Not "Going, Going, Gone": Affordable Biodiversity Gains from a Conservation Auction

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Abstract

The use and management of private land has a critical role to play in halting biodiversity loss, one of the key environmental challenges currently facing humanity. Voluntary incentive programs, where payments or other incentives are offered to landholders for the provision of environmental services, are widely used to increase conservation on private land. Despite large investments in conservation incentives globally, many outstanding knowledge gaps need to be addressed in order to support the future effectiveness of these programs.

Firstly, evidence of ecological impacts is rare and has been confined to a subset of program types and locations. Furthermore, although there are large funding shortfalls for biodiversity conservation, opportunities to leverage resources from carbon markets remain largely unexplored in empirical research. In relation to incentive program participants, much previous research has been based on narrow assumptions of the types of landholders who participate. Currently, there is also limited knowledge of the factors supporting retention of participants and of what happens when incentive contracts end.

In this thesis, these knowledge gaps are addressed using empirical data from a large scale conservation auction (incentive program). The program offered 5 or 10-year contracts to private landholders to protect and restore remnant native vegetation in South Australia's agricultural regions. This research uses both quantitative and qualitative data in a multidisciplinary approach spanning field ecology, carbon sequestration modelling, economics and sociology.

This research shows that incentive contracts for restoration of remnant native vegetation can produce biodiversity gains. Furthermore, it demonstrates that carbon markets could pay the cost of that restoration under plausible scenarios and conservative carbon prices. Absentee and group landholders were found to be important participant types, challenging the commonly held assumption that participants are generally resident individuals or families. The important role of restoration costs in participant retention and post-contract behaviour was also identified, indicating that restoration activities are unlikely to continue when incentive payments cease if the ongoing costs of restoration exceed the private benefits from participation. These findings clarify directions for future research and offer multiple approaches to improve policy and incentive design for biodiversity conservation.

Thesis declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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I acknowledge the support I have received for my research through the provision of an Australian Government Research Training Program Scholarship.

Anthelia Bond

21st June 2019

Thesis overview

This thesis is presented in a format which follows the University of Adelaide guidelines for a thesis by publication. The introduction provides a brief background, literature overview and study aims for the research covered by the thesis. More detailed background information and literature review is provided in the individual introductions of each of the publication and manuscript chapters that follow. The introduction also provides descriptive information about the study region's climate, land use and native vegetation as well as an outline of the BushBids program, the conservation incentive program used as a case study for this research. At the end of the introduction I have also listed the research outputs from this work. Chapters 2-5 contain two published papers, a manuscript submitted for review, and a manuscript prepared for submission. The concluding chapter provides a brief discussion linking the findings of the preceding chapters and giving recommendations for future research. Finally, references cited in the thesis introduction and conclusion are listed at the end of the thesis.

Chapter 1. Introduction and literature review

Biodiversity loss is one of the most significant environmental challenges currently facing humanity (Convention on Biological Diversity, 2010; IPBES, 2019; Rockström et al., 2009). Biodiversity underpins the efficiency and stability of ecological functions such as biomass production and nutrient cycling and has been linked with the provision of ecosystem services that support the human population (Cardinale et al., 2012). However, biodiversity is declining at local and global scales (Butchart et al., 2010; Cardinale et al., 2018; IPBES, 2019; Newbold et al., 2015). Terrestrial biodiversity loss is driven by the loss, fragmentation and degradation of natural habitats (Pimm and Raven, 2000) often brought about by conversion to cultivated agricultural systems (MEA, 2005). Furthermore, even when large scale habitat clearance has ceased, decline in condition of remaining habitat is likely to continue (e.g. Fagúndez, 2013; Haddad et al., 2015; Laurance et al., 2012).

Conservation targets to halt or reverse biodiversity loss, such as those under the UN Sustainable Development Goals, cannot be met by publicly governed protected areas alone (UNEP-WCMC and IUCN, 2016). Consequently, an important contribution is needed from private land (Figgis, 2004; Knight, 1999; Norton, 2000). However, the benefits produced by private land conservation are largely public benefits, while the costs are theoretically born by the private landholder (Doremus, 2003). This can mean that, for private landholders, adoption of conservation practices has a negative net benefit (benefit minus costs) and therefore private landholders are unlikely to adopt conservation practices without some form of policy intervention (Pannell, 2008).

Offering payments to private landholders for the provision of environmental services through voluntary incentive programs is one approach widely employed to overcome adoption barriers (Doremus, 2003; Kamal et al., 2015). Voluntary incentive programs have been used to purchase a wide range of environmental services including sustainable agricultural practices, creation of set aside areas, restoration of natural habitats and conservation of threatened species and ecosystems (Kamal et al., 2015). Incentive contract length has commonly been set at around 5 years (e.g. Duncan and Vesk, 2013; Kleijn et al., 2006) but has also extended to 10, 15 and 20 years (Kuhfuss et al., 2016). Incentive price can be set by the program in fixed-price schemes (e.g. European AES Batáry et al., 2015) or via auctions in revealed-price schemes (e.g. Rolfe et al., 2017). While fixed-price schemes have been more commonly used, conservation auctions or tenders have potential advantages for efficiency, and are better able to deal with heterogeneity in management and opportunity costs (Rolfe et al., 2017; Stoneham et al., 2003; Windle and Rolfe, 2008).

Globally, significant funding has been invested in conservation incentives over the last two decades (Batáry et al. 2015; Rolfe, Whitten & Windle 2017; Wu & Yu 2017). For example, the European Union contributed nearly €20 billion to Agri-Environmental Schemes between 2007 and 2013 (European Commission, 2019), the annual rent paid under the US Conservation Reserve Program in 2018 was approximately USD$1.8 billion (USDA, 2018) and more than AU$170 million was allocated through Australian conservation tenders between 2001 and 2016 (Rolfe et al., 2017). Despite these large investments, evidence of incentive program environmental impact remains rare (Ferraro, 2009). Furthermore, there are many remaining gaps in understanding participants and their interactions with incentive programs (e.g. Dayer et al., 2018; Petrzelka et al., 2012; Riley, 2016).

In this thesis I examine four key knowledge gaps related to the design and performance of conservation incentive programs (Figure 1).

i. Despite the growing understanding of farmers' environmental behaviour (Burton, 2014) and motivations for participating in incentive programs (e.g. Defrancesco et al., 2008), research to date has largely focused on one landholder type (resident farming individuals/families). However, understanding a broad range of participants is important for the design of effective programs.
ii. Evidence of incentive program environmental impact is rare and has been confined to a subset of program types and locations (Ferraro, 2009; Ferraro and Pattanayak, 2006). Impact evaluation for programs aiming to restore existing native vegetation and for revealed-price schemes is largely missing.
iii. Currently there are large shortfalls in conservation funding (Waldron et al., 2017) and the potential to fund biodiversity conservation with carbon markets has not yet been explored.
iv. Voluntary incentive program effectiveness depends on retention of participants and post-contract continuing conservation behaviour (Dayer et al., 2018; Selinske et al., 2015). However, empirical research in this area is limited and has not adequately

considered the role of implementation costs in participant retention and post-contract behaviour.

In summary, there remains much to discover about how to achieve biodiversity gains, how to engage landholders and how to pay for conservation.

The research presented in this thesis draws on a range of disciplines including ecology, carbon modelling, and social science, to address these knowledge gaps. It uses a large-scale, revealed-price, conservation incentive program, BushBids, as a case study. This program offered 5 or 10 year contracts to private landholders to restore remnant native vegetation. Under these contracts landholders agreed to manage grazing pressure (from stock and feral animals), control weeds and retain fallen logs. Below I provide more details about the research aims and approach for each study and give further detail of the BushBids program and the study environment. A data access agreement was made with O'Connor NRM Pty Ltd to enable the use of existing BushBids program data in this research (see Appendix 1).

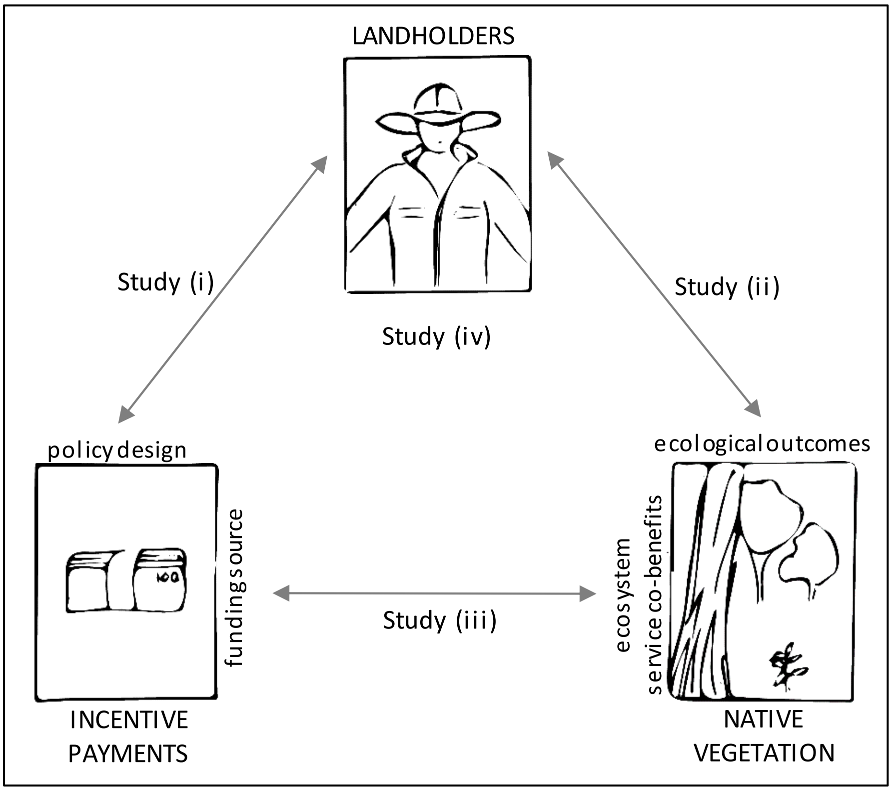

Figure 1 Conceptual diagram for conservation incentive programs where incentive payments are used to purchase environmental services from private landholders. Design of incentive policy can influence participation and should therefore be informed by knowledge of landholders (Study (i)). Incentive payments and the management practices adopted by

landholders aim to protect and restore biodiversity, but this has rarely been demonstrated (Study (ii)). Additional ecosystem services (co-benefits) may be produced, potentially offering a supplementary source of funding for incentive programs (Study (iii)). Little is currently known about participant experiences in incentive programs and how this may influence their future environmental behaviour (Study (iv)).

Study (i) Who participates in conservation incentive programs? Absentee and group landholders are in the mix.

Rural land ownership is diversifying in many regions, with growing numbers of amenity migrants (Cooke and Lane, 2015; Gosnell and Abrams, 2011) and absentee landholders (Mendham and Curtis, 2010; Petrzelka et al., 2013). Another contributor to the diversity of private land conservation participants are group landholders such as community groups, not-for-profit conservation organisations, and corporations (Fitzsimons, 2015; Gosnell and Travis, 2005; Selinske et al., 2015). However, studies of environmental behaviour in agricultural landscapes almost always conceptualise landholders as resident, farming individuals or families, both in empirical studies and reviews (e.g. Burton, 2014; Defrancesco et al., 2008; Hill et al., 2011; Perkins et al., 2013) and in economic choice experiments (e.g. Boxall et al., 2017; Wichmann et al., 2016). Only a small number of studies have considered absentee landholders (e.g.Lindhjem and Mitani, 2012; Petrzelka and Armstrong, 2015; Petrzelka et al., 2013; Petrzelka et al., 2012; Ulrich-Schad et al., 2016) and to date, group landholders as participants in conservation incentive programs have not been directly examined in the literature.

Study (i) research aims

This study aims to investigate the types of landholders who participate in conservation incentives, with particular reference to the role of absentee and group landholders.

Study (i) approach

This study characterises participants in the BushBids conservation incentive program (see further description below). A range of participant characteristics were examined, including participant involvement in primary production, whether they were resident or absentee and whether they participated as an individual/family or group. Generalised linear modelling with Bayesian model averaging was used to test the relationships between these factors and the size of the area offered in the incentive program. Human research ethics approval was granted for this research (approval number H-2016-103, see Appendix 2).

This work is presented in Chapter 2 and has been published in the journal *Land Use Policy* as

Bond AJ, O'Connor PJ, Cavagnaro TR (2018) Who participates in conservation incentive programs? Absentee and group landholders are in the mix. *Land Use Policy* 72, 410-419 https://doi.org/10.1016/j.landusepol.2017.12.067

Study (ii) Remnant woodland biodiversity gains under 10 years of revealed-price incentive payments

Evidence of conservation incentive program effectiveness is needed to inform future investment and program design, but is difficult to measure and has been relatively rare (Ferraro, 2009; Kleijn and Sutherland, 2003; Mascia et al., 2014). Most research in this area has examined European Agri-Environmental Schemes, which have largely been fixed-price incentives for environment or biodiversity enhancing agricultural practices (see Batáry et al., 2015), with little research from revealed-price incentives (e.g. Duncan and Vesk, 2013) and programs for restoration of remnant native vegetation (e.g. Lindenmayer et al., 2012a; Michael et al., 2014). While considerable efforts have been made to meet the challenges of monitoring large scale incentive programs, comprehensive Before-After-Control-Impact (BACI) designs (e.g. Bright et al., 2015) have rarely been used. Furthermore, only a small number of studies have examined ecological change over a period of ten years or longer (e.g. Riffell et al., 2008; Vesk et al., 2015).

Study (ii) research aim

This study aims to investigate the ecological outcomes from 10-year, revealed-price, incentive contracts.

Study (ii) approach

This study uses a modified before-after-control-impact design to examine the impact of incentive contracts from the Eastern Mt Lofty Ranges BushBids project. It tests whether impact sites (with contracts) changed over time relative to control sites (private land sites without contracts) and reference sites (public reserves). The study was conducted under a scientific research permit M26481-1 from the Department of Environment, Water and Natural Resources (see Appendix 3).

This work is presented in Chapter 3 and is published in the *Journal of Applied Ecology* as

Bond AJ, O'Connor PJ, Cavagnaro TR (2019) Remnant woodland biodiversity gains under 10 years of revealed-price incentive payments. *Journal of Applied Ecology* 56, 1827-1838 https://doi.org/10.1111/1365-2664.13397

Study (iii) Carbon can pay the way for biodiversity conservation

There are competing demands on land and financial resources for the provision of carbon sequestration and biodiversity conservation services (Smith et al., 2014; Waldron et al., 2017). While carbon markets are beginning to provide a means to pay for climate mitigation (World Bank et al., 2017), there are few examples of similar regulatory mechanisms for biodiversity conservation (Madsen et al., 2010), despite large shortfalls in conservation funding (Waldron et al., 2017). The land-sector carbon abatement actions of avoided deforestation and reforestation have potential to provide concomitant carbon and biodiversity benefits thereby overcoming these resource constraints (Griscom et al., 2017). However, when these actions are optimised for carbon outcomes, biodiversity outcomes may be suboptimal or even negative (Ferreira et al., 2018; Lindenmayer et al., 2012b; Venter et al., 2009). The trade of carbon sequestered through restoration of remnant native vegetation may offer a way to fund restoration while optimising biodiversity outcomes from investment in carbon abatement. While this can be hypothesised it has not previously been possible to demonstrate due to the absence of evidence about the biodiversity gains from restoration and information about restoration costs.

Study (iii) research aims

This study aims to assess whether carbon could pay for biodiversity conservation, by trading carbon sequestered from native vegetation restoration.

Study (iii) approach

Using FullCAM, the Australian Government's carbon accounting tool, this study models carbon sequestered through restoration of remnant vegetation under 10-year incentive contracts. It uses plausible scenarios of vegetation age and ecosystem degradation rate along with two recent carbon prices from an established market. It compares the estimated revenue from sequestered carbon to the average cost of restoration revealed by the incentive program.

This work is presented in Chapter 4 and has been submitted to *Nature Ecology & Evolution.*

Study (iv) Money matters for retention and post-contract management persistence in conservation incentive programs

The effectiveness of voluntary conservation incentive programs in part depends on retaining participants in the program (Knight et al., 2010; Selinske et al., 2015) and on what happens after incentive contracts end (Dayer et al., 2018). Dayer et al. (2018) used the term persistence for post-contract continuing conservation behaviour, and proposed a theory about enabling factors for persistence including cognitions, sustaining motivations, habit forming, social norms and resources. Like the initial decision to participate, retention and persistence are likely to be linked to the private net benefit (private benefits minus private costs) of implementing the incentivised conservation actions (Doremus, 2003; Engel et al., 2008; Pannell, 2008). However, this framework of private benefits and costs has not been used to interpret findings in the small number of empirical studies in this area to date (e.g. Hayes, 2012; Kuhfuss et al., 2016; Race and Curtis, 2013). Furthermore the research has primarily focussed on fixed-price, cost-share or tax relief incentive programs with few studies exploring retention and persistence in revealed-price incentive programs (e.g. Race and Curtis, 2013).

Study (iv) research aim

This study aims to investigate retention and persistence in a revealed-price, conservation incentive program, and use this empirical evidence to evaluate the theory of post-contract persistence proposed by (Dayer et al., 2018).

Study (iv) approach

This study uses data from semi-structured interviews and questionnaires conducted with incentive program participants at the conclusion of the 10-year incentive contract period. It utilises both quantitative and qualitative data, the latter analysed for content in NVivo software. Human research ethics approval was granted for this research (approval number H-2016-103, see Appendix 2).

This work has been prepared as a manuscript in the format of *Conservation Letters* and is presented in Chapter 5.

BushBids conservation incentive program

The BushBids program (Australian Government, 2006) was established to assist private landholders in agricultural landscapes to maintain and restore the ecological function of remnant native vegetation on their property. It aimed to address past and potentially continuing declines in vegetation condition or ecological function, such as those identified by Duncan and Dorrough (2009) and Perring et al. (2015). The program used a series of discriminant price, reverse auctions to purchase 5 or 10-year stewardship contracts. In these auctions landholders submitted a single sealed bid for the price they would like to receive to deliver a contract. Successful bidders were then offered a contract at their bid price. Over the period from 2006 to 2013, there were five BushBids projects (see Figure 2) with a total of eight auction rounds that established stewardship contracts for more than 21,000 ha of native habitat. All but one of the chapters in this thesis focus on the first BushBids project in the eastern Mt Lofty Ranges.

Participation was voluntary and landholders were recruited via the existing networks of government and non-government natural resources management organisations as well as advertising in local media. Landholders were invited to make an expression of interest in the program, after which a site visit was arranged for a BushBids representative to assess the native vegetation and prepare a management plan according to the landholder's objectives and program policies (O'Connor et al., 2014). A total of 163 landholders expressed interest in the program and received management plans for their native vegetation sites. Contracts were established with 59 landholders, approximately one third of those that received management plans from the BushBids program.

Management plans included a map of the native vegetation area/s offered in the program and outlined management actions intended to maintain or restore the condition or ecological function of the native vegetation (see Table 1). All management plans required retention of fallen logs (restriction on fire wood collection) and management of stock grazing (either stock exclusion, or in grassy ecosystems, conservative grazing regimes were allowed). At some sites, livestock were already excluded from the site prior to commencing the BushBids contract.

An optional, additional bundle of actions to manage other threats at the sites was elected by most landholders. This bundle included weed and feral animal control along with other actions where applicable. Target weeds and feral animals varied according to climate and other environmental conditions, however lists of species commonly targeted for control in Eastern Mt Lofty Ranges BushBids management plans are provided in Table 2 and 3. Management of grazing pressure from Kangaroos (native) was also included in the management plan in some circumstances where this grazing pressure was considered to be a threat to the ecological function of the habitat. Native species planting was occasionally included in the management plan, as a means to restore highly degraded areas or to extend or link existing native vegetation. Finally, landholders were able to elect to enter into an in-perpetuity conservation covenant, specifically a Heritage Agreement (Native Vegetation Council, 2017), as an additional service provided under the stewardship contract.

A framework for monitoring and evaluation of management and ecological outcomes was built into the BushBids program design. Baseline vegetation assessments were completed for all participating landholders prior to bidding as well as at reference sites on public land. Contracted landholders where required to report annually on management activities and compliance auditing was undertaken throughout the contract period.

Table 1 Management actions identified in BushBids management plans

Management action	Compulsory /optional
Minimise disturbance • No fertiliser application or artificial feeding, • No soil disturbance (beyond that which is necessary for agreed management actions), • No cropping, • No new dams, • No drainage alteration, and • No rock removal.	Compulsory
Retain dead trees, fallen logs and plant litter	Compulsory
Manage grazing pressure from stock • Exclude stock from the site at all times or • Periodic biomass reduction/conservation grazing in grassy ecosystems. All stock must be removed in late spring / early summer when perennial native grasses begin to flower. Conservative grazing can resume after seed on native perennial grasses has matured.	Compulsory
Weed control	Optional as a bundle, including all actions required to manage threats present at the site
Feral animal control	
Kangaroo control	
Supplementary planting	
Other threat management (e.g. prevent spread of *Phytophthora cinnamomi*, restrict vehicle access)	
Permanent site protection, apply for a permanent covenant (Heritage Agreement)	Optional

Table 2 Weeds commonly targeted for control under Eastern Mt Lofty Ranges BushBids management plans

Common name	Scientific name
African Daisy	*Senecio pterophorus*
Blackberry	*Rubus* spp.
Bridal Creeper	*Asparagus asparagoides*
Broad-leaved Cotton-bush	*Gomphocarpus cancellatus*
Gorse	*Ulex europaeus*
Horehound	*Marrubium vulgare*
Olive	*Olea europaea*
Perennial Veldt Grass	*Ehrharta calycina*
Pussy Tail Grass	*Pentameris pallida*
Rose	*Rosa canina* and *R. rubiginosa*
South African Orchid	*Disa bracteata*
Watsonia	*Watsonia meriana*

Table 3 Feral animals commonly targeted for control under Eastern Mt Lofty Ranges BushBids management plans

Common name	Scientific name
Brown Hare	*Lepus capensis*
Cat	*Felis catus*
Deer	e.g. *Dama dama, Cervus elaphus,*
European Rabbit	*Oryctolagus cuniculus*
Goat	*Capra hircus*
Red Fox	*Vulpes vulpes*

Study system

Location and landuse

The five projects of the BushBids program were located in South Australia, in the Mt Lofty Ranges, Murray-Darling Basin and South East agricultural regions and covered a large geographic area of more than 30,000 km^2. The dominant land use in the BushBids project areas was agriculture at 76-96% of land area, with residential land at 1-21% of land area. Agricultural activities in the region were diverse and included livestock grazing and intensive livestock production, broad-acre cropping (cereals, oilseed and pulses), hay and silage production, viticulture and horticulture (ABS, 2016). Native vegetation in these project areas has been extensively cleared with as little as 8% of the original extent remaining in the Eastern Mt Lofty Ranges BushBids project area (see Figure 2) (DEWNR, 2011). Of the remaining native vegetation cover, 3-59% was protected in public protected areas (e.g. National Parks) (DEWNR, 2015) and 7-38% was protected in private protected areas (covenants) (DEWNR, 2017).

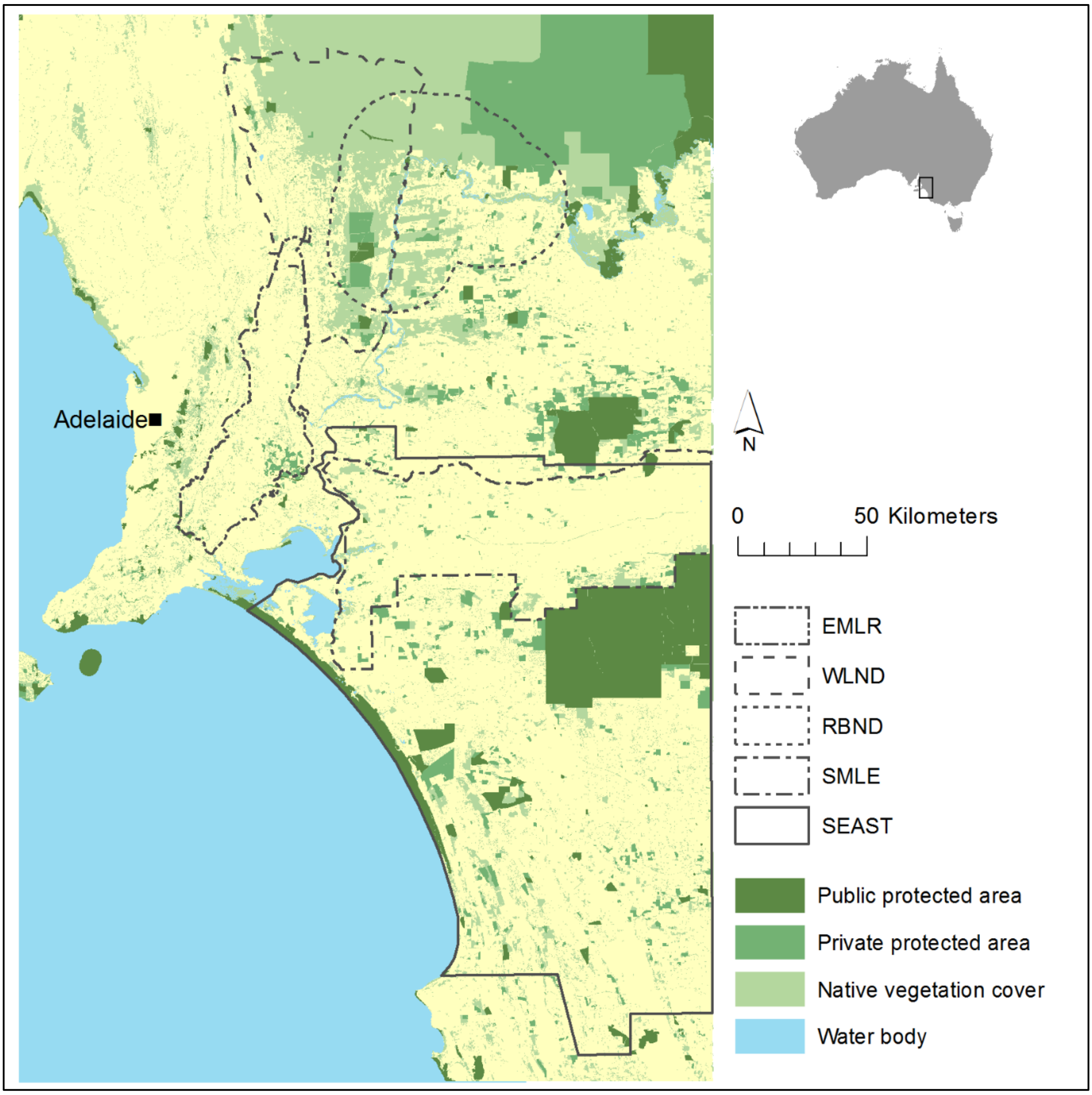

Figure 2 BushBids project locations. Eastern Mt Lofty Ranges (EMLR), Woodland (WLND), Riverbend (RBND), Southern Mallee (SMLE) and South Eastern (SEAST) in South Australia, Australia.

Climate

According to Bureau of Meteorology data (BOM, 2014), the program area has a temperate to semi-arid climate with warm to hot summers and cold winters. Winters are generally wet and summer rainfall is usually low. Average annual rainfall ranges from approximately 880 mm in the wettest part of the Eastern Mt Lofty Ranges (EMLR) to approximately 210 mm in the arid plains at the north of the Woodland and Riverbend BushBids project areas. Decreasing rainfall gradients extend from south to north and west to east.

Native vegetation

The program area's native vegetation was diverse, primarily including eucalypt dominated forests, woodlands, and mallee, as well as grasslands, wetlands, and chenopod shrublands (Department of Environment Water and Natural Resources, 2011). These regions also support threatened ecological communities including the critically endangered Iron-grass Natural Temperate Grassland of South Australia and Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia (Australian Government, 2007), the endangered Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions (Endangered Species Scientific Subcommittee, 2000), the endangered Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia (Australian Government, 2010) and the critically endangered Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains (Australian Government, 2012). Images of the vegetation at a selection of sites from Study (ii) are shown in Figure 3.

Figure 3 Vegetation at study sites (Study (ii)). (a) Mallee Box *Eucalyptus porosa* woodland reference site, (b) South Australian Blue Gum *E*. *leucoxylon* woodland reference site, (c) South Australian Blue Gum *E*. *leucoxylon* and Drooping Sheoak *Allocasuarina verticillata* woodland impact site, (d) Pink Gum *E*. *fasciculosa* woodland impact site, (e) Red Gum *E*. *camaldulensis* and Manna Gum *E*. *viminalis* ssp. *cygnetensis* woodland control site, and (f) Pink Gum *E*. *fasciculosa* woodland control site.

Research outputs

Publications

Bond AJ, O'Connor PJ, Cavagnaro TR (2018) Who participates in conservation incentive programs? Absentee and group landholders are in the mix. *Land Use Policy* 72, 410-419

Bond AJ, O'Connor PJ, Cavagnaro TR (2019) Remnant woodland biodiversity gains under10 years of revealed-price incentive payments *Journal of Applied Ecology* 56, 1827-1838

Manuscripts submitted for publication

Bond AJ, O'Connor PJ, Cavagnaro TR () Carbon can pay the way for biodiversity conservation. Manuscript submitted to *Nature Ecology & Evolution.*

Manuscripts in preparation

Bond AJ, O'Connor PJ, Cavagnaro TR () Money matters for retention and post-contract persistence in conservation incentive programs. Manuscript prepared in the format of *Conservation Letters.*

Presentations

During the course of the PhD research, presentations were made at the following conferences and events. The presenting author is shown in bold text.

Anthelia Bond, Patrick O'Connor, Sean Smukler and Timothy Cavagnaro (2018) **"**Not going, going, gone: affordable biodiversity gains from a conservation auction." invited presentation at the School of Agriculture Food and Wine Research Day, Adelaide, Australia.

Anthelia Bond, Patrick O'Connor, Sean Smukler and Timothy Cavagnaro (2018) **"**What happens when we pay landholders to manage native vegetation?" Presented in Three Minute Thesis competition, University of Adelaide, Australia.

Anthelia Bond, Patrick O'Connor and Timothy Cavagnaro (2018) "The Woodlands the landholders and the stewardship program." Presented at the NRM Science Conference, Adelaide, Australia.

Anthelia Bond, **Patrick O'Connor** and Timothy Cavagnaro (2018) "Absentee and group landowners are important participants in conservation auctions" Presented at the

Australasian Agricultural and Resource Economics Society (AARES) Conference, Adelaide, Australia.

Anthelia Bond, Patrick O'Connor and Timothy Cavagnaro (2017) "Managing remnant vegetation for biodiversity conservation: habitat condition after 10 years of management." Presented at Field Naturalists Society of South Australia, public seminar series, Adelaide, Australia.

Anthelia Bond, Patrick O'Connor and Timothy Cavagnaro (2017) "Payments for ecosystem services: what difference do they make and who puts their hand up?" Presented at Restore Regenerate Revegetate, international conference Armidale, Australia. Awarded best student speed talk for presentation.

Research reports to participants

Vegetation condition site reports created for all landholders with vegetation sites assessed for this research (33 reports, an example is provided in Appendix 4).

Draft report summarising research findings for participants in landholder interviews (See Appendix 5).

Grants and scholarships

During the course of the PhD research I applied for competitive grants and scholarships and was awarded the following:

- Endeavour Research Fellowship 2017, for a four month visit to the Sustainable Agricultural Landscapes Lab, University of British Columbia ($17,000).
- Department for Environment, Water and Natural Resources grant ($2,500).
- Field Naturalists Society of SA Lirabenda Endowment Fund grant ($2,858).

The following was awarded to PJOC and used to support this work:

- Supplementary Scholarship, Department of Environment Water and Natural Resources ($23,000).

Chapter 2. Who participates in conservation incentive programs? Absentee and group landholders are in the mix

Statement of Authorship

Title of Paper	Who participates in conservation incentive programs? Absentee and group landholders are in the mix
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted w ork w ritten in manuscript style
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Principal Author

Name of Principal Author (Candidate)	Anthelia Bond		
Contribution to the Paper	Contributed to the development of ideas and design of methodology, collated and analysed data, wrote the manuscript and acted as corresponding author.		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	17 May 2019

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Patrick O'Connor		
Contribution to the Paper	Contributed to the development of ideas and design of methodology, assisted with data analysis and interpretation, and provided feedback on the manuscript.		
Signature		Date	17/5/19

Name of Co-Author	Timothy Cavagnaro		
Contribution to the Paper	Contributed to the development of ideas and design of methodology, assisted with data analysis and interpretation, and provided feedback on the manuscript.		
Signature		Date	21/5/19.

Please cut and paste additional co-author panels here as required.

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Bayesian model averaging

ABSTRACT

Voluntary incentive programs are widely used to generate conservation actions on private land. Although there is a growing body of research about factors that influence landholder participation in incentive programs, studies generally conceptualise landholders in agricultural landscapes as owner-occupier, farming individuals or families. Few studies have considered participation by absentee landholders and fewer still have recognised group landholders (e.g. non-government organisations or community groups) as potential incentive program participants. We examined participation in a conservation stewardship tender (reverse auction) in South Australia to identify the diversity within participants, and particularly to evaluate the extent of participation by absentee landholders and groups. A diverse set of landholders participated, where nearly a quarter of participants were absentee landholders, and a small component were groups. Although small in number, groups were shown to be important because they were likely to offer larger land areas in the stewardship tender. With very little known about how absentee and group landholders may differ from their counterparts, further research is recommended to inform incentive program design. We recommend that incentive programs consider landholder diversity in order to achieve effective conservation in agricultural landscapes.

1. Introduction

At the global scale, publicly governed protected areas are not sufficient to meet environmental targets on their own (UNEP-WCMC and IUCN, 2016), leaving a significant contribution required from private landholders (Figgis, 2004; Knight, 1999; Norton, 2000). Consequently, private landholders have an important role to play in biodiversity conservation and the sustainable provision of other ecosystem services. The public good quality of biodiversity conservation and the implementation and opportunity costs of changing management mean that there are often cost barriers to optimal production of conservation benefits on private land (Kinzig et al., 2011). Offering payments to private landholders for environmental services through voluntary incentive programs is one approach widely employed to generate conservation action on private land (Doremus, 2003; Kamal et al., 2015). However the drivers of participation can be complex and in many cases remain insufficiently known (Lastra-Bravo et al., 2015; Sorice and Donlan, 2015).

When participation in incentive programs is voluntary, the environmental outcomes of the program rely on appropriate levels of participation (Mettepenningen et al., 2013; Rolfe et al., 2017; Selinske et al., 2015; Zanella et al., 2014). Positive environmental outcomes are dependent on sufficient participation from landholders responsible for the assets of interest. However, high participation is not always desirable. In programs with a finite budget where participants compete for funds, interest in participation may extend far beyond the available budget, resulting in avoidable transaction costs and inefficiencies for the program and participants (Whitten et al., 2013). Knowledge of the target audience, and the factors that influence their participation, is therefore required to inform the design of effective incentive programs (Mettepenningen et al., 2013; Morrison et al., 2012; Rolfe et al., 2017; Whitten et al., 2013).

While the level of incentives offered is a key factor, there are many other factors that influence participation in incentive programs. These include characteristics of the potential participants themselves, their landholdings, their attitudes and behaviour and the social context (Lastra-Bravo et al., 2015; Morrison et al., 2012). Research in this area commonly examines factors such as participant age, education level and experience (e.g. Comerford, 2014; Pavlis et al., 2016) and dependence on the land or associated resources (e.g. Lindhjem and Mitani, 2012;

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Table 1
BushBids conservation stewardship tenders.

Project name	Tender Rounds	Contract start	Contract length (years)	No. unique participants
Eastern Mt Lofty Ranges (EMLR)	2	2006–07	5 or 10	55
Woodland (WLND)	2	2010-11	5	32
Riverbend (RBND)	1	2013	5	23
Southern Mallee (SMLE)	1	2013	5	9
South Eastern (SEAST)	2	2013	5	44

Petrzelka et al., 2012). Social factors such as trust, connectedness and access to information (e.g. Moon, 2013; Morrison et al., 2012; Zanella et al., 2014) and attitudes and behaviour including personal satisfaction from participation, agreement with the incentive program goals, business orientation and information seeking behaviour (e.g. Comerford, 2014; Morrison et al., 2012; Pavlis et al., 2016; Reimer and Prokopy, 2014) are also frequently addressed. However, as Burton (2014) highlights, findings about the presence and direction of relationships between these factors and participation can be inconsistent or contradictory because the cause of the relationships often remain poorly understood. Another limitation of this area of research is that studies of environmental behaviour in agricultural landscapes almost always conceptualise landholders as owner-occupier farming individuals or families, in empirical studies and reviews (e.g. Burton, 2014; Defrancesco et al., 2008; Hill et al., 2011; Perkins et al., 2013) and in economic choice experiments (e.g. Boxall et al., 2017; Wichmann et al., 2016). Exceptions to this prevailing view are a small number of studies that have considered absentee landholders (e.g.Lindhjem and Mitani, 2012; Petrzelka and Armstrong, 2015; Petrzelka et al., 2013, 2012; Ulrich-Schad et al., 2016).

In many places, rural land ownership is becoming increasingly diverse, with growing numbers of non-primary producer “amenity migrants” (Cooke and Lane, 2015; Gosnell and Abrams, 2011) and absentee landholders (Mendham and Curtis, 2010; Petrzelka et al., 2013). While the influence of land use on participation has been addressed by many studies, only a small number of these have examined participation by absentee landholders. Studies of absentee landholder participation indicate that absentee landholders may be less concerned with financial incentives for land management change (Farmer et al., 2015), or accept lower incentives compared with resident owners (Lindhjem and Mitani, 2012), and that access to information can be a key barrier to participation (Petrzelka et al., 2012; Ulrich-Schad et al., 2016). Another contribution to the diversity of participants in conservation on private land is made by group landholders such as community groups, not-for-profit conservation organisations, and corporations (Fitzsimons, 2015; Gosnell and Travis, 2005; Selinske et al., 2015). To our knowledge, information about group landholders as participants in conservation incentive programs has not been directly examined in the literature.

This study aims to investigate the diversity in incentive program participants, and in particular, to identify the role of absentee landholders and groups. We took a novel approach to the characterisation of participants in a conservation stewardship program in South Australia where incentives were allocated by tender (a reverse, single-sealed-bid auction). We examined a range of participant characteristics including their involvement in primary production, whether they are resident or absentee and whether they participated as an individual/family or group. Statistical models were used to test the relationships between these factors and the size of the area offered in the tender. Results are discussed in the context of incentive program design to promote conservation on private land.

2. Materials and methods

To investigate the question of which landholders participate in conservation incentive programs we used the BushBids conservation stewardship program as a case study. This program had 163 unique participants and spanned a large geographic area (more than 30,000 km^2) in the agricultural regions to the east of Adelaide, South Australia. Average annual rainfall in the program area ranged from approximately 880 mm in the wettest part of the Mt Lofty Ranges to approximately 210 mm in the arid plains to the north of the River Murray (BOM, 2014). Agricultural activities in the program area included broad-acre cropping (cereals, pulses, oilseed), hay and silage production, horticulture, viticulture, livestock grazing, and intensive livestock production (ABS, 2016). The program area’s native vegetation was diverse, primarily including eucalypt dominated forests, woodlands, and mallee, as well as grasslands, wetlands, and chenopod shrublands (DEWNR, 2011).

2.1. BushBids conservation stewardship program

The work presented here is based on the BushBids program (Australian Government, 2006). The aim of this program was to support private landholders to maintain or restore the ecological function of remnant native vegetation on their property. Briefly, private landholders were invited to tender (bid) for 5 or 10 year contracts to manage and restore native vegetation. Over the period from 2006 to 2013, there were five BushBids projects with a total of eight tender rounds (Table 1). The projects were advertised through a variety of channels: local newspapers and newsletters; local radio and television; agricultural field days; and government and non-government organisation natural resources management networks. Participation was voluntary and landholders were not obliged to bid in the tender, or accept the contract if their bid was successful. After the landholder made an expression of interest, an on-site assessment of the location, size and condition of the native vegetation on their property was made by BushBids, and a native vegetation management plan was prepared for the landholder (O’Connor et al., 2014). Management plans mapped the area of native vegetation offered in the project and outlined management actions designed to maintain or improve the condition or ecological function of the native vegetation. Management of grazing pressure from stock and retaining fallen timber were mandatory, and always included in the management plan, while weed control and feral animal control were usually included and revegetation was occasionally included.

