The effectiveness of conservation covenants in enhancing the breeding activity of wedge-tailed eagle (*Aquila audax fleayi*) and white-bellied sea-eagle (*Haliaeetus leucogaster*) on private land in Tasmania.

Photo Credit: Graham Stephinson

Photo Credit: Dave Watts

Erin Harris

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School of Technology, Environments and Design

University of Tasmania

Declaration

I hereby declare that this thesis contains no material which has previously been accepted for the award of any other degree or diploma and contains no copy or paraphrase of material previously published or written by any other person, except where due reference is made in the text of this thesis.

Erin Harris - 170034
1st of July 2019

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Abstract

Over the last two decades conservation covenants have become the primary mechanism for securing important biodiversity values outcomes on private land in Tasmania, including the protection of threatened eagle nests. Private land constitutes almost 40% of Tasmania including about 42% of known wedge-tailed eagle nests potentially occur in areas subject to human disturbances. Eagle ecology in Tasmania and the role of conservation covenants on nests is a complex issue with both environmental and social components both playing an influencing role. With a view to understanding the effectiveness of conservation covenants in providing adequate protection of eagle breeding sites I documented the activity status of eagle nests during the 2018-2019 breeding season across three management regimes: Private land protected by Covenants; Permanent Timber Production Zones and unprotected private freehold land and compared these differing management prescriptions to eagle nest protection. I also conducted surveys and interviews with private landholders of covenanted and non-covenanted properties to understand why landholders engage in conservation covenanting programs, their attitudes towards these programs and how covenants change their land management practices. The eagle nest surveys showed that there was no difference between nest activity across the three management regimes. Nests were less likely to be active in locations with a higher percentage of forest cover within 5000 m and when located at least 500 m from a road which covenant properties were more likely to be subject to. Survey results showed that respondents were motivated to covenant their land to protect biodiversity and for financial incentives and that covenants are reducing certain activities on these properties, such as grazing, firewood harvesting and hunting. Such information is likely to provide critical context for assessing and evaluating the value of conservation covenants as a protective mechanism for eagle nests on private land.

Acronyms

AEC	Animal Ethics Committee
BHP	midlands Biodiversity Hotspot Program
DPIPWE	Department of Primary Industries, Parks, Water and Environment
EMCP	Eagle Management Constraint Period
ENPP	Eagle Nest Protection Program
EPBC	Environment Protection and Biodiversity Conservation Act 1999
FCF	Forest Conservation Fund
FPA	Forest Practices Authority
FPS	Forest Practice System
LIST	Land Information System Tasmania
MBHT	Midlands Biodiversity Hotspot Tender
NFVP	Non-Forest Vegetation Program
NMA	Nest Management Areas
NRS	National Reserve System
NVA	Natural Values Atlas
PAPL	Protected Areas on Private Land program
PFRP	Private Forest Reserves Program
PLCP	Private Land Conservation Program
PTPZ	Permanent Timber Production Zones
PTR	Private Timber Reserves
RFA	Regional Forest Agreement
STT	Sustainable Timber Tasmania
TLC	Tasmanian Land Conservancy

Contents

1 Chapter 1 – Introduction

This research project engages with the ecological and social complexities of eagle conservation on private land in Tasmania. It does so by investigating the effectiveness of conservation covenants as a protective mechanism for eagle breeding sites on private land and assessing landholder participation in covenanting programs to protect eagles. The research comprises three main components:

(1) identifying and comparing key management prescriptions between nests on covenanted land and nests managed under prescriptions on Permanent Timber Production Zones (PTPZ) designated for timber harvest;
(2) undertaking eagle nest surveys to determine nest activity; and
(3) conducting landholder surveys and interviews to identify key motivations for the uptake of covenanting programs and how efforts towards eagle conservation affects land management practices.

This introductory chapter outlines the direction of the research thesis by briefly introducing the history and concept of conservation covenanting on private land in Tasmania and exploring why landholder participation in covenanting programs is both crucial and complicated. Furthermore, this chapter highlights the significant threats to Tasmanian eagles, emphasising the importance of eagle nest protection and how conservation covenants became a key mechanism for protecting eagles on private land.

1.1 Private land conservation and covenants

Protecting natural values on private land has become a well appraised mechanism used by conservationists in Australia as a way to reduce the impacts that anthropogenic threats have on the environment (Fitzsimons & Wescott, 2001; Figgis et al., 2005; Fitzsimons, 2015). Conservation efforts on private land need to be understood in the context of the public land conservation estate. Within Australia, Tasmania is a leader in conservation reservation with the Tasmanian Reserve Estate covering 50.3% of the state (Tasmanian Government, 2018a). In 1946 the first private sanctuary in Tasmania was declared at Chauncy Vale, protecting almost 400 ha of native bushland managed for conservation (Tasmanian Heritage Council, 2018). By 1997 the Private Forest Reserve Program (PFRP) was established between the Federal and State government as part of the Regional Forest Agreement (RFA) to provide a framework for the management of Tasmanian forests on private land. This agreement allowed for the reservation process of lands to be extended from public lands to private lands to meet conservation targets. From this, the first National Protected Areas on Private Land Program (PAPL) was established in 1999 and initiated in Tasmania (Iftekhar et al., 2014). PAPL built the foundation and momentum of using conservation covenants on the title of properties as a mechanism to protect private land. In 2006 the Private Land Conservation Program (PLCP) was established in Tasmania to provide a single point of management for private land conservation covenanting programs and work with private landholders to conserve and sustainably manage natural values on their land.

The social and ecological intricacies that surround private land conservation are complex and vary significantly amongst individuals and environmental concerns (Ernst & Wallace, 2008; Moon & Cocklin, 2011; Selinske et al., 2015). The specific nature of landownership, along with its associated social and economic attributes can complicate the integration of private land into conservation management (Kamal et al., 2015). Private landholder participation in covenanting programs and keeping landholders engaged in conservation issues is widely understood to be central to the achievement of environmental goals (Kabii & Horwitz, 2006; Farmer et al., 2011; Sorice et al., 2014).

Understanding the experiences of landholders that participate in conservation covenanting programs provides critical feedback on how well conservation programs are designed and delivered in a way that works for both landholders and conservation initiatives (Comerford, 2014). Equally important is ensuring sufficient participation by private landholders in covenanting programs. Covenants that are entered into perpetuity require a long-term commitment on the part of the landholder. Diverse landholder values, experiences and motivations underpin their decision-making process, making it difficult to develop a program that works for everyone. Understanding landholder engagement with conservation programs requires the development of theoretical frameworks (Baumgart-Getz et al., 2012) to explain the uptake of actions through a variety of sociological, psychological and economic models.

1.2 Eagle nest covenants

With landholder involvement, conservation covenants have become a key instrument used to protect areas of environmental and cultural significance on private land. Covenants, as a legislatively binding mechanism, are frequently used to protect threatened species and their habits. In Tasmania, covenants have been used to protect the nesting sites of the iconic Tasmanian wedge-tailed eagle (*Aquila audax fleayi*) and white-bellied sea-eagle (*Haliaeetus leucogaster*). Both eagle species in Tasmania are under threat from a number of factors including loss of old growth habitat and disturbance around nest sites during the breeding season. Eagles also suffer from illegal shooting and poisoning, electrocution from power lines and fences, collisions with wind turbines and vehicles and human disturbances, such as forestry activity and land development (Mooney 1997; Mooney 2005; Threatened Species Section 2006; Bekessy et al. 2009). Furthermore, wedge-tailed eagles are notoriously shy nesters and are likely to desert a nest in the face of even moderate levels of human disturbances. These threats, coupled with the wedge-tailed eagles' shy behaviour, underscore the importance of conservation on private land in safeguarding eagle nesting sites.

As a conservation measure to protect eagles from ongoing decline (Threatened Species Section, 2006), a process for protecting eagle nests has been embedded into permit conditions and licence requirements during the approval process for new development projects in Tasmania that potentially impact eagles or the nesting habitat. For example, as part of the licence conditions for new wind energy generation projects, eagle nests must be protected as a standard offset requirement to counterbalance the predicted mortality of eagles arising from collision with turbines or electrocutions (Keserue-Ponte et al., 2010). In 2008, the Eagle Nest Protection Program (ENPP) was established as a partnership between the Tasmanian Land Conservancy (TLC), wind energy supplier Roaring 40s and the PLCP. This program was intended to offset wind turbine strikes as part of the wind farms permit requirements, by protecting eagle nests on private land through the application of conservation covenants. These covenants aim to reduce disturbance from private land management activities, and were applauded as a crucial eagle conservation management strategy in the Threatened Tasmanian Eagle Recovery Plan 2006-2010 (Threatened Species Section, 2006) due to the demonstrated benefits of a nest reserve at protecting eagles on forestry land (Mooney & Taylor, 1996). The TLC is contracted to deliver this offset by identifying new nests on private land and negotiating legally binding covenant agreements with private landholders to protect the eagle nests and its surrounding habitat. Under certain prescriptions, the covenants restrict specific activities on the land, with the sole purpose of the land being used for eagle and nature conservation.

1.3 Assessing covenant effectiveness and landholder motivations

In Tasmania, little is known about the effectiveness of covenants on private land in relation to eagle nest protection. This research project investigated the effectiveness of covenants, adequacy of eagle nest prescriptions and whether any additional improvement on nest protection is needed. The social science component of the project will focus on key motivations and attitudes of landholders with respect to covenanting programs, particularly in relation to eagle nest protection. Additionally, information will be sought from landholders who have eagle nests on their property to better understand how their land management practices have changed to protect eagle breeding sites.

This project is a mixed methods research project with both environmental and social science components. The overall aim is to investigate the effectiveness of conservation covenants in conserving breeding at eagle nests in Tasmania on private land. This project will focus on three different management regimes on either private or public land:

- private land that is protected by covenants (covenanted);
- public and private land in PTPZ managed under prescriptions (PTPZ Prescriptions); and
- private land that is not protected by covenants or prescription mechanisms (non-protected – control group);

They key research questions this project seeks to answer are;

1) what prescriptions exist for protecting eagle nests across the three management regimes and how do they compare in terms of their effectiveness in addressing threats to eagles?
2) is there any difference in eagle breeding activity on covenanted properties compared to non-covenanted properties or compared to properties management by PTPZ prescription?
3) What are private landholder's motivations for covenanting eagle nests on their property?
4) Have covenants changed how landholders manage their land?

1.4 Conclusion

Having briefly introduced the key elements of this research project, including the research questions, Chapter Two examines the current literature relating to conservation covenants, placing these in the wider context of the growth of private land conservation within Australia. Chapter Three provides details about and justification for the mixed-method research methodology used to investigate nest covenant effectiveness and landowner motivations. Chapter Four presents the results stemming from the environmental and social science components of the project. In Chapter Five, I describe the significance of the ecological and social findings in light of the current literature and discuss the interconnections between landholders and conservation covenants as an effective tool for protecting eagles on private land, concluding with protect limitations and future recommendations.

2 Chapter 2 – Private land conservation: The capacity of conservation covenants and landholders to protect eagle nesting sites.

In this chapter I discuss the complexities surrounding conservation on private land and the important role that private land and private landowners play in protecting eagle breeding sites. This literature review is separated into three parts. Part one outlines the changes that have been made over the last two decades to include private land in conservation initiatives and how organisations within Australia, and particularly Tasmania, have been at the forefront of natural environment protection on private land. Part one also details the use and effectiveness of conservation covenants as a mechanism for securing natural values and how they are designed to achieve effective outcomes on a landscape scale. Part two focuses on eagle nest protection in Tasmania and the threats that eagles face, emphasising

the ecological importance that eagles play in the Tasmanian environment and why protection of their breeding site is critical in maintaining function and balance within ecosystems. Part two identifies how forestry activities impact eagles and the mitigation strategies and prescriptions that are put in place on PTPZ to ensure their protection. Part three frames the ecological aspects of this project in the context of the social components that this research aims to address in relation to private landholders and their role in eagle nest protection. This section of the chapter particularly focuses on the past and present relationships between landholders and eagles and recognises both the importance of education and the difficulties in identifying key motivations of individuals regarding their uptake of covenanting programs.

2.1 Part 1 – Private land conservation

Protecting biodiversity from proliferating anthropogenic threats, such as habitat loss, direct disturbance, climate change, pollution and the introduction of invasive species (Sisk et al., 1994; Raven & Yeates, 2007; Mackey et al., 2008) has become a major challenge for environmental managers, policy makers and governments worldwide. It has been recognised that the twentieth century conservation tool of securing land in legislated public national parks alone is inadequate in protecting biodiversity (Figgis et al., 2005; Watson et al., 2011; Kamal et al., 2015). It has been acknowledged that a workable mechanism and a more holistic approach for long-term protection of biodiversity must continue to complement public reserves by including private land for conservation (Norton, 2000; Phillips, 2003; Figgis et al., 2005).

2.1.1 Global efforts

Antecedents of the global protected area movement were present in settler-society cultures of Australia, North America, New Zealand and South Africa during the 20th century. Protected areas were originally established in landscapes of high visual value and low primary conservational value with resources being allocated towards recreation and tourism, rather than conservation (Pressey, 1994; Mendel & Kirkpatrick, 1999; Anderson & Jenkins, 2006). By the 21st century the extent to which global public protected areas conserve threatened species and ecosystems is not being better determined (Watson et al., 2011; Willis et al., 2012).

Conservation on private land has recently become a necessary key augmentation of the traditional public reserve system, where innovative governance models integrate the institution of private land with desired conservation management outcomes. Arguments for the necessity of private land conservation are underpinned by motivations to increase the overall area for conservation, create connectivity across the landscape, reduce the decline of biodiversity and give especial impetus where specific conservation values and species are systematically underrepresented in the public reserve estates (Fitzsimons & Carr, 2014; Hardy et al., 2017). For example, in Tasmania it is well know that landscapes attractive to Europeans for agricultural activities - notably ‘the Midlands’ - contain species and habitat that are not well conserved within the public estate system (Mendel & Kirkpatrick, 2002; Lefroy, 2011; Cowell et al., 2013). Another key driver has been the realization that threatened species and even ecosystems both move across and occur on private land and as a result, countries that adhere by the public and private land system, such as Australia, New Zealand, the USA, Canada, South Africa and Chile have adopted the approach of private land conservation (Norton, 2000; Figgis et al., 2005; Ewing, 2008; Logan & Wekerle, 2008; Fishburn et al., 2009; Von Hase et al., 2010; Bond et al., 2013; Tecklin & Sepúlveda, 2014).

In the countries where there is a private land system, certain conditions and requirements are fundamental in achieving effective private land conservation. According to Saterson et al. (2004) these include;

(1) having **strong policies** that define specific conservation targets and methods for measuring outcomes;
(2) **prioritizing funding** – for example, putting money towards evaluating the success of conservation efforts is just as important as putting money towards conservation efforts;
(3) **knowing your ecological challenges**, as it is often difficult to separate change caused by a conservation initiative from change that would have naturally occurred; and
(4) **long term and on-going monitoring** that encompasses the dynamic economic, social and biological components of the conservation program.

2.1.2 Private land conservation in Australia

The Australian National Reserve System (NRS) is a nationwide network of Indigenous, public and private protected areas. Whilst a majority of the NRS is made up of public protected areas there has been a significant increase in both Indigenous and private protected areas over the last decade (see Figure 1).

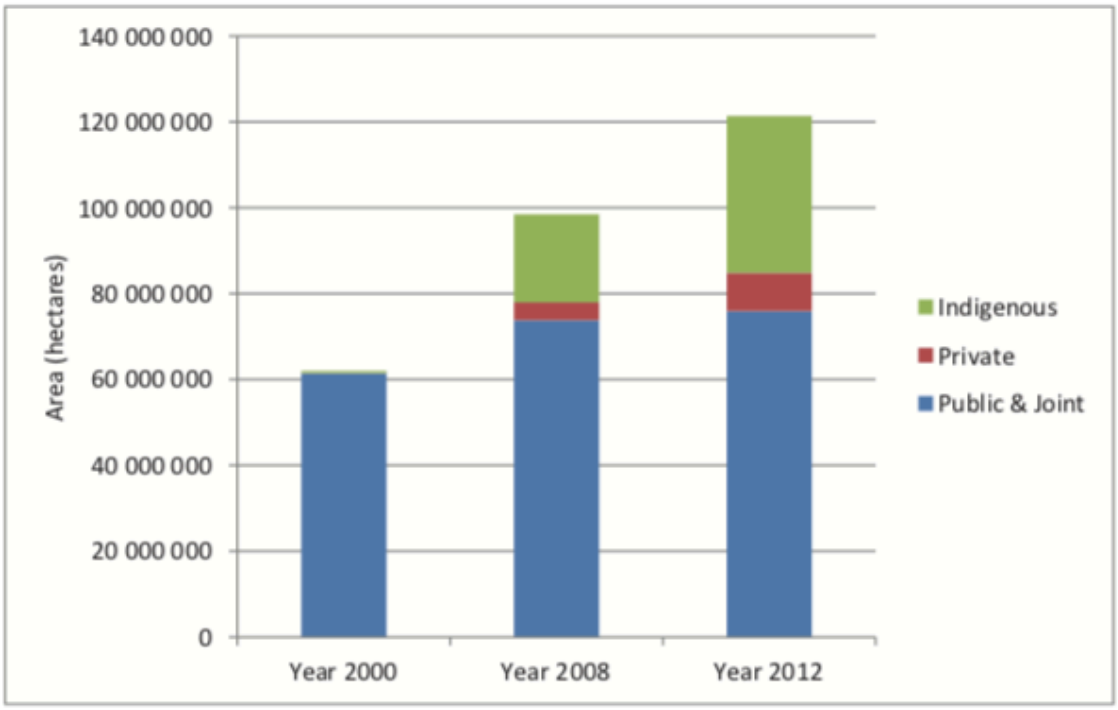

Figure 1. The increase of protected areas between 2000-2012 within the National Reserve System (Fitzsimons, 2015).

The importance of Indigenous and private protected areas in capturing areas of significance are paramount in protecting all spheres of biodiversity from anthropogenic threats. In Australia, private land covers over 62% of the landmass (Australian Survey and Land Information Group, 1993)[1] and contains a significant amount of threatened ecosystems and species (Taylor et al., 2011; Watson et al., 2011). A recent independent report by Metcalfe and Bui (2016) to the Australian Government Minister for the Environment and Energy advised that habitat loss from land clearing in Australia is

[1] AUSLIG has now merged into Geo Science Australia and the percentage of private land in Australia has not been updated since 1993.

one of the single largest threats to biodiversity and threatened species with the vast majority of land clearing occurring on private land.

Throughout Australia, private landholders are being encouraged and urged to protect particular species and habitats on their properties though a wide range of programs. These programs include voluntary non-binding agreements such '*Land for Wildlife'*, '*Landcare'* and the '*Conservation Management Network'* to high security legally-binding agreements such as easements and conservation covenants (Figgis et al., 2005). The types of conservation programs found across Australia are tailored to individual properties, depending on their goals, outcomes, jurisdiction and legislation under which they are established (Adams & Moon, 2013) and come with guidance and help from program managers on how to manage and protect the land appropriately for environmental outcomes. Most of these programs provide financial incentives to landholders, however it is not guaranteed that landholders will participate in these conservation schemes. The environmental benefits of private land conservation essentially rest on the back of landholder participation, a challenge that all conservation program managers must acknowledge and attempt to overcome.

2.1.3 Conservation covenants

Conservation covenants were devised in the 1950s in the U.S.A and have become the main tool for private land protection for countries across Latin America, Africa, the European Union, the United Kingdom, Canada and Australia (Fishburn et al., 2009; Gallo et al., 2009; Brown et al., 2011; Pocewicz et al., 2011; Reid, 2011). They are binding agreements between private landholders and an authorised body that legally enforces limitations, restrictions and conditions on the property in order to protect identified and desired natural values on the land. Covenant agreements are generally voluntarily and entered into in perpetuity and are registered on the land title, so they are carried over to the next landholder at the point of sale. In some cases, it is possible for a landholder to register for a fixed-term covenant (i.e. not in perpetuity). Some covenants, however, are mandatory and applied as an offset mechanism or as a result of a compensation clause as part of an illegal development. Covenant program managers can be government agencies, local councils or not-for-profit organisations.

Through these partnerships between landholders and covenant program managers, the natural values of the land are protected, whilst in many cases the landholder still continues to own, use and live on the property. The benefits of joining a covenanting program can range from financial benefits such as upfront payouts or as an offset compensation mechanism, exemption from land tax and rate rebates (depending on council areas), to environmental benefits such as erosion, water and salinity protection, to social benefits such as the ability for landowners to see positive environmental outcomes and a sense of pride, knowing they made an important contribution to conservation and future generations (Fitzsimons & Wescott, 2001; Fitzsimons & Carr, 2014). Depending on the property type however, these benefits may not be perceived the same by all landholders. Landholders that use their land for production and income purposes are likely to be more disinclined to see the benefits of a covenant than those who buy their land for non-production related reasons such as 'lifestyle' or 'conservation' purposes (Comerford, 2014).

2.1.4 Challenges for conservation covenanting programs in Australia

The number of conservation covenants in Australia has grown significantly, especially in the past decade (Figure 2) and are considered a primary long-term mechanism for securing natural assets on private land (Figgis, 2004; Cowell & Williams, 2006; Fitzsimons & Carr, 2014). However, the

effectiveness of conservation covenants to protect threatened species is still relatively unknown over the long-term (Merenlender et al., 2004; Morris & Rissman, 2009; Pocewicz et al., 2011; Fitzsimons & Carr, 2014), with the main areas of research focusing on the economic performance of covenants and their ecological contributions (Iftekhar et al., 2014).

