Monitoring the effectiveness of the biodiversity provisions of the Tasmanian *Forest Practices Code*

2019–20 summary report

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Disclaimers

The information presented is a broad overview of information considered relevant (by the author) to the aim of this report. Whilst the author has used best endeavours to ensure accuracy, they do not warrant that the material is free of error. Consequently, the information is provided on the basis that the author will not be liable for any error or omission. However, should any error or omission be notified, the authors will use their best endeavours to correct the information. It should also be noted that some of the results presented in this report are only preliminary.

Front page photograph: Dr Phil Bell (FPA ecologist) surveying vegetation characteristics (Photo: S Walker)

Acknowledgements

Many thanks to the large number of people that have contributed to the project summaries covered in this report. The main collaborators are acknowledged in the relevant sections. The full project reports and papers should be referred to for greater detail, ethics approvals, scientific permits and for information on the funders who have supported the projects. We have only supplied information on funders here if no other report or publication is available.

Special thanks to the people who provided us with brief summaries of their work and have allowed us to include the results from their research undertaken independent of the Forest Practices Authority. Such research provides information that can be used to assess the effectiveness of the *Forest Practices Code* provisions.

Thanks to the Board of the Forest Practices Authority for agreeing to continue to fund the biodiversity effectiveness monitoring implementation plan for 2018–2021 (RM D16/31313).

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Table of Contents

Executive summary

- The Tasmanian forest practices system follows an adaptive management framework which includes an emphasis on research, review and continual improvement.
- This report summarises projects by FPA staff and students, carried out during the 2019–20 financial year, as well a brief summary of projects done by other researchers (independent of the FPA), where the results contribute to our understanding of the effectiveness of the Tasmanian forest practices system.
- Four FPA-affiliated projects current in 2019–20 contribute to our understanding of the effectiveness of the *Forest Practices Code* provisions for biodiversity in general. A paper was published examining the retention of habitat trees in alternative silvicultural systems, including aggregated retention. The three other projects were progressions of work outlined in last year's report. An FPA-affiliated Honours project found that bats forage around plantation edges and move into the plantation itself when there are gaps in the understorey. The review of Australian treefern literature was submitted for publication and outlines the need for more research on the impact of harvesting on tree ferns. The prioritisation of threatened flora research is being written up into a report.
- There were 24 FPA-affiliated projects current in 2019–20 that contributed to our understanding of the effectiveness of *Forest Practices Code* provisions for threatened species. There was again a focus on eagles (six projects), including the initiation of an ambitious UTAS project to track 50 eagles across Tasmania. This will include 12 birds from areas subject to forestry, to help determine the effectiveness of wedge-tailed eagle management. A number of other projects are also using tracking to help determine the impact of forestry, including masked owls and devils (field work not yet commenced), green and gold frogs (field work complete) and grey goshawks (write-up of historic data). Some existing projects have not progressed much this financial year due to a lack of staff time or the need for further data (skemps and keeled snail, giant freshwater crayfish), while others have been finished and submitted for publication (*Pterostylis atriola, Hibbertia calcina*, tree fern review).
- We have seen an increase in baseline monitoring by organisations outside of the FPA, which provides important context for interpreting the potential impact of forestry. This includes monitoring of reserve condition, species abundance and diversity (in reserved or retained areas, statewide or in the production landscape depending on the project) and species specific projects such as citizen science programs monitoring eagles and burrowing crayfish. Additionally, there have been further advances in sampling techniques (e.g. acoustic monitoring) that could facilitate future monitoring.
- A couple of studies have considered the impact of forestry directly, with one PhD student finding that beetle communities take about 50 years to recover to pre-harvest levels after clearfall-burn and sow. Another PhD student found that high intensity burning reduces the biomass of soil bacteria and fungi but these take only six months to recover while harvested but unburnt areas have lower biomass one year after harvest.

1. Introduction

The Tasmanian forest practices system follows an adaptive management framework which includes an emphasis on research, review and continuing improvement (FPA, 2014a). It is widely recognised that ongoing research and monitoring is important for the scientific credibility of the *Forest Practices Code'*s provisions applied in forest management plans (Commonwealth of Australia & State of Tasmania, 1997; Davies et al., 1999; Wilkinson, 1999). Monitoring done to determine whether the specified management has achieved its objective is referred to as 'effectiveness monitoring'. There is a legislative requirement to monitor the effectiveness of *Forest Practices Code* provisions applied in forest practices plans. The Tasmanian *Forest Practices Act 1985* states that, 'the Board must…assess the implementation and **effectiveness** of a representative sample of forest practices plans'. In addition, Clause 7 of the procedures for the management of threatened species agreed with the Department of Primary Industries, Parks, Water and Environment (FPA and DPIPWE, 2014) requires monitoring of the effectiveness of management actions for threatened species. With ongoing public scrutiny of forest practices in Tasmania, the scientific basis for particular *Forest Practices Code* provisions needs to be clear.

The overarching objective of Tasmania's forest practices system is '*to achieve sustainable management of Crown and private forests with due care for the environment…*'. The sub-objective for the management of biodiversity is '*to conduct forest practices in a manner that recognises and complements the contribution of the reserve system to the maintenance of biological diversity, ecological function and evolutionary processes through the maintenance of viable breeding populations and habitat for all species'* (Forest Practices Authority, 2015). The *Forest Practices Code* (Forest Practices Authority, 2015) and associated planning tools deliver a variety of actions that aim to meet the management objective for biodiversity in areas covered by the system. The process for managing biodiversity under the forest practices system was outlined in a new publication by Munks et al. (2020), and the processes, policies and strategies involved were reviewed by Chuter and Munks (2011). The management strategies have been developed from a mixture of expert judgement, practical experience and the outcomes of research and monitoring.

Information on the effectiveness of the biodiversity provisions of the *Forest Practices Code* was reviewed in 2012 (Koch et al., 2012). This review identified gaps and these help determine priorities for future effectiveness monitoring (FPA, 2012). See Box A and Box B for the highest priorities for Code provisions and threatened fauna provisions respectively (FPA, 2012). Priorities for threatened flora species were identified in 2018–19 as part of the development of management recommendations for the Threatened Plant Adviser. The results of this work are currently being written up, but a summary of priorities is provided in Box C.

Work is done each year by FPA staff on a number of the priority effectiveness monitoring projects. The degree of effort depends on available funds, logistic considerations and staff/student availability. This report summarises findings from projects current during 2019–20 financial year. It includes projects undertaken by FPA staff (mostly in collaboration with other research providers) and those done by other researchers (independent of the FPA) where the results contribute to our understanding of the effectiveness of actions taken for biodiversity values through the forest practices system.

Box A. The priorities identified for monitoring the effectiveness of the general biodiversity-related *Forest Practices Code* provisions (FPA, 2012), in bold if progressed in 2019–20.

1. evaluate the degree to which the coupe dispersal guidelines limit the amount of harvesting within a subcatchment and thereby reduce impact on water flow;
2. determine the degree to which mature habitat availability is changing across the forest estate in Tasmania;
3. determine if hygiene measures help prevent spread of *Phytophthora cinnamomi;*
4. **determine whether significant habitat definitions for threatened species are adequate;**
5. determine whether wildlife habitat clumps help maintain forest birds, hollow users, fungi and bryophytes in forestry areas;
6. determine whether the Mature Habitat Availability Map can be used to assess availability of mature forest features (e.g. hollows and coarse woody debris);
7. determine the degree of mature forest connectivity across the production forest estate;
8. **determine whether water quality is maintained in streams under current management;**
9. determine whether soil productivity is maintained over the long-term by current forestry practices.

Box B. The priorities identified for monitoring effectiveness of threatened fauna management provisions (FPA, 2012), with projects progressed in 2019–20 indicated in bold.

1. **assess effectiveness of giant freshwater crayfish management recommendations for managing changes in stream morphology and water quality;**
2. **assess effectiveness of Skemps and burgundy snails management recommendations for managing loss of habitat;**
3. **assess effectiveness of grey goshawk management recommendations for managing loss of foraging habitat;**
4. **assess effectiveness of keeled snail management strategy;**
5. **assess effectiveness of eagle management recommendations for managing breeding failure due to disturbance;**
6. **assess effectiveness of grey goshawk management recommendations for managing loss of nesting habitat;**
7. **assess effectiveness of swift parrot management recommendations for maintaining breeding habitat;**
8. **assess effectiveness of masked owl management recommendations for maintaining potential nesting habitat.**

Box C. Draft priorities identified for monitoring the effectiveness of threatened flora management provisions (FPA, unpublished). In bold if research was done during 2019–20.

General

1. Effectiveness of *Phytophthora cinnamomi* management.
2. Effectiveness of surveys for identifying threatened plants.
3. The occurrence of threatened plants in plantations.
4. Effectiveness of the current management approach for three sites of potential significance for flora (rocky outcrops, swamps and inland *Eucalyptus amygdalina* forest).

Species specific

Rank	Species	Rank	Species
1	***Hibbertia calycina***	3	*Boronia hemichiton*
1	*Epacris moscaliana*	3	*Hibbertia rufa*
1	*Cyathea cunninghamii*	3	*Conospermum hookeri*
1	*Thynninorchis nothofagicola*	3	*Spyridium lawrencei*
		3	*Epacris virgata Beaconsfield*
2	*Blechnum spinulosum*	3	*Caladenia pallida*
2	*Euphrasia collina* subsp. *deflexifolia*	3	*Caladenia tonellii*
2	*Euphrasia collina* subsp. *gunnii*	3	*Epacris curtisiae*
2	*Euphrasia scabra*	3	*Epacris limbata*
2	*Euphrasia semipicta*	3	*Thelymitra jonesii*
2	*Isolepis habra*	3	*Pultenaea mollis*
2	*Pomaderris phylicifolia* subsp. *ericoides*	3	*Xanthorrhoea bracteata*
2	*Pomaderris phylicifolia* subsp. *phylicifolia*	3	*Epacris exserta*
2	*Sowerbaea juncea*	3	*Epacris apsleyensis*
2	*Thelymitra holmesii*	3	*Austrocynoglossum latifolium*
2	*Rhodanthe anthemoides*	3	*Bertya tasmanica* subsp. *tasmanica*
		3	*Eucalyptus perriniana*
		3	*Pomaderris pilifera* subsp. *talpicutica*
		3	*Prasophyllum crebriflorum*
		3	*Prasophyllum robustum*
		3	*Prasophyllum stellatum*
		3	*Pterostylis falcata*
		3	*Pterostylis grandiflora*
		3	*Cyathea x marcescens*
		3	*Hypolepis distans*

2. Summary report on FPA research and effectiveness monitoring covered in 2019–20

This section provides short summaries of projects that have involved FPA staff.