At a broad level, management plans were consistent throughout all five BushBids projects, however, the extent to which management actions differed from existing practices depended on participant circumstances. Management of stock grazing pressure under a BushBids management plan required complete stock exclusion from the site in most cases, but a conservative stock grazing regime was allowed in grassy ecosystems where it was used as a management tool to maintain or restore ecological function. For some participants this represented a change in management with associated forgone resources, while for participants who had already excluded stock or were already using conservative grazing practices in grassy ecosystems, there was no or minimal change required. Weed species and feral animal species targeted for control also differed between project locations and to a lesser extent, within project locations according to variation in climate and

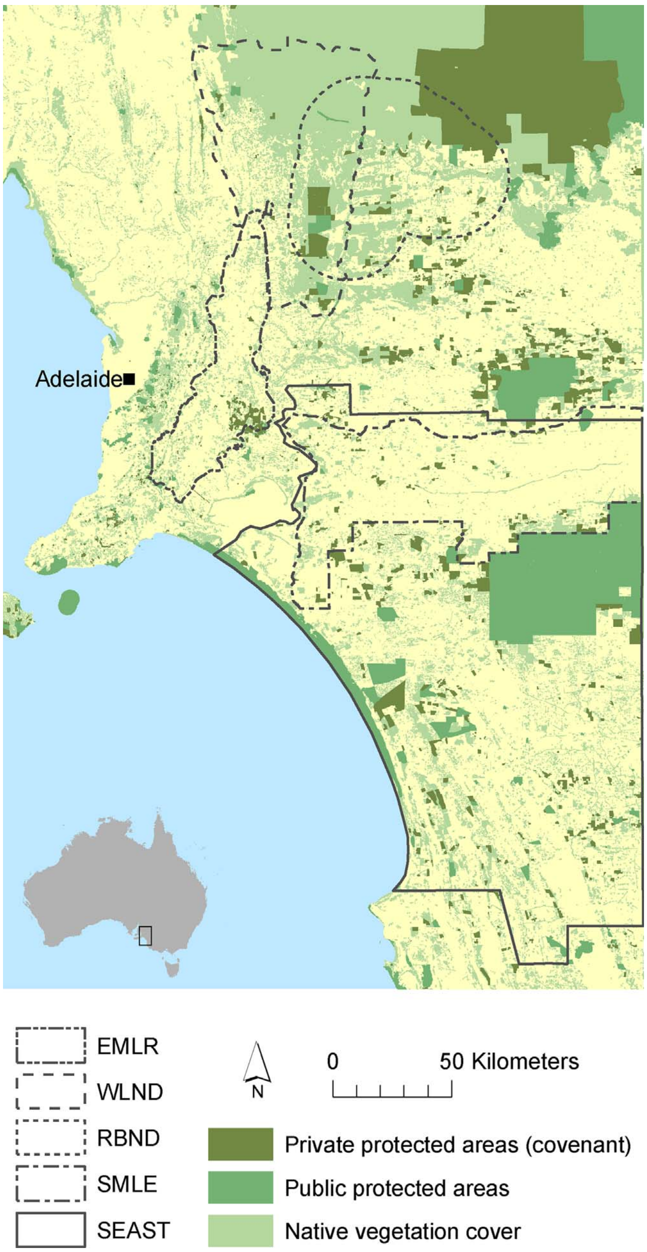

Fig. 1. BushBids project locations Eastern Mt Lofty Ranges (EMLR), Woodland (WLND), Riverbend (RBND), Southern Mallee (SMLE) and South Eastern (SEAST) in South Australia, Australia.

other environmental conditions. The management actions were intended to maintain or restore ecological function in remnant vegetation in order to address past and continuing declines identified by Duncan and Dorrough (2009) and Perring et al. (2015) for example. However, the ecological outcomes of these restoration actions have not yet been documented in research literature.

2.2. BushBids project locations

The five BushBids projects were located in the Mt Lofty Ranges, Murray-Darling Basin and South East regions of South Australia, where much of the original native vegetation has been cleared to provide land for agriculture (Fig. 1). Native vegetation cover in the project locations ranged from 8% in the Eastern Mt Lofty Ranges (EMLR) project to 61% in the Woodland (WLND) and River Bend (RBND) projects (Table 2). In addition to having the smallest proportion of remaining native vegetation, the EMLR project location had one of the smallest proportions of native vegetation protected in public protected areas (4%) and the highest proportion of residential land (21%). The WLND project location had the next largest proportion of residential land (7%) and although it had a large proportion of remnant vegetation, only 7% was protected by covenants (similar to conservation easements) on private land and only 3% was in public protected areas. The RBND location, also with a large proportion of remnant native vegetation, had similar levels of protected vegetation to the WLND location, but a smaller proportion of residential land (3%) and a larger proportion of land used for primary production (87%). The Southern Mallee (SMLE) project location had the largest proportion of land used for primary production (96%) and small proportions of remnant native vegetation (9%) and residential land (1%). Like the SMLE location, the South Eastern (SEAST) project location had a very small proportion of residential land, however this location had a moderate proportion of remnant native vegetation (22%), much of which was protected by covenants (16%) and in public protected areas (59%).

2.3. Data

Data about participants and their native vegetation were collected by the BushBids program through the expression of interest and site assessment processes. A subset of these data was made available for this study, including the size of the area offered for management at the draft management plan stage (referred to here as management plan size), the presence of proposed and existing covenants (similar to conservation easements), gender of the primary contact person/people, town of postal address and nearest town to the property, entity type, and information about the participant's involvement in primary production. This information was used to generate a set of eight categorical variables and one numerical variable characterising participants. The categorical variables were selected to provide information about the diversity of participants. Entity type, absentee status and primary production status were selected to evaluate the extent to which participants diverged from owner occupier, farming individuals or families. Gender of primary contact was included firstly to identify the extent of gender diversity in participants and secondly to evaluate how the other variables related to this fundamental demographic diversity measure. Although it's been shown that in developed economies women are more likely than men to engage in pro environmental behaviour (Hunter et al., 2004; Raymond and Brown, 2011), in this study, this trend is likely to be hidden by the gender imbalance in management and ownership of rural land noted by Raymond and Brown (2011). Three covenant (conservation easement) status variables were included to allow evaluation of how permanent covenants may interact with participation in the stewardship tender. Finally, the project location variable was included to allow evaluation of how the other participant characteristics varied with location.

Entity type includes two categories: individual/family and group. The individual/family category includes individuals or family groups where all members were connected by a familial relationship. All remaining participants shared a common characteristic in that they were groups where not all group members shared a familial relationship. This group category comprises a broad spectrum of participants including community groups, non-government organisations and corporations (other than family business structures), and also extends to include local government and informal groups where two or more group members were co-owners or co-managers with no familial relationship.

The absentee or resident variable was generated using information about the nearest town to the land offered for management and the town of the participant's postal address. Where the town nearest the land offered for management and the town of the postal address of the participant matched or were proximate, the participant was classified as resident. If the town nearest to the land offered for management and the town of the participant's postal address were spatially distant then the participant was classified as absentee. For example, these cases

Table 2
BushBids project location size, native vegetation cover and land use.

Project	Total area km^2	Native vegetation km^2 (%)[a,f]	Covenant km^2 (%)[b,d]	Public protected areas km^2 (%)[b,e]	Land use (%)[c,g]		
					Primary production	Reserve/ vacant/ recreation	Residential
EMLR	2 758	233 (8%)	88 (38%)	9 (4%)	76%	2%	21%
WLND	5 878	3 581 (61%)	245 (7%)	120 (3%)	81%	10%	7%
RBND	5 787	3 509 (61%)	735 (21%)	105 (3%)	87%	10%	3%
SMLE	6 964	618 (9%)	162 (26%)	44 (7%)	96%	1%	1%
SEAST	27 899	6 092 (22%)	961 (16%)	3 600 (59%)	84%	14%	1%

NB spatial statistics calculated using Geocentric Datum of Australia 1994 and Albers Equal Area projection in ArcGIS 10.4.1.
[a] Per cent of total area.
[b] Per cent of native vegetation.
[c] Per cent of total mapped land use ('Primary production' includes agriculture, horticulture, livestock grazing and forestry; 'Reserve/vacant/recreation' includes golf, reserve, recreation and vacant; and 'Residential' includes residential, rural residential, non-private residential and vacant residential).
[d] Spatial data source (DEWNR, 2017).
[e] Spatial data source (DEWNR, 2015).
[f] Spatial data source (DEWNR, 2011).
[g] Spatial data source (DPTI, 2016).

included participants who resided in Adelaide (or a major regional centre) but offered management services on a rural property. Some of the absentee participants resided on rural properties but offered management services on rural property in a different location. Where a participant offered land for management from two or more properties and met the criteria for being resident at one property the participant was classified as resident.

The gender of the primary contact was derived from the contact names participants gave when expressing interest in BushBids, and for the site assessment and development of the management plan. A number of participants provided contact names for more than one person and where male and female contact names were given this was classified as "both" rather than male or female.

The primary production status was assessed using a range of information collected by BushBids. This information included direct observations made by BushBids personnel, satellite imagery of the areas adjacent to the native vegetation and participant reported land use. If there was any primary production activity undertaken by the participant or by another party on the participant's property, then the participant was classified as a primary producer. Primary production activity included livestock, cropping, orchards and vineyards. Keeping horses for recreation and small scale, domestic gardening or poultry keeping were not classified as primary production activity. A small number of participants (six) could not be classified using the available information.

The project location was also included as a categorical variable. As some participants were involved in more than one BushBids project, participants were classified according to the BushBids project where their bid was successful, or if they did not make a successful bid, they were allocated to the first BushBids project they participated in.

The covenant variables categorise participants according to the presence or absence of existing and proposed covenants in their BushBids management plan. The covenants referred to in this study are similar to conservation easements in the USA (e.g. Fishburn et al., 2009), in that they are binding agreements established to conserve environmental values on private land. This study exclusively deals with Native Vegetation Heritage Agreements, a form of covenant in South Australia (Adams and Moon, 2013). Native Vegetation Heritage Agreements establish legally prescribed, usually permanent land use restrictions on a piece of land, with the agreement registered on the land title (Native Vegetation Act, 1991). Land use restrictions under Native Vegetation Heritage Agreements include restrictions on clearance or removal of native flora and fauna, introduction of non-native organisms and fertiliser, and removal or disturbance of soil and rock (Native Vegetation Council, 2017). They are generally consistent regardless of location and ecosystem type, with some relatively rare exceptions for stock grazing in grassy ecosystems (where it is used as a tool for conservation) and in the Monarto area where a specific type of Heritage Agreement was historically established with lower level restrictions. These variations in restrictions are unlikely to affect many of the participants and therefore have not been addressed in the analysis. The three covenant variables used in this study; existing covenant, proposed covenant and existing and/or proposed covenant were created from information about the presence of existing and proposed Native Vegetation Heritage Agreements within the management plans negotiated with participants. Where a Native Vegetation Heritage Agreement application had been submitted prior to participation in BushBids but the agreement had not yet been established, this was treated as an existing covenant.

The numerical variable management plan size was the total size of the area offered by the landholder for BushBids at the draft management plan stage, regardless of whether or not the landholder submitted a bid. Where the landholder participated in multiple BushBids projects and/or tender rounds, the total area offered by that landholder across all projects and rounds was used.

2.4. Data analysis

The Pearson's Chi-square test of independence with Yates' Continuity Correction was used to test whether absentee landholders and covenants were associated with primary production status. Observations from the unclassified category for primary production status were excluded from this analysis due to the small number of observations in this category. All expected frequencies were greater than five.

Ward's hierarchical cluster analysis was undertaken to identify groups within the participants. This method provided a relatively high cophenetic correlation coefficient (0.63) compared with other hierarchical cluster analysis methods and provided an interpretable solution with four groups, each containing a sufficient number of observations. A dissimilarity matrix was created for the cluster analysis using Gower's metric due to this metric's suitability for categorical variables. The dissimilarity matrix used a subset of the data: entity, gender of primary contact, primary production status, resident/absentee status and status for new and existing covenants separately. Observations in the "unclassified" category for primary production status were excluded due to the small number of observations in this category.

Linear modelling was used to test the relationship between management plan size and the predictor variables entity type, primary production status, absentee status, covenant status and gender of primary contact. The management plan size variable was natural log transformed to meet assumptions of normality, and observations with “unclassified” primary production status were removed from the dataset. A linear model of the main effects was fitted and tested with ANOVA both by adding terms to the model and dropping terms from the model. These two approaches yielded slightly different results, however, we selected the more conservative results from the additive approach for presentation here.

Generalized linear modelling with Bayesian model averaging (BMA) (Hoeting et al., 1999) was then used to confirm the results from the linear model and examine the relationship of management plan size to predictor variables within each of the four largest projects. BMA calculates an average of multiple model predictions, weighted by the posterior model probabilities. When a predictor variable had a 0.75 or greater probability of inclusion in the model, it was considered to be an important predictor (Thomson et al., 2007; Viallefont et al., 2001).

All statistical analyses were performed using R 3.2.4. The Gower’s dissimilarity matrix was created using the package cluster 2.0.5 (Maechler et al., 2016), while the package BMA 3.18.6 (Raftery et al., 2015) was used for Bayesian model averaging.

3. Results

3.1. Participants

Of the 163 participants, a large majority were individuals or families (92%) with the remainder consisting of groups (8%). The gender of the primary contact person was most frequently male (60%), although a considerable proportion of primary contacts were female (20%) or included at least one person of each gender (20%).

A little over half the participants were involved in some kind of primary production (55%), while approximately 41% were not involved in primary production and a small number (4%) could not be classified (Fig. 2(a–d)). At the time of expressing interest in the program, most participants were resident on their property (77%), however, a considerable proportion were not (23%) (Fig. 2(a)). Thirty four per cent of participants had an existing covenant (similar to a conservation easement) over part or all of the land offered in BushBids (Fig. 2(c)) and 25% of participants indicated they would like to apply for a covenant (Fig. 2(d)). Almost half of the participants (44%) did not have a covenant over the land offered in the project and were not proposing to apply for one as part of their offered management services (Fig. 2(b)).

The Chi-squared independence test revealed that resident/absentee status was dependent on primary production status (Chi-square independence test $X^2 = 23.4$, df = 1, $P < 0.0001$) with a larger proportion of absentee landholders within those not involved in primary production, compared with those landholders who were involved in primary production (Fig. 2(a)). However, no significant relationship was found between covenants and primary production status ($X^2 = 1.6$, df = 1, P = 0.2) (Fig. 2(b)).

Four groups of participants were identified through hierarchical cluster analysis and are here after referred to as clusters (Fig. 3(a–f)). Cluster 1 was the largest and included 45% of all participants. It mainly comprised participants who were classed as individuals or families (94% of Cluster 1) (Fig. 3(a)), resident (85% of Cluster 1) (Fig. 3(b)), and involved in primary production (65% of Cluster 1) (Fig. 3(c)). Nearly all participants in this cluster did not have an existing covenant (97% of Cluster 1) (Fig. 3(d)) and did not have a proposed covenant (99% of Cluster 1) (Fig. 3(f)). The next largest cluster, Cluster 2, included 23% of total participants and was comprised entirely of individuals or families (Fig. 3(a)) with a proposed covenant (Fig. 3(f)). This cluster had relatively similar proportions of primary producers (56% of Cluster 2) and non-primary producers (44% of Cluster 2) (Fig. 3(c)), a relatively large proportion of absentee landholders (25% of Cluster 2) (Fig. 3(b)) and the largest proportion of female primary contacts (42% of Cluster 2) (Fig. 3(e)) compared with the other clusters. Cluster 3 included 17% of all participants and was comprised exclusively of participants who were not involved in primary production (Fig. 3(c)) and also had a large component of absentee landholders (65% of Cluster 3) (Fig. 3(b)), groups (31% of Cluster 3) (Fig. 3(a)) and

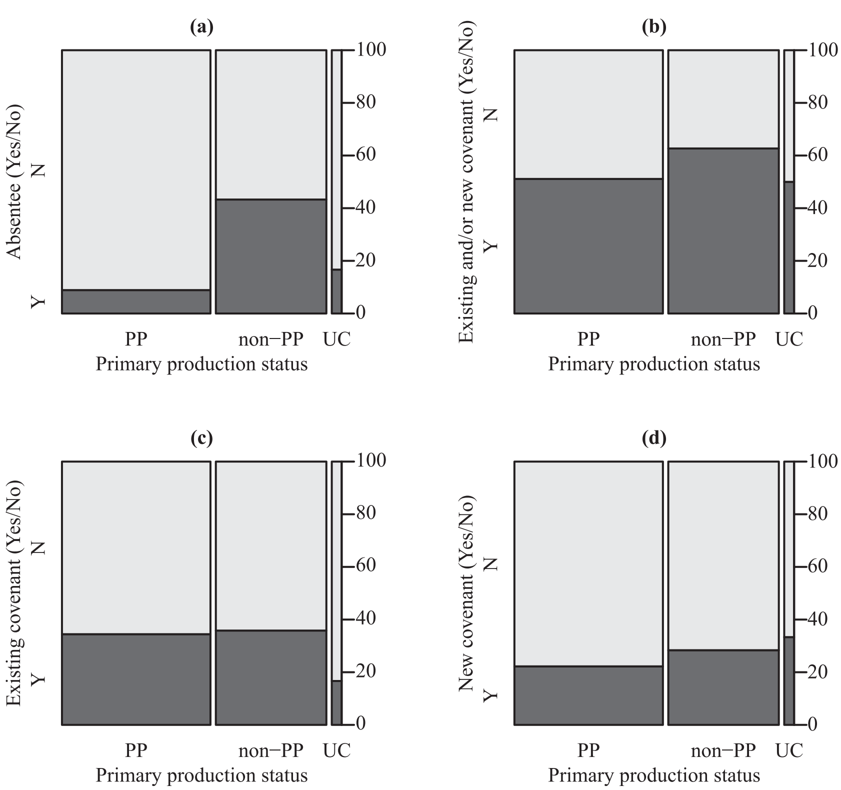

Fig. 2. Per cent of participants involved in primary production (unclassified indicated by UC) and (a) absentee or resident, (b) with an existing covenant and/or proposed covenant, (c) with an existing covenant, (d) with a proposed covenant. NB width of bar indicates proportion or per cent of participants in a given category, dark grey indicates ‘yes’ and light grey indicates ‘no’ for y-axis variables.

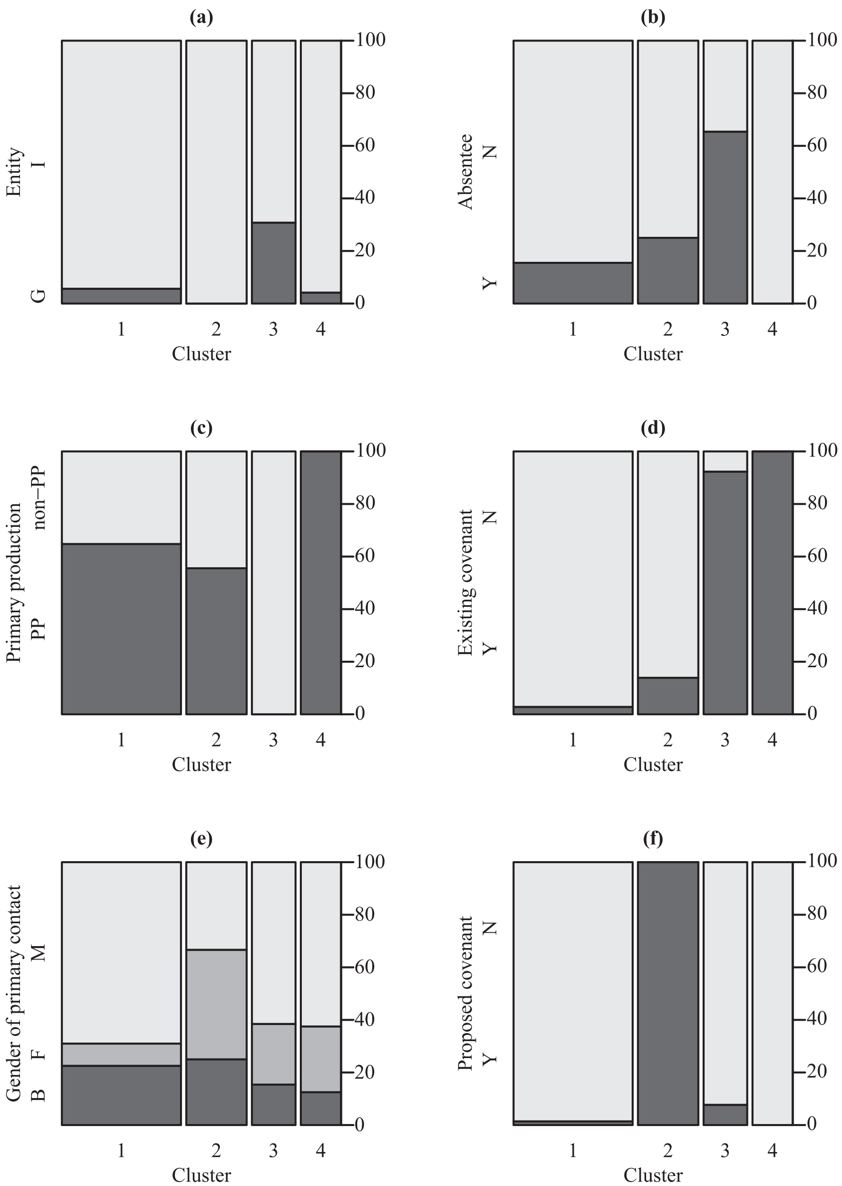

Fig. 3. Characteristics of participant clusters identified with cluster analysis. (a) per cent of entity type (G = group, I = individual/family) within clusters, (b) per cent of absentee and resident landholders within clusters, (c) per cent of primary producers and non-primary producers within clusters, (d) per cent of participants with existing covenants, (e) per cent of primary contact gender (B = both genders, F = female, M = male), and (f) per cent of participants with proposed covenants. NB width of bar indicates proportion or per cent of participants in a given cluster.

participants with an existing covenant (92% of Cluster 3) (Fig. 3(d)). Finally, Cluster 4 was the smallest cluster and included 15% of all participants. Similar to cluster 1, cluster 4 was comprised entirely of participants who were resident (Fig. 3(b)), involved in primary production (Fig. 3(c)) and not proposing a new covenant (Fig. 3(f)). However unlike cluster 1, all members of the cluster 4 had an existing covenant (Fig. 3(d)).

3.1.1. Absentee landholders

A majority of participating absentee landholders were non-primary producers (76% of 38 absentee participants) compared with 21% who were primary producers (Fig. 2(a)). Likewise, more absentee participants were individuals/families (82% of absentee participants) than were groups (18% of absentee participants). The WLND project location had the highest percentage of absentee participants (34% of participants in that project) followed by the EMLR project where 29% of participants were absentee and the RBND project where 26% of participants were absentee (Fig. 4(a)). The SMLE and SEAST projects both had lower rates of absentee participants with 11% and 9% respectively.

3.1.2. Groups

Following a similar pattern as the absentee participants, most participating groups were non-primary producers (77% of 13 participating groups), with the remaining 23% being classified as primary producers. There was a roughly even division between absentee (seven) and resident (six) participants within those classified as groups. Project locations with the highest proportions of participating groups were the RBND project where 13% of participants were groups, and both the EMLR and WLND projects where 9% of participants were groups (Fig. 4(b)). The SMLE project had no participating groups, while 5% of participants in the SEAST project were groups.

3.2. Management plan size

The size of the area offered by participants in the tenders (referred to here as management plan size) differed by four orders of magnitude ranging from 0.5 ha to 4 792.6 ha, with a median of 45.7 ha and interquartile range of 19.0 ha to 179.6 ha. Linear modelling showed a significant relationship between management plan size and both project location and entity type (see Table 3 and Supplementary Fig. S1). Other participant characteristics (primary production status, covenant status, gender of primary contact and resident/absentee status) were not significantly related to management plan size.

Generalised linear modelling with Bayesian model averaging

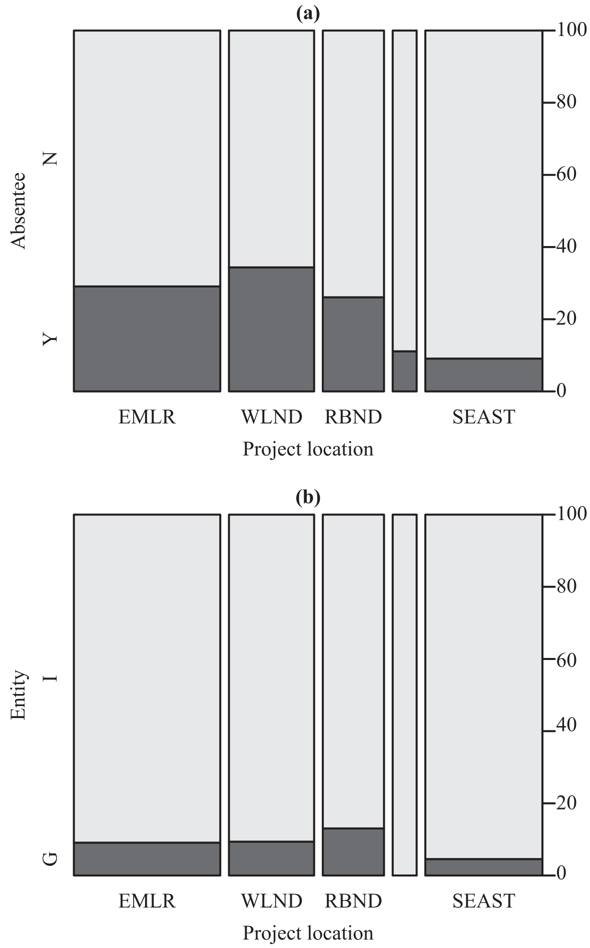

Fig. 4. Per cent of (a) absentee participants (Y = yes, N = no) and (b) participating groups (G = group, I = individual/family) in project locations (unlabelled bars are SMLE project location). NB width of bar indicates proportion or per cent of participants in each project location.

Table 3
Relationship of participant characteristics to management plan size.

Factor	Df	F value	Pr(> F)	Coefficient ± SE
Project location	4	8.4672	0.0004e-02	
WLND				1.2 ± 0.3
RBND				1.5 ± 0.4
SMLE				1.8 ± 0.5
SEAST				0.8 ± 0.3
Entity type	1	8.3245	0.0045	
Individual/family				−1.2 ± 0.4
Gender of primary contact	2	1.7511	0.1772	
Primary production status	1	3.7677	0.0542	
Resident or absentee	1	0.6255	0.4303	
Covenant status	1	2.9944	0.0857	

confirmed the relationship between management plan size and project location and entity type with these factors identified as the strongest predictors of management plan size, and the only predictors with greater than 75% chance of inclusion in the model for all project locations combined (Table 4). Entities classified as individuals or families were likely to have smaller management plans (coefficient of −1.14) than entities classified as groups. Compared with EMLR, participants in all other project locations were likely to have larger management plans (coefficients ranging from 0.97 to 2.00). The SEAST project location was the only individual location where predictors with a greater than 75% chance of inclusion were identified (Table 4). These predictors were entity type, gender of primary contact, primary production status and covenant status. Again, participants classified as individuals or families were likely to have smaller management plans than group participants. In the SEAST location, participants with female-only primary contacts were likely to have smaller management plans than participants with primary contacts that included both genders. Non-primary producers were likely to have smaller management plans than primary producers and participants with neither existing nor proposed covenants were likely to have smaller management plans than those with covenants or proposed covenants.

4. Discussion

In this study we characterised participants in a conservation stewardship tender (reverse auction) and examined how these characteristics related to the size of the area offered in the tender. The range of landholders interested in participating was diverse, including a considerable proportion of absentee landholders, a small but important constituent of groups and relatively equal proportions of primary producers and non-primary producers. Project location was the best predictor of the size of the area offered in the tender followed by entity type, with groups likely to offer larger areas compared with individuals and families. The diversity of landholders participating in the tender is consistent with the increasing diversity within agricultural landscapes highlighted by Mendham and Curtis (2010). Both absentee landholders and groups were found to be important participants, absentee landholders because they made up a considerable proportion of total participants and groups because of the larger areas they offered in the tender. Programs seeking to incentivise conservation actions on private land must understand these ownership structures, particularly where they result in participant behavioural differences compared with traditional, production oriented, family ownership models.

4.1. Absentee landholders

Absentee landholders made up nearly a quarter of all participants and came from all project locations. This large component of absentee landholders confirms their relevance within the community of private land managers in agricultural landscapes and aligns with studies showing increasing absentee ownership in various parts of the world (Petrzelka et al., 2013) including Australia (Klepeis et al., 2009; Mendham and Curtis, 2010). Further, these results provide empirical evidence of absentee landholders' interest in participating in a conservation stewardship tender, which to our knowledge has not previously been documented. Project locations with the highest rates of absentee landholder participation were the EMLR project location where much of the area is within 50 km of Adelaide (the nearest city) and the WLND and RBND project locations where the majority of the area is within 150 km of Adelaide and there is a relatively large proportion of native vegetation remaining in the landscape. Travel distance from cities is likely to influence the rates of absentee land ownership, at least for non-primary producing landholders, however other interrelated factors may also play a role such as amenity values, land productivity and value, and land use planning and policy. Although there is a substantial body of research relating to amenity migrants (Gosnell and Abrams, 2011), relatively little is known about absentee landholders. More research is needed to better understand the patterns and drivers of absentee ownership and how rates of absentee landholder participation in incentive programs compare with rates of absentee land ownership in agricultural landscapes.

Participating absentee landholders included both primary producers and non-primary producers, with most classed as non-primary producers. Absentee primary producers may have included landholders who own two or more spatially separated rural properties to take advantage of resources available in different environments (e.g. seasonal grazing for stock while crops are grown on the primary property), or landholders who reside in an urban area and manage the property remotely.

Table 4
Probability of a non-zero coefficient P(inc), coefficients, Bayesian Information Criterion (BIC) and R^2 for management plan size in all locations combined and in EMLR, SEAST, WLND and RBND locations, determined with Bayesian model averaging.

Predictor/BIC/ R^2/n	All locations		EMLR	SEAST		WLND	RBND
	P(inc)	coeff ± SD	P(inc)	P(inc)	coeff ± SD	P(inc)	P(inc)
Intercept	100.0		100.0	100.0		100.0	100.0
(Group entity, Both genders, Primary producer, EMLR location, Covenant)							
Entity type	**92.0**		15.4	**79.1**		59.6	15.1
Individual/family		−1.14 ± 0.52			−1.84 ± 1.26		
Gender of primary contact	0.0		0.0	**84.6**		2.4	1.2
Female					− 1.58 ± 0.89		
Male					− 0.10 ± 0.42		
Resident or absentee	6.5		44.9	17.4		11.7	37.2
Primary production status	32.9		11.0	**90.5**		12.0	49.4
Non-primary producer					−1.40 ± 0.71		
Project location	**100.0**		NA	NA		NA	NA
WLND		1.29 ± 0.32					
RBND		1.48 ± 0.36					
SMLR		2.00 ± 0.53					
SEAST		0.97 ± 0.31					
Covenant status	14.9		25.4	**100.0**		12.4	15.5
No covenant					−1.76 ± 0.44		
BIC	−602.3		−151.9	−98.1		−76.3	−41.6
R^2	0.22		0.06	0.56		0.12	0.19
n	157		53	42		32	21

Pr(inc) probability of inclusion.
BIC Bayesian information criterion.
Coefficient and standard deviation shown only when Pr(inc) > 75%.

Non-primary producer absentee participants are likely to have included "weekenders" who reside in urban areas and periodically visit their rural properties for recreation and/or other purposes, or groups who jointly use and manage the land for a variety purposes (such as recreation, conservation and/or non-primary production businesses). Recreation has been found to be a widespread purpose for land ownership among absentee landholders and intersection of multiple land uses is also common (Petrzelka and Armstrong, 2015; Petrzelka et al., 2009). To facilitate participation by absentee landholders, private land conservation policy makers are advised to recognise that absenteeism may coincide with a variety of often co-existing land use objectives.

Although they are a diverse group, absentee landholders may face some particular challenges for land management and incentive program participation that set them apart from resident landholders. Absentee landholders may not access the same information sources as resident landholders, therefore presenting a challenge for incentive program recruitment. Time constraints may also be a major barrier for absentee landholders, including at the time of recruitment to a program (Mendham et al., 2012), having insufficient time available to implement management actions (Kendra and Hull, 2005; Klepeis et al., 2009) or experiencing difficulties with the timing or frequency of visits required for management, such as implementing weed control at a critical weed lifecycle stage. The cost of implementing management actions may also be influenced by absentee status (Mendham et al., 2012). For example, there may be additional costs associated with travel and transport to the property and/or hired labour and equipment. However, absentee landholders' possible willingness to accept lower incentive rates (Lindhjem and Mitani, 2012) may offset additional management costs. Another management challenge potentially exacerbated by absenteeism is impacts from unauthorised access to the property (O'Connor, 2016) for activities such as off road vehicle use, camping, hunting (Kendall et al., 2013) and timber theft (Petrzelka et al., 2013). Many of these barriers or challenges faced by absentee landholders can be addressed by incentive program design. For example, program recruitment methods can be designed to reach absentee landholders through the use of appropriate advertising messages (Morrison et al., 2017), advertising channels, and timing of recruitment events (Mendham and Curtis, 2010). Absentee participation is also likely to be supported by programs that allow some flexibility in timing for engagement and implementation of management actions. Further research is needed to determine the extent to which issues affecting absentee landholders are addressed by incentive programs.

4.2. Groups

The number of group participants was relatively small, however the group entity type was positively related to management plan size. This highlights their importance as potential participants in incentive programs. Although groups have been acknowledged as managers in the private land conservation literature (Fitzsimons, 2015; Selinske et al., 2015) and in studies of landholders in agricultural landscapes (Gosnell and Travis, 2005), to our knowledge, they have not previously been considered in studies about participation in incentive programs. Participants classed as groups in this study included a wide range of group forms, from non-government organisations to local government, corporations, community groups and small informal groups of individuals who co-own and/or co-manage remnant native vegetation. We acknowledge that this is a very broad spectrum and that motivations for participation in incentive programs and objectives for land management may vary considerably between groups, however, in this study, the small number of participating groups did not allow further classification at a finer scale. Further research is needed to identify group types along with their motivations and constraints for participation in conservation incentive programs. Despite the wide variation in types of groups, there may be some characteristics that group landholders share. For example, groups may require longer time periods for decision making, a need that could be accommodated in incentive program design. As current information relating to groups and their participation in incentive programs is very scarce, it is an important area for future research to inform policy.

4.3. Covenants

Landholders with and without existing covenants (conservation easements) participated in the conservation stewardship tender and some were interested in applying for a new covenant. The largest cluster of participants identified with hierarchical cluster analysis was characterised by participants who did not have an existing covenant and did not express interest in applying for one. This highlights a large constituency of participants who were not prepared to enter into an in-perpetuity covenant but were still willing to offer management services over a five or ten year period. Participants in this cluster were resident, primary producing individuals or families. Given that previous research indicates that participation is reduced when the program employs compulsory covenanting (Comerford, 2013), this large sector of landholders may have been dissuaded from participation if the program had made covenanting mandatory.

The next largest cluster was characterised by landholders seeking a covenant and included both primary producers and non-primary producers as well as absentee and resident landholders. Therefore, there was a potential supply of covenants from both primary producers and non-primary producers and absentee and resident landholders. The final two clusters were characterised by participants who had an existing covenant and were not seeking an additional covenant. These clusters show that even with an existing covenant there is a perceived need for additional management cost recovery, that is, these landholders do not consider that a covenant on its own was sufficient to meet their management objectives.

4.4. Management plan size

Location and entity type were the only reliable predictors of management plan size when all project locations were considered together. This relationship between project location and management plan size is probably driven by differences in agricultural productivity, rainfall and proximity to the city of Adelaide and large rural centres, as well as associated differences in average land parcel size, property size and land value. Group entities were likely to include larger areas in their management plans than entities classified as individuals/families. This could be explained by the ability of groups to pool resources and therefore purchase and manage larger areas of land. It might also be a consequence of historic development patterns leaving some large areas of uncleared land with relatively low production value where buyers do not expect to recover their investment through production. With groups being more likely to offer larger areas of land in the incentive program, they may be seen as an important sector of participants to recruit. However, maximising the area of land offered by each participant or the total area offered in the incentive program may not always be desirable. For instance, an adequate number of participants is required to provide competition in a tender making it potentially undesirable to have a small number of participants offering large land areas, and there may also be significant transaction costs for each entrant meaning increasing participation beyond adequate levels is not justified by the total budget for incentive payments (Whitten et al., 2013).

The SEAST project location was the only individual project with reliable predictors of management plan size. Here, group entities, primary producers and sites with an existing covenant were associated with larger management plan sizes, while having a female primary contact was associated with smaller management plan size. The relationship to primary production status may be due to the generally larger properties held by primary producers compared with non-primary producers (Mendham and Curtis, 2010), while the relationship to covenant status may be a consequence of previous government legislation (e.g. Upper South East Dryland Salinity and Flood Management Act, 2002) and associated policy having already established covenants on many of the larger remnants in the project location.

5. Conclusion

This study challenges the notion that, in agricultural landscapes, landholders interested in conservation incentive programs are typically farming individuals or families. Using empirical evidence from a case study conservation tender program we have shown that participating landholders can be diverse in land use, residence distance from the property and land ownership structure. They may or may not use their property for primary production, they may be resident on the property or absentee and they may own the land individually or jointly as part of a group. Both absentee landholders and groups were important participants in the conservation program, absentee landholders due to their considerable numbers and groups because they were likely to offer larger land areas in the tender.

Given the importance of absentee and group landholders revealed by this study, and the extremely limited information currently available regarding these landholder types, we recommend further research to address the following knowledge gaps. Firstly, research is needed to identify more specific group types within the broad category of group landholders and to investigate their motivations and constraints for participation. For absentee landholders, research is needed to further explore the drivers and patterns of absentee land ownership and to evaluate how rates of absentee landholder participation compare to rates of absentee land ownership. Finally, research is also needed to further examine the extent to which issues affecting absentee landholders, such as access to information, time constraints and unauthorised property access, are addressed by incentive programs. This knowledge will be valuable to inform future policy design for conservation incentive programs in agricultural landscapes.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi: https://doi.org/10.1016/j.landusepol.2017.12.067

References

Adams, V.M., Moon, K., 2013. Security and equity of conservation covenants: contradictions of private protected area policies in Australia. Land Use Policy 30, 114–119.
Australian Bureau of Statistics, 2016. 7121.0 - Agricultural Commodities. Australia, 2014-15, Retrieved 18 April 2017 from. http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/7121.0Main+Features102014-15?OpenDocument.
Australian Government, 2006. Mount Lofty Initiative - Bush Bids. Retrieved 11 May 2017 from. https://www.environment.gov.au/node/13911.
Boxall, P.C., Perger, O., Packman, K., Weber, M., 2017. An experimental examination of target based conservation auctions. Land Use Policy 63, 592–600.
Bureau of Meteorology, 2014. Mean Monthly, Seasonal and Annual Rainfall Data (Base Climatological Data Sets). Retrieved 7 Dec 2016 from. http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp.
Burton, R.J.F., 2014. The influence of farmer demographic characteristics on environmental behaviour: a review. J. Environ. Manage. 135, 19–26.
Comerford, E., 2013. The impact of permanent protection on cost and participation in a conservation programme: A case study from Queensland. Land Use Policy 34, 176–182.
Comerford, E., 2014. Understanding why landholders choose to participate or withdraw from conservation programs: a case study from a Queensland conservation auction. J. Environ. Manage. 141, 169–176.
Cooke, B., Lane, R., 2015. How do amenity migrants learn to be environmental stewards of rural landscapes? Landsc. Urban Plan. 134, 43–52.
Defrancesco, E., Gatto, P., Runge, F., Trestini, S., 2008. Factors affecting farmers'participation in agri-environmental measures: a Northern Italian perspective. J.