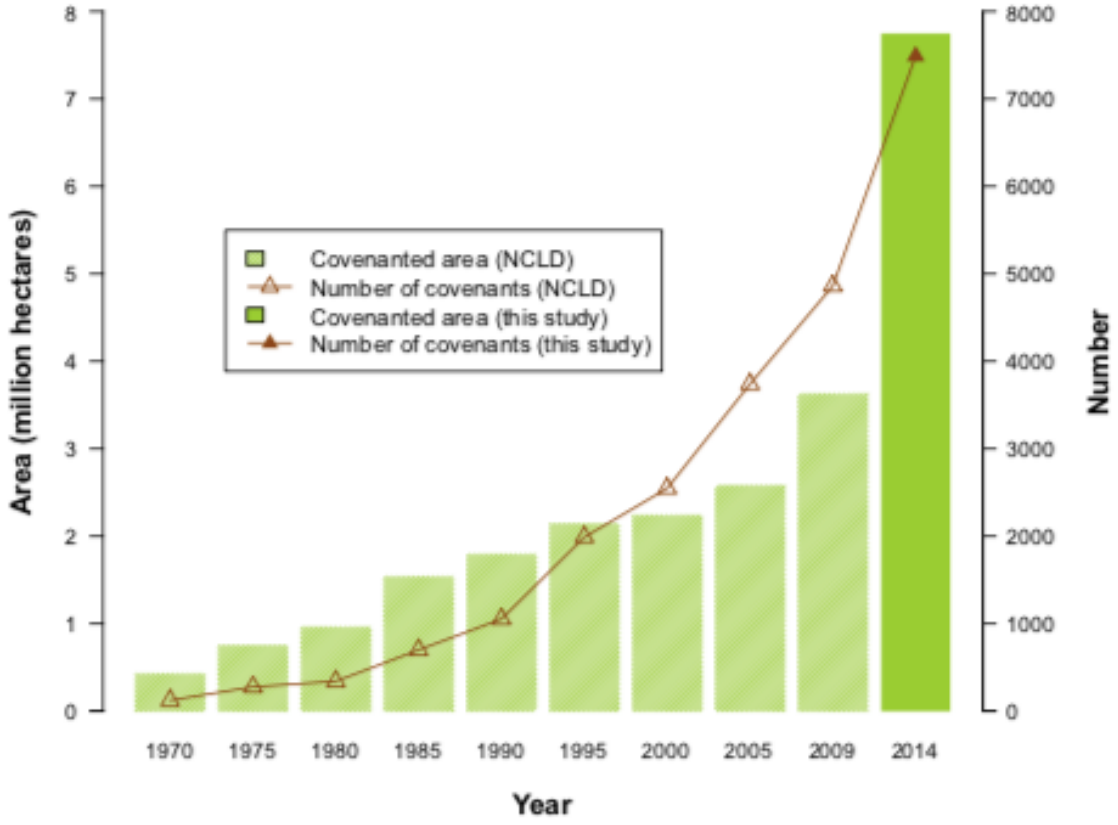

Figure 2. A cumulative trend in the number and area of covenanted properties in Australia, (Hardy et al., 2017)

Certainly, the growing use of diverse kinds of conservation covenants and easements has led to calls for increased scrutiny of exactly what they aim to protect and how they work in practice (Merenlender et al., 2004; Kiesecker et al., 2007; Rissman et al., 2007; Rissman & Merenlender, 2008). For example, if the aim of a covenant is to protect a particular species, how that species lives and moves within its environment needs to be taken into consideration. Many animals have large territories and move over an array of temporal and spatial scales. For example, the territories of the wedge-tailed eagle are somewhat elastic and movement outside territories depend on food availability, nesting conditions and between neighbouring eagles' rivalries (Olsen, 2005; Debus, 2017). Some adult eagles are also 'floaters', not attached to a territory at all (Mooney, 2005). Thus covenant boundaries may be limited in the life history function they can protect. Animals move in and out of covenants, so consequently, without capturing an animal's entire habitat range within a covenant that species may not necessarily be protected in perpetuity.

When looking at the effectiveness of covenants it is clear that in Australia there are weaknesses in the current legislation that need to be addressed when evaluating covenant effectiveness. These

weaknesses include; the ability to amend the agreement without public submissions, the power to revoke the covenant, the ability of a third party to knowingly breach the terms of a conservation covenant without it being an offence (EDO Tasmania, 2017), the government ownership of mineral exploration and extraction rights regardless of a covenant, the lack of monitoring to ensure landholder compliance (Hardy et al., 2017), and the low level of mandatory environmental outcome measurements to ensure conservation targets are met (Kiesecker et al., 2007; Lindenmayer et al., 2012a, 2012b; Fitzsimons & Carr, 2014). The last two points come down to an overall lack of resources for covenanting agencies to undertake monitoring (Fitzsimons & Carr, 2014).

2.1.5 Conservation covenants in Tasmania

As of April 2019, there were 890 conservation covenants in Tasmania, covering 110,765 ha of land (J. Smith 2019, Pers. Comm., 2nd May). Although this equates to only 1.6% of the state, these covenanted areas were purposely defined by specific areas of conservational value, such as threatened vegetation communities, threatened species or critical habitat and therefore their contribution to biodiversity is many folds greater than the area in hectares they contribute. Management prescriptions, which are legally binding under the *Nature Conservation Act, 2002* accompany these covenants which reduce or prevent certain activities from occurring within the covenant boundary. Covenants also facilitate and encourage positive conservation land management activities which in return provides further education on environmental issues amongst landholders.

Over the years, there have been a handful of covenanting programs in Tasmania that have added to the overall percentage of protected private land, such as: the Private Forest Reserves Program (PFRP); the Forest Conservation Fund (FCF); the Midlands Biodiversity Hotspot Program (BHP); Midlands Biodiversity Hotspot Tender (MBHT); the Non-Forest Vegetation Program (NFVP); Threatened Woodland Birds Program and the Revolving Fund Program; and the Eagle Nest Protection Program (ENPP) (Iftekhar et al., 2014). Although many of these programs are now closed, their covenants remain as a legacy (Table 1).

Table 1. List of conservation covenanting programs that have operated in Tasmania since 1997. *Many of these programs were co-founded and take credit for the same amount of land protected and therefore overlap in hectares may occur* (Lefroy, 2011; Iftekhar et al., 2013, 2014; Tasmanian Government, 2015a, 2015b)

Covenanting program	***Operation duration (years)***	***Program type***	***Priority conservation targets***
Protected areas on Private Land program	1999 – 2019	Covenanting program	Vegetation communities, freshwater values and threatened species.
Private Forest Reserve Program	1997 – 2006	Financial Incentive payments and covenanting program	Threatened forest communities and forest-dependent threated species.
Forest Conservation Fund	2008-2009	Commonwealth-funded program through management agreements and conservation covenants	Old-growth and under-reserved forest communities
Midlands Biodiversity Hotspot Project	2004-2007	Covenants and management agreements through incentives.	Improved management of priority natural habitat in Tasmania's midland region.
Midlands Biodiversity Hotspot Tender	2007	Conservation covenants and sealed-bid, discriminative price auction.	Native grassland, wetlands, threatened species
Non-Forest Vegetation Project	2004-2009	Financial incentives, covenanting program and Vegetation Management Agreements	Threatened species and under-reserved non-forest vegetation, particularly native grassland
Threatened Woodland Bird Program	2011-2014	Financial incentives to private landholders to covenant habitat for national threatened woodland birds	Priority for Swift Parrot and Forty-spotted Pardalote breeding habitat
Eagle Nest Protection Program	2008	Conservation Covenants	Wedge-tailed and white-bellied sea-eagle nests and surrounding habitat

The only program still in action is PAPL. This program is currently not seeking applications for new covenants on private land but focussing their efforts on supporting existing covenant owners. This means that Tasmania currently is not accepting applications for new covenants from private landholders unless under existing regulatory schemes. Two examples of this in Tasmania are:
(1) where the Forest Practices Authority (FPA) rejects a private landholders request to conduct forestry activities on their property on the basis that their land has significant natural or cultural values; and
(2) Commonwealth and State Government licence requirements as park of the Wind Energy ENPP offset program, whereby landholders that have an eagle nest on their property are approached to negotiate a covenant to protect that nest as part of the licence conditions to offset eagle strikes on their windfarms.
Whilst entering into a conservation covenant is voluntary, the likelihood of success is increased where it is initiated by a third party (Ernst & Wallace, 2008; Moon & Cocklin, 2011)

2.2 Part 2 – Eagle conservation in Tasmania

Tasmania has two species of eagle, the Tasmanian wedge-tailed eagle and the white-bellied sea-eagle. It is estimated that the population of wedge-tailed eagles in Tasmania is around 430 breeding pairs, while the sea-eagle population is around 200 breeding pairs (Debus, 2017). The wedge-tailed eagle is listed State and Federally as endangered both at a national level under the *Commonwealth Environment and Biodiversity Conservation Act 1999* and Tasmania's *Threatened Species Protection Act* 1995. The white-bellied sea-eagle is not nationally endangered but is listed as endangered in South Australia and as vulnerable in Tasmania, New South Wales and Victoria (Debus, 2017).

2.2.1 Importance of eagles

Eagles are important for many reasons. Environmentally, eagles play an important regulatory role in the ecosystem as apex predators. They stabilise prey populations which reduces the prey's risk of becoming overpopulated and consequently dying from disease or starvation therefore promoting ecosystem equilibrium and resilience. As apex predators eagles are bio-indicators of environmental health further down the food chain and can provide early warnings for the accumulation of agricultural chemicals and other pollutants in the environment. They also reduce populations of introduced species that may outcompete or displace natives species and thus by default affording native species a better chance at survival (Tasmanian Government, 2018b).

Economically, there can be a cost associated with protecting eagles. Incentives are provided to landholders as part of conservation programs to protect eagle nesting sites through covenants and whilst the landholders receive an initial payout, either by the Commonwealth through the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) Act or through developers as part of their license conditions, property revenue may decrease in the long-run for those who rely on the land for income purposes, whilst others may see it as a positive investment. Eagles also provide some degree of crop protection to farmers by moderating the damage European rabbit's and other native species cause to many farmlands. Furthermore, protection of threatened species is a legal requirement of forest certification and compliance, through this protection industries get brand certification which provides secure markets and generates money in the long term.

Socially, eagles have always inspired people and contribute to people's sense of place. They are a prime target for nature lovers photographers and bird watchers. They also have cultural significance, and feature in many of the Aboriginal Australian's rock paintings dating back 5000 years (Olsen, 2005) and dream time stories, such as Bunjil the eagle, a spiritual leader and creator of the Kulin people of central Victoria (Blows, 1995).

2.2.2 Wedge-tailed eagle conservation efforts

In the last two decades conservation efforts have focused on how to regulate and mitigate the impacts that land management activities on private land may have on nesting eagles. Private land constitutes almost 40% of Tasmania including about 42% of known wedge-tailed eagle nests (Threatened Species Section, 2006), thus a proportionally large number of nests are exposed to potential development, habitat loss and disturbance from activities that are known to negatively impact on breeding eagles. To date, many eagle territories have undergone disturbance from forestry operations resulting in extensive changes to the landscape such as conversion of native forest to plantations.

It has been well documented that the wedge-tailed eagle is a very timorous nester, with the Tasmanian subspecies being more sensitive than its mainland relative (Mooney & Holdsworth, 1991). Their low tolerance to disturbance means they are highly likely to abandon their nest if distressed, even when their nest contains an egg or chick, resulting in an unsuccessful breeding season (Mooney & Holdsworth, 1991; Threatened Species Section, 2006; Bekessy et al., 2009; Wiersma, 2010; O'Sullivan, 2014; Munks & Crane, 2017). Given their high susceptibility to disturbance coupled with their naturally low reproduction rate and high level of mortality, conservation and protection is paramount for this endangered species. Conservation of the wedge-tailed eagle in Tasmania has mainly concentrated on nest protection during habitat clearing, followed by the reduction of persecution and accidents (Mooney, 1997; Hull & Muir, 2013; Hull et al., 2013), monitoring the impacts of commercial forestry (Wiersma et al., 2009; Wiersma, 2010; Koch et al., 2013; Munks & Crane, 2017) and promoting the success of breeding by protecting nests during forestry and other land use developments (Bell & Mooney, 1999; Mooney, 2000; Bekessy et al., 2009).

2.2.3 Forestry operations and eagles

Approximately 48% of known eagle nests occur in state forests (Threatened Species Section, 2006), where timber harvesting is a potential threat (Tasmanian Government, 2018b) and therefore eagle protection is not just restricted to private land and land sanctioned for conservation. In 1997, the Tasmanian RFA was established as a bilateral agreement between the Tasmanian and Australian Governments to ensure that Tasmanian forests were being managed effectively and that appropriate practices were being use to ensure that environmental concerns were being addressed and conservation outcomes were being met (Commonwealth of Australia, State of Tasmania, 1997). The agreement recognises the wedge-tailed eagle as a species of high priority for which special consideration, such as zoning, must be established in all forest management schemes. Development of eagle nest management prescriptions for forest practices in Tasmania was largely guided by the work of Mooney and Holdsworth (1991), Mooney and Taylor (1996) and Mooney (2000) where provisions were made on the distance between forestry operations and nests and emphasis put on finding nests before logging commenced.

Sustainable Timber Tasmania (STT) are responsible for managing 800,000ha of State Forest, of which a high proportion is suitable eagle nesting habitat. Forestry prescriptions are regulated by the Forest Practice System (FPS), a self-managing system of the forestry industry that is enforced and monitored by the FPA. The breeding season for eagles in Tasmania is generally between the months of September-January, however, the Eagle Management Constraint Period (EMCP) for forestry operations near known eagle nests will cease by July to protect the early stages of breeding such as courtship and nest building. Nest activity checks are then undertaken in forestry areas by the FPA in mid-October. Forestry operations around active nests are postponed until February when the EMCP ends, whilst operations can commence again from mid October around non-active nests. All nests are protected by a minimum 10 ha nest reserve (Threatened Species Section, 2006), and active nests a 500 m noise restriction zone and 1000m 'line of sight' distance regulated with management prescriptions implemented by the FPA.

The effectiveness of these prescriptions has been monitored over decades by the FPA and studies looking into the implementation of these prescriptions suggest that nest management was of a high standard on public land, although management on private land was of a slightly lower standard (Mooney, 2000; Koch et al., 2013). These management prescriptions also ensure that searches are made for nests outside the breeding season in any areas of potential nesting habitat that have not been

searched for 2 years (Forest Practices Authority, 2014a). However, this system only protects current eagle nesting sites but does not protect future forest suitable for nesting. Commercial forestry operations are managed in accordance with the Agreed Procedures for the Management of Threatened Fauna and *all* forestry activities must comply with the responsibilities under the *Forest Practice Act 1985, Threatened Species Protection Act 1995, Environment Protection and Biodiversity Conservation Act 1999,* Tasmanian Forest Practice Code and the *Nature Conservation Act 2002 (Threatened Species Section, 2006).*

2.3 Part 3 - Landholders and covenanting programs

Eagle ecology in Tasmania and the role of conservation covenants on nests is a complex issue with both environmental and social components. There is a wealth of research (Daniels & Kirkpatrick, 2011; Moon & Cocklin, 2011; Blackmore & Doole, 2013; Comerford, 2014; Fitzsimons & Carr, 2014) which argues for the importance of understanding the interconnections between people and nature as central to conservation efforts. This is especially the case with conservation efforts directed towards private land and private landowners. Understanding why landholders engage in conservation covenanting programs, their attitudes towards these programs and how covenants change their land management practices are critical in addressing conservation issues regarding eagles in Tasmania. Such information is central to assessing and evaluating the value of conservation covenants as a protective mechanism on private land.

2.3.1 Private landholders and eagles

In the past wedge-tailed eagles were heavily persecuted due to the common belief that they attacked and killed lambs and other livestock. Bounties were placed on eagles in Queensland and Western Australia, encouraging the slaughter, making them the most persecuted bird of prey in the world (Leopole & Wolfe, 1970; Ridpath & Brooker, 1986). The myth that eagles were killing substantial numbers of healthy stock was exposed by Leopold and Wolfe (1970) of the CSIRO when they undertook an analysis on the dietary habits of wedge-tailed eagles, finding that lambs constituted only 7% of an eagles diet. Studies in Tasmania have shown that rabbits, hares, wallabies and possums are the most significant prey choice for eagles hunting in sheep grazing areas (Tasmanian Government, 2018b). While this research and consequent legal protection has resulted in a steady decline in persecutions, there is still an entrenched thinking of some landholders that wedge-tailed eagles are a pest and pose a threat to their livestock. In Tasmania eagles are a protected species and landholders face prosecution if they breach the *Threatened Species Protection Act* 1995.

2.3.2 Public education

Conservation programs that motivate landholders to take actions towards achieving conservation goals can be provided by all levels of government. Providing clear and concise programs that encourage positive relationships between private landholders and eagles is particularly important when developing covenanting programs designed for nests protection (Figgis, 2004). In order to build approval and support for conservation covenants, it is important that covenant managers disseminate the importance of their work. Without formal education on eagle conservation, landholders are likely to gain information and be exposed to eagles in an informal, *ad hoc* passive manner and thus the foundations upon which they have discovered their information on eagles may be misunderstood or contain prejudices (Parry-Jones et al., 2007). It can often be difficult to change a landholder's negative perception of eagles especially where conflict between the two occurs (Olsen, 2005).

Uptake of conservation programs are likely to be more successful when the landholder has adequate knowledge of the prescribed initiative, particularly with respect the goals and benefits of the program (Kabii & Horwitz, 2006). A landholder also needs to have confidence in the programs ability to achieve those goals and feel assured that their participation will advance the programs outcomes (Kabii & Horwitz, 2006). Even when all is known, a landholder may still choose not to participate in a conservation program. Therefore, a good relationship needs to be developed between the conservation program managers and the landholders (Wynn et al., 2001; Blackmore & Doole, 2013; Iftekhar et al., 2014). Furthermore, the relevance of a conservation initiative in terms of its consistency with landholder values, goals, socioeconomic status and attitudes towards difference aspects of the program remains necessary to its uptake.

2.3.3 Motivations for participation

Many researches have looked at what motivates a landholder to join a covenanting program (Ernst & Wallace, 2008; Farmer et al., 2011; Moon et al., 2012). However, due to differences in individual values and lifestyles as well as covenanting programs, there isn't a single answer to what motivates landholders. These studies, however, provide a collection of key motivations and determinants that help policy makers and managers of conservation programs make informed decisions. The use of incentive based programs are widely used to encourage the adoption of conservation on private land (Figgis, 2004). Incentives can be provided through dollars per hectare protected, stewardship payments, financial support such as tax breaks, rate rebates and grants or through education or through branding and certification advantages. In Tasmania, financial incentive based programs have significantly increased the total area of protected forest on private land (Department of Primary Industries, Parks, Water and Environment, 2019). Whilst financial incentives in Tasmania have encouraged some landholders who may have been disinclined to join a covenanting program otherwise, they don't necessarily increase conservation action (Yasué & Kirkpatrick, 2018). Landholder values and attitudes towards environmental issues don't necessarily change with financial incentives and thus education is paramount for those who have not chosen to participate for conservational gain.

Those who approach a conservation program solely to protect natural values on their land are generally already 'conservation minded' and form the minority of private landholders (Comerford, 2014). These landholders typically have a range of experiences, education and a positive attitude towards the environment (Ernst & Wallace, 2008; Blackmore & Doole, 2013; Comerford, 2014). However, if the proposed conservation initiative negatively affects how the landholder makes an income or impacts their livelihood or their long-term objectives then uptake is unlikely, even for the conservation minded (Moon & Cocklin, 2011). Anything that decreases the value of the land, is economically unviable or alienates the owner from their land is likely to result in the landholder being reluctant to join the program (Kabii & Horwitz, 2006). Conversely, landholders are more likely to respond positively to conservation initiatives when they are confident in their understanding of the information provided, have strong agency-landholder relationships (Wynn et al., 2001; Blackmore & Doole, 2013; Iftekhar et al., 2014), find it easy to implement and the benefits are compatible with their own personal property goals (Klapproth & Johnson, 2001).

2.3.4 Land management practices

Everyday land management practices, such as grazing, vegetation clearing, wood harvesting, shooting and recreational pursuits, to name a few, can be detrimental to breeding eagles within 500m 'out of sight' or 1000 'line of sight' of their nest. Private landholders are encouraged to protect eagle nests on

their property by adopting voluntary protection measures. For their own economic and social purposes, individual private forest owners have rights to use and manage their own land but all must abide by legislation set out by the *Forest Practices Act 1985*; *Land Use Planning and Approvals Act 1993; Nature Conservation Act 2002; Threatened Species Protection Act 1995; Environment Protection and Biodiversity Conservation Act 1999* and the Forest Practice Code. If a landholder wishes to harvest timber on their property or undertake development then they are responsible for reporting any threatened species that are found on their property to the FPA and the Department of Primary Industries, Parks, Water and the Environment (DPIPWE) (Forest Practices Authority, 2015). Under the *Threatened Species Protection Act 1995* a land management plan may be proposed to protect a threatened species.