2.1. General *Forest Practices Code* provisions for biodiversity

The following sub-sections provide a brief summary of the projects current in 2019–20 which contribute to our understanding of the effectiveness of actions and inform continual improvement of *Forest Practices Code* provisions.

2.1.1. Habitat tree assessment at the Warra SST

Mature trees provide habitat for a wide range of fauna so it is extremely important that this resource is managed appropriately in the production forest landscape. Sue Baker (UTAS) along with Sarah Munks (private), Amy Koch, and Anne Chuter (FPA) have published a paper on habitat tree availability in alternative silvicultural systems at the Warra Silvicultural Systems Trial (Baker et al., 2020). The greatest numbers of various classes of tree (small, large, live, dead) were retained in aggregated retention compared to dispersed retention and clearfelling with understorey islands. This was largely because of the higher retention levels in this silvicultural system, although tree survival is also likely to be greater because aggregates are less exposed to wind and regeneration burn impacts.

The study also compared ground-based to helicopter-based assessments of habitat trees. Helicopter surveys were much quicker and more effective at surveying trees with visible hollows in harvested coupes, but unsuitable for estimating trees/ha in unharvested forest. See Baker et al. (2020) for further details.

2.1.2. Bats in plantations

Tasmania has eight species of micro-bat, all of which use hollows for breeding and sometimes roosting. Species that rely on mature trees, including hollow-using species, have been identified as particularly vulnerable to forestry (FPA, 2017a). Mature trees are retained under the forest practices system by a variety of mechanisms, but bats are extremely mobile so can forage in areas that do not contain mature trees.

FPA-supported UTAS Honours student, Alyce Hennessy, submitted her thesis on the activity of bats in plantations in February 2020 (Hennessy, 2020). The primary aims of the study were to: (1) assess how the presence of plantation forestry influences bat activity; and (2) evaluate within-plantation bat activity and influential plantation features. She achieved these aims by evaluating bat activity and potential determining mechanisms of this activity along transects from native forests into plantations at 12 sites in the southern forests region. These potential determining mechanisms included transect position, changes to vegetation structure, and nocturnal aerial invertebrate prey availability. She focussed on four bat foraging guilds (clutter, edge-closed, edge-clutter and edge-open), represented by two to seven species within each guild. This study showed that bats are travelling from remnant native forest into Tasmanian eucalypt plantations, and frequently along the edges between plantations and patches of native forest. The edge-clutter and clutter guilds demonstrated similar activity levels in the plantation and the native forest, while the edge-closed and edge-open guilds tended to have higher activity in the native forest. Vegetation clutter generally had a weak but significantly negative impact on bats. The edge-closed and edge-clutter bats appeared to be more active deeper into the plantations. This increase in activity may be attributed to understorey gaps that tended to appear more frequently at deeper (120 m) sampling locations within the plantations. Overall, this research discovered that there are features of plantation forestry that can support bat activity. Bats appear to be foraging around plantation edges and moving into gaps within the understorey stratum of plantations. Creating edges within plantations through the establishment of understorey gaps could be a feature of complex forestry that supports this form of biodiversity within the plantation landscape.

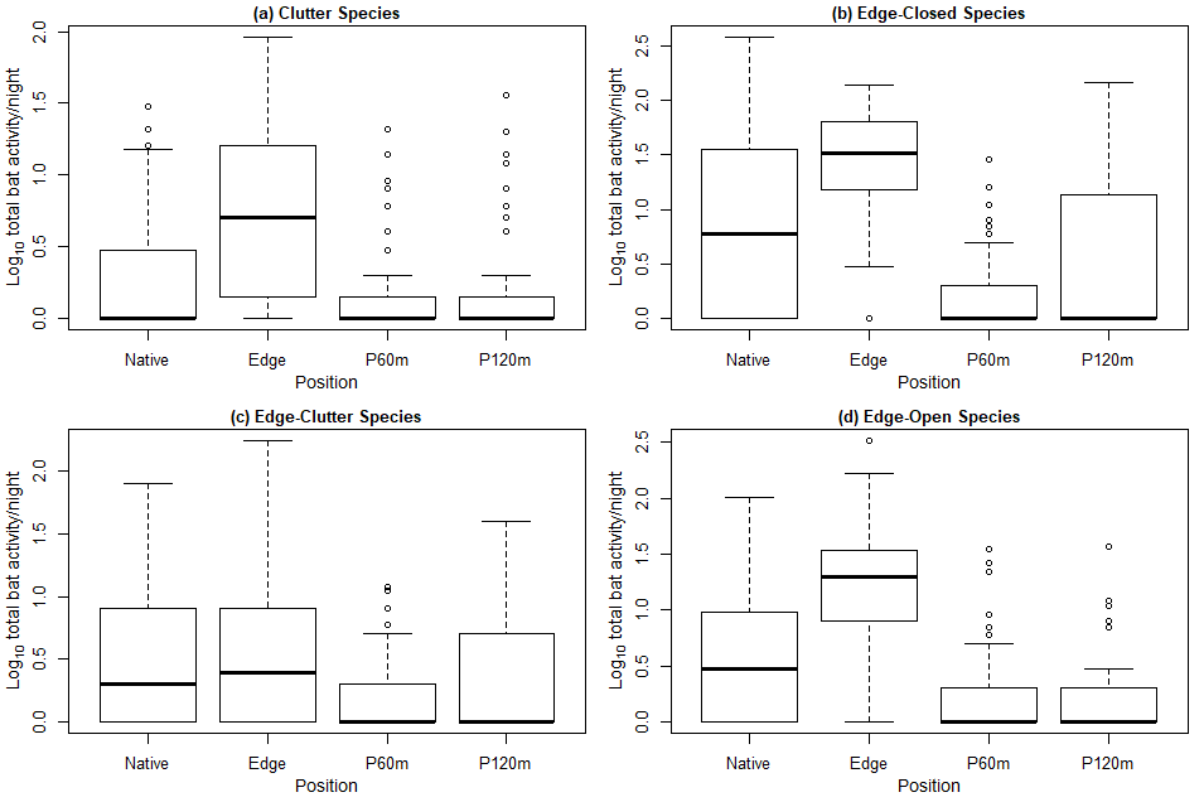

Figure 1. Median and interquartile ranges for $\log_{10}$ transformed bat activity per night for each bat guild corresponding to the different positions along the transect where 'Native'= 60 m into the native patch, 'Edge'= edge position, 'P60m'= 60 m into the plantation, and 'P120m'= 120 m into the plantation.

2.1.3. Treefern review

The *Treefern management plan* (FPA, 2017b) was introduced in 2001, with revisions in 2005, 2007, 2012 and 2017. The Plan applies to all land tenures in Tasmania and permits sustainable harvesting of *Dicksonia antarctica* in accordance with the principles detailed in the Plan, conducted under a certified forest practices plan. Aims of the *Treefern management plan* include research into the distribution, ecology, and sustainable harvesting of treeferns.

A review of Australian treefern literature has been undertaken by FPA staff. Collation of the literature identified a lack of information about key ecological events and cohort dynamics as there is no tracking of long-term impacts of disturbance to tree ferns (there is some unpublished data). While there is some information available on the impacts on tree ferns from wildfire and clearfelling, little is known about impacts due to wind (cyclone) or silvicultural practices such as shelterbelt logging, cable harvesting and salvage logging. There is a particular lack of studies documenting the population and disturbance ecology of tree ferns at a site before, during and after a commercial harvest of tree ferns themselves. Information regarding tree fern management for relevant states is included in the paper. This paper has been accepted for publication.

2.1.4. Threatened flora research prioritisation

There are hundreds of threatened plants listed in Tasmania, and many of these species have draft agreed management actions as delivered through the FPA Threatened Plant Adviser. Monitoring the effectiveness of management for all these species is not achievable in the short to medium term given current resources, and so it is important to prioritise the projects that can be undertaken. A process that prioritises flora research was detailed in Koch (2019), has been undertaken and is currently being written up into a report.

2.2. Threatened species management

The following summaries are for projects current in the 2019–20 financial year that looked at the effectiveness of provisions for threatened fauna and flora species. They contribute to priority area A4 and A8 (Box A), threatened fauna project areas B1–6, B8 (Box B) and a threatened flora project (Box C).

2.2.1. Wedge-tailed eagles

The Tasmanian wedge-tailed eagle (*Aquila audax fleayi*) is listed as endangered at both a state and federal level. It is currently recognised as an endemic sub-species. A genetics study, however, has raised questions about this taxonomic status (Burridge et al., 2013). Management of this species under the forest practices system focuses around the nest site. Given the large number of wedge-tailed eagle nests recorded in Tasmania, there is considerable interest from industry to ensure effective and efficient management. During 2019–20 FPA were involved, to varying degrees, in six projects which contribute to our understanding of the effectiveness of management actions for this species.

FPA annual nest monitoring

The FPA Eagle Research and Monitoring Program was initiated in 2007 with the aim of monitoring the rate of nest success and the timing of breeding season events. This work was revised during 2015 to limit surveys to establishing the timing of the breeding season to assist with management decisions.

Annual nest monitoring surveys were completed in November 2019. However, adverse weather and a lack of helicopter availability due to fire fighting requirements meant FPA was unable to undertake the second round of flights to determine the timing of the breeding season. In the absence of data, the recommendation was made to extend the breeding season into the first week of February. This decision was made to minimise the impacts of disturbance to any chicks that are 'late', taking industry requirements into consideration.

Strategic eagle nest management

In 2016 FPA initiated a project to develop a strategic approach to managing eagle nests in production forests. The initial work evaluated the condition of eagle nests using photographs that were routinely taken by the forest industry when conducting core work. The objective of this project is to determine how unused nests can be confidently identified.

The approach taken is being refined, the number of nests assessed expanded, and a report is due out in the 2020–21 financial year.

