should provide complementary aspects to other intact/protected areas within the landscape (Kujala et al., 2015). Additionally, impacts on communities should be considered to ensure that the siting of the offset does not create social inequities (Ali et al., 2018; Griffiths et al., 2019; Jacob et al., 2016), or introduce/exacerbate leakage (Noga, 2014). Leakage occurs when the offset activity does not stop environmental damage, but merely displaces impacts to another location (Moilanen & Laitila, 2015; Pascual et al., 2017). For example, carbon-rich peat-swamp forests in Indonesia, that are encouraged as offsets for their carbon capture abilities, have been

found to support lower levels of species diversity and threatened species than other ecosystems (Moilanen & Laitila, 2015).

There is no defined appropriate distance for an offset site in relation to a development site (Kiesecker et al., 2009; Moilanen & Kotiaho, 2018), although biodiversity offsets that are located near the development site, or at least in the same bioregion, provide additional biodiversity and social advantages. Biodiversity offsets that are further away from the development site, as is often the case with large-scale biodiversity offsets, can be less connected to and have less similar biodiversity than the development site (Yu et al., 2018). While having the biodiversity offset close to where impact has occurred is usually preferred, in some circumstances (e.g. to reduce cost, for trading up or in order to improve habitat connectivity) it may be advantageous to locate the biodiversity offset elsewhere (Rogers & Burton, 2016; Rohr et al., 2018; Tallis et al., 2015). Requirements for biodiversity offsets to be sited as close to the development site as possible can hamper efforts to ensure it is part of a larger coordinated landscape scale plan (Lukey et al., 2017), as well as hamper community access to ecosystem services (Bennun, 2014).

Biodiversity offsets that are not close the development site may require greater conservation efforts (e.g. higher multipliers) than those placed nearby. This is because natural environmental processes, such as dispersal and migration of species between the offset and the development site (or nearby sites within the bioregion), may not occur if the distance between the sites is too great (Yu et al., 2018). This lack of connectivity may increase the time taken for an offset to achieve its goals, and/or may increase the costs associated with maintenance and rehabilitation of the offset area. In order to balance the principles of sustainable development, the location of biodiversity offsets should be determined strategically as part of a landscape-scale planning framework that balances environmental, social and economic concerns for natural values.

5.5 Timescales associated with offsets

Time delays in the realisation of gains from biodiversity offsets can be substantial, taking several decades to be realised, if ever (McKenney & Kiesecker, 2010; Moreno-Mateos et al., 2015). Time delays in the delivery of the gains from an offset may cause the loss of biodiversity and could also cause greater threat to certain species or even extinction (Gardner et al., 2013; Maron et al., 2010). Additionally, these time delays can create issues in the provision of ecosystem services or intergenerational equity (King & Wilson, 2015; Overton et al., 2013).

Different offset approaches may require consideration of different timescales to ensure environmental gains are realised (Fallding, 2014). Flexibility in timing is often needed as, except in the case of advanced offsets, conservation actions related to biodiversity offsets are usually only initiated after development impacts have occurred (Moilanen & Kotiaho, 2018). While time lags in the realisation of gains from biodiversity offsets might be permitted from a practical perspective, these should not in turn pose an imminent threat to the natural values requiring protection and/or compensation (Maron et al., 2012). Furthermore, they should not create inequities from political changes over time (Taherzadeh & Howley, 2018), with the biodiversity offset commitment lessening to the detriment of communities or increasing to the detriment of developers. The risk of time lags in the delivery of biodiversity offset outcomes can be lessened by having compensatory conservation activities start in advance of the development impact (advanced offsets) (Burgin, 2008; Gardner et al., 2013; Kiesecker et al., 2009; Lodhia et al., 2018; Quétier & Lavorel, 2011; Villarroya et al., 2014). Alternately, the risks associated with time lags can be avoided or reduced by increasing the size/scale of the offset through use of a multiplier (Gardner et al., 2013; Villarroya et al., 2014), with longer time lags corresponding to offsets that are larger in scope and/or scale (Yu et al., 2018).

Time lags in the delivery of offset outcomes may be beneficial, as they can allow natural recovery rates to be observed (where these are not known prior to the

implementation of the offset) (Rohr et al., 2018). However, habitats that take a long time to recover should not be compensated for by those that are easier to restore, as this could result in biodiversity loss (Gibbons et al., 2018), particularly where out of kind offsets are permitted (Overton et al., 2013). While time lags are generally unavoidable, the cost and risk to environmental, social and economic aspects should be balanced to ensure that the principles of sustainable development are maintained.

5.6 Duration of offsets

Biodiversity offsets should focus on long-term conservation (Noga, 2014) and the environmental gains provided by biodiversity offsets should be permanent (Rosa et al., 2016). The impact from the development should be reversible to ensure that a loss of natural values does not occur (Bull et al., 2013a), and/or that the conservation actions undertaken persist (Moilanen & Kotiaho, 2018). Although in some cases, such as where the goal of a biodiversity offset is to remove pests, this would mean that the biodiversity offsets would have to continue in perpetuity as reinvasion is likely to occur when conservation actions associated with the biodiversity offset cease (Norton & Warburton, 2014). While often desirable by regulators and communities, requirements for permanent maintenance of a biodiversity offset are not feasible in practice as future societal, political, and economic priorities cannot be effectively predicted at the inception of the offset (Norton & Warburton, 2014). As such, biodiversity offsets are often required to last as long as the impacts from development (Bull et al., 2013a; Gardner et al., 2013; Githiru et al., 2015; Kiesecker et al., 2009; Simpson et al., 2017). Mechanisms to ensure longer-term management include financial instruments, such as a bond set aside as an endowment where the interest accrued from the funds covers the annual cost of management (Norton & Warburton, 2014).

In theory, biodiversity offset gains should last at least as long as residual effects of the development (Gardner et al 2013). In practice this is unlikely, based on the few available studies that have monitored biodiversity offset performance after

implementation e.g. (Clare & Krogman, 2013; May et al., 2017; Taherzadeh & Howley, 2018). There are, however, two options in the case of uncertainty of biodiversity offset outcomes or where the achievement of biodiversity offset gains are unlikely to be achieved: i) either biodiversity offsets should not be permitted (especially in the case or rare, unique, endangered species or communities, or where species and communities hold unique cultural or economic value) or ii) biodiversity loss should be accepted with the knowledge that some replacement will occur. However, monitoring of the biodiversity offsets must occur to ensure that the biodiversity offset is effective in providing adequate compensation, and to ensure that no detrimental impacts to the environmental, social or economic aspects of natural values occur, violating the principles of sustainable development.

5.7 Monitoring and measures of offset success

In order to assess the success (or failure) of an offset, there must be a set definition of what constitutes adequate/required compensation, as well as a timeframe for the delivery of this compensation (Brady & Boda, 2017). Biodiversity offset milestones should be measured against an appropriate baseline, ideally the counterfactual (Lindenmayer et al., 2017), as well as appropriate completion criteria (May et al., 2017).

Completion criteria should be developed for all offset indicators so that appropriate measurements and monitoring of desirable aspects of the ecosystem are included (Takacs, 2018). For example, Lindenmayer et al. (2017) reported that despite attempts to reduce the impacts of developments on black cockatoos in Western Australia through installation of suitable nest boxes, the boxes were instead inhabited by exotic pest species, and thus while the offset requirements were considered ‘completed’, the original outcomes intended by these offset requirements were not achieved. Monitoring is essential (Lindenmayer et al., 2017) and should include clear definitions, milestones, timeframes and monitoring methodologies (Fitzsimons & Carr, 2014; Koh et al., 2014). Multiple aspects of the values to be offset should be measured to accurately determine

offset performance (Maron et al., 2012) and to allow adaptive management measures to be undertaken. As suggested by Rohr et al. (2018), milestones should include genetic composition of species of interest, species' abundance, community composition, and ecosystem function.

Ecosystem function and services are important components of natural values, but there are no standard metrics or guidance on how these would be evaluated. McElwee (2017) suggests that the assessment of ecosystem production could be one way to assess these changes. This does not, however, provide an assessment of other cultural and community use/non-use values, which can only be assessed indirectly through community consultation. As such, biodiversity offset monitoring programs should assess ecological performance along with social and governance performance (Gelcich et al., 2017). This already occurs in some jurisdictions, such as France, where the development of biodiversity offsets requires negotiation with relevant stakeholders to ensure their interests are considered (Guillet & Semal, 2018). Stakeholder input and/or community consultation is needed to ensure that issues around conservation activities are resolved (Iritie, 2015; Rohr et al., 2018; Taherzadeh & Howley, 2018). Milestones also may need to include an aspect of disturbance, as some species will only recruit to disturbed or structurally modified ecosystems (Tierney et al., 2017). However, biodiversity offset milestones should not just focus on natural values but include consideration of ecological stability and resilience (Rohr et al., 2018). This could occur through ongoing monitoring as part of a planning framework.

Biodiversity offsets should be monitored, at a minimum, until they reach their intended goals, in order to ensure that environmental, social and economic impacts to natural values are not ongoing (Villarroya et al., 2014). Monitoring of the biodiversity offset should occur until there is confidence that gains from conservation activities are persistent, particularly in cases where the impact of the development is not reversible. Ongoing monitoring is not necessarily the responsibility of the developer and should be shared with communities and regulators as part of a planning framework.

5.8 Discussion

5.8.1 Developing a holistic model for biodiversity offsets

This review reports that determining appropriate scope, scale, location, timing, duration and monitoring components is key to the development of a holistic model for effective biodiversity offsets. An overview of best practice recommendations based on these key components is provided in Table 4.1. While there are several ways these components can be implemented in order to ensure that biodiversity offsets effectively contribute to sustainable development, consideration of each component should include the environmental, social and economic aspects of natural values. However, while the consideration of the above demonstrates best practice and provides a holistic model balancing all aspects of sustainable development, the cost and risk associated with these components must also be considered to ensure that biodiversity offsets will be feasible.

Table 5.1: Holistic model describing best practice recommendations for biodiversity offsets.

Component	Best practice recommendations
Scope	Biodiversity offset markets providing habitat restoration conservation activities
	Trading up that ensures equivalency of natural values
	Indicators for key natural values based on robust science and incorporating stakeholder input
Scale	Consideration at a landscape-scale
	Size that reflects application of multipliers used to mitigate risk
Location	Biodiversity offsets should be placed strategically where benefits are maximised, but impacts to environmental, social and economic concerns are minimised
Timing	Time lags should be minimised as far as possible
Duration	Biodiversity offsets should provide benefits that persist as long as the impacts from development
Monitoring	Stakeholder consultation and persist with monitoring until the biodiversity offset reaches its intended goals
	Include appropriate milestones and completion criteria for all natural values and should inform adaptive management

5.8.2 Cost and risk management

Key to developing a holistic model for biodiversity offsets is consideration of cost and risk management. To effectively consider cost and risk, the design and ongoing management of biodiversity offsets should include cost benefit analyses identifying key species, and also consider the cost of management, as exemplified by Carwardine et al. (2014) for conservation planning in the Pilbara region of Western Australia. Biodiversity offsets should also account for contingency costs if their intended goals are not achieved. For example, if the cost of compensation is too high, then it can increase the risk of offset failure, with developers unable to meet the costs associated with adequate compensation, and/or regulators unable to ensure adequate monitoring and enforcement. This outcome can have consequences for communities by way of

taxation and/or reduced financing for other services. Ultimately, this will result in a loss of natural values.

Having transparent milestones and completion criteria can mitigate both the costs and risks of offset failure, as uncertainty can affect the viability of a development (Miller et al., 2015). As a consequence, this may have negative economic implications and result in a reduction of services available to communities. Offset failure can also be mitigated by integrating conservation actions within planning frameworks, ensuring that the offset area effectively compensates for the loss of natural values and ensuring that reporting on offset outcomes is open and transparent (Koh et al., 2014). Similarly, the risk of offset failure can be mitigated by ensuring that adequate financing to ensure intended offset outcomes is in place prior to environmental impact (Brown & Penelope, 2016; Pilgrim et al., 2013), and by using bonds to cover costs in the event of failure and/or fines if offsets fail to reach pre-agreed milestones (Clarke & Bradford, 2014). The effectiveness of biodiversity offsets is also reliant on the availability of comprehensive and reliable datasets (Bull et al., 2018). Where this is not available, it is common for regulators to invoke the precautionary principle, allowing development to proceed, but requiring biodiversity offsets to incorporate additional measures of certainty, such as increased multipliers and/or bonds.

5.8.2.1 Inclusion of bonds

The likelihood that an offset will succeed is usually based on environmental factors, but at the neglect of public support, community benefits and cost effectiveness (Noga, 2014). However, the social risks associated with uncertain offset outcomes can be mitigated if the public interest is protected in the event that the offset fails (Brown & Penelope, 2016). A key way to achieve this is through the requirement for a bond. A bond is a monetary sum that is held as insurance until a biodiversity offset achieves certain outcomes. These outcomes should include appropriate milestones and completion criteria. Bonds not only insure against non-delivery but can also ensure duration of conservation outcomes (Norton & Warburton, 2014). Bonds are already

required in some jurisdictions, such as the New South Wales Department of Primary Industries, which operates a policy of ‘no net loss’ for marine developments and requires a monetary bond to insure against failure (Burgin, 2008).

In conjunction with bonds, conservation covenants could be used to set aside areas of land for biodiversity offsets that are only used in the event that a development has an ecological impact. This could be particularly helpful for developments that occur in areas where there is a paucity of information on natural values. Where multipliers are used to compensate for risk of failure as opposed to a bond and/or covenant, the multiplier would be much higher, as observed by Moilanen et al. (2009). This results in further cost implications both for developers and regulators. While the use of a bond and/or covenant in this case could allow the developer to avoid high costs, time delays may mean that the eventual offset may need to be much larger than originally proposed to compensate for the delays. Given that multipliers required under the precautionary principle are particularly conservative, on balance this could work in the favour of the developer.

5.8.2.2 Incorporation of biodiversity offsets in planning frameworks

Monitoring and measurement can help biodiversity offsets meet their intended goals, but they will only be as effective as their metrics, which should be suitable and robust. While ecosystem indicators are developed to measure natural values, they can also be used to evaluate the performance of biodiversity offset-related conservation activities in meeting their intended goals (Bezombes et al., 2018). Determining appropriate goals for biodiversity offsets is, however, difficult, especially prior to the commencement of conservation measures (van Teeffelen et al., 2014). As such, biodiversity offsets should be implemented as part of a planning framework to ensure that milestones, goals and completion requirements for biodiversity offsets are implemented in a strategic and transparent way. A strategic planning framework including the environmental, social and economic aspects of all natural values can reduce risks to sustainable development.

Planning frameworks are key to ensuring that biodiversity offsets are delivered strategically, and to the greatest environmental, social and economic benefit. Frameworks can assist in the identification of suitable sites for offsets (Brownlie & Botha, 2009) by identifying areas not suitable for biodiversity offsets. Unsuitable areas would include locations with competing land tenure considerations or other issues that might ultimately hamper the success of the offset (e.g. anthropogenic pressures, such as fishing), or areas where risk is too high/costs are too great for compensation. While the use of biodiversity offsets markets can be used to fill gaps in conservation priorities (Iritie, 2015), this can also be achieved by ensuring that offsets are linked to planning frameworks. Ultimately, if used in combination, greater cost and risk efficiencies may be achieved.

Planning frameworks should only be implemented within defined project constraints (Macintosh, 2015). Defining these project boundaries is essential, especially when used in combination with offset markets, as offset markets can create financial incentives that influence the decision-making process in a way that is unfavourable to the conservation of biodiversity (Maron et al., 2016b). This is particularly true where conditions of the negotiated approaches. The levy approach may operate in reverse to this, creating an incentive for regulators to seek funding for their 'conservation wish-list' rather than for projects that would compensate for the development. In this situation, developers are required to deliver projects that are in the remit of governments (Taherzadeh & Howley, 2018), meaning that social priorities may not be compensated. The financial compensation sought in this case might again be of a scale disproportionate to the impact, and could create inequities between developers, particularly if regulation allows high levels of flexibility. While planned contributions in legislation can be beneficial in avoiding these undesirable outcomes, legislation needs to be very prescriptive, which makes it difficult to ensure that all natural values of each unique ecosystem are considered. In order to capitalise on the obvious advantages of biodiversity offset markets, whilst avoiding the aforementioned failings, markets should provide adequate compensation for environmental, social and economic aspects

through habitat restoration and/or averted loss offsets, and be administered by an independent organisation.

Planning frameworks that include adaptive management and contingency planning can ensure that biodiversity offsets are more effective (May et al., 2017), that conservation outcomes are enhanced (Koh et al., 2014; Underwood, 2011) and can provide greater environmental benefits at a lower cost than those implemented as stand-alone projects (Lukey et al., 2017). Frameworks can also identify opportunities for trading up (Tallis et al., 2015) and ensure that landscape connectivity is maintained, thereby promoting population persistence (Andrello et al., 2015) and improving the likelihood that a biodiversity offset will achieve its intended goals (Birkeland & Knight-Lenihan, 2016; Simpson et al., 2017). Integration of biodiversity offsets into planning frameworks may also reduce the risks associated with averted loss offsets (Moilanen & Laitila, 2015). Incorporation into planning frameworks could ensure more comprehensive assessments of losses and gains are undertaken by having this achieved external to developers that have an impetus to minimise time and costs (Benabou, 2014).

Planning frameworks can also insure against cumulative effects of smaller development projects. While biodiversity offsets are often focused only on larger infrastructure projects, as they generate more public concern, smaller projects in aggregation can be just as detrimental, if not more so (Guillet & Semal, 2018; Peel & Godden, 2005). Conversely, planning frameworks can also enable biodiversity offsets to be delivered as a series of smaller, interconnected sites, as opposed to one larger area. Small-scale offsets are acknowledged as difficult to implement (Fallding, 2014), are subject to an increased pressure from edge effects, have increased administrative and compliance costs, and pose a risk of having a lesser environmental value than more connected and integrated areas (Lukey et al., 2017). However, when implemented strategically as part of a planning framework, small scale offsets can reduce risk of offset failure. Implementation in this way can mitigate the risks associated with offsets within one large area, such as lack of ecosystem response to

conservation actions (Moilanen et al., 2009), ecosystem decline from uncontrollable external influences (e.g. natural disasters), or requirements for further development. The likelihood of offset success can be improved in small scaled projects, by i) having several smaller varied offset areas as part of a package, ii) incorporating areas requiring different conservation actions at spatially dispersed sites, and iii) ensuring that the effects of conservation are not reduced overall through edge effects or reduced habitat connectivity.

Yet the use of interconnected, smaller offset areas may pose associated social inequities. As such, planning frameworks should be developed through a public process. This process should include contribution from relevant experts and members of the community to ensure that aspects of the environment and all associated social concerns are represented. Involvement of stakeholders can reduce the risk of offset failure, particularly in terms of ensuring long-lasting offset gains (Koh et al., 2014). By consulting stakeholders on environmental and social priorities, it is more likely that biodiversity offsets can meaningfully contribute to sustainable development.

In Australia, planning frameworks, termed bioregional plans, are possible under Section 176 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). These plans are developed by the Minister for the Environment and include consideration of environmental and social aspects. While bioregional plans have been developed for marine areas, to date no plans have been developed for terrestrial areas. The marine bioregional plans are in themselves very broad, with only five plans to cover the entire Australian maritime area. Further, the EPBC Act has restricted its consideration of the environment to Matters of National Environmental Significance (MNES), so these plans have been developed to only consider MNES. While the Minister must ensure public consultation of the draft plan, social considerations are not directly addressed by the plans. Finally, the plans are not regarded as a legislative instrument, but rather provide further information for the Minister's consideration when making a determination. In order to satisfactorily ensure

the strategic use of biodiversity in Australia to contribute to sustainable development, a planning framework is needed that can be used as a legislative instrument and ensures more detailed plans encompassing consideration of all environmental, social and economic aspects.

In the absence of planning frameworks, the location and intended conservation activities for a biodiversity offset must meaningfully contribute to sustainable development. This could involve a type of sustainable impact assessment (SIA) conducted on the offset itself, either as part of the development of an environmental impact assessment, or independently after conditional development approval that requires biodiversity offsets. An effective SIA involving stakeholder consultation will not only identify potential negative environmental, social and economic impacts, but will also assist in gaining social license to operate, reducing risks associated with offset failure. A SIA will also provide cost efficiencies in terms of monitoring, compliance and enforcement, through clearly identifying relevant key performance indicators and completion criteria.

5.8.2.3 Use of advanced offsets in the planning framework

Advanced offsets are those that have been implemented prior to development and have reached their intended goals (Abdo et al., 2019a). While the concept of advanced offsets is recognised by many regulators to be effective, this approach requires significant strategic planning (Bell, 2016), highlighting the need for a planning framework. In this way, planning frameworks could enable a bank of conservation sites that are delivered by several different parties, such as land-holders, government agencies or non-government conservation organisations that could then be used by developers as appropriate at a later date. Developers would provide a monetary sum (fee) for that biodiversity offset. Planning frameworks link with biodiversity offset markets in a strategic way and provide a biodiversity ‘savings bank’, ensuring there is a continuous overall net gain of biodiversity that increases with newer conservation

projects reaching their goals and diminishes with deleterious impacts from development.

Implementation of advanced offsets as part of a planning framework would also prevent duration issues, as the biodiversity offset would have, by definition, already achieved its goals. Costs for developers would be known, as associated conservation activities would have already been undertaken. Furthermore, if the advanced offset was ‘certified’ as having achieved its intended outcomes, costs for regulators (and therefore communities) would also be lower as ongoing monitoring and enforcement would not be required. Identification through a planning framework of suitable sites and conservation activities for biodiversity offsets would also allow flexibility for developers to provide advanced offsets where they have overcompensated and/or developed conservation programs under the planning framework. These offsets could be traded with other developers, employing ‘peer-to-peer trading’ such as has been proposed for energy providers (for example RENeW Nexus peer to peer energy trading project in Western Australia). This would not only provide efficiencies and reduce risk in terms of biodiversity benefits but would also reduce costs as the price of the advanced offset would be set by demand and not forecast on anticipated conservation activities potentially subject to change depending on future environmental, social and political needs.

While there are currently several different methods used for conservation planning available (e.g. Kiesecker et al., 2009), these are rarely suitable for the identification of areas for biodiversity offsets as they do not account for offset-specific factors such as additionality and equivalence (Yu et al., 2018). As such, these methods must be used in combination with other techniques.

5.9 Conclusion

This manuscript presents a holistic model for the design, implementation and ongoing management of direct biodiversity offsets incorporating all aspects (environmental, social, economic) of sustainable development. This holistic approach to biodiversity offsets is imperative to ensure that biodiversity offsets meaningfully contribute to sustainable development and to prevent loss of natural values and/or creation of socioeconomic inequities. While this holistic approach could be applied through a SIA, a more efficient and potentially more effective approach would have biodiversity offsets being considered strategically as part of a planning framework. In order to minimise costs and risk, thus ensuring optimal efficiency, planning frameworks used by biodiversity offsets should identify strategic opportunities for trading up, advanced offsets and adaptive management, as well as provide assurance of no net loss through the use of multipliers and/or bonds. Planning frameworks should encourage and support biodiversity offset markets and/or peer to peer trading to provide further cost saving efficiencies for both developers and regulators (and by default, communities). This should occur simultaneously with managing the risk of creating social inequities. In this way, biodiversity offsets would be able to tangibly contribute to the Sustainable Development Goals of each jurisdiction, ensuring access to new resources that are not to the detriment of the environment or communities.

Addendum 5.1

Amendments to Chapter 5 following publication

Amendment	**Location**
The reference to payments for ecosystem services as a component of a biodiversity offset market has been made in recognition that payments for ecosystem services and biodiversity offset markets are intertwined, while having different founding principles and targets (Vaissière et al., 2020). Payments for ecosystem services may also be made within the context for biodiversity offsets to secure conservation goals (BBOP, 2012). As such, payments for ecosystem services may form a component of biodiversity offset markets, and should be included through consideration of social aspects if offsets are to contribute to sustainable development. Citations: Business and Biodiversity Offsets Programme (BBOP). (2012). *Standard on biodiversity offsets*. BBOP, Washington, D.C. Retrieved from: http://bbop.forest-trends.org/pages/biodiversity_offsets Vaissière, A-C., Quétier, F., Calvet, C., Levrel, H., & Wunder, S. (2020) Biodiversity offsets and payments for environmental services: Clarifying the family ties. *Ecological Economics, 169*, 106428. https://doi.org/10.1016/j.ecolecon.2019.106428.)	Section 5.2.1, paragraph 2
The reference to biodiversity offset gain calculations refers to the fact that more than one species needs to be used in a calculator. This terminology does not make it clear that the mechanisms of the calculator these calculations also consider loss.	Section 5.2.3, paragraph 3

The reference to Lindenmayer et al. (2017) was incorrectly described within the publication on which this Chapter is based. Lindenmayer et al. (2017) did not conduct their study in Western Australia and did not describe the result of nest boxes on black cockatoos. Rather, Lindenmayer et al. (2017) reported on attempts to reduce the impacts of developments on species using hollow bearing trees through installation of suitable nest boxes, that subsequently were either unused by some native species, or inhabited by exotic pest species. However, the conclusion from the Lindenmayer et al. (2017) study is as discussed within the text of Section 5.7 - while the offset requirements were considered 'completed', the original outcomes intended by these offset requirements were not achieved.	Section 5.7, paragraph 2

Chapter 6

Defining roles and responsibilities for biodiversity offsets

Following on from the development of the offset model in Chapter 5 and the examination of the maturation of offsets in Chapter 4, this chapter identifies appropriate roles and responsibilities for the design, implementation and completion of biodiversity offsets. The implementation of biodiversity offsets requires input and participation from various parties in combination. These can include communities and Indigenous people, conservation organisations and academics. Often these roles and responsibility are poorly articulated which can lead to inefficiencies and the failure of offsets to meet their goals. This chapter uses a qualitative literature review to identify the specific roles different parties may have in relation to determining offset requirements, administering offsets and measuring the success of offsets. This information is then used to assign appropriate roles and responsibilities for better contribution to sustainable development.

6.1 Introduction

The Kunming-Montreal Global Biodiversity Framework was recently agreed to by 191 countries and provides a framework to reverse the loss of biodiversity, including an overarching goal to ensure “biodiversity is sustainably used and managed and nature’s contributions to people, including ecosystem functions and services, are valued, maintained and enhanced” (CBD, 2022a). While regulators have the responsibility to undertake this, the roles required to ensure the sustainable use and management of biodiversity is unclear.

Biodiversity offsets are a recognised mechanism to contribute to sustainable development (Díaz et al., 2019; Fallding, 2014). Biodiversity offsets have been implemented globally for more than 50 years, with the Netherlands, the United States of America (USA), France and Germany as some of the first countries that required compensation for environmental impacts (Benabou, 2014; Bull et al., 2018; Burgin, 2008; Moreno-Mateos et al., 2015). The use of biodiversity offsets has increased since this time; more than 42 countries require offsets under regulation (GIBOP, 2019), and some countries, such as Australia, have notably embraced the use of offsets (Miller et al., 2015).

The implementation of offsets is a complex interplay of many different parties; for example, the regulators that develop offset requirements but have the remit to manage and protect the environment, the developers that describe what will be affected but have the pressure to minimise financial outgoings (such as spending on offsets), the researchers (e.g. from universities, conservation organisations and government research organisations) that determine what is feasible but may also seek funding from developers to undertake environmental work or assist with the assessment of impacts, and the communities and other stakeholders that may experience negative environmental and social consequences related to the development but may also gain economic advantages from the development (e.g. jobs, community financial incentives etc.) (Macintosh, 2015). The complexity of offset design and implementation, and the contradictory purposes of different parties can often result in confusion as to the roles and responsibilities associated with the ongoing implementation of the offsets (Bull et al., 2013a). To improve efficiency and the success of biodiversity offsets, clear definitions of the roles and responsibilities of those undertaking offsets is required to ensure a meaningful contribution to sustainable development.

The aims of this research are to: i) understand the roles and responsibilities that various parties currently have in relation to biodiversity offsets; and ii) develop recommendations to ensure that roles and responsibilities for offsets are aligned with the principles of sustainable development. It is expected that developers will be assigned the greatest responsibility for biodiversity offsets as they carry the burden for offsets under regulation and are often perceived as having broader responsibility for conservation actions (Boonrueang & Reid, 2020).

6.2 Methods

This research undertook a qualitative framework synthesis (Brunton et al., 2020; Macura et al., 2019), which comprises of five stages: familiarisation, framework selection, indexing, charting, and mapping and interpretation.

During the familiarisation stage, the research question ‘are roles and responsibilities for biodiversity offsets explicitly defined?’ and a qualitative analysis of documents including peer-reviewed journal articles, published reports and media articles was chosen as the selected framework. In addition, legislative instruments (legislation, policies, published guidelines) for some countries were also synthesised to understand if roles and responsibilities were for offsets were legislated.

During the indexing stage, a broad search was then undertaken in June 2021 using focussed keywords for ‘biodiversity offsets’ and ‘environmental offsets’. The search utilised the University of Notre Dame Australia library search engine ‘FiNDit’, which accesses all of the University’s library subscriptions including academic databases such as Scopus and Web of Science, and Google and Google Scholar to provide a broader search and to access publicly available information and government department data. . The search was not restricted to a date range or geographic region, however, only published peer reviewed documents in English were included in the analysis.