Agric. Econ. 59, 114–131.
Department of Environment Water and Natural Resources, 2011. Native Vegetation Floristic Areas - NVIS - Statewide (Incomplete Version).
Department of Environment Water and Natural Resources, 2015. Protected Areas - NPWS and Conservation Reserve Boundaries. Retrieved 17 March 2017 from. https://data.sa.gov.au/data/dataset/conservation-reserve-parcels.
Department of Environment Water and Natural Resources, 2017. Vegetation Heritage Agreements.
Department of Planning Transport and Infrastructure, 2016. Land Use Generalised. Retrieved 12 May 2017 from. https://data.sa.gov.au/data/dataset/land-use-generalised-2016.
Doremus, H., 2003. A policy portfolio approach to biodiversity protection on private lands. Environ. Sci. Policy 6, 217–232.
Duncan, D.H., Dorrough, J.W., 2009. Historical and current land use shape landscape restoration options in the Australian wheat and sheep farming zone. Landsc. Urban Plan. 91, 124–132.
Farmer, J.R., Meretsky, V., Knapp, D., Chancellor, C., Fischer, B.C., 2015. Why agree to a conservation easement? Understanding the decision of conservation easement granting. Landsc. Urban Plan. 138, 11–19.
Figgis, P., 2004. Conservation on Private Lands: the Australian Experience. Retrieved 4 August 2017 from. IUCN. https://www.iucn.org/content/conservation-private-lands-australian-experience.
Fishburn, I.S., Kareiva, P., Gaston, K.J., Armsworth, P.R., 2009. The growth of easements as a conservation tool. PLoS One 4.
Fitzsimons, J.A., 2015. Private protected areas in Australia: current status and future directions. Nat. Conserv. 10, 1–23.
Gosnell, H., Abrams, J., 2011. Amenity migration: diverse conceptualizations of drivers, socioeconomic dimensions, and emerging challenges. GeoJournal 76, 303–322.
Gosnell, H., Travis, W.R., 2005. Ranchland ownership dynamics in the Rocky Mountain west. Rangel. Ecology Manage. 58, 191–198.
Hill, M.R.J., McMaster, D.G., Harrison, T., Hershmiller, A., Plews, T., 2011. A reverse auction for wetland restoration in the Assiniboine River watershed, Saskatchewan. Can. J. Agric. Econ. 59, 245–258.
Hoeting, J.A., Madigan, D., Raftery, A.E., Volinsky, C.T., 1999. Bayesian model averaging: a tutorial. Statistical Science 14, 382–417.
Hunter, L.M., Hatch, A., Johnson, A., 2004. Cross-national gender variation in environmental behaviors. Soc. Sci. Q. 85, 677–694.
Kamal, S., Grodzińska-Jurczak, M., Brown, G., 2015. Conservation on private land: a review of global strategies with a proposed classification system. J. Environ. Plan. Manage. 58, 576–597.
Kendall, B.J., Guynn Jr., D.C., Straka, T.J., Yarrow, G.K., 2013. Hunter and landowner needs and expectations and the economic impact of hunting on rural South Carolina counties (USA). Wildl. Biol. Pract. 9, 76–90.
Kendra, A., Hull, R.B., 2005. Motivations and behaviors of new forest owners in Virginia. For. Sci. 51, 142–154.
Kinzig, A.P., Perrings, C., Chapin Iii, F.S., Polasky, S., Smith, V.K., Tilman, D., Turner II, B.L., 2011. Paying for ecosystem services – promise and peril. Science 334, 603–604.
Klepeis, P., Gill, N., Chisholm, L., 2009. Emerging amenity landscapes: invasive weeds and land subdivision in rural Australia. Land Use Policy 26, 380–392.
Knight, R.L., 1999. Private lands: the neglected geography. Conserv. Biol. 13, 223–224.
Lastra-Bravo, X.B., Hubbard, C., Garrod, G., Tolón-Becerra, A., 2015. What drives farmers' participation in EU agri-environmental schemes? Results from a qualitative meta-analysis. Environ. Sci. Policy 54, 1–9.
Lindhjem, H., Mitani, Y., 2012. Forest owners' willingness to accept compensation for voluntary conservation: a contingent valuation approach. J. For. Econ. 18, 290–302.
Maechler, M., Rousseeuw, P., Struyf, A., Hubert, M., Hornik, K., Studer, M., Roudier, P., Gonzale, J., 2016. The 'cluster' Package Version 2.0.5. https://cran.r-project.org/web/packages/cluster/cluster.pdf.
Mendham, E., Curtis, A., 2010. Taking over the reins: trends and impacts of changes in rural property ownership. Soc. Nat. Resour. 23, 653–668.
Mendham, E., Curtis, A., Millar, J., 2012. The natural resource management implications of rural property turnover. Ecol. Soc. 17.
Mettepenningen, E., Vandermeulen, V., Delaet, K., Van Huylenbroeck, G., Wailes, E.J., 2013. Investigating the influence of the institutional organisation of agri-environmental schemes on scheme adoption. Land Use Policy 33, 20–30.
Moon, K., 2013. Conditional and resistant non-participation in market-based land management programs in Queensland, Australia. Land Use Policy 31, 17–25.
Morrison, M., Durante, J., Greig, J., Ward, J., Oczkowski, E., 2012. Segmenting landholders for improving the targeting of natural resource management expenditures. J. Environ. Plan. Manage. 55, 17–37.
Morrison, M., Greig, J., Waller, D., McCulloch, R., Read, D., 2017. Effective communication with difficult to reach landholders. Australas. J. Environ. Manage. 24, 133–145.
Native Vegetation Act, 1991. Retrieved 16 May 2017 from https://www.legislation.sa.gov.au/LZ/C/A/Native%20Vegetation%20Act%201991.aspx.
Native Vegetation Council, 2017. Heritage Agreements Frequently Asked Questions. Retrieved 2 Oct 2017 from. https://www.environment.sa.gov.au/managing-natural-resources/native-vegetation/protecting-enhancing/heritage-agreements.
Norton, D.A., 2000. Conservation biology and private land: shifting the focus. Conserv. Biol. 14, 1221–1223.
O'Connor, P., 2016. Woodland BushBids: Participant Experience Evaluation. Natural Resources South Australian Murray-Darling Basin.
O'Connor, P., Saison, C., Morgan, A., Bond, A., Lawley, V., 2014. South East BushBids: Native Vegetation Management in the Southern Murray Mallee and Upper South East of South Australia. Natural Resources South Australian Murray-Darling Basin.
Pavlis, E.S., Terkenli, T.S., Kristensen, S.B.P., Busck, A.G., Cosor, G.L., 2016. Patterns of agri-environmental scheme participation in Europe: indicative trends from selected case studies. Land Use Policy 57, 800–812.
Perkins, A.J., Maggs, H.E., Wilson, J.D., Watson, A., 2013. Delayed mowing increases corn bunting Emberiza calandra nestsuccess in an agri-environment scheme trial. Agric. Ecosyst. Environ. 181, 80–89.
Perring, M.P., Standish, R.J., Price, J.N., Craig, M.D., Erickson, T.E., Ruthrof, K.X., Whiteley, A.S., Valentine, L.E., Hobbs, R.J., 2015. Advances in restoration ecology: rising to the challenges of the coming decades. Ecosphere 6.
Petrzelka, P., Armstrong, A., 2015. Absentee landowners of agricultural land: infuences upon land management decision making and information usage. J. Soil Water Conserv. 70, 303–312.
Petrzelka, P., Buman, T., Ridgely, J., 2009. Engaging absentee landowners in conservation practice decisions: A descriptive study of an understudied group. J. Soil Water Conserv. 64.
Petrzelka, P., Ma, Z., Malin, S., 2013. The elephant in the room: absentee landowner issues in conservation and land management. Land Use Policy 30, 157–166.
Petrzelka, P., Malin, S., Gentry, B., 2012. Absentee landowners and conservation programs: mind the gap. Land Use Policy 29, 220–223.
Raftery, A., Hoeting, J., Volinsky, C., Ian, P., Yeung, K.Y., 2015. The 'BMA' Package Version 3.18.6. https://cran.r-project.org/web/packages/BMA/BMA.pdf.
Raymond, C.M., Brown, G., 2011. Assessing conservation opportunity on private land: socio-economic, behavioral, and spatial dimensions. J. Environ. Manage. 92, 2513–2523.
Reimer, A.P., Prokopy, L.S., 2014. Farmer participation in U.S. farm bill conservation programs. Environ. Manage. 53, 318–332.
Rolfe, J., Whitten, S., Windle, J., 2017. The Australian experience in using tenders for conservation. Land Use Policy 63, 611–620.
Selinske, M.J., Coetzee, J., Purnell, K., Knight, A.T., 2015. Understanding the motivations, satisfaction, and retention of landowners in private land conservation programs. Conserv. Lett. 8 (4), 282–289.
Sorice, M.G., Donlan, C.J., 2015. A human-centered framework for innovation in conservation incentive programs. Ambio 44, 788–792.
Thomson, J.R., Mac Nally, R., Fleishman, E., Horrocks, G., 2007. Predicting bird species distributions in reconstructed landscapes. Conserv. Biol. 21, 752–766.
Ulrich-Schad, J.D., Babin, N., Ma, Z., Prokopy, L.S., 2016. Out-of-state, out of mind? Non-operating farmland owners and conservation decision making. Land Use Policy 54, 602–613.
UNEP World Conservation Monitoring Centre and International Union for Conservation of Nature, 2016. Protected Planet Report 2016. UNEP World Conservation Monitoring Centre and International Union for Conservation of Nature.
Upper South East Dryland Salinity and Flood Management Act 2002 (Repealed). Retrieved 31 May 2017 from http://www.austlii.edu.au/au/legis/sa/repealed_act/usedsafma2002529/.
Viallefont, V., Raftery, A.E., Richardson, S., 2001. Variable selection and Bayesian model averaging in case-control studies. Stat. Med. 20, 3215–3230.
Whitten, S.M., Reeson, A., Windle, J., Rolfe, J., 2013. Designing conservation tenders to support landholder participation: a framework and case study assessment. Ecosyst. Serv. 6, 82–92.
Wichmann, B., Boxall, P., Wilson, S., Pergery, O., 2016. Auctioning risky conservation contracts. Environ. Resour. Econ. 1–34.
Zanella, M.A., Schleyer, C., Speelman, S., 2014. Why do farmers join payments for ecosystem services (PES) schemes? An assessment of PES water scheme participation in Brazil. Ecol. Econ. 105, 166–176.

Chapter 3. Remnant woodland biodiversity gains under 10 years of revealed-price incentive payments

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Overall percentage (%)	85%		
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By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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RESEARCH ARTICLE

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Remnant woodland biodiversity gains under 10 years of revealed-price incentive payments

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Abstract

1. Evaluation of conservation incentive programme outcomes is needed to direct future investment, however, monitoring of large-scale programmes is relatively rare. Research in this area has frequently relied on space-for-time substitution or similar designs, rarely controlling for counterfactual trends or potential learning or leakage effects using repeated measures taken before and after intervention at impact and independent control sites.
2. Using a Before-After-Control-Impact (BACI) monitoring design, we investigate the ecological impact of a conservation stewardship programme, where landholders set their own contract price through a reverse auction. In order to maintain or increase species and structural diversity of remnant native vegetation, contracted landholders agreed to manage grazing pressure (from stock and feral animals), control weeds and retain fallen logs. We test whether impact sites (private land under contract) changed over a 9–10 year period relative to control sites (independently managed, non-contracted private land) and reference sites (public conservation areas).
3. Modest improvements were detected in native plant species richness, log abundance and grazing pressure at impact sites compared with background changes observed at control sites. While log abundance and grazing pressure were directly managed at impact sites, the improvement in native plant species richness was assumed to be influenced by reduction in multiple pressures such as grazing pressure and weed abundance.
4. No significant intervention effects were detected in other variables including regeneration, plant litter cover, weed cover and canopy dieback. However, these variables did show changes over time which were likely due to weather, particularly an extended period of drought followed by unusually high rainfall.
5. *Policy implications*. This study shows that revealed-price incentive contracts can produce biodiversity improvement compared with the business-as-usual scenario of native vegetation management on private land. The use of a Before-After-Control-Impact monitoring design enabled the separation of treatment effects from background changes such as those linked to climate and weather, demonstrating the importance of this approach for programme evaluation. We recommend the allocation of appropriate resources for monitoring and also highlight the

need for the collection of baseline data prior to contract establishment at both impact and independently managed control sites.

KEYWORDS
conservation auction, grazing pressure, incentive, long-term monitoring, restoration, temperate grassy woodland, weed control

1 | INTRODUCTION

Biodiversity in agricultural landscapes is generally declining, while also being increasingly recognised as a necessity for ecosystem service provision (Cardinale et al., 2012). Incentive programmes are a policy mechanism widely used to address biodiversity declines on private land in agricultural landscapes (Doremus, 2003; Kamal, Grodzińska-Jurczak, & Brown, 2015) and significant funding has been invested in them (Batáry, Dicks, Kleijn, & Sutherland, 2015; Rolfe, Whitten, & Windle, 2017; Wu & Yu, 2017). However, the effectiveness of these programmes is difficult to measure (Kleijn & Sutherland, 2003) and has rarely been demonstrated (Batáry et al., 2015; Hajkowicz, 2009; Riffell, McIntyre, & Hayes, 2008).

There are numerous challenges for measuring biodiversity outcomes from large-scale incentive programmes. Dealing with high variability amongst samples and/or interventions can be a major difficulty as can separating intervention effects from background variability driven by external factors like climate or weather. In theory these challenges can be managed by adopting appropriate experimental design. Two key experimental design elements to enable robust programme evaluation were recommended by Kleijn and Sutherland (2003). These were; (a) establishment of an adequate baseline prior to intervention coupled with measurement of trends or change over time, and (b) identification and use of appropriate controls. However, there are few examples in subsequent research where these recommendations have been comprehensively adopted.

Some studies have sought to compensate for the absence of baseline data and/or measures of change by careful selection of control sites to reduce potential bias (e.g. Kleijn et al., 2006) or using space-for-time substitution designs (e.g. Lindenmayer, Wood, et al., 2012; Michael, Wood, Crane, Montague-Drake, & Lindenmayer, 2014). However, while these approaches have provided valuable insights, they remain open to the risk of bias in site selection and cannot provide information on counterfactual trends, that is the background trends or changes without intervention. The absence of baseline data in many cases is likely due to the widespread implementation of incentive programmes without adequate monitoring built into the programme design from the outset, either because of a failure to prioritise outcome evaluation or due to resource limitations (Ferraro & Pattanayak, 2006). In one case where baseline data were available but were semi-quantitative, a Bayesian modelling approach was developed to deal with ordinal baseline measurements (Duncan & Vesk, 2013). Another case took baseline measures after incentive contracts had already been awarded (Lindenmayer, Zammit, et al., 2012), leaving a period of time before monitoring establishment when site condition could have been altered by landholders seeking to influence monitoring (compliance) results. Where studies have used measures of change or trends through time, they have generally made use of pre-existing data, such as bird surveys (see Baker, Freeman, Grice, & Siriwardena, 2012; Herzon et al., 2011; Riffell et al., 2008; Vesk et al., 2015) and rarely collected baseline data tailored to the specific objectives of the incentive programme (e.g. Bright et al., 2015).

A range of approaches has also been taken for the use and selection of control sites. The absence of control sites in baseline measurement has prevented separation of intervention effects from background trends (e.g. Duncan & Vesk, 2013). Some studies have selected control sites located on the same farm or property as the impact sites (Lindenmayer, Wood, et al., 2012; Lindenmayer, Zammit, et al., 2012; Michael et al., 2014). While this strategy might conceivably maximise some elements of similarity between impact and control sites, it is compromised by the potential for bias from (a) learning and (b) leakage. Bias caused by learning may occur when the landholder's participation and learning in the programme influences how they manage control sites. Bias caused by leakage, also known as activity shifting or displacement, may occur when agricultural activities or resource use is intensified at the control site to compensate for forgone use of the impact site. Leakage is a demonstrated problem for evaluation of reserve effectiveness (Ewers & Rodrigues, 2008) and incentive programmes such as REDD+ (Van Oosterzee, Blignaut, & Bradshaw, 2012). A rare example of the use of control sites on properties not contracted by the incentive programme is provided by Bright et al. (2015).

A further limitation of the research to date is that it has been concentrated in a subset of programme types and locations. Currently, evidence of incentive programme impact on biodiversity comes mainly from European Agri-environmental schemes (AES), where interventions commonly include the creation of set aside areas or restrictions on agricultural practices (e.g. cultivation, mowing, fertiliser application) in farmland (Batáry et al., 2015). There have been few impact evaluations for incentive programmes with other types of interventions such as those aiming to improve habitat function of (restore) remnant native vegetation in agricultural landscapes (e.g. Lindenmayer, Wood, et al., 2012; Michael et al., 2014). Functional ecological change may only occur over long time scales, necessitating incentive programmes, monitoring and research that extend over equally appropriate timeframes. In the range of studies to date many have not considered the time period of intervention (Batáry et al., 2010; Firbank et al., 2003; Kohler, Verhulst, Knop, Herzog, & Kleijn, 2007) or have estimated change over a period of 5 years or fewer (Bright et al., 2015; Herzon et al., 2011), whereas just a few have considered change over a 10-year period or longer (Kleijn et al., 2006; Riffell et al., 2008; Vesk et al., 2015). Intervention and evaluation timeframes are also important because ecological outcomes may depend on temporally variable conditions such as weather (Vaughn & Young, 2010). To date, most impact evaluation research has been located in central to northern Europe, with only a small number of studies in regions with lower and/or more variable rainfall (e.g. Lindenmayer, Wood, et al., 2012; Michael et al., 2014; Vesk et al., 2015).

Most research on incentive outcomes has focussed on fixed-price incentive schemes (e.g. European AES), however, there is growing interest in conservation auctions, where participants set their own price for management. Revealed-price schemes differ from fixed-price schemes in some aspects that may influence programme outcomes. For example there may be differences in participating landholders and their motivations and behaviours (Bond, O'Connor, & Cavagnaro, 2018b; Whitten, Reeson, Windle, & Rolfe, 2013; Wünscher & Wunder, 2017), and the programme's ability to accommodate heterogeneity in management and opportunity costs (Rolfe et al., 2017). Impact evaluations of revealed-price schemes are therefore needed to add to the existing literature on incentive outcomes.

Here we investigate the impact of 10-year, revealed-price, incentive contracts in an environment of high rainfall variability. We use a large-scale conservation stewardship programme as a case study; Eastern Mt Lofty Ranges BushBids, where landholders set their own price for contracts through a conservation auction (reverse auction). In order to maintain or increase species and structural diversity of remnant native vegetation, contracted landholders agreed to manage grazing pressure (from stock and feral animals), control weeds and retain fallen logs.

Using a modified Before-After-Control-Impact (BACI) design we test whether impact sites (private land under BushBids contracts) changed over time relative to control sites (independently managed private land without BushBids contracts) and reference sites (public conservation areas). We hypothesised that 10-year BushBids contracts would produce relative gains in native vegetation condition at impact sites compared with control sites. Here we define vegetation condition to include diversity, structure and threatening processes or pressures. As the background trend in native vegetation condition in the study area was unknown, we anticipated that these gains could be shown either as larger increases or smaller decreases in native plant diversity, regeneration or structural habitat indicators at impact sites compared to control sites. For measures of threatening processes such as canopy dieback, grazing pressure and weed cover we anticipated smaller increases or larger decreases at impact sites compared with control sites. Reference sites were expected to show background changes in relatively undisturbed native vegetation under the standard of management provided by state and local government.

2 | MATERIALS AND METHODS

2.1 | Study region

This study is located in the eastern Mt Lofty Ranges of South Australia, in an area spanning approximately 3,000 km^2 (Figure 1). Native vegetation in the region includes forests and woodlands (many dominated by eucalypt species) as well as shrublands, grasslands and wetlands (Department of Environment, Water and Natural Resources, unpublished data). This study focusses on woodlands

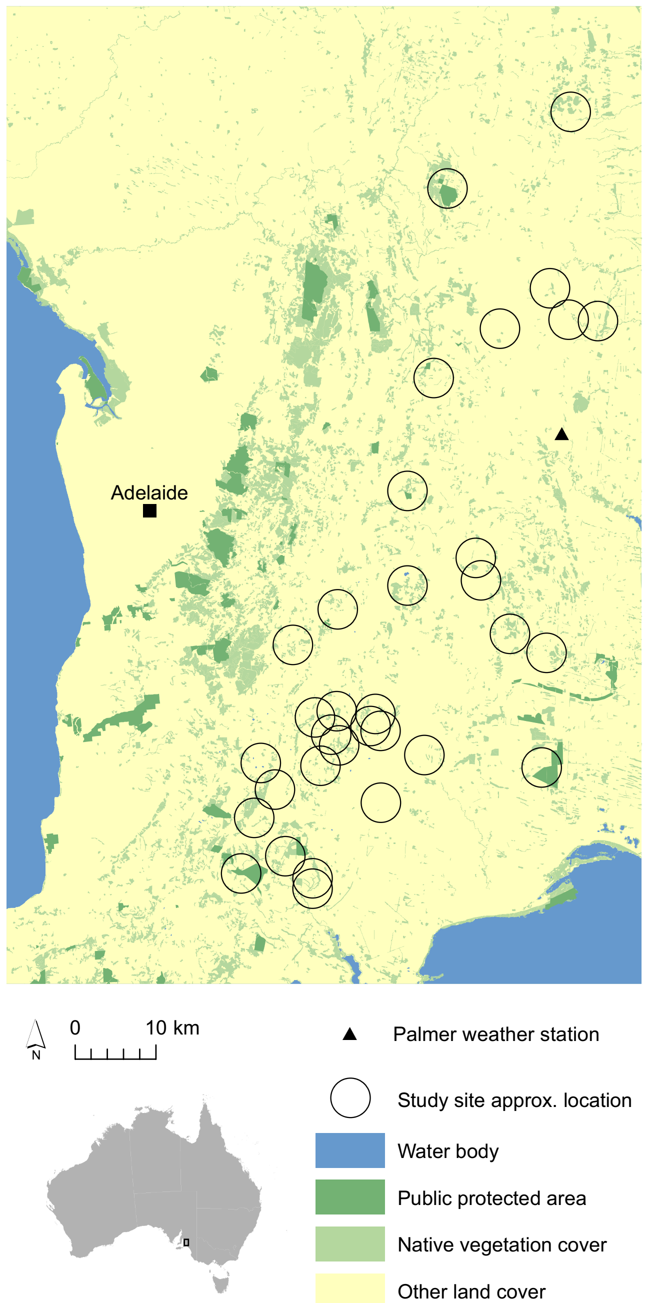

FIGURE 1 Approximate location of study sites within the eastern Mt Lofty Ranges, South Australia. Study site location accuracy has been reduced to protect the privacy of project participants

with a grassy understorey, a broad vegetation type recognised as a conservation priority (Prober, Thiele, Lunt, & Koen, 2005). For further description of the study area please see Appendix S1.

2.2 | Study region climate

The region has a temperate climate with warm, usually dry summers and an annual average rainfall ranging between approximately 890 mm and approximately 290 mm, with decreasing rainfall gradients from south to north and west to east (Bureau of Meteorology, 2014). There was an extended period of below average rainfall from 2006 to early 2010 (Appendix S2), corresponding with the final years of the 1997–2009 'millennium drought' (CSIRO, 2012), the worst recorded drought in south eastern Australia. The drought was broken by extremely high rainfall events in 2010 and 2011 both within the study region (see Appendix S2) and elsewhere in south eastern Australia (CSIRO, 2012).

2.3 | Eastern Mt Lofty Ranges BushBids project

The Eastern Mt Lofty Ranges BushBids project (Australian Government, 2006; see also Bond et al., 2018b) was established to assist private landholders with restoration and management of remnant native vegetation in agricultural landscapes. The project used a discriminant price reverse auction to establish 10-year contracts with private landholders. Under these contracts, landholders agreed to manage grazing pressure from stock and retain fallen logs, and in most cases, contracts also included weed and feral animal control. In some circumstances grazing pressure from Kangaroos (native) was also identified as a threat to be managed under the contract. See Appendix S3, for further detail of management actions and Appendix S4 for a list of weed and feral animal species commonly targeted for control. While stock grazing management was a requirement of the BushBids management plans, in many cases stock management prior to the contract was consistent with that required under the contract (either stock exclusion or conservation grazing). For this reason the ecological response was expected to be relatively modest compared to changes likely to occur after stock grazing removal. Entering into a Heritage Agreement (a type of in-perpetuity conservation covenant, see Native Vegetation Council, 2017) was an additional service landholders could elect to provide under the contracts. Almost 50% of the 2,256 ha placed under BushBids contracts was covered by new or existing Heritage Agreements (O'Connor, Morgan, & Bond, 2008). Monitoring and evaluation of management and ecological outcomes were built into the BushBids programme design.

2.4 | Study design and data

This study aimed to evaluate the impact of 10-year contracts with incentive payments set by the landholders. We used a modified BACI design, with a total of 33 sites in three *treatment* categories (impact, control and reference). There were 12 **impact** sites on private property with 10-year BushBids contracts, 10 **control** sites on private properties without a BushBids contract, and 11 **reference** sites on public land.

Contracted management at impact sites included management of grazing pressure from stock and feral animals, retention of fallen logs, weed control and management to address other threats. For two of the 12 impact sites, stock management under the BushBids contract constituted a material change compared with prior management. See Appendix S3, for further detail of management actions and Appendix S4 for a list of weed and feral animal species commonly targeted for control. Compliance with contractual requirements at impact sites was assumed to be at or near 100% based on programme auditing.

Control sites were established where landholders had expressed interest in BushBids but did not have a contract either because they withdrew before bidding or their bid was unsuccessful. While the control sites were not managed under BushBids contracts during the study period, in most cases (eight of 10) they were not grazed by stock and in many cases (six of 10) they received some similar management actions as those prescribed for impact sites (e.g. weed control). Key differences provided by the contracts were (a) a contracted programme of works set out in a 10-year management plan for continuous management against known standards, (b) comprehensive management of threats (i.e. restrictions on disturbance along with grazing pressure management, weed control and management of other threats identified at the site) and (c) incentive payments at the price set by the landholder. In contrast, management at control sites may have addressed some threats, for some of the time, to a variable and sometimes poorly defined standard.

Reference sites were located within remnant native vegetation in Conservation Parks and other reserves and were managed by state and local government authorities as well as community volunteers. Management of reference sites included stock exclusion and ostensibly the retention of fallen logs. While we have limited information regarding other management actions undertaken at reference sites we were able to ascertain that weed control was implemented at a minimum of four out of the 11 sites. In this study, reference sites represent relatively undisturbed sites managed to the standard set by state and local government.

Sites used in this study were selected on the basis of vegetation type from a wider pool of sites established when the BushBids programme was initiated. Some sites were later excluded when landholders could not be contacted at the time of reassessment. The plant community at study sites was either woodland with a sparse shrub layer and grassy understorey or woodland with a moderately dense shrub layer and a grassy understorey. *Eucalyptus* species generally dominated the overstorey except for two sites where Drooping Sheoak *Allocasuarina verticillata* was the dominant tree.

Sites were initially assessed in 2006 or 2007 before contracts were established, and were assessed again in late 2015 or early 2016 before contracts were acquitted. Most of the initial assessments and all of the final assessments were undertaken in late spring and summer. A set of variables relating to vegetation condition were measured at a sample plot within each site, with the same sample plot measured in both assessments. The measured variables are detailed in Appendix S5 and are derived from a methodology developed for assessing vegetation condition in South Australian ecosystems (Collard, Fisher, Hobbs, & Neumann, 2013; Croft, Pedler, & Milne, 2005). Here canopy dieback refers to the episodic or chronic loss of leaves from the tree canopy, often seen in *Eucalyptus* species. The causes of dieback may be biotic (e.g. pathogens, invertebrate or vertebrate herbivory, or competition) or abiotic (e.g. weather, soil, or hydrological conditions) or a combination of these interacting factors driven by human induced environmental changes (Jurskis, 2005).

2.5 | Analysis

Statistical analyses were preformed using R version 3.4.2 (R Core Team 2017). To explore patterns in vegetation condition and composition we used ordination (principal components analysis and principal coordinates analysis) in the *vegan* package (Oksanen et al., 2016). For the principal components analysis, vegetation condition variables were selected which had data available for all sites in the initial and final assessment. These were native plant species richness, vegetation structural diversity, regeneration, log abundance, weed cover and canopy dieback. To account for differences in the taxonomic resolution between initial and final assessments we used the Θ^+ index of taxonomic dissimilarity outlined by Clarke, Somerfield, and Chapman (2006) for the principal coordinates analysis. This taxonomic dissimilarity index was calculated using taxonomic levels from subspecies or variety to class.

To control for spatial autocorrelation and the potentially confounding effects of variability in vegetation composition we developed two variables for inclusion as covariates in statistical models; *locations* and *vegetation groups*. Two hierarchical cluster analyses (complete agglomeration method) were undertaken, one using the taxonomic dissimilarity index and the other using geographic coordinates of the study sites. This analysis grouped the sites into three compositionally similar *vegetation groups* and three spatially similar *locations*.

Generalised Linear Mixed Models in the *lme4* package (Bates et al., 2016) were used to test the main effects *treatment* and *time* and the interaction of *treatment* and *time*, with *site* as a random variable. Poisson distributions with log link functions were used for positive integer response variables, whereas binomial distributions with logit link functions were used for presence/absence of regeneration as well as the proportion of native plant species with signs of heavy or severe grazing. Native plant species richness and vegetation structural diversity were also tested with linear mixed models (Gaussian distribution and identity link function), because this resulted in similar or better models (evaluated with AIC), and these data did not contain zero values. Other measured variables including estimates of percentage cover were also tested with Gaussian error distribution and identity link function, because this was the most appropriate option available. Tests were performed by sequentially adding terms to the model and using AIC and *p*-values to evaluate which terms significantly improved the model. Covariates (*location* or *vegetation group*) were included where they improved the model, except in two cases. Covariates were not included in the models for biological crust and weed cover because their inclusion did not change the overall conclusions regarding the effects of *time* or *treatment* × *time*, but did result in model estimates of less than zero cover, which was probably due to the use of the Gaussian error distribution in these models. Model convergence warnings were received for models of grazing pressure and *Acacia pycnantha* regeneration, so these model estimates were cross checked using all available optimisers. Here we use the term optimisers to refer to the algorithms used to estimate variance-covariance matrices of the random effects (Bates et al., 2016). We found that all optimisers produced similar results for the grazing pressure model estimates, leading us to accept the model results. However, model estimates were not similar for the *A. pycnantha* regeneration model and therefore the model for *A. pycnantha* is not presented in the study results. GLMM partial residual plots were created using the *visreg* package version 2.4-1 (Breheny & Burchett, 2017). Finally, to provide estimates of the proportion of variance explained by the models, pseudo R^2 statistics (Nakagawa, Johnson, & Schielzeth, 2017) were calculated for the final model in the sequence for each variable using the *MuMIn* package (Barton, 2018).

3 | RESULTS

3.1 | Vegetation composition change

Three groups of compositionally similar sites were identified with ordination and hierarchical cluster analysis (Appendix S6a). These groups approximately follow a geographic and rainfall gradient from west to east. Changes in composition (taxonomic dissimilarity) were identified between the initial and final assessments, but most of these changes were small relative to the distance between the three groups and no consistent patterns in direction of change were identified (Appendix S6a).

3.2 | Vegetation condition change

A principal components analysis using multiple site condition variables (Appendix S6b) shows that there were no clear groupings of sites with respect to the factors *treatment* or *time*. Native plant species richness and vegetation structural diversity were positively correlated along both of the first two principal components, and were negatively correlated with weed cover. Generally, sites moved toward higher species richness and away from high weed cover between the initial and final assessments. Interestingly, some sites (control and reference) moved in the opposite direction with respect to the first principal component.

Time was identified as a significant factor in models of many of the response variables. Between the initial and final assessments, native plant species richness, regeneration, log abundance, plant litter cover, canopy dieback and grazing pressure all increased, whereas weed cover decreased (Figures 2–4 and Table 1). *Treatment*

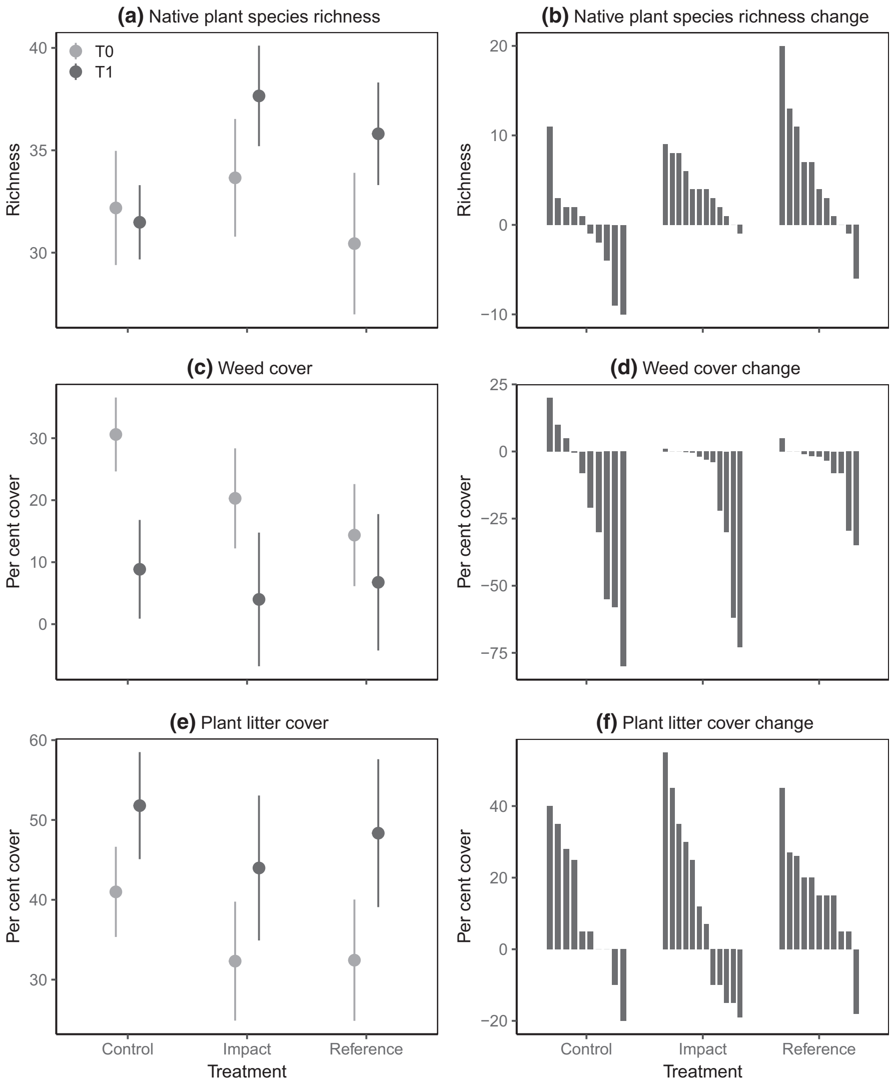

FIGURE 2 Model estimates (±*SE*) and site level change in response variables, (a, b) native plant species richness (Gaussian), (c, d) weed cover, (e, f) plant litter cover. Model estimates shown using scale of the original response variable

was a significant factor in the models for regeneration and canopy dieback, but was not found to be a significant factor in models for other response variables. Partial residual plots for models are provided in Appendix S7.

Statistically significant interactions between *treatment* and *time* were identified in models of log abundance (increase over time was smaller at control sites than at impact and reference sites) and grazing pressure (increase over time was larger at control sites compared with impact and reference sites) (Figures 3e and 4a and Table 1). Native plant species richness showed a significant interaction between *time* and *treatment* (increased over time at impact and reference sites while at control sites it decreased) when tested using Gaussian error distribution (Figure 2a and Table 1). Finally, a marginally significant (p = 0.091) interaction between *time* and *treatment* was found in the model of biological crust cover (decreased at reference sites but increased at impact and control sites) (Figure 3a and Table 1).

For most response variables, 64% or more of variation in the data was explained by the models (including fixed and random effects) (see Table 1). Regeneration and grazing pressure were the exceptions, with large proportions of unexplained variation. Random effects of *site* accounted for 18% or more of the variation for nearly all variables and were responsible for particularly high proportions of the variation in log abundance, canopy dieback and biological crust cover. The fixed effects including *treatment*, *time*, *treatment* × *time* and in some cases, one of the two examined co-variates (*vegetation group* and *location*) accounted for between 27% and 64% of the variation for most response variables.

4 | DISCUSSION

This study provides evidence of biodiversity gains (vegetation condition improvement) resulting from 10-year, revealed-price contracts for restoration of remnant native vegetation. The vegetation condition improvement is demonstrated to be additional to the confounding effects of climate or weather and potential leakage and learning which have not generally been controlled for in other studies. The results provide a unique contribution to the literature which has been dominated by studies of fixed-price incentives for set aside or

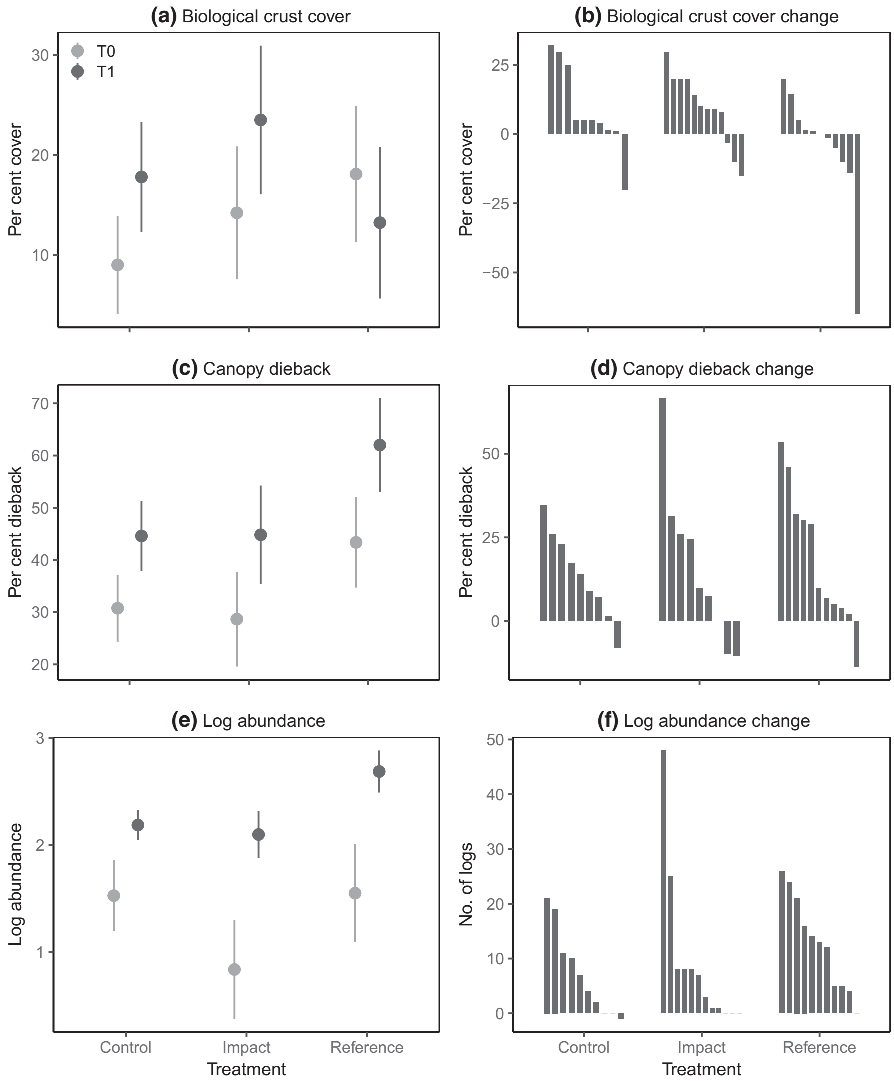

FIGURE 3 Model estimates (±*SE*) and site level change in response variables, (a, b) biological crust, (c, d) canopy dieback, (e, f) log abundance. Model estimates shown using scale of the original response variable (a, c), scale of linear predictor (e)

agricultural management change interventions, in cooler and wetter temperate climates (e.g. Baker et al., 2012; Batáry et al., 2015; Bright et al., 2015). Positive impacts of incentives have been found by some (e.g. Baker et al., 2012; Bright et al., 2015; Herzon et al., 2011; Kleijn et al., 2006; Kohler et al., 2007) but until now have not been shown in appropriately controlled studies of programmes incentivising remnant vegetation restoration.

We found significant, albeit modest, improvements in three measures of vegetation condition at impact sites compared with control sites. Native plant species richness and log abundance showed larger improvements at impact sites compared with control sites but these impact site improvements were smaller than those at reference sites. Grazing pressure at impact sites was higher at the final assessment than the initial assessment but this increase was smaller than the grazing pressure increase observed at control sites. Both grazing pressure and log abundance were directly managed through impact site contracts, whereas native plant species richness was assumed to be influenced by a reduction in multiple pressures such as grazing pressure and weed abundance. Results from these three condition measures support the hypothesis that 10-year, revealed-price contracts lead to vegetation condition improvement compared with the business-as-usual scenario on private land (control sites). The similarity in responses of impact and reference sites was expected, as reference sites were managed for conservation by state and local government and community organisations. Neither the ordination for vegetation composition nor a manual comparison of initial and final composition found any consistent patterns in composition change. This may be a result of relatively high levels of between site composition variation. Given that native plant species richness was the only diversity measure where we found significant intervention effects, we recommend future studies consider the value of alternative measures for diversity and build them into evaluations at the design stage.

In several of the measured variables, change over *time* was consistent across treatments and no statistically significant effects of intervention were found. This response was seen in regeneration, plant litter cover, weed cover and canopy dieback and we suggest it is linked to climate and weather conditions, particularly rainfall, during the contract period. We provide further discussion of changes in response to *time* in Appendix S8.