Figure 2. Eagle with a telemetry unit (Photo: J Wiersma).

Testing the effectiveness of select actions to mitigate the impact of disturbance on the Tasmanian wedge-tailed eagle

In 2018 FPA initiated a project to test whether the 500m/1km line-of-sight recommendation is effective in mitigating the impact of disturbance to breeding eagles. The project initially tried to use cameras to achieve the study aims, but logistical issues meant this approach was unsuccessful. The methodology was therefore reviewed.

In 2020 FPA decided to collaborate with UTAS researcher Dr James Pay, who is attempting to understand what factors influence eagle behaviour. Dr Pay is doing this by attaching transmitters to 50 adult eagles, and he hopes his research results will provide guidance on how to manage threats like windfarms and powerlines. As a result of FPA collaboration, Dr

Pay's research will now include data on 12 breeding eagles near active forestry operations which should provide insight into the effectiveness of eagle nest management in forestry areas.

Project design has been established and the initial plan was to begin trapping birds in 2020. However issues with receiving equipment has meant that birds will now be trapped prior to the 2021–22 breeding season, so results are expected in mid 2022.

This project is being done in collaboration with UTAS and is funded through a FWPA grant received by the FPA in 2018 with funding support from, Forico, Timberlands, Sustainable Forest Management, Sustainable Timbers Tasmania and Norske-skog.

Eagle Nesting Habitat Model

The FPA Eagle Nesting Habitat Model was created in 2013 and is used by forest planners and others to prioritise areas for nest searches (FPA, 2014b). This model is being reviewed which involves three main components:

1. Updating the nests used in construction and testing of the model. The current eagle habitat model used 926 nests. The revision includes these nests and others that have since been located.
2. Reviewing environmental variables that were used in construction of the current model. We are exploring whether aspect and elevation could be better used in model construction. For example, aspect is currently used in model construction as a categorical variable and conversion to a continuous variable may strengthen model prediction.
3. Reviewing the use of three sub-models. Currently there are sub-models for north-west Tasmania, low elevation (<850m) Tasmania and high elevation (>700m) Tasmania. Revision includes assessing whether this could be reduced to two models: north-west Tasmania and the rest of Tasmania.

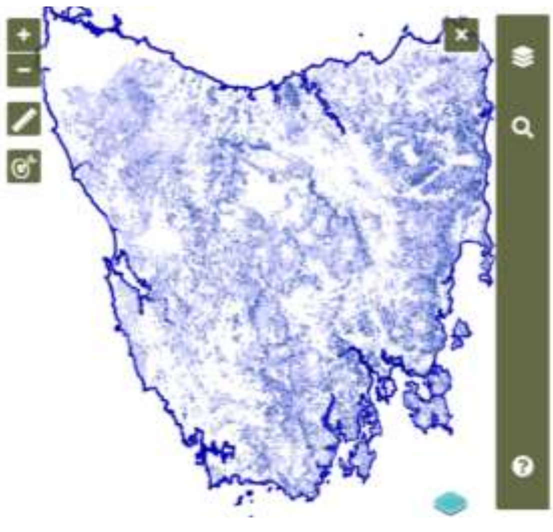

Figure 3. The existing wedge-tailed eagle habitat model for low and high elevation, as delivered via the Biodiversity Values Database.

Eagle Eye - Applying the Internet of Things to landscape scale wedge-tailed eagle management

This Sustainable Timbers Tasmanai (STT) project is testing if the application of an Industrial Internet of Things approach to monitoring wedge-tailed eagle nest activity can increase economic activity and reduce the worker safety concerns and costs that are associated with the current nest activity checking practices.

A range of sensors were set up at seven nests, and a further seven comparable nests were established as controls. One of the experimental nests was used for breeding. Some technological issues occurred early in the project, but these seem to have now been resolved. The deployment of three LoRaWAN gateway sites gave an approximate coverage area in excess of 300 square kilometres. Preliminary results suggest that passive infra-red sensors may be suitable for monitoring animal activity at the nest in a more data-efficient way than cameras can.

Additional sensors, cameras and gateways were deployed prior to the start of the 2020 breeding season, and they are now picking up nest activity. The project will be written up in the 2020–21 financial year. Partners on this project include Indicium Dynamics, Newood Holdings, FPA, PFT, DPIPWE, TasNetworks, Forico, RFF, RMS, Midway Plantations, Timberlands, Norske Skog. The project is co-funded by the National Institute for Forest Products Innovation (NIFPI).

Testing the efficacy of unmanned aircraft vehicles (a.k.a. drones) to assess eagle nest condition

This year, STT, in collaboration with the FPA, University of Tasmania (UTAS) and Esk Mapping, completed field work using drones (sub 2 kg) to assess eagle nest condition outside the breeding season.

To execute the project, risk averse guidelines were developed; including ensuring three personnel were present per flight (licensed pilot, eagle spotter, and drone spotter). Through skillful piloting and expert navigation, STT inspected 38 nests over 9 flying days, during the period between April 2020 to June 2020. Fortunately, there were no interactions between an eagle and drone.

Analysis of the drone imagery has commenced, revealing there is additional detail in the photos which is not visible from the traditional rotor-wing surveys. These photos will be included in FPA’s Strategic Eagle Management Project (above).

To date, the project results indicate that in certain circumstances, drones, can be a useful and cost-effective tool for the eagle management toolkit. With drone usage, an average of 4 to 5 nests can be inspected daily, with the nest inspection cost around $350 per nest (this is based on staff time). A final project report and a proposed ‘best practice’ guideline and procedure for using UAVs to inspect eagle nests outside the breeding season will be prepared over the coming year.

2.2.2. Masked owls

The Tasmanian masked owl (*Tyto novaehollandiae castanops*) is an endemic subspecies that is listed as Vulnerable under the EPBC Act and endangered under the Tasmanian *Threatened Species Protection Act 1995.* The Threatened Fauna Adviser recommends retention of mature forest habitat (as a surrogate for nesting habitat) in areas where the bird is likely to occur. In areas where an operation is to occur near a known masked owl nest or roost site, the FPA and DPIPWE might recommend a 100 m radius reserve be retained around such a site.

Tracking masked owl to understand their habitat use

An FPA study has been initiated to test the adequacy of using the presence of mature forest as an indication of habitat availability. This study will involve tracking six adult masked owls over about 4–6 weeks in the southern forests of Tasmania, and locating their roost sites. Information will be sought on basic life history (number of roosts per bird, home range size, hollow and tree attributes), the areas selected for foraging and roosting, and an indication of how selective the birds are in roost sites.

A trial of field methods was planned for early 2020, but issues with equipment meant the trial will occur in the second half of 2020. One of the main purposes of this trial is to determine the most efficient programming for the transmitters when the main study commences. Presuming the trial is successful, attempts will be made to trap the study birds in early 2021.

This project is being done in collaboration with UTAS and is funded through a FWPA grant received by the FPA in 2018 with funding support from, Forico, Timberlands, Sustainable Forest Management, Sustainable Timbers Tasmania and Norske-skog.

Figure 4. A masked owl (photo: Simon Grove), and a masked owl nest tree (photo: Due Dyke)

Survey of the Tasmanian masked owl in the Southern Forests using call broadcasts as a sampling protocol and an occupancy modelling approach.

Study of the environmental and habitat characteristics influencing the occurrence of the masked owl is hindered by its cryptic nature, nocturnal activity, small population size and large home range. ANU PhD candidate Adam Cisterne and his colleagues, including FPA staff, recently published a paper on the use of call playback for monitoring masked owls (Cisterne et al., 2020). This study took an occupancy modelling approach using masked owl call broadcasts as part of a rapid sampling protocol in the Southern Forests in July–September 2018. The aim of the study was to identify factors influencing the landscape occurrence of the species. The survey involved 662 visits to assess masked owl occupancy at 160 sites across the Southern Forests. Masked owl site occupancy was 12%, and estimated detectability was 0.26 (± 0.06 SE). Cumulative detection probability of masked owls over four visits was 0.7. Occupancy modelling suggested owls were more likely to be detected when mean prey count was higher. However, low detection rates hindered the development of confident occupancy predictions. To improve detectability of masked owls for future studies, there is a need to develop novel survey techniques that better account for the ecology of the species. The study also explores the potential to combine novel census approaches that exploit different aspects of masked owl ecology in order to obtain more robust and detailed data.

Study of the home range, habitat use and diet of the Tasmanian masked owl in the Huon Valley using radio telemetry.

FPA staff have been involved with the preparation of two manuscripts on masked owl ecology, based on field work done by Dave Young during his Honours research (Young, 2006). The aim of this study was to gather information to better inform the development of conservation management actions for the masked owl, particularly within the forest practices system.

Young et al. (2020) used radio telemetry to investigate home range size and habitat use of two female Tasmanian masked owls in a modified agricultural land/forest landscape in the Huon Valley. The diet was also investigated by identifying prey species from undigested prey remains in regurgitated pellets collected from roost sites. Home range estimates for two female owls were 1991 ha and 1896 ha using the Minimum Convex Polygon method, and 2507 ha and 2320 ha respectively using the Kernel Estimator method. The 50% isopleth Kernel estimated a core area of 174 ha and 309 ha for each owl respectively. Both owls used two core areas within their home range reflecting frequent foraging and roosting sites. The location and configuration of the home ranges within the landscape, and areas of core use, suggested the owls were responding to geomorphology, forest patch heterogeneity, forest structure and prey abundance and accessibility. Both owls preferentially foraged at forest edges, riparian zones and small forest patches (e.g. 0–50 ha). Frequently used foraging locations were in open forest with minimal understorey vegetation and a pasture groundcover, which probably reflects increased prey abundance, diversity and accessibility in this habitat type. The diet was dominated by locally abundant native and introduced ground dwelling mammals and marsupials. The strong association with riparian zones by the owls in this study highlights the potential importance of retaining streamside vegetation to the conservation of the masked owl.