The titles, abstracts, and executive summaries of documents retrieved were then screened for mention of roles and responsibilities for biodiversity offsets during the charting stage. Documents that either explicitly referred to roles and/or responsibilities of a particular group (party) for biodiversity offsets or where assumptions about roles and responsibilities could be inferred were included in further analysis. In addition,

legislative instruments (legislation, policies, published guidelines) for the United States of America (USA), the European Union (EU), Germany and Australia (Commonwealth, states and territories) were screened to understand if roles and responsibilities for offsets were legally required (Table 6.1). The USA and Germany were chosen as examples countries that have implemented offsets for a long period of time (Benabou, 2014; Burgin, 2008). Australia was chosen as a country that is known for its strong use of offsets to contribute to sustainable development (Fallding, 2014; Miller et al., 2015). The EU was chosen as an overarching entity incorporating several countries' (including Germany) considerations into its approach to environmental regulation and offsets.

Table 6.1: List of environmental legislation, regulation and policy reviewed.

Jurisdiction		**Legislation/policy reviewed**
USA		Code of Federal Regulations: Title 40 - Protection of Environment. Chapter I - Environmental Protection Agency. 01/07/2019.
EU		Official Journal of the European Union: Directive 2004/35/Ce of the European Parliament and of the Council, of 21 April 2004, on environmental liability with regard to the prevention and remedying of environmental damage (L 143/56)
Germany		Act on Nature Conservation and Landscape Management (*Federal Nature Conservation Act – BNatSchG*) of 29 July 2009[6]
Australia	Commonwealth	*Environment Protection and Biodiversity Conservation Act* 1999
		Environment Protection and Biodiversity Regulations 2000
		Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy 2012
	Australian Capital Territory	*Planning and Development Act 2007*
		ACT Environmental Offsets Policy
	New South Wales	*Biodiversity Conservation Act 2016*
		Local Land Services Act 2013 (as amended by the Local Land Services Amendment Act 2016)
		Biodiversity Conservation Regulation 2017
		Local Land Services Regulation 2014
		State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017
	Northern Territory	*Environmental Assessment Act*
		Guidelines on environmental offsets and associated approval conditions
	Queensland	*Environmental Offsets Act 2014*
		Environmental Offsets Regulation 2014
		Queensland Environmental Offsets Policy (Version 1.6): June 2018
	South Australia	*Native Vegetation Act 1991*
		Native Vegetation Regulations 2017
		Guide for calculating a Significant Environmental Benefit under the *Native Vegetation Act 1991* and the Native Vegetation Regulations 2017
		Policy for calculating a Significant Environmental Benefit under the *Native Vegetation Act 1991* and the Native Vegetation Regulations 2017I

[6] The (unofficial) English translated version of this document retrieved from https://www.bmuv.de/fileadmin/Daten_BMU/Download_PDF/Naturschutz/bnatschg_en_bf.pdf was reviewed.

Table 6.1 (continued): List of environmental legislation and policy reviewed.

Jurisdiction		Legislation/policy reviewed
Australia	Tasmania	*Forest Practices Act 1985*
		Nature Conservation Act 2002
		Threatened Species Protection Act 1995
		Water Management Act 1999
		Natural Resource Management Framework
		Guidelines for Natural Values Surveys - Terrestrial Development Proposals
		Policy of the Forest Practices Authority: The use of offsets
	Victoria	*Planning and Environment Act 1987*
		Guidelines for the removal, destruction or lopping of native vegetation
		A quick comparison of first party and third party offset sites
	Western Australia	*Environmental Protection Act 1986*
		WA Environmental Offsets Policy 2011
		WA Environmental Offset Guidelines
		Bilateral Agreement under section 45 of the Environmental Protection and Biodiversity Conservation Act 1999

Parties were partitioned into three distinct groups to better inform the analysis: parties that require biodiversity offsets (regulators), parties that have a legal requirement to undertake offsets (developers) and parties that have a vested interest, but not a legal requirement in relation to offsets (stakeholders). Regulators are typically involved in the setting of limits on development and offsets and in establishing targets for the protection of key matters (species, habitats, ecosystem services, heritage matters etc.) which can guide the design of biodiversity offsets (Ferreira, 2014; Gardner et al., 2013). Developers are private and/or public companies, government organisations and other institutions that have a requirement to provide a biodiversity offset to compensate for a residual significant negative impact on the environment. Stakeholders include Indigenous people and general communities that are impacted (physically, spiritually or emotionally) by an offset; Natural resource management bodies and non-government conservation organisations (NGO's), voluntary groups and other relevant organisations working in the offset area and/or areas adjacent to the offset area; Academic, research and education organisations conducting research on the environmental, social or economic aspects of the matters to be offset.

Documents were then analysed to assess how the assignment of roles and responsibilities to the design and implementation of biodiversity offsets could ensure better alignment with sustainable development. The Abdo et al. (2019b) biodiversity offset model (hereafter 'offset model') was utilised as a framework to assess this. The offset model includes 10 key biodiversity offset requirements and four recommendations for cost and risk mitigation that consider all aspects of sustainable development (environmental, social, economic). Therefore, this model was used as a framework to assess alignment of roles and responsibilities for offsets to sustainable development. The offset model was deemed suitable for this analysis as it was the only model for offsets found that has been specifically developed in consideration of sustainable development based on a Google Scholar search (English results only; conducted in September 2022) using search terms:

- "environmental offset" "sustainable development" (152 results)
- "biodiversity offset" "sustainable development" (532 results)
- "biodiversity offset model" (10 results)
- "environmental offset model" (0 results)
- "biodiversity offset framework" (14 results)

Note that results for carbon offsets were excluded from this analysis.

These results were mapped against the key biodiversity offset requirements and recommendations of the offset model, before interpretation of this data in light of relevant peer reviewed was undertaken and accompanying recommendations for offset roles and responsibilities for each party were made.

6.3 Results

The electronic database search and preliminary analysis yielded 151 documents that either explicitly discussed or provided an inference of roles and responsibilities for biodiversity offsets. Of these, only 44 documents explicitly discussed or referred to roles and responsibilities for the key biodiversity offset requirements that consider all aspects of sustainable development presented in the offset model. Six of these documents also included roles and responsibilities for the cost and risk mitigations presented in the offset model. A further three documents were analysed that only

made references to these cost and risk mitigations; resulting in the analysis of 47 documents overall.

Most of the documents analysed were published after 2011, with an apparent overall upward trend, despite variability, following this year (Figure 6.1).

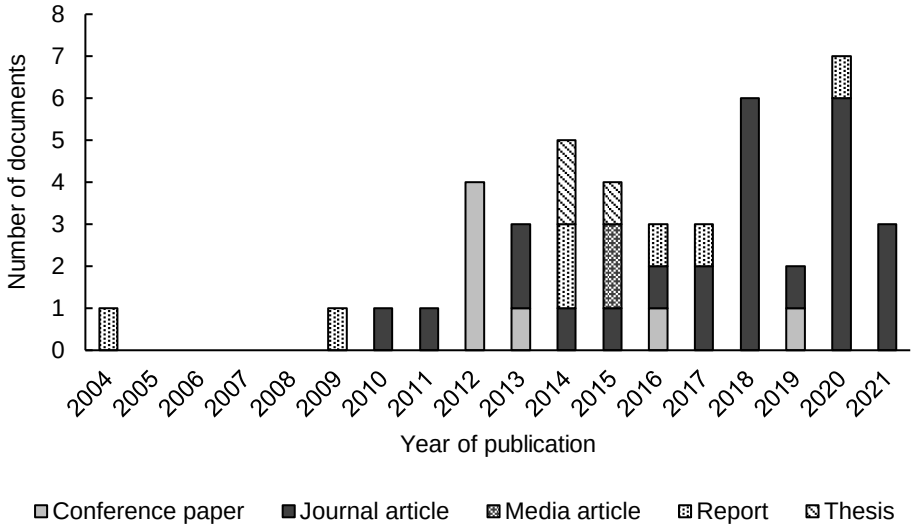

Figure 6.1: Year of publication of documents retrieved, screened and analysed (n=44) for roles and responsibilities that represent the key biodiversity offset requirements that consider all aspects of sustainable development (Chapter 5; Abdo et al., 2019b).

More than half of the documents analysed had a global focus (26), although some documents were analysed that focussed on regional areas (Europe (2), United Kingdom (1) or specific countries from across the globe (Figure 6.2).

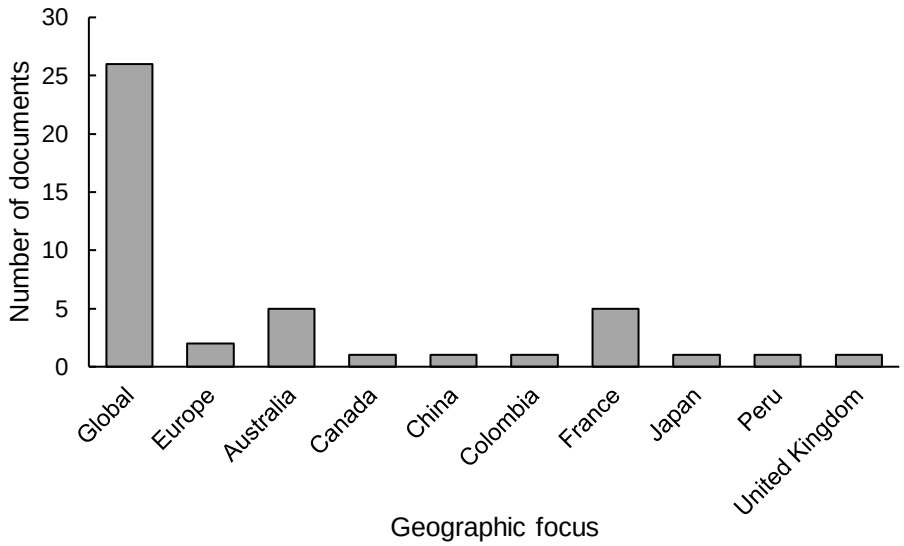

Figure 6.2: Area of geographic focus of documents retrieved, screened and analysed (n=44) for roles and responsibilities that represent the key biodiversity offset requirements that consider all aspects of sustainable development presented in Chapter 5 (Abdo et al., 2019b).

Most of documents were in formally peer reviewed documents (journal articles (25), conference papers (7), theses (3)), although some other documents such as reports (7) and media articles (2) were also analysed. There was no evidence for the assignment of roles and responsibilities in the legislative instruments for the USA, EU Germany and Australian Commonwealth, states and territories that aligned with the offset model.

Most of the documents focussed on the environmental aspect of sustainable development (32). There were two studies that had a mixed focus on social and environmental. There were fewer studies that focussed on social (7) or economic (3) aspects.

Documents analysed were focussed on specifically on the design phase of offsets; far more documents analysed focussed on offset design (18), policy (16) and development of models for offsets (6) than those that focussed on offset implementation (4).

In relation to the offsets model, references to ‘Indicators for natural values’ (35), ‘stakeholder consultation and monitoring’ (15), ‘consideration at a landscape-scale’ (13), and ‘biodiversity offset markets’ (11) were the most dominant (Table 6.2). There

were fewer than 6 references referring to roles and responsibilities for all other key biodiversity offset requirements that consider all aspects of sustainable development.

Table 6.2: Comparison of publicly available published information (n = 44) on roles and responsibilities for the key biodiversity offset requirements that consider all aspects of sustainable development presented in the offset model (Chapter 5; Abdo et al., 2019b).

Component	Best practice recommendations	Developers	Regulators	Stakeholders
Scope	Biodiversity offset markets providing habitat restoration conservation activities	Simpson et al., 2017	Ferreira, 2014; Kleining, 2017; Levin & Olsson, 2015 Simpson et al., 2017 Teklehaimanot, 2014 Yu et al., 2018 zu Ermgassen et al., 2020	Calvet et al., 2019 Levin & Olsson, 2015 Simpson et al., 2017
	Trading up that ensures equivalency of natural values	—	Maron et al., 2016a; Moilanen & Kotiaho, 2018 zu Ermgassen et al., 2020	—
	Indicators for key natural values based on robust science and incorporating stakeholder input	Bezombes et al., 2018 Benabou, 2014 Connick & Michael, 2012 Buchman, 2012; ten Kate et al., 2004 van Merwyk & Daddo, 2009 Palliggiano et al., 2012 Poulton & Bell, 2017 Rodgers & Burton, 2016	Bekessy et al., 2010 Bigard et al., 2020 Bull et al., 2015 Maron et al., 2016a; Koh et al., 2014 Moilanen & Kotiaho, 2018 Evans, 2016 Ferreira, 2014 Hahn & Richards, 2013 Sonter et al., 2020 Takacs, 2018 ten Kate et al., 2004 Simmonds et al., 2022	Basconi et al., 2020 Bigard et al., 2020 Bezombes et al., 2018 Evans, 2016 Guillet & Semal, 2018 Kamijo, 2020 McEnvoy, 2013 ten Kate et al., 2004 Griffiths et al., 2019 Hahn & Richards, 2013 Poulton & Bell, 2017
Scale	Consideration at a landscape-scale	Berges et al., 2020 Bigard et al., 2020 Palliggiano et al., 2012	Bigard et al., 2020 Berges et al., 2020; Gardner et al., 2013; Koh et al., 2014; Middle, 2019 Pilla, 2014 Quétier & Lavorel, 2011 Yu et al., 2018	Bigard et al., 2020

Table 6.2 (continued): Comparison of publicly available published information (n = 44) on roles and responsibilities for the key biodiversity offset requirements that consider all aspects of sustainable development presented in the offset model (Chapter 4; Abdo et al., 2019b)

Component	Best practice recommendations	Developers	Regulators	Stakeholders
	Size that reflects application of multipliers used to mitigate risk	—	—	—
Location	Biodiversity offsets should be placed strategically where benefits are maximised, but impacts to environmental, social and economic concerns are minimised	—	Koh et al., 2014 Takacs, 2018	—
Timing	Time lags should be minimised as far as possible	Benabou, 2014	Bull et al., 2015 Gardner et al., 2013 Quétier & Lavorel, 2011 Takacs, 2018	—
Duration	Biodiversity offsets should provide benefits that persist as long as the impacts from development	Roussel, 2017	Damiens et al., 2021 Ferreira, 2014	—
Monitoring	Stakeholder consultation and persist with monitoring until the biodiversity offset reaches its intended goals	Buchman, 2012 Connick & Michael, 2012 Maron & Louis, 2018 Palliggiano et al., 2012 Poulton & Bell, 2017	Bekessy et al., 2010 Koh et al., 2014	Basconi et al., 2020 Buchman, 2012 Connick & Michael, 2012 Koh et al., 2014 Guillet & Semal, 2018 Palliggiano et al., 2012 Poulton & Bell, 2017 ten Kate et al., 2004
	Include appropriate milestones and completion criteria for all natural values and should inform adaptive management	ten Kate et al., 2004	—	Basconi et al., 2020 Calvet et al., 2019 McEnvoy, 2013

In total, there were nine documents that referred to the roles and responsibilities for the cost and risk mitigations identified for offset model (Table 6.3). Most of the documents analysed referred to or made inferences about roles and responsibilities for regulators, although some referred to developers (2) or stakeholders (1). Except for the inclusion of bonds, there was at least one document found that referred to, or made inferences about, roles and responsibilities for all cost and risk mitigations.

Table 6.3: Comparison of publicly available published information (n=9) on roles and responsibilities for the cost and risk for the offset model (Chapter 5; Abdo et al., 2019b).

Mitigation	Developers	Regulators	Stakeholders
Transparent milestones and completion criteria	—	Bull et al., 2016 Evans, 2016 Pope et al., 2021	—
Inclusion of bonds	—	—	—
Strategic planning frameworks	Bigard et al., 2020	Pilla, 2014 ten Kate et al., 2004 Tarabon et al., 2021 Koh et al., 2014	Bigard et al., 2020
Advanced offsets	Benabou, 2014	—	—

6.4 Discussion

The overall increasing trend over time in documentation that included roles and responsibilities for biodiversity offsets reflects the importance and increasing focus on this area of offsets. However, there was a paucity of documented information on roles and responsibilities for biodiversity offsets, with only 36% of search results explicitly referring to or making inferences about biodiversity offsets roles and responsibilities. Importantly, none of the legislative instruments analysed (legislation, regulation, policies, guidelines) defined or explicitly referred to roles and responsibilities for biodiversity offsets. This lack of transparency can lead to ineffectiveness, inequalities and poor compliance (Abdo et al., 2021; Bidaud et al., 2018; Bull et al., 2018; Theis et

al., 2020). Most of the documents analysed had a global focus indicating that the assignment of roles and responsibilities for offsets are required at a global level.

There was a disproportionate focus on the environment (73%) among the documents analysed, with far less consideration of social or economic aspects of offsets. This is consistent with other studies that have found poor consideration of social and economic aspects in relation to biodiversity offsets (Scholte et al., 2016; Takacs, 2018). Lack of adequate consideration of social aspects (i.e. cultural, spiritual and inherent values of nature and ecosystems) of offsets can lead to loss of ecosystem services and the displacement of people (Ali et al., 2018; Benabou, 2014; Bidaud et al., 2018; Lim et al., 2017; Narain & Maron, 2018), causing loss of cultural connection and knowledge, and negatively impacting human wellbeing. Lack of economic consideration can result in offset-related costs that are unachievable or that are higher than punitive fines for non-delivery of offsets, creating disincentive for developers to deliver adequate compensation through offsets (Fallding, 2014; Habib et al., 2013; Lindenmayer et al., 2017; Rohr et al., 2018). Clear definition of roles and responsibilities related to these aspects can ensure that these aspects are adequately considered, leading to offsets that are more effective in their contribution to sustainable development.

6.4.1 Assignment of roles and responsibilities

Most of the references relating to roles and responsibilities for components of the offset model were associated with the design phase of offsets. This indicates that roles and responsibilities for the implementation and completion phases of offsets are likely poorly considered resulting in confusion, inefficiency and poor execution and perhaps even omission of components related to these phases. While it may be assumed that many of the roles and responsibilities related to these components may belong to one party or another, better transparency will reduce confusion and improve efficiency, ultimately resulting in improvements in the protection and conservation of natural values (Bull et al., 2013a).

6.4.1.1 Regulators

Regulators are typically responsible for the protection and conservation of the environment and sustainable development as a signatory to relevant international agreements. As such, they are therefore also responsible for more transparent, effective and better defined offsetting policies that are more consistent and enshrined within legislation (Abdo et al., 2019a; Abdo et al., 2021; Bekessy et al., 2010; Bull et al., 2016; Clare & Krogman, 2013; Evans, 2016; Ferreira, 2014; Hahn & Richards, 2013; Kamijo, 2020; Koh et al., 2014; Maron et al., 2018; Maron et al., 2016b; Middle, 2019; UN Environment, 2018). Therefore, the greatest number of roles and responsibilities related to the recommendations of the offset model were assigned to regulators.

Regulators have the overarching responsibility to create the rules for biodiversity offsets (Podhorsky, 2020; zu Ermgassen et al., 2020) through legislative instruments, including roles and responsibilities for offset design, implementation and completion (Ferreira, 2014; Rodgers & Burton, 2016; Yu et al., 2019). However, there was no evidence for the assignment of roles and responsibilities for offsets within the legislative instruments analysed, despite the broad geographic and jurisdictional level — regional (EU), country-based (USA, Germany, Australian Commonwealth Government) or sub-country (Australian states and territories) — of legislative instruments analysed. Regulators should ensure transparency of these rules and incorporate appropriate accounting to ensure biodiversity offsets are effective in providing adequate compensation for their impacts (Evans, 2016; Forster et al., 2019; Gardner et al., 2013; Maron & Louis, 2018).

While regulators might hold these responsibilities, some roles associated with these responsibilities do not have to be undertaken by regulators and may be delegated to other parties. Developers and stakeholders, as users of ecosystems and the values attributed to them, have moral and ethical obligations to the environment that should also be recognised. This could create time and cost efficiencies for regulators,

particularly in countries where effective environmental regulation is restrained by available resources.

If regulators undertook some of these roles themselves, it could ensure better transparency and consistency in the approach to offsets. For example, if regulators provided strategic landscape-scale planning frameworks for each bioregion, improvements could be made in the governance of biodiversity offsets, uptake by developers, involvement of stakeholders, and environmental and social outcomes (Fallding, 2014; Gordon, 2015; Lim et al., 2017; Maron et al., 2016b; O'Brien, 2020; Pittock et al., 2012; Walker et al., 2009). This would facilitate other parties, such as stakeholders, to take on a greater role in the design, implementation and completion of offsets. Furthermore, there may be reductions in ethical and social concerns and the level of negotiation required surrounding developments and offsets (Clare & Krogman, 2013; Guillet & Semal, 2018; Lukey et al., 2017; Maron et al., 2016b; Walker et al., 2009), and risks around the misuse of biodiversity offsets (Fallding, 2014). Planning in this way would also identify knowledge gaps of key variables that could be filled in part by indirect offsets where appropriate.

6.4.1.2 Developers

Developers were found to be assigned roles and responsibilities for most components (7 of 10); and notably, for more components related to the implementation stage of offsets. Developers should be involved in the design of offsets and the development of appropriate indicators for monitoring and assessment of offset effectiveness (Bezombes et al., 2018; ten Kate et al., 2004). Developers have the responsibility to implement offsets in line with best practice and regulators requirements (Abdo et al., 2019a; Abdo et al., 2021), and to consult and collaborate with stakeholders to ensure transparency and mitigate social impacts (Buchman, 2012; Connick & Michael, 2012; Koh et al., 2014; Maron & Louis, 2018). Collaboration with stakeholders can also ensure additionality and that offsets do not displace other conservation activities

planned or already in place through other parties (Guillet & Semal, 2018; Maron & Louis, 2018).

While regulators have the overall role to ensure that compensation is appropriate and adequate prior to approving a biodiversity offset (Abdo et al., 2021; Forster et al., 2019; Griffiths et al., 2019; Kuras et al., 2020), developers have the responsibility to ensure that offsets are adequately resourced throughout the life of the offset and until completion criteria have been satisfied (Damiens et al., 2021; Le Coënt et al., 2016; McEnvoy, 2013). The use of bonds is a best practice mechanism that regulators can require and/or developers can use voluntarily to ensure that offset actions are adequately resourced throughout implementation and completion regardless of economic fluctuations (Abdo et al., 2019b). However, none of the documents analysed identified the roles and responsibilities for the use of bonds for offsets.

6.4.1.3 Stakeholders

Stakeholders incorporate a broad group that may be involved in offsets as third-party service providers, affected communities or subject matter experts. Despite this, stakeholders had the smallest number of documents related to roles and responsibilities for offsets. Stakeholders have a responsibility to collaborate and participate in offsets as the environmental and social costs of development and the implementation of biodiversity offsets are borne by the public (Basconi et al., 2020; Buchman, 2012; Connick & Michael, 2012; Forster et al., 2019; Koh et al., 2014; Le Coënt et al., 2016; McEnvoy, 2013). This includes oversight of offset projects to ensure that they deliver adequate environmental compensation and participate in appeal processes if offsets are found to be inappropriate or insufficient. However, consideration of who has the responsibility to facilitate and resource the involvement of stakeholders requires further investigation. Appropriate stakeholder input into the design phase of offsets is of particular importance (Abdo et al., 2019b; Evans, 2015; Guillet & Semal, 2018; McEnvoy, 2013; Noga, 2014) to ensure the incorporation of contemporary scientific, technical and cultural knowledge.

6.4.1.4 Collaboration between parties

Only 15 documents (10%) assigned the same roles and responsibilities to several parties; this was mostly observed between stakeholders and either developers or regulators. Collaborative approaches to offsets can lower costs and improve effectiveness and efficiency. For example, Lodhia et al. (2018) reported that the success of ecological conservation goals was dependent on the linking of ecological, technical and business resources. However, care needs to be taken to ensure that all parties are willing participants in collaboration and that each party is aware of how information and services supplied might be used by other parties (Damiens et al., 2021; Maron & Louis, 2018). There was no evidence from the document analysis that developers and regulators work together. However, collaboration between developers and regulators would be beneficial in ensuring that offsets are feasible and that there is consideration of the economic attributes of sustainable development.

It is the responsibility of all parties to ensure that offsets are fair and equitable (Maron & Louis 2018). As such, transparency in collaborative approaches to offsets are paramount. While collaborative approaches have many benefits, offset roles should not overlap, and collaborations should not be undertaken in inappropriate ways. For example, regulators and other government entities should not be service providers that implement offsets as this could provide an impetus for corruption. Further, stakeholders such as offset brokers should not be assessors, as this would provide opportunity to unfairly participate in offset markets (AONSW, 2022). Use of an independent board comprised of multiple relevant stakeholders (e.g. regulators, industry bodies of developers, Non-Government Organisations (NGOs), community members, scientific experts), could assist in the delivery of collaborative approaches, ensuring appropriate consultation, co-design and implementation, and transparency, improving objectivity and effectiveness (Clare & Kogman, 2013; Koh et al., 2014; Pittock et al., 2012).

6.4.2 Recommendations

Recommendations for the responsibilities related to biodiversity offset design and implementation have been developed to improve offset success and the ability to contribute to the aspirations of sustainable development. These recommendations have been developed from the gaps identified in this research in consideration of the offsets model:

- Regulators should be responsible for ensuring roles and responsibilities of each party involved in offset implementation are clearly defined, to minimise risk and enable time (therefore cost) efficiencies;
- Regulators should be responsible for ensuring all key biodiversity offset requirements are achieved for all aspects of sustainable development (as demonstrated by the offset model)
- Regulators should be responsible for monitoring the completion of offsets by the responsible party;
- Regulators should be responsible for ensuring that offset requirements minimise cost and risk;
- Developers should be responsible for implementing biodiversity offsets for that contribute to all aspects of sustainable development;
- Developers should be responsible for ensuring offsets are efficient and reduce risk through the use of transparent milestones and completion criteria, which could include the use of strategic planning frameworks for offset design and implementation, and use of bonds and advanced offsets to further reduce risk; and
- Stakeholders should be responsible for participating in relevant key biodiversity offset requirements, such as such as identification of indicators, appropriate offset milestones and completion criteria, input into offset location, timing, and duration, and oversight of offset implementation , which aligns aspects of sustainable development (as demonstrated by the offset model).

While the above recommendations assigned the responsibility to regulators to ensure key biodiversity offset recommendations and implement best practice recommendations, the application of this recommendation assumes that regulators are a singular entity. In countries with multiple overlapping jurisdictions or overly complex regulatory systems, further definition of roles and responsibilities of regulators is required.

For some areas, such as the EU, or for countries with complex legal systems, such as Australia, different entities have the ability to require offsets even for the same development (Abdo et al., 2019a). This can cause a high level of difficulty and complexity in terms of the associated governance and cross-jurisdictional issues (Fallding, 2014; Guillet & Semal, 2018; Pittock et al., 2012). In Australia, the Commonwealth government is working to mitigate this issue through the development of a statutory national standard for biodiversity offsets (DCCEEW, 2022a). While this is a positive approach and would ensure consistency in the use of biodiversity offsets between various levels of government in Australia, it is recommended that this be extended to include strategic landscape-scale planning frameworks that identify locations suitable for development and offsets (Abdo et al., 2019b) and account for the effects of cumulative impacts and climate change. This would remove the apportioning of resources due to arbitrary governmental borders and provide greater transparency related to offsets, improving efficiency, certainty of costs and outcomes and significantly reducing administrative burden (Abdo et al., 2019b). This approach could also work in other areas, for example, the EU could provide a European standard on offsets and undertake strategic landscape scale-planning for bioregions across the continent.

Under the aforementioned approach, regulators with responsibility on a finer scale, such as the Australian states and territories or the European countries, would have full responsibility for monitoring, compliance and enforcement of biodiversity offset requirements. This approach would provide the benefit of greater transparency, equity

and streamlined approvals, while allowing entities with the greatest knowledge of their environments, having a finer scale approach, to monitor and enforce. A more defined approach such as this is of particular importance to ensure the adequate conservation of highly connected systems such as rivers and ground water systems. This approach will improve efficiency, reduce confusion and economic burden, enabling better focussed and resourced conservation management (Guillet & Semal, 2018) that can better contribute to sustainable development.

6.5 Conclusion

To avoid adverse environmental, social and economic consequences now and into the future it is important that development is undertaken in a sustainable way. Biodiversity offsets can be used to achieve this. However, clear definitions of the roles and responsibilities of different parties in relation to offsets is required to ensure that they are designed and implemented to meaningfully contribute to sustainable development.

Collaboration of developers, regulators and stakeholders on biodiversity offsets is essential to ensure that the environmental, social and economic aspects of sustainable development are adequately considered. Collaborative approaches to the design and implementation of offsets are recommended, with each party having clearly defined roles and responsibilities. This would prevent negative outcomes from the cross-purposes of each party reducing offset outcomes that are then unable to provide adequate compensation for development. Assigning roles and responsibilities within legislative instruments for each party related to offsets and, where required, each level of government, can improve the efficiency and cost-effectiveness of offsets and facilitate positive environmental, social and economic outcomes.