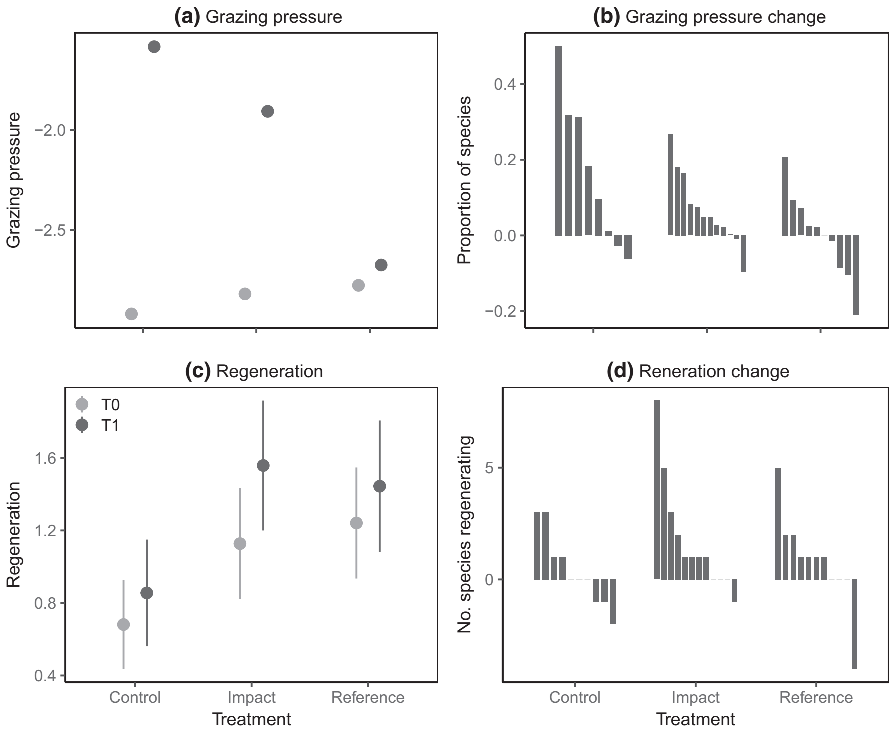

FIGURE 4 Model estimates (±*SE*) and site level change in response variables, (a, b) grazing pressure, (c, d) regeneration. Model estimates shown using scale of linear predictor

TABLE 1 Effects of *treatment* and *time* on vegetation condition variables

Response variable	Model family	Covariate and predictors (sequentially added)	AIC	*p*	Estimate ± *SE* (from final model in sequence)	Pseudo R^{2a} marginal, conditional
Native plant species richness	Poisson		460.54		Intercept: 3.41 ± 0.11	
		Vegetation group	434.29	***	Group 2: −0.31 ± 0.11, Group 3: −0.62 ± 0.10	
		Treatment	433.92		Impact: 0.11 ± 0.12, Reference: −0.01 ± 0.13	
		Time	**430.08**	*	T1 −0.03 ± 0.10	
		Treatment × time	430.88		ImpactT1: 0.18 ± 0.13 ReferenceT1: 0.21 ± 0.12	0.58, 0.76
Native plant species richness	Gaussian		464.00		Intercept: 32.18 ± 2.79	
		Vegetation group	437.51	***	Group 2: −8.72 ± 2.94, Group 3: −15.41 ± 2.67	
		Treatment	438.78		Impact: 1.47 ± 2.88, Reference: −1.74 ± 3.46	
		Time	**433.34**	**	T1: −0.70 ± 1.81	
		Treatment × time	**430.96**	*	ImpactT1: 4.70 ± 2.46 ReferenceT1: 6.06 ± 2.51	0.63, 0.93
Regeneration	Poisson		287.69		Intercept: 0.68 ± 0.24	
		Treatment	**284.20**	*	Impact: 0.45 ± 0.31, Reference: 0.56 ± 0.31	
		Time	**281.24**	*	T1 0.17 ± 0.29	
		Treatment × time	284.45		ImpactT1: 0.26 ± 0.36, ReferenceT1: 0.03 ± 0.36	0.18, 0.39
Vegetation structural diversity	Gaussian		326.43		Intercept: 14.00 ± 1.01	
		Vegetation group	307.78	***	Group 2: −2.32 ± 1.03, Group 3: −4.29 ± 0.94	
		Treatment	**306.70**	†	Impact: 2.11 ± 1.06, Reference:1.66 ± 1.26	
		Time	**304.96**	†	T1: 1.30 ± 0.80	
		Treatment × time	307.96		ImpactT1: −0.30 ± 1.08 ReferenceT1: −1.03 ± 1.11	0.42, 0.64
Log abundance	Poisson		595.93		Intercept: 1.53 ± 0.33	
		Treatment	597.81		Impact: −0.69 ± 0.46, Reference: 0.02 ± 0.46	

(Continues)

TABLE 1 (Continued)

Response variable	Model family	Covariate and predictors (sequentially added)	AIC	p	Estimate ± *SE* (from final model in sequence)	Pseudo R^{2a} marginal, conditional
		Time	**445.01**	***	T1 0.66 ± 0.14	
		Treatment × time	**439.92**	*	ImpactT1: 0.60 ± 0.22, ReferenceT1: 0.48 ± 0.20	0.27, 0.93
Canopy dieback	Gaussian		522.92		Intercept: 30.76 ± 6.42	
		Treatment	**520.84**	*	Impact: −2.09 ± 9.08, Reference: 12.61 ± 8.65	
		Time	**506.79**	***	T1: 13.84 ± 6.67	
		Treatment × time	510.47		ImpactT1: 2.32 ± 9.44 ReferenceT1: 4.82 ± 9.00	0.42, 0.97
Plant litter cover	Gaussian		583.22		Intercept: 40.99 ± 5.65	
		Location	576.19	**	Group 2: −18.00 ± 6.03, Group 3: −11.93 ± 6.12	
		Treatment	577.89		Impact: −8.68 ± 7.45, Reference: −8.56 ± 7.60	
		Time	**568.85**	***	T1: 10.80 ± 6.70	
		Treatment × time	572.45		ImpactT1: 0.87 ± 9.08 ReferenceT1: 5.11 ± 9.26	0.60, 0.96
Biological crust cover	Gaussian		551.97		Intercept: 9.00 ± 4.91	
		Treatment	554.89		Impact: 5.21 ± 6.65, Reference: 9.09 ± 6.79	
		Time	554.91		T1: 8.80 ± 5.49	
		Treatment × time	**554.09**	†	ImpactT1: 0.49 ± 7.44 ReferenceT1: −13.66 ± 7.59	0.18, 0.93
Weed cover	Gaussian		589.20		Intercept: 30.60 ± 5.96	
		Treatment	590.68		Impact: −10.31 ± 8.07, Reference: −16.24 ± 8.24	
		Time	**582.04**	**	T1: −21.75 ± 7.96	
		Treatment × time	584.22		ImpactT1: 5.45 ± 10.78 ReferenceT1: 14.14 ± 11.00	0.64, 0.94
Grazing pressure (Proportion of native species with signs of heavy or severe vertebrate herbivore damage)	Binomial		289.37		Intercept: −2.92 ± 0.00	
		Treatment	289.03		Impact: 0.10 ± 0.00, Reference: 0.14 ± 0.00	
		Time	**272.79**	***	T1: 1.34 ± 0.00	
		Treatment × time	**270.16**	*	ImpactT1: −0.42 ± 0.00 ReferenceT1: −1.24 ± 0.00	0.07, 0.15

Notes: [a]Pseudo R^2 where marginal R^2 indicates the variance explained by the fixed effects and conditional R^2 indicates the variance explained by the model including both fixed and random effects.
***$p < 0.001$, **$p = 0.001–0.01$, *$p = 0.01–0.05$, †$p = 0.05–0.1$.

Model performance was generally good, with models explaining a large proportion of the variance for most response variables. However, this was not the case for the regeneration and grazing pressure variables, suggesting future studies may benefit from the exploration of alternative measures or analysis methods for these indicators of condition. Random effects (*site*) were responsible for a relatively large proportion of the variance in many cases, which highlights the need to account for this source of variation in future studies. When detected, the intervention effect therefore accounted for a relatively small amount of the overall variance, highlighting the challenges of demonstrating restoration outcomes in a real incentive programme with heterogeneous sites in an environment with high rainfall variability and long response times for change.

In this study we addressed the challenge of control site selection using control sites located on independent properties, thereby avoiding the potential confounding effects of learning and leakage when control sites are paired with impact sites on the same property. We argue that although this approach may result in greater 'noise' in the data and does not provide a contrast between management and no management (Duncan & Reich, 2016), it is the best approach to control for a realistic business-as-usual scenario in incentive programme impact evaluations. It would not have been practical to prevent management at control sites, nor would preventing management be a realistic representation of what happens in the absence of a revealed-price incentive programme. A 'no management' control would therefore not be a true counterfactual scenario. The use of unsuccessful and non-bidding properties for control sites may have led to a conservative estimate of effect size, as it is possible that these landholders, on average, engage in conservation management practices to a greater extent than the general population of landholders. However, the revealed-price programme is likely to recruit a breadth of landholders, including those who would not engage in any conservation actions without sufficient financial incentives (Whitten et al., 2013).

In addition to using the BACI design with independent, business-as-usual control sites, we controlled for background variability by focussing the study on one broad vegetation type (woodlands with a grassy understorey), and maximising the sample size within the constraints of site availability and vegetation type. Larger sample sizes may be possible in programmes where there is a greater number of potential sites, such as in larger programmes and/or programmes that focus on a single vegetation community or on a small number of related communities. However, these factors are driven by programme objectives and budgets and are therefore outside the control of evaluation studies. It may also be possible to enhance the ability to detect change in future studies by improving the accuracy of some vegetation measures (e.g. see Gorrod & Keith, 2009).

5 | CONCLUSIONS

This study provides the first example of evaluation of an incentive programme for restoration of remnant native vegetation using a BACI monitoring design. Furthermore, the evaluation is for a programme where landholders set their own price for management, a situation where participant type, motivation and behaviours are understood to be different to those in fixed-price incentive programmes. This study also adds to our understanding of restoration of remnant native vegetation using private-land incentive payments in an environment with relatively low but highly variable rainfall, where vegetation recovery is likely to require long time scales. The study provides evidence that revealed-price incentive contracts produced positive, though moderate, changes in vegetation compared with the business-as-usual scenario of native vegetation management on private land.

Gains achieved over the 10-year programme were modest compared with concurrent changes that were likely due to high rainfall events in the middle of the study period. The use of the BACI monitoring design enabled the separation of treatment effects from these background changes, highlighting the importance of BACI designs for programme evaluation. While BACI approaches have rarely been used in the published research on conservation incentive programme effectiveness to date, we have demonstrated their value and the need to build them into future programmes at the programme establishment phase. We recommend the allocation of appropriate resources for monitoring (appropriate to the scale of investment and level of outcome uncertainty) and also highlight the need for collection of baseline data prior to contract establishment at both impact and independently managed control sites.

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AUTHORS' CONTRIBUTIONS

P.J.O'C. and A.J.B. conceived the ideas and designed the methodology; A.J.B., P.J.O'C. and others collected the data; A.J.B., T.R.C. and P.J.O'C. analysed the data; A.J.B. led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

DATA ACCESSIBILITY

Data are available at the Figshare repository https://doi.org/10.25909/5b581a5a151da (Bond, O'Connor, & Cavagnaro, 2018a).

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REFERENCES

Australian Government.. (2006). *Mount Lofty Initiative – BushBids*. Retrieved from https://www.environment.gov.au/node/13911

Baker, D. J., Freeman, S. N., Grice, P. V., & Siriwardena, G. M. (2012). Landscape-scale responses of birds to agri-environment management: A test of the English Environmental Stewardship scheme. *Journal of Applied Ecology*, *49*, 871–882. https://doi.org/10.1111/j.1365-2664.2012.02161.x

Barton, K. (2018). MuMIn: Multi-model inference. R package version 1.42.1. Retrieved from https://CRAN.R-project.org/package=MuMIn

Batáry, P., Báldi, A., Sárospataki, M., Kohler, F., Verhulst, J., Knop, E., … Kleijn, D. (2010). Effect of conservation management on bees and insect-pollinated grassland plant communities in three European countries. *Agriculture, Ecosystems and Environment*, *136*, 35–39. https://doi.org/10.1016/j.agee.2009.11.004

Batáry, P., Dicks, L. V., Kleijn, D., & Sutherland, W. J. (2015). The role of agri-environment schemes in conservation and environmental management. *Conservation Biology*, *29*, 1006–1016. https://doi.org/10.1111/cobi.12536

Bates, D., Maechler, M., Bolker, B., Walker, S., Christensen, R. H. B., Singmann, H., … Green, P. (2016). The 'lme4' linear mixed-effects models using 'Eigen' and S4 package version 1.1-12. Retrieved from https://cran.r-project.org/web/packages/lme4/index.html

Bond, A. J., O'Connor, P. J., & Cavagnaro, T. R. (2018a). Data from: Remnant woodland biodiversity gains under ten years of revealed-price incentive payments. *Figshare*, https://doi.org/10.25909/5b581a5a151da

Bond, A. J., O'Connor, P. J., & Cavagnaro, T. R. (2018b). Who participates in conservation incentive programs? Absentee and group landholders are in the mix. *Land Use Policy*, *72*, 410–419. https://doi.org/10.1016/j.landusepol.2017.12.067

Breheny, P., & Burchett, W. (2017). *visreg: Visualization of Regression Models*. R package version 2.4-1. Retrieved from https://CRAN.R-project.org/package=visreg

Bright, J. A., Morris, A. J., Field, R. H., Cooke, A. I., Grice, P. V., Walker, L. K., … Peach, W. J. (2015). Higher-tier agri-environment scheme enhances breeding densities of some priority farmland birds in England. *Agriculture, Ecosystems and Environment*, *203*, 69–79. https://doi.org/10.1016/j.agee.2015.01.021

Bureau of Meteorology. (2014). *Mean monthly, seasonal and annual rainfall data (base climatological data sets)*. Retrieved from http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp

Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., … Naeem, S. (2012). Biodiversity loss and its impact on humanity. *Nature*, *486*, 59–67. https://doi.org/10.1038/nature11148

Clarke, K. R., Somerfield, P. J., & Chapman, M. G. (2006). On resemblance measures for ecological studies, including taxonomic dissimilarities and a zero-adjusted Bray-Curtis coefficient for denuded assemblages. *Journal of Experimental Marine Biology and Ecology*, *330*, 55–80. https://doi.org/10.1016/j.jembe.2005.12.017

Collard, S., Fisher, A., Hobbs, T., & Neumann, C. (2013). Indicators of biodiversity and carbon storage in remnant and planted vegetation in the Mount Lofty Ranges of South Australia: Lessons for 'biodiverse' plantings. *Ecological Management and Restoration*, *14*, 150–155. https://doi.org/10.1111/emr.12039

Croft, S., Pedler, J., & Milne, T. (2005). *Bushland condition monitoring manual southern Mt Lofty Ranges*. Adelaide, SA: Nature Conservation Society of South Australia.

CSIRO. (2012). *Climate and water availability in south-eastern Australia: A synthesis of findings from Phase 2 of the South Eastern Australian Climate Initiative (SEACI). CSIRO*. Retrieved from http://www.seaci.org/publications/synthesis.html

Doremus, H. (2003). A policy portfolio approach to biodiversity protection on private lands. *Environmental Science and Policy*, *6*, 217–232. https://doi.org/10.1016/S1462-9011(03)00036-4

Duncan, D., & Reich, P. (2016). Controls and counterfactual information in agro-ecological investment. In D. Ansell, F. Gibson, & D. Salt (Eds.), *Learning from agri-environment schemes in Australia: Investing in biodiversity and other ecosystem services on farms* (pp. 237–253). Acton, ACT: ANU Press.

Duncan, D. H., & Vesk, P. A. (2013). Examining change over time in habitat attributes using Bayesian reinterpretation of categorical assessments. *Ecological Applications*, *23*, 1277–1287.

Ewers, R. M., & Rodrigues, A. S. L. (2008). Estimates of reserve effectiveness are confounded by leakage. *Trends in Ecology and Evolution*, *23*, 113–116. https://doi.org/10.1016/j.tree.2007.11.008

Ferraro, P. J., & Pattanayak, S. K. (2006). Money for nothing? A call for empirical evaluation of biodiversity conservation investments. *PLoS Biology*, *4*, 482–488. https://doi.org/10.1371/journal.pbio.0040105

Firbank, L. G., Smart, S. M., Crabb, J., Critchley, C. N. R., Fowbert, J. W., Fuller, R. J., … Hill, M. O. (2003). Agronomic and ecological costs and benefits of set-aside in England. *Agriculture, Ecosystems and Environment*, *95*, 73–85.

Gorrod, E. J., & Keith, D. A. (2009). Observer variation in field assessments of vegetation condition: Implications for biodiversity conservation. *Ecological Management and Restoration*, *10*, 31–40. https://doi.org/10.1111/j.1442-8903.2009.00437.x

Hajkowicz, S. (2009). The evolution of Australia's natural resource management programs: Towards improved targeting and evaluation of investments. *Land Use Policy*, *26*, 471–478. https://doi.org/10.1016/j.landusepol.2008.06.004

Herzon, I., Ekroos, J., Rintala, J., Tiainen, J., Seimola, T., & Vepsäläinen, V. (2011). Importance of set-aside for breeding birds of open farmland in Finland. *Agriculture, Ecosystems and Environment*, *143*, 3–7. https://doi.org/10.1016/j.agee.2011.05.006

Jurskis, V. (2005). Eucalypt decline in Australia, and a general concept of tree decline and dieback. *Forest Ecology and Management*, *215*, 1–20. https://doi.org/10.1016/j.foreco.2005.04.026

Kamal, S., Grodzińska-Jurczak, M., & Brown, G. (2015). Conservation on private land: A review of global strategies with a proposed classification system. *Journal of Environmental Planning and Management*, *58*, 576–597. https://doi.org/10.1080/09640568.2013.875463

Kleijn, D., Baquero, R. A., Clough, Y., Díaz, M., De Esteban, J., Fernández, F., … Yela, J. L. (2006). Mixed biodiversity benefits of agri-environment schemes in five European countries. *Ecology Letters*, *9*, 243–254. https://doi.org/10.1111/j.1461-0248.2005.00869.x

Kleijn, D., & Sutherland, W. J. (2003). How effective are European agri-environment schemes in conserving and promoting biodiversity? *Journal of Applied Ecology*, *40*, 947–969. https://doi.org/10.1111/j.1365-2664.2003.00868.x

Kohler, F., Verhulst, J., Knop, E., Herzog, F., & Kleijn, D. (2007). Indirect effects of grassland extensification schemes on pollinators in two contrasting European countries. *Biological Conservation*, *135*, 302–307. https://doi.org/10.1016/j.biocon.2006.10.037

Lindenmayer, D., Wood, J., Montague-Drake, R., Michael, D., Crane, M., Okada, S., … Gibbons, P. (2012). Is biodiversity management effective? Cross-sectional relationships between management, bird response and vegetation attributes in an Australian agri-environment scheme. *Biological Conservation*, *152*, 62–73. https://doi.org/10.1016/j.biocon.2012.02.026

Lindenmayer, D. B., Zammit, C., Attwood, S. J., Burns, E., Shepherd, C. L., Kay, G., & Wood, J. (2012). A novel and cost-effective monitoring approach for outcomes in an Australian biodiversity conservation incentive program. *PLoS ONE*, *7*, e50872. https://doi.org/10.1371/journal.pone.0050872

Michael, D. R., Wood, J. T., Crane, M., Montague-Drake, R., & Lindenmayer, D. B. (2014). How effective are agri-environment schemes for protecting and improving herpetofaunal diversity in Australian endangered woodland ecosystems? *Journal of Applied Ecology*, *51*, 494–504. https://doi.org/10.1111/1365-2664.12215

Nakagawa, S., Johnson, P. C. D., & Schielzeth, H. (2017). The coefficient of determination R-2 and intra-class correlation coefficient from generalized linear mixed-effects models revisited and expanded. *Journal of the Royal Society Interface*, *14*, 11. https://doi.org/10.1098/rsif.2017.0213

Native Vegetation Council. (2017). Heritage agreements frequently asked questions. Retrieved from https://www.environment.sa.gov.au/managing-natural-resources/native-vegetation/protecting-enhancing/heritage-agreements

O'Connor, P., Morgan, A., & Bond, A. (2008). *BushBids: Biodiversity stewardship in the eastern Mount Lofty Ranges, South Australia*. Retrieved from https://www.oconnornrm.com.au/publications

Oksanen, J., Blanchet, F. G., Friendly, M., Kindt, R., Legendre, P., McGlinn, D., … Wagner, H. (2016). The 'vegan' community ecology package version 2.4-0. Retrieved from https://cran.r-project.org/web/packages/vegan/index.html

Prober, S. M., Thiele, K. R., Lunt, I. D., & Koen, T. B. (2005). Restoring ecological function in temperate grassy woodlands: Manipulating soil nutrients, exotic annuals and native perennial grasses through carbon supplements and spring burns. *Journal of Applied Ecology*, *42*, 1073–1085. https://doi.org/10.1111/j.1365-2664.2005.01095.x

R Core Team. (2017). R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Riffell, S., McIntyre, N., & Hayes, R. (2008). Agricultural set-aside programs and grassland birds: Insights from broad-scale population trends. *Landscape Online*, *8*, 1–20. https://doi.org/10.3097/LO.200808

Rolfe, J., Whitten, S., & Windle, J. (2017). The Australian experience in using tenders for conservation. *Land Use Policy*, *63*, 611–620. https://doi.org/10.1016/j.landusepol.2015.01.037

Van Oosterzee, P., Blignaut, J., & Bradshaw, C. J. A. (2012). iREDD hedges against avoided deforestation's unholy trinity of leakage, permanence and additionality. *Conservation Letters*, *5*, 266–273. https://doi.org/10.1111/j.1755-263X.2012.00237.x

Vaughn, K. J., & Young, T. P. (2010). Contingent conclusions: Year of initiation influences ecological field experiments, but temporal replication is rare. *Restoration Ecology*, *18*, 59–64. https://doi.org/10.1111/j.1526-100X.2010.00714.x

Vesk, P. A., Robinson, D., van der Ree, R., Wilson, C. M., Saywell, S., & McCarthy, M. A. (2015). Demographic effects of habitat restoration for the grey-crowned babbler *Pomatostomus temporalis*, in Victoria, Australia. *PLoS ONE*, *10*, 18. https://doi.org/10.1371/journal.pone.0130153

Whitten, S. M., Reeson, A., Windle, J., & Rolfe, J. (2013). Designing conservation tenders to support landholder participation: A framework and case study assessment. *Ecosystem Services*, *6*, 82–92. https://doi.org/10.1016/j.ecoser.2012.11.001

Wu, J., & Yu, J. (2017). Efficiency-equity tradeoffs in targeting payments for ecosystem services. *American Journal of Agricultural Economics*, *99*, 894–913. https://doi.org/10.1093/ajae/aaw095

Wünscher, T., & Wunder, S. (2017). Conservation tenders in low-income countries: Opportunities and challenges. *Land Use Policy*, *63*, 672–678. https://doi.org/10.1016/j.landusepol.2016.12.026

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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Appendix S1. Study region description

The study region is within 80 km of the state capital city of Adelaide, and approximately 21% was residential land while 76% of land was used for primary production (DPTI 2016). Agricultural activities in the region were diverse and included livestock grazing and intensive livestock production, hay and silage production, viticulture, horticulture and broad-acre cropping (cereals and oilseed) (ABS 2016). Less than 10% of the region was covered by remnant native vegetation, and only 4% of this was protected in public protected areas such as Conservation Parks (DEWNR 2011; DEWNR 2015). Three vegetation communities in the region are listed as critically endangered under the *Environment Protection and Biodiversity Conservation Act* 1999; Swamps of the Fleurieu Peninsula (Australian Government 2013), Iron-grass Natural Temperate Grassland of South Australia (Australian Government 2007), and Peppermint Box *Eucalyptus odorata* Grassy Woodland of South Australia (Australian Government 2007).

References

Australian Bureau of Statistics (2016) 7121.0 - Agricultural Commodities, Australia, 2014-15. Retrieved 18 April 2017 from http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/7121.0Main+Features102014-15?OpenDocument.

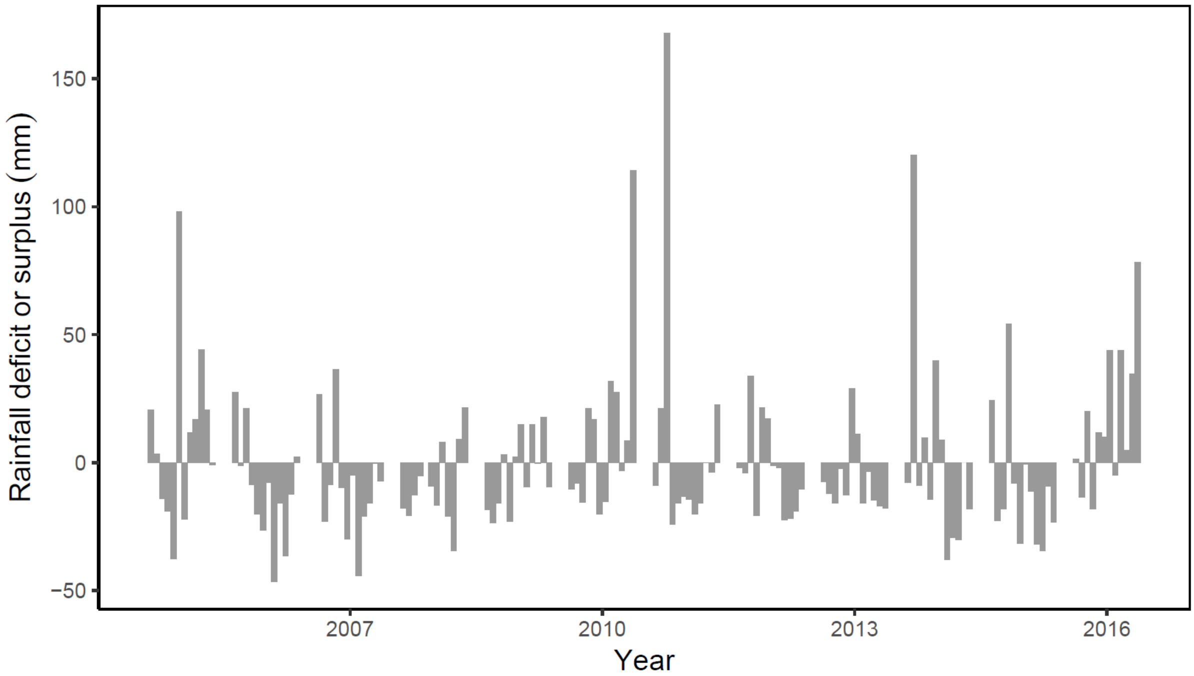
Australian Government (2007) EPBC Act policy statement 3.7 - Peppermint Box (Eucalyptus odorata) Grassy Woodland of South Australia and Iron-grass Natural Temperate Grassland of South Australia. Department of the Environment and Water Resources Retrieved 24 October 2018 from http://www.environment.gov.au/resource/peppermint-box-eucalyptus-odorata-grassy-woodland-south-australia-and-iron-grass-natural.

Australian Government (2013) Approved Conservation Advice for the Swamps of the Fleurieu Peninsula ecological community. Department of the Environment Retrieved 19 March 2019 from http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=31.

Department of Environment Water and Natural Resources (2011) Native Vegetation Floristic Areas - NVIS - Statewide (Incomplete Version).

Department of Environment Water and Natural Resources (2015) Protected Areas - NPWS and Conservation Reserve Boundaries. Retrieved 17 March 2017 from https://data.sa.gov.au/data/dataset/conservation-reserve-parcels.

Department of Planning Transport and Infrastructure (2016) Land Use Generalised. Retrieved 12 May 2017 from https://data.sa.gov.au/data/dataset/land-use-generalised-2016.



Appendix S2. Monthly rainfall recorded at the Palmer SA weather station 2005-2016, shown as deficit or surplus with respect to long term average. Data source (BOM 2018). NB data were not available for May 2008.

Reference

Bureau of Meteorology (2018) Monthly rainfall data, Palmer SA weather station (no. 024525). Retrieved 5 July 2018 from http://www.bom.gov.au/climate/data/index.shtml?bookmark=200.

Appendix S3. Management actions identified in BushBids management plans for impact sites

Management action	Compulsory /optional	Number of management plans
Minimise disturbance • No fertiliser application or artificial feeding, • No soil disturbance (beyond that which is necessary for agreed management actions), • No cropping, • No new dams, • No drainage alteration, • No rock removal.	Compulsory	12
Retain dead trees, fallen logs and plant litter	Compulsory	12
Manage grazing pressure from stock • Exclude stock from the site at all times or • Periodic biomass reduction/conservation grazing in grassy ecosystems. All stock must be removed in late spring / early summer when perennial native grasses begin to flower. Conservative grazing can resume after seed on native perennial grasses has matured.	Compulsory	12
Weed control	Optional as a bundle, including all actions required to manage threats present at the site	12
Feral animal control		11
Kangaroo control		4
Supplementary planting		3
Other threat management (e.g. prevent spread of *Phytophthora cinnamomi*, restrict vehicle access)		2
Permanent site protection, apply for a permanent covenant (Heritage Agreement)	Optional	2[a]

[a]Note that 7 impact sites had existing Heritage Agreements

Appendix S4. Weeds and feral animals targeted for control under BushBids management plans at impact sites.

Weeds identified for control varied with site conditions but frequently included the following species

African Daisy *Senecio pterophorus*,

Blackberry *Rubus* species,

Bridal Creeper *Asparagus asparagoides*,

Broad-leaved Cotton-bush *Gomphocarpus cancellatus*,

Gorse *Ulex europaeus*,

Horehound *Marrubium vulgare*,

South African Orchid *Disa bracteata*,

Olive *Olea europaea*,

Perennial Veldt Grass *Ehrharta calycina*,

Pussy Tail Grass *Pentameris pallida*,

Rose *Rosa canina* and *R. rubiginosa*, and

Watsonia *Watsonia meriana*.

Feral animals identified for control included

European Rabbit *Oryctolagus cuniculus*,

Brown Hare *Lepus capensis*,

Deer e.g. *Dama dama*, *Cervus elaphus*,

Goat *Capra hircus*,

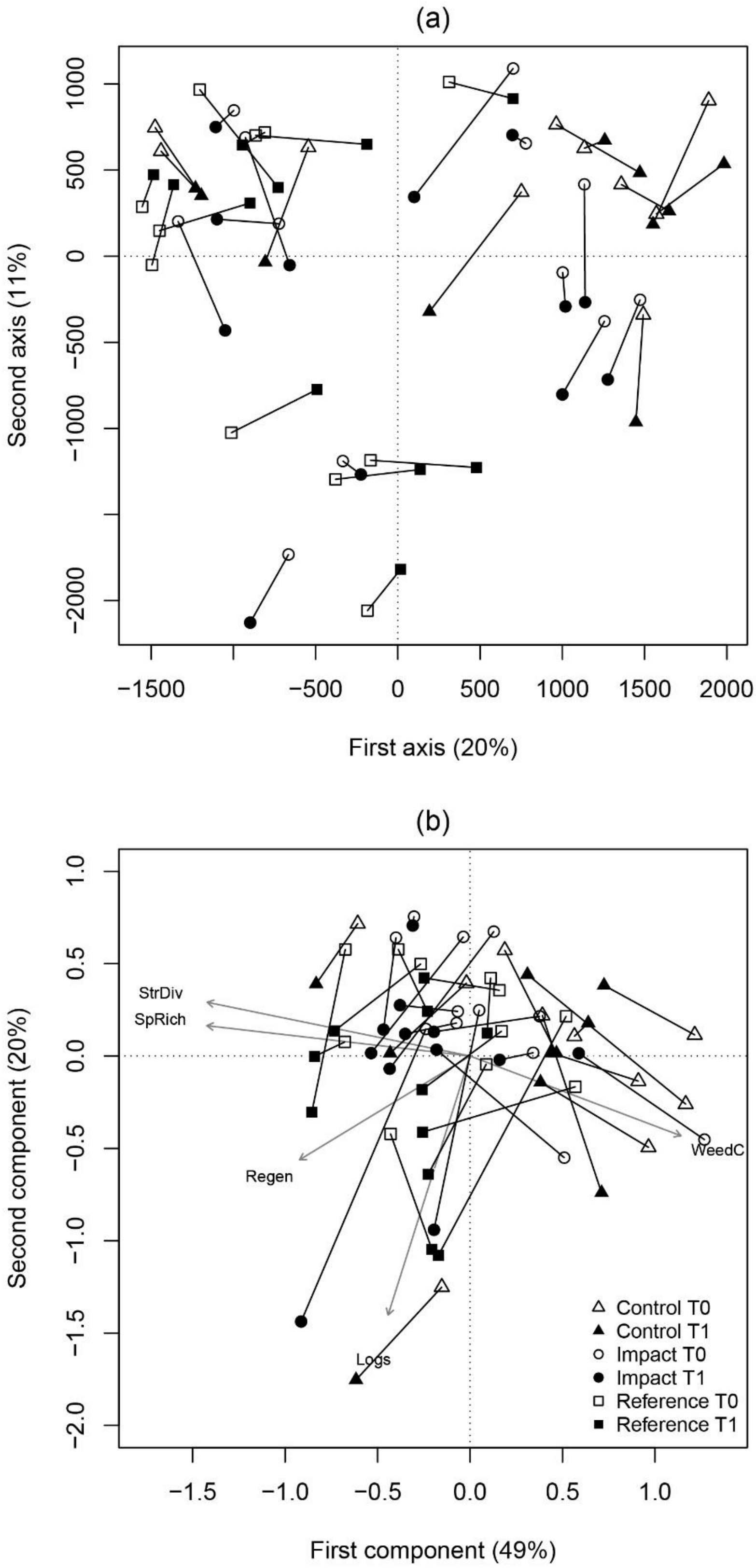
Red Fox *Vulpes vulpes*, and

Cat *Felis catus.*

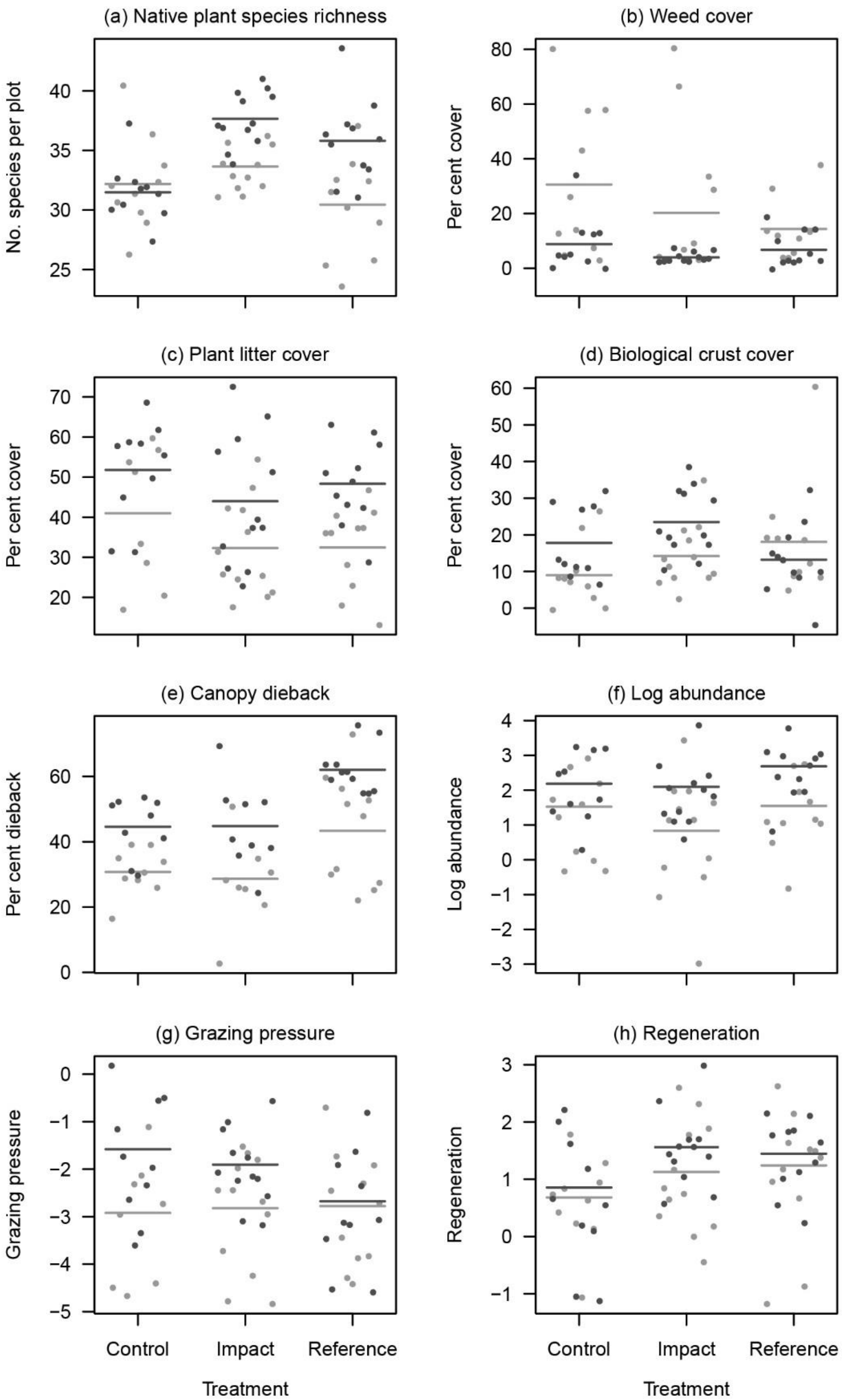
Appendix S5. Vegetation variables measured at study sites

Variable	Description	Sampling unit	
		30 m x 30 m plot	10 nearest trees to one plot corner
Plant species presence	List of all plants observed within plot.	✓	
Native plant species richness	Number of native plant taxa.	✓	
Vegetation structural diversity index	Number and cover of plant structural layers.	✓	
Regeneration	The number of native tree and shrub species regenerating.	✓	
Logs	Number of logs with greater than 10 cm diameter.	✓	
Grazing pressure	The proportion of native plant species with signs of heavy or severe vertebrate herbivore damage.	✓	
Weed cover	Visual estimate of cover (at ground level).	✓	
Plant litter cover	Visual estimate of cover.	✓	
Biological crust cover	Visual estimate of cover. Biological crust is defined here as the crust formed on the surface of soil and rock by organisms including bryophytes, lichens, algae, cyanobacteria and fungi.	✓	
Canopy dieback	Visual estimate of per cent canopy dieback. Average over 10 trees.		✓

A single sample plot was located at each study site, with sites being patches of native vegetation. Vegetation condition variables such as weed cover were generally heterogeneous within sites and sample plots were situated in locations of roughly average condition for the site. Therefore, large changes in measured weed cover may not necessarily be expected within the sample plots because target weed species may have been absent or originally present at low cover levels within the sample plot.



Appendix S6. (a) Ordination (PCoA) of sites based on plant taxonomic dissimilarity, (b) ordination (PCA) of sites based on vegetation condition variables. Condition variables include structural diversity index (StrDiv), species richness (SpRich), regeneration (Regen), log abundance (Logs) and weed cover (WeedC). T0 and T1 measures linked for each site.



Appendix S7. Partial residual plots for modelled effects of treatment and time (a) native plant species richness (Gaussian), (b) weed cover, (c) plant litter cover, (d) biological crust cover, (e) canopy dieback, (f) log abundance, (g) grazing pressure, and (h) regeneration. T0 shown in light grey and T1 in dark grey. Model estimates are shown by horizontal lines and residuals are shown by points. Plots (a-e) use the scale of the original response variable, plots (f-h) use the scale of the linear predictor.

Appendix S8. Explanatory notes for change over time observed in response variables

Condition measure/ response variable	Change over time	Explanatory notes
Native plant species richness Regeneration	Increase increase	Increases in plant species richness and regeneration were likely due to the large rainfall events in the middle of the study period that brought an end to extended drought conditions.
Log abundance	increase	The increase in log abundance may also have been a result of weather conditions including several severe wind events in the twelve months leading up to the final assessments and the high rainfall of 2010-2011 which may have increased tree vulnerability to wind damage via ground softening or increases in pests and pathogens.
Weed cover Plant litter cover	decrease increase	The decrease in weed cover and increase in plant litter cover are likely to be a result of the unusually dry conditions in spring 2015, immediately preceding the final assessment. This meant that at the time of the final assessments annual grassy weeds had mostly died off and were assessed as plant litter cover rather than weed cover.
Biological crust	decrease at reference sites	Increased plant litter cover may also explain the decrease in biological crust cover recorded at reference sites, as plant litter cover may inhibit biological crust (Read *et al*. 2008) and/or may have prevented detection of a proportion of the biological crust cover present.
Canopy dieback	increase	The increase in canopy dieback may have been an episodic event in response to the dry spring conditions preceding the final assessment. However concern about long term decline in tree health has been raised for Pink Gum *Eucalyptus fasciculosa* in the study region (Ward 2005), and many other eucalypts in southern Australia (Jurskis 2005), suggesting further investigation of long term trends in tree health is needed.
Grazing pressure	increase	Increase in grazing pressure across impact and control sites may have also been influenced by dry spring conditions in 2015 along with longer term responses such as increases in native and feral herbivores in response to the 2010-2011 rainfall events (DEWNR 2015).

References

Department of Environment, Water and Natural Resources (2015) 2016 Quota Report for Commercial Kangaroo Harvest in South Australia. Retrieved 5 June 2018 from https://www.environment.sa.gov.au/topics/plants-and-animals/Abundant_species/kangaroo-conservation-and-management/quotas-harvest-data.

Jurskis, V. (2005) Eucalypt decline in Australia, and a general concept of tree decline and dieback. *Forest Ecology and Management*, **215,** 1-20. doi:10.1016/j.foreco.2005.04.026.

Read, C.F., Duncan, D.H., Vesk, P.A. & Elith, J. (2008) Biological soil crust distribution is related to patterns of fragmentation and landuse in a dryland agricultural landscape of southern Australia. *Landscape Ecology,* **23,** 1093-1105. doi:10.1007/s10980-008-9270-3.

Ward, M.J. (2005) Patterns of box mistletoe Amyema miquelii infection and pink gum Eucalyptus fasciculosa condition in the Mount Lofty Ranges, South Australia. *Forest Ecology and Management*, **213,** 1-14. doi:10.1016/j.foreco.2005.03.011.

Chapter 4. Carbon can pay the way for biodiversity conservation

Statement of Authorship

Title of Paper	Carbon can pay the way for biodiversity conservation
Publication Status	☐ Published ☐ Accepted for Publication ☑ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Bond, A.J., O'Connor, P.J. & Cavagnaro, T.R. () Carbon can pay the way for biodiversity conservation. Submitted to *Nature Ecology & Evolution*

Principal Author

Name of Principal Author (Candidate)	Anthelia Bond		
Contribution to the Paper	Contributed to the development of ideas and design of methodology, undertook modelling and analysis, wrote the manuscript and acted as corresponding author.		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	17 June 2019

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By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Patrick O'Connor		
Contribution to the Paper	Conceived the study, contributed to the development of ideas and design of methodology, assisted with analysis and interpretation, and provided feedback on the manuscript.		
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Contribution to the Paper	Contributed to the development of ideas and design of methodology, assisted with analysis and interpretation, and provided feedback on the manuscript.		
Signature		Date	17th June, 2019.

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Title

Carbon can pay the way for biodiversity conservation

Authors

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Constraints on available land and funding are hindering land-based carbon emissions reduction and biodiversity conservation[1,2]. Avoided deforestation, reforestation and restoration can simultaneously reduce carbon emissions and conserve biodiversity, potentially offering efficient solutions for these resource constraints[3]. However, when avoided deforestation and reforestation prioritize carbon outcomes, biodiversity outcomes can be suboptimal, uncertain or even negative[4-6]. Restoration of remnant native vegetation may provide an opportunity to prioritize biodiversity outcomes while harnessing carbon markets for concurrent production of carbon and biodiversity benefits. Here we demonstrate that carbon sequestered by restoring temperate remnant woodland can pay the cost of the restored biodiversity. This is shown using plausible scenarios of vegetation age and ecosystem degradation rate, conservative carbon prices in an established market (the world's largest for forest-based emissions reductions), and the restoration cost revealed by a 10-year conservation incentive payment scheme. When recovery rates are high, market rates for carbon can pay the full cost of restoration, with additional independent investment needed in cases where recovery trajectories are slower. The use of carbon markets to fund restoration provides a solution for constrained resources and problematic trade-offs between carbon and biodiversity outcomes. Multi-attribute markets offer the potential to greatly increase the extent of restoration for biodiversity conservation, while providing an affordable source of carbon sequestration.