A landholder's willingness to change their land management practices is another challenge conservation manager must consider when approaching landholders to adopt a conservation covenant. What was once a daily management activity of a landholder could suddenly become an offence. If a landholder were to breach the terms and conditions of their covenant it could result in fines of up to $15,700 under Tasmanian law. Covenants are a permanent instrument applied to the land title and many landholders opt to covenant a portion of their property that is typically rugged and of no use to them financially. Covenanting sections of their land allow landholders to achieve their conservational outcomes without the loss of potential income. Even when a covenant is established ensuring compliance is maintained on covenanted properties requires frequent on-going monitoring of the land by covenant and forestry authorities. The concern that there is a lack of monitoring and enforcement of 'breaches' within conservation covenanting programs in Australia is highlighted within the literature as an ongoing issue (Figgis et al., 2005; Fitzsimons & Carr, 2014; England, 2015; Hardy et al., 2017).

2.4 Concluding chapter 1

In this chapter I have outlined the extent of private land conservation in Australia, noting that this mechanism has facilitated a greater degree of environmental protection for threatened species and ecosystems. Conservation covenants in Tasmania have been providing eagles and their habitat with a protective mechanism for the last two decades. However, it is still unknown to what extent conservation covenants increase the security for breeding eagles. The following chapters explore this knowledge gap by comparing the activity status of eagle nests on covenanted land with nests on land protected by management prescriptions and non-protected land. A variety of habitat variables that may influence activity are assessed and compared against nest activity and the three different management regimes. Furthermore, information collected from landholder surveys will provide feedback on the motivations of landholders for joining covenanting programs and whether this has changed the way in which landholders manage their land especially in regard to eagles.

3 Chapter 3 –Methods

3.1 Introduction

In this chapter I describe the mixed methods methodology used to generate data for the ecological and social components of this research project. I have adopted a pragmatic methodological position (Creswell & Creswell, 2018) that aligns with specific methods as suited to specific research questions. Hence, I have used four methods of ecological analysis to address research questions relating to the effectiveness of covenants in protecting eagle nests. In summary:

1) I qualitatively compared covenant management prescriptions with forestry management prescriptions on Permanent Timber Production Zones (PTPZ) using the non-protected properties on private land as the control group.
2) I compared the activity status of nests protected by covenants with the activity status of nests protected by PTPZ prescription and nests on non-protected private land.
3) I tested whether the activity status and management regimes were influenced by certain habitat variables.
4) I tested whether the activity status of nests within covenants was influenced by specific characteristics of the covenants.

To better understand landholder motivations and land management practices relevant to eagle conservation, I utilised two social science methods. In summary:

1) I developed two survey questionnaires specifically designed for the landholders on covenanted and non-covenanted properties to understand their motivations for joining or not joining a covenanting program and how their land practices have changed or might change in the implementation of a covenant.
2) I conducted over the phone and face-to-face interviews with willing survey participants for both covenanted property owners and non-covenant property owners to gain a more in depth understanding of their survey answers.

Below I elaborate on the mix of ecological and social science research methods outlines above.

3.2 Part one: Ecological methods

3.2.1 Comparison of management prescriptions

Using the current literature and a selection of land management plans, Tasmanian Government websites, documents and personal communications with eagle and covenant program experts, I undertook an analysis of the three different land management regimes specific to eagles. This comprised:

1. a list of threats to eagles and an assessment of the severity of these threats.
2. A comparison of the restrictions/regulations in place to manage these threats on covenanted and PTPZ land using non-protected land as a control; and
3. An indicative critical analysis of the effectiveness of these restrictions, based on expert opinion from experienced eagle researchers.

3.2.2 Study Species

This research project focused on Tasmania's two eagle species, the Tasmanian wedge-tailed eagle and the white-bellied sea-eagle as pictured in Figure 3. When referring to 'eagle nest' in this study I am referring to the nest of either species. Species identification is irrelevant for this study for several reasons:

(1) offsets from the Eagle Nest Protection Program (ENPP) apply to both species of eagle nest;
(2) it is well known that both eagle species may use a nest build by the other species (Mooney & Holdsworth, 1991); and
(3) both eagle species are managed on covenanted land and PTPZ land with the same prescriptive measures (Threatened Species Section, 2006).

Figure 3. Image (left) White-bellied sea-eagle photographed by Fareed Mohmed and (right) Tasmanian wedge-tailed eagle photographed by Nic Betts.

3.2.3 Study area

Tasmania is located 240km south of mainland Australia at approximately 42°S, 147°E. Characterised by its cool maritime climate and average temperature of 15 degrees, Tasmania is a temperate island with mild summers and cold winters. The study area primarily focused on the central and eastern half of Tasmania due to the majority of the ENPP offset covenants occurring in this sector of Tasmania on private land. Focusing on the eastern half of the state also reduced the confounding effect of the environment between the east and west of the state. The dry open and modified landscapes in the east are contrasted by the dense wet forests in the west (Kirkpatrick, 1977).

3.2.4 Nest selection

Eagle nests were located using the raptor nest database on the Land Information System Tasmania '*The LIST'* (Tasmanian Government, 2019a) and information regarding the nest details, such as coordinates, nest ID and eagle species was found on the Natural Values Atlas (NVA) (Tasmanian Government, 2019b). Using '*The LIST'*, a layer of land tenure was incorporated onto the map where the three different management types were focused on (see Figure 4 over the page):

- Conservation covenants (covenanted);
- Permanent Timber Production Zones (PTPZ prescriptions); and
- Private freehold land (non-protected).

Private Timber Reserves (PTR) are classified as private freehold land. There were 11 out of 47 nests that were on private land that were in PTR subject to forest management plans under the Forest Practice Code, but they were otherwise subject to private decision-making. The effects of their inclusion in the private 'non-protected' category were tested by repeating all statistical analyse including them in the PTPZ category. These analyses had results that did not differ in any important way from those reported in this thesis.

Across the three land management regimes 157 nests were selected in total. Nests on covenanted properties were selected in three different ways. Firstly, the offset nests from the ENPP were selected (n=24). The location of these offset nests was provided by the DPIPWE. Secondly, nests on the Tasmanian Land Conservancy's (TLC) covenanted reserves were also selected (n=8). The remaining

covenanted nests were selected from the '*The LIST'* using the raptor nest and conservation covenant layers (n=24). In total 56 nests were selected on covenanted land to be surveyed for nest activity. Nests that occurred on private properties and PTPZ land were selected from a list of nest IDs and coordinates provided by the FPA. From this list, nests were selected due to their location being in the same general area as the covenanted nests to minimise variation in vegetation type, climate and landscape attributes (Figure 4). In total 46 nests were selected on non-protected properties and 55 nests were selected as protected by PTPZ prescriptions. All nests within this project are assumed to be independent of one another. Nests were selected based on their location being within a covenant, on PTPZ land or on non-protected private land. Whilst some nests were known to be within close proximity to one another on some of these properties, without knowing the territories of the individuals I haven't assumed that any nests belong to the same breeding pair.

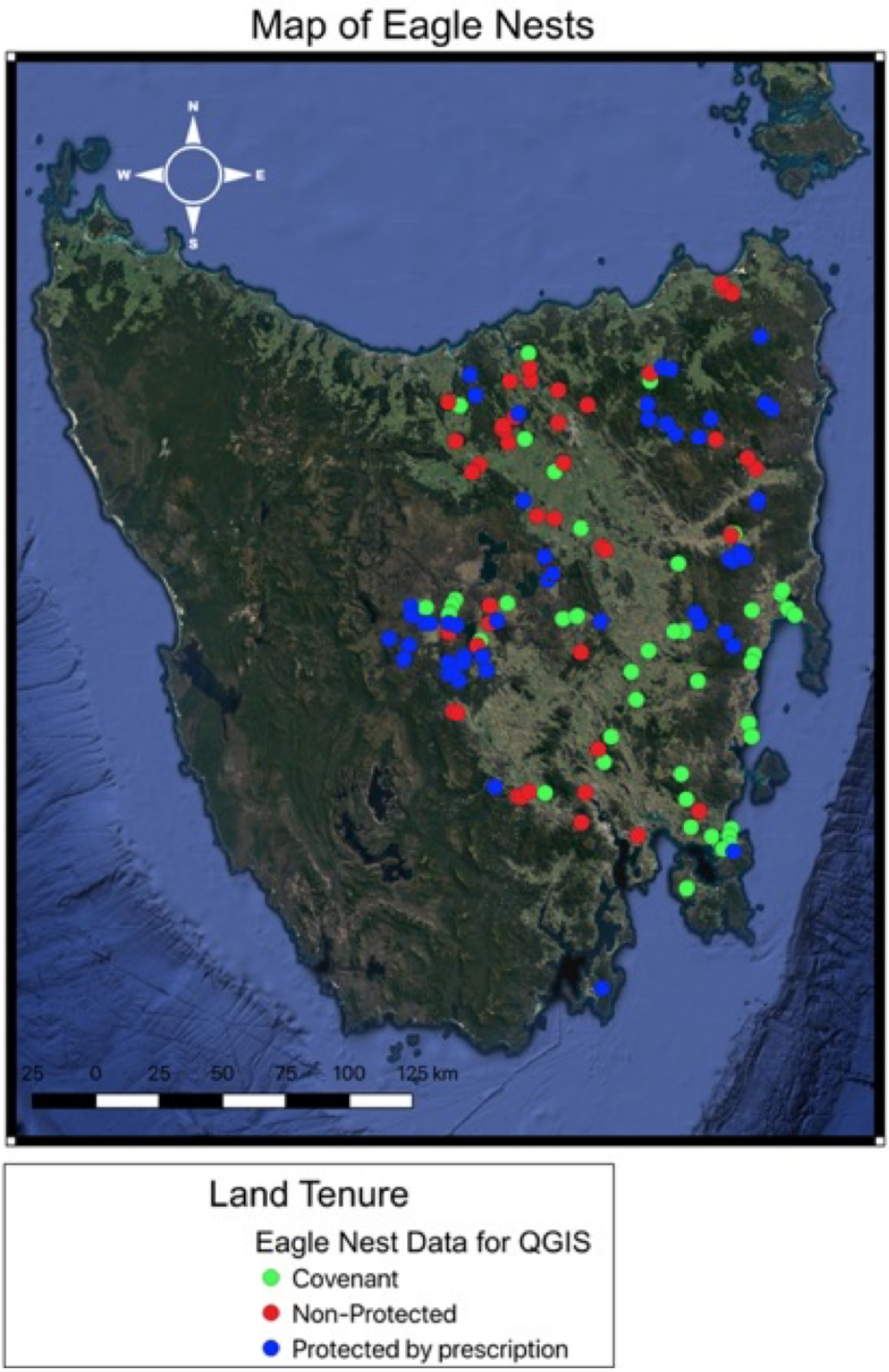

Figure 4. Eagle nest survey sites across three management regimes in Tasmania.

3.2.5 Aerial nest activity surveys

Aerial surveys were conducted for 43 of the covenanted nests using a light-weight-fixed-wing aircraft (Cessna 172, Par Avion) and a pilot with low-flying accreditation. To determine the exact location of the nest prior to the survey, I utilised several Google map images of each nest site at different levels of amplification, GPS coordinates and expert knowledge on eagle nesting sites was used. All 43 eagle nests were surveyed by myself with the assistance of an experience eagle researcher. Nests were surveyed for activity during the breeding season between the 19th of December 2018 and the 3rd of January 2019 when nestlings were likely to be at least 7 weeks old but not yet fledged. Of the

remaining 13 covenanted nests, 5 nests were surveyed by TLC field officers during November 2018 and 8 were surveyed by the FPA during their November-December 2018 annual nest checks. Nests situated on private land and nests protected by prescriptions on PTPZ land were also surveyed by the FPA during November-December 2018. The activity status for these nests was obtained through the FPA with permission from various contractors and forestry companies who requested the nest checks by the FPA.

Surveys were conducted with approval of University of Tasmania Animal Ethics Committee (Animal Ethics Number: A0017612) (Appendix 2) and conform to the requirements of the current edition of the *Australian code of Practice for the care and use of animals for scientific purposes* (National Health and Medical Research Council, 2013). A scientific research permit was also granted by DPIPWE for the disturbance of wedge-tailed eagles and white-bellied sea-eagles by aerial nest surveys (Scientific Permit TFA 18237) (Appendix 4). Data collected included; the time, date, weather, nest ID, nest coordinates, nest appearance and nest activity status. Observations made during the flight surveys were used to determine nest activity status (Table 2).

Table 2. Activity status definitions.

Activity Status	Observation
Active [2]	Activity as the *use* of a nest and was defined as: **1) Successful:** a nest containing a nestling 6 weeks of age or older (Olsen, 2005) or the nest showing signs of a chick(s) possibly fledging[3] with the nest having evidence of high use with a flat top, the presence of down, white wash, food scraps or fresh green nest material. **2) Productive:** nests containing incubating parents, egg(s) or hatchling(s), under 6 weeks of age. **3) Maintained**: nests exhibited signs of use, such as white-wash, fresh nesting material such as brown sticks, green leaves or food scraps.
Non-Active	Non-active nests showed no signs of use, nests were often degraded and partially or fully bleached with no signs of new nesting material.

3.2.6 Habitat variables

Environmental and anthropogenic attributes that are likely to contribute to the disturbance of eagles and their breeding activities were selected for analysis. Nests were mapped using the nest coordinates and layers of geographic features, including vegetation type, roads, land parcels, reserve boundaries and land type were added to the map. Points, lines and polygons were then used to determine habitat variables used in statistical analysis (described in Table 3). Three covenant characterises that vary and possibly influence the level of disturbance were identified and accounted for also and are described in Table 4.

[2] As noted above, it is important to remember that 'productive 'nests may not necessarily become 'successful' and a 'maintained' nests may not necessarily become 'productive' or 'successful'

[3] The presence of a flat top combined with whitewash and green leaves is the best predictor of the presence of an aged nestling although it can never be confirmed that the chick did in fact fledge (Wiersma & Koch, 2012)

Table 3. Methods used to measure habitat variables that may influence eagle nest activity and their necessary associated data transformations. Habitat description followed by Koch et al (2013).

Variables	Description
Percentage of native forest surrounding a nest at; 500 m, 1000 m and 5000 m radius	Using the TASVEG (digital vegetation map of Tasmania) map layer in QGIS and three different polygon buffers of 500 m, 1000 m and 5000 m radius over each nest, the percentage of native forest within these three buffers was calculated. Three main types of native forested habitat were determined as prime eagle habitat; Dry eucalypt forest and woodland (D), wet eucalypt forest and woodland (W) and non-eucalyptus forest and woodland (N). Variables were square-root transformed in analysis to satisfy assumptions of normality
Forest patch size surrounding nest	Forest patch was categorised into three groups. 1. <10 ha (the minimum size required for an eagle reserve), 2. 10-35 ha and 3. >35 ha (the suggested size of the offset conservation covenants). Using QGIS, the polygon feature was used to determine the amount of native forest surrounding each nest. Narrowing strips of native forest and heavily patched landscapes were not included as part of the overall 'forest patch' and thus this test differs against percentage of native forest surrounding by only including intact forest.
Distance from nest to the boundary of native forest (m)	The distance from each nest to the boundary of the native forest (TASVEG vegetation group D, W or N) was measured using the straight-line measuring tool in QGIS. The boundary of native forest was anything that wasn't dry eucalyptus forest and woodland, wet eucalyptus and forested woodland and non-eucalyptus forest and woodland.
Percentage of non-native habitat surrounding a nest at; 500 m, 1000 m and 5000 m radius	The percentage of non-native habitat surrounding each nest was also calculated at 500 m, 1000 m and 5000 m radius, as per above with the native forest. The non-native habitat included: agricultural land, extra-urban miscellaneous, marram grassland, permanent easements, plantations for silviculture, *Pteridium esculentum* (fern land), regenerating cleared land, spartina marshland, unverified plantations for silviculture, urban areas and weed infestation. Variables were square-root transformed in analysis to satisfy assumptions of normality
Distance from nest to the nearest non-native habitat (m)	The distance from each nest to the nearest non-native habitat (anything in the TASVEG vegetation group of F) was measured using the straight line measuring tool in QGIS.
Roads (m) within 1000 m of nest	The length of road and railway within a 1000 m radius of each nests was estimated using the topographic layer in '*The LIST'*. All road types and railways were included.
Road Type	The average road type (most common) that occurred within 1000 m of each nest was estimated and recorded. Where two road types occurred, the highest number was recorded. Road types were separated into 4 categories. **1 - low impact** (bush tracks and small off-roads rarely used by multiple vehicles). **2 - low/medium impact** (dirt roads, typically used by vehicles). **3 - medium/high impact** (suburban and country roads including railways, used by many vehicles daily). **4 - high impact** (main roads and highways used by a high number of vehicles daily).
Distance from nest to nearest road (m)	The distance from each nest to the closest road was recorded using the straight-line measuring tool in the '*The LIST*' overlayed with the roads topographic layer. All four types of road detailed above were considered as 'road'.

Table 4. Methods used to measure the influence of variables specific to conservation covenants

Covenant Size	The measured area of the covenanted nests was determined using the measuring tool in '*The LIST'* and was represented in hectares[4].
Distance from nest to covenant boundary [5]	The distance from each nest to the boundary of the covenant was measured using the straight-line measuring tool in QGIS.
Percentage of covenanted land surrounding nest	A 35 ha buffer zone was applied to each nest found on covenanted land. Due to the variation in covenant size and shape and an inability to encompass a nest to its full potential (i.e. some nests occurred on the boundary of a covenant, rather than directly in the centre) the percentage of covenanted land within a 35ha buffer zone surrounding the nest was calculated to determine how well the covenant captures the landscape around the eagle nest. A 35 ha buffer was selected as this is higher end of the scale most relevant to the current conservation covenant recommendations of 30-35 ha within the ENPP.

3.2.7 Data analysis

Qualitative assessment of the prescriptions

I identified a list of threats from the literature, they were categorised as those causing;

1. Loss of critical habitat – habitat loss.
2. Disturbance – this includes disturbances that alter the behaviour of eagles during nesting and leading up to nesting.
3. Direct risk – this encompasses **persecution** (Shooting, trapping, felling of tree and deliberate poisoning of eagles), **accidents** (collisions with man-made objects such as windfarms and powerlines and non-target poisoning such as chemical pollution) and **collecting** (deliberate 'take' that is not persecution, such as opportunistic shooting for trophies and taxidermy or egg collecting).

The level of potential threat from human activities on nesting eagles were given a risk assessment rating of high, moderate, low or negligible based on information presented from previous wedge-tailed eagle recovery plans (Gaffney & Mooney, 1992; Bell & Mooney, 1999; Threatened Species Section, 2006) and personal communication with Tasmanian eagle experts (N. Mooney and J. Wiersma, 2019, pers comms).

I then identified and compared the main protective mechanisms in place on covenanted properties and PTPZ land to protect eagles. To do this, I identified the main regulations and restrictions put in place to protect eagles using online government websites (Forest Practices Authority, 2006, 2014b, 2014a, 2015, 2017; Sustainable Timber Tasmania, 2019; Tasmanian Government, 2018b, 2018c, 2019c), personal communications (J. Smith; L. Walters, Pers. Comm., 2019) and reviewing several TLC Nature Conservation Plans and covenant agreement terms and condition reports. I then compiled a table comparing the differences between the regulations and restrictions in place under each management regime. An indicative critical analysis of how well each restriction and regulation address specific threats was then undertaken based on expert opinion. However, this critical analysis does not from part of the results of the thesis as it was determined that additional research needs to be

[4] It should also be noted that groups of neighbouring conservation covenants were considered one large covenant regardless of ownership.

[5] Not all covenants were placed on a property to protect an eagle nest and therefore some nests were known to be close to the covenant boundary.

undertaken to increase the robustness of the findings[6](This critical analysis can be found in Appendix 14).

Nest Surveys
Of the 157 nests targeted for surveys, a total of 30 nests could not be found when conducting eagle nest surveys. These 30 'not found' nests were then excluded from all statistical analysis comparing habitat variables against 'nest activity' as it was impossible to know their activity status. However, for the statistical analysis between the habitat variables and 'management regime', the 30 'not-found' nests were included, as these nests are still identified on the '*The LIST'* and NVA and therefore their surrounding habitat variables could still be identified and compared with their relevant management regime.

Nest activity across the three management regimes
To determine whether the proportion of active nests differed significantly between the three different management regimes, a Chi-square test was used. Herein, results that yielded a p-value of <0.05 were considered to be significantly different.

Habitat Variables
The habitat variable data was visually inspected for normality and homogeneity of variance. Transformation of data, using the square-root transformation was employed to reduce heteroscedasticity for several habitat variables. Some data didn't conform to an approximate normal distribution and therefore non-parametric methods were also used to determine if they would be more useful than parametric approaches. Nest activity (e.g. active vs not active) and management regime (visual land tenure) were first separately tested against each continuous habitat variable using a one-way analysis of variance (ANOVA). For the habitat variable 'percentage of native forest within 5000 m of a nest', the result of the ANOVA between non-transformed and transformed data (square root) varied substantially, by indicating a significant result for non-transformed data and a non-significant result for transformed data. To re-calibrate this variation, a Kruskal-Wallis tests on ranks was used as a non-parametric method for testing whether the samples originated from the same distribution. The p-value from the Kruskal-Wallis test was given as the overall result for this particular habitat variable against nest activity. To determine which management regimes indicated a significant relationship with the habitat variables a Tukeys pairwise test was used. For the two categorical habitat variables 'Road Type' and "Forest patch size" a Chi-squared test was used to test against both nest activity and management regime.