Chapter 7

Aligning biodiversity offsets with sustainable development in areas of competing land use

Chapter 7 provides real world application of a holistic offsets model, drawing on the learnings from Chapters 2–6, to develop an offset plan aligned for the Western Australian Jarrah Forest. This model demonstrates how a fund aligned with best practice, can be used to support sustainable development in areas of competing land use.

The results of this chapter, along with the other findings of this thesis, contribute to the discussion provided in Chapter 8, where the contribution of offsets to sustainable development is considered and future recommendations to ensure the longevity of offsets as an effective tool in sustainable development are provided.

7.1 Introduction

Biodiversity offsets can be achieved directly through financial contribution, protection of land (averted loss), or conservation actions (restoration, rehabilitation, changes to management), or indirectly through contributions to improve knowledge of environmental matters whereby a paucity of information exists (Chapter 4; Fallding, 2014; Maron et al., 2012). However, offsets can be difficult to achieve in areas where available land is scarce and, therefore, protection and conservation offsets become technically infeasible (Sonter et al., 2020). Where development cannot be avoided in such areas and is required for social and/or economic reasons, alternative options that are aligned with the principles of sustainable development are needed. Financial contributions into an appropriate trust, such as a conservation trust fund, are one way to achieve offsets in these areas (Pope et al., 2021).

Conservation trust funds are legal entities that manage financing for long-term conservation projects (Bath et al., 2020; Doinjashvili et al., 2021; Bladon et al., 2014). The Conservation Finance Alliance defined funds as “mechanisms and strategies that generate, manage, and deploy financial resources and align incentives to achieve nature conservation outcomes.” (Meyers et al., 2020). The earliest conservation trust funds were established approximately 30 years ago as mostly independent (from government) funding sources to fill gaps in conservation for specific protected areas or protected area systems (Bath, 2020). However, over the past 10 years, the use of conservation trust funds has diverged, with more being initiated by governments or coming under government control, and many expanding scope, encompassing marine and coastal systems, economic livelihoods and climate change mitigation (Bath, 2020).

Conservation trust funds operate by gaining financial contributions from various sources and using these contributions to fund conservation activities (Bath et al., 2020). While conservation trust funds may gain contributions from several sources, financial contributions from biodiversity offsets into conservation trust funds is increasing (Bath et al., 2020) and, in some cases, conservation trust funds are being developed specifically for biodiversity offsets (e.g. Pilbara Environmental Offset Fund). As of 2020, there were 108 conservation trust funds globally representing more than 65 countries with several additional global funds identified (Bath et al., 2020). Of these,

10% had incorporated financial contributions from biodiversity offsets to finance conservation projects (Bath et al., 2020).

Conservation trust funds have been used to support the provision of offsets since at least the last decade, however, despite their benefits in funding conservation and improving biodiversity, their use has been controversial (Bath et al., 2020; Bladon, 2014; Evans et al., 2021; Tarabon, et al., 2021). A recent audit of the New South Wales Biodiversity Offset Scheme in Australia raised key concerns about integrity, transparency and sustainability and found a lack of effectiveness to supply offset credits (AONSW, 2022). The Deputy Premier of New South Wales also criticised the Biodiversity Offset Scheme for hindering industrial investment in the state (Thompson, 2021). Maron et al. (2016) also highlighted the risk of funds being absorbed into government revenue, mismanaged, or used inappropriately for projects that do not provide adequate compensation. Regardless, the use of conservation trust funds is set to continue due to their importance in contributing to international conservation goals by narrowing the funding gap for protected areas and biological corridors and providing social benefits (Bath et al., 2020). This study aims to develop a fund aligned for the Western Australian Jarrah Forest, using a comparison of available funds, to demonstrate how a fund, if aligned with best practice, can be used to support sustainable development in areas of competing land use.

In Australia, the Jarrah Forest bioregion of Western Australia (IBRA 7; henceforth ‘Jarrah Forest’) exemplifies an area that increasingly requires biodiversity offsets, but where land is scarce and is set to become scarcer. The Jarrah Forest (Thackway & Cresswell, 1995) is of regional, national and global significance. It sits within the Southwest global biodiversity hotspot of Australia, and is one of 36 biodiversity hotspots globally that together comprise less than 3% of the earth’s surface but collectively contain more than 40% of the earth’s biodiversity (Habel et al., 2019). The Southwest biodiversity hotspot has more than 7,200 vascular plant species, of which almost 80% are endemic (Lambers & Bradshaw, 2016). The Jarrah Forest, specifically, has nine nationally and 15 regionally important wetlands of significance (McKenzie et al., 2003). It also has high endemism with approximately 750 different species from 95 different families, supporting 52 flora and 22 fauna listed threatened species (McKenzie et al., 2003; Standish et al., 2015). Currently 5% of the region falls within state and national reserves (Wardell-Johnson, 2016). Despite its environmental

and social significance, the condition of the Jarrah Forest is in decline retaining less than 30% of its original extent of natural vegetation (Gardner & Stoneman, 2003; Myers et al., 2000; Ruprecht, 2018). Pressure from natural phenomena including fire, *Phytophthora* dieback, reduced rainfall and a warming climate has had further negative impacts (McCaw et al., 2011; Standish et al., 2015; Wardell-Johnson, 2016). The structure of the Jarrah Forest has also shifted in structure from mature trees to be dominated by smaller saplings and woodland trees (McCaw et al., 2011; Standish et al., 2015; Wardell-Johnson, 2016).

The socio-economic value of the Jarrah Forest primarily relates to its natural products; its urban areas are strongly associated with the mining, forestry and agricultural industries. There are also several active, large scale resource extraction projects within the Jarrah Forest bioregion, targeting precious metals (gold, copper), bauxite, and coal (CME, 2021). Forestry is and has historically been a significant land use within the Jarrah Forest, with very few areas of the forest that have not been impacted by some degree of logging (Wardell-Johnson, 2016). Both mining and forestry are currently permitted throughout the region, including in state and national forest areas (DBCA, 2018). However, the Government of Western Australia has committed to ending logging of native forests by 2024 (CPC, 2022). Dry-land agriculture and grazing is also important in the bioregion (DPIRD, 2016). Due to the increasing need for land for biodiversity offsets, coupled with diversity of competing land uses and increasing scarcity of available land, the Jarrah Forest is an example of a region that would benefit from a model that considers these pressures and ensures that biodiversity offsets contribute to sustainable development in the region.

This study investigates the alignment of existing funds with best practice, using the Abdo et al. (2019b) biodiversity offset model (hereafter ‘offset model’), and uses learnings from this review to develop a best practice fund for the Jarrah Forest region of Western Australia that has applicability both elsewhere in Australia and globally. The aim of this research is to demonstrate how conservation trust funds for biodiversity offsets can be used to support sustainable development, particularly in areas of competing land use.

7.2 Methods

Internet searches were conducted in September 2022. Google and Google Scholar search engines were used to identify Conservation Trust Funds that had been specifically developed for biodiversity offsets (henceforth ‘offset funds’) used within Australia. The University of Notre Dame Australia’s library search engine ‘FiNDit’, which accesses all of the University’s library subscriptions including academic databases such as Scopus and Web of Science, was utilised, as well as Google and Google Scholar to provide a broader search and to access publicly available information and government department data. Searches were conducted using the terms “environmental offset fund” and “biodiversity offset fund”. In addition, sites for Australian government departments with responsibility for biodiversity offsets were searched for mention of funds. This focus on Australian funds was made as Australia's complexity regarding environmental requirements (Chapter 2; Abdo et al., 2019a) means that the best type of offset fund for the Jarrah Forest would be based on an Australian context. Therefore, the use of offset funds in other countries was not investigated.

Information on these offset funds was reviewed to determine if they could be implemented in a way that aligns with sustainable development. The offset model includes 10 key biodiversity offset requirements and four cost and risk mitigations that consider all aspects of sustainable development and was therefore used as a framework to assess each offset fund. The offset model was deemed suitable for this analysis as it was the only model for offsets found that has specifically been developed in consideration of sustainable development based on a Google Scholar search (English results only; conducted in September 2022) using the following search terms:

- “environmental offset” “sustainable development” (152 results)
- “biodiversity offset” “sustainable development” (532 results)
- “biodiversity offset model” (10 results)
- “environmental offset model” (0 results)
- “biodiversity offset framework” (14 results)

Note that results for carbon offsets were excluded from this analysis.

7.3 Results

There were seven offset funds within Australia that were identified by the internet search:

1. Biodiversity Conservation Trust (New South Wales)
2. Environmental Offsets Fund (Queensland)
3. Native Vegetation Fund (South Australia)
4. Environmental Rehabilitation and Recovery Fund (Western Australia)
5. Pilbara Environmental Offsets Fund (Western Australia)
6. Great Victoria Desert Biodiversity Trust (Western Australia)
7. Gunduwa Regional Conservation Association (Western Australia)

All funds reviewed demonstrated biodiversity offset markets, being based on financial contributions from developers that are used to acquit their biodiversity offset requirements. However, alignment with other elements of the offsets model was mixed (Table 7.1). Further detail about each fund is described below.

Table 7.1: Biodiversity offset funds with aspects that exemplify the offsets model. X indicates demonstration of offset model component.

Offset model component (Abdo et al., 2019)		Offset funds						
		Biodiversity Conservation Trust	Environmental Offsets Fund	Environmental Rehabilitation and Recovery Fund	Native Vegetation Fund	Pilbara Environmental Offsets Fund	Great Victoria Desert Biodiversity Trust	Gunduwa Regional Conservation Association
Scope	Biodiversity offset markets providing habitat restoration conservation activities	X	X	X	X	X	X	X
	Trading up that ensures equivalency of natural values				X	X	X	X
	Indicators for key natural values based on robust science and incorporating stakeholder input				X	X		
Scale	Consideration at a landscape-scale	X		X	X	X	X	
	Size that reflects application of multipliers used to mitigate risk	X						
Location	Biodiversity offsets should be placed strategically where benefits are maximised, but impacts to environmental, social and economic concerns are minimised	X		X		X	X	
Timing	Time lags should be minimised as far as possible	X	X					
Duration	Biodiversity offsets should provide benefits that persist as long as the impacts from development	X	X	X	X			X

Table 7.1 (continued): Biodiversity offset funds with aspects that exemplify the offsets model. X indicates demonstration of offset model component.

Offset model component (Abdo et al., 2019)		**Offset funds**						
		Biodiversity Conservation Trust	Environmental Offsets Fund	Environmental Rehabilitation and Recovery Fund	Native Vegetation Fund	Pilbara Environmental Offsets Fund	Great Victoria Desert Biodiversity Trust	Gunduwa Regional Conservation Association
Monitoring	Stakeholder consultation and persist with monitoring until the biodiversity offset reaches its intended goals		X		X		X	
	Include appropriate milestones and completion criteria for all natural values and should inform adaptive management	X						

7.3.1 Biodiversity Conservation Trust (New South Wales)

The New South Wales Government administers the Biodiversity Conservation Trust (BCT) that, among contributions from other sources, also enables developers to make payments in lieu of offset requirements under the NSW Biodiversity Offset Scheme (BCT, 2022a). The BCT has four specific roles: securing land through voluntary Biodiversity Stewardship Agreements with landholders, managing payments, securing offsets for developers, and securing offsets for governments (BCT, 2022b). Under the Biodiversity Offsets Program, the BCT enables landholders to generate biodiversity offset credits for land that they will protect in perpetuity and manage (BCT, 2021). These hectares of land are turned into 'credits' that the landholder receives an annual payment for management actions when retired (through purchase by a developer) or sold (BCT, 2022b; BCT, 2022c). To be used as offsets, these credits must be 'like-for-like' in that they must have similar environmental values (ecosystems, species) to those that they are required to be offset under the NSW *Biodiversity Conservation Act 2016*. (BCT, 2022c; DPE, 2022). Sufficient funds are held in the trust to ensure long-term management of offsets (DPE, 2022). When an offset requirement has been fully acquitted through credits, it is included in the BCTs report on acquitted obligations (BCT, 2022c). In addition, the BCT undertakes strategic purchases of biodiversity offset credits for future use (BCT, 2021).

The BCTs most recent annual report (BCT, 2021) indicates potential alignment with the offsets model through minimisation of time lags and consideration at a landscape scale through the strategic use of credits. Location and duration are aligned with the offset model as landholders volunteer to take part (minimising negative socioeconomic outcomes of offset location) and agreements are in perpetuity, ensuring offsets persist at least as long as impacts of development (BCT, 2021; BCT, 2022c). Ongoing monitoring and assessment of conservation actions are required and the BCT undertakes site inspections to confirm results (BCT, 2022c). Although there is consultation with the landholder regarding monitoring and management, there is no

evidence that broader consultation with other stakeholders is included in the program. The BCT's Biodiversity Offsets Payment Calculator indicates that quantification of risk is considered through the application of a risk premium that 'is commensurate with the risk of acquitting an offset obligation' and indexation that 'accounts for the time between when a charge is issued and when a proponent chooses to make a payment into the Fund.' (BCT, 2022d). Similarly, information about key natural values and the potential of trading up is not included in publicly available information about the fund and therefore has not been recorded as demonstrating this component of the offset model.

7.3.2 Environmental Offsets Fund (Queensland)

The Queensland Government enables developers to make payments in lieu of undertaking conservation projects as offsets (QG, 2022a). The Queensland Government's Financial Settlement Offset Calculator is used by developers to calculate their payment before submitting a request to contribute to the fund first to the administering agency and then to the Offset Fund Management and Delivery unit (QG, 2022a). The Queensland Department of Environment and Science (DES), under oversight by the Offsets Project Management Committee (including members from science, finance, industry and landholders), then uses these funds to act as a de facto offsets broker, investigating like-for-like offset options, engaging providers, executing contracts and managing offset sites for up to 20 years (QG, 2022b).

Requirements for financial settlement offsets are stated in the current (version 1.12) Queensland Offsets Environmental Policy (DES, 2022). This policy aligns with the minimisation of time lags and duration if impacts from development occur (DES, 2022). Although not stated explicitly in the policy, the oversight of the Management Committee may also demonstrate alignment with the scope and monitoring components of the model requiring stakeholder input. While the policy does describe the use of multipliers, and that risk has been factored into the financial settlement calculation, this has a maximum of four, and therefore it is unlikely to represent a mitigation of risk in situations where higher multipliers are required to provide adequate compensation.

Additionally, there is no consideration of how the risk of time delays between payment and offset delivery might change actual costs of the delivery of offsets. Strategic consideration of offset scale and location are not discussed and therefore have not been recorded as demonstrating this component.

7.3.3 Native Vegetation Fund (South Australia)

The South Australian Department of Environment and Water (DEW) administers the Native Vegetation Fund, enabling developers unable to secure suitable offsets for the clearing of vegetation to make payments in lieu of offsets (DEW, 2022). The funds are dispersed by DEW through a grant process, whereby interested parties apply for grants to undertake “enhancement, conservation, and management of native vegetation” (DEW, 2022). It requires grant proposals to align with the principles outlined in the Policy for a Significant Environmental Benefit (DEW, 2022).

The Policy for a Significant Environmental Benefit aligns with trading up, landscape-scale, and duration recommendations of the offset model (DEWNR, 2020). In addition, the policy requires stakeholder participation and use of “best available scientific data and knowledge”, indicating alignment with “Indicators for key natural values based on robust science and incorporating stakeholder input” and “Stakeholder consultation and persist with monitoring until the biodiversity offset reaches its intended goals” of the offsets model (DEWNR, 2020). Risk to offset performance is considered in terms of rainfall, but not in terms of other risks such as time delays or the influence of other pressures on the offset area.

7.3.4 Government of Western Australia offset funds

Western Australia has two active offsets funds administered by the Western Australian Department of Water and Environmental Regulation (DWER): the Environmental Rehabilitation and Recovery Fund (ERRF) and the Pilbara Environmental Offsets Fund (PEOF).

7.3.4.1 Environmental Rehabilitation and Recovery Fund

There is no formal mention of a Western Australian-wide offset fund in relevant legislation, policies and guidelines. However, offsets generated funding has become available for conservation projects as part of the ERRF under the Government of Western Australian's Green Jobs Plan for environmental/conservation job creation (GWA, 2022a). Projects to be funded by the ERRF must be aligned with relevant offset principles and be proportionate, strategic and landscape scale, enduring and secure in the longer term (i.e. in perpetuity) and additional to activities that are already required under legislation (GWA, 2021). This aligns with scale, location and duration components of the offsets model. However, due to the lack of publicly available information on the ERRF, it is unknown if further it aligns with further components of the offsets model. A search (September 2022) of the Government of Western Australia's Offset Register[7] revealed 17 projects (n=275) (excluding those in the Pilbara) that had provided financial contributions in lieu of offsets.

7.3.4.2 Pilbara Environmental Offsets Fund

The Western Australian Government DWER also administers the PEOF, which is also overseen by an implementation advisory group and the project recommendation group (GWA, 2022b). The fund was designed to improve the implementation of biodiversity offsets across the region through a strategic landscape-scale approach that builds on existing programs (GWA, 2022b). The fund is perpetual, periodically aggregating payments to undertake broad-scale conservation projects across the region in collaboration with traditional owners, conservation agencies, industry and government (GWA, 2022b). Projects implemented under the fund must be aligned with their "key offset policy principles" of relevant and proportional, cost-effective, strategic and landscape-scale, tangible improvement, enduring and secure in the longer term,

---

[7] https://www.offsetsregister.wa.gov.au/public/searchregister/searchlist [8] https://www.offsetsregister.wa.gov.au/public/searchregister/searchlist

additional to existing legislative obligations (GWA, 2022b). Due to the scarcity of land in the Pilbara, many of the projects build on existing conservation programs that include land management activities (GWA, 2022b). For example, Aboriginal rangers accessed funding to undertake an invasive weed removal project at Tharra to improve ecosystem health (Scott, 2022).

The key policy principles and governance implemented by PEOF demonstrate alignment with scope, scale, location and duration components of the offsets model. A size that reflects application of multipliers used to mitigate risk, timing and monitoring are not mentioned. A search (September 2022) of the Government of Western Australia's Offset Register[8] revealed 32 projects (n=38) that had provided financial contributions in lieu of offsets in the Pilbara.

7.3.5 Great Victoria Desert Biodiversity Trust (Western Australia)

The Great Victoria Desert Biodiversity Trust (GVDBT) was established by AngloGold Ashanti in 2013 to deliver offsets for the AngloGold Ashanti – IGO Tropicana Gold Mine (More to Mining, 2022). Its overarching purpose is to "conserve and increase knowledge of biodiversity in the Great Victoria Desert" (GVDBT, 2022a). The GVDBT has four specific purposes: to establish a bioregional plan, facilitate/undertake priority research, fund on-the-ground conservation/environmental management, and facilitate indigenous involvement in conservation and land management activities (GVDBT, 2022b). To date the GVDBT has predominantly used its funds to undertake research projects (GVDBT, 2022a). However, it has also developed a bioregional plan in conjunction with stakeholders to enable all parties to identify priorities for the region (GVDBT, 2022a; CM, N.D.). The trust is overseen by a management panel composed of members from the Western Australia environmental regulator (DWER) and AngloGold Ashanti (GVDBT, 2022b). In addition, activities undertaken with funding from the GVDBT are informed by a technical advisory group of relevant experts

[8] https://www.offsetsregister.wa.gov.au/public/searchregister/searchlist

(GVDBT, 2022b). While there is a commitment that several payments will be made into the fund over its lifetime (MCA, 2020; Tropicana Joint Venture, 2022), this differs from the aforementioned government established funds in that there is not an ongoing supply of funding and therefore the trust will eventually exhaust its funding.

The purposes of the GVDBT demonstrate alignment with scope and monitoring components of the offsets model. The bioregional plan demonstrates landscape and location components of the offsets model through its identification of priority projects. In addition, the consultation of stakeholders for the bioregional plan and the governance of the GVDBT demonstrate components of the offsets model that require stakeholder involvement; 'Indicators for key natural values based on robust science and incorporating stakeholder input' and 'Stakeholder consultation and persist with monitoring until the biodiversity offset reaches its intended goals'.

7.3.6 Gunduwa Regional Conservation Association (Western Australia)

The Gunduwa Regional Conservation Association (GRCA) was established as an offset for the Mount Gibson Iron Ore Mine and Infrastructure Project (GRCA, 2017), but has since expanded to enable voluntary contributions from other parties. Funding for GRCA is provided annually by the developers of the mine, Mount Gibson Mining Limited and Extension Hill Pty Ltd. to protect biodiversity, improve certain environmental values and manage funds to achieve biodiversity outcomes (GRCA, 2017; Ministerial Statement 753 (https://www.epa.wa.gov.au/sites/default/files/Ministerial_Statement/000753_0.pdf)). The GRCA uses a landscape scale approach for its focus area, however this is smaller than the bioregion (GRCA, 2017). While it has a business plan for this area, this does not include the identification of regional priorities as would be expected in a strategic landscape scale plan. A management committee oversees GRCA, however, members may also voluntarily join (GRCA, 2017). The dispersal of funds from GRCA comes through a grant process, whereby organisations apply for funding for specific projects, GRCA reviews these and disperses funds as appropriate (GRCA, 2017). Mount

Gibson Mining Limited and Extension Hill Pty Ltd are required to fund the GRCA for the life of the Mount Gibson Iron Ore Mine and Infrastructure Project, estimated to be 20 years (Ministerial Statement 753).

The GRCA is aligned with scope and duration components of the offsets model. The GRCA and provision of funding through a grant process enable potential for trading up. The requirement for the fund to persist for the duration of the mine exemplifies the duration component of the offsets model. Although the fund is governed by a management committee, there is no indication that stakeholders have input into indicators or monitoring of projects financed by the fund.

7.4 Discussion

There were not any funds that exemplified all ten (10) components of the offsets model. The Biodiversity Conservation Trust and Native Vegetation Fund included the most components of the offset model (6), while the Gunduwa Regional Conservation Association (3) included the least. Differences in the components exemplified by funds are likely due to differences in the scale and purposes of the funds. Both the Biodiversity Conservation Trust and the Native Vegetation Fund are administered by government for native vegetation clearing (BCT, 2022a; DEW, 2022), whereas the Gunduwa Regional Conservation Association is administered by a developer for a specific development over a much smaller, defined area (GRCA, 2017). However, regardless of scale and purpose, further consideration of the elements of the offsets model could improve environmental and socioeconomic outcomes.

All funds used some form of quantification system to determine the quantum of financial contributions from developers. However some calculators have been deemed unsuitable (AONSW, 2022). Additionally, when the implementation of projects is delayed, changes to the cost of restoration (and project management/governance) can result in a shortfall of funding. To reduce this risk, it is recommended that bonds are

also required when developers elect to provide financial contributions in lieu of offsets (Abdo et al., 2019b). Specifically, it is recommended that two bonds be required: one bond, refundable on offset implementation, to account for changes in cost due to delays the implementation of an offset project; and a second bond, refundable on offset completion, that accounts for adaptive management measures and interventions that may be required should the offset fail to provide its environmental (and social) benefits.

Duration and scale (consideration at landscape scale) were the components of the offsets model that were exemplified by most of the funds. Most of the funds reviewed covered large areas, landscape scale or greater, and thus considered the distribution of financing at a landscape scale. Additionally, most funds were perpetual, with financing being consistently added and distributed, enabling projects to endure for extended periods.

Conversely, milestones and completion criteria were only exemplified by one fund (Biodiversity Conservation Trust, New South Wales). The lack of consideration of milestones and completion criteria is consistent with the findings of offset projects in general as discussed in Chapter 5 (Abdo et al., 2019b). Additionally, despite the Environmental Offsets Fund (Queensland) explicitly describing the use of multipliers, and the other funds incorporating some form of multiplier as part of the required financial contribution to the fund, the use of multipliers to specifically minimise risk was only exemplified by the Biodiversity Conservation Trust. Given that funds aggregate environmental compensatory requirements from multiple projects, environmental values provided as offsets can be simplified and/or the identification of appropriate multipliers to ensure adequate compensation can be confounded. To ensure adequate compensation is provided for all environmental values, it is recommended that the use of relevant expert knowledge and scientific studies is embedded in all offset projects undertaken under a fund.

7.4.1 Application to the Jarrah Forest

The Environmental Rehabilitation and Recovery Fund is available to the Jarrah Forest in Western Australia, however, information on this fund was lacking and therefore it was difficult to ascertain how well aligned this fund was with the offsets model. Additionally, this fund is administered by the Western Australian Government, which is not aligned with best practice for funds whereby autonomy is recommended (Bladon, 2014). Independent funds can provide continuity and stability despite government changes and may be more flexible, being able to respond to urgent needs in a more timely manner (Bath et al., 2020). In total, the Environmental Rehabilitation and Recovery Fund was found to align with only four components of the offset model. There was no evidence that this fund was aligned to 'Trading up that ensures equivalency of natural values' and 'Indicators for key natural values based on robust science and incorporating stakeholder input', and components of scope 'Size that reflects application of multipliers used to mitigate risk' components of scale, or timing and monitoring components. Therefore, learnings from the other funds reviewed have been used to improve the design of a fund that supports sustainable development for the Jarrah Forest.

The use of a management committee including relevant experts to oversee the fund, as demonstrated by Environmental Offsets Fund (Queensland), the Pilbara Environmental Offsets Fund (Western Australia), Great Victoria Desert Biodiversity Trust (Western Australia) and Gunduwa Regional Conservation Association (Western Australia), could be used to facilitate 'Indicators for key natural values based on robust science and incorporating stakeholder input' and 'Stakeholder consultation and persist with monitoring until the biodiversity offset reaches its intended goals'. While a management committee for the Jarrah Forest could be established within the Western Australian Government, it is recommended that a management committee for the Jarrah Forest be independent as aligned with best practice (Bladon, 2014; Bath et al., 2020). Several funds, including the Environmental Rehabilitation and Recovery Fund

(Western Australia), were administered by the government departments that regulate offsets, creating a potential conflict of interest, and enabling non-transparency and potential misuse of funds. Administration/oversight by an independent multi-stakeholder management committee is recommended to avoid potential misuse of funds (and/or public distrust in offsets through perceived misuse of funds). There are several existing organisations that could undertake management of a fund for the Jarrah Forest, these include government-funded independent institutes such as Western Australian Biodiversity Science Institute (WABSI), or regional/national non-government conservation organisations. To avoid criticism of the governance of funds such as that recently published for the New South Wales Biodiversity Offset Scheme, management of the fund in alignment with a best practice governance guideline such as the Conservation Finance Alliances 'Practice Standards for Conservation Trust Funds' (Bath et al., 2020; Spergel & Mikitin, 2014) is recommended.

The Biodiversity Conservation Trust Fund (New South Wales) was the only fund to exemplify 'Include appropriate milestones and completion criteria for all natural values and should inform adaptive management'. It achieved this through a requirement for on-going monitoring and assessment of conservation actions associated with the fund (BCT, 2022b). However a recent audit of this fund found that goals and performance metrics were not clearly linked to offset requirements and represented a risk for the provision of adequate compensation (AONSW, 2022). Oversight of on-going monitoring and assessment would require expert knowledge to ensure that this is relevant, effective and appropriate. It is therefore recommended that the independent management committee for the Jarrah Forest fund be composed of representatives with expert knowledge of the regional environment to facilitate this. Additionally the use of relevant expert knowledge and/or strategic landscape scale plans can enable 'Trading up that ensures equivalency of natural values' by identifying key priorities for the region (see Chapter 5; Abdo et al., 2019b), and direct finance to these key priorities instead of providing strict 'like-for-like' compensation or tradeable credits as exemplified by the BCT. Use of an independent management committee to decide on

relevant projects could also ensure that funding is not directed towards projects for which the government has an ongoing commitment to deliver, which could reduce overall environmental benefits for a region. For the Jarrah Forest, relevant representatives would include experts from each of the predominant industries (forestry, mining, agriculture), community, relevant regulatory bodies (i.e. Environmental Protection Authority; Department of Biodiversity, Conservation and Attraction; Department of Water and Environmental Regulation; Department of Primary Industries and Regional Development; Department of Climate Change, Energy, the Environment and Water) and representatives with expert knowledge of environmental matters (e.g. species, ecosystems) relevant to the Jarrah Forest.

While some funds mentioned a requirement for offsets to be proportional, other than for the Biodiversity Conservation Trust there was no clear use of multipliers to mitigate risk and therefore no other funds were deemed to demonstrate this component of the offsets model. There is a body of literature that discusses the need for appropriate multipliers (e.g. Bull & Brownlie, 2015; Bull et al., 2016; McKenney, 2005; Moilanen et al., 2009; Quétier & Lavorel, 2011), and there has been much contention around the adequacy of multipliers used, including those required by regulators (Bell, 2016; Bull et al., 2017b; Fallding, 2014; May et al., 2017). Ensuring the offset is sized sufficiently to mitigate risk under a fund could become confounded as offset funds often aggregate the compensatory requirements of several projects into larger strategic offsets (e.g. GWA, 2022b). It is recommended that relevant stakeholder input to strategic consideration of all environmental and socioeconomic values be included to mitigate against this risk. For the Jarrah Forest, while existing calculators provided by the Western Australian and Commonwealth governments would determine the offset quantum, these calculate the size of land required to undertake an offset and therefore are not as relevant to areas with a paucity of land available for offsets. The use of a fund, drawing on stakeholder knowledge to ensure that the full offset quantum can be acquitted through a combination of collaborative projects with existing land holders and

land acquisition (where required), would ensure that offsets for the region were sufficient to compensate for the impacts of development.