A number of roost sites were identified through radio tracking of the two adult females and by observations of a juvenile and an adult male within the same home range areas (Young et al., in press). Frequently used roosting sites were in the core area of use for the two radio-tracked female owls in two neighbouring home ranges. Roost sites were typically associated with small watercourses, on the edges of large contiguous forest patches within a complex mosaic of forest and pasture. A juvenile owl used a high number of different vegetation roost sites after dispersing from the presumed natal territory. In contrast, the adult female used few roosts, including two vegetation roosts and one tree hollow, while only one tree hollow roost was located for the adult male. Roost sites of the male and female owl were less than 400 m apart and were both less than 1200 m from the presumed nest tree. This strongly suggests that the spatial proximity of nest and roost sites may be critical to facilitate territorial, foraging and reproductive behaviours of breeding pairs.

2.2.3. Grey goshawk (*Accipiter novaehollandiae*)

The Tasmanian population of the grey goshawk is listed as endangered under the *Tasmanian Threatened Species Protection Act 1995.* Grey goshawks are thought to be threatened by habitat loss, persecution, collision and poison (http://www.threatenedspecieslink.tas.gov.au/grey-goshawk). The grey goshawk is found in eastern and northern Australia and New Guinea, but the white colour morph predominates in Tasmania.

Grey goshawks have been recorded over much of Tasmania, but most sightings are from large areas of wet forest including rainforests. Anecdotal information suggests that forest with a closed canopy and low stem density, below 600 m altitude, is favoured by the birds for nesting during summer months. Goshawks also appear to require forest with an open structure under the canopy for foraging (FPA, 2010). A large proportion of potential habitat is outside of the reserve system.

Figure 5. Dr Sarah Munks doing the radio-tracking of grey goshawks in the mid 1990s. This research is now being written up into publication.

Tracking goshawks – write-up of historic data

In the mid 1990s FPA was involved in a radio-tracking study in north-western Tasmania that aimed to gather data on the characteristics of habitat used by grey goshawks for foraging and nesting. Only a few birds were tracked, but these data are an important resource given the paucity of information on this species. FPA has contracted Dr Sarah Munks to complete the data analysis and write-up of this project.

Habitat use by grey goshawks in southern Tasmania

Keen naturalist Dave Young has taken a particular interest in the grey goshawk and has located a surprising number of nest sites south of Hobart. He is hoping to take this research further in a more formal capacity and is liaising with UTAS and FPA about potential higher research degree opportunities. He is receiving advice and support from FPA staff.

2.2.4. Swift parrot

The swift parrot (*Lathamus discolor*) is federally listed as Critically Endangered and state listed as endangered. This species relies on tree hollows for nesting, and forages primarily on the flowers of *Eucalyptus globulus* and *E. ovata*. Management recommendations for this species in areas covered by the forest practices system are provided in the Threatened Fauna Adviser.

Establishing a selective harvesting trial to enhance foraging habitat for swift parrot

Sustainable Timber Tasmania (STT) recently planned a selective harvesting trial to investigate whether selective harvesting can be effective in enhancing foraging habitat for swift parrots. The trial is occurring in a dense stand of 1967 mixed *Eucalyptus obliqua-Eucalyptus globulus- Eucalyptus regnans* regrowth forest. Thinning the stand but selectively retaining *E. globulus* trees is expected to accelerate the growth and flowering potential of the retained trees. The trial also retains any potential nesting habitat trees.

Three treatments will be applied: a no-harvest zone (control); selectively retaining trees every 7–8 metres; and selectively retaining trees at a 10–12 m tree spacing. Retained trees are selected based on their potential as swift parrot foraging or nesting habitat. After selective harvest, the retained trees will be left in perpetuity through establishing a swift parrot special management zone over the coupe.

In consultation with FPA specialists, a monitoring plan has been developed where the growth and flowering response of retained trees across the three treatment types will be monitored over the next 10 years.

2.2.5. Devils and quolls

Tasmania supports the most diverse guild of marsupial carnivores on the planet, consisting of Tasmanian devils (*Sarcophilus harrisii*), spotted-tailed quolls (*Dasyurus maculatus*) and eastern quolls (*Dasyurus viverrinus*). These carnivores occupy an important role in Tasmanian ecosystems, and all three are federally listed as threatened (devils and spotted-tailed quolls are also listed under state legislation). They are all managed under the forest practices system, and FPA have been involved in two projects in the last financial year.

Monitoring devil dens in plantations before and after harvest

FPA have been monitoring a small cave in a 110 ha Norske Skog pine plantation in the Florentine Valley since it was identified as a potential Tasmanian devil den in 2014. Careful harvesting prescriptions were developed in consultation with species experts and Norkse Skog. Monitoring was carried out before and after the plantation was harvested. Cameras were continuously deployed between mid-2014 and mid-2017, and then for the peak of devil denning season only (winter–spring) each year from mid-2017. Cameras were removed from the site in December 2019 following a lack of evidence of denning activity of any species. Of the five additional caves which were added to the monitoring in 2018–19, all were removed in 2019–20 due to a lack of evidence of devil activity.

In the 2019–20 denning season, cameras detected high numbers of birds (commonly superb fairy wrens), pademelons, wombats and non-native rats, as well as occasional records of brushtail possum, devils, echidna and eastern quolls. All of these detections were of animals passing through or briefly visiting the cave. No individuals were observed to be frequently entering or exiting the cave. Only one video recorded a devil entering the burrow inside the cave, and no exit was recorded. This may be due to a camera failure not detecting the departing devil, or possibly that the devil used an unmonitored, alternative exit through the network of karst. These observations indicates that the local fauna are still accessing the site but do not seem to be using the target cave for breeding. Camera footage quality continued to decline substantially with the increased growth in weeds and bracken in the harvested area, which caused many ‘false triggers’ and decreased battery life.

Two new monitoring sites were established on potential devil dens in coupes near Bothwell in June 2020. These will remain in place prior to, during and after the proposed harvesting operations.

Figure 6. Adult male devil investigates the cave, Sept 2019.

Figure 7. Adult eastern quoll entering and departing through the smaller cave entrance, Sept 2019.

Figure 8. Echidna feeding in the soil of the cave entrance, Oct 2019.

Effects of production forestry landscapes and operations on devils and quolls

UTAS PhD student Evie Jones and her colleagues aim to discover how Tasmanian marsupial carnivores respond to forestry landscapes and operations, to identify ways that production forests could be managed to enhance their conservation. Evie will use a network of remote cameras across three production forest landscapes to determine the distribution and abundance of devils and quolls. Biological samples from live-trapping will provide measures of carnivore health across these landscapes.

Additionally, devils will be fitted with GPS radio-collars spanning before, during and after two plantation logging operations to identify how clearfelling affects their movements and den use. Evie will radio-track devils to their dens prior to logging and revisit these dens post-logging to assess their condition. GPS tracking will allow identification of denning behaviour and den sites post-logging. Monthly trapping and sampling of devils and quolls during this period will measure how forest harvesting operations impact their health.

The project is partly funded through a FWPA grant received by the FPA in 2020 with funding support from Forico, Timberlands, Sustainable Forest Management, Sustainable Timbers Tasmania and Norske-Skog. FPA staff are also providing supervisory and technical support.

2.2.6. Green and gold frogs: The role of modified landscapes in their ecology and conservation.

Litoria raniformis (green and gold or growling grass frog) is the largest endemic frog on the island of Tasmania and is currently classified as threatened at a state and national level. Habitat loss due to land-use change is considered one of the major pressures faced by this species, accelerating its decline in recent decades. This Deakin University PhD project, begun in June 2017, investigates the influence of differing matrix quality (commercial forestry vs. cleared pasture) on the ecology of *L. raniformis*. The effectiveness of current *L. raniformis* management in forestry areas was of particular interest to this work, with an aim to help inform future management. Following two field seasons, conducted in the summers of 2017–18 and 2018–19, research is now in the final phase of write-up.

Field research was focused around anthropogenic ‘dams’ (small man-made ponds for watering livestock and firefighting) located within commercial plantations and agricultural sites in central and northern Tasmania. Across two field seasons 89 dams were selected for multiple nocturnal amphibian surveys during which *L. raniformis* presence, absence and abundance were recorded. Of the 89 dams surveyed, 13 were found to be occupied by *L. raniformis*. Analyses revealed a significant negative association between the likelihood of *L. raniformis* presence at a dam and the amount of commercial plantation in the surrounding landscape (a 1 km buffer). Dams were more likely to be occupied as native dry eucalypt woodland increased in coverage within the same buffer. Estimated abundance of *L. raniformis* was similarly negatively correlated with increasing plantation cover at the landscape-scale. Potential occupancy and abundance were not significantly influenced by the amount of pastoral land in the surrounding landscape.

Mature *L. raniformis* located at five sites were included in a telemetric tracking program. Twenty-five adult frogs were tagged and tracked between October 2018 and April 2019. The primary factor influencing the proportion of time spent by tagged animals in proximity to a dam was the density of verge-side vegetation and individual weight. Cumulative distance moved over the course of the tracking period was similarly influenced by the vegetation density surrounding dams. Frogs located at vegetation poor ponds abandoned dams earlier in the breeding season and travelled further post-breeding; travelling into and between patches of native woodland. Dams with abundant buffering vegetation were able to support tagged *L. raniformis* in-situ throughout the tracking period, with dense adjacent vegetation potentially providing adequate long-term shelter and foraging opportunities.

Current forestry practices intended to protect *L. raniformis* focus on the retention of exclusionary buffer zones around plantation-based waterbodies (30 m). While this policy has a number of benefits for aquatic biodiversity (preventing sedimentation, eutrophication and allowing for vegetative regrowth), it falls short of addressing the year-round needs of *L. raniformis*. Without the presence and retention of proximal native dry eucalypt woodland in which *L. raniformis* can over-winter, interior plantation ponds do not appear to meet the seasonal habitat needs of this species. Future forestry conservation management should work to encourage the preservation of remnant and intruding native woodland within commercial plantation blocks along with continued safeguarding of waterside buffers.

This project received some financial and technical support from FPA.

Figure 9. A green and gold frog in a pond with aquatic vegetation (photo: T Garvey).

2.2.7. Giant freshwater crayfish

The giant freshwater crayfish (*Astacopsis gouldi*) is listed as vulnerable under both state and federal legislation. In the recovery plan for this species, habitat disturbance by forestry is listed as a threatening process (Commonwealth of Australia, 2017). The Threatened Fauna Adviser recommends that the giant freshwater crayfish habitat suitability map and field surveys be used to assess habitat quality for this species, and that wider streamside reserves are implemented in areas of higher quality habitat (FPA, 2013).