Covenant influences on nest activity
Covenant variables were visually inspected for normality and homogeneity of variance. An ANOVA was used to independently test all three covenant variables with nest activity.

3.3 Part two: Social methods.

The social science component of the study used a mixed-methods research design with two primary phases similar to that of Farmer et al. (2011). They include a survey questionnaire administered via mail and a Survey Monkey electronic version (phase 1); and qualitative semi-structured interviews conducted in person and by telephone (phase 2). The aim of the questionnaire survey was to generate

[6] The indicative critical analysis is included in Appendix 13.

an overall picture of landholder perceptions, motivations and practices, which the qualitative interviews facilitated deeper investigation.

3.3.1 Selection and recruitment of participants

Participants were selected if they were the owners of the covenant or private non-protected properties that had nests surveyed as part of this project. The location of the eagle nests and their associated property addresses is publicly available online from '*The LIST*' and NVA. Human ethics was obtained for the social science components of the project – (Ethics Approval - H0017965) (Appendix 6).

For phase 1, participants were separated into two groups: landholders with conservation covenants (n=36) and landholders without covenants on private freehold land (n=38). The number of potential participants was lower than the number of nests surveyed for both covenanted and non-protected properties as some landholders owned more than one of the properties surveyed, and some properties contained more than one eagle nest.

Once selected, participants (n=72) were mailed a postcard with an URL link to an online survey instrument (Figure 5). An amended version of the 'total design method' advanced by (Dillman et al., 2014) was adopted to maximise response rates. Hence, participants also had the option to request a paper copy of the survey by emailing the email address provided on the postcard. Information about the project and the nature of participation for both covenanted and non-covenanted properties was provided in an introductory page before the start of the survey. A reminder letter was sent out to landholders for those who had not completed the online survey within two weeks of postage. In addition, a hard copy of the survey with a stamped self-addressed envelope, was provided to aid those for whom the online survey was not an option. Answers from hard copy surveys were manually entered in to the survey monkey to keep all the information on one platform.

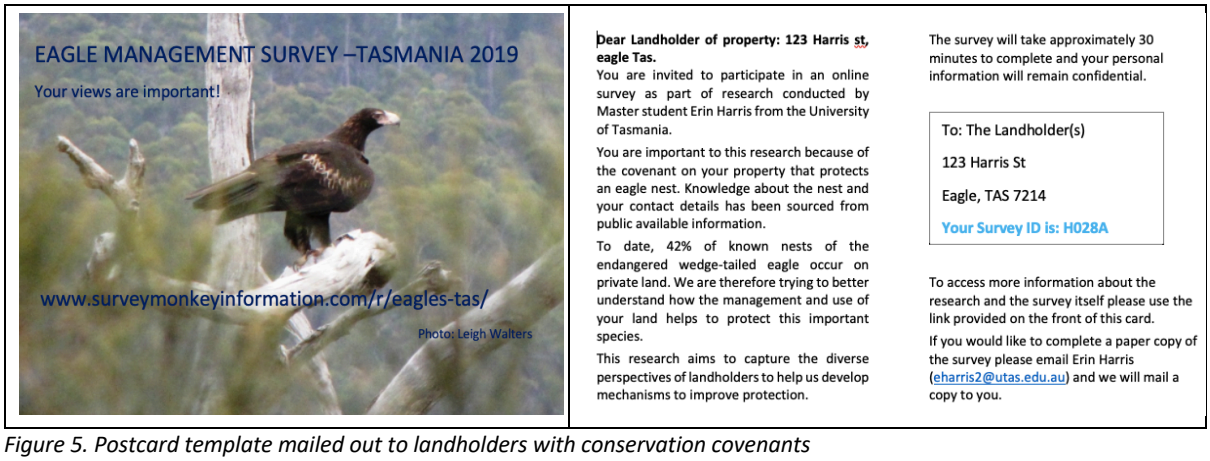

Figure 5. Postcard template mailed out to landholders with conservation covenants

For phase 2. Landholders from each property type (covenanted or non-protected) were selected from phase 1 based on their willingness to participate in a face-to-face or over the phone interview. Willingness to participate was subject to those who, at the end of their survey, entered their email or phone number to be further contacted for an interview.

3.3.2 Phase 1 – Online and mail survey questionnaire

A review of the literature relating to landholder involvement in covenant programs was undertaken to assist in formulating a structured survey instrument. The literature review allowed me to generate

information across different peer reviewed papers looking at the motivations for participation (Kabii & Horwitz, 2006; Ernst & Wallace, 2008; Whitten et al., 2008; Farmer, 2009; Moon & Cocklin, 2011; Blackmore & Doole, 2013; Sorice et al., 2014; Selinske et al., 2015) which underpinned the types of questions asked.

Two surveys were developed for this project using the online Survey Monkey program. Both surveys consisted of three parts (both surveys can be found in full in Appendix 9). Part 1, sought general landholder demographics, such as age, gender, schooling and employment. Part 2, gathered information about the property, such as how long it has been in the family, who manages it, what its used for and how often the eagles are seen on it. Part 3, explored the landholder's attitude towards conservation covenants including their motivations for joining the program, their motivations for protecting eagles, changes to their land management practices since joining the covenanting program and their experience with the covenanting program. For landholders without a covenant, questions were directed at what would motivate them to join, what land management activities they would be willing to decrease to protect eagles and their reasons for not joining a covenanting program.

Both surveys contained a selection of multiple-choice questions as well as uni-dimensional five-point Likert scale tables that elicited quantitative responses used to measure motivations and attitudes (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree). Surveys were altered slightly depending on the property type. For example, covenanted properties were asked "How much has changed of the following land management practices in relation to the covenanted eagle nest site" on a 1-6 Likert scale answers went as: (1 = decreased a lot, 2 = decreased a little, 3 = not changed, 4 = increased a little, 5 = increased a lot, 6 = not applicable to my property). For non-protected properties this question was: 'Which of the following land management practices *would* you be willing to change during the eagle breeding season" on a Likert scale of 1-4 (1 = not at all, 2 = decrease a little, 3 = decrease a lot, 4 = not applicable to my property). The land management practices included were the same across both surveys.

3.3.3 Phase 2 – Interviews

A small number of semi-structured in-depth interviews were chosen as a method to explore key themes and issues identified from the survey in greater depth (see Appendix 12 for both covenant and non-covenant property interview questions). The interviews generated contextualized understanding as to why landowners covenant their land, how a covenant affects their land management practices, how effective they believe covenants are, what sort of monitoring occurs on their property, what they believe the primary threats to eagles are, and what they perceive to be the community consensus is surrounding eagles in their local area. Interviews were undertaken in a location of the participants choice or over the phone. A risk assessment form was completed prior to field work and a call out procedure was set up for any emergencies.

3.3.4 Data analysis

Surveys

Responses mailed in as a hard copy were entered into their respective Survey Monkey to facilitate analysis. Answers from both covenanted and non-covenanted properties surveys were then exported into an excel spread sheet. Using excel each question response was broken down into percentages to allow for easy use of conversion to graphs and tables. For the Likert scale responses, strongly agree and agree answers were grouped together for better clarity and likewise with strongly disagree and disagree. Plots were developed from raw data using the 'Likert' library in R.

Interviews
Interview transcripts were analysed deductively to identify exemplars of key themes, issues and patterns already identified from the survey data. Attention was also paid to documenting illustrative and indicative participant responses that could shed light on the underlying reasons and rationales for the results obtained from the survey questionnaire. Select results from the interviews are reported in conjunction with the survey data to provide an overall picture of landholder understandings of eagles and eagle nest covenants.

3.3.5 Conclusion
In this chapter I have outlined the key elements of the mixed methods design used to generate data relevant to the research questions outlined in Chapter 1. There are distinct ecological and social science components to the research and the methods selected reflect these.

4 Chapter 4 - Results
This chapter has been separated into two parts. Part 1 contains the ecological results and Part 2 the social science results. The significant and relevant outcomes of this result section will be discussed further in the discussion in Chapter 5.

4.1 Part 1 – Ecological results

4.1.1 Qualitative comparison of prescriptions
A qualitative analysis of the threats to eagles concluded that all threats present at least a moderate to high negative impact on eagles (Table 5). The rankings for these were assigned with advice from specific eagle experts (N. Mooney and J. Wiersma, 2019, pers comms). The current solution to overcome these threats on covenant and PTPZ land has been the development of buffer zones and 'no activity' zones (Table 6). All tenure types, including private land are to follow legislation set out by the *Forest Practices Act 1985*; *Land Use Planning and Approvals Act 1993; Nature Conservation Act 2002; Threatened Species Protection Act 1995* (TSPA)*; Environment Protection and Biodiversity Conservation Act 1999* (EPBC)*;* and the Forest Practice Code (2015). A comparison of the prescriptions regarding the various land management activities that present a threat to eagles can be found in Table 7.

Table 5. Level of potential threats to both the bird and their nest that various human activities represent to nesting eagles. Habitat loss (direct loss to habitat including nesting tree), Disturbance (disturbance that results in disruption to nesting behaviour), Direct risk (physical impact causing harm or death to an eagle). Negligible is labeled as 'neg'

Threat	Habitat loss	Disturbance	Direct risk
Point construction. (E.g. buildings, bridges, small dams, minor fencing.)	**Moderate**	**High** *- Noise* *- Line of sight*	**Low** *- Collisions* *- Electrocution*
Spatially extended construction. (E.g. roads, large dams, major fencing, powerlines, windfarms)	**High**	**High** *- Noise* *- Line of sight*	**Moderate** *- Collisions* *- Electrocutions*
Subdivision	**High**	**High** *- Ongoing impact from people moving outwards*	**Moderate** *- Car collisions* *- Electrocution*
Clearing (including firebreaks)	**High**	**High**	**Moderate** *- Active nests can be felled*
Fuel reduction burning	**High**	**High** *- Presence of people* *- Presence of aircraft*	**Low** *- Active nests can be burned*
Wildfire fighting	**Low**	**High** *- Human presence - Aircraft presence*	**Low** *- Collision with low flying aircraft.*
Firewood Collection	**Moderate** *- Felling of nest tree*	**High** *- Noise* *- Human presence*	**Neg**
Vehicle use	**Low**	**Moderate** *- Noise*	**Low**
Aircraft use, including drones.	**Neg**	**High** *- Noise*	**Moderate**
Research (bird watching directed at eagles)	**Neg**	**High** *- Human presence*	**Neg**
Management of eagles on forestry and covenant land (nest surveys)	**Neg**	**High** *- Noise* *- Human presence*	**Low** *- Collision with low flying aircraft.*
Recreation (camping, climbing, birdwatching)	**Low**	**High** *- Noise* *- Human presence*	**Neg**
Stock Management (Mustering)	**Low**	**Moderate** *- Noise* *- Human presence*	**Neg**
Hunting	**Neg**	**High** *- Noise* *- Human presence*	**Moderate**
Weed control	**Low**	**Moderate** *- Human presence*	**Neg**
Pest Poisoning	**Neg**	**Moderate**	**Moderate** *- Secondary and non-target poisoning*
Intensive agriculture	**Moderate**	**Moderate** *- Human presence*	**Neg**

Table 6. Current eagle nest protection measures across the three land tenures.

Prescription	**Covenanted**	**PTPZ prescriptions**	**Non-Protected**
Nest reserves and Nest Management Areas	Under the ENPP 32-35 ha was identified as a suitable size for covenants protecting eagles. All conservation covenants are inherently a buffer zone around eagle nests[7].	A minimal 10 ha nest reserve was adopted on PTPZ land, excluding any activity from ever occurring within this area, even when the nest is known to not be active.	The Threatened Species Section of the Tasmanian Government governs the protection of eagle nests on *all* land tenures. If land has an agreed land management plan or covenant, then a buffer may apply to an eagle nest under the *Threatened Species Protection Act 1995.*
Further Protection	Further protection on top of the covenant can be an eagle Nest Management Area (NMA) this area is 20ha[8] and is to be managed as intact forest, free from habitat modification. No activity is to occur in the NMA during the breeding season which is defined for covenants as 1st of n to 31st of January for sea-eagles, and 1st of July to the end of February for wedge-tailed eagles.	A 'no activity' zone was implemented for active nest, where no disturbance could occur within 500 m Out of Sight (OOS) (a mechanical noise exclusion area) or 1000 m, Line of sight (LOS) of the nest (Wiersma et al., 2009). Between the 1st of June and end of February is the Eagle Management Constraint Period (EMCP). The EMCP is longer than the 'breeding season' and incorporates courtship and nest building. Forestry operations cease in June (FPA decides the date) until nest activity is checked in mid-October. If those nests are deemed *active* then operations are further postponed to February (FPA decides the date). If *inactive*, operations can recommence.	Whilst it is an offence to injure or harm an eagle or cut down its nesting tree, there are no restrictions/regulations for how close a nest may be approached. Development applications and permits to undertake certain land management activities may have conditions attached that are legally binding. Otherwise private landholders are only encouraged to protect eagle nests on their property by adopting voluntary protection measures (Tasmanian Government, 2019c)

[7] Covenants vary in size and some covenants selected for this project were not necessarily put on the property to protect the eagle nest that resided on them, due to this some covenants in this project were as small as 10ha. Some nests also occurred close to the covenant boundaries, meaning they may be potentially disturbed or physically exposed to human activities on neighboring land.

[8] An eagle NMA can be from 20ha to the size of the entire covenant. NMA are generally put on large covenants to specifically protect the eagle nest on that land with stricter restrictions than the covenant. This means that landholders can do certain activities on their covenanted land so long as they are outside the NMA. Some of the properties considered in this project had a NMA of 50ha.

Table 7. Comparison of prescriptions across three different management regimes in regard to eagle nest protection. Regulations and restrictions are addressed through a critical analysis from experienced eagle researcher.

Threat	Covenanted prescriptions	PTPZ prescriptions	Advice/restrictions and regulations for all land tenures
1. Construction	Infrastructure is generally NOT permitted in the NMA. Infrastructure is to be located in areas that minimise land clearing. Construction or maintenance of fences must only be conducted outside the breeding season.	Point construction such as quarries must not occur within the 10 ha buffer, 500 m OOS or 1000 m LOS of an active nest. If the nest is not active, then operations may continue. Some road development is subject to agreement with the Forest Practices Authority.	DPIPWE's EPA and Local Councils are responsible for regulating the building of infrastructure on private land. Activities that may have a direct impact on the eagles must be referred to the Minister to undergo an environmental assessment as governed by the Threatened Species Protection Act (TSPA). The Threatened Species Link (TSL) advises to reduce noise and visual disturbances around nest during breeding season.
2. Subdivisions	No subdivision development activity permitted on the covenant at all.	No subdivision development is permitted on PTPZs.	Local councils are responsible for regulating subdivisions. It is an offence to harm or injure an eagle or fell an eagle nesting tree under the EPBC.
3. Vegetation clearing	No major vegetation clearing is permitted on a covenant at all. Outside the breeding season, clearing related to weed management, fire hazard reduction or firewood collecting is only permitted under authorisation from the Minister.	Vegetation clearing is not permitted within 500 m OOS or 1000 m LOS of active nests. Nests in these areas should be protected by an informal nest reserve of at least 10 ha in which clearing shouldn't occur.	It is an offence to fell an eagle nest tree. Land clearing controls apply to native forest through the *Policy for maintaining a Permanent Native Forest Estate.* All forest clearing in excess of 1 ha/property/year is to be managed under a Forest Practice Plan. There are no controls on clearing non-forest vegetation that is not threatened (Forest Practices Authority, 2017). There are no restrictions unless the vegetation is endangered.
4. Fuel reduction burning	No burning is permitted within the NMA during the breeding season unless (back burning) to stop a wildfire. The owner must consult with DPIPWE and obtain permits from the Tasmanian Fire Service (TFS) to burn. Planned burns must only be for the purpose of fire hazard reduction or the management of natural values.	Low intensity burning is only allowed to be conducted within 500 m OOS or 1000 m LOS of the nest outside the breeding season. High intensity burns are not allowed to be conducted during the EMCP. No burns are to be conducted within the 10 ha buffer zone surrounding the nest	The TSL advises landholders to seek advice from the Threatened Species Section (DPIPWE) before burning near an eagle nest. Planned burnings are regulated by the TFS and the Natural and Cultural Heritage Division and Parks and Wildlife Service divisions of DPIPWE. Planned burns, as part of the broader fuel reduction program, are regulated by the Fuel Reduction Unit in TFS.
5. Firewood Collection	No firewood collecting is permitted within the NMA during the breeding season. Outside the breeding season, limited firewood collection may be allowed subject to authorisation from the Minister.	Sustainable Timber Tasmania allocates a number of areas within PTPZ land where firewood can be collected with a permit. Permits are not for commercial ventures and are for personal use only and collection cannot be within the nest reserve.	There is no regulation of collection of firewood on private land outside the clearing limits that trigger a Timber Harvesting Plan.
6. Vehicle use	Vehicles are not generally permitted in NMA during the breeding season. If vehicle access is required it should be minimised to only necessary use, be confined to existing tracks and if there is a need to stop people must remain in the vehicle.	Vehicles are not permitted within 500 m OOS or 1000 m LOS of an active nest. No vehicles are permitted within the 10 ha buffer zone during the EMCP.	Off-road vehicles are permitted on private land, although it is advised by the TSL to avoid driving near eagles during their breeding periods.

Threat	Covenanted prescriptions	PTPZ prescriptions	Advice/restrictions and regulations for all land tenures
7. Aircraft use, including drones.	No Activities are permitted in the NMA that may impact on eagles unless for research purposes.	Aircraft use is not covered under the Forest Practice Act's definition of a forest operation. Industries can conduct aerial spraying of plantations within 1 km of a nest	Aircrafts have no minimal distance that they can fly in regards to an eagle nest.
8. Research (directed at eagles)	All fauna research requires an animal ethics permit required under the Tasmanian *Animal Welfare Act 1993* and the *Australian code for the care and use of animals for scientific purposes, 2013.* Animal ethics is obtained through the respective research bodies own Animal Ethics Committee (AEC). For institutions that don't have their own AEC, DPIPWE may consider proposals.		
9. Management	If there is a standard operating procedure in place to monitor eagle nests for management purposes, then an ethics permit is not required. Although monitoring of eagle nests on covenants is generally minimal. Management of wildfires around within nest reserves is permitted.		
10. Recreation (E.g. hiking, picnicking, biking and camping)	No human is permitted within NMA during the breeding season for recreational use. Outside the breeding season activities that can be deleterious to the conservation values of the covenant are not permitted.	The general public is welcome to visit PTPZ land but are advised to contact the Regional Offices beforehand. No camping in signed 'no camping' areas. Recreational activities are not permitted within the nest reserve.	Recreation on private land is permitted and encouraged and essentially unregulated and unrestricted. The TSL advises landholders to minimise their impact and avoid activities near nesting eagles during the breeding season.
11. Stock Management	Grazing is generally not permitted in the NMA during the breeding season. Mustering is not allowed at all during the breeding season.	Not applicable to PTPZ land.	Grazing is permitted at any time.
12. Hunting	No hunting is permitted within NMA during the breeding season. Control of exotic species is permitted outside the breeding season. Control of native species may be permitted outside the breeding season if authorised by the Minister and subject to standard permit requirements.	Hunters need a permit (from DPIPWE) to hunt on PTPZ land and may be restricted from entering eagle nesting sites at the discretion of the relevant Regional Forest Manager (Sustainable Timber Tasmania, 2019). Hunting at night is prohibited (Sustainable Timber Tasmania, 2019).	Feral, non-game species (rabbits, hares, cats, starlings, blackbirds, long-billed corellas) and non-protected native species (forest raven, great cormorant) may be hunted at any time. Regulations apply for hunting seasons of game species such as deer and native species. Hunting can occur anywhere on a private property. It is an offence to kill an eagle.
13. Weed control	The owner must control and where possible eradicate weeds. Declared weeds must be controlled (*Weed Management Act, 1999)* Control should only occur outside the breeding season.	Declared weeds must be controlled (*Weed Management Act 1999)*. Weed management can occur within the 10.ha buffer where nests are known to be not active.	Landholders must comply with the *Weed Management Act 1999*. Landholders can clear weeds anywhere on their property at any time of the year. Declared weeds must be controlled (*Weed Management Act 1999)*.
14. Pest Poisoning	No pest poisoning is permitted within the NMA during the breeding season. Pest poisoning is generally not permitted unless authorized by the Minister in exceptional circumstances, and subject to all other regulations.	1080 baits are not permitted on PTPZ land anymore.	It is an offence to use any poison outside the register list of poisons specified Under the Animal Welfare Act. Registered poison use come with responsibilities under civil law that must be followed. The use of anticoagulant pesticides and 1080 (dangerous to many animals, eagles included) require a permit under the *Nature Conservation Act 2002*.
15. Intensive agriculture	No intensive agriculture is permitted within the covenant or NMA.	Not applicable to PTPZ properties.	The TSPA governs the protection of eagles and any agricultural activities that are likely to have a significant impact on the eagles must be referred to the Minister to undergo environmental assessment.