Climate change and biodiversity loss are arguably the greatest environmental challenges currently facing humanity[7-9]. Land use has a critical role to play in both climate change mitigation[3] and biodiversity conservation[10], however there are competing demands on land for the provision of these and other ecosystem services[1]. The establishment of carbon markets is beginning to provide funds for carbon emissions abatement including land based carbon sequestration[11], however there are few examples of similar regulatory mechanisms for biodiversity conservation[12], despite large shortfalls in conservation funding [2].

Land-based interventions to reduce carbon emissions, such as avoided deforestation and reforestation, have potential to provide co-benefits for biodiversity. However, when these interventions are optimized for carbon outcomes, biodiversity outcomes may be suboptimal or even negative[5,6,13]. Furthermore, concerns have been raised about the certainty of biodiversity benefits from plantings[4] and the timescales required for such benefits to be realized[14]. Approaches to improve biodiversity outcomes from avoided deforestation and carbon plantings have been suggested but may require trade-offs in carbon outcomes[15]. These approaches include improved planning to optimize carbon and biodiversity outcomes[5,16,17] and additional markets or other investment to purchase biodiversity outcomes[16,18]. In the absence of strong regulatory or market mechanisms specifically for biodiversity, biodiversity outcomes may remain a secondary concern in forest-sector emissions reduction investment. However, restoration of remnant native vegetation could offer a way to optimize biodiversity outcomes from investment in carbon emissions reduction, while avoiding potential trade-offs in carbon outcomes.

Here we investigate whether carbon markets could pay for biodiversity conservation in Australia’s Emissions Reduction Fund (ERF), the trading scheme which accounted for the majority of the world’s traded forest-based emissions reductions in 2015 and 2016[19]. We model carbon sequestered through restoration of temperate remnant native vegetation under 10-year contracts from a revealed-price conservation incentive payment scheme[20]. The conservation incentive scheme was located in the Mt Lofty Ranges, a peri-urban region in

South Australia, recognized as a center of plant biodiversity[21]. Restoration contracts were initiated in 2006 and 2007, and required management of grazing pressure from stock and feral animals, weed control, and retention of fallen logs[20]. Using the FullCAM model, which is employed in ERF carbon accounting methodologies, we estimate carbon sequestered under nine plausible scenarios. Each scenario includes one of three fire (or clearance) events aligned with major historical wildfires in the study environment and one of three ecosystem degradation rates (Table 1). These ecosystem degradation rates (modeled as discounted growth rates) were used to represent the effects of degrading processes such as grazing pressure from feral animals, weed invasion and firewood collection. Using two recent carbon prices (AUD\$12 and AUD\$23 tCO_2e^{-1}), we compare the value of the carbon sequestered by restoration to the average cost of restoration revealed through the conservation incentive scheme (AUD\$59 ha^{-1} yr^{-1}).

Table 1. Modeled scenarios with year of last fire and degradation rate

		Degradation rate (proportion of standard growth rate)		
		high (0.25)	medium (0.5)	low (0.75)
Fire/ clearance (year)	(1983)	1983, high	1983, medium	1983, low
	(1955)	1955, high	1955, medium	1955, low
	(1939)	1939, high	1939, medium	1939, low

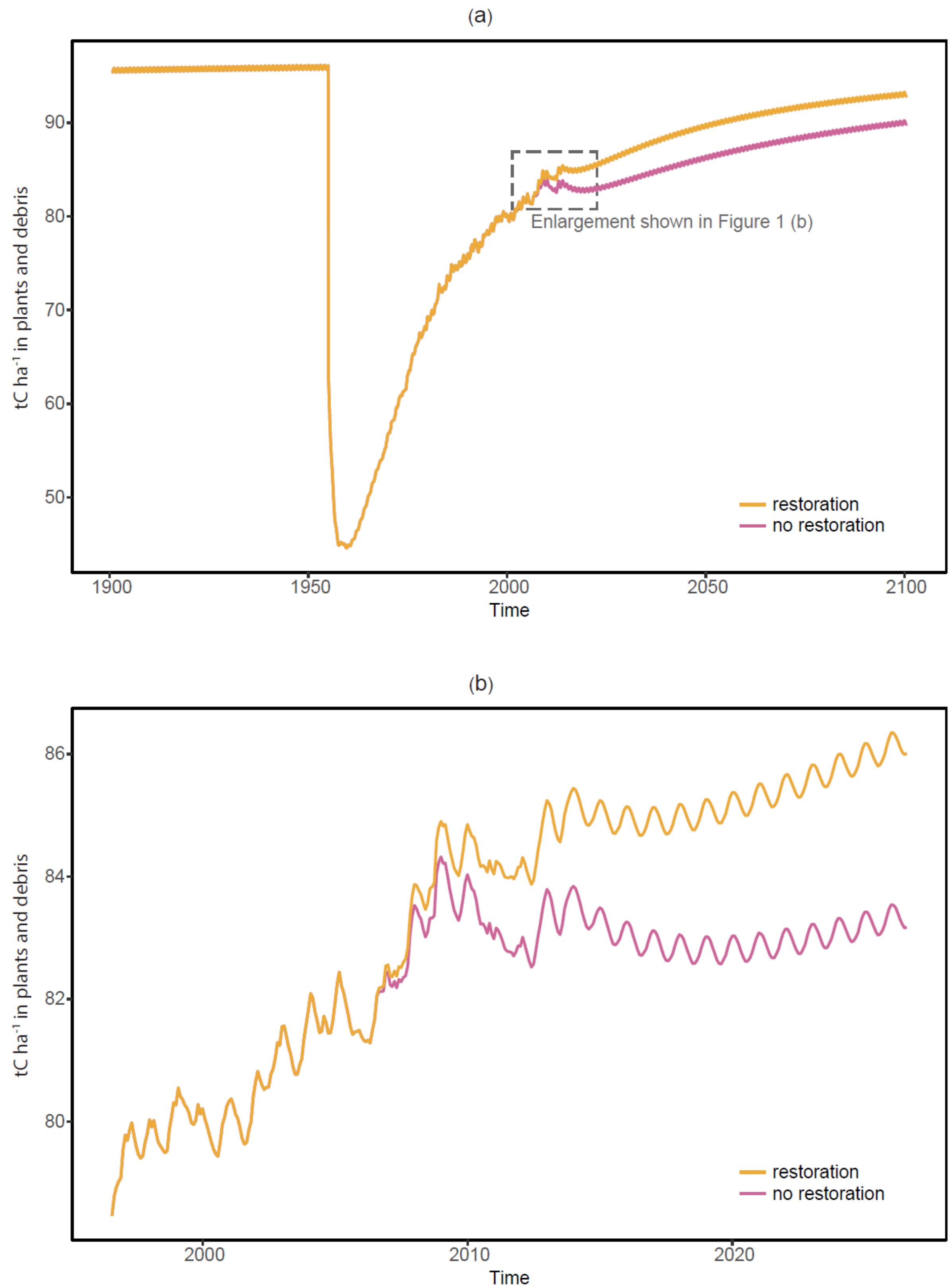

Figure 1. Modeled carbon in plants and debris at a typical study site, with and without restoration beginning in 2006, under the 1955 fire, medium degradation scenario. Time period 1900-2030 shown at (a), time period 1996-2026 shown at (b).

We found that sequestered carbon can pay a substantial proportion of the restoration cost under plausible scenarios of vegetation age and degradation rate, with carbon prices at levels recently posted in the carbon market (Figure 2). The full cost of restoration can be covered by carbon sequestration alone when recovery rates are high (e.g. scenarios with 1983 or 1955 fire/clearance and high degradation rate). In other scenarios, carbon sequestration can pay a substantial proportion of the restoration cost, but additional, independent investment is also required.

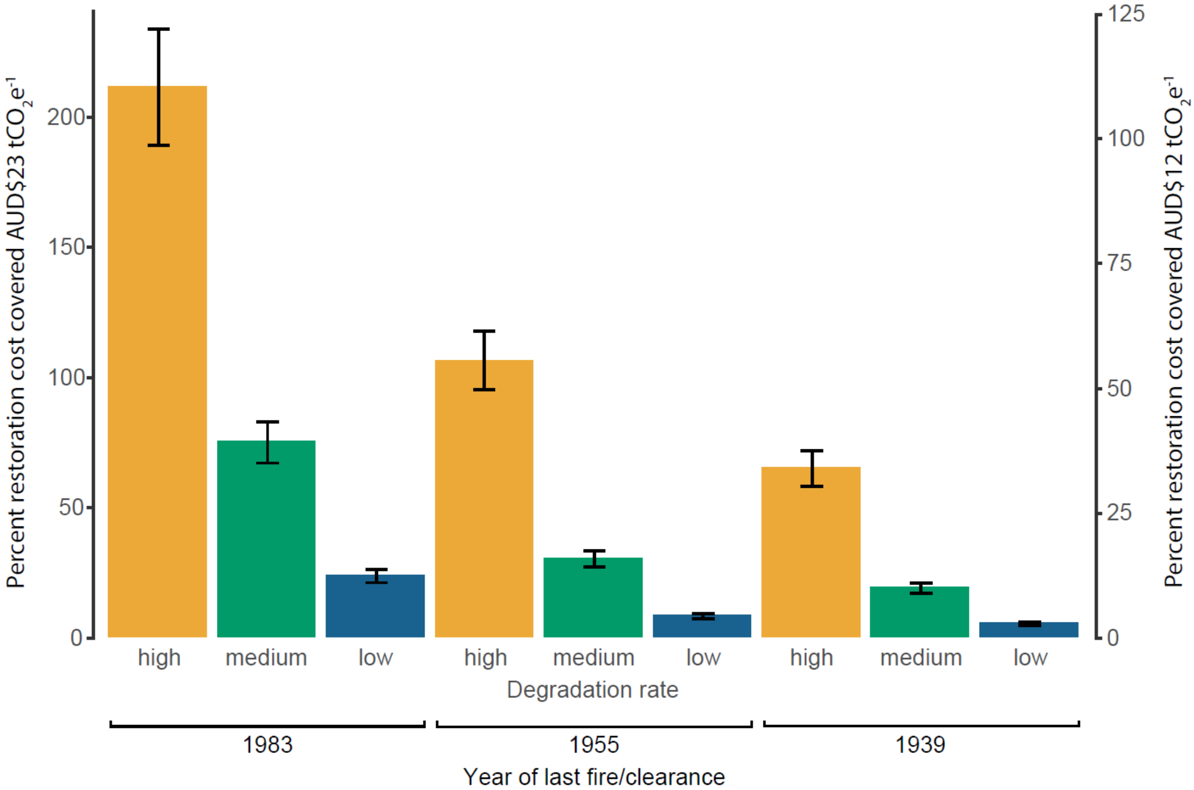

Figure 2. Mean (±SE) percent of 10-year restoration cost covered by carbon sequestered under modeled scenarios, with carbon price at AUD$23 tCO_2e^{-1} and AUD$12 tCO_2e^{-1} (*n*=12)

We used time since fire (or clearance), and degradation rate to model a range of vegetation recovery rates. Younger vegetation with a higher growth rate, and therefore a higher recovery rate, provided more sequestered carbon over the 10-year restoration period. Higher rates of degradation also provided higher recovery rates under modeled scenarios because we assumed degrading processes were completely negated by restoration. Average rates of carbon sequestration estimated here ranged from less than 0.1 tC ha^{-1} yr^{-1} to 1.5 tC ha^{-1} yr^{-1}. The mid point of this range falls within an independently estimated range for carbon sequestration potential in temperate Australian woodlands (0.35-0.77 tC ha^{-1} yr^{-1})[22]. Degradation and recovery are likely to depend on fire and management history in addition to productivity[22]. While site productivity is already accounted for in FullCAM models, strategies to account for fire and management history will be required in methodologies for estimating carbon sequestration from remnant native vegetation restoration.

Carbon price has a large influence on the proportion of restoration cost that can be covered by carbon markets. Here we used two prices for carbon, the lowest (AUD$12 tCO_2e^{-1}) is the average price paid by the ERF for the eight auctions which purchased 193 Mt CO_2e between 2015 and 2018 inclusive[23]. This is a conservative price, driven by the ERF policy principle to purchase the lowest cost carbon abatement[24]. In practice these emissions reductions have largely been from two vegetation methods; avoided deforestation and assisted natural regeneration (ANR) on marginal land requiring little management intervention to assist regeneration[25,26]. The second price used here (AUD$23 tCO_2e^{-1}) is the initial price set by the Australian Government under the Clean Energy Act 2011 which came into effect on the 1st July 2012 and was repealed two years later[27]. These carbon prices are at the lower end of the global range of carbon prices[28] and are well below the estimated median social cost of carbon emissions (US$400 tCO_2e^{-1})[29]. At AUD$12 tCO_2e^{-1}, supply of carbon sequestration through planting has been very limited in southern Australia, with estimates showing that prices of at least AUD$50 tCO_2e^{-1} would be required to increase supply[18].

While presenting these findings we note a number of caveats. Firstly, the modeled carbon shown here includes only carbon in plants (above and below-ground biomass) and debris. The inclusion of soil carbon pools may increase estimates, especially over longer time periods[22,30]. We used the FullCAM model, which is employed by approved methodologies for assessing carbon credits under the ERF, however no methodology for restoration of remnant native vegetation had been approved at the time of writing. In the absence of a FullCAM model specific to the study system we used one that was considered to provide a realistic substitute (please refer to methods section below for details). Further refinement and calibration of modeling and methodologies may therefore improve the accuracy of carbon sequestration estimates. We also acknowledge that restoration of remnant vegetation will not necessarily produce carbon benefits if restoration transitions vegetation from higher to lower carbon stocks (e.g. forest to grassland). Finally, while coupling carbon sequestration and biodiversity services in this way offers potential benefits, careful policy design will be required to minimize transaction costs and overcome other challenges presented by asynchronous carbon and biodiversity markets and policies.

We have shown here that carbon sequestration can pay for restoration under conservative carbon prices with plausible ecosystem degradation and recovery rates. This presents an opportunity to increase the extent of restoration within constrained budgets for biodiversity conservation. It also offers an affordable source of carbon sequestration with demonstrated biodiversity benefits. The use of carbon markets to fund remnant native vegetation restoration thereby provides a means to prioritize biodiversity outcomes in forest based carbon emissions reduction, and overcome challenges posed by constrained resources for climate change and biodiversity loss mitigation. To enable trading of carbon sequestered through restoration, suitable regulatory and policy conditions are required, including regulatory frameworks for carbon markets and methodologies to calculate carbon sequestrated by restoration.

Methods

The conservation incentive scheme

This study uses a conservation incentive scheme, Eastern Mt Lofty Ranges BushBids, as a case study. Briefly, this scheme invited private landholders to tender a price for 10-year contracts for restoration of remnant native vegetation. Contracts were established in 2006 and 2007 and management actions included retention of fallen logs, exclusion or management of domestic stock grazing, weed control, and control of grazing pressure from feral and over-abundant native animals. For further details of the BushBids project see Bond, et al. [31] and Bond, et al. [20]. The average cost of the restoration contracts was (AUD\$59 ha^{-1} yr^{-1})[32].

Study area and sites

The study area is within the eastern Mt Lofty Ranges of South Australia and has a temperate climate with a wide ranging annual average rainfall between approximately 290 mm in the north east and approximately 890 mm in the south west[33]. The area's native vegetation mainly consists of eucalypt dominated forests and woodlands and has been reduced to less than 10 % of its former extent[34]. We modeled carbon sequestration at twelve woodland sites contracted through the BushBids project.

FullCAM model and Emission Reduction Fund (ERF) methodology

To estimate carbon sequestration through restoration of remnant native vegetation, we used the FullCAM model, version 4.0.3.26[35] which was developed by the Australian Government for national carbon accounting. At the time of this study, no methodologies for management or restoration of remnant woodlands had been approved under the ERF. We therefore designed a modeling procedure following relevant components of approved methodologies

"Reforestation by Environmental or Mallee Plantings - FullCAM" and "Human-induced regeneration of a permanent even-aged native forest 1.1"[36-38].

Model settings and scenarios

Carbon sequestration from restoration was estimated by subtracting modeled carbon stocks under a business-as-usual scenario from modeled carbon stocks under a restoration scenario at the conclusion of a 10-year restoration period (2006-2016). Three historical fire (or clearance) scenarios were included to model plausible growth or recovery rates. Additionally, three levels of degradation were used to simulate the effects of degrading processes such as stock grazing, grazing by feral animals and over-abundant native animals as well as weed invasion and fire-wood collection (further detailed below). All simulations were initiated in the year 1606 to allow a period of more than 300 years for stabilisation of carbon stocks prior to modeled events including fire, degradation and restoration.

The study landscape and its temperate woodlands are relatively fire prone with fire frequency estimated to be multi-decadal[39,40]. To represent the range of vegetation age since fire in the study area, we used three historic major wildfire events; 1983, 1955 and 1939[41]. The forest treatment "age advance" was used to model ecosystem degradation and was effectively a growth setback. It was initiated in 1946, in line with post-World War II agricultural intensification in southern Australia[42] for the earliest fire scenario and three years after fire in the more recent fire scenarios. In 2006, at the start of the restoration period, degradation was removed to simulate the mitigating effects of restoration. Estimated 2016 carbon stocks were then compared to an otherwise identical scenario where degradation continued. We selected three plausible degradation levels including growth setback of; 3 in 4 years (0.25 times standard growth rate), 1 in 2 years (0.5 times standard growth rate), and 1 in 4 years (0.75 times standard growth rate).

We used the "Mixed species environmental planting–temperate" model within FullCAM, with a geometric block planting of 500-1500 plants per ha with trees making up at least 75 % of plants. FullCAM's "mixed species environmental planting-temperate" model was recently refined and calibrated[43,44], and was considered to be the most suitable for this study in the absence of appropriate, calibrated models specifically for remnant woodland in the study area. Empirical data collected at the study sites showed that, with a mean of approximately 400 trees ha^{-1}, tree density was at the lower boundary (375 trees ha^{-1}) of the specified range in the model parameter selected (500-1500 plants ha^{-1} and >75% trees).

Data analysis and presentation

Data analysis was performed in R[45] and plots created with the *ggplot2* package[46].

Data availability

Data generated during the current study and R code used for analysis are available in the Figshare repository https://doi.org/10.25909/5cf08c6820044. These data were used to create figures 1 and 2. To protect the privacy of conservation incentive scheme participants, spatial location of study sites has been withheld.

Competing interests

Prior to conducting this research, PJO'C & AJB were employed by O'Connor NRM Pty Ltd in the design and implementation of the BushBids program.

Author Contributions

PJOC conceived the study. AJB conducted analyses and led the writing of the manuscript. PJOC and TRC contributed to study design and interpretation and provided ideas and critical feedback.

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References

1 Smith, P. *et al.* in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (eds O. Edenhofer *et al.*) Ch. Agriculture, Forestry and Other Land Use (AFOLU), 811-922 (Cambridge University Press, 2014).

2 Waldron, A. *et al.* Reductions in global biodiversity loss predicted from conservation spending. *Nature* **551**, 364-367, doi:10.1038/nature24295 (2017).

3 Griscom, B. W. *et al.* Natural climate solutions. *Proceedings of the National Academy of Sciences of the United States of America* **114**, 11645-11650, doi:10.1073/pnas.1710465114 (2017).

4 Maron, M. *et al.* Faustian bargains? Restoration realities in the context of biodiversity offset policies. *Biological Conservation* **155**, 141-148, doi:10.1016/j.biocon.2012.06.003 (2012).

5 Ferreira, J. *et al.* Carbon-focused conservation may fail to protect the most biodiverse tropical forests. *Nature Climate Change* **8**, 744-749, doi:10.1038/s41558-018-0225-7 (2018).

6 Lindenmayer, D. B. *et al.* Avoiding bio-perversity from carbon sequestration solutions. *Conserv. Lett.* **5**, 28-36, doi:10.1111/j.1755-263X.2011.00213.x (2012).

7 Rockström, J. *et al.* A safe operating space for humanity. *Nature* **461**, 472-475, doi:10.1038/461472a (2009).

8 Convention on Biological Diversity. *Conference of the Parties Decision X/2: Strategic plan for biodiversity 2011-2020.*, <www.cbd.int/decision/cop?id=12268> (2010).

9 Intergovernmental Panel on Climate Change. in *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels*

and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (eds V. Masson-Delmotte *et al.*) Ch. Summary for Policymakers, (World Meteorological Organization, 2018).

10 Kehoe, L. *et al.* Biodiversity at risk under future cropland expansion and intensification. *Nature Ecology and Evolution* **1**, 1129-1135, doi:10.1038/s41559-017-0234-3 (2017).

11 World Bank, Ecofys & Vivid Economics. State and Trends of Carbon Pricing 2017. (World Bank, Washington, DC, 2017).

12 Madsen, B., Carroll, N. & Moore Brands, K. State of Biodiversity Markets Report: Offset and Compensation Programs Worldwide. (Ecosystem Marketplace, Washington, DC, 2010).

13 Venter, O. *et al.* Harnessing carbon payments to protect biodiversity. *Science* **326**, 1368, doi:10.1126/science.1180289 (2009).

14 Munro, N. T. *et al.* Bird's Response to Revegetation of Different Structure and Floristics-Are "Restoration Plantings" Restoring Bird Communities? *Restoration Ecology* **19**, 223-235, doi:10.1111/j.1526-100X.2010.00703.x (2011).

15 Anderson-Teixeira, K. J. Prioritizing biodiversity and carbon. *Nature Climate Change* **8**, 667-668, doi:10.1038/s41558-018-0242-6 (2018).

16 Phelps, J., Webb, E. L. & Adams, W. M. Biodiversity co-benefits of policies to reduce forest-carbon emissions. *Nature Climate Change* **2**, 497-503, doi:10.1038/nclimate1462 (2012).

17 Di Marco, M., Watson, J. E. M., Currie, D. J., Possingham, H. P. & Venter, O. The extent and predictability of the biodiversity–carbon correlation. *Ecology Letters* **21**, 365-375, doi:10.1111/ele.12903 (2018).

18 Bryan, B. A. *et al.* Supply of carbon sequestration and biodiversity services from Australia's agricultural land under global change. *Global Environmental Change* **28**, 166-181, doi:10.1016/j.gloenvcha.2014.06.013 (2014).

19 Hamrick, K. & Gallant, M. Fertile Ground Sate of Forest Carbon Finance 2017. (Ecosystem Marketplace, Washington, DC, 2017).

20 Bond, A. J., O'Connor, P. J. & Cavagnaro, T. R. Remnant woodland biodiversity gains under 10 years of revealed-price incentive payments. *Journal of Applied Ecology* **56**, 1827-1838, doi:10.1111/1365-2664.13397 (2019).

21 Guerin, G. R., Biffin, E., Baruch, Z. & Lowe, A. J. Identifying centres of plant biodiversity in South Australia. *PLoS One* **11**, doi:10.1371/journal.pone.0144779 (2016).

22 Paul, K. *et al.* Potential for Carbon Abatement through Restoration of Australian Woodlands. Report for Department of the Environment and Energy. (CSIRO Agriculture, Canberra, Australia, 2016).

23 Australian Government. *Emissions Resudction Fund Auction Results*, <http://www.cleanenergyregulator.gov.au/ERF/Auctions-results> (2018).

24 Australian Government. Emissions Reduction Fund White Paper. (Department of the Environment and Energy, Canberra, Australia, 2014).

25 Burke, P. J. Undermined by Adverse Selection: Australia's Direct Action Abatement Subsidies. *Economic Papers* **35**, 216-229, doi:10.1111/1759-3441.12138 (2016).

26 Evans, M. C. Effective incentives for reforestation: lessons from Australia's carbon farming policies. *Current Opinion in Environmental Sustainability* **32**, 38-45, doi:10.1016/j.cosust.2018.04.002 (2018).

27 Crowley, K. Up and down with climate politics 2013–2016: the repeal of carbon pricing in Australia. *Wiley Interdisciplinary Reviews: Climate Change* **8**, doi:10.1002/wcc.458 (2017).

28 The World Bank. *Carbon Pricing Dashboard*, <https://carbonpricingdashboard.worldbank.org/map_data> (2019).

29 Ricke, K., Drouet, L., Caldeira, K. & Tavoni, M. Country-level social cost of carbon. *Nature Climate Change* **8**, 895-900, doi:10.1038/s41558-018-0282-y (2018).

30 Paul, K. I. *et al.* Using measured stocks of biomass and litter carbon to constrain modelled estimates of sequestration of soil organic carbon under contrasting mixed-species environmental plantings. *Science of the Total Environment* **615**, 348-359, doi:10.1016/j.scitotenv.2017.09.263 (2018).

31 Bond, A. J., O'Connor, P. J. & Cavagnaro, T. R. Who participates in conservation incentive programs? Absentee and group landholders are in the mix. *Land Use Policy* **72**, 410-419, doi:10.1016/j.landusepol.2017.12.067 (2018).

32 O'Connor, P., Morgan, A. & Bond, A. BushBids: Biodiversity Stewardship in the Eastern Mount Lofty Ranges, South Australia. (O'Connor NRM Pty Ltd, South Australia, 2008).

33 Bureau of Meteorology. Mean monthly, seasonal and annual rainfall data (base climatological data sets). (Bureau of Meteorology, Australia, 2014).

34 Department of Environment Water and Natural Resources. Native Vegetation Floristic Areas - NVIS - Statewide (Incomplete Version). (Department of Environment Water and Natural Resources, South Australia, 2011).

35 Richards, G. P. & Evans, D. M. W. Development of a carbon accounting model (FullCAM Vers. 1.0) for the Australian continent. *Australian Forestry* **67**, 277-283, doi:10.1080/00049158.2004.10674947 (2004).

36 Department of the Environment and Energy. *Emissions Reduction Fund Methods*, <http://www.environment.gov.au/climate-change/government/emissions-reduction-fund/methods> (2018).

37 Department of the Environment and Energy. Requirements for using the Full Carbon Accounting Model (FullCAM) in the Emissions Reduction Fund (ERF) methodology determination: Carbon Credits (Carbon Farming Initiative) (Reforestation by Environmental or Mallee Plantings—FullCAM) Methodology Determination 2014 Version 2.0. (Australian Government Department of the Environment and Energy, Canberra, Australia, 2016).

38 Department of the Environment and Energy. Requirements for using the Full Carbon Accounting Model (FullCAM) in the Emissions Reduction Fund (ERF) methodology determination: Carbon Credits (Carbon Farming Initiative) (Human Induced Regeneration of a Permanent Even Aged Native Forest—1.1) Methodology Determination 2013 Version 2.0. (Department of the Environment and Energy, Canberra, Australia, 2016).

39 Bradstock, R. A. A biogeographic model of fire regimes in Australia: Current and future implications. *Global Ecology and Biogeography* **19**, 145-158, doi:10.1111/j.1466-8238.2009.00512.x (2010).

40 Hobbs, R. in *Flammable Australia* (eds Ross A. Bradstock, Jann E. Williams, & A. Malxolm Gill) Ch. Fire regimes and their effects in Australian temperte woodlands, 305-326 (Cambridge University Press, 2002).

41 Healey, D. T. in *The Economics of Bushfires: The South Australian Experience* (eds Derek T. Healey, F. G. Jarrett, & J.M. McKay) Ch. Introduction, (Oxford University Press, 1985).

42 Duncan, D. H. & Dorrough, J. W. Historical and current land use shape landscape restoration options in the Australian wheat and sheep farming zone. *Landscape and Urban Planning* **91**, 124-132, doi:10.1016/j.landurbplan.2008.12.007 (2009).

43 Paul, K. *et al.* Improved estimation of biomass accumulation by environmental planting and mallee plantings using FullCAM. (CSIRO Sustainable Agriculture Flagship, Canberra, Australia, 2013).

44 Paul, K. I. *et al.* Improved models for estimating temporal changes in carbon sequestration in above-ground biomass of mixed-species environmental plantings. *Forest Ecology and Management* **338**, 208-218, doi:10.1016/j.foreco.2014.11.025 (2015).

45 R Core Team. R: A language and environment for statistical computing., (Vienna, Austria, 2017).

46 Wickham, H. ggplot2: Elegant Graphics for Data Analysis. (Springer-Verlag, New York, 2009).

Chapter 5. Money matters for retention and post-contract persistence in conservation incentive programs

Statement of Authorship

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Contribution to the Paper	Contributed to the development of ideas and design of methodology, collected and analysed data, wrote the manuscript and acted as corresponding author.		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
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By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

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Name of Co-Author	Patrick O'Connor		
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Title

Money matters for retention and post-contract management persistence in conservation incentive programs

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Abstract

Voluntary incentive programs are widely used in private land conservation, however their effectiveness relies on retaining participants for the full term of the incentive contract and on what happens after these contracts expire. A theory outlining the factors that may support post-contract persistence (continuation of incentivised land management) has been proposed by Dayer et al. (2018). However, few empirical studies have explored post-contract persistence, and to our knowledge, none have interpreted findings within the framework of relative private costs and benefits. We evaluate the proposed theory of persistence, using interview and questionnaire data from participants at the conclusion of ten-year, revealed-price, incentive contracts for conservation of remnant native vegetation. We find that net private benefits or costs were critical determinants for persistence. In some circumstances persistence cannot be expected in the absence of ongoing financial support for private landholders.

1. Introduction

Protection and restoration of natural habitat on private land is essential for meeting global biodiversity conservation goals (IPBES 2019; Knight 1999). However, management and opportunity costs can present a major barrier to the adoption of conservation practices on private land. In situations where the private cost of conservation outweighs the private benefits, incentives can be used to overcome this barrier (Doremus 2003; Pannell 2008). Currently, incentive payments (through voluntary incentive programs) are widely used to purchase conservation management services from private landholders (Batáry et al. 2015; Doremus 2003; Kamal et al. 2015; Riffell et al. 2008; Rolfe et al. 2017).

There has been much research attention given to landholder motivations for participation in voluntary conservation programs (e.g. Brodt et al. 2009; Farmer et al. 2015; Lastra-Bravo et al. 2015; Moon and Cocklin 2011), information which is important for the design of effective landholder engagement strategies. However, the ability to retain landholders in voluntary programs is also central to program effectiveness (Knight et al. 2010; Selinske et al. 2015). Research on factors influencing retention in conservation programs has been more limited to date, but has identified a similar suite of factors to those linked with motivations for participation. Factors linked to retention include: interactions with program staff (Selinske et al. 2015); trust in the program delivery agency (Lutter et al. 2019); larger property sizes or enrolled areas (Defrancesco et al. 2018; Farmer et al. 2017); younger landholders (Defrancesco et al. 2018); pro-environmental attitudes (Farmer et al. 2017; Lutter et al. 2019); social norms (actions or attitudes of landholders in the neighbourhood) (Chen et al. 2009; Defrancesco et al. 2018); and observation of positive environmental changes (Farmer et al. 2017).

A case has also been made that conservation incentive programs aim to engender "persistence", that is, the continuation of conservation actions or behaviour after incentive payments stop (Dayer et al. 2018). The idea that incentive programs may lead to persistence appears to contradict economic theory underpinning payments for ecosystem services (PES), which indicates that continuation of conservation actions cannot be expected when payments cease (Engel et al. 2008). Noting meagre empirical research in this area, Dayer et al. (2018) proposed five factors that may contribute to persistence: cognitions (e.g. attitudes and perceptions); sustaining motivations; habit forming; social norms; and resources. Empirical studies have found that persistence is most likely for actions where ongoing costs are low (Jackson-Smith et al. 2010; Kuhfuss et al. 2016; Roberts and Lubowski 2007). Persistence has also been linked to actions which provide private benefits such as social acknowledgement, satisfaction and social connection (Kuhfuss et al. 2016; Ramsdell et al. 2016). Where persistence was unlikely, this was because perceived benefits were insufficient (Hayes 2012) or costs of continuing action where too high (Race and Curtis 2013).

Given that economic theory indicates incentives are useful when private costs outweigh private benefits (Doremus 2003; Pannell 2008), it would be expected that retention and persistence are influenced by net private benefits (private benefits minus costs). However, studies to date have not framed their findings in this way, and few have specifically explored the role and influence of management costs. A further limitation of the research relating to retention and persistence in private land conservation is its focus on fixed-price, cost-share or tax relief incentive programs. Moreover there has been very limited attention given to revealed-price incentive programs where participants bid for conservation contracts in reverse auctions. These types of programs are better able to accommodate heterogeneity in management and opportunity costs (Rolfe et al. 2017) and may therefore engage a different set of landholders with differing motivations and behaviours (Bond et al. 2018; Whitten et al. 2013; Wünscher and Wunder 2017).

Here we investigate retention and post incentive contract management persistence in a revealed-price conservation incentive program. The program offered private landholders ten-year incentive contracts to restore remnant native vegetation in a peri-urban, agricultural landscape in southern Australia. We use data from semi-structured interviews and a questionnaire to identify participant response to cost uncertainty, perceived benefits from participation and the implications for retention and post-contract persistence. We evaluate the theory of post-contract persistence proposed by Dayer et al. (2018), finding that net private benefits or costs were the key limiting factor for persistence.

2. Research methods and context

This study examines the views and experiences of participants in a revealed-price incentive program, Eastern Mt Lofty Ranges BushBids. The study area spans approximately 3 000 km^2 in the Mt Lofty Ranges, South Australia. This area is a peri-urban to rural landscape with approximately 21% being residential land and 76% of land used for primary production (DPTI 2016). Agricultural activities include livestock grazing and intensive production, hay and silage production, viticulture, horticulture and broad-acre cropping (cereals and oilseed) (ABS 2016). The area has been recognised as a centre of plant biodiversity (Guerin et al. 2016), and has less than 10% of the original native vegetation cover remaining (DEWNR 2011).

The BushBids program aimed to support private landholders to maintain or restore the ecological function of remnant native vegetation (Bond et al. 2018). In 2006 and 2007 the program offered five or ten-year contracts to landholders through a discriminant price, reverse auction. More than 2 000 ha of native vegetation were placed under contract with 39 landholders for AU$1.2M in incentive payments (O'Connor et al. 2008). Under these contracts, landholders agreed to a comprehensive set of vegetation management actions which included: minimising soil and vegetation disturbance; retaining fallen logs; managing grazing pressure from livestock; controlling weeds and feral animals (in most cases); and controlling kangaroos (in some cases). Contracted landholders were required to report on the implementation of contracted actions annually, with annual incentive payments conditional on satisfactory reporting and compliance audits. Further details of the program are provided in (Bond et al. 2018; Bond et al. 2019).

Landholders who had expressed interest in BushBids and/or with current BushBids contracts were interviewed and surveyed between June 2016 and August 2018. Eligible landholders for this study included those who were nearing the end of their ten-year contracts as well as landholders without BushBids contracts who had made unsuccessful bids in the auction or had withdrawn from the program before bidding. All eligible landholders who had agreed to be contacted by the researchers were invited to participate in this study. Semi-structured interviews were conducted in person or by telephone to obtain information about the participant's experience managing their remnant native vegetation and their views about management in the future (see S1, supporting information, for interview guides). Interviews also collected demographic information (see S2 for summary). Attempts were made to interview all 26 landholders who had agreed to be contacted by the researchers, however five could not be reached, or verbally agreed to the interview but did not provide the necessary written consent. Seventeen of the 21 interviews were conducted with contracted landholders while four were conducted with landholders without contracts. A follow up questionnaire was used to elicit a hypothetical bid price for native vegetation management over the next ten-year period (see S3 for questionnaire). As the questionnaire asked for separate prices for managing grazing pressure, weeds and other threats, transactions costs (such as the cost of reporting) may not have been included in responses. Bid estimates may therefore be slightly conservative. Eleven questionnaire responses were received from participants with contracts (response rate 65%). This study also used existing data from the conservation incentive program.

Descriptive statistics were used to analyse quantitative data from interviews and questionnaires. Previous bid prices were adjusted for inflation between 2006 and 2016 using the Australian Bureau of Statistics inflation calculator (ABS 2019) and are shown as 2016 dollar values. Interview transcripts were coded for content using NVivo and plots were made using the *ggplot2* package (Wickham 2009) in R (R Core Team 2017).

3. Results

Bidders used their own time to increase competitiveness and to compensate for incomplete information.

The majority of participants reported that the actual cost of materials was less than or close to the cost for materials that was included in their bid price (Table 1). The cost of hired labour was less accurately matched with the bid price, with few participants reporting that the actual cost of hired labour was close to the cost included in the bid, and both negative and positive differences in costs reported. All participants used their own labour to implement management actions and most reported that the amount of their own time used was more than the amount included in their bid price.

There were two key reasons for the difference between actual costs and bid price reported by participants. Firstly, participants reported having incomplete information about the costs at the time of bidding, illustrated by the following quotation.

> *"I'd estimated in there, the time, as in wages, to do certain jobs, but didn't allow for the fact that it was such rugged terrain and a lot of time was packing up and getting to the job, not so much on the job."* (Landholder 14)

Secondly, many participants reported that, in order to increase their bid's competitiveness, they did not include the full cost of management in their bid. Participants commonly used their own labour to compensate for costs not included in the bid price.

> *"I also think I probably would have missed out on BushBids if I'd costed in my time."* (Landholder 13)

> *"Because we were already … personally committed to wanting to continue to do that sort of work but some assistance would be fantastic."* (Landholder 7)

"We kind of thought, well, if we make the bid too high then we won't get it. So, we kind of compromised a bit and thought well we're going to be doing work anyway ... so we're willing to volunteer our time on our own property anyway." (Landholder 5)

Table 1 Actual cost of management compared to cost included in the bid price (*n*=17)

	Less than bid	Close to bid	More than bid	Not in bid & didn't use	Did not answer
Materials	3	7	4	2	1
Hired labour	4	2	5	4	2
Own labour	1	4	12[a]	0	0

[a] Own time spent was reported to be 10-400% more than included in bid

Perceived effectiveness was dependent on action type and was best for weed control. Grazing pressure from livestock was universally agreed to be about the same or lower during the contract period than immediately prior to the contract period (Table 2). Where livestock grazing pressure was perceived as similar, this was because these sites had already been destocked or were under a conservation grazing regime prior to contract establishment. Grazing pressure from rabbits during the contract period was sometimes seen as lower than the time before contracts, but was often reported as similar (Table 2). The landholder's control efforts, biological control agents and the management actions of others in the landscape were factors considered to influence rabbit grazing pressure. Many participants reported an increase in grazing pressure from kangaroos during the contract period (Table 2), and 11 of the 21 participants were concerned about the current level of kangaroo grazing pressure. Climate or weather conditions and land management in the surrounding landscape were key factors thought to be influencing grazing pressure from kangaroos. Participants reported a reduction in the cover of most weed species at the end of the contract period (Table 3), and largely attributed these changes to their management actions.

Table 2 Perceived grazing pressure during contract period compared to before contract (*n*=21, respondents without contracts shown in parentheses)

Source	Higher	About the same	Lower	Unsure	Total
Livestock	0	13 (3)	3 (1)	1	17 (4)
Rabbits	2	7 (2)	5 (1)	3 (1)	17 (4)
Kangaroos	8 (3)	7 (1)	0	2	17 (4)

Table 3 Perceived weed cover at the end of contract period compared to start of the contract period (*n*=21, respondents without contracts shown in parentheses)

Weed species	More	About the same	Less	Unsure	Total
African Daisy *Senecio pterophorus*	0	2	2 (1)	0	4 (1)
Blackberry *Rubus* species	0	1	3	0	4
Boxthorn *Lycium ferocissimum*	0	1	4	0	5
Bridal Creeper *Asparagus asparagoides*	1 (1)	1	6	0	8 (1)
Cottonbush *Gomphocarpus cancellatus*	0	1	6	0	7
Gorse *Ulex europaeus*	(1)	0	3 (1)	0	3 (2)
Horehound *Marrubium vulgare*	0	1	6	(1)	7 (1)
Monadenia *Disa bracteata*	1 (1)	0	4	1(1)	6 (2)
Olive *Olea europaea*	0	2	6 (1)	0	8 (1)
Perennial Veldt Grass *Ehrharta calycina*	0	1	2	2	5
Pussy-tail Grass *Pentameris pallida*	0	1	1	2	4

Participant's motivations were sustained by enjoyment of the environment, achievement of their aims, interest and support provided by the program and a sense of accountability under the contracts.

Some participants described their native vegetation with pride and enthusiasm and exhibited a sense of satisfaction in their achievements.

> *"It's all looking good. You should come up and see it actually, this time of the year… the hills are like alpine hillsides."* (Landholder 3)

"Whenever we saw something, I could say, wow, that's such and such a reptile ..." (Landholder 15)

"There's less, you know, gorse everywhere and you're getting rid of the olive trees and things as well, so it sort of makes it feel more, you know, friendly. …You just feel you can go places that you … didn't have access to before…. It's quite rewarding, I think, to see the weeds and things going." (Landholder 17)

Engagement in the program offered a sense of public or community support and interest for participants' conservation efforts. Additionally, the management plan's priorities and targets played a role in motivating some participants. Likewise having contractual obligations was reported as a positive motivation.

"I think knowing somebody's interested is very important… probably I spent more hours in there than I might have, or let's say more hours working rather than sitting and enjoying than I would have if I hadn't had BushBids." (Landholder 6)

"I said I'd do this work anyway. But you know, I don't know whether that's entirely true. I might not have been quite as diligent about it, I don't think. I think it made me more diligent about reaching targets…. Yeah, you do feel like there's someone kind of looking at what you're doing a little bit, and I see that in a positive way, I don't see it as a negative at all." (Landholder 13)

"…feeling, the obligation, the obligation to spend more time on biodiversity threatening processes." (Landholder 8.1)

"having...the management plan and knowing that we've got a contract there, it gives us some focus." (Landholder 12)

Weeding was habitual for some participants

Several participants reported that weed control was habitual as illustrated by the following quotations.

> *"...you do it all the time, you know, whenever you see something..."* (Landholder 17)

> *"So I guess it's sort of given me a more regular approach to weed control. Yeah, just that consistency and in going in at the same time each year... you don't forget about that."* (Landholder 15)

> *"Probably at least every second day I'm over there taking the dog for a wander and you end up pulling the weeds."* (Landholder 13)

Some participants wanted more opportunities for conservation related social connection

Some participants asked for opportunities to meet other participants, and for signs to identify participation in the program.