Headwater stream management for the giant freshwater crayfish

One of the main ways forestry may impact the species is by increasing sedimentation levels downstream. While the Threatened Fauna Adviser recommends wider streamside reserves in areas of higher quality habitat, there is concern that upstream management in areas that do not provide quality habitat (and therefore only standard class 4 stream guidelines are recommended) is inadequate for managing downstream habitat for this species (T. Walsh pers. comm.). Therefore FPA initiated a study, in collaboration with STT, UTAS and DPIPWE, testing the effectiveness of the class 4 stream guidelines in reducing sediment input to sub-catchments that support the giant freshwater crayfish. A pilot study of the field methods was done, which found that the sample size would need to double from that planned. A second pilot study was planned to determine if an alternative single and rapid assessment method could be used. However implementation of this work was delayed due to COVID-19. This pilot study is planned for 2020–21. The results of this second pilot study will be used to finalise the sampling regime, and then funding will be sought to do the broader study.

eDNA sampling

A collaborative project involving FPA, UTAS, DPIPWE and UCanberra has been initiated to try and develop a highly sensitive, highly specific genetic assay to enable detection of *Astacopsis gouldi* from environmental DNA (eDNA) water samples. A suitable region for genetic assays has been determined. Water samples from streams containing *A. gouldi*, and one that did not, were sent to the University of Canberra for processing. Detection was recorded in eDNA samples from five out of eight field sites. No detection was recorded from the negative site (negative control site). A manuscript is being prepared from this work, but further work is required to determine the sampling regime needed to confirm species presence/absence at a site.

The project is funded through a FWPA grant received by the FPA in 2018 with funding support from, Forico, Timberlands, Sustainable Forest Management, Sustainable Timbers Tasmania and Norske-Skog.

2.2.8. Skemps snail management strategy

The Skemps snail (*Charopidae* sp ‘Skemps’) is a small, flat land snail known only from inland wet sclerophyll and rainforest, within an area of approximately 225 km^2, in north-east Tasmania. It is listed as rare under State legislation. The primary management objective for Skemps snail is to implement actions that will assist the maintenance of populations throughout its range, primarily through the protection of known sites and the maintenance of potential habitat (Threatened Fauna Adviser 2014). A collaborative project between FPA, STT and private researcher Kevin Bonham, assessed whether potential habitat and populations of Skemps snail were maintained by retaining a) streamside reserves and b) a minimum of 20% of the coupe including suitable non-riparian areas.

The data is being reviewed and more sampling may be required to adequately determine the effectiveness of current management. This project is currently on hold until resources are available to complete the project.

2.2.9. Managing keeled snails

The keeled snail (*Austrorhytida lamproides* Cox) occurs only in far north-western Tasmania and southern Victoria, and is listed as rare under the *Tasmanian Threatened Species Protection Act 1995*. A keeled snail management plan was developed for Tasmania’s public production forests in 2000, with four key management strategies that aimed to limit the conversion of potential habitat (wet forest and rainforest) and maintain the age structure and distribution of habitat for the species. A collaborative project between FPA, STT and private researcher Kevin Bonham examined the degree to which the management strategies have been implemented, and been effective.

In 2013, live keeled snails were detected at 10 of 31 surveyed sites and in 2016, live keeled snails were detected at 17 of 31 surveyed sites. Models suggested the presence of keeled snails may be influenced by survey year and percentage of area within a 200 m radius that was less than 20 yo, while the abundance of keeled snails may be influenced by forest type with greater numbers found in plantation and mature forest than young or regrowth forest. However, none of the models were significantly different to the null model so all results should be interpreted with caution. Only limited sampling was done in plantation forest, so further sampling may be warranted to confirm whether plantations do have higher abundance of keeled snails than young native forest. The population viability analysis previously done on the keeled snails assumed a negative impact of plantation establishment on the species (Taylor et al., 2003), so the impact of forestry may be lower than was previously assumed.

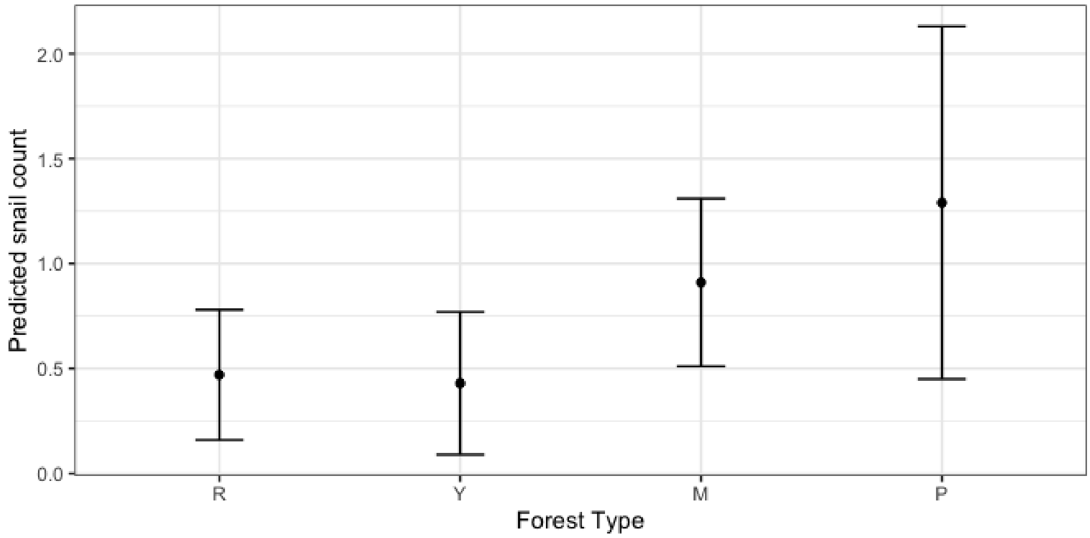

Figure 10: Predicted counts of keeled snails by forest type (R = regrowth, Y = young forest <20yo, M = mature forest >100yo and P = plantation forest). Note the large error bars indicating uncertainty in model results.

2.2.10. Simsons stag beetle

Hoplogonus simsoni (Simsons stag beetle) is a threatened species of stag beetle listed as vulnerable on both the Tasmanian *Threatened Species Protection Act* 1995 and Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999. It is found in the leaf litter of rainforest, damp forest, mixed forest and wet eucalypt forests in the Blue Tier area in north-eastern Tasmania. While the majority of known records of this species are from former production forest areas (FPPF land) and formal reserves, forestry operations do still occur within the species range.

A species management plan was developed for this restricted range species based on research outcomes. The aim was to complement the retention of 'current' habitat with measures that considered the temporal dynamics of habitat maintenance. The plan was delivered to planners in 2001 through the Threatened Fauna Adviser (TFA) and a Public Authority Management Agreement (PAMA). A decision was made not to renew the PAMA in 2017 primarily because conversion of public forests to plantation ceased in 2006 (Yee, pers. comm.). However, mitigation measures are still required through the TFA, for public and private forest, because temporary habitat loss from native forest harvesting and the removal of coarse-woody debris remains a potential threat to the conservation of the species.

A 10 year before-after-control-impact study was completed in 2008. This study aimed to assess the medium term impact of native forest harvesting (clearfell burn and sow and thinning) on the beetle and the effectiveness of mitigation measures. FPA have contracted Dr Sarah Munks to complete the analysis and write-up of this work.

2.2.11. Modelling the distribution of threatened flora

Historically the forest practices system has managed threatened flora by requiring surveys in areas of potential habitat that occur within specified proximity of known records. The effectiveness of this as an approach is strongly influenced by the number of known records of a particular species. In comparison, habitat suitability models are developed using data on known records, but they are not spatially limited by proximity to these known records. These models help predict where suitable habitat for threatened plants may be found across Tasmania and are expected to be a more effective method for identifying new localities.

The FPA have developed habitat suitability models for most threatened plants managed under the forest practices system. These models used Maximum entropy modelling, or MaxEnt, a stand-alone algorithm based software which estimates the relationship between presence-only species records and the environmental and spatial characteristics of those sites (Elith et al. 2011). For the threatened flora habitat suitability models, the species records come from the Natural Values Atlas and the habitat variables include TasVeg communities, geology type, elevation and bioclimatic variables. The models produced can be used to obtain a measure of habitat suitability in a geographical area and therefore as a means of approximating the relative likelihood that a given location will be occupied by a species (Bateman, 2010). These models do not aim to replace field surveys for forest planners, but to advise on locations to target and then survey, saving time and money on planning. The models were finalised in 2019–20 and have been written up in a Technical Note available on the FPA website.

2.2.12. Response of *Pterostylis atriola* (snug greenhood) to forestry disturbance

FPA (Anne Chuter) and ECOtas (Mark Wapstra) undertook a long term research project looking at the response of *Pterostylis atriola* to forestry-related disturbance events. Summaries of this work have been provided in previous reports, and a manuscript was published in 2019–20 (Wapstra and Chuter 2019).

2.2.13. Long-term monitoring of the vulnerable shrub *Hibbertia calycina*

Hibbertia calycina is a distinctive shrub restricted to north-eastern Tasmania that is listed as vulnerable on the Tasmanian *Threatened Species Protection Act 1995*, but not at a national level. Populations of this species were monitored in 1995, 2003–04 and 2017–2018. Results found *H. calycina* distribution is restricted to isolated clumps on highly insolated ridges and steep upper slopes of fine-grained Mathinna-series sedimentary rocks in dry sclerophyll forest dominated by *Eucalyptus sieberi* L. Johnson. A total of nine populations with an estimated area of occupancy 0.43 km^2 and extent of occurrence measuring 95 km^2, were documented, demonstrating that the current listing of *H. calycina* as vulnerable is appropriate (*Tasmanian Threatened Species Protection Act 1995*). The distribution of the present population is probably a result of natural factors (i.e. restriction to a narrow habitat range and natural fire events) and anthropogenic factors (managed fire frequency and intensity, and illegal firewood cutting). The species is potentially impacted by *Phytophthora cinnamomi*, although the impact is likely less problematic than initially postulated. *Hibbertia calycina* appears to be stable without active management, in a landscape of regular fire. Management focused on regulating fire and roading in the landscape is recommended.