4.1.2 Nest activity and management regime

In total 157 nests were surveyed; 56 nests on covenanted land, 55 nests on Permanent Timber Production Zones (PTPZ prescriptions) and 46 nests on non-protected land. Of the 157 nests surveyed 46.5% of nests were active (n=73), 34.4% were not-active (n= 54) and 19.1% were not found (n=30) (Table 8).

Table 8. Percentage and number of nest activity status across the three management regimes.

Activity Status	Covenanted		PTPZ prescriptions		Non-protected	
	Number	%	Number	%	Number	%
Active	28	50	25	45.4	20	43.8
Not- Active	13	23.2	28	51	13	28.1
Not Found	15	26. 8	2	3.6	13	28.1
Total number of nests	**56**	**100**	**55**	**100**	**46**	**100**

The proportion of active nests was slightly higher on covenanted and non-protected management regimes, compared to those managed under PTPZ prescriptions (Table 9), however this difference was not statistically significant, suggesting nest activity was not directly related to land management regime ($Chi^2 = 4.946$, d.f = 2, p = 0.084).

Table 9. Chi-square Test for homogeneity between 'Activity' and 'Management regime'.

	Covenanted	PTPZ prescriptions	Non-Protected	All
Active	28	25	20	**73**
Expected	*23.57*	*30.46*	*18.97*	
Not Active	13	28	13	**54**
Expected	*17.43*	*22.54*	*14.03*	
All	**41**	**52**	**34**	**127**

4.1.3 Habitat variables and nest activity

Of the 10 continuous habitat variables included in the analysis, only two variables were found to be directly related to nest activity. The two variables 'percentage of native forest within 5000 m of nest' and 'distance from nest to nearest road' were found to have a statistically significant relationship with the activity status of the nest (Table 10).

The two categorical habitat variables 'Road type' and 'Forest patch size' had no relationship with the activity of nests. Road type ($Chi^2 = 7.201$, d.f = 4, p = 0.126), Forest Type ($Chi^2 = 1.326$, d.f = 2, p = 0.515).

Table 10. Analysis of variance between the various continuous habitat variables and 'Nest Activity'. Habitat variables that have a p-value of <0.05 are highlighted in bold indicating a significant relationship.

Habitat Variables	Mean value (active nests)	Mean value (non-active nests)	f-value	p-value
Percentage of native forest within 500 m of nest.	73.42%	77.74%	0.26	0.609
Percentage of native forest within 1000 m of nest.	65.32%	71.06%	0.417	0.138
Percentage of native forest within 5000 m of nest.	51.96%	61.28%	0.071	**0.019**
Shortest distance from nest to boundary of forest patch.	353.9 m	349.2 m	0.00	0.955
Percentage of non-native habitat within 500 m of nest.	16.81%	14.54%	0.57	0.451
Percentage of non-native habitat within 1000 m of nest.	22.90%	21.58%	0.45	0.505
Percentage of non-native habitat within 5000 m of nest.	30.42%	28.91%	0.49	0.486
Shortest distance from nest to non-native habitat.	880 m	861 m	0.01	0.924
Roads within 1000 m of nest.	3813 m	4257 m	0.88	0.347
Distance from nest to nearest road.	528.6 m	322.5 m	5.41	**0.022**

Nests were less likely to be active in locations with a higher percentage of forest cover within 5000 m (ANOVA, F = 0.071, d.f = 1, p = 0.019) with a mean forest cover of 51.96% (+/- 2.7 standard error) for active nests compared to a mean forest cover of 61.28% (+/- 3.3 standard error) for non-active nests. The percentage of forest cover surrounding active nests was also much more variable, with values between 30% and 71% of forest cover compared to between 52% and 76% for non-active nests.

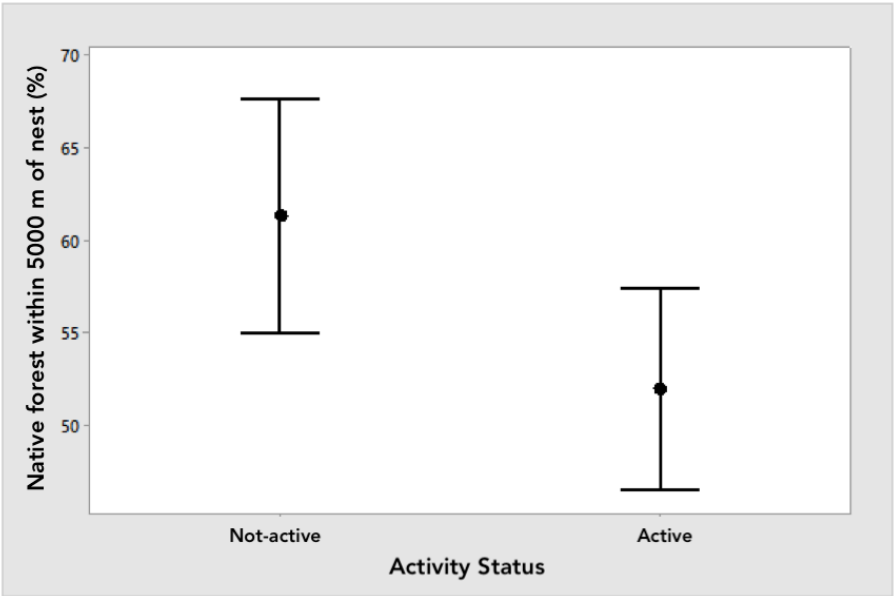

Figure 6. Interval plot of the percentage of forested land within 5000 m of the nest in relationship to nest activity status

Nests were also more likely to be active when located further away from roads (this included any type of road) (Figure 7, ANOVA, F = 5.41, d.f = 1, p = 0.022). The average distance to road for an active nest was 528 m (+/- 73 m standard error), compared to an average of 322.5 m (+/- 27m standard error) for non-active nests. Interestingly, however, 17 of the 73 active nests (23%) located in this study were within 200 m of a road including one active nest only 10 m from the closest road.

Figure 7. Interval plot of the distance from nest to the nearest road in relation to activity status

4.1.4 Habitat variables and management regime

Of the 10 continuous habitat variables tested, all had a statistically significant relationship with management regime (Table 11). Overall, native forest cover was greater and the distance to forest boundary longer on PTPZs than on covenanted and non-protected land, while the reverse was true of non-native habitat (See Appendix 14). Nests on covenanted land were typically further from roads (ANOVA, F = 3.99, d.f = 2, p = 0.020) with the average distance from the nest to road on covenanted properties being 587 m (+/- 108.5 standard error) compared to an average of 308 m (+/- 23.74 standard error) for PTPZ properties. The total length of road within 1000 m of a nest was also significantly shorter surrounding covenanted nests compared to nests protected by PTPZ prescriptions and nests with no protection at all (ANOVA, F = 7.27, d.f = 2, p = 0.001).

Table 11. Analysis of variance between habitat variables and management regime and their associated P-values. All habitat variables have a P-value of <0.05 and are therefore significant and highlighted in bold.

Habitat Variables	Mean Covenanted	Mean PTPZ Prescriptions	Mean Non-protected	f-value	p-value
Percentage of Native forest within 500 m of nest.	70.09%	83.82%	61.85%	9.56	**0.000**
Percentage of Native forest within 1000 m of nest.	58.29%	80.52%	53.61%	13.12	**0.000**
Percentage of Native forest within 5000 m of nest.	44.43%	70.99%	42.04%	28.22	**0.000**
Shortest distance from nest to boundary of forest patch.	360.1 m	451.3 m	200.5 m	3.76	**0.025**
Percentage of non-native habitat within 500 m of nest.	18.18%	8.94%	30.82%	11.13	**0.000**
Percentage of non-native habitat within 1000 m of nest.	25.96%	12.54%	37.59%	14.00	**0.000**
Percentage of non-native habitat within 5000 m of nest.	31.90%	17.71%	49.43%	24.63	**0.000**
Shortest distance from nest to non-native habitat	794 m	1219 m	356.2 m	9.83	**0.001**
Roads within 1000 m of nest	3081 m	4616 m	4768 m	7.27	**0.001**
Distance from nest to nearest road	587 m	308.3 m	401.3 m	3.99	**0.020**

Of the two categorical variables examined 'forest patch size' and 'road type' showed a statistically significant relationship with management regime. The proportion of forest patch size was larger on covenant and PTPZ land than it was on non-protected properties ($Chi^2 = 17.192$, d.f = 4, p = 0.002). Non-protected properties had more nests occurring within less than 10 ha of forested land than covenanted nests and nests on PTPZ properties (Table 12), and there was a higher proportion of type 1 roads (quiet bush tracks) and a lower proportion of type 4 roads (busy highway) surrounding covenanted nests compared to the other two land tenures (Table 13, $Chi^2 = 28.950$, d.f = 8, p = <0.001).

Table 12. Chi-square test of nests occurring within three different patch sizes, greater than 35 ha, between 10-35 ha and less than 10 ha across three difference management regimes.

Forest patch size	***Covenanted***	***PTPZ prescription***	***Non-Protected***	***All***
<10 ha *Expected*	2 *7.847*	7 *7.707*	13 *6.446*	**22**
10 – 35 ha *Expected*	9 *5.350*	2 *5.255*	4 *4.395*	**15**
>35 ha *Expected*	45 *42.803*	46 *42.038*	29 *35.159*	**120**
All	**56**	**55**	**46**	**157**

Table 13. Chi-square test of the average road types occurring within 1000 m of nests across three different management regimes. Road types included: 1 - low impact (bush tracks and small off-roads rarely used by multiple vehicles). 2 - low/medium impact (dirt roads, typically used by vehicles). 3 - medium/high impact (suburban and country roads including railways, used by many vehicles daily). 4 - high impact (main roads and highways used by a high number of vehicles daily).

Road Type	***Covenanted***	***PTPZ Prescriptions***	***Non-Protected***	***All***
No Roads	4	0	3	**7**
Expected	*2.497*	*2.452*	*2.051*	
Type 1	30	14	10	**54**
Expected	*19.261*	*18.917*	*15.822*	
Type 2	15	31	18	**64**
Expected	*22.828*	*22.420*	*18.752*	
Type 3	6	4	5	**15**
Expected	*5.350*	*5.255*	*4.395*	
Type 4	1	6	10	**17**
Expected	*6.064*	*5.955*	*5.981*	
All	**56**	**55**	**46**	**157**

4.1.5 Covenanted land

There was no statistically significant relationships between the activity of a nest and the size of the covenant (ANOVA, F = 0.02, d.f =1, P = 0.888), the distance from the nest to the covenant boundary (ANOVA, F = 0.12, d.f, 1, P = 0.732) or the percentage of covenanted land within a 35 ha buffer surrounding the nest (ANOVA, F = 0.75, d.f = 1, P = 0.393). When including a 35 ha buffer directly around the nests (See Table 4 in Methods), on average 71% of all covenants were included within this buffer.

4.2 Part 2 – Social science results: questionnaire survey and qualitative interviews

Of the 36 covenant surveys and 38 non-protected surveys distributed (n=75), 33.3% of covenant surveys were completed (n= 12) and 23.6% of non-protected surveys were completed (n=9). Four landholders with conservation covenants were interviewed between the 6th and 11th of June. One landholder from a non-covenanted property was interviewed on the 18th of June. The results from the survey and the interviews are presented together below, with the interview material used to illustrate, exemplify and elaborate on key findings from the survey.

4.2.1 Demographics

The majority of survey respondents were male (male=15, female = 6), with far more males responding on non-protected properties than covenanted properties (Figure 8). The age of respondents varied between the ages of 35-75, with most aged between 55-64 years (Figure 9). Most participants from non-protected properties had a tertiary degree or diploma; whereas the majority of covenant owners had either a tertiary degree, diploma or a postgraduate degree (Figure 10). Nearly all of the respondents across both management regimes were self-employed or employed full-time with only one part-time/causal worker and two retirees both on conservation properties (Figure 11). Most participants made an income from their land with three covenanted properties solely used for conservation and four properties, for lifestyle purposes (Figure 12).

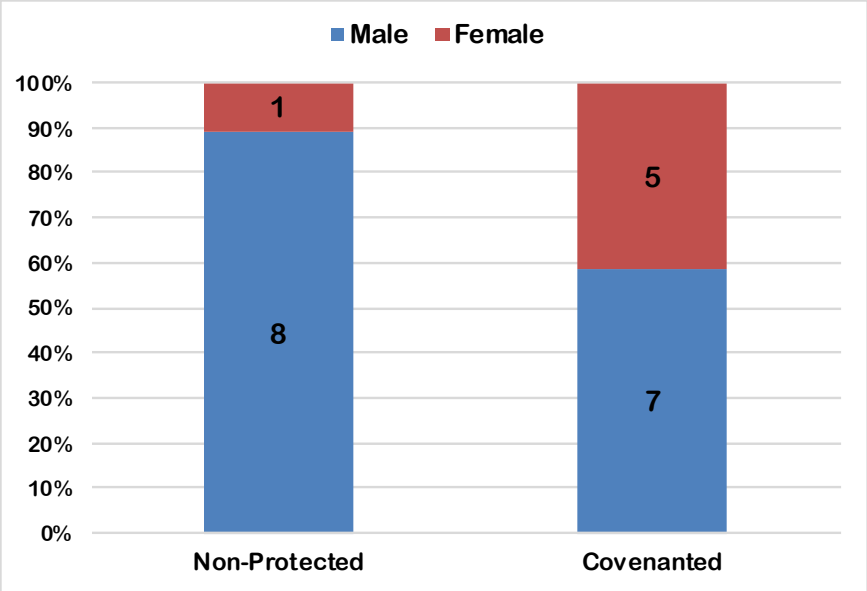

Figure 8. Gender of survey participants across both covenant and non-protected properties.

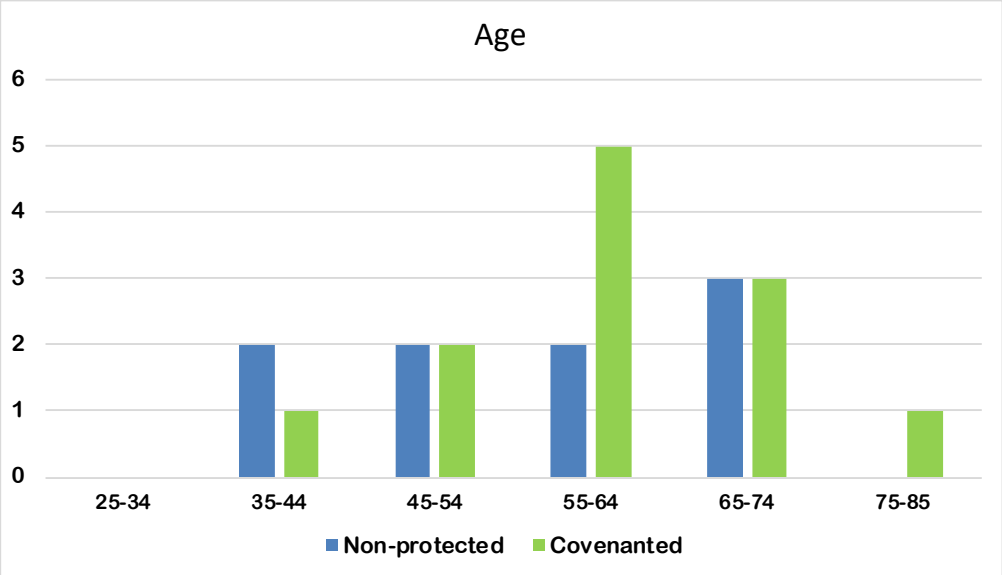

Figure 9. Age of participants across both land tenures

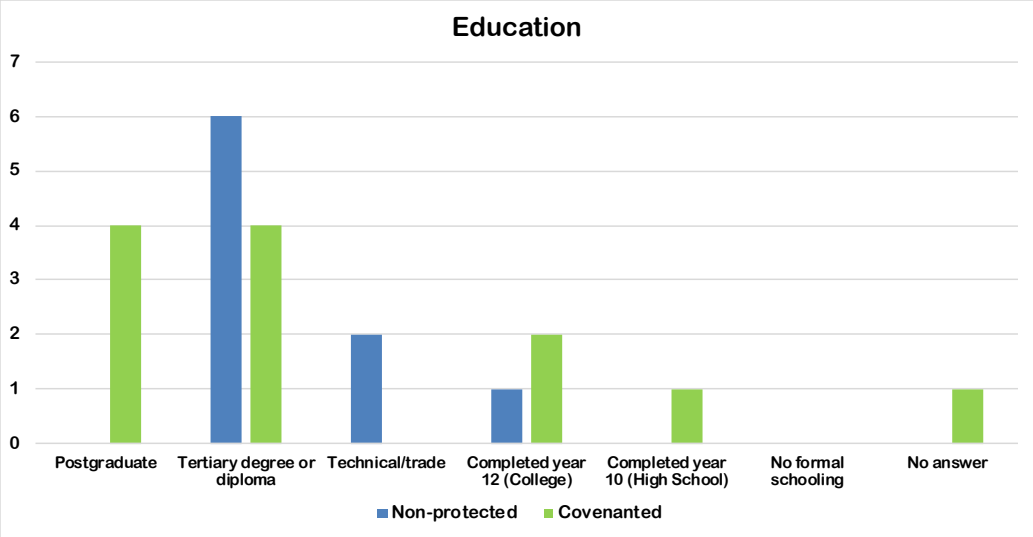

Figure 10. Education level of participants across both land tenures

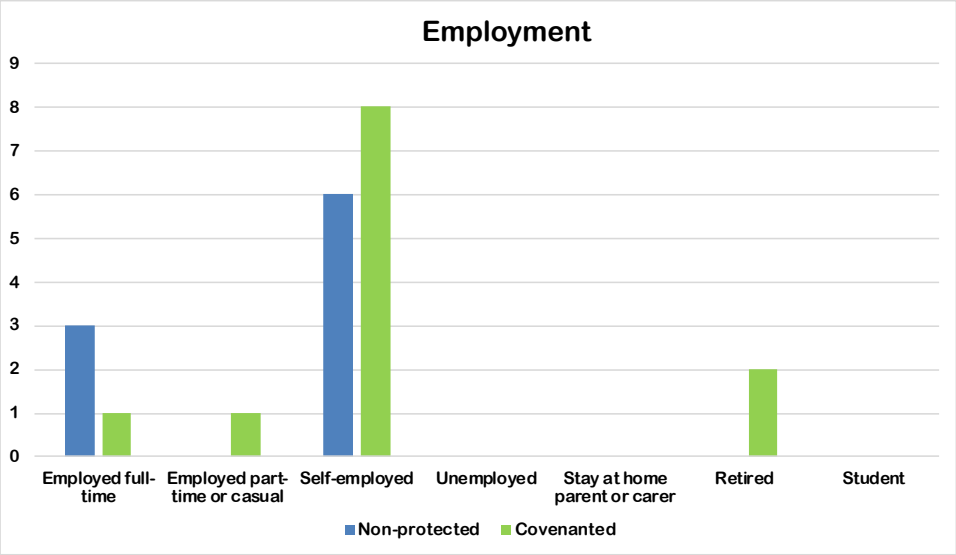

Figure 11. Employment type of participants across both land tenures

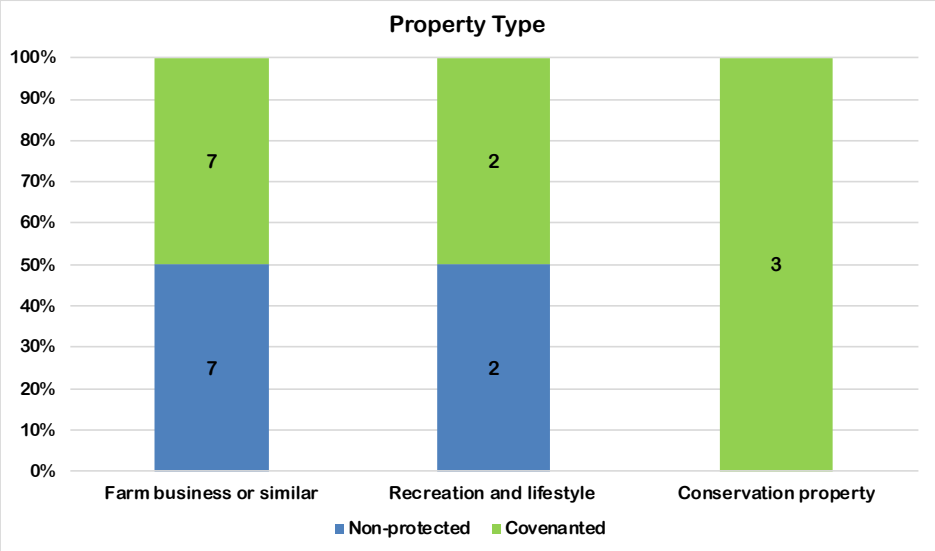

Figure 12. Property types of each participant across both land tenures

4.2.2 Motivations for participating in covenanting programs

The results of respondent's answers from a 5-point Likert scale for what motivated them to join a conservation covenanting program are presented in Figure 13.