The minimisation of time lags was only exemplified by two funds, the Biodiversity Conservation Trust (New South Wales) and Environmental Offsets Fund (Queensland) that both stated this requirement but did not provide a process for this. Within the boundaries of a fund, offset time lags could potentially be greatly reduced, particularly if conservation projects were established ahead of need (i.e. as advanced offsets), with the fund operating as a savings bank as discussed by Bekessy et al. (2010). Additionally, if the fund is robust and perpetual, there would be potential for conservation projects to persist for long timeframes/in perpetuity as long-term funding could be repetitively assigned to these projects based on contributions from developers over time. The aggregation of offsets would ensure that conservation projects were more enduring, by enabling the fund to direct offsets towards the continuation of projects that require further longevity, providing better environmental and social outcomes. This is particularly pertinent for the Jarrah Forest given the slow growing habit of Jarrah trees (Koch & Ward, 2005) and the long time required to achieve certain attributes, such as nesting hollows for endangered black cockatoos (Whitford & Williams, 2002). The use of an independent fund to administer offsets not only has application in areas where land for offsets is scarce but could also provide strategic benefits and efficiencies in other landscapes, by improving transparency, addressing the needs of various parties and initiating/strengthening collaborations, and providing continuity and a long-term focus on conservation (Bath et al., 2020; Bladon et al., 2014; Meyers, 2020).

Table 7.2 summarises these findings regarding a best practice fund for the Jarrah Forest in the context of the offset model.

Table 7.2: A best practice fund for the Jarrah Forest in the context of the offset model.

Offset model component (Abdo et al., 2019)		**Best practice offset fund**
Scope	Biodiversity offset markets providing habitat restoration conservation activities	The fund should not represent a market with credits, but should instead be a fund governed by an independent expert committee that finances key priority projects on a landscape-scale basis
	Trading up that ensures equivalency of natural values	Independent management committee comprised of relevant experts using stakeholder input to ensure that strategic key priorities for the region are identified and that funding is directed to deliver benefits for these key priorities.
	Indicators for key natural values based on robust science and incorporating stakeholder input	Independent management committee comprised of relevant experts using stakeholder input to ensure that appropriate indicators that represent strategic key priorities for the region are identified and incorporated into monitoring, evaluation and completion criteria.
Scale	Consideration at a landscape-scale	Independent management committee comprised of relevant experts using stakeholder input to ensure that strategic key priorities for the region are identified and that funding is directed to deliver benefits for these key priorities.
	Size that reflects application of multipliers used to mitigate risk	Independent management committee comprised of relevant experts using stakeholder input to ensure financial payments into the fund are sufficient to reduce the risk of inadequate compensation for the impacts of development.
Location	Biodiversity offsets should be placed strategically where benefits are maximised, but impacts to environmental, social and economic concerns are minimised	Offset funds should be initiated for a region at the landscape level and capture funding from developments within this region to ensure that offset funding is directed to strategic key priorities within the same region.
Timing	Time lags should be minimised as far as possible	Independent management committee should ensure the use the offset fund as a savings bank with key priority projects provided in advance of offset requirements where possible. Independent management committee to hold bonds from developers to account for changes in cost due to delays the implementation of an offset project.
Duration	Biodiversity offsets should provide benefits that persist as long as the impacts from development	Independent management committee should ensure that the fund is perpetual, repetitively providing funding into projects that are long-term to deliver long-term outcomes for key priorities.

Table 7.2 (continued): A best practice fund for the Jarrah Forest in the context of the offset model.

Offset model component (Abdo et al., 2019)		**Best practice offset fund**
Monitoring	Stakeholder consultation and persist with monitoring until the biodiversity offset reaches its intended goals	Independent management committee comprised of relevant experts using stakeholder input to ensure that ongoing monitoring and assessment is relevant, effective and appropriate. Independent management committee to hold bonds from developers that account for adaptive management measures and interventions that may be required should the offset fail to provide its environmental (and social) benefits.
	Include appropriate milestones and completion criteria for all natural values and should inform adaptive management	Independent management committee to use expert knowledge and stakeholder input to ensure that milestones and completion criteria are relevant for strategic key priorities for the region.

7.4.2 Global application

While this study exemplifies the application of biodiversity offsets in an Australian context, the solutions presented here are of potential benefit to other regions globally. Land availability in many other areas is also critical. For example, Allan et al. (2022) reported that Canada, Costa Rica, Suriname and Ecuador need to conserve more than 80% of their land area to safeguard biodiversity.

The European Union (EU) has a similar paucity of land available for offsets and, with offsets required by several member countries/provinces and the proposal for the EUs Nature Restoration Law adopted by the Commission in June 2022 (EU, 2022), a similar set of competing environmental requirements. Europe is densely populated and, with more than 60% of land under private ownership, land available for protection and/or conservation is scarce (Hermoso et al., 2019). There are 27 countries (Member States) that are bound to uphold the EUs environmental policy and overarching approach to sustainable development (Alberton, 2012). However, there are differences in how each Member State approaches protection of the environment and at which level, state, regional or provincial (Alberton, 2012). A strategic European-wide approach to offsets through use of an offset fund(s) would be beneficial in ensuring environmental

protection throughout this continent. This would be of particular benefit to cross-boundary migratory species, such as the Saiga, preventing the need for dynamic solutions that could be difficult to implement in practice (Bull et al., 2013b). Use of an independent fund to administer offsets could not only enable a more pragmatic approach to land scarcity but could also improve flexibility in the centralised system. In the 1980s the EU utilised a centralised system for the reduction of pollution; however, this system was implemented individually by businesses and was ultimately abandoned for being inflexible and costly (Alberton, 2012). It is therefore recommended that an independent fund be used to administer a centralised approach to biodiversity offsets to enable the implementation of offsets to be efficient and cost effective. Appointment of an expert committee to identify solutions would enable flexibility in the identification of solutions and cost effectiveness using targeted environmental solutions rather than a broad 'one-fits-all' approach.

The use of funds to better enable strategic biodiversity offsets would also be beneficial in South Africa. South Africa is the third most biodiverse country in the world with three global biodiversity hotspots: the Cape Floristic Region, the Succulent Karoo (shared with Namibia) and the Maputaland-Pondoland-Albany hotspot (shared with Mozambique and Swaziland) (Midgley, 2015; RDLR, 2017). Offsets in South Africa are required as conditions of environmental approval (Midgley, 2015). South Africa has recently released the National Biodiversity Offsets Guideline that requires developers to secure offset sites in the long-term (DFFE, 2021). A large proportion (73%) of South Africa is privately owned, meaning that most offsets will be required to be undertaken on private land (RDLR, 2017). While the legislative structure in South Africa is more simplistic than the case presented for the Jarrah Forest in Western Australia, application of offsets through a strategic independent fund could enable flexible arrangements that reduce negative socio-economic impacts of offsets, such as setting aside land for conservation purposes. Through the advantages gained by providing additional funding and governance, a fund could also support further uptake of private protected areas and ensure better management. Further, it could ensure that

conservation decisions are strategic and focussed on sustainable development, incorporating concerns of all social groups. This would be of benefit to a country with a complicated social history such as South Africa.

7.5 Conclusion

Land is becoming increasingly scarce and is likely to continue to decrease in availability, even in areas where it is currently abundant, due to increasing development to support increases in human population and the associated needs for additional services. To ensure that development can continue in a way that is not entirely detrimental to the environment, the use of financial contributions within the framework of conservation trust funds, or ‘offset funds’, to support offsets is expected to continue. However, without consideration of best practice elements of offsets, in consideration of sustainable development, loss of natural values will likely still occur. This research has demonstrated that funds can be designed to deliver a best practice biodiversity offset model that contributes to sustainable development in areas where a paucity of land exists.

Chapter 8

Discussion and conclusion

“Our biggest challenge in this new century is to take an idea that seems abstract – sustainable development – and turn it into a reality for all of the world’s people.”

Kofi Annan

This research shows that biodiversity offsets can be efficient, effective and positive environmental, social and economic contributions. Biodiversity loss is a global crisis, for which biodiversity offsets provides a solution (Ma, 2022). Biodiversity offsets are environmental compensatory schemes designed to provide beneficial environmental values to compensate for residual loss to biodiversity, during all stages of development. While biodiversity offsets are often used to demonstrate sustainable development, they have often been found to be lacking in their ability to balance environmental, social and economic aspects (Chapter 5; Abdo et al., 2019b; Bull et al., 2014; Coggan et al., 2013b; Fallding, 2014; zu Ermgassen et al., 2019), perpetuating a pretence of sustainability whilst enabling the destruction of environmental and socioeconomic values. Despite the limitations in the current use of biodiversity offsets, this research has shown that aligning biodiversity offsets with the principles of sustainable development can compensate for biodiversity loss and provide social and economic benefits. Figure 8.1 depicts how research outcomes improve the design, implementation and completion of offsets to enhance the environmental, social and economic outcomes of sustainable development.

8.1 Research outcomes

Despite Australia being recognised as having embraced the use of biodiversity offsets for sustainable development (Madsen et al., 2011; Midgley, 2015; Miller et al., 2015), this research reports that the use of offsets is flawed. Inconsistencies in biodiversity offsets requirements among Australian jurisdictions are leading to gaps in environmental protection and loss of biodiversity (Chapter 2). Additionally, this research established that offsets were inequitable and ineffective in terms of transparency, measurability and enforceability leading to loss of natural values (biodiversity and ecosystem function and services) and cost inefficiencies (Chapter 3). Even though the Australian Commonwealth government has the overarching responsibility for the environment, Commonwealth legislation and policies were found to have gaps in environmental protection and to not consider social and economic impacts related to offsets. Therefore Australia is not meeting their international environmental obligations under the Convention on Biological Diversity and the 2030 Agenda for Sustainable Development.

Implementation of the Commonwealths' environmental offset policy in 2012 has done little to address these limitations and, despite a Senate review (The Senate, 2014), a 10-yearly review (Samuel, 2020), and an audit (ANAO, 2020) of Commonwealth environmental legislation, there have been no further improvements to the consideration of biodiversity offsets (Chapter 4).

Identifying environmental, social and economic impacts of offsets and the use of offsets within strategic landscape-scale frameworks demonstrated that offsets have the potential to make a real contribution to sustainable development (Chapter 5). Strategic planning frameworks can optimise the efficiency of offsets, identify strategic opportunities for trading up, support offset markets and peer to peer trading, and reduce costs and risk. Assignment of roles and responsibilities for offsets will improve transparency of offset design and implementation, and the ability of offsets to contribute to the goals of sustainable development (Chapter 6). In particular, the involvement of stakeholders in offset design, implementation and completion is crucial to ensure incorporation of scientific, technical and cultural knowledge and ensure consideration of environmental and socioeconomic values. The use of an independent offset fund, informed by relevant experts and in combination with the strategic planning frameworks, can enable sustainable development even in areas where there where there is a high requirement for biodiversity offsets but a paucity of available land for offset activities, such as Western Australia's Southwest global biodiversity hotspot (Chapter 7).

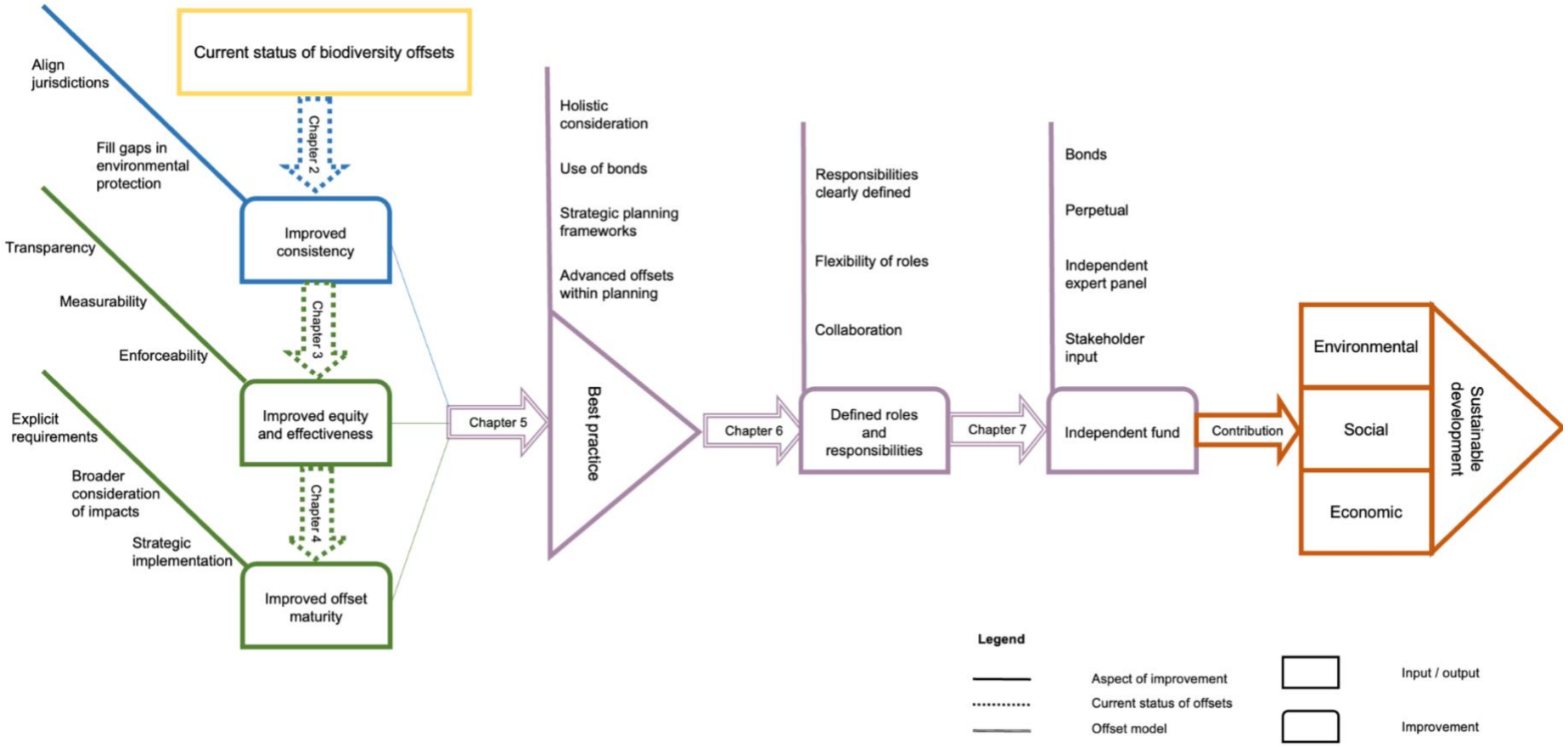

Figure 8.1: Depiction of research recommendations for the design, implementation and completion of offsets to enhance the environmental, social and economic outcomes of sustainable development.

More than a decade ago, McKenney and Kiesecker (2010) suggested that biodiversity offset policy in Australia should take a quantitative approach and incorporate additionality, probability of success and time to conservation maturity. However, a review of the literature has found that this has not occurred despite implementation of offset policies. If biodiversity offsets are to be transparent, equitable and effective in their capacity to achieve sustainable development, then Australian legislation and policy must explicitly include requirements for biodiversity offsets that are aligned with the principles of sustainable development as recommended in this research. Entrenching these offset requirements in legislation can avoid:

- uncertainties / risk of failure (Grimm, & Köppel, 2019);
- poor governance and implementation of biodiversity offsets (Fallding, 2014; Gordon, 2015; Josefsson et al., 2021; Pittock et al., 2012; Walker et al., 2009);
- poor uptake by developers (Lim et al., 2017);
- poor environmental and/or social outcomes (Gibbons et al., 2018; Josefsson et al., 2021; Lim et al., 2017; Maron et al., 2016b; Pittock et al., 2012; Tupala et al., 2022);
- increased ethical and social concerns (Maron et al., 2016b; Pope et al., 2021; Tupala et al., 2022);
- increased negotiation around offset requirements leading to inequities between developers and communities and the loss of biodiversity/ecosystem services (Clare & Krogman, 2013; Guillet & Semal, 2018; Walker et al., 2009); and
- community distrust of the offset process leading to loss of social license to operate (Lukey et al., 2017; Tupala et al., 2022).

While biodiversity offsets may be an imperfect solution, when designed in consideration of the principles of sustainable development, they have an opportunity

to prevent the negative environmental and social impacts of development, and, if used strategically, may even reverse biodiversity loss and create socioeconomic benefits.

8.2 Implications of research

The results of this research provide the first model and worked examples of biodiversity offset design, implementation and completion stages aligned with the environmental, social and economic aspects of sustainable development. While other best practice models of offsets have been published, none of these models incorporate the principles of sustainable development for all stages of biodiversity offsets. For example, Pope et al. (2021) developed a framework for habitat protection and restoration to improve biodiversity offset outcomes. However, this framework focusses on the design stage of offsets with some minor consideration of implementation but does not include consideration of offset completion or social and economic aspects. Similarly, Grimm and Koppel (2019) developed a framework for offset design and implementation that also focussed on environmental aspects of offsets. Simpson et al. (2022) developed an ecological-economic model for offsets that incorporated landholder choice based on economic decisions but did not more holistically consider social considerations such as cultural, spiritual and recreation values nor other economic considerations related to the broader community. Simmonds et al. (2020) developed a framework for biodiversity offsets to better contribute to biodiversity targets that, while strategic, does not consider social and economic impacts nor explore ethical considerations of this approach.

Analysis of the current status of offsets in Australia (Chapters 2, 3 and 4) identifies gaps in the use of offsets to contribute to sustainable development, recommending that offsets be entrenched in legislation and aligned with the principles of sustainable development. The outcomes and recommendations of this research can be utilised for the improvement of offset requirements by not only Australian regulators, but other

countries considering the use of offsets. While many of the conclusions and outcomes have been directed towards regulators, use by developers in a voluntary sense would not only improve biodiversity offset outcomes more broadly, but could also directly benefit developers through the better assurance of offset outcomes, reduced cost implication of offsets and improved reputation. Similarly, the outcomes of this research could be used more broadly by stakeholders through consultation mechanisms and lobbying. This would ensure improved biodiversity offsets outcomes for communities, even in the absence of commitments by developers or formal regulatory requirements.

Models to improve the use of offsets to achieve sustainable development were developed in Chapters 5, 6 and 7. These models identify key biodiversity offset requirements, cost and risk mitigations, roles and responsibilities and the use of offsets in areas of low land availability to contribute to sustainable development. Again these have applicability to not only Australian regulators, developers and communities, but also to other countries using or considering the use of offsets in environmental regulation.

8.2.1 Implications of research in the Australian context

This research highlighted gaps in the use of offsets in Australia to achieve effective environmental compensation and to contribute to sustainable development. Subsequent findings of reviews and audits conducted on Commonwealth and New South Wales environmental legislation (ANAO, 2020; Samuel, 2020, AONSW, 2022) similarly found inadequate environmental compensation through the use of offsets and confirm the outcomes of this research. The Commonwealth is currently updating their legislation following the review and audit. Recommendations arising from this research identify best practice offset solutions that contribute to sustainable development and therefore have particular relevance to Australian jurisdictions, such as the Commonwealth, when amending their environmental legislation.

As identified in Chapter 6, although regulators have a primary responsibility to ensure many aspects of offsets, developers and stakeholders also have roles within the development, implementation and completion of offsets. Therefore the recommendations of this research also have relevance to these parties to ensure that offsets can meaningfully contribute to sustainable development.

Chapter 7 identifies how funds can be used to deliver offsets in areas with a low availability of land. Despite Australia's large size, land availability for offsets in Australia is decreasing and is likely to continue to do so. Australia's economy is over reliant on extractive industries that require access to large areas of land (Harvard Growth Lab, 2020). As these industries continue to increase in size, so too will their requirement for offsets. The recommendations from Chapter 7 have particular relevance to ensure that offsets can continue to be delivered in a way that meaningfully contributes to sustainable development.

Australia is ecologically significant with high levels of endemism, but conversely a high rate of biodiversity loss (Bradshaw, 2012; Cresswell and Murphy, 2016; Woinarski et al., 2015). However, there is a relatively large area of Australia that could be restored to reverse this loss. For example, Renwick et al. (2014) reported that approximately 12% (92 million hectares) of Australia's land mass has potential for biodiverse regenerative planting. Biodiversity offsets, while intended to provide compensation for the impacts of development, are also recognised as one way to fund and incentivise this restoration (Burgin, 2008; Fallding, 2014; Guillet & Semal, 2018; Kiesecker et al., 2009; Takacs, 2018). This research has shown that aligning the design, implementation and completion of offsets to the principles of sustainable development can result in environmental, social and economic gains.

While this research uses an Australian context to discuss the ability of biodiversity offsets to achieve sustainable development, it has application at a global scale. Australia has a complex legal system with three levels of government that can require offsets independently. Therefore, it serves as a good case for the design and

implementation of offsets even in landscapes with similar complexity and/or overlapping legal requirements.

8.2.2 Implications of research in the global context

Globally, 196 countries have ratified the Convention on Biological Diversity (CBD) agreeing to promote sustainable development (CBD, 2022b). Further, the Sustainable Development Agenda, including the Sustainable Development Goals, was unanimously agreed to by all 193 members of the United Nations in 2015 (SDG, 2015). Biodiversity offsets are often used to achieve sustainable development and, despite their omission from the CBD, contribute to several of the Sustainable Development Goals, particularly life on land, life below water, and sustainable cities and communities, but also climate action, good health and wellbeing, affordable and clean energy, industry innovation and infrastructure, and responsible consumption and production (UN, 2019). There are 100 countries that have or are developing biodiversity offsets and other compensation policies (GIBOP, 2019), with many more expected to follow suit. While standards for offsets exist internationally (e.g. IFC, 2022; ten Kate et al., 2004), there is no formal global agreement, such as through an international convention, for the development, implementation and completion of offsets. Requirements for offsets that include the strategic consideration of environmental, social and economic aspects will be required to ensure that environmental conservation is achieved without additional negative outcomes.

While the use of offsets globally may not be as extensive as use in Australia, biodiversity offsets use around the world has been increasing and is likely to intensify. For example, in response to the Dasgupta Review (Dasgupta, 2021), the United Kingdom, which has not required biodiversity offsets to date, now requires all new large-scale infrastructure projects to employ a nature positive approach for natural values – where the condition and/or extent of air, water, soils, plants, animals and/or minerals is improved (HM Treasury, 2021). Biodiversity offsets are likely to be a key tool used to achieve this goal. Biodiversity offsets are increasingly likely to be used to

meet similar ‘nature positive’ requirements in other regions globally, particularly considering the deepening biodiversity and climate crises. While this is an essential step for nature, it does not necessarily take into consideration the social and economic impacts of development and, therefore, will not necessarily contribute to sustainable development. Implementation of the offset model (Chapter 5) and the potential creation of an independent governing body and fund for offsets (Chapter 7), would ensure that biodiversity offsets could provide real contributions to sustainable development and meet the aspirations of both the CBD and Sustainable Development Agenda.

Developers and financiers have a unique opportunity to drive sustainable development to ensure long-term positive outcomes for their companies, shareholders, community and the environment, particularly when undertaking offsets that exceed when minimum compensatory requirements (e.g. net gain offsets). Requirements on developers for environmental disclosures, such as the globally endorsed framework available through the Taskforce on Nature-related Financial Disclosures (TNFD, 2023), are likely to become more important. This, coupled with the increasing awareness of the community regarding biodiversity loss, can negatively impact company share prices and/or sales (WEF & PWC, 2020). Provision of appropriately designed biodiversity offsets can conversely favour a developer in terms of community acceptance and trust, regulator confidence and facilitation of future government approvals.

Global financiers also have obligations to ensure biodiversity offsets contribute to sustainable development. Many global financiers already have environmental and social requirements, such as the Equator Principles and the International Finance Corporations Performance Standard 6, for developers requiring finance (EPA, 2022; IFC, 2022). While these requirements involve the use biodiversity offsets as compensation for unavoidable impacts, there is still a lack of adequate consideration of all environmental, social and economic aspects for offsets. Better alignment with best practice and holistic consideration of offsets incorporating all aspects of sustainable development (as presented in Chapter 5) would enable banks to be more

ethical and improve public trust and, therefore, customer base and share price. This is of particular relevance as the markets for products with minimal environmental and social impacts (i.e. 'ethical') continues to increase (First Insight Inc., 2022).

8.2.3 Link between biodiversity offsets and conservation projects

Conservation projects have some synergies with biodiversity offsets as they both undertake similar activities, for example, revegetation, rehabilitation and environmental management. However, biodiversity offset projects are not directly comparable to conservation projects as they have greater complexity due to their requirement to provide compensation for the environmental impacts of development. Additionally, biodiversity offsets have a greater requirement than conservation projects for monitoring and evaluation to meet required outcomes and guard against failure which can result in net loss of biodiversity. While conservation projects are generally more simplistic in their aims (i.e. to create environmental benefit; are not associated with development), the conclusions and outcomes of this research could also be applied to conservation projects. Alignment with the offsets model and cost and risk mitigations (Chapter 5), transparency in the assignment of roles and responsibilities (Chapter 6) and the use of conservation trust funds with independent multistakeholder governance (Chapter 7) would enable conservation projects to be more rigorous, efficient and effective in their delivery and contribution to sustainable development.

Involving stakeholders in the design and implementation of conservation projects, as suggested for offsets in Chapter 5, would improve project design and reduce the risk of failure through the incorporation of local knowledge. In addition, in-kind support offered by communities and other interested stakeholders could reduce costs associated with conservation projects and potentially increase the longevity of conservation actions if stakeholders can be motivated to continue conservation works following completion of required offset programs (e.g. handover of successfully rehabilitated resilient landscapes to community groups to maintain and use for recreational and cultural purposes). This approach can also mitigate negative socio-

economic implications associated with the location of conservation projects, as discussed for offsets in Chapter 5.

Choice of location for many conservation projects can be hindered by land availability (Sonter et al., 2020), as discussed in Chapter 7. More formal consideration of the location for conservation projects within a strategic landscape scale planning framework would enable environmental benefits to be targeted to highest priority areas. In addition, social and economic implications associated with the changing use of an area for conservation could be better mitigated through strategic site identification. Strategic planning could also facilitate collaboration between different conservation organisations, enabling larger and/or more connected projects to be completed, maximising environmental, social and economic benefits.

Metrics used to monitor and evaluate biodiversity offset outcomes could similarly be applied to conservation projects to determine the degree of positive environmental (and social) impact. The recommendation to assess ecological performance along with social and governance performance (Chapter 5) would enable the assessment of conservation projects in the context of sustainable development. This would be of particular benefit to governments with requirements to report on the delivery of sustainable development outcomes (e.g. Sustainable Development Goals) under international agreements. Further, the ability to assess the contribution of conservation projects to sustainable development may attract further voluntary funding by private organisations seeking to improve their sustainability credentials. Approaching conservation projects with the more rigorous consideration applied to biodiversity offsets would enable further rigour in project delivery, improving environmental and socio-economic outcomes.

8.2.4 Cost implications

This research makes several recommendations for the improvement of biodiversity offsets to better meet the intentions of sustainable development. However, the financial implications of implementing these measures have not been further investigated.

Broadening consideration of additional environmental, social and economic outcomes and increasing stakeholder involvement and engagement as suggested in Chapters 5 and 6, is likely to increase costs to developers and regulators. Similarly, the impact of costs related to the development of strategic landscape-scale planning frameworks and advanced offsets (Chapter 5) is unresolved. While improving offset effectiveness through a specific legislation (Chapter 3), strategic landscape-scale planning frameworks (Chapter 5), identification of specific roles and responsibilities for offsets (Chapter 6), and the use of funds, bonds and independent boards (Chapter 7) are likely to improve efficiency and thus reduce costs, the overall cost impact to developers and regulators relating to incorporation of these aspects, is unknown.

Research into the cost implications of these recommendations would enable the business case for the implementation of best practice offsets to be developed. While models such as environmental accounts already seek to balance environmental and economic costs (ESSC, 2019; UN, 2014), specific models to incorporate social elements and assign appropriate roles and responsibilities would assist in the enabling the business case to encourage the uptake of the recommendations developed through this research.

8.3 Limitations and opportunities for further research

8.3.1 Data availability

This research largely utilised reviews of publicly available documentation (legislation, policy, journal articles, reports) to assess biodiversity offsets in the Australian context and make recommendations for how offsets can be used to contribute to sustainable development more broadly. However, as found by others (e.g. Bull et al., 2018; Grimm, & Köppel, 2019; Josefsson et al., 2021), there were few documents that assessed biodiversity offset outcomes. It is likely that this information does exist, particularly within developers' archives; however, due to commercial concerns or the lack of

related requirements, this literature is not necessarily openly available for public scrutiny.

The literature review in Chapter 4 was unable to source a broad range of information surrounding the outcomes (post-implementation) of offset requirements. In particular, there was a lack of information on whether offsets met the criteria they were conditioned to provide or achieved compensation for the impacts of development.