This work has been a collaborative project involving Perpetua Turner, Steve Casey, Amy Koch (FPA) and Mark Wapstra (ECOtas), with Katrina Hopkins, Fred Duncan (now ECOtas) and Allison Woolley (DPIPWE). The manuscript on this research was refined in 2019–20 and has been submitted for publication.

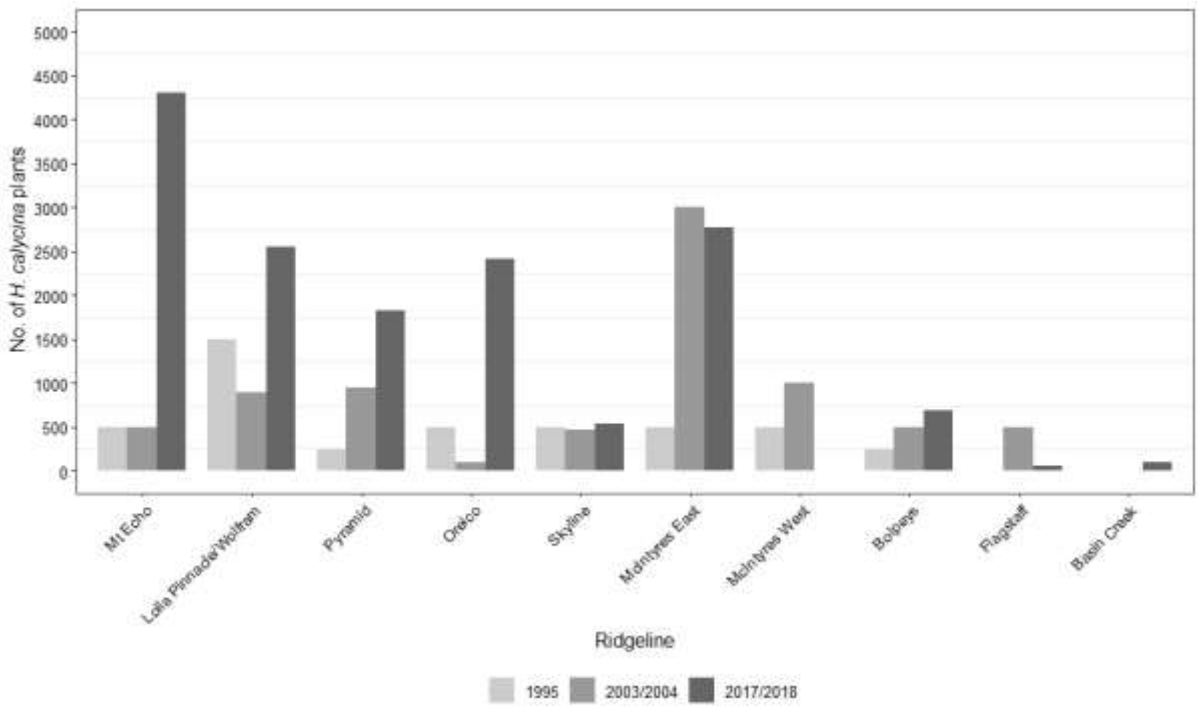

Figure 11. Number of *Hibbertia calycina* plants recorded during each survey by ridgeline. Note: some incomplete data e.g. McIntyres West, Flagstaff and Basin Creek.

2.2.14. Regeneration of threatened native vegetation communities

Currently, the forest practices system and the Permanent native forest estate policy do not seek to limit or restrict the harvest of threatened native forest types where the silvicultural system ensures successful regeneration and maintenance of that forest community. FPA initiated a research project to investigate whether previously harvested threatened forest communities have successfully regenerated. Site selection commenced, but the field work did not commence due to COVID-19. The study will be progressed in 2020–21.

3. Other Tasmanian project outcomes that contribute to our understanding of the effectiveness of *Forest Practices Code* provisions for biodiversity in 2019–20

These studies have mostly been done independently of the FPA, but the results have either been published as a thesis or scientific publication or the authors have contacted the FPA. Only a brief summary of the results relevant to the forest practices system are presented here.

3.1. General *Forest Practices Code* provisions for biodiversity

3.1.1. Assessing the impact of forestry

The sub-objective for the management of biodiversity under the forest practices system is '*to conduct forest practices in a manner that recognises and complements the contribution of the reserve system to the maintenance of biological diversity, ecological function and evolutionary processes through the maintenance of viable breeding populations and habitat for all species'* (Forest Practices Authority, 2015). It is therefore important that studies are conducted that assess the impact of forestry on non-threatened values as well as threatened species. Two studies in 2019–20 have directly examined the impact of forestry on biodiversity values.

Assessing the impact of forestry on beetle composition using beetle metabarcoding

PhD candidate Mingxin Liu (UTAS) has conducted a landscape ecology experiment in the Florentine Valley to test the relative importance of landscape context and forest influence together with other characteristics of mature forest in facilitating re-establishment of mature forest beetles into harvested areas. This study shows that beetle communities in regeneration forests of late successional stage (clearfelled ~50 years ago) have almost recovered to comparable condition of that in unlogged mature forests. Geographic position of sites is the main factor influencing turnover in beetle communities, but they still benefit slightly from the source of mature forests in the surrounding landscape. Mingxin's research has shown that DNA metabarcoding is fairly comparable to microscope-based ID based on morphology for detecting species presence/absence, although a barcoded reference collection is required to match identities to the Tasmanian Forest Insect Collection. Mingxin is also looking at whether DNA metabarcoding could provide quantitative information of species abundance for community analysis. His study shows that estimating species abundance or biomass with DNA metabarcoding is still unreliable, but future research might improve its accuracy. See Liu et al. (in press) and Liu et al. (2020b) for further details.

This project is part of an ARC-Linkage project led by Sue Baker and Greg Jordan. The project involves collaboration among several UTAS academics (Chris Burridge, Michael Charleston, Jules Freeman), external collaborators (Andrew Bissett from CSIRO and Laurence Clarke from Antarctic Division) and research students.

Assessing forestry impacts on the succession of soil microbial communities

PhD candidate Hans Ammitzboll (UTAS) is using next generation sequencing to investigate how soil microbial communities recover from the impacts of harvesting and regeneration burning in wet eucalypt forests. He has found that high intensity burning significantly reduces the biomass of soil bacteria and fungi, but that this lost biomass is recovered within six months post burn. In contrast, areas logged and not burnt still have decreased fungal biomass one-year post regeneration burning. The impacts of logging and burning on the compositions of bacteria and fungi communities are still present at one-year post-burn but a clear succession towards pre-burn community compositions is evident. Hans is currently investigating the relationships between these soil microbial communities and the recovering eucalypt cohort and other vegetation.

This project is part of an ARC-Linkage project led by Sue Baker and Greg Jordan. The project involves collaboration among several UTAS academics (Chris Burridge, Michael Charleston, Jules Freeman), external collaborators (Andrew Bissett from CSIRO and Laurence Clarke from Antarctic Division) and research students.

a) b)

Figure 12. (a) Photo of a clearfelled coupe 12 months post-regeneration burning; (b) Close up of area burnt at high-severity showing regenerating *Eucalyptus obliqua* and *Pomaderris apetala*, with 0.5m^2 quadrat.

3.1.2. Variation in *Eucalyptus delegatensis* post-fire recovery strategies

Item 8.16 of the *Forest Practices Code* states that ‘forest practices will be conducted in a manner that meets legislative requirements and actively manages forest fuels and forest access to maintain forest health, regeneration and ecological functions and reduce the risk and severity of damage from unplanned fires’. Provided below is the abstract for a recent publication by Rodriguez-Cubillo et al. (2020) on the impact of fire on harvested *Eucalyptus delegatensis* forest.

‘*Eucalyptus delegatensis* is native to the Australian Alps (subsp. delegatensis) and montane Tasmania (subsp. tasmaniensis). Post-fire regeneration mechanisms of the obligate-seeder subspecies on the Australian mainland are well-known, but less is known about the resprouter Tasmanian subspecies. In January 2016, large tracts of *Eucalyptus delegatensis* forests in central Tasmania, logged at different intensities, were burnt by low- and high-severity fires.

They used statistical modelling to understand how tree survival, vegetative regeneration and seedling recruitment differed according to understorey type, fire severity, logging intensity and tree size (DBH). Fire severity, defined as unburnt, low-severity (fire scarring on the stem and/or lower canopy burnt) and high-severity (full canopy burnt), affected tree survival: 84% of trees were alive in unburnt transects, compared with 43% in low-severity transects and 36% in high-severity transects. Epicormic resprouting was the dominant mode of vegetative recovery, with < 1% of total trees recovering solely by basal resprouting. Fire severity significantly affected epicormic resprouting, with 70% of live stems resprouting post-fire in low-severity transects and 99% in high-severity transects, compared with 4% in unburnt transects. Tree survival was strongly influenced by tree size: in high-severity transects, 24% of trees with DBH < 20 cm were alive, compared with 88% of trees with DBH ≥ 20 cm. These differences in survival were primarily because large trees were more likely to resprout epicormically, with epicormic shoots present on 24% of live trees with DBH < 20 cm, compared with 79% of live trees with DBH ≥ 80 cm. The strong effect of tree size renders clear-felled forests especially vulnerable to fire during the several decades when all the regenerating trees are small (DBH < 20 cm). Seedling recruitment was uncommon, independent of understorey type and logging intensity, but with higher occurrence on high-severity (54%) than low-severity (19%) or unburnt (15%) transects. When present, seedling densities were typically low: median = 400 and maximum = 4.104 seedlings ha−1. This study highlights that mature forests of *Eucalyptus delegatensis* in Tasmania are more resilient (able to return to pre-disturbance conditions) to single high-severity fires than their mainland counterparts, because they can recover more quickly through epicormic resprouting. However, clear-felling reduces this resilience for several decades because it decreases median tree size and, hence, leads to higher post-fire mortality. It is difficult to predict how the Tasmanian subspecies will respond to an increased frequency of high-severity fires associated with a projected warmer and drier climate' (Rodriguez-Cubillo et al., 2020).