> *"to keep our enthusiasm going and probably those of others it would be good to ... get* [program participants]*...together to discuss things."* (Landholder 8.1)

> *"I would quite happily, at the bottom of our driveway, put a sign up saying we have received ten years of funding from BushBids.... I put it on my list, but it's on a bit of a backburner, to paint up a sign."* (Landholder 3)

Participants wanted to continue work post contract but costs remained a barrier for many

All participants indicated that ongoing management was required over the next ten-year period to continue to protect and restore biodiversity. All landholders said they would continue with weed control, and most indicated they would manage livestock and control rabbits (Table 4). Approximately half indicated they would undertake some management or control of kangaroos.

Table 4 Management actions participants indicated they would adopt in the future (*n*=19, respondents without contracts shown in parentheses)

Management action	Number of participants
Livestock management	15 (3)
Rabbit control	13 (3)
Kangaroo control or management	8 (2)
Control other grazing animals (Deer and/or Hares)	3
Weed control	15 (4)

In a small number of cases (3 contracted participants), cost was no longer a barrier to implementing these conservation actions. More commonly, participants expressed their intention to implement some conservation management actions regardless of future payments, but indicated that future payments would enable additional or increased management.

> *"I would cost in one day a fortnight to…include my labour time. What that would actually do is speed up the process, because I would say, 'No, I'm not working in my business, I'm working on my land and I'm actually getting a bit of payment for it.' …So that would increase the work that I would be able to do."* (Landholder 13)

> *"Without* [future payments] *we would still continue on with the rabbit control, monitoring kangaroo numbers and control them if needed, and definitely running reduced sheep numbers. But we'll probably need to increase sheep numbers*

above the levels that we were running with the BushBids program." (Landholder 14)

"I'm really keen to keep on top of the weed management … if we had money coming from outside then I could afford to employ someone else when I'm no longer able to do it myself … I mean it's a lot of walking up and down the hills with a spray pack on your back …having had this major illness I realised I'm not going to be able to do it forever." (Landholder 8.2)

Bid prices remained similar for lower cost bidders and decreased for higher cost bidders

Most of the six bidders with the lowest previous bid price (per hectare per year) indicated they would seek similar amounts to their previous bid for management over the next ten years (Figure 1). Three of the five higher cost bidders decreased their price in their new bids. It should be noted however that new bids may not have included transaction costs and may there therefore be conservative estimates.

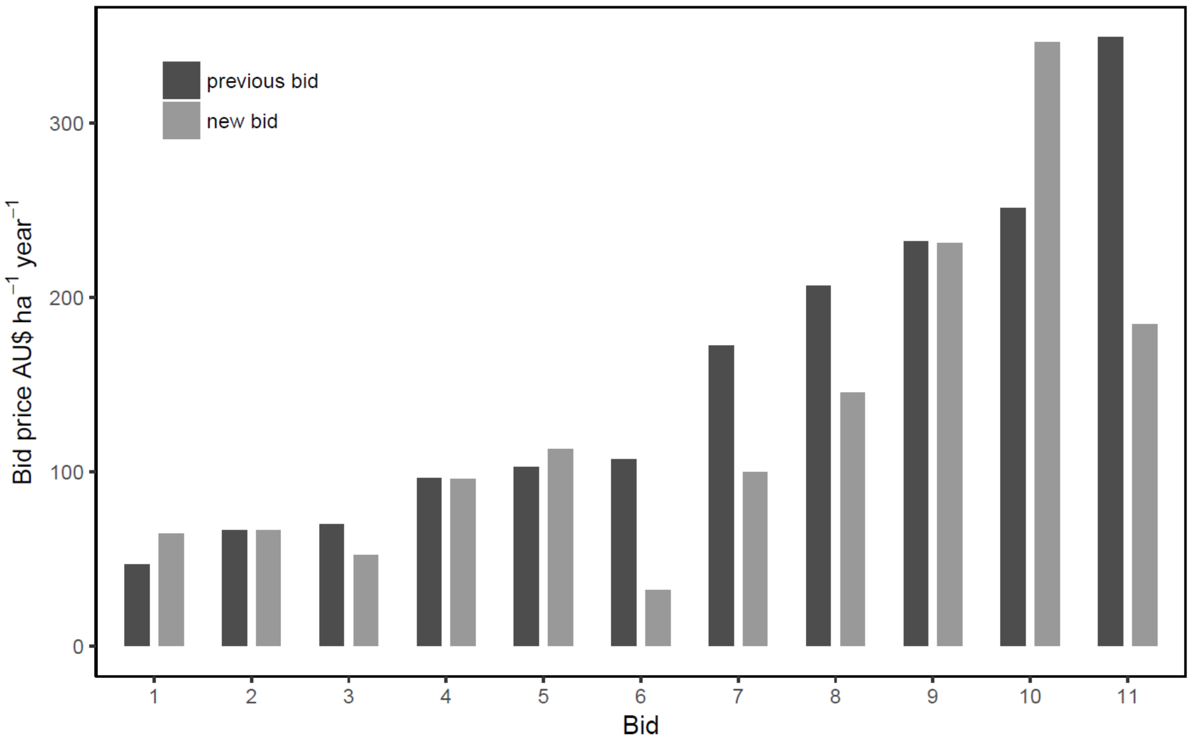

Figure 1 Previous and new bid prices for contracted landholders. Previous bid prices for a ten-year period between 2006 and 2017, adjusted for inflation and shown as 2016 $ values. New bid prices for a ten-year period between 2016 and 2028.

4. Discussion

Bid prices were lower than the actual cost of management for many successful bidders, which was due, at least in part, to competition and cost uncertainty. This is consistent with findings from economic choice experiments where “fear of missing out” was dominant in auctions with both downward pressure on price (competition) and upward pressure on price (cost uncertainty) (Wichmann et al. 2016). Most participants coped with the shortfall between the actual cost of management and the bid price by contributing more of their own time than costed in their bid. Even where the difference between bid price and actual cost was unexpected, participants continued with their contracts. In these cases private benefits may have been underestimated at the time of bidding or the private benefits from staying in the contract may have increased during participation.

We found evidence of the four social factors that, along with resources, Dayer et al. (2018) proposed as pathways to persistence: cognitions, sustaining motivations, habit forming and social norms. In relation to cognitions, all landholders perceived at least some of their management actions as successful, with control of most weed species and livestock management most likely to be reported as effective. However, difficulties were reported in relation to managing grazing pressure from rabbits and kangaroos and controlling some weed species (data not shown). These challenges did not appear to impact retention or persistence at the contract or broad vegetation management level, although they may have influenced the specific actions implemented or intended for the future. We found evidence of a range of sustaining motivations including the sense of: accountability, others’ interest in their conservation efforts, enjoyment, satisfaction and achievement. At least some participants reported that weed control was habitual. Finally, we also found evidence of social norms supporting participation, with some participants looking for opportunities to connect with others and have their work acknowledged. These could be seen as non-financial private benefits (Pannell 2008) for program participants that would contribute to offsetting the cost of management.

At the conclusion of the ten-year contract period, participants believed that ongoing management was needed to continue to protect and restore biodiversity. This was expected given the likelihood of new and recurring weed invasion and continuing grazing pressure from feral and native animals in the study system (Yates and Hobbs 1997). Participants expressed a desire to continue conservation management, however most said they would not be able to continue to manage to the standard or extent they wished without further funding support. In general, bid prices estimated for the next ten years were similar to or lower than previous bids. Where bids decreased, this may be a result of higher upfront costs included in the original bid, with reduced management costs following the initial investment.

Although we found evidence of social factors that support persistence and retention, financial resources were identified as the critical barrier to persistence. This is likely to be the case for similar incentive programs where the costs (management and opportunity) of meeting conservation objectives are ongoing and outweigh the landholder's private benefits from participation. In programs where there are initial adoption barriers, but land use or management change has a net private benefit, ongoing financial resources are not likely to be critical for persistence. Researchers, policy makers and practitioners should therefore exercise caution when making assumptions about post contract persistence. To avoid misleading associations with the term "incentive", it may be beneficial to use the term "payments for ecosystem services" (PES) (Engel et al. 2008) in cases where implementation costs are expected to be ongoing. Finally, where post-contract persistence cannot be expected due to ongoing costs, continuing investment may be required in order to maintain and extend conservation gains.

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Supporting information

Additional supporting information may be found in the online version of this article.

Supplementary 1. Interview guides for contracted and non-contracted properties

Supplementary 2. Landholder demographic characteristics

Supplementary 3. Questionnaire

References

ABS [Australian Bureau of Statistics]. (2016) 7121.0 - Agricultural Commodities, Australia, 2014-15. http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/7121.0Main+Features102014-15?OpenDocument (visited 18 April 2017).

ABS [Australian Bureau of Statistics]. (2019) Consumer Price Index Inflation Calculator. https://www.abs.gov.au/websitedbs/d3310114.nsf/home/Consumer+Price+Index+Inflation+Calculator (visited 14 Jun 2019).

Batáry P., Dicks L.V., Kleijn D., Sutherland W.J. (2015) The role of agri-environment schemes in conservation and environmental management. *Conservation Biology* **29**, 1006-1016.

Bond A.J., O'Connor P.J., Cavagnaro T.R. (2018) Who participates in conservation incentive programs? Absentee and group landholders are in the mix. *Land Use Policy* **72**, 410-419.

Bond A.J., O'Connor P.J., Cavagnaro T.R. (2019) Remnant woodland biodiversity gains under 10 years of revealed-price incentive payments. *Journal of Applied Ecology* **56**, 1827-1838.

Brodt S., Klonsky K., Jackson L., Brush S.B., Smukler S. (2009) Factors affecting adoption of hedgerows and other biodiversity-enhancing features on farms in California, USA. *Agroforestry Systems* **76**, 195-206.

Chen X., Lupi F., He G., Liu J. (2009) Linking social norms to efficient conservation investment in payments for ecosystem services. *Proceedings of the National Academy of Sciences of the United States of America* **106**, 11812-11817.

Dayer A.A., Lutter S.H., Sesser K.A., Hickey C.M., Gardali T. (2018) Private Landowner Conservation Behavior Following Participation in Voluntary Incentive Programs: Recommendations to Facilitate Behavioral Persistence. *Conserv Lett* **11**.

Defrancesco E., Gatto P., Mozzato D. (2018) To leave or not to leave? Understanding determinants of farmers' choices to remain in or abandon agri-environmental schemes. *Land Use Policy* **76**, 460-470.

DEWNR [Department of Environment Water and Natural Resources]. (2011) Native Vegetation Floristic Areas - NVIS - Statewide (Incomplete Version).

Doremus H. (2003) A policy portfolio approach to biodiversity protection on private lands. *Environmental Science and Policy* **6**, 217-232.

DPTI [Department of Planning Transport and Infrastructure]. (2016) Land Use Generalised. https://data.sa.gov.au/data/dataset/land-use-generalised-2016 (visited 12 May 2017).

Engel S., Pagiola S., Wunder S. (2008) Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological Economics* **65**, 663-674.

Farmer J.R., Ma Z., Drescher M., Knackmuhs E.G., Dickinson S.L. (2017) Private Landowners, Voluntary Conservation Programs, and Implementation of Conservation Friendly Land Management Practices. *Conserv Lett* **10**, 58-66.

Farmer J.R., Meretsky V., Knapp D., Chancellor C., Fischer B.C. (2015) Why agree to a conservation easement? Understanding the decision of conservation easement granting. *Landscape and Urban Planning* **138**, 11-19.

Guerin G.R., Biffin E., Baruch Z., Lowe A.J. (2016) Identifying centres of plant biodiversity in South Australia. *PLoS One* **11**.

Hayes T.M. (2012) Payment for ecosystem services, sustained behavioural change, and adaptive management: Peasant perspectives in the Colombian Andes. *Environmental Conservation* **39**, 144-153.

IPBES [Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services]. (2019) Summary for policymakers of the global assessment report on biodiversity and ecosystem services – unedited advance version. Bonn, Germany.

Jackson-Smith D.B., Hailing M., De La Hoz E., McEvoy J.P., Horsburgh J.S. (2010) Measuring conservation program best management practice implementation and maintenance at the watershed scale. *Journal of Soil and Water Conservation* **65**, 413-423.

Kamal S., Grodzińska-Jurczak M., Brown G. (2015) Conservation on private land: a review of global strategies with a proposed classification system. *Journal of Environmental Planning and Management* **58**, 576-597.

Knight A.T., Cowling R.M., Difford M., Campbell B.M. (2010) Mapping human and social dimensions of conservation opportunity for the scheduling of conservation action on private land. *Conservation Biology* **24**, 1348-1358.

Knight R.L. (1999) Private lands: The neglected geography. *Conservation Biology* **13**, 223-224.

Kuhfuss L., Préget R., Thoyer S., Hanley N., Le Coent P., Désolé M. (2016) Nudges, social norms, and permanence in agri-environmental schemes. *Land Economics* **92**, 641-655.

Lastra-Bravo X.B., Hubbard C., Garrod G., Tolón-Becerra A. (2015) What drives farmers' participation in EU agri-environmental schemes?: Results from a qualitative meta-analysis. *Environmental Science and Policy* **54**, 1-9.

Lutter S.H., Dayer A.A., Larkin J.L. (2019) Young Forest Conservation Incentive Programs: Explaining Re-Enrollment and Post-program Persistence. *Environmental Management* **63**, 270-281.

Moon K., Cocklin C. (2011) Participation in biodiversity conservation: Motivations and barriers of Australian landholders. *Journal of Rural Studies* **27**, 331-342.

O'Connor P., Morgan A., Bond A. [O'Connor NRM Pty Ltd]. (2008) BushBids: Biodiversity Stewardship in the Eastern Mount Lofty Ranges, South Australia. South Australia http://www.oconnornrm.com.au/publications (visited 4 June 2018).

Pannell D.J. (2008) Public benefits, private benefits, and policy mechanism choice for land-use change for environmental benefits. *Land Economics* **84**, 225-240.

R Core Team. (2017) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria https://www.R-project.org/.

Race D., Curtis A. (2013) Reflections on the Effectiveness of Market-Based Instruments to Secure Long-Term Environmental Gains in Southeast Australia: Understanding Landholders' Experiences. *Society and Natural Resources* **26**, 1050-1065.

Ramsdell C.P., Sorice M.G., Dwyer A.M. (2016) Using financial incentives to motivate conservation of an at-risk species on private lands. *Environmental Conservation* **43**, 34-44.

Riffell S., McIntyre N., Hayes R. (2008) Agricultural set-aside programs and grassland birds: Insights from broad-scale population trends. *Landscape Online* **8**, 1-20.

Roberts M.J., Lubowski R.N. (2007) Enduring impacts of land retirement policies: Evidence from the conservation reserve program. *Land Economics* **83**, 516-538.

Rolfe J., Whitten S., Windle J. (2017) The Australian experience in using tenders for conservation. *Land Use Policy* **63**, 611-620.

Selinske M.J., Coetzee J., Purnell K., Knight A.T. (2015) Understanding the Motivations, Satisfaction, and Retention of Landowners in Private Land Conservation Programs. *Conserv Lett* **8**, 282-289.

Whitten S.M., Reeson A., Windle J., Rolfe J. (2013) Designing conservation tenders to support landholder participation: A framework and case study assessment. *Ecosystem Services* **6**, 82-92.

Wichmann B., Boxall P., Wilson S., Pergery O. (2016) Auctioning Risky Conservation Contracts. *Environmental and Resource Economics*, 1-34.

Wickham H. (2009) ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag, New York.

Wünscher T., Wunder S. (2017) Conservation tenders in low-income countries: Opportunities and challenges. *Land Use Policy* **63**, 672-678.

Yates C.J., Hobbs R.J. (1997) Temperate eucalypt woodlands: A review of their status, processes threatening their persistence and techniques for restoration. *Australian Journal of Botany* **45**, 949-973.

Appendix S1. Interview guides for contracted and non-contracted properties

Contracted properties

1. The BushBids sites

1.1. First I would like to ask you about your BushBids sites during the period since the BushBids contact began (or since you took over the contract and property from the previous owner). Could you please tell me about any changes you have noticed at your BushBids sites during that time?

2. Participation

2.1. What difference, if any, has participation in BushBids made to you?

3. Bid price

3.1. Next I would like to ask you about how your bid price compared with the actual cost of management. I will ask you about materials, hired help and your time separately.

3.1.1. Was the actual cost of materials:

❑ less than priced in your bid	❑ close to the price in your bid	❑more than priced in your bid	❑not included in your bid	If different, by what percentage ……………………%

If different, please tell me why there was a difference?...

❑ deliberate	❑ estimation error	❑other reason……………………..

Prompt for more information on why deliberately different or estimation error if necessary

3.1.2. Was the actual cost of hired help:

❑ less than priced in your bid	❑ close to the price in your bid	❑more than priced in your bid	❑not included in your bid	If different, by what percentage ……………………%

If different, please tell me why there was a difference?...

❑ deliberate	❑ estimation error	❑other reason……………………..

Prompt for more information on why deliberately different or estimation error if necessary

3.1.3. Was the actual amount of your time:

❑ less than priced in your bid	❑ close to the price in your bid	❑more than priced in your bid	❑not included in your bid	If different, by what percentage ……………………%

If different, please tell me why there was a difference?...

❑ deliberate	❑ estimation error	❑other reason……………………..

Prompt for more information on why deliberately different or estimation error if necessary

4. Grazing pressure management

Now I would like to ask you about the grazing pressure at your BushBids sites during the BushBids contract, compared with the time before BushBids. I will ask you to consider grazing pressure from stock, rabbits and kangaroos separately, and then invite you to tell me about grazing pressure from any other animals.

4.1. How would you rate the grazing pressure from **stock** at your sites during the BushBids contract compared with the time before BushBids? Was the **stock** grazing pressure:

❑ higher than the time before BushBids	❑ about the same as the time before BushBids	❑less than the time before BushBis	❑unsure

4.1.1.How much of the change was due to your management actions:
❑none ❑some ❑about half ❑most ❑all

4.1.2.What other factors contributed to this change if any?

4.1.3.How did these factors contribute to the change?

4.2. How would you rate the grazing pressure from **rabbits** at your sites during the BushBids contract compared with the time before BushBids? Was the **rabbit** grazing pressure:

❑ higher than the time before BushBids	❑ about the same as the time before BushBids	❑less than the time before BushBis	❑unsure

4.2.1.How much of the change was due to your management actions:
❑none ❑some ❑about half ❑most ❑all

4.2.2.What other factors contributed to this change if any?

4.2.3.How did these factors contribute to the change?

4.3. How would you rate the grazing pressure from **kangaroos** at your sites during the BushBids contract compared with the time before BushBids? Was the **kangaroo** grazing pressure:

❑ higher than the time before BushBids	❑ about the same as the time before BushBids	❑less than the time before BushBis	❑unsure

4.3.1.How much of the change was due to your management actions:
❑none ❑some ❑about half ❑most ❑all

4.3.2.What other factors contributed to this change if any?

4.3.3.How did these factors contribute to the change?

4.4. Are there any other animals contributing to grazing pressure on your property that you would like to mention?

4.5. How would you rate the grazing pressure from [**other animal**] at your sites during the BushBids contract compared with the time before BushBids? Was the [**other animal**] grazing pressure:

❑ higher than the time before BushBids	❑ about the same as the time before BushBids	❑less than the time before BushBis	❑unsure

4.5.1. How much of the change was due to your management actions:

❑none ❑some ❑about half ❑most ❑all

4.5.2. What other factors contributed to this change if any?

4.5.3. How did these factors contribute to the change?

4.6. In your opinion, which actions will be required to manage grazing pressure at your BushBids sites over the next ten years after your BushBids contract is completed? [read list of management actions]

- ❑ Exclude stock
- ❑ Conservation grazing (stock grazing with restrictions designed to promote native species)
- ❑ Control rabbits
- ❑ Control kangaroos
- ❑ Other…………..…..………………………………………………………………..
- ❑ Other…………..…..……………………………………………………………..……
- ❑ Other…………..…..……………………………………………………..………………

4.7. Which of those actions would you take, if you didn't have a contract and funding? Again, please consider the period of ten years immediately after your current BushBids contract is completed [read list of management actions]

- ❑ Exclude stock
- ❑ Conservation grazing (stock grazing with restrictions designed to promote native species)
- ❑ Control rabbits
- ❑ Control kangaroos
- ❑ Other…………..…..…………………………………………………………………………
- ❑ Other…………..…..……………………………………………………………..……
- ❑ Other…………..…..……………………………………………………..………………

4.8. Which actions would your take if you did have a contract with funding? Again, please consider the period of ten years immediately after your current BushBids contract is completed [read list of management actions]

- ❑ Exclude stock
- ❑ Conservation grazing (stock grazing with restrictions designed to promote native species)
- ❑ Control rabbits
- ❑ Control kangaroos
- ❑ Other…………..…..…………………………………………………………………………
- ❑ Other…………..…..……………………………………………………………..……
- ❑ Other…………..…..……………………………………………………..………………

5. Weed management

5.1. Now I would like to ask you about the current weed cover at your BushBids sites compared with the time before BushBids. I will ask you to consider five weeds identified for control in your BushBids management plan [list five weeds from management plan]

5.1.1. How would you rate the cover of [XX weed] at your BushBids sites in the last year compared with the time before BushBids? In the last year, did the weed have:

❑ more cover ❑ about the same cover ❑less cover ❑unsure

5.1.1.1. How much of the change was due to your management actions:
❑none ❑some ❑about half ❑most ❑all

5.1.1.2. What other factors contributed to this change if any?

5.1.1.3. How did these factors contribute to the change?

5.1.2. How would you rate the cover of [XX weed] at your BushBids sites in the last year compared with the time before BushBids? In the last year, did the weed have:

❑ more cover ❑ about the same cover ❑less cover ❑unsure

5.1.2.1. How much of the change was due to your management actions:
❑none ❑some ❑about half ❑most ❑all

5.1.2.2. What other factors contributed to this change if any?

5.1.2.3. How did these factors contribute to the change?

5.1.3. How would you rate the cover of [XX weed] at your BushBids sites in the last year compared with the time before BushBids? In the last year, did the weed have:

❑ more cover ❑ about the same cover ❑less cover ❑unsure

5.1.3.1. How much of the change was due to your management actions:
❑none ❑some ❑about half ❑most ❑all

5.1.3.2. What other factors contributed to this change if any?

5.1.3.3. How did these factors contribute to the change?

5.1.4. How would you rate the cover of [XX weed] at your BushBids sites in the last year compared with the time before BushBids? In the last year, did the weed have:

❑ more cover ❑ about the same cover ❑less cover ❑unsure

5.1.4.1. How much of the change was due to your management actions:
❑none ❑some ❑about half ❑most ❑all

5.1.4.2. What other factors contributed to this change if any?

5.1.4.3. How did these factors contribute to the change?

5.1.5. How would you rate the cover of [XX weed] at your BushBids sites in the last year compared with the time before BushBids? In the last year, did the weed have:

❑ more cover ❑ about the same cover ❑less cover ❑unsure

5.1.5.1. How much of the change was due to your management actions:
❑none ❑some ❑about half ❑most ❑all

5.1.5.2. What other factors contributed to this change if any?

5.1.5.3. How did these factors contribute to the change?

5.2. In your opinion, what are the five most important weeds to manage over the next ten years after your BushBids contract is completed?
1…………………………………………………………
2…………………………………………………………
3…………………………………………………………
4…………………………………………………………
5…………………………………………………………

5.3. Which of those weeds would you manage, if you didn't have a contract and funding? Again, please consider the period of ten years immediately after your current BushBids contract is completed.
1…………………………………………………………
2…………………………………………………………
3…………………………………………………………
4…………………………………………………………
5…………………………………………………………

5.4. Which of those weeds would you manage, if you did have a contract and funding? Again, please consider the period of ten years immediately after your current BushBids contract is completed.
1…………………………………………………………
2…………………………………………………………
3…………………………………………………………
4…………………………………………………………
5…………………………………………………………

6. Other management actions

6.1. Are there any other actions you would like to take to manage your sites in the future?

7. Further comments

7.1. Do you have any further comments?

8. Land manager and property details

8.1. What is your total property size?

8.2. What proportion of your property is native vegetation?

8.3. Approximately what percentage of your household income is derived from your property?

8.4. How long have you had your property?

8.5. Who is the primary decision maker for native vegetation on your property?
[Ask for gender if not clear from answer]

8.6. What is your age?

8.7. Do you or any of your family members belong to a community, professional or environmental group(s)?

- ❑ Community group(s) Please list:
- ❑ Professional group(s) Please list:
- ❑ Environmental group(s) Please list:
- ❑ None

Non-contracted properties

1. The bushland

1.1. First I would to ask you about your bushland on your property over the last 9 or 10 years since you expressed interest in BushBids. Could you please tell me about any changes you have noticed in your bushland during that time?

2. Grazing pressure management

2.1. Did you take any actions to manage grazing pressure in your bushland since receiving the BushBids site assessment and management plan? [If yes please list]

2.2. Did you receive funding or support from another source to help with these management actions?

❑ yes ❑ no

2.2.1. If yes, which organisation/s provided the funding or support:

funding	other support	
❑	❑	Heritage Agreement Grant Scheme
❑	❑	Local Action Planning Group
❑	❑	NRM Board
❑	❑	Trees For Life
❑	❑	Greening Australia
❑	❑	Other……………………….
❑	❑	Other……………………….

Now I would like to ask you about the grazing pressure in your bushland during the time since the BushBids site visit, compared with the time before that. I will ask you to consider grazing pressure from stock, rabbits and kangaroos separately, and then invite you to tell me about grazing pressure from any other animals.

2.3. How would you rate the grazing pressure from **stock** in your bushland since the BushBids site visit compared with the time before that? Was the **stock** grazing pressure:

❑ higher than the time before BushBids ❑ about the same as the time before BushBids ❑less than the time before BushBis ❑unsure

2.3.1. How much of the change was due to your management actions:
❑none ❑some ❑about half ❑most ❑all

2.3.2. What other factors contributed to this change if any?

2.3.3. How did these factors contribute to the change?

2.4. How would you rate the grazing pressure from **rabbits** in your bushland since the BushBids site visit compared with the time before that? Was the **rabbit** grazing pressure:

❑ higher than the time before BushBids ❑ about the same as the time before BushBids ❑less than the time before BushBis ❑unsure

2.4.1.How much of the change was due to your management actions:
❑none ❑some ❑about half ❑most ❑all

2.4.2.What other factors contributed to this change if any?

2.4.3.How did these factors contribute to the change?

2.5. How would you rate the grazing pressure from **kangaroos** in your bushland since the BushBids site visit compared with the time before that? Was the **kangaroo** grazing pressure:

❑ higher than the time before BushBids ❑ about the same as the time before BushBids ❑less than the time before BushBis ❑unsure

2.5.1.How much of the change was due to your management actions:
❑none ❑some ❑about half ❑most ❑all

2.5.2.What other factors contributed to this change if any?

2.5.3.How did these factors contribute to the change?

2.6. Are there any other animals contributing to grazing pressure on your property that you would like to mention?

2.7. How would you rate the grazing pressure from [**other animal**] in your bushland during the BushBids contract compared with the time before BushBids? Was the [**other animal**] grazing pressure:

❑ higher than the time before BushBids ❑ about the same as the time before BushBids ❑less than the time before BushBis ❑unsure

2.7.1.How much of the change was due to your management actions:
❑none ❑some ❑about half ❑most ❑all

2.7.2.What other factors contributed to this change if any?

2.7.3.How did these factors contribute to the change?

2.8. In your opinion, which actions will be required to manage grazing pressure in your bushland sites over the next ten years? [read list of management actions]

- ❑ Exclude stock
- ❑ Conservation grazing (stock grazing with restrictions designed to promote native species)
- ❑ Control rabbits
- ❑ Control kangaroos
- ❑ Other……………………………………………………………………………..
- ❑ Other………………………………………………………………………………
- ❑ Other………………………………………………………………………………

2.9. Which actions would your take over the next ten years if you didn't have a contract with funding? [read list of management actions]

- ❑ Exclude stock
- ❑ Conservation grazing (stock grazing with restrictions designed to promote native species)
- ❑ Control rabbits
- ❑ Control kangaroos
- ❑ Other……………………………………………………………………………..
- ❑ Other………………………………………………………………………………
- ❑ Other………………………………………………………………………………

2.10. Which actions would your take over the next ten years if you did have a contract with funding? [read list of management actions]

- ❑ Exclude stock
- ❑ Conservation grazing (stock grazing with restrictions designed to promote native species)
- ❑ Control rabbits
- ❑ Control kangaroos
- ❑ Other……………………………………………………………………………..
- ❑ Other………………………………………………………………………………
- ❑ Other………………………………………………………………………………

3. Weed management

3.1. Did you take any actions to manage weeds in your bushland since receiving the BushBids site assessment and management plan?

3.2. Did you receive funding or support from another source to help with these management actions?

❑ yes ❑ no

1.1.1. If yes, which organisation/s provided the funding or support:

funding	other support	
❑	❑	Heritage Agreement Grant Scheme
❑	❑	Local Action Planning Group
❑	❑	NRM Board
❑	❑	Trees For Life
❑	❑	Greening Australia
❑	❑	Other………………………
❑	❑	Other………………………

3.3. Now I would like to ask you about the current weed cover in your bushland compared with the time before BushBids. I will ask you to consider five weeds identified for control in your BushBids management plan [list five weeds from management plan]

3.3.1. How would you rate the cover of [XX weed] in your bushland in the last year compared with the time before BushBids? In the last year, did the weed have:

❑ more cover ❑ about the same cover ❑ less cover ❑ unsure

3.3.1.1. How much of the change was due to your management actions:

❑ none ❑ some ❑ about half ❑ most ❑ all

3.3.1.2. What other factors contributed to this change if any?

3.3.1.3. How did these factors contribute to the change?

3.3.2. How would you rate the cover of [XX weed] in your bushland in the last year compared with the time before BushBids? In the last year, did the weed have:

❑ more cover ❑ about the same cover ❑ less cover ❑ unsure

3.3.2.1. How much of the change was due to your management actions:

❑ none ❑ some ❑ about half ❑ most ❑ all

3.3.2.2. What other factors contributed to this change if any?

3.3.2.3. How did these factors contribute to the change?

3.3.3. How would you rate the cover of [XX weed] in your bushland in the last year compared with the time before BushBids? In the last year, did the weed have:

❑ more cover ❑ about the same cover ❑ less cover ❑ unsure

3.3.3.1. How much of the change was due to your management actions:

❑ none ❑ some ❑ about half ❑ most ❑ all

3.3.3.2. What other factors contributed to this change if any?

3.3.3.3. How did these factors contribute to the change?

3.3.4. How would you rate the cover of [XX weed] in your bushland in the last year compared with the time before BushBids? In the last year, did the weed have:

❑ more cover ❑ about the same cover ❑ less cover ❑ unsure

3.3.4.1. How much of the change was due to your management actions:

❑ none ❑ some ❑ about half ❑ most ❑ all

3.3.4.2. What other factors contributed to this change if any?

3.3.4.3. How did these factors contribute to the change?

3.3.5. How would you rate the cover of [XX weed] in your bushland in the last year compared with the time before BushBids? In the last year, did the weed have:

❑ more cover ❑ about the same cover ❑ less cover ❑ unsure

3.3.5.1. How much of the change was due to your management actions:

❑ none ❑ some ❑ about half ❑ most ❑ all

3.3.5.2. What other factors contributed to this change if any?

3.3.5.3. How did these factors contribute to the change?

3.4. In your opinion, what are the five most important weeds to manage in your bushland over the next ten years?

1…………………………………………………………
2…………………………………………………………
3…………………………………………………………
4…………………………………………………………
5…………………………………………………………

3.5. Which of these weeds would you manage over the next ten years if you didn't have a contract with funding?

1…………………………………………………………
2…………………………………………………………
3…………………………………………………………
4…………………………………………………………
5…………………………………………………………

3.6. Which of these weeds would you manage over the next ten years if you did have a contract with funding?

1…………………………………………………………
2…………………………………………………………
3…………………………………………………………
4…………………………………………………………
5…………………………………………………………

4. Other management actions

4.1. Are there any other actions you would like to take to manage your bushland in the future?

5. Further comments

5.1. Do you have any further comments?

6. Land manager and property details

6.1. What is your total property size?

6.2. What proportion of your property is native vegetation?

6.3. Approximately what percentage of your household income is derived from your property?

6.4. How long have you had your property?

6.5. Who is the primary decision maker for native vegetation on your property?
[Ask for gender if not clear from answer]

6.6. What is your age?

6.7. Do you or any of your family members belong to a community, professional or environmental group(s)?

- ❑ Community group(s) Please list:
- ❑ Professional group(s) Please list:
- ❑ Environmental group(s) Please list:
- ❑ None

Appendix S2. Landholder demographic characteristics

Primary decision makers for native vegetation were male (9), family groups (6), female (5), and a business (1). Participation in environmental, community and professional groups was high (95%).

Table S2. Demographic characteristics of participants

	Median	Min	Max
Property size (ha)	43	7	>1500
Per cent of property with native veg cover	75	17	100
Per cent of household income derived from property	0	0	100
Year property acquired by landholder's family	1992	2012*	Pre-1970
Age of landholder	60	37	82

*Landholder purchased property during contract period and took over contract from the previous owner

Appendix S3. Questionnaire

In this follow up questionnaire we would like you to provide an estimated bid price for each of the three groups of management actions discussed in the interview.

We do not expect you to go to a lot of trouble to source quotes to calculate your estimated bid price. Please just provide your best estimate of the price you would seek to implement the listed management actions over the next ten years.

It is important that your estimated bid prices are relevant to the same area and sites as originally included in your BushBids management plan. For your reference, the total area is XXX ha and the sites are identified in the attached map/s.

1. These are the actions you indicated would be required over the next ten years to manage **grazing pressure** in your BushBids sites.

   - List of actions

   1.1. If you could bid in a program like BushBids to undertake the actions listed above to manage grazing pressure at your BushBids sites over the next ten years, what price would you bid?

$

2. These are the **weeds** you indicated are priorities to manage over the next ten years at your BushBids sites.

   - List of weeds

   2.1. If you could bid in a program like BushBids to manage these weeds in your BushBids sites over the next ten years, what price would you bid?

$

3. These are the **other management actions** you indicated you would take to manage your BushBids sites over the next ten years.

   - List of actions

   3.1. If you could bid in a program like BushBids to take these management actions over the next ten years what price would you bid?

$

Chapter 6. Conclusion

The research presented in this thesis provides policy relevant insights for biodiversity conservation on private land. It shows that 10-year, revealed-price incentive contracts for restoration of remnant native vegetation can produce biodiversity gains compared with the business as usual scenario of native vegetation management on private land (Chapter 3, see Figure 4 (ii) below). Following on from this, Chapter 4 shows that carbon markets could pay the cost of that restoration, offering the opportunity to increase the extent of restoration within constrained budgets and provide demonstrated biodiversity benefits from investment in carbon emissions reduction (Figure 4 (iii)). Furthermore, the research offers new insights about the landholders who participate in conservation incentive programs. The assumption that landholders are generally farming individuals and families is challenged in Chapter 1, which highlights the role of absentee and group landholders (Figure 4 (i)). Chapter 5, shows that participants use their own time (at no cost) to increase the competitiveness of their bids and compensate for unexpected shortfalls between bid price and the actual cost of management (Figure 4 (iv)). It also qualifies Dayer et al. (2018)'s theory of persistence by demonstrating that post-contract continuation of conservation behaviour depends on continuing incentive payments when private costs exceed private benefits. Taken together these findings advance our understanding of what it takes to produce a biodiversity gain through restoration of remnant vegetation, how to increase the impact of available resources for biodiversity conservation and how to support and engage with landholders for private land conservation.

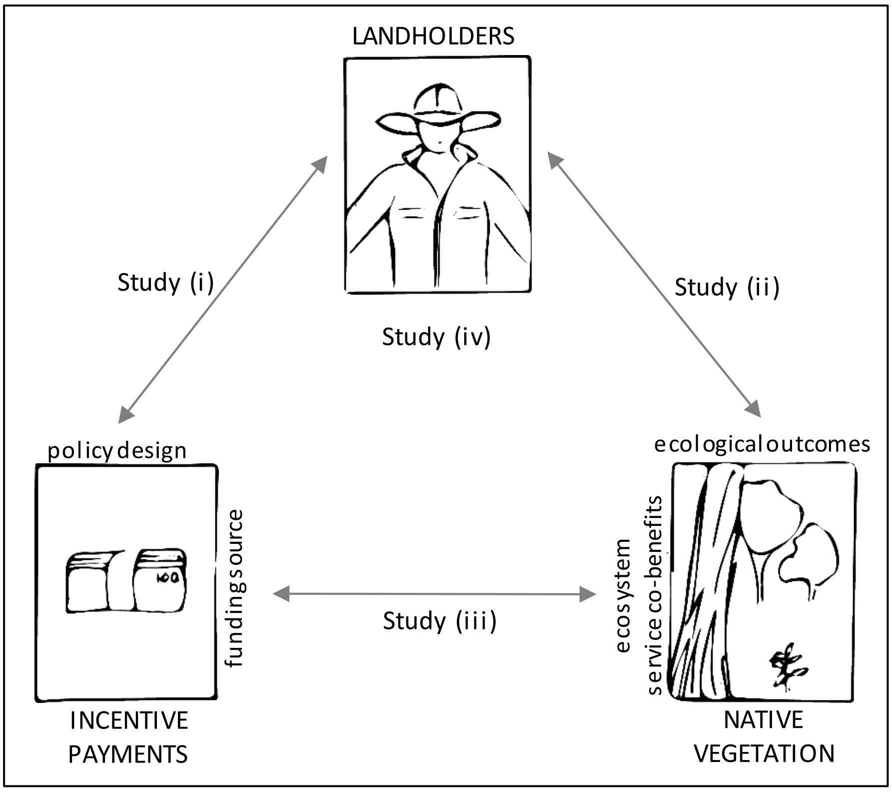

Figure 4 Conceptual diagram for conservation incentive programs where incentive payments are used to purchase environmental services from private landholders. Findings presented in this thesis include; study (i) absentee and group landholders contribute to the range of landholder types participating in conservation incentives; study (ii) incentive contracts can produce biodiversity gains compared to the business as usual scenario; study (iii) carbon markets can pay for restoration, study (iv) participants use their own time to compensate for uncertainty in management costs and where management costs are ongoing, participants are unlikely to persist with their desired standard and extent of management if incentive payments cease.

The key finding that incentive contracts produced a biodiversity gain was made possible by the use of a Before-After-Control-Impact (BACI) monitoring design. Although acknowledged as good practice, BACI designs have rarely been used in conservation incentive impact evaluation (Ferraro, 2009; Kleijn and Sutherland, 2003). However, see Bright et al. (2015) for example. The BACI design facilitated the detection of incentive contract impacts on native vegetation relative to the influence of external factors such as climate and weather. It also provided a step toward understanding background trajectories in vegetation condition, information which is needed for native vegetation policies but is often missing (e.g. Maron et al., 2015; McCarthy et al., 2004).

Evidence of biodiversity gain from conservation incentive payments presented here provides support for continued use of these programs. Furthermore, when linked with the incentive price, or cost of achieving the biodiversity gain, this information has the potential to greatly assist in prioritisation and allocation of conservation investment. It may also assist in accounting for and valuing biodiversity in markets for carbon and other ecosystem services, as suggested in Chapter 4, for example. Finally this unique dataset provides critical, previously lacking information for native vegetation offset policies where predicted biodiversity gains are used to calculate the size of the restoration area needed to offset losses from vegetation clearance (Maron et al., 2016). The dataset will enable the evaluation of offset policies currently in use, as well as supporting considerably improved accuracy in the calculation of offset ratios.

Policy design must address the needs of target participants including emerging and previously unrecognised participant types such as absentee and group landholders identified in study (i). Future participation may be influenced by changing land ownership linked to climate change, as well as the evolution of landholder attitudes, behaviours and social norms (Riley, 2016). Increasing program budgets (e.g. through linking biodiversity with carbon markets as examined in Study (iii)) may also make incentive payments accessible to landholders who have lower net private benefits from participation (Study (iv)). Consideration should also be given to post-contract support for participants, such as the opportunity for new or renewed incentive contracts, because persistence without incentives is unlikely when private costs exceed private benefits and ongoing management is required (Study (iv)).

There are many factors that may influence restoration costs in the future. In addition to market prices for materials, services and labour, participant's private benefits and risk can also influence bid price (Pannell, 2008; Whitten et al., 2013; Wichmann et al., 2016). The program studied here is likely to have engaged a high proportion of the low-cost bidders in the landscape, so additional bidders from the same landscape may seek higher prices. Furthermore, where ongoing management is required to maintain or restore biodiversity as shown in Studies (ii) and (iv), bid prices are unlikely to be substantially reduced for subsequent contracts (Study (iv)).

A number of potential directions for future research have been identified throughout this thesis. They are presented together here as a guide to future work.

- Given absentee landholders were identified as important incentive program participants, further research is needed to improve knowledge of absentee land ownership patterns, and the drivers and constraints to their participation in incentive programs.
- As is the case for absentee landholders, further research is needed regarding group land ownership, the identification of group types and the drivers and constraints to incentive program participation.
- Given that the measured impacts of intervention were modest compared with background changes, and that others have identified the importance of climate and weather on environmental outcomes (e.g. Vaughn and Young, 2010), further medium and long-term studies on the ecological impact of conservation incentives are needed.
- To improve the sensitivity in future outcome evaluations for remnant native vegetation restoration, sampling strategies could be refined or modified. This could include increasing sample size, modifying within-site sampling strategies and modifying response variable measures. However, modifications to sampling strategies should be evaluated for cost effectiveness and practicality of implementation in conservation incentive programs.
- Evidence of biodiversity gains from this research (10-year, BACI designed study) will, for the first time, enable the calculation of Australian native vegetation offset ratios based on empirical evidence.
- As this research shows that carbon markets can pay for 10-year restoration contracts under plausible scenarios, further research is needed to explore the relationship between restoration costs and carbon sequestration over longer time periods and in other environments.