Chapter 6 was unable to identify a large body of information about appropriate roles and responsibilities for biodiversity offsets. This included a lack of description of roles and responsibilities for various aspects of offsets in legislation, policies and associated guidelines. This may be due to an absence of reporting on the implementation of biodiversity offsets. However, as Chapter 4 identified that many of the requirements related to biodiversity offsets are contained within plans and strategies, it is perhaps more likely that this information is contained within grey literature that is not publicly available. The approach used by this research is likely to have overestimated the ability of offsets to align with best practice as it is likely that developers would more readily make available positive stories regarding biodiversity offsets, and as such, these examples would be publicly available and could be included in this research. Conversely, less accessible grey literature or grey literature that is not publicly available may provide additional insights into offsets that do not meet intended outcomes. Examples of ineffective offsets have the capacity to contribute to development of offsets for sustainable development by enabling identification of areas where the offset system is flawed or where improvements can be made. This highlights the clear need for transparency in terms of biodiversity offsets to ensure progression of offsets as a tool for sustainable development. Requiring offset outcomes to be reported and made publicly available through legislation could remedy this issue. Further research incorporating grey literature would be of benefit to test and improve the outcomes of this research. Research into how to best encourage and/or require developers to make data related to offset outcomes publicly available would also be of

benefit. Further, development of a publicly available register of offset outcomes would assist in the identification of gaps in conservation for strategic landscape scale planning frameworks. Although several jurisdictions already make offset requirements publicly available, inclusion of outcomes from offset actions to meet these requirements is recommended.

8.3.2 Data collection

Data collected for Chapters 2 and 3 were restricted to legislation, policy and published guidelines for different Australian jurisdictions. Data was collected from publicly available sources to reflect the transparency of documentation readily available to both developers and communities affected by biodiversity offsets. This approach necessarily narrowed the scope of analysis and opportunity to benefit from direct engagement with relevant experts and personnel involved in the regulation/enforcement of offset requirements. Had the scope been wider, it may have been possible to verify interpretation of offsets policies and procedures and expand the data available for analysis. For example, additional information may have been made available from regulator discussions with developers about offset plans prior to a formal requirement for offsets being established. Issues related to transparency regarding offset requirements is discussed in Chapters 3, 4 and 5.

8.3.3 Data analysis

As discussed in Section 8.3.2, the limitation on data collected may have constrained the analyses able to be conducted. While it is unlikely that the conclusions would have changed, further analysis of the trade-offs of the different sustainable development considerations (Chapter 2) and indicators discussed (Chapter 3) may identify further gaps in the consideration of offsets within the context of sustainable development.

Data for all chapters was collected and analysed by one person to ensure consistency of results over time. However, involving multiple people in the ranking/weighting of results may have improved the accuracy of results. Undertaking a test of this approach

may be beneficial when undertaking further research that involves ranking and/or weighting of qualitative information gained through documents review.

8.3.4 Offset outcomes

Chapters 5, 6 and 7 provide policy and process recommendations for the best practice design, implementation and completion of biodiversity offsets. However, it is recognised that, even with the most effective policies and processes in place, biodiversity offsets may still perform poorly. Identification of appropriate metrics for the monitoring and evaluation of offsets was outside the scope of this research but is important to the evaluation of offset success and completion. Additionally, the identification of appropriate indicators and milestones is also a variable that will influence offset performance. While metrics, indicators and milestones are likely to be project and site specific, future research into how this could be standardised on a regional basis would be beneficial and could be included within strategic landscape-scale planning frameworks.

Further, implementation of biodiversity offset policies and processes can cause well-designed offset requirements to become ineffective or inequitable. However, ensuring transparency related to offset design, implementation and completion as suggested by Chapters 2, 3 and 4, ensuring clarity of roles and responsibilities that provide oversight as recommended by Chapter 6, and use of independent management committees as described in Chapter 7, can mitigate some of this risk.

8.4 Recommendations

8.4.1 Biodiversity offsets legislative instruments

An overarching outcome of this research is that dedicated legislative instruments for biodiversity offsets that incorporate the principles of sustainable development are

required. It is therefore recommended that dedicated legislation instruments be created for biodiversity offsets that:

- consider compensation for all natural values as well as social and economic impacts of development (Chapter 5);
- consider the environmental, social and economic impacts of offset implementation and completion (Chapter 5);
- divulge the responsibility for the approval of offsets to an independent board comprised of relevant stakeholders (Chapter 6);
- include the key biodiversity offset requirements described in the offset model (Chapter 5);
- facilitate the use of the cost and risk mitigations (Chapter 5);
- dictate roles and responsibilities for all design, implementation and completion components of offsets (Chapter 6); and
- facilitate biodiversity market mechanisms including peer to peer trading (Chapter 5) and the use of funds in conjunction with strategic planning frameworks (Chapter 7).

There were 191 countries that recently agreed to the Kunming-Montreal Global Biodiversity Framework which provides a framework to reverse the loss of biodiversity, including through the sustainable use and management of biodiversity (CBD, 2022a). Aligning biodiversity offsets with the principles of sustainable development can assist in the ratification of this agreement and achievement of this goal.

8.4.2 Strategic use of offsets

The use of biodiversity offsets in Australia, a country that has been internationally recognised for its use of offsets, was found to be low, as discussed in Chapter 4. While this may be a result of other mechanisms used to prevent net environmental damage from development, given that the loss of biodiversity has continued both in Australia and elsewhere, it can be assumed that more needs to be done to protect the environment.

If offsets can be improved to adequately compensate for environmental damage (or to provide additional environmental benefits) then it may be inferred that their use should be more frequently required. However, given that the implementation of biodiversity offsets comes with expectation that damage has occurred elsewhere, then their use should remain as a last resort after the application of the Mitigation Hierarchy. Further, offsets should only be utilised where areas that should not be developed/offset due to environmental, social or economic significance have been identified through strategic planning , as discussed in Chapter 5.

8.4.2.1 Landscape scale planning frameworks

Strategic landscape scale planning frameworks can ensure the environmental, social and economic benefits of biodiversity offsets are optimised (Chapter 5). This is of particular importance where the concept of ‘trading up’ (or the use of offsets towards inequivalent strategic outcomes) is permitted. Where trading up is enabled without strategic consideration or appropriate metrics, natural values may be compromised, and net loss may occur. However, as discussed in Chapter 7, where trading up occurs in conjunction with landscape scale plans and relevant expert knowledge, it can maximise environmental and social benefits and reduce costs. However, few frameworks are in place and those that exist rarely take a sustainable development approach, considering environmental, economic and social factors in balance. For example, the Strategic Assessment of Western Australia's Perth and Peel Regions attempted to develop a strategic framework but was ultimately unsuccessful due to the complexity of the task, with costs, risks and benefits coming into question (DAWE, 2021). As landscape scale planning frameworks are key to ensuring offsets (and other conservation projects) are strategic and meaningfully contribute to sustainable development, further research into how these can be undertaken in an efficient and cost-effective manner is essential. This would enable the broader use of offsets, ultimately improving environmental management and sustainable development.

8.4.2.2 Nature-positive solutions

The use of offsets to deliver outcomes that exceed adequate compensation (net gain) can be interpreted as an unfair economic burden on developers, particularly where this is unevenly applied, as discussed in Chapter 3. Similarly, where offsets are required to deliver outcomes that are within the remit of governments, this can be unethical (Chapter 3) and reduce conservation and environmental benefit overall. However, the strategic use of offsets as described in Chapters 5 and 7 may enable overall net contributions to sustainable development to be delivered. Ensuring the transparency and equity of offsets through a strategic landscape-scale planning framework, as discussed in Chapters 3 and 5, can ensure that net gain requirements are evenly and equitably applied. Similarly, the use of an independent management committee, as discussed in Chapter 7, to direct offsets towards ongoing regional priorities, can ensure overall benefits to sustainable development are maximised. Further, the use of an independent management committee, in combination with strategic landscape-scale planning frameworks, can ensure that outcomes complement those undertaken by government rather than replacing these efforts.

The benefits associated with the use of a conservation trust fund in areas where competition for land is high and available land for protection or conservation offsets is scarce was highlighted in Chapter 7. While several funds globally have been specifically developed for offsets, none of these funds have been designed specifically in consideration of sustainable development. This is likely because there is a paucity of research linking biodiversity offsets to sustainable development, despite offsets being recognised as a mechanism to achieve sustainable development (Díaz et al., 2019; Fallding, 2014; Miller et al., 2015). While Chapter 7 recommended that the involvement of stakeholders could mitigate risks that offsets would not provide adequate compensation or contribute to sustainable development, a requirement for stakeholders to be involved in the design and implementation of funds for offsets would ensure transparency and repeatability. Future research into how transparency and

repeatability could be best achieved would improve the use of funds and provide better assurance about their ability to deliver best practice offset solutions, thus improving broader offset use.

8.4.3 Biodiversity offsets and climate change

Biodiversity loss and climate change are two major global challenges that are interlinked (Habibullah et al., 2021). The loss of natural habitats can release carbon, contributing to climate change and, similarly, climate change variables (e.g. temperature, precipitation, natural disasters) contribute to the loss of biodiversity and natural habitats (Habibullah et al., 2021). Given the significant relationship between climate change and biodiversity loss, it is recommended that further research be directed into how to ensure offsets can be maintained under altered climate regimes and withstand the impacts of climate changes, such as more intense bushfires or storms, more frequent floods or longer period of droughts. In addition, research is recommended into both the cost and risk implications of climate change on biodiversity offsets as well as how use of biodiversity offsets within a sustainable development framework can contribute to the mitigation of climate change.

Implementation of best practice biodiversity offsets that support sustainable development not only has the potential to align with the CBD, Kumming-Montreal Global Biodiversity Framework and Sustainable Development Goals, but may also have climate related benefits. Biodiversity offsets could concurrently reverse environmental damage in areas that have suffered degradation and contribute to climate change mitigation. This can occur by increasing carbon sequestration through planting trees that improve degraded ecological communities.

The demand for carbon markets is increasing. The Taskforce on Scaling Voluntary Carbon Markets predicts that carbon markets will be worth $50 billion by 2030 (Blaufelder et al., 2021) and $200 billion by 2050 as predicted by German Bank Berenberg (Watson, 2020). However, while carbon markets often require

sequestration of carbon through the planting of trees, or seagrass and mangroves in the case of blue carbon, carbon sequestration plantings are not required to consider native habitats and biodiversity (DISR, 2022). Carbon offsets that are not designed to consider biodiversity, while cost-effective and with the capacity to generate more credits, do not mitigate the overall loss of biodiversity (Andres et al., 2022). The use of biodiversity offsets combined with carbon offsets could be a solution to this conundrum. Although there are some existing programs that consider biodiversity in combination with carbon capture (e.g. REDD+ (UNCC, 2023) Carbon + Biodiversity Pilot (DCCEEW, 2023)), these programs do not consider how biodiversity offsets could also contribute to improved carbon capture. Allowance of 'stacking' biodiversity credits on carbon credit scheme could create a greater environmental incentive to organisations seeking biodiversity offsets, carbon offsets or a combination of both. Further, biodiversity offsets are often required in perpetuity and therefore can provide longer-lasting benefits compared to carbon credit schemes that are typically for a fixed period, such as in Australia where they are required for 25–100 years (CER, N.D.). However, care would need to ensure that biodiversity and carbon benefits could only be credited where these were additional to any passive benefit that would otherwise occur from an offset project under standard requirements (i.e. biodiversity generated from a carbon planting would need to be better than what is required under a standard carbon capture project). Further research into the alignment of carbon offsets to best practice biodiversity offsets (Chapters 5 and 7) would ensure that these schemes are not in conflict and can contribute to sustainable development.

8.5 Conclusions

We are currently in a biodiversity crisis and there is a growing need for the transparent consideration of impacts to biodiversity. The recently accepted Kunming-Montreal Global Biodiversity Framework and the Taskforce on Nature-related Financial Disclosures are linking development impacts from biodiversity with negative economic

and reputational repercussions for those causing avoidable loss of biodiversity. An increase in the use of biodiversity offsets is likely to compensate for biodiversity loss and mitigate these repercussions.

While the current use of biodiversity offsets is flawed, this research has shown that offsets can be designed and implemented to not only provide adequate compensation but, if used strategically, biodiversity offsets can potentially provide environmental, social and economic gains. This has benefits not only for regulators in terms of cost and risk reduction, but also for developers, financiers and stakeholders. However changes to legislation are required to ensure that these concepts are robust and implemented in transparent, consistent and repeatable ways. Without changes to the use of biodiversity offsets, they will continue to hide the true loss of environmental, social and economic values from development, and contribute to the critical loss of biodiversity, ecosystem services and ecosystem functions which may never be replaced.

References

Abdo, L., Griffin, S., & Kemp, A. (2019a). Apples for oranges: Disparities in offset legislation and policy among jurisdictions and its implications for environmental protection and sustainable development in Australia. *Environmental Management and Sustainable Development, 8*(1) 172–200. doi: 10.5296/emsd.v8i1.14081

Abdo, L. J., Kemp, A., Coupland, G., & Griffin, S. (2019b). Biodiversity offsets can be a valuable tool in achieving sustainable development: Developing a holistic model for biodiversity offsets that incorporates environmental, social and economic aspects of sustainable development. *Journal of Sustainable Development, 12*(5) 65–83. doi: 10.5539/jsd.v12n5p65

Abdo, L., Griffin, S., Kemp, A., & Coupland, G. (2021). Disparity in biodiversity offset regulation across Australia may impact their effectiveness. *Australasian Journal of Environmental Management, 28*(2), 81–103. doi: 10.1080/14486563.2021.1919231

ACT Government Environment and Planning (ACT GEP) (2015). ACT *Environmental Offsets Policy*. ACT Government Environment and Planning, Canberra, ACT. Retrieved from: http://www.environment.act.gov.au/cpr/environmental-offsets-policy

Alberton, M. (2012). Environmental protection in the EU member states: Changing institutional scenarios and trends. *L'Europe en Formation* 363(1) 287–300. Retrieved from: https://www.cairn.info/revue-l-europe-en-formation-2012-1-page-287.htm?contenu=article

Alho, C. J. R. (2012). The importance of biodiversity to human health: An ecological perspective. *Estudos Avançados, 26*(74), 151–165. https://doi.org/10.1590/S0103-40142012000100011

Ali, M., Kennedy, C. M., Kiesecker, J., & Geng, Y. (2018). Integrating biodiversity offsets within Circular Economy policy in China. *Journal of Cleaner Production*, *185*, 32–43. doi: 10.1016/j.jclepro.2018.03.027

Allan, J. R., Possingham, H. P., Atkinson, S. C., Waldron, A., Marco, M. D., Butchart, S. H. M., Adams, V. M., Kissling, W. D., Worsdell, T. & Watson, J. E. M. (2022). The minimum land area requiring conservation attention to safeguard biodiversity. *Science* 376(6597), 1094–1101. doi: 10.1126/science.abl9127

Allen, C., Metternicht, G., & Wiedmann, T. (2018). Prioritising SDG targets: Assessing baselines, gaps and interlinkages. *Sustainability Science, 14,* 421–438. doi: 10.1007/s11625-018-0596-8

Almond, R. E. A., Grooten M., & Petersen, T., (Eds). (2020) *Living Planet Report 2020 - Bending the curve of biodiversity loss*. WWF, Gland, Switzerland. Retrieved from: https://membership.zsl.org/sites/default/files/LPR%202020%20Full%20report.pdf

Andrello, M., Jacobi, M. N., Manel, S., Thuiller, W., & Mouillot, D. (2015). Extending networks of protected areas to optimize connectivity and population growth rate. *Ecography, 38*(3), 273–282. doi: 10.1111/ecog.00975

Andres, S. E., Standish, R. J., Lieurance, P. E., Mills, C. H., Harper, R. J., Butler, D. W., Adams, V. M., Lehmann, C., Tetu, S. G., Cuneo, P., Offord, C. A., & Gallagher, R. V. (2022). Defining biodiverse reforestation: Why it matters for climate change mitigation and biodiversity. *Plants, People, Planet, 5*(1) 27–38. doi: 10.1002/ppp3.10329

Apostolopoulou, E. (2016). Biodiversity offsetting in England: Governance rescaling, socio-spatial injustices, and the neoliberalization of nature. *Web Ecology, 16*, 67–71. doi: 10.5194/we-16-67-2016

Arlidge, W. N. S., Bull, J. W., Addison, P. F. E., Burgass, M. J., Gianuca, D., Gorham, T. M., Jacob, C., Shumway, N., Sinclair, S. P., Watson, J. E. M., Wilcox, C., & Milner-Gulland, E. J. (2018). A global mitigation hierarchy for nature conservation, *BioScience*, *68*(5), 336–347. doi: 10.1093/biosci/biy029

Audit Office of New South Wales (AONSW) (2022). *Performance audit: Effectiveness of the Biodiversity Offset Scheme. Audit Office of New South Wales*. Retrieved from: https://www.audit.nsw.gov.au/sites/default/files/documents/FINAL%20-%20Effectiveness%20of%20the%20Biodiversity%20Offsets%20Scheme.PDF

Austin, A. D., Yeates, D. K., Cassis, G., Fletcher, M. J., La Salle, J., Lawrence, J. F., McQuillan, P. B., Mound, L. A., Bickel, D. J., Gullan, P. J., Hales, D. F., & Taylor, G. S. (2004). Insects 'Down Under'– Diversity, endemism and evolution of the Australian insect fauna: examples from select orders. *Australian Journal of Entomology, 43*(3), 216–234. doi: 10.1111/j.1326-6756.2004.00448.x

Australian National Audit Office (ANAO) (2020). *Referrals, Assessments and Approvals of Controlled Actions under the* Environment Protection and Biodiversity Conservation Act 1999. Canberra, ACT. Retrieved from: https://www.anao.gov.au/work/performance-audit/referrals-assessments-and-approvals-controlled-actions-under-the-epbc-act

Basconi, L., Cadier, C., & Guerrero-Limón, G. (2020). Challenges in marine restoration ecology: how techniques, assessment metrics, and ecosystem valuation can lead to improved restoration success. In *YOUMARES 9 - The Oceans: Our Research, Our Future* (pp. 83-99). doi: 10.1007/978-3-030-20389-4_5

Bath, P., Guzmán-Valladares, A., Luján-Gallegos, V. and Mathias, K. (2020), *Conservation Trust Funds 2020: global vision, local action*. Conservation Finance Alliance, New York. Retrieved from: https://www.conservationfinancealliance.org/10-year-review

Bekessy, S. A., Wintle, B. A., Lindenmayer, D. B., McCarthy, M. A., Colyvan, M., Burgman, M. A., & Possingham, H. P. (2010). The biodiversity bank cannot be a lending bank. *Conservation Letters, 3*(3), 151–158. doi: 10.1111/j.1755-263X.2010.00110.x

Bell, J. (2016). Implementing an outcomes-based approach to marine biodiversity offsets: Lessons from the Great Barrier Reef. *Australasian Journal of Environmental Management, 23*(3), 314–329. doi: 10.1080/14486563.2015.1081837

Bellard, C., Bertelsmeier, C., Leadley, P., Thuiller, W., & Courchamp, F. (2012). Impacts of climate change on the future of biodiversity. *Ecology Letters, 15*(4), 365–377. doi: 10.1111/j.1461-0248.2011.01736

Benabou, S. (2014). Making up for lost nature? A critical review of the international development of voluntary biodiversity offsets. *Environment and Society, 5*(1) 103–123. doi: 10.3167/ares.2014.050107

Bennun, L. A., Ekstrom, J., & Bull, J. (2014). *Integrating the value of natural capital into private and public investment: the role of information. The* Biodiversity Conservancy, Cambridge, U.K. Retrieved from: https://www.thebiodiversityconsultancy.com/fileadmin/user_upload/Natural-capital-information-and-metrics-Bellagio-White-Paper-4-Word_AT-1.pdf

Berges, L., Avon, C., Bezombes, L., Clauzel, C., Duflot, R., Foltete, J. C., Gaucherand, S., Girardet, X., & Spiegelberger, T. (2020). Environmental mitigation hierarchy and biodiversity offsets revisited through habitat connectivity modelling. *Journal of Environmental Management, 256*, 109950. doi: 10.1016/j.jenvman.2019.109950

Bezombes, L., Gaucherand, S., Spiegelberger, T., Gouraud, V., & Kerbiriou, C. (2018). A set of organized indicators to conciliate scientific knowledge, offset policies requirements and operational constraints in the context of biodiversity

offsets. *Ecological Indicators, 93,* 1244–1252. doi: 10.1016/j.ecolind.2018.06.027

Bidaud, C., Schreckenberg, K., & Jones, J. P. G. (2018). The local costs of biodiversity offsets: Comparing standards, policy and practice. *Land Use Policy, 77*, 43–50. doi: 10.1016/j.landusepol.2018.05.003

Bigard, C., Pioch, S., & Thompson, J. D. (2017). The inclusion of biodiversity in environmental impact assessment: Policy-related progress limited by gaps and semantic confusion. *Journal of Environmental Management, 200*, 35–45. doi: 10.1016/j.jenvman.2017.05.057

Biodiversity Conservation Trust (BCT) (2022a). *Pay into the fund to offset development.* Department Planning, Industry and Environment, Parramatta, NSW. Retrieved from: https://www.bct.nsw.gov.au/cards/pay-fund-offset-development

Biodiversity Conservation Trust (BCT) (2022b). *Biodiversity offsets program outcomes.* Department Planning, Industry and Environment, Parramatta, NSW. Retrieved from: https://www.bct.nsw.gov.au/info/biodiversity-offsets-program-outcomes

Biodiversity Conservation Trust (BCT) (2022c). *Biodiversity offsets program.* Department Planning, Industry and Environment, Parramatta, NSW. Retrieved from: https://www.bct.nsw.gov.au/biodiversity-offsets-program

Biodiversity Conservation Trust (BCT) (2022d). *Appendix 1: Biodiversity Offsets Payment Calculator*. Department Planning, Industry and Environment, Parramatta, NSW. Retrieved from: https://www.bct.nsw.gov.au/sites/default/files/2022-09/Biodiversity%20Offsets%20Payment%20Calculator%20Order%2030%20Sep%202022.pdf

Biodiversity Conservation Trust (BCT) (2021). *Annual Report 2020–21.* Department Planning, Industry and Environment, Parramatta, NSW. Retrieved from: https://www.bct.nsw.gov.au/publications

Birkeland, J., & Knight-Lenihan, S. (2016). Biodiversity offsetting and net positive design. *Journal of Urban Design, 21*(1), 50–66. doi: 10.1080/13574809.2015.1129891

Bladon, A., Essam Yassin Mohammed, E. Y., & Milner-Gulland., E. J. (2014). *A Review of Conservation Trust Funds for Sustainable Marine Resources Management: Conditions for Success.* IIED Working Paper. IIED, London. Retrieved from: http://pubs.iied.org/16574IIED

Blaufelder, C., Levy, C., Mannion, P. & Pinner, D. (2021). *A blueprint for scaling voluntary carbon markets to meet the climate challenge*. McKinsey Sustainability. Retrieved from: https://www.mckinsey.com/business-functions/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge

Boonrueang, S., & Reid, C. (2020). Conservation agreements and environmental governance: The role of nongovernmental actors. *Review of European, Comparative and International Environmental Law, 30*(1) 118–127. doi: 10.1111/reel.12375

Bradshaw, C. J. A., (2012). Little left to lose: Deforestation and forest degradation in Australia since European colonization. *Journal of Plant Ecology, 5*(1): 109–120. doi: 10.1093/jpe/rtr038

Brady, A. F., & Boda, C. S. (2017). How do we know if managed realignment for coastal habitat compensation is successful? Insights from the implementation of the EU Birds and Habitats Directive in England. *Ocean & Coastal Management, 143*, 164–174. doi: 10.1016/j.ocecoaman.2016.11.013

Broadhurst, L., & Coates, D. (2017). Plant conservation in Australia: Current directions and future challenges. *Plant Diversity, 39*(6), 348–356. doi: 10.1016/j.pld.2017.09.005.

Brown, M., A., & Penelope, J. (2016). Biodiversity offsets in New Zealand: Addressing the risks and maximising the benefits. *Policy Quarterly, 12*(1), 35–41. doi: 10.26686/pq.v12i1.4580

Brown, P. H., & Lant, C. L. (1999). The effect of wetland mitigation banking on the achievement of no-net-loss. *Environmental Management, 23*, 333–345. doi: 10.1007/s002679900190

Brownlie, S., & Botha, M. (2009). Biodiversity offsets: Adding to the conservation estate, or 'no net loss'? *Impact Assessment and Project Appraisal, 27*(3), 227–231. doi: 10.3152/146155109X465968

Brunton, G., Oliver, S., & Thomas, J. (2020). Innovations in framework synthesis as a systematic review method. *Research Synthesis Methods, 11*, 316–330. doi: 10.1002/jrsm.1399.

Buchman, A. (2012). *Oil and gas and NGOs: New rules of engagement?* International Conference on Health Safety and Environment in Oil and Gas Exploration and Production, 11–13 September 2012, Perth Convention and Exhibition Centre, Perth, Western Australia. Retrieved from: https://www.proceedings.com/16126.html

Budiharta, S., Meijaard, E., Gaveau, D. L. A., Struebig, M. J., Wilting, A., Kramer-Schadt, S., Niedballa, J., Raes, N., Maron, M. & Wilson, K. A. (2018). Restoration to offset the impacts of developments at a landscape scale reveals opportunities, challenges and tough choices. *Global Environmental Change, 52*, 152–161. doi: 10.1016/j.gloenvcha.2018.07.008

Bull, J. W., & Brownlie, S. (2015). The transition from No Net Loss to a Net Gain of biodiversity is far from trivial. *Oryx, 51*(1), 53–59. doi: 10.1017/s0030605315000861

Bull, J. W., Abatayo, A. L., & Strange, N. (2017a). Counterintuitive proposals for trans-boundary ecological compensation under 'no net loss' biodiversity policy. *Ecological Economics, 142*, 185–193. doi: 10.1016/j.ecolecon.2017.06.010

Bull, J. W., Brauneder, K., Darbi, M., Van Teeffelen, A. J. A., Quétier, F., Brooks, S. E., Dunnett, S., & Strange, N. (2018). Data transparency regarding the implementation of European 'no net loss' biodiversity policies. *Biological Conservation, 218*, 64–72. doi: 10.1016/j.biocon.2017.12.002

Bull, J. W., Gordon, A., Watson, J. E. M., Maron, M., & Carvalho, S. (2016). Seeking convergence on the key concepts in 'no net loss' policy. *Journal of Applied Ecology, 53*(6), 1686–1693. doi: 10.1111/1365-2664.12726

Bull, J. W., Hardy, M. J., Moilanen, A., & Gordon, A. (2015). Categories of flexibility in biodiversity offsetting, and their implications for conservation. *Biological Conservation*, *192*, 522–532 doi: 10.1016/j.biocon.2015.08.003

Bull, J. W., Lloyd, S. P., & Strange, N. (2017b). Implementation gap between the theory and practice of biodiversity offset multipliers. *Conservation Letters, 10*(6), 656–669. doi: 10.1111/conl.12335

Bull, J. W., & Maron, M. (2016). How humans drive speciation as well as extinction. *Procedings of the Royal Society B, 283,* 20160600. doi: 10.1098/rspb.2016.0600

Bull, J. W., Milner-Gulland, E. J., Suttle, K. B., & Singh, N. J. (2014). Comparing biodiversity offset calculation methods with a case study in Uzbekistan. *Biological Conservation, 178*, 2–10. doi:10.1016/j.biocon.2014.07.006

Bull, J. W., Suttle, K. B., Gordon, A., Singh, N. J., & Milner-Gulland, E. J. (2013a). Biodiversity offsets in theory and practice. *Oryx, 47*(3), 369–380. doi: 10.1017/s003060531200172x

Bull, J. W., Suttle, K. B., Singh, N. J., & Milner-Gulland, E. J. (2013b). Conservation when nothing stands still: Moving targets and biodiversity offsets. *Frontiers in Ecology and the Environment, 11*(4), 203–210. doi: 10.1890/120020

Bullock, J. M., Aronson, J., Newton, A. C., Pywell, R. F., & Rey-Benayas, J. M. (2011). Restoration of ecosystem services and biodiversity: Conflicts and opportunities. *Trends in Ecology and Evolution, 26*(10), 541–549. doi: 10.1016/j.tree.2011.06.011

Burgin, S. (2008). BioBanking: An environmental scientist's view of the role of biodiversity banking offsets in conservation. *Biodiversity and Conservation, 17*(4), 807–816. doi: 10.1007/s10531-008-9319-2

Burton, M., Rogers, A., & Richert, C. (2017). Community acceptance of biodiversity offsets: evidence from a choice experiment. *Australian Journal of Agricultural and Resource Economics, 61*(1), 95–114. doi: 10.1111/1467-8489.12151

Business and Biodiversity Offsets Programme (BBOP). (2012). *Standard on biodiversity offsets*. BBOP, Washington, D.C. Retrieved from: http://bbop.forest-trends.org/pages/biodiversity_offsets

Business and Biodiversity Offsets Programme (BBOP) (2018). *Mitigation hierarchy*. BBOP, Washington, D.C. Retrieved from: http://bbop.forest-trends.org/pages/mitigation_hierarchy

Business and Biodiversity Offsets Programme (BBOP). (2019). *Biodiversity offsets*. BBOP, Washington, D.C. Retrieved from: http://bbop.forest-trends.org/pages/biodiversity_offsets

Calvet, C., Coënt, P. L., Napoleone, C., & Quétier, F. (2019). Challenges of achieving biodiversity offset outcomes through agri-environmental schemes: Evidence

from an empirical study in southern France. *Ecological Economics, 163*, 113–125. doi: 10.1016/j.ecolecon.2019.03.026

Carreras Gamarra, M. J., & Toombs, T. P. (2017). Thirty years of species conservation banking in the U.S.: Comparing policy to practice. *Biological Conservation, 214*, 6–12. doi: 10.1016/j.biocon.2017.07.021

Carreras Gamarra, M. J., Lassoie, J. P., & Milder, J. (2018). Accounting for no net loss: A critical assessment of biodiversity offsetting metrics and methods. *Journal of Environmental Management, 220*, 36–43. doi: 10.1016/j.jenvman.2018.05.008

Carver, L. (2015). *Measuring the value of what? An ethnographic account of the transformation of 'Nature' under the DEFRA biodiversity offsetting metric.* LCSV working paper series no. 11. The Leverhulme Centre for the Study of Value, Manchester, U.K. Retrieved from: https://hummedia.manchester.ac.uk/institutes/gdi/publications/workingpapers/archive/lcsv/lcsv-wp11-carver.pdf

Carwardine, J., Nicol, S., Van Leeuwen, S., Walters, B., Firn, J., Reeson, A., Martin, T. G., & Chades, I. (2014). *Priority threat management for Pilbara species of conservation significance*. CSIRO, Brisbane, QLD. Retrieved from: https://publications.csiro.au/rpr/pub?list=SEA&pid=csiro:EP14416

Chamber of Minerals and Energy (CME) (2021). *Map of resource projects in Western Australia*. Chamber of Minerals and Energy, Perth, Western Australia. Retrieved from: https://www.cmewa.com.au/about/wa-resources/project-map/

Christie, M., Fazey, I., Cooper, R., Hyde, T., Kenter, J. O. (2012). An evaluation of monetary and non-monetary techniques for assessing the importance of biodiversity and ecosystem services to people in countries with developing economies. *Ecological Economics, 83,* 67–78. https://doi.org/10.1016/j.ecolecon.2012.08.012.