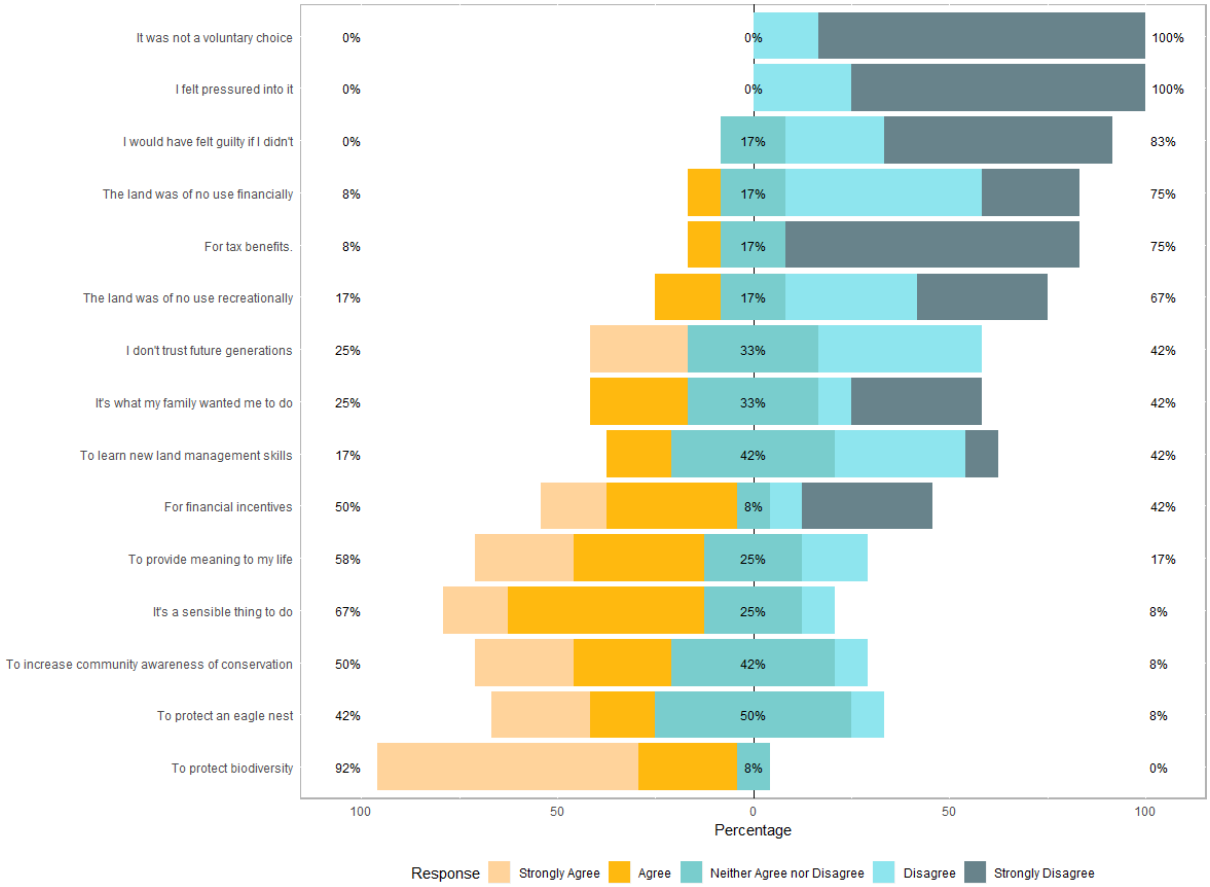

Figure 13. A Likert scale representing (in percentages) what motivated participants of conservation covenant properties to join a covenanting program

Of the 12 participants with conservation covenants, 92% of respondents either strongly agreed or agreed that "Protecting biodiversity and natural values such as threatened species and habitats" was a primary motivation for them joining the covenanting program. In the interviews, it was apparent that the motivation to protect biodiversity was evident even for those who generate an income from their land:

> We're really, really keen on wildlife. (W020E)

> Our neighbour covenanted the land, we thought he did it for finance reasons, but he didn't, he did it to conserve it for proper reasons, even though he is a sheep farmer, he saw it as beneficial to conserving the vegetation and protect the wildlife. (W019E).

> Our primary industry is sheep grazing, but my parents were very supportive of conservation and also wanted to protect the wildlife such as the eagles. (W034E)

> My dad had the ability to log the property but never did. After he passed, I had to pay for the property so it wouldn't be logged, otherwise that eagle nest would have been gone 20 years ago. I wanted to protect the bush and just leave it. (W036E)

A further 67% of survey respondents also strongly agreed or agreed that they joined a covenanting program because "It's a sensible thing given the decline in biodiversity" and 58% agreed it "It provides me with more meaning to life". Of the 12 survey respondents, no one felt pressured into covenanting their property and all agreed that covenanting their property was a voluntary choice. Respondents (83%) strongly disagreed or disagreed that they covenanted their land out of guilt and 75% of respondents admit that their land was of use to them financially before covenanting the property and that tax benefits were not a primary motivator for covenanting their land.

Furthermore, eagle nest protection wasn't considered a primary motivation for survey respondents covenanting their property with only 42% agreeing it was a key motivation, a lower percentage than what financial incentives received from survey respondents at 50 %.

When covenanted owners were asked what their key motivations for protecting an eagle nest on their property were, 80% of respondents strongly agreed and agreed that it was because "eagle play an important ecological role in the Tasmanian ecosystem" with a further 70% agreeing that they have a "strong personal connection to the eagles" on their property and 50% of respondents agreeing that "financial incentives" were a key motivation to protect the eagles (Figure 14). One survey respondent left a comment at the end of their survey about eagles taking lambs;

> Eagles to the east of York Plains are now regularly reported by farming friends that they are preying on stock. Healthy young lambs around 3-4 months old are being targeted. Some eagles puncture the lungs of lambs when they are grabbed, and lambs then die. Eagles in the last 5 years have been very bold and not shy of farming activities. They have circled me and followed me on the motor bike. Eagles are about daily; you can get close to the eagles at times. (W009E)

When asked what they thought the wider consensus was in their surrounding community regarding eagles, interviewees from both covenanted and non-covenanted properties documented a sense that attitudes were in the process of changing and that the eagle population was strong:

> I do think that most people that have an eagle tree on their property…so long as they don't think that it is going to interfere with what they might do with their property or the future of their children…. are probably quite happy to have a covenant on it. (W020E).

> I think it depends a little bit on the individual farming family as to whether they see eagles as a threat or whether they are something they want to conserve, in saying that I think the eagle population is strong in our area, it is not uncommon to see an eagle daily. Myself and other farmers provide them with a lot of food though, through wildlife culling, it keeps the eagles away from the sheep. I am only new to farming, but I have never seen an eagle take a live lamb, I have seen them take dead ones, but I have been told they do take live ones. (W034E).

> The public image of eagles has changed. People like seeing them and know they are an important part of the ecosystem and know they have been hit hard in the past. This new generation coming on certainly have a more positive mindset towards eagles, the older generation are not managing these farms anymore and they're the ones that were shooting them. It was just the culture back then. (W036E)

> My neighbour said the eagles had picked up a few of his lambs, but his reaction to that is to cull some of the wallabies for the eagles to consume, to elevate the problem of the eagles taking the lambs. (W019E).
>
> Most of the neighbours are cropping farmers so they don't have issues with the eagles, and I don't see the eagles over near the one neighbour who does graze sheep. I have never had the eagles try to take lambs, but I did see a sea-eagle eating a lamb that died in birth. I haven't had trouble with the wedge-tails taking lambs, but they have flow down to check out my dog a few times. There are probably some landholders though that would take any chance they get to shoot them, like that guy over in Victoria recently, especially on some of the bigger properties where no one would ever know. (W040S).

One interviewee who covenanted their land which completely restricted their own income possibilities felt strongly about the eagles on their land:

> It was a sheep grazing property; it has shearing sheds and fences. It is wonderful sheep country. I miss that possibility of an income, but I do love the eagles and it is a place they have always been and I want them to always be there. (W036E)

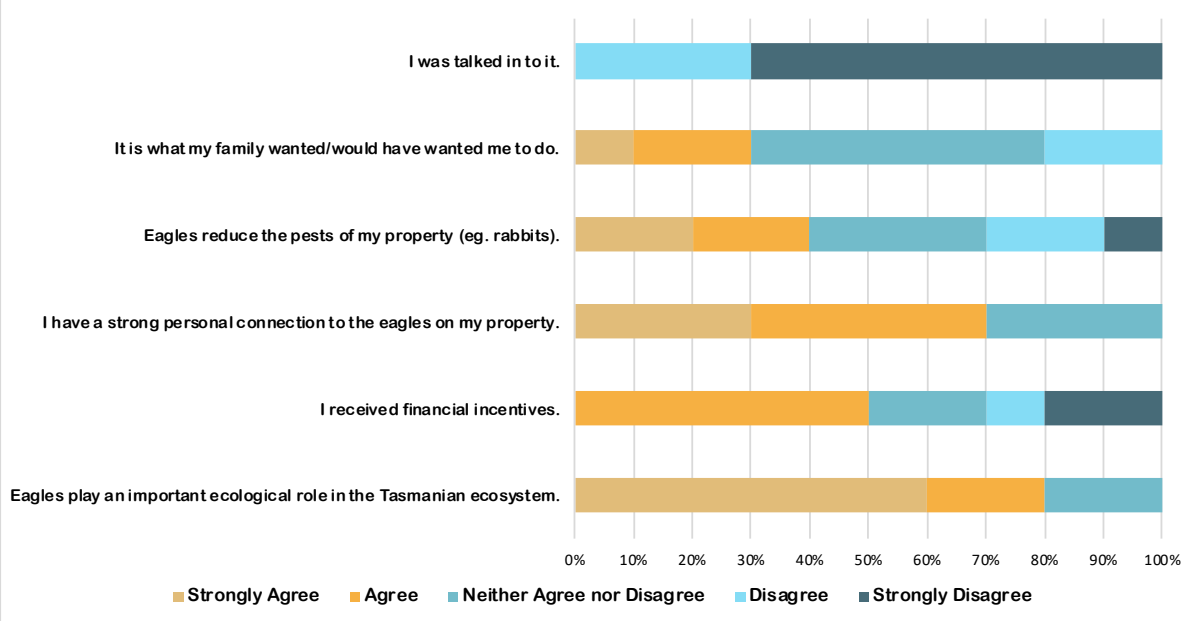

Figure 14. Motivations for participants with covenanted properties to protect an eagle nest site

Most respondents with conservation covenants (67%) joined their respective covenanting program by approaching an organisation (Figure 15). When asked what they would like to see more of from the program 33% of respondents didn't think anything extra was needed, a further 33% of respondents said that they would like to receive greater financial assistance (Figure 16), followed by more practical assistance (17%). One respondent (W030E) selected 'other' stating that they wanted to have "more flexibility in what we can do with the land". This same respondent was the only landholder that agreed that they regretted covenanting their land, expressing that "the covenant is too restricted on how we can use the land". All respondents agreed that they did not regret covenanting their land, although two respondents said that they neither agreed nor disagreed with regretting covenanting their land stating that:

> The proponents of the covenanting program did not tell the whole truth. (W008E).

> I may well regret covenanting my land into the future but as things stand, I am happy with the covenant but when/if eagles and the property or my situation change, who knows. (W036E).

When respondent W036E was later interviewed and asked to elaborate on why they may regret covenanting their property in the future it was evident that the respondent was upset with the system:

> I covenanted the property and got a bit of money back for it. That money went into an account to manage the land for conservation but because of my circumstances that money has gone and was given to my ex-partner after we divorced. There is nothing left now to pay anything into the future, and it had nothing to do with my mismanagement of the property. That money should have been set aside for the property, so now I have nothing, my situation is not good, there is a lot wrong with the system. (W036E).

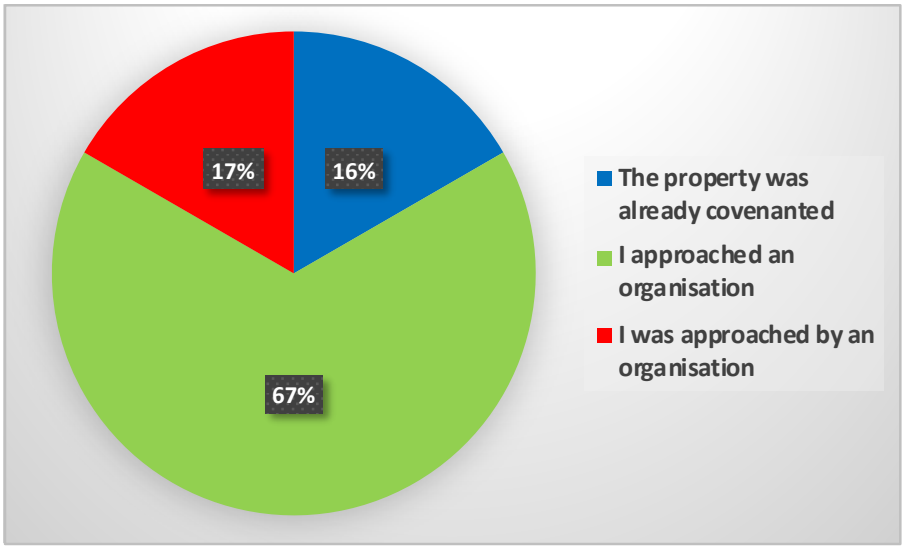

Figure 15. A pie chart of how respondents of covenanted properties got involved in their respective conservation covenant program

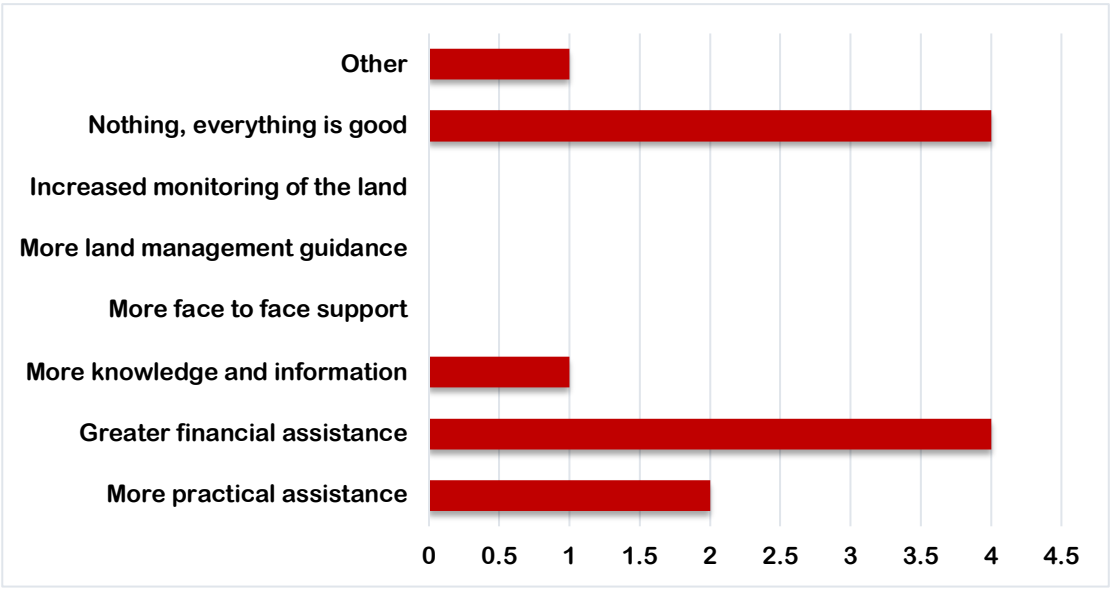

Figure 16. What further assistance conservation covenant owners would like from their respective covenanting bodies

For non-covenanted landholders, the results of respondent's answers from a 5-point Likert scale for what *would* motivate them to join a conservation covenanting program are found in Figure 17. Of the 9 participants without conservation covenants, 38% of respondents either strongly agreed or agreed that "protecting an eagle nest" and "financial incentives" are primary motivations for them possibly joining a covenanting program. Eagle nest protection was slightly higher than with 25% strongly agreeing. however, most respondents disagreed that protecting an eagle nest was a primary motivation.

Of the one non-covenanted landholder interviewed the main motivation for them possibly covenanting their land was "financial incentives", particularly to be used to benefit their farming practices:

> We were going to have the land logged this year. We are going to log 55 acers out of the 85 acers, so we are leaving a 35 acers circle around the eagle nest, which I didn't want to log anyway, for me the eagle nest was a good excuse to not allow them to log it. We are logging it because the undergrowth is just too thick, you can't even walk through it. Ideally, if there was money available, I'd like to clear all the rubbish under the trees so I can open it up for the cattle to graze in and leave the trees standing. So if there was government money available to protect that area where the eagle nest is that will allow me to clear all the weeds then I prefer that idea" (W040S).

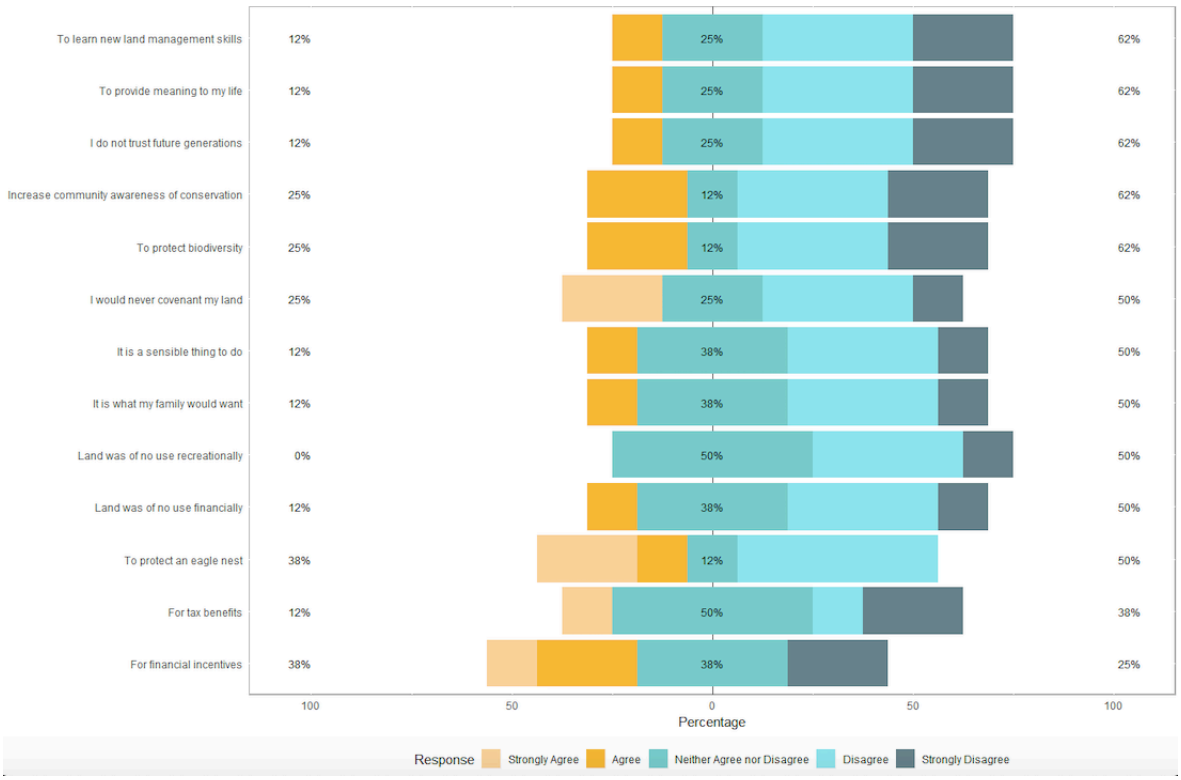

Figure 17. A Likert scale representing (in percentages) what would motivate participants of non-covenanted properties to join a covenanting program

4.2.3 Changes to land management activities.

When asked how their land management activities have changed since joining a covenanting program, 33-67% of all land management activities had "not changed" since properties were covenanted, with revegetation and controlled burning of vegetation being the main activities that had not changed

(67%). The land activity that had "decreased" both a little and a lot was livestock grazing (50%) and firewood harvesting (50%) followed by hunting of both feral and native animals and recreation (all 33%). Whilst no land activity 'increased a lot' the land activity that mostly 'increased a little' was 'weed control (50%) followed by fencing/other infrastructure (33%) and recreation (17%) (Figure 18). In interviews, participants explained on how their management practices had been influences by having a covenant:

> Some of our covenants allow grazing, the one with the eagle does, but it's rough country over there. The intensity of grazing has reduced though, we move the sheep more often now, whilst another covenant is a 'no grazing' zone, they have different restrictions. (W034E).

Some interview participants also reported a reduced disturbance to the eagles from third-parties:

> Since we moved here, activities from trespassers has decreased. We do get people shooting along the road, it's illegal to shoot on a public road. Wood-hookers have reduced, but we have caught people, we tell them it is a conservation property and they usually say "we have always done this" but they leave when we tell them. (W020E)

> Our neighbours are good at policing who comes in along the road, so we don't get many trespassers. (W019E).