- Further refinement and calibration of the FullCAM carbon accounting model is needed to support the accounting of carbon sequestered by remnant vegetation restoration.
- Further empirical research is needed relating to the role of costs in participant retention and post-contract behavioural persistence, particularly relating to participant learning and the implications of aging landholder demographics.

In summary, the research presented in this thesis provides support for continued use of incentive payments for private land conservation, and highlights the opportunity to increase the extent of restoration by harnessing carbon markets. It contributes critical information for biodiversity conservation investment and offsets polices and provides insights to refine engagement with landholders through incentive programs. These findings offer multiple approaches to increase or improve conservation efforts and contribute to halting biodiversity loss.

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References

[dataset] Australian Bureau of Statistics, 2016. 7121.0 - Agricultural Commodities, Australia, 2014-15, Retrieved 18 April 2017 from http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/7121.0Main+Features102014-15?OpenDocument.

Australian Government 2006. Mount Lofty Initiative - Bush Bids, Retrieved 11 May 2017 from https://www.environment.gov.au/node/13911.

Australian Government, 2007. EPBC Act policy statement 3.7 - Peppermint Box (Eucalyptus odorata) Grassy Woodland of South Australia and Iron-grass Natural Temperate Grassland of South Australia., Department of the Environment and Water Resources, Retrieved 24 October 2018 from http://www.environment.gov.au/resource/peppermint-box-eucalyptus-odorata-grassy-woodland-south-australia-and-iron-grass-natural.

Australian Government, 2010. Approved Conservation Advice for the Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grasslands of South-east Australia., Department of the Environment Water Heritage and the Arts, Retrieved 3 January 2019 from http://www.environment.gov.au/biodiversity/threatened/communities/pubs/86-conservation-advice.pdf.

Australian Government, 2012. Approved Conservation Advice for the Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains, Department of Sustainability Environment Water Population and Communities, Retrieved 3 January 2019 from http://www.environment.gov.au/biodiversity/threatened/communities/pubs/97-conservation-advice.pdf.

Batáry, P., Dicks, L.V., Kleijn, D., Sutherland, W.J., 2015. The role of agri-environment schemes in conservation and environmental management. Conservation Biology 29, 1006-1016.

[dataset] Bureau of Meteorology, 2014. Mean monthly, seasonal and annual rainfall data (base climatological data sets), Retrieved 7 Dec 2016 from http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp.

Boxall, P.C., Perger, O., Packman, K., Weber, M., 2017. An experimental examination of target based conservation auctions. Land Use Policy 63, 592-600.

Bright, J.A., Morris, A.J., Field, R.H., Cooke, A.I., Grice, P.V., Walker, L.K., Fern, J., Peach, W.J., 2015. Higher-tier agri-environment scheme enhances breeding densities of some priority farmland birds in England. Agriculture, Ecosystems and Environment 203, 69-79.

Burton, R.J.F., 2014. The influence of farmer demographic characteristics on environmental behaviour: A review. J. Environ. Manage. 135, 19-26.

Butchart, S.H.M., Walpole, M., Collen, B., Van Strien, A., Scharlemann, J.P.W., Almond, R.E.A., Baillie, J.E.M., Bomhard, B., Brown, C., Bruno, J., Carpenter, K.E., Carr, G.M., Chanson, J., Chenery, A.M., Csirke, J., Davidson, N.C., Dentener, F., Foster, M., Galli, A., Galloway, J.N., Genovesi, P., Gregory, R.D., Hockings, M., Kapos, V., Lamarque, J.F., Leverington, F., Loh, J., McGeoch, M.A., McRae, L., Minasyan, A., Morcillo, M.H., Oldfield, T.E.E., Pauly, D., Quader, S., Revenga, C., Sauer, J.R., Skolnik, B., Spear, D., Stanwell-Smith, D., Stuart, S.N., Symes, A., Tierney, M., Tyrrell, T.D., Vié, J.C., Watson, R., 2010. Global biodiversity: Indicators of recent declines. Science 328, 1164-1168.

Cardinale, B.J., Duffy, J.E., Gonzalez, A., Hooper, D.U., Perrings, C., Venail, P., Narwani, A., MacE, G.M., Tilman, D., Wardle, D.A., Kinzig, A.P., Daily, G.C., Loreau, M., Grace, J.B., Larigauderie, A., Srivastava, D.S., Naeem, S., 2012. Biodiversity loss and its impact on humanity. Nature 486, 59-67.

Cardinale, B.J., Gonzalez, A., Allington, G.R.H., Loreau, M., 2018. Is local biodiversity declining or not? A summary of the debate over analysis of species richness time trends. Biological Conservation.

Convention on Biological Diversity 2010. Conference of the Parties Decision X/2: Strategic plan for biodiversity 2011-2020., Retrieved 23 October 2018 from www.cbd.int/decision/cop?id=12268.

Cooke, B., Lane, R., 2015. How do amenity migrants learn to be environmental stewards of rural landscapes? Landscape and Urban Planning 134, 43-52.

Dayer, A.A., Lutter, S.H., Sesser, K.A., Hickey, C.M., Gardali, T., 2018. Private Landowner Conservation Behavior Following Participation in Voluntary Incentive Programs: Recommendations to Facilitate Behavioral Persistence. Conserv. Lett. 11.

Defrancesco, E., Gatto, P., Runge, F., Trestini, S., 2008. Factors affecting farmers'participation in agri-environmental measures: A northern Italian perspective. Journal of Agricultural Economics 59, 114-131.

Department of Environment Water and Natural Resources, 2011. Native Vegetation Floristic Areas - NVIS - Statewide (Incomplete Version), Department of Environment Water and Natural Resources.

[dataset] Department of Environment Water and Natural Resources, 2011. Native Vegetation Floristic Areas - NVIS - Statewide (Incomplete Version).

[dataset] Department of Environment Water and Natural Resources, 2015. Protected Areas - NPWS and Conservation Reserve Boundaries, Retrieved 17 March 2017 from https://data.sa.gov.au/data/dataset/conservation-reserve-parcels.

[dataset] Department of Environment Water and Natural Resources, 2017. Vegetation Heritage Agreements.

Doremus, H., 2003. A policy portfolio approach to biodiversity protection on private lands. Environmental Science and Policy 6, 217-232.

Duncan, D.H., Dorrough, J.W., 2009. Historical and current land use shape landscape restoration options in the Australian wheat and sheep farming zone. Landscape and Urban Planning 91, 124-132.

Duncan, D.H., Vesk, P.A., 2013. Examining change over time in habitat attributes using Bayesian reinterpretation of categorical assessments. Ecological Applications 23, 1277-1287.

Endangered Species Scientific Subcommittee 2000. Commonwealth Listing Advice on Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions., Retrieved 3 January 2019 from http://www.environment.gov.au/biodiversity/threatened/communities/buloke-grassy-woodlands.html.

Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: An overview of the issues. Ecological Economics 65, 663-674.

European Commission 2019. Agri-environment measures, Retrieved 8 January 2019 from https://ec.europa.eu/agriculture/envir/measures_en.

Fagúndez, J., 2013. Heathlands confronting global change: Drivers of biodiversity loss from past to future scenarios. Annals of Botany 111, 151-172.

Ferraro, P.J., 2009. Counterfactual thinking and impact evaluation in environmental policy. New Directions for Evaluation 2009, 75-84.

Ferraro, P.J., Pattanayak, S.K., 2006. Money for nothing? A call for empirical evaluation of biodiversity conservation investments. PLoS Biology 4, 482-488.

Ferreira, J., Lennox, G.D., Gardner, T.A., Thomson, J.R., Berenguer, E., Lees, A.C., Mac Nally, R., Aragão, L.E.O.C., Ferraz, S.F.B., Louzada, J., Moura, N.G., Oliveira, V.H.F., Pardini, R., Solar, R.R.C., Vieira, I.C.G., Barlow, J., 2018. Carbon-focused conservation may fail to protect the most biodiverse tropical forests. Nature Climate Change 8, 744-749.

Figgis, P., 2004. Conservation on Private Lands: the Australian Experience, IUCN, Retrieved 4 August 2017 from https://www.iucn.org/content/conservation-private-lands-australian-experience.

Fitzsimons, J.A., 2015. Private protected areas in Australia: Current status and future directions. Nature Conservation 10, 1-23.

Gosnell, H., Abrams, J., 2011. Amenity migration: Diverse conceptualizations of drivers, socioeconomic dimensions, and emerging challenges. GeoJournal 76, 303-322.

Gosnell, H., Travis, W.R., 2005. Ranchland ownership dynamics in the Rocky Mountain west. Rangeland Ecology and Management 58, 191-198.

Griscom, B.W., Adams, J., Ellis, P.W., Houghton, R.A., Lomax, G., Miteva, D.A., Schlesinger, W.H., Shoch, D., Siikamäki, J.V., Smith, P., Woodbury, P., Zganjar, C., Blackman, A., Campari, J., Conant, R.T., Delgado, C., Elias, P., Gopalakrishna, T., Hamsik, M.R., Herrero, M., Kiesecker, J., Landis, E., Laestadius, L., Leavitt, S.M., Minnemeyer, S., Polasky, S., Potapov, P., Putz, F.E., Sanderman, J., Silvius, M., Wollenberg, E., Fargione, J., 2017. Natural climate solutions. Proceedings of the National Academy of Sciences of the United States of America 114, 11645-11650.

Haddad, N.M., Brudvig, L.A., Clobert, J., Davies, K.F., Gonzalez, A., Holt, R.D., Lovejoy, T.E., Sexton, J.O., Austin, M.P., Collins, C.D., Cook, W.M., Damschen, E.I., Ewers, R.M., Foster, B.L., Jenkins, C.N., King, A.J., Laurance, W.F., Levey, D.J., Margules, C.R., Melbourne, B.A., Nicholls, A.O., Orrock, J.L., Song, D.X., Townshend, J.R., 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. Science Advances 1.

Hayes, T.M., 2012. Payment for ecosystem services, sustained behavioural change, and adaptive management: Peasant perspectives in the Colombian Andes. Environmental Conservation 39, 144-153.

Hill, M.R.J., McMaster, D.G., Harrison, T., Hershmiller, A., Plews, T., 2011. A Reverse Auction for Wetland Restoration in the Assiniboine River Watershed, Saskatchewan. Canadian Journal of Agricultural Economics 59, 245-258.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019. Summary for policymakers of the global assessment report on biodiversity and ecosystem services – unedited advance version, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Kamal, S., Grodzińska-Jurczak, M., Brown, G., 2015. Conservation on private land: a review of global strategies with a proposed classification system. Journal of Environmental Planning and Management 58, 576-597.

Kleijn, D., Baquero, R.A., Clough, Y., Díaz, M., De Esteban, J., Fernández, F., Gabriel, D., Herzog, F., Holzschuh, A., Jöhl, R., Knop, E., Kruess, A., Marshall, E.J.P., Steffan-Dewenter, I., Tscharntke, T., Verhulst, J., West, T.M., Yela, J.L., 2006. Mixed biodiversity benefits of agri-environment schemes in five European countries. Ecology Letters 9, 243-254.

Kleijn, D., Sutherland, W.J., 2003. How effective are European agri-environment schemes in conserving and promoting biodiversity? Journal of Applied Ecology 40, 947-969.

Knight, A.T., Cowling, R.M., Difford, M., Campbell, B.M., 2010. Mapping human and social dimensions of conservation opportunity for the scheduling of conservation action on private land. Conservation Biology 24, 1348-1358.

Knight, R.L., 1999. Private lands: The neglected geography. Conservation Biology 13, 223-224.

Kuhfuss, L., Préget, R., Thoyer, S., Hanley, N., Le Coent, P., Désolé, M., 2016. Nudges, social norms, and permanence in agri-environmental schemes. Land Economics 92, 641-655.

Laurance, W.F., Carolina Useche, D., Rendeiro, J., Kalka, M., Bradshaw, C.J.A., Sloan, S.P., Laurance, S.G., Campbell, M., Abernethy, K., Alvarez, P., Arroyo-Rodriguez, V., Ashton, P., Benítez-Malvido, J., Blom, A., Bobo, K.S., Cannon, C.H., Cao, M., Carroll, R., Chapman, C., Coates, R., Cords, M., Danielsen, F., De Dijn, B., Dinerstein, E., Donnelly, M.A., Edwards, D., Edwards, F., Farwig, N., Fashing, P., Forget, P.M., Foster, M., Gale, G., Harris, D., Harrison, R., Hart, J., Karpanty, S., John Kress, W., Krishnaswamy, J., Logsdon, W., Lovett, J., Magnusson, W., Maisels, F., Marshall, A.R., McClearn, D., Mudappa, D., Nielsen, M.R., Pearson, R., Pitman, N., Van Der Ploeg, J., Plumptre, A., Poulsen, J., Quesada, M., Rainey, H., Robinson, D., Roetgers, C., Rovero, F., Scatena, F., Schulze, C., Sheil, D., Struhsaker, T., Terborgh, J., Thomas, D., Timm, R., Nicolas Urbina-Cardona, J., Vasudevan, K., Joseph Wright, S., Carlos Arias-G, J., Arroyo, L., Ashton, M., Auzel, P., Babaasa, D., Babweteera, F., Baker, P., Banki, O., Bass, M., Bila-Isia, I., Blake, S., Brockelman, W., Brokaw, N., Brühl, C.A., Bunyavejchewin, S., Chao, J.T., Chave, J., Chellam, R., Clark, C.J., Clavijo, J., Congdon, R., Corlett, R., Dattaraja, H.S., Dave, C., Davies, G., De Mello Beisiegel, B., De Nazaré Paes Da Silva, R., Di Fiore, A., Diesmos, A., Dirzo, R., Doran-Sheehy, D., Eaton, M., Emmons, L., Estrada, A., Ewango, C., Fedigan, L., Feer, F., Fruth, B., Giacalone Willis, J., Goodale, U., Goodman, S., Guix, J.C., Guthiga, P., Haber, W., Hamer, K., Herbinger, I., Hill, J., Huang, Z., Fang Sun, I., Ickes, K., Itoh, A., Ivanauskas, N., Jackes, B., Janovec, J., Janzen, D., Jiangming, M., Jin, C., Jones, T., Justiniano, H., Kalko, E., Kasangaki, A., Killeen, T., King, H.B., Klop, E., Knott, C., Koné, I., Kudavidanage, E., Lahoz Da Silva Ribeiro, J., Lattke, J., Laval, R., Lawton, R., Leal, M., Leighton, M., Lentino, M., Leonel, C., Lindsell, J., Ling-Ling, L., Eduard Linsenmair, K., Losos, E., Lugo, A., Lwanga, J., MacK, A.L., Martins, M., Scott McGraw, W., McNab, R., Montag, L., Myers Thompson, J., Nabe-Nielsen, J., Nakagawa, M., Nepal, S., Norconk, M., Novotny, V., O'Donnell, S., Opiang, M., Ouboter, P., Parker, K., Parthasarathy, N., Pisciotta, K., Prawiradilaga, D., Pringle, C., Rajathurai, S., Reichard, U., Reinartz, G., Renton, K., Reynolds, G., Reynolds, V., Riley, E., Rödel, M.O., Rothman, J., Round, P., Sakai, S., Sanaiotti, T., Savini, T., Schaab, G., Seidensticker, J., Siaka, A., Silman, M.R., Smith, T.B., De Almeida, S.S., Sodhi, N., Stanford, C., Stewart, K., Stokes, E., Stoner, K.E., Sukumar, R., Surbeck, M., Tobler, M., Tscharntke, T., Turkalo, A., Umapathy, G., Van Weerd, M., Vega Rivera, J., Venkataraman, M., Venn, L., Verea, C., Volkmer De Castilho, C., Waltert, M., Wang, B., Watts, D., Weber, W., West, P., Whitacre, D., Whitney, K., Wilkie, D., Williams, S., Wright, D.D., Wright, P., Xiankai, L., Yonzon, P., Zamzani, F., 2012. Averting biodiversity collapse in tropical forest protected areas. Nature 489, 290-293.

Lindenmayer, D., Wood, J., Montague-Drake, R., Michael, D., Crane, M., Okada, S., MacGregor, C., Gibbons, P., 2012a. Is biodiversity management effective? Cross-sectional relationships between management, bird response and vegetation attributes in an Australian agri-environment scheme. Biological Conservation 152, 62-73.

Lindenmayer, D.B., Hulvey, K.B., Hobbs, R.J., Colyvan, M., Felton, A., Possingham, H., Steffen, W., Wilson, K., Youngentob, K., Gibbons, P., 2012b. Avoiding bio-perversity from carbon sequestration solutions. Conserv. Lett. 5, 28-36.

Lindhjem, H., Mitani, Y., 2012. Forest owners' willingness to accept compensation for voluntary conservation: A contingent valuation approach. Journal of Forest Economics 18, 290-302.

Ecosystem Marketplace, 2010. State of Biodiversity Markets Report: Offset and Compensation Programs Worldwide, Ecosystem Marketplace, Retrieved 23 October 2018 from http://www.ecosystemmarketplace.com/documents/acrobat/sbdmr.pdf.

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.

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., 2016. Taming a Wicked Problem: Resolving Controversies in Biodiversity Offsetting. Bioscience 66, 489-498.

Mascia, M.B., Pailler, S., Thieme, M.L., Rowe, A., Bottrill, M.C., Danielsen, F., Geldmann, J., Naidoo, R., Pullin, A.S., Burgess, N.D., 2014. Commonalities and complementarities among approaches to conservation monitoring and evaluation. Biological Conservation 169, 258-267.

McCarthy, M.A., Parris, K.M., Van Der Ree, R., McDonnell, M.J., Burgman, M.A., Williams, N.S.G., McLean, N., Harper, M.J., Meyer, R., Hahs, A., Coates, T., 2004. The habitat hectares approach to vegetation assessment: An evaluation and suggestions for improvement. Ecological Management and Restoration 5, 24-27.

Millennium Ecosystem Assessment 2005. Ecosystems and Human Well Being: Synthesis, Millennium Ecosystem Assessment Retrieved 5 July 2018 from http://www.millenniumassessment.org/en/index.html.

Mendham, E., Curtis, A., 2010. Taking over the reins: Trends and impacts of changes in rural property ownership. Society and Natural Resources 23, 653-668.

Michael, D.R., Wood, J.T., Crane, M., Montague-Drake, R., Lindenmayer, D.B., 2014. How effective are agri-environment schemes for protecting and improving herpetofaunal diversity in Australian endangered woodland ecosystems? Journal of Applied Ecology 51, 494-504.

Native Vegetation Council 2017. Heritage Agreements Frequently Asked Questions, Retrieved 2 Oct 2017 from https://www.environment.sa.gov.au/managing-natural-resources/native-vegetation/protecting-enhancing/heritage-agreements.

Newbold, T., Hudson, L.N., Hill, S.L.L., Contu, S., Lysenko, I., Senior, R.A., Börger, L., Bennett, D.J., Choimes, A., Collen, B., Day, J., De Palma, A., Díaz, S., Echeverria-Londoño, S., Edgar, M.J., Feldman, A., Garon, M., Harrison, M.L.K., Alhusseini, T., Ingram, D.J., Itescu, Y., Kattge, J., Kemp, V., Kirkpatrick, L., Kleyer, M., Correia, D.L.P., Martin, C.D., Meiri, S., Novosolov, M., Pan, Y., Phillips, H.R.P., Purves, D.W., Robinson, A., Simpson, J., Tuck, S.L., Weiher, E., White, H.J., Ewers, R.M., MacE, G.M., Scharlemann, J.P.W., Purvis, A., 2015. Global effects of land use on local terrestrial biodiversity. Nature 520, 45-50.

Norton, D.A., 2000. Conservation biology and private land: Shifting the focus. Conservation Biology 14, 1221-1223.

O'Connor, P., Saison, C., Morgan, A., Bond, A., Lawley, V., 2014. South East BushBids: Native Vegetation Management in the Southern Murray Mallee and Upper South East of South Australia. Natural Resources South Australian Murray-Darling Basin.

Pannell, D.J., 2008. Public benefits, private benefits, and policy mechanism choice for land-use change for environmental benefits. Land Economics 84, 225-240.

Perkins, A.J., Maggs, H.E., Wilson, J.D., Watson, A., 2013. Delayed mowing increases corn bunting Emberiza calandra nestsuccess in an agri-environment scheme trial. Agriculture, Ecosystems and Environment 181, 80-89.

Perring, M.P., Standish, R.J., Price, J.N., Craig, M.D., Erickson, T.E., Ruthrof, K.X., Whiteley, A.S., Valentine, L.E., Hobbs, R.J., 2015. Advances in restoration ecology: Rising to the challenges of the coming decades. Ecosphere 6.

Petrzelka, P., Armstrong, A., 2015. Absentee landowners of agricultural land: Infuences upon land management decision making and information usage. Journal of Soil and Water Conservation 70, 303-312.

Petrzelka, P., Ma, Z., Malin, S., 2013. The elephant in the room: Absentee landowner issues in conservation and land management. Land Use Policy 30, 157-166.

Petrzelka, P., Malin, S., Gentry, B., 2012. Absentee landowners and conservation programs: Mind the gap. Land Use Policy 29, 220-223.

Pimm, S.L., Raven, P., 2000. Extinction by numbers. Nature 403, 843-845.

Race, D., Curtis, A., 2013. Reflections on the Effectiveness of Market-Based Instruments to Secure Long-Term Environmental Gains in Southeast Australia: Understanding Landholders' Experiences. Society and Natural Resources 26, 1050-1065.

Riffell, S., McIntyre, N., Hayes, R., 2008. Agricultural set-aside programs and grassland birds: Insights from broad-scale population trends. Landscape Online 8, 1-20.

Riley, M., 2016. How does longer term participation in agri-environment schemes [re]shape farmers' environmental dispositions and identities? Land Use Policy 52, 62-75.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., De Wit, C.A., Hughes, T., Van Der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., Foley, J.A., 2009. A safe operating space for humanity. Nature 461, 472-475.

Rolfe, J., Whitten, S., Windle, J., 2017. The Australian experience in using tenders for conservation. Land Use Policy 63, 611-620.

Selinske, M.J., Coetzee, J., Purnell, K., Knight, A.T., 2015. Understanding the Motivations, Satisfaction, and Retention of Landowners in Private Land Conservation Programs. Conserv. Lett. 8, 282-289.

Smith, P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E.A., Haberl, H., Harper, R., House, J., Jafari, M., Masera, O., Mbow, C., Ravindranath, N.H., Rice, C.W., Robledo, A.C., Romanovskaya, A., Sperling, F., Tubiello, F., 2014. in: Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlömer, S., von Stechow, C., Zwickel, T., Minx, J.C. (Eds.), Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 811-922.

Stoneham, G., Chaudhri, V., Ha, A., Strappazzon, L., 2003. Auctions for conservation contracts: an empirical examination of Victoria's BushTender trial. The Australian Journal of Agricultural and Resource Economics 47, 477-500.

Ulrich-Schad, J.D., Babin, N., Ma, Z., Prokopy, L.S., 2016. Out-of-state, out of mind? Non-operating farmland owners and conservation decision making. Land Use Policy 54, 602-613.

UNEP World Conservation Monitoring Centre and International Union for Conservation of Nature, 2016. Protected Planet Report 2016, UNEP World Conservation Monitoring Centre and International Union for Conservation of Nature.

United States Department of Agriculture,, 2018. Conservation Reserve Program Monthly Summary – October 2018, United States Department of Agriculture,, Retrieved 8 January 2019 from https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Conservation/PDF/OCT2018%20Summary.pdf.

Vaughn, K.J., Young, T.P., 2010. Contingent Conclusions: Year of Initiation Influences Ecological Field Experiments, but Temporal Replication is Rare. Restoration Ecology 18, 59-64.

Venter, O., Laurance, W.F., Iwamura, T., Wilson, K.A., Fuller, R.A., Possingham, H.P., 2009. Harnessing carbon payments to protect biodiversity. Science 326, 1368.

Vesk, P.A., Robinson, D., van der Ree, R., Wilson, C.M., Saywell, S., McCarthy, M.A., 2015. Demographic Effects of Habitat Restoration for the Grey-Crowned Babbler Pomatostomus temporalis, in Victoria, Australia. PLoS One 10, 18.

Waldron, A., Miller, D.C., Redding, D., Mooers, A., Kuhn, T.S., Nibbelink, N., Roberts, J.T., Tobias, J.A., Gittleman, J.L., 2017. Reductions in global biodiversity loss predicted from conservation spending. Nature 551, 364-367.

Whitten, S.M., Reeson, A., Windle, J., Rolfe, J., 2013. Designing conservation tenders to support landholder participation: A framework and case study assessment. Ecosystem Services 6, 82-92.

Wichmann, B., Boxall, P., Wilson, S., Pergery, O., 2016. Auctioning Risky Conservation Contracts. Environmental and Resource Economics, 1-34.

Windle, J., Rolfe, J., 2008. Exploring the efficiencies of using competitive tenders over fixed price grants to protect biodiversity in Australian rangelands. Land Use Policy 25, 388-398.

World Bank, 2017. State and Trends of Carbon Pricing 2017, World Bank.

Appendix 1 Data access agreement

THE UNIVERSITY OF ADELAIDE AUSTRALIA

UNIVERSITY OF ADELAIDE

CONFIDENTIALITY DEED

THIS DEED made as of the ____________ day of ____________ 2015

PARTIES

THE UNIVERSITY OF ADELAIDE (ABN 61 249 878 937), a body corporate established pursuant to the provisions of the *University of Adelaide Act 1971* (SA) and having its principal office at North Terrace, Adelaide, South Australia, 5000 **(the Recipient)**.

O'CONNOR NRM (ABN 61 114 028 572) of 20 Adelaide St, Maylands SA, **(the Discloser)**.

RECITALS

The Recipient, through its School of Agricdture, Food and Wine, has arranged for its student Anthelia Bond (the **Student**) to conduct a Higher Degree by Research project in relation to the influence of market based incentives on land manager behaviour and ecosystem service provision in agricultural landscapes (the **Project**). The Project shall be supervised by Timothy Cavagnaro, an employeeof the Recipient (each a **Supervisor**).

The Recipient wishes to have access for the Agreed Purpose (as defined below) to certain information held by the Discloser. The Recipient has agreed to enter into this Deed in relation to the protection by the Recipient of the confidentiality of the information to be disclosed by the Discloser to the Recipient.

IT IS AGREED

1. Definitions

1.1 In this Deed:

Affiliate means, in respect of a party, a corporation that is related to that party under section 228 of the *Corporations Act 2001* (Cth).

Agreed Purpose means the sole and exclusive purpose for which the Information has been supplied by the Discloser to the Recipient, being the conduct by Student of the Project and the preparation, review and assessment of Student's Thesis on that Project.

Information means any information designated as confidential or which by its nature is confidential or which is disclosed in circumstances importing an obligation of confidence, which is disclosed or made available directly or indirectly by or on behalf of the Discloser to the Recipient or the Student for the purposes of the Project before, on or after the date of this Deed, which may include pre-existing biophysical and social data generated by the Eastern Mt Lofty Ranges BushBids project.

Person means an individual or a corporate body, partnership or other legal entity.

Thesis means any work, or subject matter other than a work, prepared by the Student and submitted as part of the requirements for examination for the award of a degree at the University.

A reference to the **Discloser** includes a reference to its Affiliates.

2. Confidentiality

2.1 The Recipient must treat the Information as proprietary and confidential and must not disclose the Information to any third party except for the Agreed Purpose.

2.2 The Recipient's obligations under clauses 2, 3 and 4.3 of this Deed do not apply to any Information which:

(a) is in the public domain at the time of disclosure, or becomes part of the public domain after disclosure, otherwise than through a breach of this Agreement (but compilations of information which are not public shall not be treated as being public by reason of them containing information which is);

(b) the Recipient can prove was in its lawful possession prior to disclosure to it by the Discloser and which was not acquired directly or indirectly from the Discloser under an obligation of confidentiality;

(c) is lawfully and bona fide obtained by the Recipient from a third Person who, to the knowledge and reasonable belief of the Recipient, did not receive the Information directly or indirectly from the Discloser under an obligation of confidentiality; or

(d) is required to be disclosed by law or applicable legal process (subject to the Recipient claiming any immunity, privilege or restriction, on and from disclosure, that it can reasonably claim and always provided that the Recipient will immediately notify the Discloser of any such request, where possible before, or as soon as practicable after, making the disclosure).

2.3 The Recipient must keep the Information in safe custody at all times and not use or copy the Information or reduce it into tangible or recorded form other than for the Agreed Purpose.

2.4 The Recipient will promptly notify the Discloser in writing upon the completion of use of the Information for the Agreed Purpose.

2.5 The Recipient must inform the Discloser immediately if it becomes aware or suspects that there has been a breach of the obligations in this Deed or an unauthorised use or disclosure of the Information has occurred.

3. Access to Information

3.1 The Recipient will limit access to the Information to:

(a) those staff and students of the School of Agriculture Food and Wine (which will include the Student and the Supervisor(s)); and

(b) to Affiliates, consultants, professional advisers, agents or associates of the Recipient,

who reasonably require access to the Information in relation to the Project.

3.2 Each Person to whom Information is disclosed will be advised by the Recipient of the confidential nature of the Information and will be obliged to treat the Information as strictly confidential in the same manner as the Recipient under this Deed.

3.3 The Recipient will be liable to the Discloser for any act or omission of the Student or any other Person to whom it discloses the Information as if those actions or omissions were the Recipient's own.

4. Use of the Information

4.1 The Recipient acknowledges that it is making independent use of the Information and will verify all information upon which it intends to rely to its own satisfaction and that the Discloser does not make any representation or warranty, express or implied as to the quality, accuracy or completeness of the Information and does not accept any responsibility for:

(a) any errors or omissions in the Information; or

(b) any interpretation, opinion or conclusion that the Recipient may form as a result of examining the Information.

4.2 Except to the extent that exclusion of liability is not permitted by law, the Discloser is not liable (whether on the basis of negligence or otherwise) and does not accept any responsibility for any loss or damage that the Recipient or anyone else may suffer or incur as a result of using, relying on or disclosing any of the Information.

4.3 The Recipient shall not publish the Information or any conclusions that could only have been drawn using the Information without the prior written consent of the Discloser and on such conditions as the Discloser may wish to impose. The Discloser agrees that approval to publish the Information and conclusions shall not be unreasonably withheld.

4.4 Nothing in this Deed shall prevent the Student or the Recipient from providing the Thesis to the Recipient's examiners (**Examiners**) for assessment. In recognition of the confidentiality of the Information, the Recipient will provide a copy of the Thesis to the Discloser prior to submission to the Examiners for assessment.

4.5 At the request of the Discloser by notice to the Recipient not less than 30 days prior to submission of the Thesis:

(a) the Thesis will be submitted to the Examiners in confidence; and

(b) the Recipient will ensure that the Thesis is kept confidential for a period of no more than 12 months from the submission of the Thesis.

4.6 The Discloser acknowledges that the Student retains ownership of all copyright in the Thesis.

5. **Property, Return and Destruction of Information**

5.1 Information that is the property of the Discloser shall remain its property and no other rights other than those expressly granted by this Deed are conferred upon the Recipient. The Discloser may demand the return or destruction of all Information, at any time upon giving written notice to the Recipient. Subject to clause 5.2, but otherwise irrespective of any other provision in this Deed, the Student must cease to use Information or any part of it for any purpose upon receipt of a demand for its return or destruction under this clause 5.1.

5.2 Within 20 days of receipt of a notice under clause 5.1, the Recipient will return or destroy all of the original Information and destroy all copies and reproductions (whether written, electronic or otherwise) in its possession and in the possession of the Student and any other Persons to whom it was disclosed. If required by the Discloser, the Recipient will certify on oath that it has complied with this clause 5.2. Required hard copy and digital versions of the final Thesis are exempt from being returned or destroyed.

6. **Term**

6.1 This Deed shall remain in effect until the expiry of two years from the date of acceptance of the Thesis by the Recipient.

7. **Notices**

7.1 All notices under this Deed shall be in writing and sent to the address of each party as set out below or any other address that is subsequently notified:

The Recipient

Dean of the Waite
School of Agriculture Food and Wine
School Building, Waite Campus, Urrbrae
The University of Adelaide, South Australia, 5064
Fax: 08 8313 7109

The Discloser

Patrick O'Connor
O'Connor NRM
PO Box 265 Stepney, SA, 5069
Phone: 08 7324 4161

8. **Miscellaneous**

8.1 This is the entire agreement between the parties about its subject matter and replaces all oral and written prior communications and agreements between the parties.

8.2 South Australian law applies to this Deed and proceedings must be commenced in the courts of South Australia or the Adelaide Registry of the Federal Court of Australia.

8.3 A waiver by a party in respect of a breach of a provision of this Deed must not be taken to be a waiver unless given in writing and will not constitute a waiver of any other breach. The failure by a party at any time to enforce a provision of this Deed must not be construed as a waiver by that party of that provision or in any way affect the validity of this Deed or any part of it.

8.4 The Recipient recognises and agrees that monetary damages alone may not be adequate compensation to the Discloser for a breach by the Recipient or any Person to whom the Information is disclosed and the Discloser shall be entitled to both legal and equitable remedies, including injunctions and specific performance, in the event of any breach of this Deed.

8.5 This Deed may only be varied by the parties in writing.

8.6 This Deed may be signed electronically and in counterparts.

EXECUTED AS A DEED

Signed, sealed and delivered for and on behalf of
The University of Adelaide
by its authorised representative:

Name of authorised representative

Professor Mike Brooks
DEPUTY VICE-CHANCELLOR AND
VICE-PRESIDENT (RESEARCH)

Signature of authorised representative

Date: 25/11/15

Signed, sealed and delivered for and on behalf of
O'Connor NRM
by its authorised representative:

Patrick O'Connor

Name of authorised representative

Patrick O'Connor

Digitally signed by Patrick O'Connor
Date: 2015.11.27 13:24:32 +10'30'

Signature of authorised representative

Date: 27/11/15

I, **Anthelia Bond**, acknowledge the terms of this Deed and agree to comply with its terms in so far as they apply to me.

Signature of Student

Date: 7/12/2015

I, **Timothy Cavagnaro**, acknowledge the terms of this Deed.

Signature of Supervisor

Date: 7/12/2015

Appendix 2 Human research ethics approval documents

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY

SABINE SCHREIBER
SECRETARY
HUMAN RESEARCH ETHICS COMMITTEE
THE UNIVERSITY OF ADELAIDE
LEVEL 4, RUNDLE MALL PLAZA
50 RUNDLE MALL
ADELAIDE SA 5000 AUSTRALIA

TELEPHONE +61 8 8313 6028
FACSIMILE +61 8 8313 3700
email: hrec@adelaide.edu.au
CRICOS Provider Number 00123M

16 May 2016

Dr P O'Connor
Soil and Water

Dear Dr O'Connor

PROJECT NO: H-2016-103
Managing native vegetation on private land - land manager experiences and perspectives on future management

The ethics application for the above project has been reviewed by the Convenor of the Human Research Ethics Committee and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research (2007)*.

The ethics expiry date for this project is: 31 May 2019

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled *Annual Report on Project Status* is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/ethics/human/guidelines/reporting. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the Information Sheet and the signed Consent Form to retain. It is also a condition of approval that you **immediately report** anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol; and
- the project is discontinued before the expected date of completion.

Please refer to the following ethics approval document for any additional conditions that may apply to this project.

Yours sincerely

Professor Paul Delfabbro
Convenor
Human Research Ethics Committee

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY

SABINE SCHREIBER
SECRETARY
HUMAN RESEARCH ETHICS COMMITTEE
THE UNIVERSITY OF ADELAIDE
LEVEL 4, RUNDLE MALL PLAZA
50 RUNDLE MALL
ADELAIDE SA 5000 AUSTRALIA

TELEPHONE +61 8 8313 6028
FACSIMILE +61 8 8313 3700
email: hrec@adelaide.edu.au
CRICOS Provider Number 00123M

Applicant: Dr P O'Connor

School: Soil and Water

Project Title: ***Managing native vegetation on private land - land manager experiences and perspectives on future management***

THE UNIVERSITY OF ADELAIDE HUMAN RESEARCH ETHICS COMMITTEE

Project No: **H-2016-103** RM No: 0000021617

APPROVED for the period until: **31 May 2019**

Thank you for the response dated 2.5.16 and 12.5.16 to the matters raised. It is noted that this study will be conducted by Anthelia Bond, Masters student.

Refer also to the accompanying letter setting out requirements applying to approval.

PD

Professor Paul Delfabbro
Convenor
Human Research Ethics Committee

Date: 16 May 2016

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY

SABINE SCHREIBER
SECRETARY
HUMAN RESEARCH ETHICS COMMITTEE
THE UNIVERSITY OF ADELAIDE
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50 RUNDLE MALL
ADELAIDE SA 5000 AUSTRALIA

TELEPHONE +61 8 8313 6028
FACSIMILE +61 8 8313 3700
email: hrec@adelaide.edu.au
CRICOS Provider Number 00123M

18 October 2016

Associate Professor P O'Connor
Centre for Global Food and Resources

Dear Associate Professor O'Connor

PROJECT NO: H-2016-103
Managing native vegetation on private land- land manager experiences and perspectives on future management

Thank you for the revised application and emails dated 07.10.16, 12.10.2016 and 14.10.2016 from PhD candidate Anthelia Bond requesting amendments to the above project. On behalf of the Human Research Ethics Committee I have approved the amendment requested to the recruitment method. I have also approved the request to receive access to an existing dataset and aerial photographs from Department of Environment, Water and Natural Resources, with the understanding that all identifying information will be removed once it has been used to summarise entity type, land use and gender. Approval to receive the dataset and photographs are subject to any additional approvals the Department may require.

The ethics expiry date for this project is: 31 May 2019

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled *Annual Report on Project Status* is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/rb/oreci/human/reporting/. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the Information Sheet and the signed Consent Form to retain. It is also a condition of approval that you **immediately report** anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol; and
- the project is discontinued before the expected date of completion.

Yours sincerely

For **Professor Paul Delfabbro**
Convenor
Human Research Ethics Committee

RESEARCH SERVICES
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY
THE UNIVERSITY OF ADELAIDE

LEVEL 4, RUNDLE MALL PLAZA
50 RUNDLE MALL
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FACSIMILE +61 8 8313 3700
EMAIL hrec@adelaide.edu.au

CRICOS Provider Number 00123M

14 March 2017

Associate Professor O'Connor
Global Food Studies

Dear Associate Professor O'Connor

ETHICS APPROVAL No: **H-2016-103**

PROJECT TITLE: **Managing native vegetation on private land—land manager experiences and perspectives on future management**

Thank you for the amendment request for the above project and the response to matters raised provided by PhD student Anthelia Bond on the 02.03.2017 and 10.03.2017, respectively. The requests to add Assistant Professor Sean Smukler as a researcher, temporarily store de-identified data at University of British Colombia, access additional de-identified data (from Eastern Mt Lofty Ranges BushBids project), extend scope of study aims, and add an additional aim associated with October 2016 amendment, as outlined in application documents provided on the 02.03.2017, have been reviewed and approved by the Low Risk Human Research Ethics Review Group (Faculty of Arts and Faculty of the Professions).

The ethics expiry date for this project is 31 May 2019.

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled *Annual Report on Project Status* is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/research-services/oreci/human/reporting/. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the Information Sheet and the signed Consent Form to retain. It is also a condition of approval that you **immediately report** anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol; and
- the project is discontinued before the expected date of completion.

Yours sincerely

DR JOHN TIBBY

Co-Convenor
Low Risk Human Research Ethics Review Group
(Faculty of Arts and Faculty of the Professions)

DR ANNA OLIJNK

Co-Convenor
Low Risk Human Research Ethics Review Group
(Faculty of Arts and Faculty of the Professions)

Appendix 3 Scientific research permit

Government of South Australia
Department of Environment, Water and Natural Resources

PERMIT TO UNDERTAKE SCIENTIFIC RESEARCH

Permit Holder	Ms A Bond University of Adelaide Soils Group, School of Agriculture, Food and Wine PMB1 GLEN OSMOND SA AUSTRALIA 5064

Project Title: Eastern Mt Lofty Ranges BushBids: biodiversity and carbon sequestration outcomes from 10 year contracts for native vegetation management.

Permit Number: M26481-1

This permit is valid from 3/11/2015 to 31/10/2016 unless cancelled or revoked

Legislative Permissions:
Permit issued under section(s) 69(2);
Sections 10(1)(b), 49(1)(a) of the *National Parks and Wildlife Act 1972* as they relate to regulation(s) 30(1), 31(a)(i), 31(a)(ii), 31(b), 31(c)(i), 32 of the *National Parks and Wildlife (National Parks) Regulations 2001*

YOU MUST CONTACT THE APPROPRIATE NATURAL RESOURCES CENTRE REGIONAL OFFICES BEFORE COLLECTING ANY SPECIMENS OF FLORA OR FAUNA OR ENTERING A RESERVE

FAILURE TO DO THIS MAY RESULT IN PERMIT WITHDRAWAL AND A FINE

CARRY THIS PERMIT WITH YOU WHEN CONDUCTING RESEARCH IN THE FIELD
A photocopy plus other ID must be carried by any additional named collectors who are collecting independently

For any enquiries relating to this permit, contact:
Department of Environment, Water and Natural Resources Postal Address: GPO Box 1047, Adelaide, 5001, SA

Location: Plant Biodiversity Centre, Hackney Road, Adelaide
Telephone 08 8222 9478 Fax 08 8212 4661
Email: DEWNRresearchpermits@sa.gov.au

The SA Department of Environment, Water and Natural Resources (the Department) encourages scientific research both within the State's system of conservation reserves and on our protected native plants and animals. It is only through increased scientific understanding that we can develop a soundly based system of conservation management for the State.