Chung, N., Miasojedow, B., Startek, M., & Gambin, A. (2019). Jaccard/Tanimoto similarity test and estimation methods for biological presence-absence data. *BMC Bioinformatics, 20*(15), 644. Retrieved from: https://doi.org/10.1186/s12859-019-3118-5

Clare, S., & Krogman, N. (2013). Bureaucratic slippage and environmental offset policies: The case of wetland management in Alberta. *Society & Natural Resources, 26*(6), 672–687. doi: 10.1080/08941920.2013.779341

Clarke, K. D., & Bradford, M. J. (2014). *A review of equivalency in offsetting policies*. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Ottawa, Canada. Retrieved from: https://publications.gc.ca/collections/collection_2015/mpo-dfo/Fs70-5-2014-109-eng.pdf

Clarke, K. R., Gorley, R. N., Somerfield, P. J., & Warwick, R. M. (2014). *Change in marine communities: an approach to statistical analysis and interpretation* (3rd edition). Plymouth, UK: PRIMER-E. Retrieved from: https://www.scribd.com/document/481168804/Change-in-Marine-Communities-3rd-ed-PRIMER-pdf

Clean Energy Regulator (CER) (N.D.). *Factsheet: Environmental plantings projects*. Retrieved from: https://www.cleanenergyregulator.gov.au/DocumentAssets/Documents/Factsheet%20-%20Environmental%20plantings.pdf

Coggan, A., Buitelaar, E., Bennett, J., & Whitten, S. M. (2013a). Transferable mitigation of environmental impacts of development: Two cases of offsets in Australia. *Journal of Environmental Policy & Planning, 15*(2), 303–322. doi: 10.1080/1523908X.2013.781350

Coggan, A., Buitelaar, E., Whitten, S., & Bennett, J. (2013b). Factors that influence transaction costs in development offsets: Who bears what and why? *Ecological Economics, 88*, 222–231. doi: 10.1016/j.ecolecon.2012.12.007

Coker, M. E., Bond, N. R., Chee, Y. E., & Walsh, C. J. (2018). Alternatives to biodiversity offsets for mitigating the effects of urbanization on stream ecosystems. *Conservation Biology, 32*(4), 789–797. doi: 10.1111/cobi.13057

Commonwealth of Australia (CoA) (1992). *Intergovernmental Agreement on the Environment*. Retrieved from: http://www.environment.gov.au/about-us/esd/publications/intergovernmental-agreement

Connick, S., & Michael, J. L. (2012). *Managing environmental risks and contributing to scientific advancement through external partnerships: Models for industry*. International Conference on Health Safety and Environment in Oil and Gas Exploration and Production, 11–13 September 2012, Perth Convention and Exhibition Centre, Perth, Western Australia. Retrieved from: https://www.proceedings.com/16126.html

Conservation Heirarchy (CH) (2023). *What is the mitigation & conservation hierarchy?* Retrieved from: https://conservationhierarchy.org/what-is-conservation-hierarchy/

Conservation Management (CM) (N.D.) *A biodiversity conservation plan for Shield and Central subregions of the Great Victoria Desert*. Great Victoria Desert Biodiversity Trust. Retrieved from: https://secureservercdn.net/45.40.150.109/y35.bf7.myftpupload.com/wp-content/uploads/2020/03/SCS-Biodiversity-Conservation-Plan-Rev0.pdf

Conservation and Parks Commission (CPC) (2022). Draft Forest Management Plan 2024-2033. Conservation and Parks Commission, Perth. Retrieved from: https://www.dbca.wa.gov.au/sites/default/files/2022-10/Draft%20FMP%202024-2033%20Web%20version%20v4.pdf

Convention on Biological Diversity (CBD) (n.d.) *The value of biodiversity and ecosystem services.* Retrieved from: https://www.cbd.int/2011-2020/about/biodiversity

Convention on Biological Diversity (CBD) (2006). *Global biodiversity outlook 2.* Secretariat of the Convention on Biological Diversity, Montreal, Canada. Retrieved from: https://www.cbd.int/doc/gbo/gbo2/cbd-gbo2-en.pdf

Convention on Biological Diversity (CBD) (2009). *Sustaining life on earth.* Retrieved from: https://www.cbd.int/convention/guide/?id=changing

Convention on Biological Diversity (CBD) (2010). *What is impact assessment?* Retrieved from: https://www.cbd.int/impact/whatis.shtml

Convention on Biological Diversity (CBD) (2011). *Strategic plan for biodiversity 2011–2020 and the Aichi Targets*. Retrieved from: https://www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf

Convention on Biological Diversity (CBD) (2017a). *The Convention: Introduction*. Retrieved from: https://www.cbd.int/development/

Convention on Biological Diversity (CBD) (2017b). *Biodiversity for development*. Retrieved from: https://www.cbd.int/intro/default.shtml

Convention on Biological Diversity (CBD) (2020). *Zero draft of the Post-2020 Global Biodiversity Framework*. Retrieved from: https://www.cbd.int/doc/c/efb0/1f84/a892b98d2982a829962b6371/wg2020-02-03-en.pdf

Convention on Biological Diversity (CBD) (2022a). *COP15: nations adopt four goals, 23 targets for 2030 in landmark un biodiversity agreement*. Retrieved from: https://www.cbd.int/article/cop15-cbd-press- release-final-19dec2022

Convention on Biological Diversity (CBD) (2022b). *List of Parties*. Retrieved from: https://www.cbd.int/information/parties.shtml

Coralie, C., Guillaume, O., & Claude, N. (2015). Tracking the origins and development of biodiversity offsetting in academic research and its implications for conservation: A review. *Biological Conservation, 192* 492–503. doi: 10.1016/j.biocon.2015.08.036

Council of Australian Governments (COAG) (1997). *Heads of Agreement on Commonwealth and State roles and responsibilities for the environment*. Retrieved from: http://www.environment.gov.au/resource/heads-agreement-commonwealth-and-state-roles-and-responsibilities-environment

Cowie, R. H., Bouchet, P. & Fontaine, B. (2022). The sixth mass extinction: Fact, fiction or speculation?. *Biological Reviews, 97,* 640–663. doi: 10.1111/brv.12816

Cresswell, I. D. & Murphy, H. (2016). Biodiversity: Importance of biodiversity. In: *Australia state of the environment 2016*, Australian Government Department of the Environment and Energy, Canberra, ACT. Retrieved from: https://soe.environment.gov.au/theme/biodiversity/topic/2016/importance-biodiversity, DOI 10.4226/94/58b65ac828812

Crisp, M. D., Laffan, S., H. P. Linder, H. P. & Monro, A. (2001). Endemism in the Australian flora. *Journal of Biogeography, 28*, 183–198. Retrieved from: https://biology-assets.anu.edu.au/hosted_sites/Crisp/pdfs/Crisp2001_endemism.pdf

Damiens, F. L. P., Backstrom, A., & Gordon, A. (2021). Governing for “no net loss” of biodiversity over the long term: Challenges and pathways forward. *One Earth, 4*(1), 60–74. doi: 10.1016/j.oneear.2020.12.012

Dasgupta, P. (2021). *The economics of biodiversity: The Dasgupta review.* HM Treasury, London, United Kingdom. Retrieved from: https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review

Department of Agriculture, Water and the Environment (DAWE) (2021). *Strategic assessment of the Perth and Peel regions*. Retrieved from: https://www.wa.gov.au/organisation/department-of-the-premier-and-cabinet/strategic-assessment-of-the-perth-and-peel-regions-0

Department of Biodiversity, Conservation and Attractions (DBCA) (2018). *The forest management system in Western Australia: An overview.* Department of Biodiversity, Conservation and Attractions, Kensington, Western Australia. Retrieved from: https://www.dbca.wa.gov.au/sites/default/files/2021-11/An%20Overview%20of%20WAs%20Forest%20Management%20System%202018%20%282.69MB%29_0.pdf

Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2022a). *EPBC Act reform*. Retrieved from: https://www.dcceew.gov.au/environment/epbc/epbc-act-reform

Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2022b). *EPBC Act environmental offsets policy*. Department of Climate Change, Energy, the Environment and Water, Canberra, ACT. Retrieved from: https://www.dcceew.gov.au/environment/epbc/publications/epbc-act-environmental-offsets-policy

Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2023). *Carbon + Biodiversity Pilot*. Department of Climate Change, Energy, the Environment and Water, Canberra, ACT. Retrieved from: https://www.dcceew.gov.au/environment/environmental-markets/agriculture-stewardship/c-b-pilot

Department for Environment, Food & Rural Affairs (DEFR) (2023). *Guidance: Understanding biodiversity net gain*. Crown, London, United Kingdom. Retrieved from: https://www.gov.uk/guidance/understanding-biodiversity-net-gain#further-information

Department of Environment, Land, Water and Planning (DELWP) (2017a). *Biodiversity information explanatory document: Measuring value when removing or offsetting native vegetation*. Department of Environment, Land, Water and Planning, Melbourne, Victoria. Retrieved from: https://www.environment.vic.gov.au/__data/assets/pdf_file/0025/91267/Biodiversity-information-explanatory-document-Measuring-value-when-removing-or-.pdf

Department of Environment, Land, Water and Planning (DELWP) (2017b). *Guidelines for the removal, destruction or lopping of native vegetation*. Department of Environment, Land, Water and Planning, Melbourne, Victoria. Retrieved from: https://www.environment.vic.gov.au/__data/assets/pdf_file/0021/91146/Guidelines-for-the-removal,-destruction-or-lopping-of-native-vegetation,-2017.pdf

Department of Environment, Land, Water and Planning (DELWP) (2017c). *A quick comparison of first party and third party offset sites*. Department of Environment, Land, Water and Planning, Melbourne, Victoria. Retrieved from: https://www.environment.vic.gov.au/__data/assets/pdf_file/0023/329450/Info-sheet-A-quick-comparison-of-first-party-and-third-party-offset-sites.pdf

Department of Environment and Natural Resources (DENR) (2018). *Natural resource maps* (NR Maps). Retrieved from: http://nrmaps.nt.gov.au/nrmaps.html

Department of Environment and Science (DES) (2018). *Queensland environmental offsets policy: V.1.6*. Department of Environment and Science, Brisbane, Queensland. Retrieved from: https://www.ehp.qld.gov.au/assets/documents/pollution/management/offsets/offsets-policyv1-6.pdf

Department of Environment and Science (DES) (2022). *Queensland environmental offsets policy*. Version 1.12. State of Queensland. Retrieved from:

https://environment.des.qld.gov.au/__data/assets/pdf_file/0022/266062/offsets-policyv1-12.pdf

Department for Environment and Water (DEW) (2017). *Offsetting*. Retrieved from: https://www.environment.sa.gov.au/topics/native-vegetation/offsetting

Department for Environment and Water (DEW) (2022). *Significant environmental benefit grants*. Government of South Australia. Retrieved from: https://www.environment.sa.gov.au/get-involved/grants-and-funding/native-vegetation-incentives-programs/significant-environmental-benefit-grants

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2009). *Ecosystem services: Key concepts and applications*. Department of the Environment, Water, Heritage and the Arts, Canberra. Retrieved from: https://www.dcceew.gov.au/sites/default/files/documents/ecosystem-services.pdf

Department of Environment, Water and Natural Resources (DEWNR) (2017a). *Policy for calculating a significant environmental benefit under the* Native Vegetation Act 1991 *and the* Native Vegetation Regulations 2017. Department of Environment, Water and Natural Resources, Adelaide, South Australia. Retrieved from: https://www.environment.sa.gov.au/topics/native-vegetation/offsetting

Department of Environment, Water and Natural Resources (DEWNR) (2017b). *Guide for calculating a significant environmental benefit under the* Native Vegetation Act 1991 *and the* Native Vegetation Regulations 2017. Department of Environment, Water and Natural Resources, Adelaide, South Australia. Retrieved from: https://www.environment.sa.gov.au/topics/native-vegetation/offsetting

Department of Environment, Water and Natural Resources (DEWNR) (2020). *Policy for a significant environmental benefit*. Government of South Australia.

Retrieved from: https://cdn.environment.sa.gov.au/environment/docs/native_vegetation_significant_environmental_benefit_policy_1_july_2019.pdf

Department of Foreign Affairs and Trade (DFAT) (2018). *Tracking Australia's progress on the Sustainable Development Goals*. Commonwealth of Australia, Canberra, ACT. Retrieved from: https://www.dfat.gov.au/sites/default/files/sdgs-data-report-tracking-progress.pdf.

Department of Forestry, Fisheries and the Environment. (DFFE) (2021). *National biodiversity offset guideline issued under section 24J of the* National Environmental Management Act. First Edition, October 2021. Republic of South Africa. Retrieved from: https://www.dffe.gov.za/sites/default/files/legislations/draftnationalbiodiversityoffsetguideline_draftNBOG2021october.pdf

Department of Industry, Science and Resources (DISR) (2022). *Methods for the Emissions Reduction Fund*. Retrieved from: https://www.industry.gov.au/regulations-and-standards/methods-for-the-emissions-reduction-fund

Department of Planning and Environment (DPE) (2022). *About the biodiversity offsets scheme.* Department Planning, Industry and Environment, NSW. Retrieved from: https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity-offsets-scheme/about-the-biodiversity-offsets-scheme

Department of Primary Industries and Regional Development (DPIRD) (2016). *Potentially arable areas in the Western Australian wheatbelt*. Department of Primary Industries and Regional Development, Perth, Western Australia. Retrieved from: https://researchlibrary.agric.wa.gov.au/gis_maps/20/

Department of Primary Industries, Water and Environment (DPIWE) (2002). *Tasmanian natural resource management framework*. Department of Primary Industries, Water and Environment, Hobart, Tasmania. Retrieved from: http://dpipwe.tas.gov.au/Documents/ReportNoPics.pdf

Department of Sustainability and the Environment (DSE) (2003). *Victoria's native vegetation management: A framework for action*. Department of Sustainability and the Environment, Victoria. Retrieved from: https://www.environment.vic.gov.au/__data/assets/pdf_file/0021/90363/Native_Vegetation_Management_-_A_Framework_for_Action.pdf

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012a). Environment Protection and Biodiversity Conservation Act 1999 *environmental offsets policy*. Department of Sustainability, Environment, Water, Populations and Communities, Canberra, ACT. Retrieved from: https://www.environment.gov.au/epbc/publications/epbc-act-environmental-offsets-policy

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012b). *How to use the offsets assessment guide*. Department of Sustainability, Environment, Water, Populations and Communities, Canberra, ACT. Retrieved from: https://www.environment.gov.au/system/files/resources/12630bb4-2c10-4c8e-815f-2d7862bf87e7/files/offsets-how-use.pdf

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012c). *Statement of environmental and assurance outcomes*. Department of Sustainability, Environment, Water, Populations and Communities, Canberra, ACT. Retrieved from: http://www.environment.gov.au/resource/draft-framework-standards-accreditation-and-statement-environmental-and-assurance-outcomes

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012d). *Draft framework of standards for accreditation of environmental approvals under the* Environmental Protection and Biodiversity Conservation Act 1999. Department of Sustainability, Environment, Water, Populations and Communities, Canberra, ACT. Retrieved from: http://www.environment.gov.au/resource/draft-framework-standards-accreditation-and-statement-environmental-and-assurance-outcomes

Di Minin, E., Soutullo, A., Bartesaghi, L., Rios, M., Szephegyi, M. N., & Moilanen, A. (2017). Integrating biodiversity, ecosystem services and socio-economic data to identify priority areas and landowners for conservation actions at the national scale. *Biological Conservation, 206*, 56–64. doi: 10.1016/j.biocon.2016.11.037

Díaz, S., Fargione, J., Chapin III, F. S. & Tilman, D. (2006). Biodiversity loss threatens human well-being. *PLoS Biology 4*(8): e277. doi: 10.1371/journal.pbio.0040277

Díaz, S., Settele, J., Brondízio, E. S., Ngo, H. T., Guèze, M., Agard, J., Arneth, A., Balvanera, P., Brauman, K. A., Butchart, S. H. M., Chan, K. M. A., Garibaldi, L. A., Ichii, K., Liu, J., Subramanian, S. M., Midgley, G. F., Miloslavich, P., Molnár, Z., Obura, D., Pfaff, A., Polasky, S., Purvis, A., Razzaque, J., Reyers, B., Roy Chowdhury, R., Shin, Y. J., Visseren-Hamakers, I. J., Willis, K. J. and Zayas, C. N. (eds.) (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*. IPBES secretariat, Bonn, Germany. doi: 10.5281/zenodo.3553579

Doinjashvili, P., Méral, P. & Andriamahefazafy, F. (2021) Sustaining protected areas through conservation trust funds: A review. *International Journal of Sustainable Development & World Ecology, 28*(3): 193–202. doi:10.1080/13504509.2020.1762257

Duelli, P., & Obrist, M. K. (2003). Biodiversity indicators: The choice of values and measures. *Agriculture, Ecosystems & Environment, 98*(1-3), 87–98. doi: 10.1016/s0167-8809(03)00072-0

Duffy, J. E. (2009). Why Biodiversity Is Important to the Functioning of Real-World Ecosystems. *Frontiers in Ecology and the Environment, 7*(8), 437–444. http://www.jstor.org/stable/25595199

Ecologically Sustainable Development Steering Committee (ESDSC) (1992). *National Strategy for ecologically sustainable development*. Ecologically Sustainable Development Steering Committee, Canberra, Australian Capital Territory. Retrieved from: http://www.environment.gov.au/about-us/esd/publications/national-esd-strategy

Environment Defenders Office (Victoria) Ltd. (EDO) (2014). *Senate inquiry into environmental offsets.* Environment Defenders Office (Victoria) Ltd, Melbourne, Victoria. Retrieved from: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwimu9_9uNb9AhXt9zgGHcVNDewQFnoECAwQAQ&url=https%3A%2F%2Fwww.aph.gov.au%2FDocumentStore.ashx%3Fid%3Dfb1c24f9-4b14-42f4-95ea-7d5a217689b0%26subId%3D251072&usg=AOvVaw00BQ0u_DPlSs6PBWj4shXO

Environment, Land, Water and Planning (ELWP) (2018). *Native vegetation*. Retrieved from: https://www.environment.vic.gov.au/native-vegetation/native-vegetation

Environment, Planning and Sustainable Development Directorate (EPSDD) (2018). *Environmental offsets policy*. Retrieved from: https://www.environment.act.gov.au/cpr/environmental-offsets-policy

Environmental Protection Authority (EPA) (2014). *WA environmental offset guidelines: August 2014*. Environmental Protection Authority, Perth, Western Australia. Retrieved from: https://www.der.wa.gov.au/your-environment/offsets

Environmental Protection Authority (EPA) (2018). *WA Environmental offsets policy and guidelines*. Environmental Protection Authority, Perth, Western Australia:. Retrieved from: http://www.epa.wa.gov.au/guidelines-and-procedures/wa-environmental-offsets-policy-and-guidelines

Equator Principles Association (EPA) (2022). *The equator principles*. Retrieved from: https://equator-principles.com/about-the-equator-principles/

European Statistical System Committee (ESSC) (2019). *39th Meeting of the European Statistical System Committee: 7th February 2019*. Item 3 of the agenda, European strategy for environmental accounts 2019-2023. Work Programme Objective 05. European Statistical System Committee, Luxembourg. Retrieved from: https://ec.europa.eu/eurostat/documents/1798247/6191525/European+Strategy+for+Environmental+Accounts/

European Union (EU) (2022). *Nature restoration law*. European Union. Retrieved from: https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law_en

Evans, M. C. (2015). Offsetting in the context of policy: What happens to the theory when it hits the real world?. *Decision Point: 91*. Retrieved from: http://decision-point.com.au/?article=offsetting-in-the-context-of-policy

Evans, M. C. (2016). Deforestation in Australia: Drivers, trends and policy responses. *Pacific Conservation Biology, 22*(2), 130. doi: 10.1071/pc15052

Evans, M., Maseyk, F., Davitt, G., & Maron, M. (2021). *Typical offsets for threatened species*. Threatened Species Recovery Hub Project 5.1 report. National Environmental Science Programme, Brisbane, Queensland. Retrieved from:

https://www.nespthreatenedspecies.edu.au/media/50pmkic2/5-1-typical-offsets-for-threatened-species_v2.pdf

Fallding, M. (2014). Biodiversity offsets: Practice and promise. *Environmental and Planning Law Journal, 31*(11), 11–33. Retrieved from: https://www.researchgate.net/publication/286129580_Biodiversity_offsets_Practice_and_promise#fullTextFileContent

Ferreira, C. (2014). *Biodiversity offset markets: Current challenges and prospective developments*. (Doctor of Philosophy), Coventry University, UK. Retrieved from: https://pureportal.coventry.ac.uk/en/publications/biodiverity-offset-markets-current-challenges-and-prospective-dev

Filoche, G. (2017). Playing musical chairs with land use obligations: Market-based instruments and environmental public policies in Brazil. *Land Use Policy, 63*, 20–29. doi: 10.1016/j.landusepol.2017.01.012

First Insight Inc. (2022). *The sustainability disconnect between consumers and retail executives*. The Baker Retailing Center at the Wharton School of the University of Pennsylvania. Retrieved from: https://www.firstinsight.com/hubfs/docs/The-Sustainability-Disconnect-Between%20Consumers-and-Retail-Executives-2022.pdf?utm_campaign=The%20State%20of%20Consumer%20Spending&utm_medium=email&_hsmi=200921549&_hsenc=p2ANqtz--V-4oehkPUuDJEs-FFk5MQjPS0qI71MB9mtQvrton5qz2FNgCUxxtgVebH3DY7wSWLBJSqk1ICwtVwx-2SCOO-w9tVEQ&utm_content=200921549&utm_source=hs_automation

Fitzsimons, J. A., & Carr, C. B. (2014). Conservation covenants on private land: Issues with measuring and achieving biodiversity outcomes in Australia. *Environmenal Management, 54*(3), 606–616. doi: 10.1007/s00267-014-0329-4

Foerster, A., & McDonald, J. (2016). Thresholds, scale and strategy for biodiversity offsets in Australia: Where to draw the line? *Environmental Law and Management, 28*, 13–30.

Forest Practices Authority (FPA) (2011). *The use of offsets to compensate for the loss of significant biodiversity values within forest practices plans*. Forest Practice Authority, Hobart, Tasmania. Retrieved from: http://www.fpa.tas.gov.au/__data/assets/pdf_file/0010/110611/FPA_policy_on_offsets.pdf

Fortun, P. R., 2017. *Environmental Impact Assessment*. European Union. Retrieved from: https://europa.eu/capacity4dev/public-environment-climate/wiki/environmental-impact-assessment

Forster, J., Schmidt, S., Bartkowski, B., Lienhoop, N., Albert, C., & Wittmer, H. (2019). Incorporating environmental costs of ecosystem service loss in political decision making: A synthesis of monetary values for Germany. *PLoS One, 14*(2), e0211419. doi: 10.1371/journal.pone.0211419

Foster, D. (2013). *Biodiversity offsetting for mining and energy development*. Biodiversity Offsetting for Mining & Energy Development Conference, 9–10 April, Four Points by Sheraton Hotel, Perth, Western Australia.

Gamfeldt, L., Hillebrand, H., & Jonsson, P. R. (2008). Multiple Functions Increase the Importance of Biodiversity for Overall Ecosystem Functioning. *Ecology, 89*(5), 1223–1231. http://www.jstor.org/stable/27651669

Gardner, J. & Stoneman, G. (2003). Bauxite mining and conservation of the Jarrah Forest in southwest Australia. In *IUCN ICMM Workshop: Mining, Protected Areas and Biodiversity Conservation: Searching and Pursuing Best Practice and Reporting in the Mining Industry*, 7–9 July 2002, Gland, Switzerland. Retrieved from: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2

ahUKEwjw8eH1s9v9AhXp-jgGHfidCskQFnoECAsQAQ&url=https%3A%2F%2Fwww.aph.gov.au%2FDocumentStore.ashx%3Fid%3D7556809e-1029-4162-8aaf-eb5bb90a562f%26subId%3D510096&usg=AOvVaw13smyxEiTdWMxlPDoO0FEE

Gardner, T. A., Von Hase, A., Brownlie, S., Ekstrom, J. M., Pilgrim, J. D., Savy, C. E., Stephens, R. T., Treweek, J., Ussher, G. T., & ten Kate, K. (2013). Biodiversity offsets and the challenge of achieving no net loss. *Conservation Biology, 27*(6), 1254–1264. doi: 10.1111/cobi.12118

Gelcich, S., Vargas, C., Carreras, M. J., Castilla, J. C., & Donlan, C. J. (2017). Achieving biodiversity benefits with offsets: Research gaps, challenges, and needs. *Ambio, 46*(2), 184–189. doi: 10.1007/s13280-016-0810-9

Ghosh, S. (2015). Capitalisation of nature: Political economy of forest/biodiversity offsets. *Economic and Political Weekly, L*(16), 53–60. Retrieved from: https://www.epw.in/journal/2015/16/special-articles/capitalisation-nature.html

Ghosh, S. (2017). Compensatory afforestation: 'Compensating' loss of forests or disguising forest offsets? *Economic & Political Weekly, LII*(38), 67–75. Retrieved from: https://www.jstor.org/stable/26697755

Gibbons, P., & Lindenmayer, D. B. (2007). Offsets for land clearing: No net loss or the tail wagging the dog? *Ecological Management & Restoration 8*(1), 26–31. doi: 10.1111/j.1442-8903.2007.00328.x.