3.1.3. Exploring land management options: Conserving biodiversity in timber production forests

UTAS researcher Sue Baker recently commenced an ARC Future Fellowship to investigate the impacts of different approaches to timber harvesting and reservation on biodiversity. The aim of this project is to develop and field-test a novel framework to reconcile forest conservation with production. The project seeks to resolve whether intensive forestry coupled with a large reserve network (land sparing) produces better biodiversity outcomes than less intensive forestry with fewer reserves (land sharing) or whether some intermediate strategy is optimal. The research will integrate abundances of plant and animal species with timber yield data from a large southern Tasmanian landscape. Plants and animals will be surveyed across a gradient of forest ages and land-use intensity from plantations, native forest silviculture to unmanaged reserves. Survey results will be synthesised with global data on biodiversity responses to forestry.

3.1.4. Baseline monitoring

To understand the impact of forestry on biodiversity, it is important that we develop a 'baseline' and determine the status of biodiversity values in areas not subject to forestry. These values may change over time so on-going monitoring is important. Several studies have contributed to our baseline knowledge of biodiversity values in areas outside the production estate, or have established long-term sampling studies that will help identify trends in biodiversity values over time.

Reserve monitoring on Permanent Timber Production Zone Land

In 2017 Sustainable Timber Tasmania (STT) initiated a monitoring program aimed at assessing the condition, and thus effectiveness, of reserves set aside on PTPZ land to manage special values. This includes wildlife habitat strips, streamside reserves, long-term retention zones and other special management zones for threatened species. The methodology involves a visual assessment of vegetation condition and key threats and impacts, including exotic-weed incursions, pest and disease, escaped fire, windthrow, canopy dieback, and illegal activities such as wood hooking and rubbish dumping. In addition, several fixed photopoints for monitoring change are established and re-photographed each year.

In 2018 the program focused on southern reserves in Franklin, Hastings and Southport. Given the extensive fires in the south of the state in the summer of 2018–19 it was decided to reassess these same sites in 2019–20 (STT, 2020). Franklin was heavily affected by the Riveaux fire while both Hastings and Southport remained unburnt.

Areas impacted by the Riveaux wildfire exhibited higher average damage scores and an increase in the frequency of moderate and severe damage symptoms. This was found in all vegetation strata but was particularly severe throughout the understorey. Of the fire damaged reserve areas assessed in the Franklin block, over 80% suffered severe damage to the understorey and severe or moderate damage to the midstorey, while 42% showed moderate or severe damage to the overstorey. Areas damaged by wildfire were found to be at increased risk of wind damage to the mid and understorey, and at greater risk of exotic weed incursion (STT, 2020). Rate of recovery after wildlife depends on a range of interacting factors, but in this fire the patchiness of the burn should help promote recovery and substantial survival was seen in overstorey trees. The authors estimated that understorey diversity and complexity may fully recover within 20–30 years in severely burnt areas if no further fires occur (STT, 2020, based on work by DSE 2003, McLean 2012, Pyrke and Marsden-Smedley 2005).

Damage scores in assessed reserves unaffected by fire remained low and there appeared to be minimal adverse changes over time. The only exception was an apparent increase in moderate levels of damage to the overstorey which may be due to an increase in leaf beetle defoliation but may also be an artefact of changes in crown health assessment methodologies. There may also have been a slight increase in the severity of exotic weed incursions over time. The authors supported the conclusion made in Wotherspoon (2019) that fire, as well as ongoing increases in hotter and more erratic weather due to climate change, are likely to have the greatest adverse impact on the reserve system into the future (STT, 2020).

Monitoring priority wildlife in the Tasmanian Wilderness World Heritage Area: A pilot survey on the Central Plateau

The Tasmanian Wilderness World Heritage Area (TWWHA) provides a large area of protected native habitat for a range of wildlife species. A report has been released which documents the results of a pilot survey of priority wildlife to assess survey techniques (Driessen et al., 2020). Priority wildlife species identified were fallow deer, Tasmania devil, eastern quoll, spotted-tailed quoll and common wombat.

The pilot survey was conducted at four locations comprising 42 stations on the Central Plateau. Each station was surveyed with a remote sensing camera and a fish oil lure for 73–82 days. A total 15,884 images of mammals were recorded representing 4,147 visits by 15 species. The five most commonly recorded species were Bennett’s wallaby (2,511 visits), brushtail possum (363), common wombat (278), eastern quoll (272) and Tasmanian devil (200). Sixteen species of bird were recorded from 743 images/285 visits. The most commonly recorded birds were black currawong (75 visits), forest raven (45), Australian magpie (45) and Australasian pipit (39) (Driessen et al., 2020). The pilot survey demonstrated that the camera-trap methods used were effective in detecting all priority species and provided important information on detection probabilities and timeframes.

The pilot survey also compared activity of mammals in areas burnt by the 2019 bushfire with comparable unburnt areas (Driessen et al., 2020). This was undertaken to provide an insight into how the monitoring program could be used but was not designed to fully assess the impact of the bushfire on mammal activity. Notwithstanding these caveats, the survey results suggest that the mammal composition in burnt areas was similar to that of unburnt areas, with the exception of wombats which appeared to be less active in recently burnt areas.

Establishing baseline fauna monitoring of the Tasmania Island Ark Midland plantings

Greening Australia have initiated a project, called Tasmania Island Ark, to restore 15,000 ha of habitat across the Tasmanian Midlands to create a stronghold for endangered wildlife and reconnect people and nature, while revitalising local farming communities.

UTAS Honours student Kawinwit Kittipalawattanapol is setting up a baseline monitoring program to determine whether the restoration plantings are being used by mammals, frogs, birds and invertebrates. The goal is to provide long-term monitoring guidelines to track the changes in faunal communities and inform Greening Australia for future directions in their adaptive restoration management. Monitoring sites have been set up in 5yo woodland restoration plantings (n = 4) and nearby bare paddocks (n = 4) and remnant woodlands (n = 4). In riparian habitats there was a lack of intact remnant sites, so monitoring sites are at restoration plantings (n = 5) and bare paddocks (n = 5).

To account for non-independency of restoration sites across the landscape, they used cross-fence comparison approach to compare each paired sites (i.e. Bare site vs Reference site, Bare site vs Restoration site and Restoration site vs Reference site). They surveyed for mammals, birds, frogs and ground-dwelling invertebrates at each site. They used invertebrate data to help explain presence of threatened insectivorous avian communities within the sites.

They used multivariate statistical models to compare wildlife communities between habitat types and test for relationships with structural habitat and landscape variables. The communities were compared between each habitat type to assess the trajectory of the restoration efforts. The preliminary bird and mammal data is provided in Table 1.

Table 1. List of species of conservation concern present at the sites that is found so far within the study. Note: This is not the complete analysis of the communities and only includes findings from bird and mammal surveys. The number n represents the number of sites surveyed so far.

Habitat type	Site	Taxa	Species of conservation concern present at the site
Riparian	Restoration plantings	Birds (n = 5)	Superb fairy-wren (*Malurus cyaneus*)
		Mammals (n = 4)	Spotted-tail quoll (*Dasyurus maculatus*) Feral cat (*Felis catus*)
	Bare paddocks	Birds (n = 5)	Superb fairy-wren
		Mammals (n = 5)	Feral cat
Woodland	Restoration plantings	Birds (n = 4)	Brown thornbill (*Acanthiza pusilla*) Yellow-rumped thornbill (*Acanthiza chrysorrhoa*) Superb fairy-wren Yellow wattlebird (*Anthochaera paradoxa*)
		Mammals (n = 2)	Feral cat Fallow deer (*Dama dama*)
	Bare paddocks	Birds (n = 4)	Yellow-rumped thornbill Superb fairy-wren
		Mammals (n = 1)	-
	Remnant woodlands	Birds (n = 4)	Brown thornbill Superb fairy-wren Yellow wattlebird
		Mammals (n = 1)	Spotted-tail quoll Tasmanian devil (*Sarchophilus harrisii*) Feral cat Fallow deer

Trend monitoring of Tasmanian birds

An annual survey for Tasmanian birds was initiated in 1971 in the form of the Tasmanian Bird Report. Significant improvements in data storage and processing have occurred since this time. The annual bird surveys were reviewed and reinvigorated in 2014 and an annual report is now put out on the status of Tasmania’s birds. The focus is primarily on terrestrial birds that regularly breed or visit Tasmania, although other species are examined at times. Surveys are undertaken by volunteers and so survey-site selection is based on personal preference, access and logistical considerations and so are not evenly distributed across the state. Attempts are made to achieve representative habitat and geographical coverage, but again this is not optimised. Surveys done are one of four different types: (1) 2 ha/20 minute surveys, (2) 500 m area surveys that search a larger area for variable durations, (3) 5 km area surveys which have highly variable observer effort and (4) incidental records which are not used in trend analyses.

One of the objective of these surveys is to compare the reporting rates between years for each bird species to provide an indication of possible changes in abundance and/or distribution. To date, detailed analyses have been undertaken to June 2017. Emerging trends of decreases in some endemic species are under scrutiny to assess whether these species meet the criteria for nominating for threatened species status (Newman et al., 2020). Changes in winter records are suggestive of a possible shift in migratory species over-wintering in Tasmania, and changes in reporting rates of insectivorous species have been linked with increasing air temperatures. The role of Tasmania as a drought refuge for some woodland bird species and numerous species of waterbirds was examined in the 2016/17 analyses. The annual Tasmanian Bird Reports are available from the BirdLife Tasmania web page (http://birdlife.org.au/locations/birdlife-tasmania), which include the annual State of Tasmania's Birds.

Monitoring birds on PTPZ land through field surveys and acoustic recorders in NE Tas - Goulds Country

STT has continued its native bird monitoring program on Permanent Timber Production Zone (PTPZ) land. In spring 2019 the focus of the program shifted to the Goulds Country forest block in north-western Tasmania.

The program involved deploying both bioacoustic recorders and ornithologist Andrew Hingston, to collect baseline bird data from 12 patches of mature forest in landscape of varying levels of mature habitat availability and land-use change. Each site was field surveyed at least six times from 12 to 20 September 2019. Bioacoustic recorders recorded bird calls at sunrise, during the day, sunset and through the night. STT intends to process the data through some machine learning bird call classifiers, recently developed by UTAS researchers Scott Whitemore, Mike Charleston and James Montgomery. This technology should provide a feasible and affordable option for monitoring key conservation species and detecting population trends over time.