In carrying out such research projects, you should be conscious that you are manipulating a part of Australia's natural heritage and this carries certain responsibilities. Some of the more obvious responsibilities are outlined under the standard conditions listed below. In addition the Department requires you to always conduct your research project in such a way as to have the smallest possible impact on the natural environment.

The permit/licence is issued subject to the following standard and additional conditions. Failure to adhere to the conditions constitutes a breach which can result in permit withdrawal and potential prosecution.

Standard permit Conditions

1. This permit does not authorise access or entry onto any land without the consent of the landowner or relevant authority having control of the land.
2. This permit does not authorise collection of any specimens without the consent of the landowner or relevant authority having control of the land. Where the collection is of protected animals (or their eggs) consent must be in writing and granted not more than six months beforehand.
3. The relevant Natural Resources Centre regional office(s) must be notified at least 10 days prior to undertaking any research within those regions.
4. Upon arrival in a reserve attended by a resident Ranger, the permit must be shown to the Ranger before research is undertaken. Details of any vehicles to be used in field work should also be provided.
5. The permit holder and field assistants must comply with any instructions given by a Ranger, landholder or authority in respect to access.
6. The permit holder, all field assistants and any third party carrier must adhere to the National Parks and Wildlife (National Parks) Regulations 2001 pertaining to correct conduct in a reserve.
7. Standard practices to minimise the risk of Phytophthora (Root rot fungus) spread must be used at all times in vulnerable areas: ensure awareness of Phytophthora; heed warning signs; stay on formed tracks; adopt hygiene procedures.
8. Where collection of samples is approved under this permit, samples collected shall be limited in size and taken where they will cause the least disfigurement or disturbance.
9. Where collection of specimens is approved under this permit, the number of specimens of any one species which may be taken is limited to the number specified in the permit, or where the number is not stated to the minimum number required to achieve the aims of the approved research proposal.
10. The permit holder is responsible for the actions of other persons who may undertake this research or collect specimens on their behalf. It is a defence to the provisions of this clause if the permit holder is able to demonstrate that the actions of other persons operating under the permit were inconsistent with directions given to them by the permit holder.
11. Specimens collected may not be exported from this State unless approved under this permit or otherwise approved by the Director, National Parks and Wildlife (or delegate).
12. Specimens or the progeny and carcasses of animals taken under the permit may not be sold or transferred without the written consent of the Director, National Parks and Wildlife (or delegate) and all such specimens shall be disposed of in the manner specified in this permit at the termination of the permit or a time specified by the Director (or delegate).
13. Any research approved under this permit and involving the use of vertebrate animals requires a current 'Licence for Teaching, Research or Experimentation Involving Animals' issued to either the permit-holder or the permit-holder's organisation, an approval from an official South Australian Animal Ethics/Welfare Committee (in addition to any approval from committees outside of the State) and compliance with the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes (Australian Government; National Health and Medical Research Council, 2004)
14. If vertebrate animals are collected under this permit and exported for use in a scientific research project in another State or Territory, the project and use of the animals must have the approval of the relevant State or Territory animal ethics or welfare committee.
15. Upon completion of the research, all equipment and markers must be removed, unless specific approval to the contrary has been obtained from the land owner or relevant authority having control of the land.
16. At the end of the permit period, and before any renewal is granted, the Research Permit Officer must be provided with a full report (or satisfactory progress report) on the research carried out under the permit. For flora or vertebrate fauna research and if otherwise requested, a dataset of all collections/captures must be provided in electronic format, unless alternative arrangements have been made. The dataset must comply with the Department's dataset requirements and include, as a minimum, the observer(s) name, scientific name (including sub-species if relevant), number of individuals observed/collected, date of sighting/collection, location coordinates, datum and accuracy, and observation/collection method. A suitable electronic template is available on request.
17. If an account of the research is published, or information circulated, a copy of the account or information must be lodged with the Research Permit Officer, as soon as practicable after its publication or circulation.
18. When planning and conducting your research, you must be aware that your work may intrude on locations or involve species with cultural significance to local Aboriginal communities. As part of your project planning it would be a courtesy, and in some cases a requirement, to consult with local Aboriginal representatives to determine any potential impacts and the means of avoiding or limiting them.
19. Under the *Aboriginal Heritage Act 1988* it is an offence to damage, disturb or interfere with any Aboriginal site, to damage any Aboriginal objects and to disturb or interfere with any Aboriginal object or remains without the authorisation of the Minister for Aboriginal Affairs and Reconciliation. It is the applicants' responsibility to obtain their own advice in relation to this matter. Any findings of Aboriginal object or remains must be reported to The Aboriginal Affairs and Reconciliation Division, Department of the Premier and Cabinet.

Additional Conditions:

1. ADDITIONAL COLLECTORS
Additional personnel may collect specimens under this permit if authorised by the permit holder. A letter of authorisation from the permit holder, identification and a copy of the permit must be carried in the field and presented on request.

Remember that it is the permit holder's responsibility to ensure that the actions of other persons who may undertake this research or collect specimens on their behalf are consistent with the conditions of the permit. If the person is to undertake fauna based survey work their name will need to be present on the Wildlife Ethics Committee Approval and therefore an amendment may need to be applied for.

2. FIELD WORK IN RESERVES
Field work in reserves should be carried out in areas of low visitor presence, or at times of low visitor use.

The appropriate local regional DEWNR Natural Resources Centre Office must be contacted prior to conducting field work to arrange specific reserve access conditions.

Researchers should take particular care to discuss with Park Rangers any conditions within the reserve which might affect the safe conduct of their research including; the requirement to close reserves on days of catastrophic fire danger or the development of an adequate bushfire survival plan. The CFS website can provide some guidance. Researchers are required to comply with their organisation's Work Health Safety (WHS/OHS) policy.

The permit holder, all field assistants and any carrier must adhere to the National Parks and Wildlife (National Parks) Regulations 2001 pertaining to correct conduct in a reserve.

In remote regions, notification must be provided at least one month in advance.

3. MINIMISING THE IMPACT OF FLORA SPECIMEN COLLECTING
No more than ten percent of the visible local population (within an area of continuous habitat) is to be collected.

Where possible, material should not be collected from isolated plants.

Ensure that any damage to the plants is kept to a minimum.

No more than 20% of the seed stock or 5% of the foliage may be removed from any one plant.

Specimens should be collected so as to cause minimal disfigurement and disturbance. Wherever possible, repair any damage eg restore soil surface.

Use suitable sharp implements and clean/disinfect them appropriately between each plant to prevent the transmission of pests or diseases.

Avoid damage to surrounding plants including trampling understorey and ground cover species.

Where possible specimens are to be collected away from normal public visibility, or at times of low public presence.

Planned collections of any known threatened species (National Parks and Wildlife Act Schedules) must be discussed with the NRM regions, DEWNR Ecologist, Threatened Species/Communities (phone 08 8303 9376) or State Herbarium of South Australia prior to collection to determine the necessity of collections and any potential impacts on species recovery actions.

Collections of species classified as endangered or vulnerable are permitted on the condition that:
. an accurate description is made of the population location and habitat
. a count of the local population size and the number of specimens taken from that population is recorded (limited to 10% of the visible population or 'one specimen for every ten plants found').

Collection of additional material from endangered and vulnerable species will require specific approval based on the identification of sufficiently large populations.

4. PHYTOPHTHORA
The appropriate Natural Resources Centre (NRM) regional office is to be contacted prior to conducting field work to determine the current status of Phytophthora (root rot fungus) infection in your planned research locations.

Areas of known Phytophthora infection must not be entered unless specific approval is obtained and appropriate quarantine precautions are put in place.

Areas of suspected Phytophthora infection (i.e. visual symptoms - dead/dying plants - indicate Phytophthora infection, however soil sampling has not been conducted or Phytophthora has not yet been identified) should be treated as areas of known Phytophthora infection.

In areas susceptible to Phytophthora infection but where no known outbreaks have occurred, standard practices to minimise the risk of Phytophthora spread must be used, e.g.

. Avoid driving or walking in areas when soils are wet and sticky
. Stay on formed roads and tracks where possible
. Heed warning signs

. Clean vehicles, boots and other field equipment coming into contact with soil, preferably on site or at the park cleaning station
. Ensure that all equipment, plants and raw materials brought into the area are free of Phytophthora
. Report any unusual plant death to the DEWNR Officer of the national park/conservation park/wilderness protection area.

Refer to the DEWNR document `Hygiene procedures for footwear, equipment and vehicles' for information on specific hygiene procedures. Apply for a copy email to DEWNRresearchpermits@sa.gov.au .

Where research does not require the collection of soil samples but where soil may inadvertently be removed from site, e.g. when collecting whole plant specimens, as much soil as possible must be removed from the specimen at the site of collection (for plants this may require washing the roots). If all the soil cannot be removed without risk of damage to the specimen, then the specimen must be stored in such a manner as to prevent subsequent transfer of soil to other locations (e.g. a moisture resistant bag - double closed to prevent spillage). Once away from the collection site any additional loose soil and surplus specimen material must be disposed of in a safe manner (e.g. burnt or otherwise sterilised as appropriate).

Collection of unhealthy plant material is to be avoided unless specified as part of the research, and quarantine precautions are followed.

Where soil collection or disturbance is required it must be specified as a part of the research. Care must be taken to avoid loss of sampled material at other sites by securely storing samples and cleaning collection equipment, clothing etc on-site (even within sites).

5. CONTAMINATION AND RISK OF SPREADING WEEDS
Any activity involving movement of soil and the use of heavy machinery has the potential to spread invasive species. The `Arrive Clean, Leave Clean ' guidelines http://www.environment.gov.au/biodiversity/invasive-species/publications/arrive-clean-leave-clean detail how to prevent the spread of invasive plant diseases such as Phytophthora and Myrtle Rust (which can affect Eucalyptus spp. and Melaleuca spp.) and the spread of weed species.

Clothing, hats, footwear, tools, equipment, machinery and vehicles can transport invasive species. Ensure all clothing, hats, footwear, tools, equipment, machinery and vehicles are free of mud, soil and organic matter before entering and exiting bushland. Use a solution of 70% ethanol or methylated spirits in 30% water to disinfect items that may be contaminated (including hats, footwear, tools, equipment). Remove all weed seeds, mud, soil and organic matter from clothing, footwear, tools, equipment, machinery and vehicles.

Phytoclean mixed with water at appropriate ratio should be used for larger items, machinery and vehicles as it is less toxic than ethanol or methylated spirits and therefore better suited to application in large volumes ? often required to thoroughly clean the tyres and undercarriage of a muddy vehicle.

Use a wash-down facility for vehicles and machinery if available, or wash-down on a hard, well-drained surface, for example a road, and on ramps if possible. Pay particular attention to cleaning mud flaps and tyres. Dispose of wash-down water so that it drains back into a low area of the infested zone away from waterways. If this is not possible, empty it into a waste container for responsible disposal offsite. Do not allow wash-down water to drain into clean bushland. Do not drive through wash-down water.

6. MINIMUM DATASET
Researchers must collect at least a minimum set of data when collecting specimens or undertaking observations of any research topic under a Scientific Research Permit, and ensure that the information collected is accurate, comprehensive and has relevance beyond the confines of the project for which it may have been originally intended.

You must collect the following information as a minimum requirement:
Observer(s) name and contact details
Scientific Name (including sub-species if relevant)
Number of individuals observed
Date of sighting/collection
Location Coordinates, Datum and Accuracy
Observation/Collection Method

Data as above must accompany all specimens lodged at a Museum, Herbarium or University collection.

Data for flora, vertebrate fauna and any other research subject matter (including observations) must be provided to the Research Permits email mailbox at: DEWNRresearchpermits@sa.gov.au for inclusion in the Biological Databases of SA unless it has already been reported to an approved organisation for inclusion into their database (eg ABBBS, Birds Australia, State Herbarium of South Australia, South Australian Museum). The data must be submitted on the 'DEWNR data returns template' (an Excel spreadsheet) unless other arrangements have been made.

Approved Specimens to be Collected and/or Observational Activities Conducted:

SPECIMEN:	Plants.
ACTIVITY:	Collect plant specimens for identification purposes.
NUMBER SIZE:	Voucher plus duplicate.
LOCALITY:	Selected DEWNR reserves in the Adelaide and Mount Lofty Ranges and SA Murray-Darling Basin NRM regions (refer to Approved Locations section).

SPECIMEN: Plant litter.
ACTIVITY: Collect plant litter samples by hand.
NUMBER SIZE: Dead biomass <25mm diameter than can be detached by hand from the ground surface. From five 25x25cm quadrats in each monitoring plot.
LOCALITY: Selected DEWNR reserves in the Adelaide and Mount Lofty Ranges and SA Murray-Darling Basin NRM regions (refer to Approved Locations section).

SPECIMEN: Soils.
ACTIVITY: Collect soil samples.
NUMBER SIZE: 5 samples at each of two depths (0-5cm and 5-30cm) from each monitoring site. 3 additional samples for bulk density measurements at depths (0cm and 20cm).
LOCALITY: Selected DEWNR reserves in the Adelaide and Mount Lofty Ranges and SA Murray-Darling Basin NRM regions (refer to Approved Locations section).

ACTIVITY: Undertake vegetation assessment as per Bushland Condition Monitoring methodology.
NUMBER SIZE: At each monitoring site.
LOCALITY: Selected DEWNR reserves in the Adelaide and Mount Lofty Ranges and SA Murray-Darling Basin NRM regions (refer to Approved Locations section).

Approved Activities:
The vegetation assessments will follow the Nature Conservation Scoiety of South Australia's Bushland Condition Monitoring methodolgy (Croft et al. 2005) and will measure the following variables associated with a 30m x 30m, permanently marked, monitoring plot:
- Plant species diversity
- Weed abundance and threat
- Structural diversity
- Regeneration
- Tree and shrub health
- Tree habitat features
- Feral animals
- Total grazing pressure

In addition to these non-destructive measures, some plant specimens and plant litter and soil samples will be collected:

Plant specimens for identification purposes- sufficient material for one herbarium specimen for each plant species recorded within nearby monitoring plots and when there is uncertainty with field identification.

Plant litter samples-litter collected from five 25x25cm quadrats in each monitoring plot.

Soil samples-five samples at each of two depths (0-5cm and 5-30cm) from each monitoring site and three additional samples for bulk density measurement at depths (0cm and 20cm) from each monitoring site. The small holes created by soil sampling will be back filled using surrounding soil material to minimise disturbance and other impacts.

In most cases there will be only one monitoring plot in each Conservation Park or Recreation Park, however, in a limited number of cases two monitoring plots may be re-assessed in a park.

Approved Locations:
List of reserves this permit is valid for:
Poonthie Ruwe Conservation Park
Monarto Conservation Park
Kyeema Conservation Park
Kaiserstuhl Conservation Park
Hale Conservation Park
Finniss Conservation Park
Ferries - McDonald Conservation Park
Charleston Conservation Park
Cromer Conservation Park
Totness Recreation Park

Specimen Disposition:
Plant speciemens will be used at The University of Adelaide and deposited at the State Herbarium of South Australia where they will be stored with the TREND plant specimens. Litter and soil samples will be consumed by analysis.

Others Involved and Field Assistants:
Field assistants will not be conducting any work independently of the permit holder.

Before carrying out any field work under this Scientific Permit you must contact the Natural Resources Centre regional Office(s) and comply with any instructions given with respect to access and specimen collection on reserve, and notify them of any specimen collection off reserves:

Natural Resources Centre Adelaide & Mount Lofty Ranges	**Gawler** – 8 Adelaide Road, Gawler SA 5188. Phone (08) 8523 7700
	Black Hill – 115 Maryvale Road, Athelstone SA 5076. Phone (08) 8336 0901
	Willunga – 5 Aldinga Road, Willunga SA 5172. Phone (08) 8550 3400
Natural Resources Centre South Australian Murray Darling Basin	**Murray Bridge** - 110A Mannum Road, Murray Bridge SA 5253 phone: (08) 8532 9100

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Lynnette Kajar

Research Permits Officer (Delegate)

Appendix 4 Vegetation condition assessment report to landholder

Bushland condition monitoring site report EXAMPLE

Vegetation association: *Eucalyptus leucoxylon* Open Woodland
Vegetation community type: SMLR3.1 Smooth Barked Gum Woodlands with an Open Shrub and Grassy Understorey

Image date 7/1/2007

Image date 3/12/2015

1. Plant species

Scientific name	Common Name	Native?	Conservation status	Recorded 7/1/2007	Recorded 3/12/2015	Comments
Acacia paradoxa	Kangaroo Thorn	Native		yes	yes	
Acacia pycnantha	Golden Wattle	Native		yes	yes	
Aira sp.	Hair-grass	Weed			yes	
Allocasuarina verticillata	Drooping Sheoak	Native		yes	yes	
Amphipogon caricinus var. *caricinus*	Long Grey-beard Grass	Native		yes	yes	
Arthropodium fimbriatum	Nodding Vanilla-lily	Native			yes	
Arthropodium sp.	Vanilla-lily	Native		yes		
Arthropodium strictum	Common Vanilla-lily	Native			yes	
Astroloma humifusum	Cranberry Heath	Native		yes	yes	
Austrodanthonia setacea	Small-flower Wallaby-grass	Native			yes	
Austrodanthonia sp.		Native		2 species		
Austrostipa semibarbata	Fibrous Spear-grass	Native			yes	
Austrostipa sp.	Spear-grass	Native		2 species		
Avena sp.	Oat	Weed			yes	
Billardiera cymosa.		Native		yes	yes	
Bossiaea prostrata	Creeping Bossiaea	Native		yes		
Briza maxima	Large Quaking-grass	Weed		yes	yes	
Brunonia australis	Blue Pincushion	Native			yes	
Burchardia umbellata	Milkmaids	Native		yes	yes	
Bursaria spinosa	Bursaria	Native		yes	yes	
Chamaescilla corymbosa var. *corymbosa*	Blue Squill	Native			yes	
Convolvulus angustissimus		Native			yes	
Convolvulus sp.		Native		yes		
Cynoglossum sp.	Hound's-tongue	Native			yes	
Deyeuxia quadriseta	Reed Bent-grass	Native			yes	
Dianella revoluta var. *revoluta*	Black-anther Flax-lily	Native		yes		
Dianella sp.	Flax-lily	Native			yes	
Ehrharta longiflora	Annual Veldt Grass	Weed			yes	
Eucalyptus fasciculosa	Pink Gum	Native	Rare		yes	

Scientific name	Common Name	Native?	Conservation status	Recorded 7/1/2007	Recorded 3/12/2015	Comments
Eucalyptus leucoxylon	South Australian Blue Gum	Native		yes	yes	
Exocarpos cupressiformis	Native Cherry	Native		yes	yes	
Gonocarpus sp.	Raspwort	Native			yes	
Gramineae sp.	Grass Family	Weed		yes		
Grevillea lavandulacea ssp. *lavandulacea*	Spider-flower	Native		yes	yes	
Grevillea rosmarinifolia ssp. *rosmarinifolia*	Rosemary Grevillea	Weed		yes	yes	
Hakea carinata	Erect Hakea	Native		yes	yes	
Hedera helix ssp. *helix*	Ivy	Weed			yes	
Hibbertia crinita		Native			yes	
Hibbertia exutiacies	Prickly Guinea-flower	Native		yes	yes	
Hibbertia sp.	Guinea-flower	Native		yes		
Kennedia prostrata	Scarlet Runner	Native			yes	
Lepidosperma curtisiae	Little Sword-sedge	Native			yes	
Lepidosperma semiteres	Wire Rapier-sedge	Native		yes	yes	
Lepidosperma sp.	Sword-sedge/Rapier-sedge	Native		yes		
Lomandra densiflora	Soft Tussock Mat-rush	Native		yes	yes	
Lomandra micrantha	Small-flower Mat-rush	Native		yes	yes	
Lomandra sororia	Sword Mat-rush	Native		yes		
Microlaena stipoides var. *stipoides*	Weeping Rice-grass	Native			yes	
Olearia ramulosa	Twiggy Daisy-bush	Native		yes	yes	
Pimelea humilis	Low Riceflower	Native		yes	yes	
Poa sp.	Winter Grass	Weed		yes		
Pultenaea pedunculata	Matted Bush-pea	Native		yes	yes	
Rhamnus alaternus	Blowfly Bush	Weed			yes	
Tetratheca pilosa ssp. *pilosa*	Hairy Pink-bells	Native		yes		
Thelymitra sp.	Sun-orchid	Native			yes	
Themeda triandra	Kangaroo Grass	Native			yes	
Thysanotus patersonii	Twining Fringe-lily	Native		yes	yes	
Tricoryne elatior	Yellow Rush-lily	Native			yes	
Ulex europaeus	Gorse	Weed		yes	yes	

2. Regeneration of trees and woody shrubs

Scientific name	Common name	Regenerating 2006-07	Regenerating 2015-16
Acacia pycnantha	Golden Wattle	yes	yes
Allocasuarina verticillata	Drooping Sheoak	yes	yes
Bursaria spinosa	Bursaria	yes	yes
Eucalyptus fasciculosa	Pink Gum		yes
Eucalyptus leucoxylon	SA Blue Gum	yes	yes
Olearia ramulosa	Twiggy Daisy-bush	yes	yes

3. Diversity of plant life forms

Life form	Estimated cover 2006-07	Estimated cover 2015-16
Tall Trees > 15m		6
Medium Trees 5 - 15m	5	2
Small Trees < 5m	1	1.5
Tall Shrubs > 2m	30	10
Medium Shrubs 0.5 - 2m	40	40
Small Shrubs < 0.5m	30	30
Herbs	0.5	1
Mat Plants/Groundcovers	0.5	0.1
Tall Grasses > 0.5m	1	1.5
Low Grasses < 0.5m	5	10
Low Tussocks < 0.5m	30	4
Vines, Twiners, Climbers	0.5	1

4. Weed cover

Scientific name	Common name	Estimated cover 2006-07	Estimated cover 2015-16
Avena sp.	Oat		0.1
Briza maxima	Large Quaking-grass	0.5	
Ehrharta longiflora	Annual Veldt Grass		0.1
Gramineae sp.	Grass Family	0.5	
Grevillea rosmarinifolia ssp. *rosmarinifolia*	Rosemary Grevillea	0.5	0.4
Poa sp.	Meadow-grass/Tussock-grass	0.5	
Rhamnus alaternus	Blowfly Bush		0.1
Ulex europaeus	Gorse	0.5	0.2

5. Ground cover

Ground cover component	Estimated cover 2006-07	Estimated cover 2015-16
Native Ground Cover	90	45
Weed Ground Cover	2	1
Leaf Litter	25	40
Exposed Rock	0	0
Moss, lichen etc	0.5	15
Bare Ground	0	1

6. Fallen logs and trees

Number 2006-07	Number 2015-16
1	22

7. Grazing pressure

Scientific name	Common name	2006-07				2015-16			
		Approx total	% lightly grazed	% heavily grazed	% severely grazed	Approx total	% lightly grazed	% heavily grazed	% severely grazed
Gonocarpus sp.	Raspwort					10	10	10	

8. Tree health and habitat

Assessment date	Tree number	Tree species	Distance (m)	Bearing	Girth at breast height (cm)	% canopy dieback	Number of mistletoe	Hollows present	Comment
7/01/2007	1	*Eucalyptus leucoxylon*	6.00	340	66	70	6.00	no	
7/01/2007	2	*Eucalyptus leucoxylon*	6.80	40	63	60	6.80	no	
7/01/2007	3	*Eucalyptus leucoxylon*	6.00	35	34	100	6.00	no	
7/01/2007	4	*Eucalyptus leucoxylon*	7.00	80	75	40	7.00	no	
7/01/2007	5	*Eucalyptus leucoxylon*	14.20	195	86	60	14.20	yes	
7/01/2007	6	*Eucalyptus leucoxylon*	10.10	260	77	30	10.10	no	
7/01/2007	7	*Eucalyptus leucoxylon*	10.50	315	47	80	10.50	no	
7/01/2007	8	*Eucalyptus leucoxylon*	10.50	340	54	30	10.50	no	
7/01/2007	9	*Eucalyptus leucoxylon*	12.00	0	95	50	12.00	no	
7/01/2007	10	*Eucalyptus leucoxylon*	13.00	60	65	60	13.00	no	
3/12/2015	1	*Eucalyptus leucoxylon*	6.10	340	67	98	6.10	yes	
3/12/2015	2	*Eucalyptus leucoxylon*	6.50	47	69	70	6.50	yes	
3/12/2015	3	*Eucalyptus leucoxylon*	5.50	35	38	100	5.50	yes	
3/12/2015	4	*Eucalyptus leucoxylon*	7.10	81	89	25	7.10	yes	
3/12/2015	5	*Eucalyptus leucoxylon*	14.40	195	81	85	14.40	yes	
3/12/2015	6	*Eucalyptus leucoxylon*	10.30	255	109	50	10.30	yes	
3/12/2015	7	*Eucalyptus leucoxylon*	10.60	311	45	100	10.60	yes	
3/12/2015	8	*Eucalyptus leucoxylon*	10.70	339	56	40	10.70	yes	
3/12/2015	9	*Eucalyptus leucoxylon*	11.50	0	102	35	11.50	yes	
3/12/2015	10	*Eucalyptus leucoxylon*	13.00	62	82	75	13.00	yes	

9. Summary of bushland condition scores

	2006-2007 assessment		2015-2016 assessment	
	Score	Rating	Score	Rating
Native plant species	32	Excellent	39	Excellent
Diversity of plant life forms	21	Excellent	19	Excellent
Regeneration	5	Good	6	Excellent
Weed threat and abundance	12	Good	16	Good
Ground cover	4	Good	4	Good
Fallen logs	1	Very poor	22	Excellent
Tree health (dieback)	-3.8	Poor	-4.2	Poor
Mistletoe	1	Excellent	1	Excellent
Grazing pressure	0	Excellent	-1	Excellent

10. Explanatory notes

Information presented in this report was collected using the Bushland Condition Monitoring Methodology (Croft, Pedler & Milne 2005). This methodology uses a 30 x 30 m monitoring plot for most of the condition measures, however the measures relating to trees are taken by assessing the ten nearest mature trees to one of the plot corners.

Plant species
This is a list of all plant species found in the plot. It is possible that some species present were missed, misidentified or not visible at the time of assessment. Therefore the absence of a species in the list of species found at the second assessment is not necessarily an indication of permanent loss from the plot or bushland. Conservation status indicated follows the Threatened Species Schedules of the *National Parks and Wildlife Act 1972*.

Regeneration of trees and woody shrubs
This section shows the native tree and shrub species regenerating at the time of each assessment. Species with seedlings or juvenile plants present were recorded as regenerating.

Diversity of plant life forms
The cover estimates shown in section 3 give the percentage cover (projected foliage cover) of each vegetation layer or type. Differences between assessments may reflect genuine changes but in some cases could be due to a difference in the way vegetation at the site was classified into structural layers.

Weed cover
The table in section 4 presents estimated cover (projected foliage cover) for the five most abundant weeds at the time of each assessment. At many sites, weed cover was lower at the second assessment, which may have been due to the unusually dry conditions in spring 2015 and/or management efforts.

Ground cover
The estimated cover of ground cover components is shown in section 5. Rather than projected foliage cover, these estimates of cover for weeds and native plants relate to the part of the plants present at ground level only. Also note that some components may have overlapping cover, like moss or lichen on exposed rock for example, and therefore, cover estimates may add up to more than 100%.

Fallen logs and trees
This is a count of the number of fallen logs and trees with a diameter of 10 cm or more. Logs provide important habitat for a range of organisms including fungi, moss, plants, invertebrates, reptiles, birds and mammals. Logs can also play an important role in retention of moisture and the cycling and retention of carbon and other nutrients (Holland, Clarke & Bennett 2017).

Grazing pressure
Section 7 presents information collected about grazing pressure on native plant species. Each native species with signs of grazing is recorded along with an estimate of the total number of plants (of that species) in the monitoring plot and the percentage of plants lightly, heavily or severely grazed. At many sites, the number of species with signs of grazing and the extent of grazing pressure was higher at the second assessment. This may be a result of dry conditions in spring 2015 and may also have been influenced by increasing numbers of native and/or feral animals following the big rains of 2010/2011.

Tree health and habitat
At each assessment the 10 nearest mature trees to one corner of the monitoring plot were measured. The distance and bearing shown provide the tree's location in relation to the corner of the monitoring plot. Standing dead trees were included. There are several reasons why the list of trees measured in the second assessment may not exactly correspond to the list measured in the first assessment. Some trees may have been consumed by fire or fallen over. Multi trunked trees may have been measured as multiple trees in one of the assessments and juvenile trees excluded from measurement in the first assessment may have matured by the second assessment. Where trees measured in the second assessment do not correspond with the same tree measured in the first assessment this is noted in the comments column.

In some instances the girth at breast height measurement indicates a possible reduction in tree size between the first and second assessment. This may be plausible if the tree is dead or has lost bark for other reasons, but is otherwise likely to be a result of variability in the measurement (e.g. variability in the height at which the measurement was taken).

Tree canopy dieback was generally greater at the time of the second assessment. This may not be a cause for concern as it could have been a short term seasonal increase influenced by the unusually dry spring in 2015. However, long term dieback in Eucalypts is a concern in many parts of Australia and therefore ongoing monitoring (formal or in formal) may help identify long term trends and possible management responses.

In the second assessment of tree hollows, a smaller limit for the size of hollows was used. This may partially explain an increase in the number of trees with hollows present at the second assessment.

Bushland condition scores
The scores shown in this section correspond to the scores outlined in the Bushland Condition Monitoring Methodology (Croft, Pedler & Milne 2005). For all scores except weed abundance and threat, a higher number indicates a better score. The weed threat and abundance score moves in the opposite direction, with a higher score indicating higher weed cover and/or more weeds with higher threat ratings.

Ratings are on a five point scale from very poor, to poor, moderate, good and excellent. They are derived from comparing the site score to benchmarks for a long undisturbed patch of a similar vegetation community. Please note that a poor or very poor rating does not indicate bushland of low value. It simply indicates that the bushland is not in as good condition for that indicator as would be expected in an undisturbed environment.

Any questions?

If you have any questions you are welcome to contact me by phone 0427544220 or by email anthelia.bond@adelaide.edu.au (before the end of December 2018) or anthelia.bond@gmail.com (from January 2019).

References

Croft, S., Pedler, J. & Milne, T. (2005) *Bushland Condition Monitoring Manual Southern Mt Lofty Ranges*. Nature Conservation Society of South Australia.

Holland, G.J., Clarke, M.F. & Bennett, A.F. (2017) Prescribed burning consumes key forest structural components: Implications for landscape heterogeneity. *Ecological Applications,* **27,** 845-858.

Appendix 5 Draft report to interview participants

Landholder views and experiences from 10 years of native vegetation management in the eastern Mt Lofty Ranges

Confidential report to research participants - not for distribution

June 2019

Anthelia Bond
PhD Candidate,
School of Agriculture Food and Wine
The University of Adelaide

Confidentiality statement

This report has been provided for feedback to study participants. Please do not distribute it further without prior consent from the author.

Disclaimer

Although reasonable care has been taken in preparing the information contained in this document, the author and the University of Adelaide accept no responsibility for the results of any actions taken on the basis of information in this report, nor for the accuracy or completeness of any material contained herein.

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Introduction

Private landholders can make an important contribution to halting biodiversity loss. Private land conservation is critically important, because public protected areas like National Parks are insufficient to address global environmental challenges on their own. Conservation programs like BushBids recognise the public environmental benefits that private landholders can provide and aim to support landholders with their conservation efforts. However, funding for conservation on private land has generally been provided through fixed-price, relatively short-term contracts. As a result, not much is known about the challenges and benefits of longer-term contracts where landholders set their own price through a tender or auction process.

This study aimed to find out about the experiences and views of BushBids participants, what supported participants in their 10-year contracts and what is needed to continue conservation in the future. Twenty-one landholders who participated in the Eastern Mt Lofty Ranges BushBids project were interviewed, including 17 who had BushBids contracts and four who didn't. Information from these interviews and follow-up questionnaires is presented here to provide a summary of results to study participants.

The results presented below may assist in understanding what supported landholders to deliver the contracts and what is required to support landholders to continue with conservation in the future. Firstly a summary of participants' demographic information is provided, followed by information about how bid prices compared with the actual costs of management and how participants dealt with differences. Following on from this, information is presented about motivating factors that may sustain and support landholders in their conservation work. Finally, information about requirements and costs for future management is provided.

Participant demographic characteristics

The median age at the end of the 10-year program period was 60 (Table 1). There were large ranges in property size and length of property ownership (Table 1). Primary decision makers for native vegetation management were male (9), family groups (6), female (5), and a business (1). Participation in environmental, community and professional groups was high (95%).

Table 1. Demographic characteristics of participants

	Median	Min	Max
Property size (ha)	43	7	>1500
Per cent of property with native veg cover	75	17	100
Per cent of household income derived from property	0	0	100
Year property acquired by landholder's family	1992	2012*	Pre-1970
Age of landholder	60	37	82

*Landholder purchased property during contract period and took over contract from the previous owner

Bidders used their own time to increase competitiveness and to compensate for incomplete information

The majority of participants reported that the actual cost of materials was less than or close to the cost for materials that was included in their bid price (Table 2). The cost of hired labour was less accurately matched with the bid price, with few participants reporting that the actual cost of hired labour was close to the cost included in the bid, and both negative and positive differences in costs reported. All participants used their own labour to implement management actions and most reported that the amount of their own time used was more than the amount included in their bid price.

Table 2 Actual cost of management compared to cost included in the bid price (*n*=17)

	Less than bid	Close to bid	More than bid	Not in bid & didn't use	Did not answer
Materials	3	7	4	2	1
Hired labour	4	2	5	4	2
Own labour	1	4	12[a]	0	0

[a] Own time spent was reported to be 10-400% more than included in bid

There were two key reasons for the difference between actual costs and bid price reported by participants. Firstly, participants reported having incomplete information about the costs at the time of bidding, illustrated by the following quotation.

> *"I'd estimated in there, the time, as in wages, to do certain jobs, but didn't allow for the fact that it was such rugged terrain and a lot of time was packing up and getting to the job, not so much on the job."* (Participant 14)

Secondly, many participants reported that, in order to increase their bid's competitiveness, they did not include the full cost of management in their bid. Participants commonly used their own labour to compensate for costs not included in the bid price.

> *"I also think I probably would have missed out on BushBids if I'd costed in my time."* (Participant 13)
>
> *"Because we were already … personally committed to wanting to continue to do that sort of work but some assistance would be fantastic."* (Participant 7)
>
> *"We kind of thought, well, if we make the bid too high then we won't get it. So, we kind of compromised a bit and thought well we're going to be doing work anyway … so we're willing to volunteer our time on our own property anyway."* (Participant 5)

Perceived effectiveness was dependent on action type and was best for weed control

Grazing pressure from livestock was universally agreed to be about the same or lower during the contract period than immediately prior to the contract period (Table 3). Where livestock grazing pressure was perceived as similar, this was because these sites had already been destocked or were under a conservation grazing regime prior to contract establishment. Grazing pressure from rabbits during the contract period was sometimes seen as lower than the time before contracts, but was often reported as similar (Table 3). The landholder's control efforts, biological control agents and the management actions of others in the landscape were factors considered to influence rabbit grazing pressure. Many participants reported an increase in grazing pressure from kangaroos during the contract period (Table 3), and 11 of the 21 participants were concerned about the current level of kangaroo grazing pressure. Climatic or weather conditions and land management in the surrounding landscape were key factors thought to be influencing grazing pressure from kangaroos. Participants reported a reduction in the cover of most weed species at the end of the contract period (Table 4), and largely attributed these changes to their management actions.

Table 3 Perceived grazing pressure during contract period compared to before contract (*n*=21, respondents without contracts shown in parentheses)

Source	Higher	About the same	Lower	Unsure	Total
Livestock	0	13 (3)	3 (1)	1	17 (4)
Rabbits	2	7 (2)	5 (1)	3 (1)	17 (4)
Kangaroos	8 (3)	7 (1)	0	2	17 (4)

Table 4 Perceived weed cover at the end of contract period compared to start of the contract period (*n*=21, respondents without contracts shown in parentheses)

Weed species	More	About the same	Less	Unsure	Total
African Daisy *Senecio pterophorus*	0	2	2 (1)	0	4 (1)
Blackberry *Rubus* species	0	1	3	0	4
Boxthorn *Lycium ferocissimum*	0	1	4	0	5
Bridal Creeper *Asparagus asparagoides*	1 (1)	1	6	0	8 (1)
Cottonbush *Gomphocarpus cancellatus*	0	1	6	0	7
Gorse *Ulex europaeus*	(1)	0	3 (1)	0	3 (2)
Horehound *Marrubium vulgare*	0	1	6	(1)	7 (1)
Monadenia *Disa bracteata*	1 (1)	0	4	1(1)	6 (2)
Olive *Olea europaea*	0	2	6 (1)	0	8 (1)
Perennial Veldt Grass *Ehrharta calycina*	0	1	2	2	5
Pussy-tail Grass *Pentameris pallida*	0	1	1	2	4

Participants' motivations were sustained by enjoyment of the environment, achievement of their aims, interest and support provided by the program and a sense of accountability under the contracts.

Some participants described their native vegetation with pride and enthusiasm and exhibited a sense of satisfaction in their achievements.

> *"It's all looking good. You should come up and see it actually, this time of the year… the hills are like alpine hillsides."* (Participant 3)
>
> *"Whenever we saw something, I could say, wow, that's such and such a reptile…"* (Participant 15)
>
> *"There's less, you know, gorse everywhere and you're getting rid of the olive trees and things as well, so it sort of makes it feel more, you know, friendly. …You just feel you can go places that you … didn't have access to before…. It's quite rewarding, I*

think, to see the weeds and things going. That feeling of satisfaction." (Participant 17)

Engagement in the program offered a sense of public or community support and interest for participants' conservation efforts. Additionally, the management plan's priorities and targets played a role in motivating some participants. Likewise having contractual obligations was reported as a positive motivation.

"I think knowing somebody's interested is very important… probably I spent more hours in there than I might have, or let's say more hours working rather than sitting and enjoying than I would have if I hadn't had BushBids." (Participant 6)

"There'd been a dramatic increase in the weediness of certain parts of the property… the BushBids support has really encouraged me to get in and try and turn that around." (Participant 7)

"We would have been keen to have been actively managing our property, but being presented with a management plan, just sort of got us on the track. It's a real positive starting point." (Participant 3)

"I said I'd do this work anyway. But you know, I don't know whether that's entirely true. I might not have been quite as diligent about it, I don't think. I think it made me more diligent about reaching targets…. Yeah, you do feel like there's someone kind of looking at what you're doing a little bit, and I see that in a positive way, I don't see it as a negative at all." (Participant 13)

"…feeling, the obligation, the obligation to spend more time on biodiversity threatening processes." (Participant 8.1)

"having...the management plan and knowing that we've got a contract there, it gives us some focus." (Participant 12)

Weeding was habitual for some participants

Several participants reported that weed control was habitual as illustrated by the following quotations.

"…you do it all the time, you know, whenever you see something…" (Participant 17)

"So I guess it's sort of given me a more regular approach to weed control. Yeah, just that consistency and in going in at the same time each year… you don't forget about that." (Participant 15)

"Probably at least every second day I'm over there taking the dog for a wander and you end up pulling the weeds." (Participant 13)

Some participants wanted more opportunities for conservation related social connection

Some participants asked for opportunities to meet other participants, and for signs to identify participation in the program.

"to keep our enthusiasm going and probably those of others it would be good to … get [program participants]*…together to discuss things."* (Participant 8.1)

"I would quite happily, at the bottom of our driveway, put a sign up saying we have received ten years of funding from BushBids…. I put it on my list, but it's on a bit of a backburner, to paint up a sign." (Participant 3)

Participants wanted to continue work post contract but costs remained a barrier for many

All participants indicated that ongoing management was required over the next 10-year period to continue to protect and restore biodiversity. All landholders said they would continue with weed control, and most indicated they would manage livestock and control rabbits (Table 5). Approximately half indicated they would undertake some management or control of kangaroos.

Table 5 Management actions participants indicated they would adopt in the future (*n*=19, respondents without contracts shown in parentheses)

Management action	Number of participants
Livestock management	15 (3)
Rabbit control	13 (3)
Kangaroo control or management	8 (2)
Control other grazing animals (Deer and/or Hares)	3
Weed control	15 (4)

In a small number of cases (3 contracted participants), cost was no longer a barrier to implementing these conservation actions. More commonly, participants expressed their intention to implement some conservation management actions regardless of future funding, but indicated that future payments would enable additional or increased management.

> *"I would cost in one day a fortnight to…include my labour time. What that would actually do is speed up the process, because I would say, 'No, I'm not working in my business, I'm working on my land and I'm actually getting a bit of payment for it.' …So that would increase the work that I would be able to do."* (Participant 13)
>
> *"Without* [future incentive payments] *we would still continue on with the rabbit control, monitoring kangaroo numbers and control them if needed, and definitely running reduced sheep numbers. But we'll probably need to increase sheep numbers above the levels that we were running with the BushBids program."* (Participant 14)
>
> *"I'm really keen to keep on top of the weed management … if we had money coming from outside then I could afford to employ someone else when I'm no longer able to do it myself … I mean it's a lot of walking up and down the hills with a spray pack on your back …having had this major illness I realised I'm not going to be able to do it forever."* (Participant 8.2)

Conclusions

The main conclusions of this study are as follows:

- Participants dealt with cost uncertainty and competition by contributing their own time.
- Most management actions were seen as effective, however some difficulties were noted for managing grazing pressure (e.g. from kangaroos) and managing some weed species when these are strongly influenced by conditions in the surrounding landscape and/or where effective management techniques are difficult to access or unavailable.
- Factors that may support the continuation of participants' conservation efforts were present including habit formation and the sense of satisfaction, enjoyment or accountability.
- Participants agreed that ongoing management was needed to maintain and extend conservation gains made over the 10-year period.

- All participants indicated they would like to continue management in the future. However, most indicated that without additional funding support they would not be able to do as much as they would like.