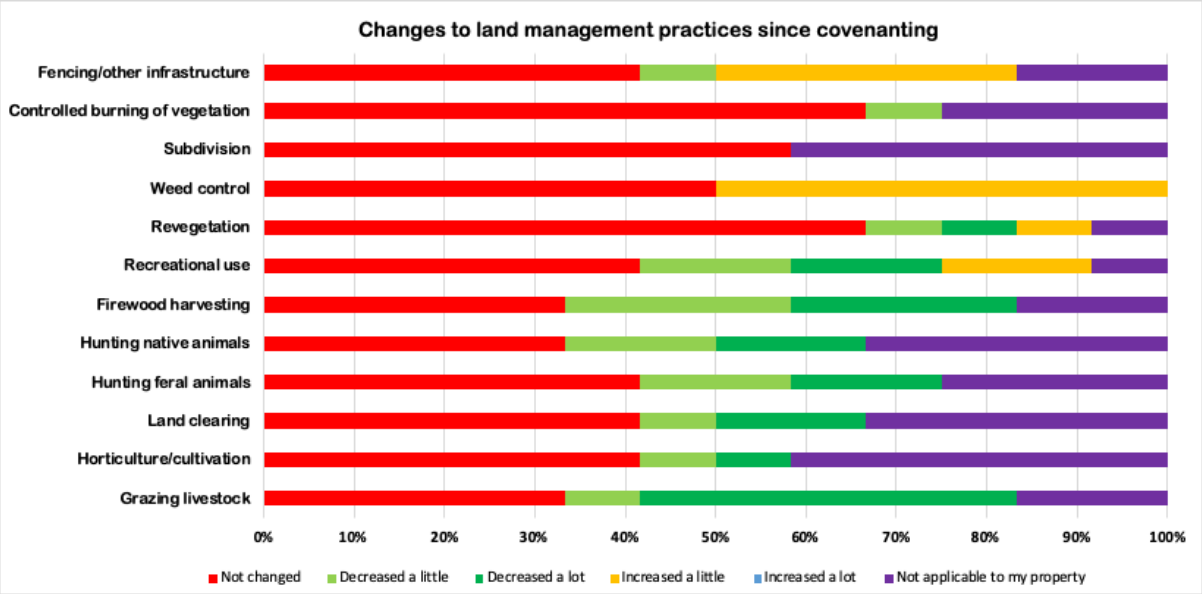

Figure 18. A Likert scale of the changes to land management practices for landholders with conservation covenants since covenanting their property.

For non-protected properties 50% of land holders were willing to 'decrease a little' "hunting native animals" and "firewood harvesting". Furthermore 25% of participants said they would 'decrease a lot' "land clearing, fencing/other infrastructure and controlled burning of vegetation" (Figure 19).

The interview response for this question with participant W040S was of uncertainly, explaining that it would depend on how restricting the covenant was on what they could and could not do to the land:

> Depending on the restrictions, but I don't use the land where the nest is now, if I clear out the undergrowth and weeds, I would like to graze but that's it. My intention is to leave the area of

> bush surrounding the eagle, we might want to fell a tree here and there for firewood or posts if needed though. (W040S).

Furthermore, when asked what land management activities they believed were the greatest threat to the eagles, participant W040S believe that land clearing and possible persecution due to lamb protection were the greatest threats.

> There is some land clearing going on, there was another 340 acres of bush next to our bush that has just been logged. The biggest threat though is, if the eagles started preying on lambs more, farmers won't like that. The wallaby problem has declined in the area due to culling and fencing, so the eagles don't have much native food about. (W040S).

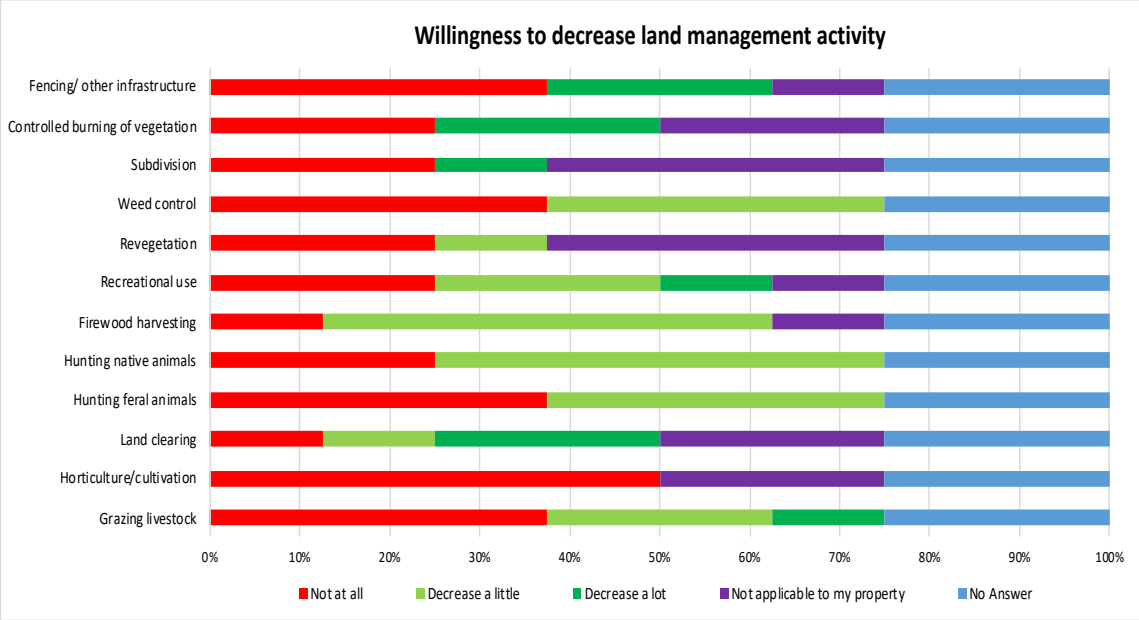

Figure 19. A Likert scale of what landholders of non-protected properties would be willing to change on their property if they were to get a conservation covenant.

Interview participants from covenanting properties also touched on several other topics not mentioned in the survey that, as the project went on, were considered relevant information. These themes included property monitoring for compliance and conservational outcomes on covenanted properties, why many landholders don't participate in covenanting programs and whether they think conservation covenants are effective. When covenant owners were asked if monitoring occurred on their property the answers from interviewees were varied:

> Yes, a few times, though they don't have enough time to do it often, they only have two or three officers and so they have to concentrate on people who they think are not doing the right thing. They don't focus on the eagle nest, its more monitoring vegetation. (W020E).

> Yes, a few times we have had people out, to make sure we are doing everything right (W034E).

> No, I have heard nothing, for 12 years, which is not good, no one has contacted me, we did several years of monitoring at the start but nothing recent. (W036E).

> No, they haven't asked to come out at all, I haven't had any contact with them really, I would like to have an investigation with all the wildlife, to see what is actually there on the property (W019E).

Furthermore, one participant was concerned that the lack of monitoring may result in misuse of the covenants.

> There is no money for monitoring. A lot of farmers know that, so they covenant their land for financial incentives. We know of a guy who did it strictly for the money, he said 'they wouldn't know what I am doing here, they don't come to check the property, so I just do what I always use to do. (W020E).

Interviewees were asked what they thought were the main reasons for landholders choosing not to participate in covenanting programs to protect an eagle nest:

> I think there are a lot of farmers that would still like to protect eagles without a covenant, a lot of farmers don't like the idea of a covenant on their property, they don't want government people on their land nor to be told how to use their land. (W034E).

> People are worried they are tying their kids' hands by putting a covenant on. Also, our neighbours were going to get a covenant but pulled out at the last minute. I think a lot of people are frighted that the government tells them what to do. (W020E).

> The biggest issue, where I think the community has fallen short of this, and this is a local council thing, there is no reduction on the rates or tax benefits, they value the property as if it's a working farm and they rate it as such and charge me as such. The property's value is only a third or a quarter of what it was because nothing can be done with it [due to having a covenant] and it is really unfair for the landholders to take all the brunt by paying council rates on the land. Who is going to buy land where the rates are still the same, but you can't do anything on the property and make an income from it? I think the community should have to pay to protect the eagles, through the local council. (W036E).

Finally, interviewees were asked whether they though covenants were effective and if not whether they could think of a more effective way to protect eagles. Covenant owners collectively thought covenants were effective in the hands of the right owners. Participant W034E and W036E both came up with very similar ideas to protect the eagles during the breeding season that might be more attractive to a wider variety of landholders. This was through the uses of a buffer zone, such as an eagle Nest Management Area where financial incentives (paid by the community) were provided to protect this area during the breeding season, rather than covenanting the whole property.

> Yes, I do think covenants are effective, definitely! If it didn't have a covenant, people could have subdivided this property, and now they can't. (W020E).

> Maybe there are other ways to protect eagle nests, like those 20 ha protection zones. I am of the view, that if the community want landholders to protect eagles then the community needs to pay for it. We need to know what sort of cost the community is willing to bare for landholders to protect their eagle on their property within 20 ha. I think most farmers would prefer an annual contribution for offsetting what they have to do around their nest at 20 ha. Farmers that don't want covenants still probably want to protect eagles so I think that would be a more effective tool than trying to get someone to covenant their whole property. (W034E).

> I think it comes down to the landholder, do they like eagles and want to protect them or are they just after a financial incentive? For my own situation, if I hadn't covenanted my land it could have been logged in the future when the land changes hand, covenants are effective if the land changes hands. As for something more effective…I think an agreement about the nest and a little financial incentive will help the eagles better than a covenant, because many farmers won't covenant their land and have someone tell them what to do. (W036E).
>
> I think they are effective, but I also think they could be more effective. For example, isolated covenants could be more effective if the land around them became covenanted also, protecting eagles is more effective if you protect the habitat around the nest also from all sides, their hunting habitat is just as important as their nesting habitat. (W019E).

4.2.4 Conclusion

The results from this chapter will be further explored in Chapter 5, where I discuss these results in the context of the ecological and social research questions.

5 Chapter 5 – Discussion

This discussion chapter is organised around the four key research questions that have provided direction for the research. In Part 1 I focus on addressing the ecological research questions relating to the different land management regimes operating in Tasmania and the effectiveness of covenants in protecting eagle nests. In Part 2 I discuss the social science research questions pertaining to landholder motivations for covenants and changes to land management practices as a result of covenants. Lastly, I bring together key aspects of the ecological and social findings to create an overall representation of eagle nest protection in Tasmania.

5.1 Part 1 – The effectiveness of conservation covenants in enhancing the breeding activity of eagles in Tasmania

This research thesis has sought to better understand the effectiveness of covenants as a specific mechanism for protecting eagles nest covenants in Tasmania. Covenant effectiveness has been a topic of recent interest within private land conservation organisations such as the Tasmanian Land Conservancy (TLC), relevant government departments within the Department of Primary Industries, Parks, Water and Environment (DPIPWE), such as the Private Land Conservation Program (PLCP), as well as within academic literatures (Fitzsimons & Carr, 2014; Iftekhar et al., 2014; Hardy et al., 2017). Concerns about the effectiveness of covenants have ranged from political economy approaches that critique covenants as a means for facilitating ongoing 'business as usual' development (Gibbons & Lindenmayer, 2007; England, 2015) to technical approaches that see inherent value in covenants, but have raised questions about their design, monitoring and enforcement (Adams & Moon, 2013; Fitzsimons & Carr, 2014). This project adds insight into the growing level of knowledge about the effectiveness of covenants by focusing on the socio-ecological approaches that identifies a covenants ability to promote positive ecological outcomes and how the role of landholders help achieve those results.

5.1.1 Comparisons of prescription

This study found that prescriptions aimed at protecting eagle nests on both covenanted land and PTPZ prescription land provide critical protection during the breeding season where eagles are the most susceptible to disturbance. This included no construction, subdivision, vegetation clearing (excluding

weed control), fuel reduction burning, firewood collection, vehicle use, recreation, hunting, pest poisoning or intensive agricultural activity surrounding a nest. For PTPZ this meant no activities within a minimum of a 10 ha nest reserve at all times or within 500 m 'out of sight' (OOS) (a mechanical noise exclusion area) and 1000 m 'line of sight' (LOS) of an active nest during the breeding season. For covenant properties this meant no activity within the 20 ha Nest Management Area (NMA) during the breeding season or depending on the covenant, not on the covenant at all. In contrast non-protected land has little to no regulation of activities that occur on these properties in regard to eagle nests and the only protection eagles have on these properties are guidelines and restrictions that may be set out by local councils, the *Environmental Protection and Biodiversity Conservation Act 1999* or *Threatened Species Protection Act 1995,* which apply across all land tenures. Whilst the two prescriptions had a lot of similarities a few strengths and weaknesses relating to placement and size of the buffers and the eagle's line of sight were apparent.

Firstly, the placement and size of the buffer zones surrounding the nest is important. When choosing a nest to protect for the Eagle Nest Protection Program (ENPP) officers from the Tasmanian Land Conservancy reported that it was important to concentrate on protecting the land uphill from the nest due to greater disturbance to eagles above the nest compared to below it (pers com. Leigh Walters, 2019). The Forest Practices Authority (FPA) also aim to protect nests on PTPZ land with greater protection on the uphill slope (Forest Practices Authority, 2006). The extra protection uphill from the slope allows for less disturbance to the eagles. It was recommended by Mooney and Holdsworth (1991) that a 20 ha buffer zone around eagle nests was necessary, although this recommendation has never been adopted by the commercial forest industry. Despite this, the 10 ha minimal reserve zone has been considered an effective prescription against disturbances (Koch et al., 2013) although it should be noted that many nest reserves on PTPZ are larger than 10 ha and that 10 ha is a minimum. Other studies concluded that whilst spatial buffers for birds of prey to reduce disturbance are considered to be an effective tool for conservation (Richardson & Miller, 1997; Guinn, 2013; Cruz et al., 2018), increasing their size, especially for larger raptors in tall emergent trees, would allow more line of sight protection in the greater landscape thus increasing eagle breeding success (Mooney & Holdsworth, 1991; Dennis et al., 2011; Debus et al., 2014). Covenanted properties, where possible, adopt the recommended 20 ha NMA although not all covenants have an eagle NMA, in these cases the covenant solely provides the protection, with results from this study indicating that 71% of all covenants were protecting at least 35 ha of direct land surrounding the nests, well over the 20 ha recommendation. Furthermore, the forest patch size surrounding both covenant and PTPZ nests was generally greater than 35 ha. significantly larger compared to non-protected land.

Secondly, a clear line of sight is an important factor in an eagle's response to a particular disturbance. Thus by reducing activities within the line of sight of a nest can significantly reduce the threat to the eagle (Richardson & Miller, 1997). The 1000 m LOS regulations were generally completely adopted on PTPZ land, whereas adoption on covenanted lands were more restricted, likely owing to the locations of the nest in relation to covenant boundaries. On average, nests were within 258.8 m of a covenant boundary (where the majority of neighbouring properties were non-protected), a far less distance than the 1000 m LOS recommendations. therefore, adopting the use of a 1000 m LOS on covenant properties would be beneficial to eagle nest protection. Interestingly though, the distance from the nest to the boundary had no apparent effects on nest activity. However, this result should be considered with caution and could be attributed to several factors:

(1) the neighbouring property may not have been within LOS of the nest due to topography;
(2) the neighbouring properties may be well forested;

(3) the neighbouring properties may be used for light sheep grazing only - without the presence of humans, sheep grazing doesn't disturb nesting eagle (N. Mooney 2019, pers coms.); and
(4) habituation could be occurring with some individual eagles nesting within small covenants or close to the boundary.

Overall, both eagle NMA on covenants and nest reserves on PTPZ land should aim for a minimum 20 ha reserve as recommended for larger birds of prey and all covenants with eagle nests should include a NMA to ensure greater protection surrounding the nest. Furthermore, current covenants do risk greater potential disturbance from neighbouring properties and unlike PTPZ do not always take into account the eagles potential 1000 m LOS. The differences between these management prescriptions provide useful information on their strengths and weaknesses that can be used to develop sounder prescriptions in the future.

5.1.2 Nest activity and management regime

In this research an analysis of nest activity rates across the three different management regimes revealed no significant relationship between the proportion of active nests across the three regimes. On face value, this finding suggests that covenanted prescriptions are no more effective than PTPZ prescriptions or non-protected properties when it comes to enhancing eagle nest activity. The lack of a significant relationship between nest activity and management regime deserves careful consideration and contextualisation, especially given the high levels of protection through management prescriptions for nests on both covenanted and PTPZ properties compared to nests with no protection in place. Indeed, the result does not necessarily mean covenants are unsuccessful in their goal to protect eagle breeding sites. It may be that variation between covenant properties and non-protected properties may not be that different from one another or an underlying effect is skewing the results. Similarities in the nest activity rates of the three different land regimes may be attributed to several different factors. Below I offer three possible explanations for this result.

Firstly, the habitats targeted by eagles for nesting are primarily old-growth eucalypt forests and woodland, high up on slopes with sheltered aspects (Mooney, 2005). This habitat is generally not well suited to many agricultural land use activities and for similar reasons has been subject to limited land conversion pressures associated with urban development (Joppa & Pfaff, 2009). Therefore, the threats to eagles identified in Chapter 4 (Table 5) are likely to be already reduced, even in the absence of more formal protection. It is likely that the data has been skewed towards these rugged landscapes over-representing the activity of non-protected properties in the dataset and underrepresenting the less-intact landscapes that eagles are now unable to nest in (Threatened Species Section, 2006). A review of the nest site topography found that over 60% of nests on both covenant and non-protected properties were on relatively steep slopes. Furthermore, it is also likely that the land offered up as offset land is skewed towards these rugged landscapes that are not at risk of development and thus covenants on these lands may make no difference when compared to non-protected land.

Secondly, over the last two decades, Tasmanian private landholders have been encouraged to restore nesting habitats for eagles (Threatened Species Section, 2006) and establish individual agreements and management plans under the *Threatened Species Protection Act 1995* (Bell & Mooney, 1999). Whilst many landowners opted out of the formal uptake of these management plans, they were still provided with an excellent means of education in land management practices conducive to eagle nest protection. Consequently, it is likely that some aspects of eagle nest protection may have been voluntarily implemented by landholders seeking to protect nesting eagles on their property. There is evidence to suggest that knowledge and awareness of environmental issues results in greater positive

conservational outcomes on private land (Kabii & Horwitz, 2006; Comerford, 2014; Kittredge et al., 2015). Surveys and interviews conducted for this project also indicated a growing positive relationship between landholders and eagles giving evidence to suggest that landholders want to protect eagles on their property regardless of formal protection.

Thirdly, this project analysed the activity status of nests rather than nest success as measured by presence of an advance fledgling. So whilst it was assumed that the nests were from different breeding pairs, some nests that occurred within about 6 km of one another may still have been alternate nests of the same breeding pairs (Mooney & Holdsworth, 1991; Olsen, 2005). Breeding pairs are known to often maintain several nests in their territory but only used one for breeding (Mooney & Taylor, 1996; Mooney & Holdsworth, 1991). This behaviour may have resulted in a higher activity result in areas subject to disturbance, such as non-protected land, where eagles may have prospected a site for breeding (through nest maintenance) in several nests before moving on to another nest.

Other studies have attempted to analyse the effectiveness of conservation covenants in protecting various degrees of biodiversity. For example, positive environmental outcomes to covenants are evident in studies that have adopted a focused approach, such as the effectiveness of covenants on reducing habitat loss in agricultural areas (Braza, 2017) and maintaining biodiversity in sagebrush ecosystems (Pocewicz et al., 2011). Despite this, there is still limited published information regarding the overall effectiveness of conservation covenants. When Fitzsimons and Carr (2014) attempted to overcome this knowledge gap they were met with the difficulty of determining covenant effectiveness due to the lack of resources and capacity for conservation programs to monitor biological outcomes. Furthermore, whilst I couldn't find any information in the literature specific to conservation covenants and their effectiveness in conserving eagle nesting sites, I did find evidence that supports the use of spatial and temporal buffer zones as an effective tool for reducing human disturbances towards raptors (Richardson & Miller, 1997; Thurstans, 2009; Knight & Gutzwiller, 2013).

5.1.3 Native forest within 5000 m of nest

Native forest within 5000 m of a nest was one of the two habitat variables found to have a significant influence on nest activity. Active nests were associated with a lower and more variable percentage of native forest cover within 5000 m radius of the nest, compared to non-active nests. Whilst dense undisturbed native forest provides critical nesting habitat for eagles (Mooney, 2005), open landscapes, including anthropogenically modified landscapes, such as agricultural grazing land, has in many cases provided increased prey foraging opportunities for eagles (Olsen, 2005; Preston et al., 2017). Eagle populations are known to fluctuate with food abundance which could result in more active nests occurring where landscapes are more open (Preston et al., 2017). Aumann (2001) reported that a decline in wedge-tailed eagle sightings during 1997 in the Northern Territory was directly correlated with the eradication of rabbit populations during that same year. Interviews with participants and communication with eagle expert (N. Mooney 2019, Pers comm. June 28th) suggest that the widespread intense lethal control of grazing wildlife in agricultural areas by landholders has increased the number of eagles seen on these properties. It is likely that the heterogeneous landscapes over 5000 m from a nest are providing eagles with more foraging opportunities which in return, with well protected nests, increases breeding success.

Regarding covenant effectiveness, covenanted properties provided more native forest than non-protected properties and less native forest than PTPZ within 5000 m of the nest. This result suggests that covenant properties, as might be expected for conservation on private land, are situated in

locations where the percentage of native and non-native habitat is more optimal in the greater landscape for promoting eagle nest activity. A study conducted by Sergio et al. (2006) found that an alpine golden eagle population preferred heterogeneous landscapes for foraging, selecting for both rugged topography and open habitat rich in prey in the larger landscape of their breeding site, this is a similar finding to Anderson (2001) who found a positive increase in the density of four raptor species directly related to heterogeneous landscapes in Honduras. In Tasmania, when looking at breeding success of eagles around agricultural land Koch et al. (2013) found that nests were more successful where there were higher amounts of agricultural land within 4000 radius. Whilst the percentage of non-native habitat with 500 m, 1000 m or 5000 m of a nest didn't have any significant influence on nest activity in the research reported here, other open productive native landscapes such as native grasslands could be the reason for this result. Future research into the optimal landscape within 5000 m of an eagle nest and whether heterogeneous landscapes are more ideal should be considered in future studies for Tasmanian eagles.