Gibbons, P., Macintosh, A., Constable, A. L., & Hayashi, K. (2018). Outcomes from 10 years of biodiversity offsetting. *Global Change Biology, 24*(2), e643–e654. doi: 10.1111/gcb.13977

GIBOP (2019). *Global Inventory of Biodiversity Offset Policies (GIBOP)*. International Union for the Conservation of Nature, The Biodiversity Consultancy, Durrell

Institute of Conservation & Ecology. Retrieved from: https://portals.iucn.org/offsetpolicy/

Gibson, R. B. (2009). Beyond the pillars: Sustainability assessment as a framework for effective integration of social, economic and ecological considerations in significant decision-making. In Sheate, W. R. (Ed.), *Tools, Techniques and Approaches for Sustainability: Collected Writings in Environmental Assessment Policy and Management*. World Scientific Publishing Co Pte Ltd., Singapore. doi: 10.1142/7519

Githiru, M., King, M. W., Bauche, P., Simon, C., Boles, J., Rindt, C., & Victurine, R. (2015). Should biodiversity offsets help finance underfunded Protected Areas? *Biological Conservation, 191*, 819–826. doi: 10.1016/j.biocon.2015.07.033

Godbold, J. A., & Solan, M. (2009). Relative importance of biodiversity and the abiotic environment in mediating an ecosystem process. *Marine Ecology Progress Series, 396,* 273–282*.* doi: 10.3354/meps08401

Godden, D., & Vernon, D. (2003). *Theoretical issues in using offsets for managing biodiversity*. Annual Conference of the Australian Agricultural and Resource Economics Society, 12–14 February Fremantle. doi: 10.22004/ag.econ.57872

Gonçalves, B., Marques, A., Soares, A. M. V. D. M., & Pereira, H. M. (2015). Biodiversity offsets: From current challenges to harmonized metrics. *Current Opinion in Environmental Sustainability, 14*, 61–67. doi: 10.1016/j.cosust.2015.03.008

Gordon, A. (2015). Step forward then look back. *Decision Point, 91*. Retrieved from: http://decision-point.com.au/?article=step-forward-then-look-back

Government of Western Australia (GWA) (2011). *WA environmental offsets policy*. Government of Western Australia, Perth, Western Australia. Retrieved from: https://www.der.wa.gov.au/your-environment/offsets

Government of Western Australia (GWA) (2021). *Environmental revegetation and rehabilitation fund*. Government of Western Australia. Retrieved from: https://www.wa.gov.au/service/environment/business-and-community-assistance/environmental-revegetation-and-rehabilitation-fund

Government of Western Australia (GWA) (2022a). *Green jobs plan*. Government of Western Australia. Retrieved from: https://www.wa.gov.au/organisation/department-of-water-and-environmental-regulation/green-jobs-plan

Government of Western Australia (GWA) (2022b). *Program: Pilbara environmental offsets fund.* Government of Western Australia. Retrieved from: https://www.wa.gov.au/service/environment/business-and-community-assistance/program-pilbara-environmental-offsets-fund

Great Victoria Desert Biodiversity Trust (GVDBT) (2022a). *What we do*. AngloGold Ashanti. Retrieved from: http://gvdbiodiversitytrust.org.au/?page_id=272

Great Victoria Desert Biodiversity Trust (GVDBT) (2022b). *About the Trust*. AngloGold Ashanti. Retrieved from: http://gvdbiodiversitytrust.org.au/?page_id=61

Griffiths, V. F., Bull, J. W., Baker, J., & Milner-Gulland, E. J. (2019). No net loss for people and biodiversity. *Conservation Biology, 33*(1), 76–87. doi: 10.1111/cobi.13184

Grimm, M., & Köppel, J. (2019). Biodiversity offset program design and implementation. *Sustainability, 11*(24), 6903. doi: 10.3390/su11246903

Grinlinton, D. (2017). The Use of biodiversity offsets in mining and energy development: A view from ‘Down Under’. *Environmental Law Review 19*(4), 244–265. doi: 10.2139/ssrn.2830341.

Guillet, F., & Semal, L. (2018). Policy flaws of biodiversity offsetting as a conservation strategy. *Biological Conservation, 221*, 86–90. doi: 10.1016/j.biocon.2018.03.001

Gunduwa Regional Conservation Association (GRCA) (2017). *Business Plan: Collaboration across the landscape*. Gunduwa Regional Conservation Association. Retrieved from: https://gunduwa.org.au/wp-content/uploads/2016/05/GUNDUWA-BUSINESS-PLAN-4th-Edition.pdf

Habel, J. C., Rasche, L., Schneider, U.A., Engler, J.O., Schmid, E., Rödder, D., Meyer, S.T., Trapp, N., Sos del Diego, R., Eggermont, H., Lens, L., & Storket N. E. (2019). Final countdown for biodiversity hotspots. *Conservation Letters, 12*(6), e12668. Doi: 10.1111/conl.12668

Habib, T. J., Farr, D. R., Schneider, R. R., & Boutin, S. (2013). Economic and ecological outcomes of flexible biodiversity offset systems. *Conservation Biology, 27*(6), 1313–1323. Doi: 10.1111/cobi.12098

Habibullah, S., Din, B. H., Tan, S. H., & Zahid, H. (2021). Impact of climate change on biodiversity loss: Global evidence. *Environmental Science and Pollution Research, 29*, 1073–1086. https://doi.org/10.1007/s11356-021-15702-8

Hahn, T., Koh, N.S., & Elmqvist, T. (2022). No net loss of biodiversity, green growth, and the need to address drivers. *One Earth*. doi: 10.1016/j.oneear.2022.05.022

Hahn, R., & Richards, K. (2013). Understanding the effectiveness of environmental offset policies. *Journal of Regulatory Economics, 44*(1), 103–119. doi: 10.1007/s11149-013-9211-1

Harper, D. J., & Quigley, J. T. (2005). A comparison of the areal extent of fish habitat gains and losses associated with selected compensation projects in Canada. *Fisheries, 30*, 18–25. doi: 10.1577/1548-8446

Harvard Growth Lab (2020). *Atlas of economic complexity: Australia.* Retrieved from: https://atlas.cid.harvard.edu/countries/14

Hermoso, V., Morán-Ordóñez, A., Canessa, S., & Brotons, L. (2019). A dynamic strategy for EU conservation. *Science, 363*(6427) 592–593. doi: 10.1126/science.aaw3615

Hillebrand, H., & Matthiessen, B. (2009), Biodiversity in a complex world: consolidation and progress in functional biodiversity research. *Ecology Letters, 12*, 1405–1419. https://doi.org/10.1111/j.1461-0248.2009.01388.x

Hooper, D.U., Chapin, F.S., III, Ewel, J.J., Hector, A., Inchausti, P., Lavorel, S., Lawton, J.H., Lodge, D.M., Loreau, M., Naeem, S., Schmid, B., Setälä, H., Symstad, A.J., Vandermeer, J., & Wardle, D.A. (2005). Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. *Ecological Monographs, 75*, 3–35. https://doi.org/10.1890/04-0922

HM Treasury (2021). *The Economics of Biodiversity: The Dasgupta Review: Government Response*. The Crown, London, England. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1002824/Dasgupta_Response__web_July.pdf

Independent review of the EPBC Act. (2020). *About the Review*. Retrieved from: https://epbcactreview.environment.gov.au/about-review

INPEX (2012). *Coastal Offsets Strategy*. INPEX Corporation, Perth, Western Australia.

International Association for Impact Assessment (IAIA). (2009). *What is Impact Assessment?* International Association for Impact Assessment, Fargo, United States. Retrieved from: https://www.iaia.org/wiki-details.php?ID=4

International Finance Corporation (IFC) (2022). *Performance Standard 6.* Retrieved from:

https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/performance-standards/ps6

International Institute for Sustainable Development (IISD) (2017). *Topic: Sustainable development*. Retrieved from: http://www.iisd.org/topic/sustainable-development

Iritie, B. G. J. J. (2015). Economic growth and biodiversity: An overview conservation policies in Africa. *Journal of Sustainable Development, 8*(2), 196–208. doi: 10.5539/jsd.v8n2p196

Isbell, F., Balvanera, P., Mori, A. S., He, J.-S., Bullock, J. M., Regmi, G. R., Seabloom, E. W., Ferrier, S., Sala, O. E., Guerrero-Ramírez, N. R., Tavella, J., Larkin, D. J., Schmid, B., Outhwaite, C. L., Pramual, P., Borer, E. T., Loreau, M., Omotoriogun, T. C., Obura, D. O., Anderson, M., Portales-Reyes, C., Kirkman, K., Vergara, P. M., Clark, A. T., Komatsu, K. J., Petchey, O. L., Weiskopf, S. R., Williams, L. J., Collins, S. L., Eisenhauer, N., Trisos, C. H., Renard, D., Wright, A. J., Tripathi, P., Cowles, J., Byrnes, J. E., Reich, P. B., Purvis, A., Sharip, Z., O'Connor, M. I., Kazanski, C. E., Haddad, N. M., Soto, E. H., Dee, L. E., Díaz, S., Zirbel, C. R., Avolio, M. L., Wang, S., Ma, Z., Liang, J., Farah, H. C., Johnson, J. A., Miller, B. W., Hautier, Y., Smith, M. D., Knops, J. M., Myers, B. J., Harmáčková, Z. V., Cortés, J., Harfoot, M. B., Gonzalez, A., Newbold, T., Oehri, J., Mazón, M., Dobbs, C., & Palmer, M. S. (2022). Expert perspectives on global biodiversity loss and its drivers and impacts on people. *Frontiers in Ecology and the Environment,* 21(2), 94–103 doi: 10.1002/fee.2536

Jacob, C., Buffard, A., Pioch, S., & Thorin, S. (2018). Marine ecosystem restoration and biodiversity offset. *Ecological Engineering, 120*, 585–594. doi: 10.1016/j.ecoleng.2017.09.007

Jacob, C., Vaissiere, A.-C., Bas, A., & Calvet, C. (2016). Investigating the inclusion of ecosystem services in biodiversity offsetting. *Ecosystem Services, 21*, 92–102. doi: 10.1016/j.ecoser.2016.07.010

Jaureguiberry, P., Titeux, N., Wiemers, M., Bowler, D. E., Coscieme, L., Golden, A. S., Guerra, C. A., Jacob, U., Takahashi, Y., Settele, J., Díaz, S., Molnár, Z., & Purvis, A. (2022). The direct drivers of recent global anthropogenic biodiversity loss. *Science Advances, 8*(45), eabm9982. doi: 10.1126/sciadv.abm9982

Johansson, T., Hjältén, J., de Jong, J., & von Stedingk, H. (2013). Environmental considerations from legislation and certification in managed forest stands: A review of their importance for biodiversity. *Forest Ecology and Management, 303*, 98–112. https://doi.org/10.1016/j.foreco.2013.04.012.

Josefsson, J., Ahlbäck Widenfalk, L., Blicharska, M., Hedblom, M., Pärt, T., Ranius, T., & Öckinger, E. (2021). Compensating for lost nature values through biodiversity offsetting – Where is the evidence? *Biological Conservation, 257*, 109117. doi: 10.1016/j.biocon.2021.109117

Kamijo, T. (2020). *Prospects of integrating biodiversity offsets in Japan's cooperation projects: A review of experience from developing countries.* JICA Research Institute, Shinjuku-ku, Japan. Retrieved from: https://www.jica.go.jp/jica-ri/publication/workingpaper/wp_203.html

Kier, G., Kreft, H., Lee, T. M., Jetz, W., Ibisch, P. L., Nowicki, C., Mutke, J., & Barthlott, W. (2009). A global assessment of endemism and species richness across island and mainland regions. *Proceedings of the National Academy of Sciences (PNAS) 106*(23), 9322–9327. doi: 10.1073/pnas.0810306106

Kiesecker, J. M., Copeland, H., Pocewicz, A., Nibbelink, N., McKenney, B., Dahlke, J., Holloran, M., & Stroud, D. (2009). A framework for implementing biodiversity offsets: selecting sites and determining scale. *BioScience, 59*(1), 77–84. https://doi.org/10.1525/bio.2009.59.1.11

King, S., & Wilson, L. (2015). *Experimental biodiversity accounting as a component of the System of Environmental- Economic Accounting Experimental Ecosystem Accounting (SEEA-EEA)*. Supporting document to the Advancing the SEEA Experimental Ecosystem Accounting project. United Nations. Retrieved from: http://urban.nina.no/documents/5/download

Kleining, B. (2017). Biodiversity protection under the habitats directive: Is habitats banking our new hope? *Environmental Law Review, 19*(2), 113–125. doi: 10.1177/1461452917714442

Koch, J. M. & Ward, S. C. (2005). Thirteen-year growth of jarrah (*Eucalyptus marginata*) on rehabilitated bauxite mines in south-western Australia. *Australian Forestry 68*(3), 176–185. Retrieved from: http://svc043.wic023v.server-web.com/pdf/pdf-members/afj/AFJ%202005%20v68/AFJ%20September%202005%2068-3/jkoch.pdf

Koh, N. S., Hahn, T., & Ituarte-Lima, C. (2014). *A comparative analysis of ecological compensation programs: The effect of program design on the social and ecological outcomes* (Masters). Uppsala University, Sweden. Retrieved from: https://www.diva-portal.org/smash/get/diva2:772933/FULLTEXT01.pdf

Kormos, R., Mead, D., & Vinnedge, B. (2015). *Biodiversity offsetting in the United States: Lesson learned on maximising their ecological potential*. Retrieved from: https://assets.fauna-flora.org/wp-content/uploads/2017/12/FFI_2015_Biodiversity-offsets-USA.pdf

Kujala, H., Whitehead, A. L., Morris, W. K., & Wintle, B. A. (2015). Towards strategic offsetting of biodiversity loss using spatial prioritization concepts and tools: A case study on mining impacts in Australia. *Biological Conservation, 192*, 513–521. doi: 10.1016/j.biocon.2015.08.017

Kuras, E. R., Warren, P. S., Zinda, J. A., Aronson, M. F. J., Cilliers, S., Goddard, M. A., Nilon, Charles H., & Winkler, R. (2020). Urban socioeconomic inequality and biodiversity often converge, but not always: A global meta-analysis. *Landscape and Urban Planning, 198*, 103799. doi:10.1016/j.landurbplan.2020.103799

Kylin, H. L. (2017). *Assessing the performance of Ecological Compensation in Sweden: A comparative case study of an emerging tool in different contexts*. (Masters), Stockholm University, Stockholm, Sweden. Retrieved from: http://www.diva-portal.org/smash/get/diva2:1110722/FULLTEXT01.pdf

Laitila, J., Moilanen, A., & Pouzols, F. M. (2014). A method for calculating minimum biodiversity offset multipliers accounting for time discounting, additionality and permanence. *Methods in Ecology and Evolution 5*: 1247–1254.

Lambers, H. & Bradshaw, D. (2016). *Australia's south west: a hotspot for wildlife and plants that deserves World Heritage status*. The Conversation. Retrieved from: https://theconversation.com/australias-south-west-a-hotspot-for-wildlife-and-plants-that-deserves-world-heritage-status-54885

Lefcheck, J., Byrnes, J., Isbell, F. Gamfeldt, L., Griffin, J. N., Eisenhauer, N., Hensel, M. J. S., Hector, A., Cardinale B. J. & Duffy J. E. (2015). Biodiversity enhances ecosystem multifunctionality across trophic levels and habitats. *Nature Communications 6,* 6936. doi: 10.1038/ncomms7936

Le Coënt, P., Preget, R., & Thoyer, S. (2016). *Compensating environmental losses versus creating environmental gains: Implications for biodiversity offsets and agri-environmental contracts.* 90th Annual Conference of the Agricultural Economics Society, 4–6 April 2016, University of Warwick, England. doi: 10.22004/ag.econ.236365

Levin, L., & Olsson, L. (2015). *Upsetting offsets: A case study of Colombia and their legislation of biodiversity offsetting.* (Masters), Linköping University, Linköping,

Sweden. Retrieved from: http://www.diva-portal.org/smash/get/diva2:856041/FULLTEXT01.pdf

Lim, F. K. S., Carrasco, L. R., McHardy, J., & Edwards, D. P. (2017). Perverse market outcomes from biodiversity conservation interventions. *Conservation Letters, 10*(5), 506–516. doi: 10.1111/conl.12332

Lindenmayer, D. B., Crane, M., Evans, M. C., Maron, M., Gibbons, P., Bekessy, S., & Blanchard, W. (2017). The anatomy of a failed offset. *Biological Conservation, 210*, 286–292. doi: 10.1016/j.biocon.2017.04.022

Lodhia, S., Martin, N., & Rice, J. (2018). Appraising offsets as a tool for integrated environmental planning and management. *Journal of Cleaner Production, 178*, 34–44. doi: 10.1016/j.jclepro.2018.01.004

Lohbeck, M., Bongers, F., Martinez-Ramos, M., Poorter, L. (2016). The importance of biodiversity and dominance for multiple ecosystem functions in a human-modified tropical landscape. *Ecology, 97*(10), 2772–2779. doi: 10.1002/ecy.1499

Lukey, P., Cumming, T., Paras, S., Kubiszewski, I., & Lloyd, S. (2017). Making biodiversity offsets work in South Africa: A governance perspective. *Ecosystem Services, 27*, 281–290. doi:10.1016/j.ecoser.2017.05.001

Ma, D. (2022). *Ecosystem services offsets in coastal areas*. (Doctor of Philosophy). University of Queensland, Australia. Retrieved from: https://espace.library.uq.edu.au/view/UQ:2dc1928

Mabon, L., Song Tung, N., Thi Kim Dung, N., Thi Tram, P., Thi Thanh Nga, C., Thu Quynh, L., Thanh Trung, D., Thi Huyen Thu, N., Thi Bich Nguyet, N., Hong Ngoc, L., Thi Tuyet, T., Thi Cam Tu, B., Ngoc Anh, T., Mueller-Hirth, N., & Yuill, C. (2018). Bringing social and cultural considerations into environmental management for vulnerable coastal communities: Responses to environmental

change in Xuan Thuy National Park, Nam Dinh Province, Vietnam. *Ocean & Coastal Management, 158*, 32–44. doi: 10.1016/j.ocecoaman.2018.03.022

Mace, G. M., Barrett, M., Burgess, N. D., Cornell, S. E., Freeman, R., Grooten, M., & Purvis, A. (2018). Aiming higher to bend the curve of biodiversity loss. *Nature Sustainability, 1*(9), 448–451. doi: 10.1038/s41893-018-0130-0

Macura, B., Suškevičs, M., Garside, R., Hannes, K., Rees, R., & Rodela, R. (2019). Systematic reviews of qualitative evidence for environmental policy and management: An overview of different methodological options. *Environmental Evidence, 8*(24). doi: 10.1186/s13750-019-0168-0

Macintosh, A. (2015). The impact of ESD on Australia's environmental institutions. *Australasian Journal of Environmental Management, 22*(1), 33–45. doi: 10.1080/14486563.2014.999724

MacLaren, L. 2017. *Roe 8 offset plan fundamentally flawed: Greens*. Retrieved from: http://lynnmaclaren.org.au/news/roe-8-offset-plan-fundamentally-flawed-greens.

Madsen, B., Carroll, N., Kandy, D., & Bennett, G. (2011). *2011 update: State of biodiversity markets*. Forest Trends, Washington, D.C. Retrieved from: http://www.ecosystemmarketplace.com/reports/2011_update_sbdm

Mandle, L., Douglass, J., Lozano, J. S., Sharp, R. P., Vogl, A. L., Denu, D., Walschburger, T., & Tallis, H. (2016). OPAL: An open-source software tool for integrating biodiversity and ecosystem services into impact assessment and mitigation decisions. *Environmental Modelling & Software 84*, 121–133. doi:10.1016/j.envsoft.2016.06.008.

Mann, C. (2015). Strategies for sustainable policy design: Constructive assessment of biodiversity offsets and banking. *Ecosystem Services*, *16*, 266–274. doi:10.1016/j.ecoser.2015.07.001.

Maron, M. (2012). *Replacing lost ecosystems - the devil is in the detail: Balancing biodiversity offsets with restoration reality.* Decision Point, 63.

Maron, M., Brownlie, S., Bull, J. W., Evans, M. C., von Hase, A., Quétier, F., Watson, J. E. M., & Gordon, A. (2018). The many meanings of no net loss in environmental policy. *Nature Sustainability, 1*(1), 19–27. doi: 10.1038/s41893-017-0007-7

Maron, M., Bull, J. W., Evans, M. C., & Gordon, A. (2015). Locking in loss: Baselines of decline in Australian biodiversity offset policies. *Biological Conservation, 192*, 504–512. doi: 10.1016/j.biocon.2015.05.017

Maron, M., Dunn, P. K., McAlpine, C. A., & Apan, A. (2010). Can offsets really compensate for habitat removal? The case of the endangered red-tailed black-cockatoo. *Journal of Applied Ecology, 47*, 348–355. doi:1365-2664.2010.01787.x

Maron, M., Gordon, A., Mackey, B. G., Possingham, H. P., & Watson, J. E. M. (2016a). Interactions between biodiversity offsets and protected area commitments: Avoiding perverse outcomes. *Conservation Letters, 9*(5), 384–389. doi: 10.1111/conl.12222

Maron, M., Hobbs, R. J., Moilanen, A., Matthews, J. W., Christie, K., Gardner, T. A., Keith, D. A., Lindenmayer, D. B., & McAlpine, C. A. (2012). Faustian bargains? Restoration realities in the context of biodiversity offset policies. *Biological Conservation, 155*, 141–148. doi: 10.1016/j.biocon.2012.06.003

Maron, M., Ives, C. D., Kujala, H., Bull, J. W., Maseyk, F. J. F., Bekessy, S., Gordon, A., Watson, J. E. M., Lentini, P. E., Gibbons, P., Possingham, H. P., Hobbs, R. J., Keith, D. A., Wintle, B. A.& Evans, M. C. (2016b). Taming a wicked problem: Resolving controversies in biodiversity offsetting. *BioScience, 66*(6), 489–498. doi:10.1093/biosci/biw038

Maron, M., & Louis, W. R. (2018). Does it matter why we do restoration? Volunteers, offset markets and the need for full disclosure. *Ecological Management & Restoration, 19*, 73–78. doi: 10.1111/emr.12330

Marselle, M. R., Hartig, T., Cox, D. T. C., de Bell, S., Knapp, S., Lindley, S., Triguero-Mas, M., Böhning-Gaese, K., Braubach, M., Cook, P. A., de Vries, S., Heintz-Buschart, A., Hofmann, M., Irvine, K. N., Kabisch, N., Kolek, F., Kraemer, R., Markevych, I., Martens, D., Müller, R., Nieuwenhuijsen, M., Potts, J. M., Stadler, J., Walton, S., Warber, S. L., Aletta Bonn, A. (2021). Pathways linking biodiversity to human health: A conceptual framework. *Environment International*,*150*, 106420. doi: 10.1016/j.envint.2021.106420.

Martin, N., Evans, M., Rice, J., Lodhia, S., & Gibbons, P. (2016). Using offsets to mitigate environmental impacts of major projects: A stakeholder analysis. *Journal of Environmental Management, 179*, 58–65. doi: 10.1016/j.jenvman.2016.04.054

Maseyk, F. J. F., Barea, L. P., Stephens, R. T. T., Possingham, H. P., Dutson, G., & Maron, M. (2016). A disaggregated biodiversity offset accounting model to improve estimation of ecological equivalency and no net loss. *Biological Conservation, 204*, 322–332. doi: 10.1016/j.biocon.2016.10.016

May, J., Hobbs, R. J., & Valentine, L. E. (2017). Are offsets effective? An evaluation of recent environmental offsets in Western Australia. *Biological Conservation, 206*, 249–257. doi: 10.1016/j.biocon.2016.11.038

Mazor, T., Doropoulos, C., Schwarzmueller, F., Gladish, D. W., Kumaran, N., Merkel, K., Di Marco, M., & Gagic, V. (2018). Global mismatch of policy and research on drivers of biodiversity loss. *Nature Ecology & Evolution, 2*(7), 1071–1074. doi: 10.1038/s41559-018-0563-x

McCaw, L., Robinson, R. & Williams, M. R. (2011). Integrated biodiversity monitoring for the Jarrah (*Eucalyptus marginata*) Forest in south-west Western Australia:

The FORESTCHECK project. *Australian Forestry, 74*(4), 240–253. doi: 10.1080/00049158.2011.10676369

McDonald, J., McCormack, P. C., & Foerster, A. (2016). Promoting resilience to climate change in Australian conservation law: The case of biodiversity offsets. *UNSW Law Journal, 39*(4), 1612–1651. Retrieved from: https://www.unswlawjournal.unsw.edu.au/wp-content/uploads/2017/09/39-4-4.pdf

McElwee, P. (2017). The metrics of making ecosystem services. *Environment and Society, 8*(1), 96–124. doi: 10.3167/ares.2017.080105

McEnvoy, S. (2013). *Environmental offsets*. Biodiversity Offsetting for Mining & Energy Development Conference, 9–10 April, Four Points by Sheraton Hotel, Perth, Western Australia.

McKenney, B. (2005). *Environmental offset policies, principles, and methods: A review of selected legislative frameworks*. Biodiversity Neutral Initiative. Retrieved from: https://www.forest-trends.org/publications/environmental-offset-policies-principles-and-methods-a-review-of-selected-legislative-frameworks-2/

McKenney, B. A., & Kiesecker, J. M. (2010). Policy development for biodiversity offsets: a review of offset frameworks. *Environmental Management, 45*(1), 165–176. http://link.springer.com/article/10.1007%2Fs00267-009-9396-3

McKenzie, N. L., May, J. E. & and McKenna, S. (2003). *A biodiversity audit of Western Australia's 53 Biogeographical Subregions in 2002. Department of Conservation and Land Management.* Kensington, Western Australia. Retrieved from: https://www.dpaw.wa.gov.au/images/documents/about/science/projects/waaudit/2002_bio_summary.pdf

Meyers, D., Bohorquez, J., Cumming, T., Emerton, L., Heuvel, O.v.d., Riva, M., and Victurine, R. (2020). *Conservation finance: A framework*. Conservation Finance Alliance. Retrieved from: https://static1.squarespace.com/static/57e1f17b37c58156a98f1ee4/t/5e728a4e1e6cc747e7cdbdc2/1584564815888/Conservation+Finance+Framework+March+2020.pdf

Middle, G. (2019). *The national biodiversity offsets conference workshop outcomes*. The National Biodiversity Offsets Conference, 26–28 August, Hotel Realm, Canberra, ACT. Retrieved from: https://static1.squarespace.com/static/55165963e4b05c72e7f1d862/t/5e09a1b3e3302c0f49dd0f67/1577689541208/The+2019+National+Biodiversity+Offsets+Conference+-+Workshop+Outcomes_Final_Final.pdf

Midgley, D. (2015). *Biodiversity offsets: Towards an effective legal framework in South Africa*. (LLM), University of Cape Town, Cape Town, South Africa. Retrieved from: https://open.uct.ac.za/handle/11427/15166

Millennium Ecosystem Assessment (MEA) (2005). *A Report of the Millennium Ecosystem Assessment*: *Ecosystems and Human Well-Being*. Island Press, Washington DC.

Miller, K. L., Trezise, J. A., Kraus, S., Dripps, K., Evans, M. C., Gibbons, P., Possingham, H. P., & Maron, M. (2015). The development of the Australian environmental offsets policy: From theory to practice. *Environmental Conservation, 42*(4), 306–314. doi: 10.1017/s037689291400040x

Minerals Council of Australia (MCA) (2020) *Partnerships in action: Great Victoria Desert biodiversity trust.* Minerals Council of Australia. Retrieved from: http://www.tropicanajv.com.au/irm/PDF/791ab056-2f09-45fe-aa0d-fd0eafd66999/GVDBiodiversityTrust2020FactSheet

Moilanen, A., & Kotiaho, J. S. (2018). Fifteen operationally important decisions in the planning of biodiversity offsets. *Biological Conservation, 227*, 112–120. doi: 10.1016/j.biocon.2018.09.002

Moilanen, A., & Laitila, J. (2015). Indirect leakage leads to a failure of avoided loss biodiversity offsetting. *Journal of Applied Ecology, 53*(1) 106–111. doi: 10.1111/1365-2664.12565

Moilanen, A., van Teeffelen, A. J. A., Ben-Haim, Y., & Ferrier, S. (2009). How much compensation is enough? A framework for incorporating uncertainty and time discounting when calculating offset ratios for impacted habitat. R*estoration Ecology, 17*(4), 470–478. doi: 10.1111/j.1526–100X.2008.00382.x

Moldan, B. & Dahl, A. L. (2007). Challenges to sustainability indicators. In Hák, T., Moldan, B. & Dahl, A. L. (Eds). *Sustainability indicators: A scientific assessment*. Island Press, Washington, D.C., USA.