5.1.4 Distance between nest and closest road

The proximity of nests to a road was the only other habitat variable that had a significant relationship on nest activity. Nests were more likely to be active the further away the road was to the nest, suggesting that vehicles negatively impact nesting eagles. This is consistent amongst other reports on wedge-tailed eagles in Tasmania (Mooney & Holdsworth, 1991; Debus et al., 2007). In Tasmania, results from a study conducted by Wiersma et al. (2009) indicated that the nesting attempts of wedge-tailed eagles were more likely where roads were at least 500 m from the nest. This directly correlates with the findings where the mean number of active nests were 528 m from the closest road. Furthermore, the negative impact that roads have on eagles in Tasmania has also been found for several other raptor species. In a systematic review by Martínez-Abraín et al. (2010), the nesting location of 10 different raptor species showed a negative nesting response to the proximity of roads. Of these 10 species, three of them were eagles; Spanish Imperial eagle (*A. adalberti*), booted eagle (*A. pennata*) and the bald eagle (*H. leucocephalus*). They also found the species most affected by roads were the larger birds of prey, that nested in large trees rather than on cliffs. Both Tasmanian eagle species usually nest in tall, emergent eucalyptus trees (Threatened Species Section, 2006; Debus, 2017). It is also important to note that the type of road did not appear to have any adverse effect on the activity status of the nest suggesting that low-intensity road disturbance is equally as important to look at when managing for eagle nest protection as high-level road disturbance. When comparing the distance from the nest to the road across the three different management regimes, covenanted properties had a significantly greater distance between the nest and the closest road. In terms of the research question, these results suggest that covenant properties are significantly better suited at providing adequate protection from the adverse effects of roads. Although this could also be reframed to suggest that the types of lands chosen to be covenants are further away from roads. This again highlights the issue raised that land offered up as offset land is generally more rugged and isolated and thus at less risk of disturbance than areas subject to land management pressures.

Of the 73 active nests in this study, 17 were active within 200 m of a road, between the road types 1-4. It is likely that local experience and habituation to humans could have played a role in the behavioural responses of individual eagles to these roads, or that some of these roads are seldom used. Habituation to human disturbances by individuals has been seen in other bird species, such as shorebirds (Baudains & Lloyd, 2007), house sparrows (Vincze et al., 2016), Egyptian vultures (Zuberogoitia et al., 2008) and other birds of prey (Holmes et al., 1993; Steidl & Anthony, 2000; Ferrer et al., 2007; Ferrer & Harte, 1997). As with wedge-tailed eagles and white-bellied sea-eagles, bald eagles can be highly susceptible to human disturbances (Grubb & King, 1991; Steidl & Anthony,

2000; Arnett et al., 2001) although in some cases habituation is known to occur (Millsap et al., 2004; Guinn, 2013). Furthermore, habituation has been found to occur in wedge-tailed eagles on the rural fringe of New England in NSW (Debus et al., 2007) and white-bellied sea-eagles in South Australia (Debus et al., 2014). The former study, in New England, found one particular incubating female showing no reaction to trucks, heavy machinery or cars within 30 m of her nest. Whilst Tasmanian wedge-tailed eagles are known to be more susceptible to disturbances than mainland Australia wedge-tailed eagles (Mooney, 2005) the results suggest some habituation to human activities may be occurring.

5.2 Part 2 – The social complexities of private land conservation: Motivations for participation and changes to land management activities.

Conservation covenants have become a primary tool for securing conservation biodiversity outcome on private land in Tasmania and Australia. Whilst the social results from this research project reflect only a small number of private landholders within Tasmania, Part 2 of the discussion draws upon the indicative aspects of these results to further understand the effectiveness of conservation covenants as a mechanism for protecting eagle breeding sites. This is achieved by understanding the motivations and values of private landholders for participating in such covenanting programs and how their management practices support the objectives of the existing covenants. Furthermore, the social research can help improve the information on landholder understanding of species needs and habitat protection which can be used to inform future initiatives into private land conservation.

5.2.1 Motivations for participating in covenanting programs

Respondents of covenanting programs reported a relatively wide variety of motivations for participation, however the standout primary motivation was ‘to protect biodiversity’. This result is very similar to findings by Klapproth & Johnson (2001) who also found that motivations in conservation programs varied amongst landholders and that a positive attitude towards environmental issues was a key determinant in covenant uptake, with most participants expressing that their primary motivation for joining the conservation program was to improve the overall health of their property and protect habitat for wildlife. Comerford (2014) also found a very similar result where 98% of participants expressed that the environment was either a very important or extremely important reason for them participating in the conservation program.

Protecting an eagle nest essentially falls under the category of protecting biodiversity, but surprisingly when given as a separate response to the question only 42% of respondents ‘strongly agreed’ or ‘agreed’ that protecting an eagle nest was a motivation for them joining the covenanting program. For respondents on non-covenanted properties, protecting an eagle nest and financial incentives were a potential motivation for them possibly joining a covenanting program. Australian farmers have always had a love-hate relationship with eagles (Olsen, 2005) and Tasmania is no exception. When Kirkpatrick et al. (2007, p. 116 & 118) asked Tasmanian graziers about their attachments to native animals their responses regarding wedge-tailed eagles highlighted their affection for the bird, although this affection was also underpinned by the nuisance of having them build nests on their property:

> I have 1400 acres that’s not good for grazing. It’s OK for logging except for eagles’ nests (two), I would prefer that the eagles’ nests were on the neighbour’s property! I like to see them, and I won’t shoot them, but I am restricted by them being there.

> We had a lot of eagles until they were electrocuted. I saw two yesterday but there used to be more than that. I only know one farmer who shot eagles. Everyone else is proud of them and tries to protect them.

Interview participants expressed this love hate relationship in their responses with eagles being viewed as a nuisance to sheep farmers although the new generations are more willing to coexist with the eagles rather than persecute them. The attitudes of Tasmanian landholders nowadays, towards native animals has been found to be overwhelming positive (Daniels & Kirkpatrick, 2011) which was highlighted in the survey respondents where landholders mostly agreed that "eagles play an important ecological role in the Tasmanian ecosystem" and that they "have a strong personal connection to the eagles on my property".

Financial incentives did play a role in the adoption of covenants with half of the covenant respondents agreeing that it was a primary motivation for them covenanting their land and protecting an eagle nest. Likewise, non-covenant property owners were also primarily motivated by financial incentives. Furthermore, respondents of covenanting programs also wanted to see a little more on-going financial support from the covenanting programs. Whilst this result is not consistent with similar studies by Comerford (2014) and Farmer et al. (2011) who both found that financial considerations for participating in conservation programs was one of least concern, it is important to note that whilst financial incentives were a primary motivation for half of the covenant survey respondents, they were also not a primary motivation for the other half. This evidence suggests that whilst the effect of financial incentives is sufficient enough to not be dismissed and likely influences landholders who may not have otherwise engaged in a conservation program, the potential to offer meaningful financial incentives is rare and they are not necessarily a motivation for all landholders. Landholders with positive environmental motivations, such as those in Comerford (2014) and Farmer et al. (2011) studies, will uptake covenants purely to protect biodiversity without the need for incentives. In a related theme, one interview participant expressed concern about the way their covenanting system operated. This landholder was given money as part of the conservation program to manage their land accordingly, however, this money was given to their ex-partner during a divorce, which renders the money useless to its purpose towards conservation. Examples like this are complex and varied but it does highlight issues regarding the use of financial incentives to manage land for conservation and the need to ensure mechanisms are in place so that the money provided is put to the purpose intended.

5.2.2 Land management practices

Human activities are known to impact eagles in three different ways: (1) by direct loss or degeneration of critical habitat; (2) through physical harm; and (3) via ongoing disturbance that alters nesting behaviour. The presence of humans and the noise associated with many human activities can significantly alter the breeding behaviour of eagles, causing nest failure, even if the human disturbance is far from the nest (Richardson & Miller, 1997). The restrictions and regulations surrounding conservation covenants aim to reduce human disturbances on breeding eagles and safeguard them visually from human activities through the implementation of buffer zones such as an eagle NMA. The results from the survey give evidence to support that the covenants are reducing certain activities on these properties, such as grazing, firewood harvesting, hunting and some recreation. These results also show that some activities have increased such as weed control, fencing and some recreation. Covenant regulations do require that weeds are controlled on the properties and fencing is usually required to protect certain aspects of the covenant. However, despite these restrictions and regulations, 'no change' was evident to some degree across all land management practices since the covenant was adopted. It is important to know that each covenant is different, and

some flexibility can be orchestrated in the planning process to tailor the covenant to meet the needs of the landholder (Greene, 2004). Interviewee W034E explained that one of their covenants restricts grazing whilst the other (around the eagle nest) does not. Due to covenant variation, some covenants may not be as strict with certain management activities than others. Landholders also may not have needed to change their land management practices due to the location of their covenant. Furthermore, when looking at the land titles of the covenant properties, many landholders owned the adjacent properties that weren't covenanted and as mentioned above, many covenants are put on areas of land that are not well suited to agricultural land use activities (Joppa & Pfaff, 2009) and thus it is likely landholders have covenanted sections of their land for conservation and kept domestic areas free for business operations.

Protective mechanisms to restrict human activities from occurring within covenants can only be effective if landholders comply with such directives. The concern that there is a lack of monitoring and enforcement of 'breaches' within conservation covenanting programs in Australia is highlighted within the literature (Figgis et al., 2005; Fitzsimons & Carr, 2014; England, 2015; Hardy et al., 2017) and was also stressed by covenant interview participants. In a review reporting on how well existing conservation covenant programs work in practice in Australia, England (2015, p.103), stated that "conservation covenant programs on private land are not frequently monitored" resulting in increased difficulty measuring long-term impacts. Whilst half of the interview participants said that every now and then covenant program officers enter the property to do vegetation monitoring the other half said monitoring is lacking entirely. In a conversation with an officer from the PLCP it was reported that there is no designated program or policy, for routine eagle nest monitoring within the PLCP. Monitoring for compliance is also limited to the number of staff, time and money. With over 900 covenants in Tasmania, typically 75-100 covenants are visited per year, some more often than others, therefore it could be 10 years or more between covenant visits. A 2016 study by Hardy et al. (2017) indicated that the proactive monitoring of conservation covenants to ensure compliance is relatively low across all Australian states and that breaching of obligations was relatively high in Tasmania compared to other states, although given the constraints on covenant monitoring the author noted that it is likely the number of breaches for other states is a lot higher. The biggest issue for covenant agencies – both governmental and non-governmental – is limited resources to undertake regular monitoring. Limited resources play a major role in the covenanting organisations ability to effectively monitor programs to ensure compliance (Fitzsimons & Carr, 2014).

For non-protected properties, whilst most survey respondents didn't want to change their land management activities, 50% were willing to 'decrease a little' hunting and firewood harvesting in an effort to protect eagles. In a study conducted by Moon and Cocklin (2011) respondents who used their land for production and business purposes were concerned about the program reducing their ability to provide themselves an income through grazing and other means. The interactions between a landholder's willingness to change their land management activities are reflected in motivations to covenant their property. The results from the owners of non-protected land indicate that a commitment to conservation represents a risk to their livelihood and income which is evident from many other studies (Ernst & Wallace, 2008; Sorice et al., 2014; Selinske et al., 2015). Interviews with covenanted landholders expressed that whilst there is an interest in landholders to protect eagles on their property, there is a concern regarding the restrictions of conservation covenants and the interference from government on their rights which is likely limiting the uptake of covenants.

5.3 Conclusion: The socio-ecology of eagle conservation

5.3.1 Limitations

Several limitations were evident throughout this study that can help improve future research. Initially this project had unanticipated challenges in data generation, resulting in a difference between the timing of the FPA's annual eagle nest surveys conducted between October and November and nests surveyed by myself and an experienced eagle researcher conducted in the last week of December and first week of January. The differences in the timing of nests surveyed made it difficult to compare the two survey results as nests checked in the later months may have lost chicks that would have been apparent and considered productive in the earlier months, meaning the earlier checks would have had a higher productivity rate than the later checks. To overcome this knowledge-gap I included 'maintained' as a type of nest activity so that any later checked nests that may have been productive in the earlier months but empty during the later checks weren't overlooked. Likewise, any earlier nests checked that may have been productive but not successful were not incorrectly presumed successful. Using 'active' as the positive measurement of nest use, rather than 'productive' or 'successful' allowed for more continuity between the early and late nest checks.

It became apparent during the nest surveys that not all nests could be found in the limited time that was available to conduct eagle nest checks under animal ethic guidelines that restricted 'time spent' in the vicinity of a nest. Whilst some nests on covenanted land were later found to have been lost in wildfires, tree falls, storms or completely degraded through long periods of inactivity and lack of maintenance, the high number of not-found nests may also have been due to lack of precision in coordinates, dense canopy cover and unfamiliar nests sites that haven't been checked for years. The likeliness of the latter playing a role in the number of nests 'not found' on covenanted and non-protected land is reflected in the low number of 'not found' nests in the group protected by PTPZ prescriptions. Planning updates for forestry operations and ongoing monitoring of eagle nests by experienced staff at the FPA who are familiar with the nesting sites (Wiersma et al., 2009; Wiersma, 2010; Wiersma & Koch, 2011; Koch et al., 2013) is likely the reason more nests were found near forestry operations. To overcome this issue and keep within the necessary guidelines of animal ethics procedures, future studies should select for more eagle nests than statistically needed. Furthermore, when ground searches were conducted by experienced eagle researchers and conservation covenant officers to find a sample of the 'not found' covenant nests, 4/6 were completely missing and therefore not active, thus the true activity of covenant nests may be considerably lower than analysed.

Another limitation was the limited number of landholders to survey and interview. Originally the idea was to compare the nest activity surveys with the land management practices through surveys and interviews with the landholders, meaning I would have around 50 landholders with covenants and 50 landholders without covenants to survey and interview. It became apparent that many landholders owned multiple properties with eagle nests and several nests occurred on the same properties, reducing the overall number of participants. The overall low number of surveys completed meant that the project could only use descriptive statistics rather than inferential statistics. Furthermore, I only received interest in an interview from one owner of non-protected land. On reflection this was not surprising, as the project was about conservation covenants and eagle nest protection and landholders motivated by their covenant and lived experiences were probably more likely to take part in research than those who aren't interested in a covenant (Yasué & Kirkpatrick, 2018). Providing an incentive to landholders for participation, such as the chance to be in the draw to win a price has been proven to increase the rate of participation (Fan & Yan, 2010).

5.3.2 Future recommendations

I have identified several future recommendations that have become apparent throughout this research project as being important in further understanding the effectiveness of conservation covenants in protecting eagle breeding sites. These recommendations are:

(1) Covenant design – The results of this project conclude that covenants prescriptions could also focus on reducing the disturbance from roads as this was found to be an extremely important disturbance factor. This is an important finding as this information can be used to enhance the restrictions of vehicle use on roads which fall within a covenant when implementing future covenanting programs to protect eagles. Furthermore, many of the covenanted nests were found on the boundary of the covenant where neighbouring disturbances such as roads could become an ongoing issue for breeding eagles. Whilst the proximity from the nest to the boundary had no effect on the breeding activity of the eagle during this study, this result may not be a true representation of eagle nest breeding activity over consecutive years. Eagle nest buffer zones should therefore be individually designed depending on the nests location and the type of disturbances in the area, such as the proximity to roads (Richardson & Miller, 1997; Martin et al., 2011), to incorporate neighbouring properties to complete a buffer size of at least 20 ha with more protection on the uphill slopes. This may mean ongoing liaison and education with multiple land owners to create buffers around a nest that isn't restricted by property titles and property boundaries and investigating other mechanisms that have legislative protection but more flexibility in design.

(2) Program design – It is inevitable that a covenanting program isn't attractive to or an option for everyone. This research demonstrates that an eagle protection program needs to be tailored to meet the diverse values and goals of different landholders. Moon and Cocklin (2011) found that when projects are inflexible, landholders tend to feel constrained and concerned about their future financial options, making inflexibly a major barrier to participation. Some covenanting programs, for example, offer flexibility where under certain negotiated terms in the covenant agreement certain land management activities, such as light grazing, is permitted (Moon & Cocklin, 2011). For covenant program managers, adapting programs to meet landholder values and goals may compromise environmental outcomes, however the alternative of designing a fixed program means that it will only appeal to a small number of individuals who are likely to be conservation minded anyway. Hence there could be significant scope to vary the prescriptions to suit agricultural landholders. This research project also identified the importance of financial incentives in encouraging landholders who wouldn't have otherwise been interested in the covenanting program. To ensure compliance is being met and that the terms of the negotiations aren't having any adverse impact on the breeding eagles, offering financial incentives as an annuity rather than a lump sum, where effective monitoring can take place before each payment would provide more encouragement to landholders to do the right thing.

(3) Stricter monitoring - Whilst I believe the prescriptions of conservation covenants are adequate in protecting eagles, keeping up with regular covenant monitoring and ensuring landholder compliance is an ongoing issue for covenant programs throughout Australia. Regular monitoring is of particular importance where conservation covenants are implemented to count towards conservation targets that are on a national or international level (Fitzsimons & Carr, 2014). It would be difficult for covenanting programs or government bodies to confidently report on the efficiency and effectiveness of conservation covenants in achieving conservation goals without effective compliance action.

Careful examination of the success of current and past covenanting programs is essential when designing a cost-effective program for conservation on private land to ensure allocation of resources is appropriate (Pannell & Wilkinson, 2009). Allocating more resources towards monitoring and finding more effective cost-effective tools is important in further understanding the effectiveness of conservation covenants on eagle nesting sites.

(4) Further research - The findings suggest that conservation covenants provide adequate protection from roads and are situated in areas both suited for eagle breeding and foraging. However, this result is just a small snapshot in time and whilst it does reflect the results of others findings, further yearly nest surveys need to be conducted on these properties to understand how often the eagles are using the nests and to gauge whether non-active nests are actually being used in future breeding seasons as population trends are unlikely to become apparent until after several generations. Whilst it may not be feasible, cost wise, for covenanting programs to check all covenant nests it could be feasible to select a subset of covenanted nests to compare with nests on non-protected land checked by the FPA during their annual nest checks. Using this smaller subset of nests will allow for looking at the probability of nests being successful. Furthermore, providing well-chosen counterfactuals on this issue will further advance our knowledge of the success of conservation covenants. For example, further fundamental empirical evaluations into whether eagle nest would be active had the covenants not existed would provide clearer evidence on the effects of covenants (Ferraro & Pattanayak, 2006).

5.3.3 Concluding statement

The results of this study have shed some light on the ability and adequacy of conservation covenants to safeguard valuable eagle nesting sites on private land in Tasmania. In regard to the research questions of whether conservation covenants are effective or not, the findings from this project indicate that conservation covenants do play an important role in protecting eagle nests. Conservation covenants are typically selected for their high conservational priorities and thus provide a level of legal protection to these areas that was otherwise not there. Ideally, eagles require sheltered native old-growth eucalypt forest, with minimal human disturbance in order to breed successfully (Mooney, 2005) and as this study and other studies suggest, with less roads (Debus et al., 2007; Wiersma et al., 2009) and open landscapes over larger spatial scales (Koch et al., 2013). The covenanted properties surveyed in this thesis generally conformed to these eagle nesting requirements. Roads were significantly further away on covenanted land that on PTPZ or non-covenanted private land, and covenanted land also exhibited more open lands within the greater landscape compared to PTPZ. The prescriptions surrounding the eagle nests on covenanted land are relatively strict and if compliance is met would likely be providing adequate protection though their large buffer zones.

However, the effectiveness of conservation covenants should not be exclusively addressed through ecological findings and expertise. Equally as important is addressing the values and ethics of the landholders participating in covenanting programs and landholders not participating. The owners of covenanted land overwhelmingly had a great appreciation and respect for nature through their voluntary choice to protect biodiversity and natural values such as threatened species and habitats. Where there is a genuine motive to protect biodiversity, and the choice to enter a covenanting program is voluntary then there is a good chance that the covenant will succeed in delivering long lasting environmental outcomes, whilst also offering a cost-effective scheme for increasing the national reserve system (England, 2015). A generational shift towards a more positive relationship between landholders and eagles is also evident throughout the survey and interview results with both covenant and non-covenant landholders indicating a general desire to protecting eagles on their

property with some willingness to reduce their land management practices if need be, especially if financial incentives were available to do so.

This project has helped inform the adequacy of eagle nest prescriptions on covenanted properties through identifying the areas where conservation covenants succeed in protecting eagles and the areas where improvement in nest protection is further needed on private land. The information collected in this project gives insight into nest persistence in the landscape that can contribute to state databases, such as the Natural Values Atlas as well as help improve the information on the status of eagles in Tasmania which could feed directly into a new recovery plan. Furthermore, it improves the overall information on the value of covenants as a protective mechanism for conserving eagles.

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