More to Mining (2022). *AngloGold Ashanti and the Great Victoria Desert biodiversity trust*. Minerals Council of Australia. Retrieved from: https://www.moretomining.com.au/case-studies/anglogold-ashanti-and-the-great-victoria-desert-biodiversity-trust

Moreno-Mateos, D., Maris, V., Béchet, A., & Curran, M. (2015). The true loss caused by biodiversity offsets. *Biological Conservation, 192*, 552–559. doi: 10.1016/j.biocon.2015.08.016

Morley, J., Buchanan, G., Edward T.A. Mitchard, E. T. A. & Keane, A. (2020). Implications of the World Bank's environmental and social framework for biodiversity. *Conservation Letters, 14*(1) e12759. doi: 10.1111/conl.12759

Myers, N., Mittermeier, R., Mittermeier, C., de Fonseca, G. A. B. & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature, 403*, 853–858. doi: 10.1038/35002501

Narain, D., & Maron, M. (2018). Cost shifting and other perverse incentives in biodiversity offsetting in India. *Conservation Biology, 32*(4), 782–788. doi: 10.1111/cobi.13100

Natural and Cultural Heritage Division (NCHD) (2015). *Guidelines for natural values surveys - terrestrial development proposals*. Department of Primary Industries, Parks, Water and Environment, Hobart, Tasmania. Retrieved from http://dpipwe.tas.gov.au/Documents/Guidelines%20for%20Natural%20Values%20Surveys%20related%20to%20Development%20Proposals.pdf

Nijnik, M., & Miller, D. (2017). Valuation of ecosystem services: paradox or Pandora's box for decision-makers? *One Ecosystem, 2*, e14808. doi: 10.3897/oneeco.2.e14808

Niner, H. J., Milligan, B., Jones, P. J. S., & Styan, C. A. (2017). Realising a vision of no net loss through marine biodiversity offsetting in Australia. *Ocean & Coastal Management, 148*, 22–30. doi: 10.1016/j.ocecoaman.2017.07.006

Noga, W. (2014). *Two papers on the cost effectiveness of conservation programs*. (Masters), University of Alberta, Alberta, Canada. Retrieved from: https://era.library.ualberta.ca/items/180e37a2-ac6d-4e74-aa58-a3c6470fcf73

Northern Territory Environmental Protection Authority (NTEPA) (2013). *Guidelines on environmental offsets and associated approval conditions*. Northern Territory Environmental Protection Authority, Darwin, Northern Territory. Retrieved from: https://ntepa.nt.gov.au/__data/assets/pdf_file/0007/287431/guideline_assessment_environmental_offsets.pdf

Norton, D. A. (2009). Biodiversity offsets: Two New Zealand case studies and an assessment framework. *Environmental Management, 43*(4), 698–706. doi: 10.1007/s00267-008-9192-5

Norton, D. A., & Warburton, B. (2014). The potential for biodiversity offsetting to fund effective invasive species control. *Conservation Biology, 29*(1), 5–11. doi: 10.1111/cobi.12345

O'Brien, A. (2020). *Critical review of assumptions of gains in biodiversity under Victorian offsetting policy*. (Masters), RMIT University, Melbourne, Victoria. doi: 10.31219/osf.io/nv4za

Oettle, R. 2008. *The environment for sale?* (Masters), Lund University, Lund, Sweden. Retrieved from: https://www.lumes.lu.se/sites/lumes.lu.se/files/oettle_ruth.pdf

Office of Environment and Heritage (OEH) (2017). *Biodiversity Offsets Scheme*. Office of Environment and Heritage, Sydney, NSW. Retrieved from: https://www.environment.nsw.gov.au/biodiversity/offsetsscheme.htm

Oliver, T. H., Heard, M. S., Isaac, N. J. B., Roy, D. B., Procter, D., Eigenbrod, F., Freckleton, R., Hector, A., Orme, C. D. L., Petchey, O. L., Proença, V., Raffaelli, D., Suttle, K. B., Mace, G. M., Martín-López, B., Woodcock, B. A., & Bullock, J. M. (2015). Biodiversity and resilience of ecosystem functions. *Trends in Ecology & Evolution, 30*(11), 673–684. doi: 10.1016/j.tree.2015.08.009

Overton, J. M., Stephens, R. T., & Ferrier, S. (2013). Net present biodiversity value and the design of biodiversity offsets. *Ambio, 42*(1), 100–110. doi: 10.1007/s13280-012-0342-x

Ozdemiroglu, E., Kriström, B., Cole, S., Riera, P., & Borrego, D. A. (2009). *Environmental Liability Directive and the use of economics in compensation, offsets and habitat banking*. UK Network for Environmental Economists, March, London, England. Retrieved from: https://www.researchgate.net/publication/237713726_Environmental_Liability_

Directive_and_the_use_of_economics_in_compensation_offsets_and_habitat_banking

Palliggiano, D., Pedroni, P. M., Pavanel, E., Marconi, M., Baizhigitova, A., Sali, J., Reed, T., & Howard, P. (2012). *Addressing and managing reliance and potential impacts on biodiversity and ecosystem services of Oil & Gas global operations*. International Conference on Health Safety and Environment in Oil and Gas Exploration and Production, 11–13 September 2012, Perth Convention and Exhibition Centre, Perth, Western Australia. Retrieved from: https://www.proceedings.com/16126.html

Pascual, U., Palomo, I., Adams, W. M., Chan, K. M. A., Daw, T. M., Garmendia, E., Gómez-Baggethun, E., de Groot, R. S., Mace, G. M., Martín-López, B., & Phelps, J. (2017). Off-stage ecosystem service burdens: A blind spot for global sustainability. *Environmental Research Letters, 12*(7), 075001. doi: 10.1088/1748-9326/aa7392

Peel, J., & Godden, L. (2005). Australian environmental management: A 'dams' story. *University of New South Wales Law Journal, 28*(3), 668–695. Retrieved from: https://www.unswlawjournal.unsw.edu.au/article/australian-environmental-management-a-dams-story

Phalan B, Hayes G, Brooks S, Marsh, D., Howard, P., Costelloe, B., Vira, B., Kowalska, A., & Whitaker, S. (2018). Avoiding impacts on biodiversity through strengthening the first stage of the mitigation hierarchy. *Oryx, 52*(2), 316–324. doi:10.1017/S0030605316001034

Pilgrim, J. D., Brownlie, S., Ekstrom, J. M. M., Gardner, T. A., von Hase, A., ten Kate, K., Savy, C. E., Stephens, R.T., Temple, H. J., & Treweek, J. (2013). A process for assessing the offsetability of biodiversity impacts. *Conservation Letters, 6*(5), 376–384. doi: 10.1111/conl.12002

Pilla, E. (2014). *Towards the development of metrics for no net loss biodiversity in Peru.* Technical note No. IDB-TN-708. Inter-American Development Bank, Washington D.C., USA. Retrieved from: https://publications.iadb.org/publications/english/viewer/Towards-the-Development-of-Metrics-for-No-Net-Loss-of-Biodiversity-in-Peru.pdf

Pittock, J., Cork, S., & Maynard, S. (2012). The state of the application of ecosystems services in Australia. *Ecosystem Services, 1*(1), 111–120. doi: 10.1016/j.ecoser.2012.07.010

Podhorsky, A. (2020). Environmental certification programs: How does information provision compare with taxation? *Journal of Public Economic Theory*, *22,* 1772–1800. doi: 10.1111/jpet.12450

Pope, J., Bond, A., Hugé, J., & Morrison-Saunders, A. (2017). Reconceptualising sustainability assessment. *Environmental Impact Assessment Review, 62*, 205–215. doi: 10.1016/j.eiar.2016.11.002

Pope, J., Morrison-Saunders, A., Bond, A., & Retief, F. (2021). When is an offset not an offset? A framework of necessary conditions for biodiversity offsets. *Environmental Management, 67*(2), 424–435. doi: 10.1007/s00267-020-01415-0

Pörtner, H.O., Scholes, R.J., Agard, J., Archer, E., Arneth, A., Bai, X., Barnes, D., Burrows, M., Chan, L., Cheung, W.L., Diamond, S., Donatti, C., Duarte, C., Eisenhauer, N., Foden, W., Gasalla, M. A., Handa, C., Hickler, T., Hoegh-Guldberg, O., Ichii, K., Jacob, U., Insarov, G., Kiessling, W., Leadley, P., Leemans, R., Levin, L., Lim, M., Maharaj, S., Managi, S., Marquet, P. A., McElwee, P., Midgley, G., Oberdorff, T., Obura, D., Osman, E., Pandit, R., Pascual, U., Pires, A. P. F., Popp, A., Reyes-García, V., Sankaran, M., Settele, J., Shin, Y. J., Sintayehu, D. W., Smith, P., Steiner, N., Strassburg, B., Sukumar, R., Trisos, C., Val, A.L., Wu, J., Aldrian, E., Parmesan, C., Pichs-Madruga, R., Roberts, D.C., Rogers, A.D., Díaz, S., Fischer, M., Hashimoto,

S., Lavorel, S., Wu, N., & Ngo, H.T. (2021). *IPBES-IPCC co-sponsored workshop report on biodiversity and climate change*. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and Intergovernmental Panel on Climate Change (IPCC). doi: 10.5281/zenodo.4782538

Poulton, D. W., & Bell, A. (2017). *Navigating the Swamp: Lessons on Wetland Offsetting for Ontario*. Ontario Nature's Greenway Guide Series, Ontario Nature. Toronto, Canada. doi: 10.2139/ssrn.3066226

Prévost, B., & Rivaud, A. (2019). From conservation to offsetting and neoliberalization: Institutional change, risks and opportunities in the French context. *Environment and Planning E: Nature and Space, 2*(2), 323–347. doi: 10.1177/2514848619836039

Queensland Government (QG) (2018). *Environmental Offsets: Legislation*. Queensland Government, Brisbane, Queensland. Retrieved from: https://www.qld.gov.au/environment/pollution/management/offsets

Queensland Government (QG) (2022a). *Deciding how to deliver an environmental offset: Financial settlement offset*. Queensland Government, Qld. Retrieved from: https://www.qld.gov.au/environment/management/environmental/offsets/delivering/delivering-financial

Queensland Government (QG) (2022b). *How does the government invest environmental offset funds?*. Queensland Government, Qld. Retrieved from: https://www.qld.gov.au/environment/management/environmental/offsets/investing-funds

Quétier, F., & Lavorel, S. (2011). Assessing ecological equivalence in biodiversity offset schemes: Key issues and solutions. *Biological Conservation, 144*(12), 2991–2999. doi: 10.1016/j.biocon.2011.09.002

Reid, C., & Nsoh, W. (2014). Whose ecosystem is it anyway? Private and public rights under new approaches to biodiversity conservation. *Journal of Human Rights and the Environment, 5*(2), 112–135. Retrieved from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2721733

Renwick, A. R., Robinson, C. J., Martin, T. G., May, T., Polglase, P., Possingham, H. P., & Carwardine, J. (2014). Biodiverse planting for carbon and biodiversity on indigenous land. *PLoS One, 9*(3):e91281. doi: 10.1371/journal.pone.0091281

Reyers, B., Biggs, R., Cumming, G. S., Elmqvist, T., Hejnowicz, A. P., & Polasky, S. (2013). Getting the measure of ecosystem services: a social-ecological approach. *Frontiers in Ecology and the Environment, 11*(5), 268-273. doi: 10.1890/120144

Roberts, I. (2013). *Consideration of prospectivity in identifying land based conservation offsets*. Biodiversity Offsetting for Mining & Energy Development Conference, 9–10 April, Four Points by Sheraton Hotel, Perth, Western Australia.

Robinson, J. (2004). Squaring the circle? Some thoughts on the idea of sustainable development. *Ecological Economics, 48* 369–384. doi:10.1016/j.ecolecon.2003.10.017

Rogers, A. A., & Burton, M. P. (2016). *Public preferences for the design of biodiversity offset policies in Australia*. Working Paper 1601, School of Agricultural and Resource Economics, University of Western Australia, Crawley, Western Australia. doi: 10.22004/ag.econ.231533

Rohr, J. R., Bernhardt, E. S., Cadotte, M. W., & Clements, W. H. (2018). The ecology and economics of restoration: When, what, where, and how to restore ecosystems. *Ecology and Society, 23*(2). doi: 10.5751/es-09876-230215

Romanelli, C., Cooper, D., Campbell-Lendrum, D., Maiero, M., Karesh, W.B., Hunter, D., & Golden, C.D. (2015) *Connecting global priorities: biodiversity and human*

health: a state of knowledge review. World Health Organization and Secretariat of the Convention on Biological Diversity, Geneva, Switzerland. Retrieved from: https://www.who.int/publications/i/item/connecting-global-priorities-biodiversity-and-human-health

Rosa, J., Novachi, G., & Sánchez, L. E. (2016). *Offsetting and compensating biodiversity and ecosystem services losses in mining*. IAIA16: 36th Annual Conference of the International Association for Impact Assessment, 11–14 May 2016, Nagoya Congress Center, Aichi-Nagoya, Japan. Retrieved from: https://www.researchgate.net/publication/306248675_Offsetting_and_compensating_biodiversity_and_ecosystem_services_losses_in_mining

Rosa, J. C. S., Campos, P. B. R., Nascimento, C. B., Souza, B. A., Valetich, R., & Sánchez, L. E. (2022) Enhancing ecological connectivity through biodiversity offsets to mitigate impacts on habitats of large mammals in tropical forest environments. *Impact Assessment and Project Appraisal*. doi: 10.1080/14615517.2022.2090086

Roussel, S., Tardieu, L., & Vaissière, A.-C. (2017). *A Latent Class Approach to Investigate Farmers' Preferences for Biodiversity Offset Contracts*. 4th French Association of Environmental and Resource Economists Annual Conference, 12–13 September, Nancy, France. Retrieved from: http://faere.fr/pub/Conf2017/FAERE2017_Roussel.pdf

Ruppert, J. L. W., Hogg, J., & Poesch, M. S. (2018). Community assembly and the sustainability of habitat offsetting targets in the first compensation lake in the oil sands region in Alberta, Canada. *Biological Conservation, 219*, 138–146. doi: 10.1016/j.biocon.2018.01.014

Ruprecht, J. K. (2018). *Impact of forest disturbance on jarrah (*Eucalyptus marginata*) forest hydrology.* (Doctor of Philosophy), School of Veterinary and Life Sciences, Murdoch University, Australia. Retrieved from: https://researchrepository.murdoch.edu.au/id/eprint/40880/1/Ruprecht2018.pdf

Rural Development and Land Refrom (RDLR) (2017). *Land Audit Report November 2017, Version 2: Phase II: Private Land Ownership by Race, Gender And Nationality.* Rural Development and Land Refrom, Republic of South Africa. Retrieved from: https://cisp.cachefly.net/assets/articles/attachments/73229_land_audit_report13feb2018.pdf

Samuel, G. 2020. *Independent Review of the EPBC Act: Interim Report*. Department of Agriculture, Water and the Environment, Canberra, ACT. Retrieved from: https://epbcactreview.environment.gov.au/resources/interim-report

Scholte, S. S. K., van Zanten, B. T., Verburg, P. H., & van Teeffelen, A. J. A. (2016). Willingness to offset? Residents' perspectives on compensating impacts from urban development through woodland restoration. *Land Use Policy, 58*, 403–414. doi: 10.1016/j.landusepol.2016.08.008

Scott, A. (2022). Budadee Rangers deliver Environment Offset Fund project at Tharra to remove invasive weeds. *Pilbara News*. 7th April 2022. Retrieved from: https://libraryguides.vu.edu.au/apa-referencing/7Newspapers

Shutler, J., & Watson, A. (2020). *The oceans are absorbing more carbon than previously thought*. Retrieved from: https://www.weforum.org/agenda/2020/10/oceans-absorb-carbon-seas-climate-change-environment-water-co2/

Simmonds, J. S., von Hase, A., F., Q., Brownlie, S., Maron, M., Possingham, H. P., Souquet, M., zu Ermgassen, S. O. S. E., ten Kate, K., Costa, H. M., & Sonter, L. J. (2022). Aligning ecological compensation policies with the Post-2020 Global Biodiversity Framework to achieve real net gain in biodiversity. *Conservation Science and Practice, 4*, e12634. doi: 10.1111/csp2.12634

Simmonds, J. S., Sonter, L. J., Watson, J. E., et al. Bennun, L., Costa, H. N., Dutson, G., Edwards, S., Grantham, H., Griffiths, V. F., Jones, J. P. G., Kiesecker, J.,

Possingham, H. P., Puydarrieux, P., Quétier, F., Rainer, H., Rainey, H., Roe, D., Savy, C. E., Souquet, M., ten Kate, K., Victurine, R., von Hase, A., & Maron, M. (2020). Moving from biodiversity offsets to a target-based approach for ecological compensation. *Conservation Letters,* 13:e12695. doi: 10.1111/conl.12695

Simpson, K., de Vries, F. P., Armsworth, P., & Hanley, N. (2017). *Designing markets for biodiversity offsets: Lessons from tradable pollution permits*. Retrieved from: http://www.st-andrew doi: s.ac.uk/gsd/research/ eediscus/

Simpson, K. H., de Vries, F. P., Dallimer, M., Armsworth, P. R., & Hanley, N. (2022). Ecological and economic implications of alternative metrics in biodiversity offset markets. *Conservation Biology*, 36, e13906. doi: 10.1111/cobi.13906vecon/en

Spergel, B., & Mikitin, K., (2014). *Practice Standards for Conservation Trust Funds*. Conservation Finance Alliance, New York. Retrieved from: https://static1.squarespace.com/static/57e1f17b37c58156a98f1ee4/t/5953eae486e6c0fb1c81cb93/1498671896001/CFA_Standards_full-compressed.pdf

Sonter, L. J., Simmonds, J. S., Watson, J. E. M., Jones, J. P. G., Kiesecker, J. M., Costa, H. M., Bennun, L., Edwards, S., Grantham, H. S., Griffiths, V. F., Jones, K., Sochi, K., Puydarrieux, P., Quetier, F., Rainer, H., Rainey, H., Roe, D., Satar, M., Soares-Filho, B. S., Starkey, M., ten Kate, K., Victurine, R., von Hase, A., Wells, J. A., & Maron, M. (2020). Local conditions and policy design determine whether ecological compensation can achieve No net loss goals. *Nature Communications, 11*(1), 2072. doi:10.1038/s41467-020-15861-1

Standish, R. J, Daws, M. I., Gove, A. D., Didham, R. K., Grigg, A. H., Koch, J. M. & Hobbs, R. J. (2015). Long-term data suggest jarrah-forest establishment at restored mine sites is resistant to climate variability. *Journal of Ecology 103*(1), 78–89. Retrieved from: https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2745.12301

Steffen, W., Burbidge, S., Hughes, L., Kitching, R., Lindenmayer, D., Musgrave, W., Stafford Smith, M., & Werner, P. A. (2009). *Australia's biordiversity and climate change: A strategic assessment of the vulnerability of Australia's biodiversity to climate change.* A report to the Natural Resource Management Ministerial Council commissioned by the Australian Givernment. CSIRO Publishing. Retrieved from: https://www.agriculture.gov.au/sites/default/files/documents/biodiversity-vulnerability-assessment.pdf

Sudol, M. F., & Ambrose, R. F. (2002). The US Clean Water Act and habitat replacement: Evaluation of mitigation sites in Orange County, California, USA. *Environmental Management, 30*, 0727–0734. doi: 10.1007/s00267-002-2787-3

Sustainable Development Goals (SDG) (2015). *193 Member States*. Retrieved from: https://www.un.org/sustainabledevelopment/blog/tag/193-member-states/

Taherzadeh, O., & Howley, P. (2018). No net loss of what, for whom?: Stakeholder perspectives on biodiversity offsetting in England. *Environment, Development and Sustainability 20*, 1807–1830. doi: 10.1007/s10668-017-9967-z

Takacs, D. (2018). Are Koalas fungible? Biodiversity offsetting and the law. *N.Y.U. Environmental Law Journal, 26*(26.2), 161–226. Retrieved from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3195995

Tallis, H., Kennedy, C. M., Ruckelshaus, M., Goldstein, J., & Kiesecker, J. M. (2015). Mitigation for one & all: An integrated framework for mitigation of development impacts on biodiversity and ecosystem services. *Environmental Impact Assessment Review, 55*, 21–34. doi: 10.1016/j.eiar.2015.06.005

Tarabon, S., Dutoit, T., & Isselin-Nondedeu, F. (2021). Pooling biodiversity offsets to improve habitat connectivity and species conservation. *Journal of*

Environmental Management, 277, 111425. doi: 10.1016/j.jenvman.2020.111425

Taskforce on Nature-related Financial Disclosures (TNFD) (2023). *About*. Retrieved from: https://tnfd.global/about/

Teklehaimanot, K. W. (2014). *How is biodiversity operating? A study of its governance structure, strengths and weaknesses and the processes of institutionalizating it in the UK*. (Masters), Norwegian University of Life Sciences, Ås, Norway. Retrieved from: https://nmbu.brage.unit.no/nmbu-xmlui/handle/11250/219850

ten Kate, K., & Jeter, J. (2012). *Overview and status of the Business and Biodiversity Offsets Program*. International Conference on Health Safety and Environment in Oil and Gas Exploration and Production, 11–13 September 2012, Perth Convention and Exhibition Centre, Perth, Western Australia. Retrieved from: https://www.proceedings.com/16126.html

ten Kate, K., Bishop, J., & Bayon, R. (2004). *Biodiversity offsets: Views, experience, and the business case*. IUCN, Gland, Switzerland and Cambridge, UK and Insight Investment, London, UK. Retrieved from: https://www.forest-trends.org/wp-content/uploads/imported/34biodiv-offsets-views-experience-pdf.pdf

Thackway R. & Cresswell, I. D. (1995) (Eds). *An Interim Biogeographic Regionalisation for Australia: a framework for establishing the national system of reserves, Version 4.0*. Australian Nature Conservation Agency, Canberra, ACT. Retrieved from: https://www.dcceew.gov.au/environment/land/nrs/publications/ibra-framework-setting-priorities-nrs-cooperative-program

The Biodiversity Consultancy (TBC) (2013). *Government policies on biodiversity offsets*. The Biodiversity Consultancy, Cambridge, UK. Retrieved from:

https://www.thebiodiversityconsultancy.com/knowledge-and-resources/government-policies-on-biodiversity-offsets-72/

The Biodiversity Consultancy (TBC) (2015). *A cross-sector guide for implementing the Mitigation Hierarchy.* The Cross Sector Biodiversity Initiative. Retrieved from http://www.csbi.org.uk/our-work/mitigation-hierarchy-guide/

The Senate (2014). *Environment and Communications References Committee: Environmental offsets*. Commonwealth of Australia, Canberra, ACT. Retrieved from: https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Environmental_Offsets

Theis, S., Ruppert, J. L. W., Roberts, K. N., Minns, C. K., Koops, M., & Poesch, M. S. (2020). Compliance with and ecosystem function of biodiversity offsets in North American and European freshwaters. *Conservation Biology, 34*(1), 41–53. doi:10.1111/cobi.13343

Thompson, A. (2021). 'Greatest handbrake to investment': NSW to review biodiversity offset scheme. *The Sydney Morning Herald.* 6/08/2020. Retrieved from: https://www.smh.com.au/national/nsw/greatest-handbrake-to-investment-deputy-premier-says-biodiversity-offset-scheme-is-broken-20210806-p58ggc.html

Thrupp, L. A. (2008). The importance of biodiversity in agroecosystems. *Journal of crop improvement, 12*(1–2), 315–337. https://doi.org/10.1300/J411v12n01_03

Tierney, D. A., Sommerville, K. D., Tierney, K. E., Fatemi, M., & Gross, C. L. (2017). Trading populations—can biodiversity offsets effectively compensate for population losses? *Biodiversity and Conservation, 26*(9), 2115–2131. doi: 10.1007/s10531-017-1348-2

Towie, N. (2011). 'Corrupt' payouts ex-EPA Chief claims. *Sunday Times*. 13/11/2011.

Tropicana Joint Venture (2022). *Biodiversity trust*. AngloGold Ashanti Australia Ltd and Regis Resources Ltd. Retrieved from: http://www.tropicanajv.com.au/irm/content/biodiversity-trust1.aspx?RID=339

Tupala, A-K., Huttunen, S., & Panu Halme, P. (2022). Social impacts of biodiversity offsetting: A review. *Biological Conservation, 267*, 109431. doi: 10.1016/j.biocon.2021.109431.

Turner, R. E., Redmond, A. M., and Zedler, J. B. (2001). Count it by acre or function—mitigation adds up to net loss of wetlands. *National Wetlands Newsletter 23*(6), 5–16. Retrieved from: https://biotech.law.lsu.edu/blog/2001-ELI-turner.pdf

Underwood, J. G. (2011). Combining landscape-level conservation planning and biodiversity offset programs: A case study. *Environmental Management, 47*(1), 121–129. doi: 10.1007/s00267-010-9589-9

United Nations (UN) (2014). *System of Environmental- Economic Accounting 2012: Experimental Ecosystem Accounting*. Report developed by United Nations, European Union, Food and Agriculture Organization of the United Nations, Organisation for Economic Co-operation and Development, and World Bank Group. Retrieved from: https://unstats.un.org/unsd/envaccounting/seeaRev/eea_final_en.pdf

United Nations (UN) (2019). *Sustainable Development Goals: 17 goals to transform our world*. United Nations, Nairobi, Kenya. Retrieved from: https://www.un.org/sustainabledevelopment

United Nations (UN) (2020). *Life on land: Why it matters*. Retrieved from: https://www.un.org/sustainabledevelopment/wp-content/uploads/2019/07/15_Why-It-Matters-2020.pdf

United Nations (UN) (2022). *Press Release: Nations adopt four goals, 23 targets for 2030 in landmark UN biodiversity agreement*. Retrieved from:

https://www.un.org/sustainabledevelopment/blog/2022/12/press-release-nations-adopt-four-goals-23-targets-for-2030-in-landmark-un-biodiversity-agreement/

United Nations Climate Change (UNCC) (2023). *What is REDD+?* Retrieved from: https://unfccc.int/topics/land-use/workstreams/redd/what-is-redd#The-REDD-success-story

van Merwyk, T., & Daddo, S. (2009). *Structuring environmental offsets for a sustainable advantage.* Forest Trends. Washington, D.C. Retrieved from: https://www.forest-trends.org/publications/structuring-environmental-offsets-for-a-sustainable-advantage/

van Teeffelen, A. J. A., Opdam, P., Wätzold, F., Hartig, F., Johst, K., Drechsler, M., Vos, C. C., Wissel, S., & Quétier, F. (2014). Ecological and economic conditions and associated institutional challenges for conservation banking in dynamic landscapes. *Landscape and Urban Planning, 130*, 64–72. doi: 10.1016/j.landurbplan.2014.06.004

Villarroya, A., Barros, A. C., & Kiesecker, J. (2014). Policy development for environmental licensing and biodiversity offsets in Latin America. *PLoS One, 9*(9), e107144. doi: 10.1371/journal.pone.0107144

Walker, S., Brower, A. L., Stephens, R. T. T., & Lee, W. G. (2009). Why bartering biodiversity fails. *Conservation Letters, 2*(4), 149–157. doi: 10.1111/j.1755-263X.2009.00061.x

Walz, U. (2015). Indicators to monitor the structural diversity of landscapes. *Ecological Modelling, 295*, 88–106. doi: 10.1016/j.ecolmodel.2014.07.011

Wardell-Johnson, G. (2016). *EcoCheck: Australia's Southwest jarrah forests have lost their iconic giants*. The Conversation. Retrieved from: https://theconversation.com/ecocheck-australias-southwest-jarrah-forests-have-lost-their-iconic-giants-49150

Warren, R., VanDerWal, J., Price, J., Welbergen, J. A., Atkinson, I., Ramirez-Villegas, J., Osborn, T. J., Jarvis, A., Shoo, L. P., Williams, S. E., & Lowe, J. (2013). Quantifying the benefit of early climate change mitigation in avoiding biodiversity loss. *Nature Climate Change, 3*, 678–682. doi: 10.1038/nclimate1887

Watson, F. (2020). *Global carbon offsets market could be worth $200 billion by 2050: Berenberg*. S&P Global. Retrieved from: https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/natural-gas/051320-global-carbon-offsets-market-could-be-worth-200-bil-by-2050-berenberg

Whitford, K. R. & Williams, M. R. (2002). Hollows in jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*) trees: II. Selecting trees to retain for hollow dependent fauna. *Forest Ecology and Management 160*(1–3), 215–232. doi: 10.1016/S0378-1127(01)00446-7

Woinarski, J. C., Burbidge, A. A., & Harrison, P. L. (2015). Ongoing unraveling of a continental fauna: Decline and extinction of australian mammals since european settlement. *Procedings of the National Academy of Sciences of the United States of America 112*(15): 4531–4540. doi:10.1073/pnas.1417301112.

World Commission on Environment and Development (WCED) (1987). *Our common future*. Oxford University Press, Oxford. Retrieved from: http://www.un-documents.net/our-common-future.pdf

World Economic Forum (WEF) & PWC (2020). *Nature risk rising: Why the crisis engulfing nature matters for business and the economy*. New Nature Economy series. World Economic Forum, Geneva, Switzerland. Retrieved from: https://www3.weforum.org/docs/WEF_New_Nature_Economy_Report_2020.pdf

Yeates, D. K., Metcalfe, D. J., Westcott D. A. & Butler, A. (2020) Australia's biodiversity: status and trends. In: Morton, S., Sheppard, A., & Lonsdale M. (eds). *Biodiversity: Science and solutions for Australia*. CSIRO Publishing, Collingwood, Victoria. Retrieved from: www.csiro.au/biodiversitybook.

Yu, S., Cui, B., & Gibbons, P. (2018). A method for identifying suitable biodiversity offset sites and its application to reclamation of coastal wetlands in China. *Biological Conservation, 227*, 284–291. doi: 10.1016/j.biocon.2018.09.030

Yu, S., Cui, B., Xie, C., Ma, X., Man, Y., & Ning, Z. (2019). Ecological offsetting in china's coastal wetlands: existing challenges and strategies for future improvement. *Chinese Geographical Science, 29*(2), 202–213. doi: 10.1007/s11769-019-1024-4

zu Ermgassen, S. O. S. E., Baker, J., Griffiths, R. A., Strange, N., Struebig, M. J., & Bull, J. W. (2019). The ecological outcomes of biodiversity offsets under "no net loss" policies: A global review. *Conservation Letters, 12*(6). doi:10.1111/conl.12664

zu Ermgassen, S. O. S. E., Maron, M., Walker, C. M. C., Gordon, A., Simmonds, J. S., Strange, N., Robertson, M., & Bull, J. W. (2020). The hidden biodiversity risks of increasing flexibility in biodiversity offset trades. *Biological Conservation, 252*, 108861. doi: 10.1016/j.biocon.2020.108861.