Based on field surveys, a bird species list has been generated for each survey site. The most common species detected across these sites were grey fantail, Tasmanian thornbill, and Tasmanian scrubwren (all disturbance sensitive - mature forest associated species), and the striated pardalote (an obligate hollow user). Also commonly observed was the brown thornbill. Notedly, the grey fantail, Tasmanian thornbill and striated pardalote were the most common species detected from the 2017 north-west bird monitoring surveys.

Overall, these surveys provide useful baseline data that documents the bird species that inhabit retained mature forest patches in the production forest landscape. From this data, STT will monitor the persistence and trend in bird populations on PTPZ land over time.

In spring 2020 STT are planning to resurvey southern forest areas in both bush-fire affected and non-bushfire affected areas. These areas were surveyed in 2012 as part of Sue Baker's (UTAS), Tim Wardlaw and Simon Grove's (previously FT) biodiversity research. Having two surveys will allow comparison of bird activity before and after the 2019 Riveaux Road bushfire. They will also extend their monitoring to include mammals and bats, trialing the use of remote cameras and bat detectors respectively.

3.1.5. Advancing monitoring techniques

One of the factors limiting the amount of effectiveness monitoring being done in Tasmania, are the resources available to do the work. Monitoring techniques and tools are evolving rapidly, and improvements can facilitate a greater amount of effective research to assess the impact of forestry on biodiversity. Some studies outlined above (e.g. utilising eDNA or metabarcoding) already identify advances in monitoring techniques, but some additional studies are outlined below.

Machine learning bird identification

PhD candidate Scott Whitemore (UTAS) is developing machine learning recognisers to identify bird species from acoustic recordings. He has overcome a number of challenges that were hindering successful identification. He has built a recogniser for Tasmanian wet forest bird species that uses convolutional neural networks (CNN) to provide a probability that a bird is present in a particular recording. Amongst other advantages over random forest machine learning, CNN is much quicker to train with tagged recording, taking around one hour. Scott has managed to solve a bias issue caused by the presence of rare vs. common species so that the error is fairly comparable (in previous versions the recogniser had much greater performance for common species). Scott also investigated a range of metrics for assessing the performance of the recogniser and demonstrated biases associated with most commonly used metrics. He showed that the Matthews Correlation Coefficient performs consistently better than the standard metrics. This combines the probability of false positives and true negatives, which are both important aspects of a successful recogniser. These advances mean that the recogniser has greatly improved success with median accuracy across species of 87%. The accuracy varies from species to species; for example, it currently ranges from best predictive accuracy for black currawong (96%) and worst for superb fairy wren (64%). The latter species is known to have a wide vocabulary; thus it is possible that a more comprehensive tagged training dataset might improve prediction success. The recogniser is unable to distinguish the two species of thornbill, which are known to have very similar calls.

This project is part of an ARC-Linkage project led by Sue Baker and Greg Jordan. The project involves collaboration among several UTAS academics (Chris Burridge, Michael Charleston, Jules Freeman), external collaborators (Andrew Bissett from CSIRO and Laurence Clarke from Antarctic Division) and research students.

Ecoacoustics work by ICT Discipline at the University of Tasmania

Externally to the ARC Centre for Forest Value, the ICT Discipline at the University of Tasmania has been working collaboratively with STT, Tasmania Land Conservancy and NRM South to progress techniques for acoustic monitoring of natural habitats, a field known as ecoacoustics. This led to the creation of the citizen science site Birdsong in 2018, which has been used by interested amateur and professional ornithologists to annotate (identify) bird calls in recordings from north-western Tasmania and Victorian forests.

ICT's work in ecoacoustics has two themes: efficient processing of bioacoustics workflows to enable rigorous, robust, yet cost-effective analysis of the large volumes of audio data being collected (Brown et al., 2019; Brown et al., 2020; KVSN et al., 2020); and novel analysis techniques based on acoustic indices, which are statistical descriptions of the qualities of audio that can be related to biodiversity (Li et al., 2019; Watkins and Montgomery, 2020). The second theme has been the subject of a number of research projects, with publications in preparation.

3.2. Threatened fauna provisions

3.2.1. Swift parrot

The swift parrot (*Lathamus discolor*) is an endangered species that relies on tree hollows for nesting, and forages primarily on the flowers of *Eucalyptus globulus* and *E. ovata*. Management recommendations for this species in areas covered by the forest practices system are provided in the Threatened Fauna Adviser. Since 2007 a population monitoring program, established by DPIPWE, has been documenting impacts to the species including wildfire and nest site availability, predation, population size and geographic range. These are factors that impact breeding success.

Automated broadcast of a predator call did not reduce predation pressure by sugar gliders on birds

One of the key threats to swift parrots is predation by the introduced sugar glider (*Petaurus breviceps*). A recent study by ANU researchers examined whether broadcasting the calls of a predator (masked owl) would reduce nest predation (Owens et al., 2020). An extract from the manuscript abstract is provided below.

Figure 13. The threatened swift parrot, which is at risk from predation by sugar gliders (photo: Mick Brown).

They designed a solar-powered, automated weatherproof stereo for long-term call broadcast in a forest environment. Call broadcast did not reduce the likelihood of sugar glider nest predation on either active bird nests or artificial nests baited with farmed quail eggs. If they elicited fear in sugar glider individuals with call broadcast, this fear did not result in behavioural changes that could be exploited to achieve the conservation objective of lower predation.

3.2.2. Forty-spotted pardalote

The forty-spotted pardalote (*Pardalotus quadragintus*) is an endangered, sedentary, cryptic and specialised bird endemic to the island of Tasmania, Australia. This species has undergone an extreme range contraction over the past century and is now largely confined to a few small islands off the east coast of Tasmania. Historically the range included offshore islands, headlands and peninsulas in south-eastern Tasmania, and extended northwards along the east coast to Flinders Island. Major threats include habitat loss and degradation, introduced predators, competition from aggressive birds, drought, poor dispersal ability, and the larvae of a fly parasite (*Passeromyia longicornis*) which is a major cause of nestling mortality. Forty-spotted pardalotes favour white gum forest habitat (*Eucalyptus viminalis*) where they feed on insects, lerps, and manna (a sugary substance exuded by *E. viminalis*, which is also known as manna gum). Management recommendations for this species in areas covered by the forest practices system are provided in the Threatened Fauna Adviser.

Occupancy and density of a habitat specialist and a sympatric generalist songbird species in Tasmania.

Below is the abstract from Alves et al. (2019).

Patterns of distribution and abundance of species are dependent on their particular ecological requirements. Taking specialisation into account is important for interpreting population parameters. Here, we evaluate population parameters of an endangered habitat specialist, the forty-spotted pardalote (*Pardalotus quadragintus*; dependent on white gum *Eucalyptus viminalis* in south-eastern Tasmania), and a sympatric congeneric habitat generalist, the striated pardalote (*Pardalotus striatus*). We used occupancy models to estimate occupancy of both species, and distance sampling models to estimate population density and size on North Bruny Island. Within their shared habitat (i.e. white gum forest), we also fitted hierarchical distance sampling models to estimate density in relation to fine-scale habitat features. We show that forty-spotted pardalotes only occurred in forests where white gums were present, with a mean density of 2.7 birds per hectare. The density of forty-spotted pardalotes decreased in areas with abundant small trees and trees with dead crowns, but they increased in areas where larger white gums were abundant. The striated pardalote was widespread, but where white gums were present, they occurred at 2.1 birds per hectare, compared to 0.6 birds per hectare in forests where white gums were absent. Within white gum habitat, the relative abundance of forty-spotted pardalotes and dead trees had a positive effect on the density of striated pardalotes while small trees had a negative effect. Our study reveals that although widespread, the generalist is most abundant in the limited areas of habitat suitable for the specialist, and this indicates the need of future research to look at whether this pattern of occurrence exacerbates competition in resource depleted habitats.

'Self-fumigation' of nests by an endangered avian host using insecticide-treated feathers increases reproductive success more than tenfold.

Below is the abstract from article by Alves et al. (2020).

Parasites can cause great fitness cost to their hosts, however, their impact on host populations is often unknown. In healthy populations, parasites are not expected to cause declines, but they can be devastating to small and/or declining populations. Nest ectoparasites can have detrimental impacts on the breeding output of their hosts and are emerging as a threat to several endangered bird species. Therefore, finding cost-effect ways to reduce the impact of parasites on endangered hosts is crucial. Although 'close-order' management techniques available to manage nest parasites are effective, they are often expensive and might not be suitable for species that are intolerant of intensive manipulation. We tested a low cost, 'close-order' management technique to control parasites and boost nest productivity in an endangered passerine. The endangered forty-spotted pardalote *Pardalotus quadragintus* is exploited by an ectoparasitic fly *Passeromyia longicornis*, an obligate subcutaneous parasite of nestling birds. We offered adult pardalotes the opportunity to 'self-fumigate' their nests by supplying feathers treated with insecticide with which to line their nests and tested whether this boosted nest productivity. Pardalotes readily incorporated the experimental feathers in nest building, and survival of hatchlings was significantly higher in nests lined with treated feathers (95%) compared to nests lined with control feathers (8%). This represents a substantially greater improvement in reproductive success than in previous experimental studies, offering the strongest evidence yet that self-fumigation is a highly effective, simple and low cost 'close-order' management technique for defending endangered birds against ectoparasites.

3.2.3. Wedge-tailed eagles

Where? Where? Wedgie! State-wide monitoring of Tasmanian wedge-tailed eagle population

Where? Where? Wedgie! was launched in 2018 by the Bookend Trust, to monitor state-wide Tasmanian wedge-tailed eagle population trends. Additional aims are to improve public understanding of the science and to unite recovery efforts. In this low-cost, long-term citizen science project, volunteers survey annually for presence/absence of all raptors and 'white cockatoos'. A dedicated website (naturetrackers.com.au) coordinates effort across regularly spaced squares, and provides training in the survey method and raptor identification. Additional training and promotion are achieved through media, school visits, online lessons, and community talks - assisted by governmental and non-governmental organisations, corporates and interested individuals.

The 2018 pilot found that sufficient, capable participants were available to enable detection of significant (>40%) between-year changes in Tasmanian wedge-tailed eagle population size. Further, of 196 respondents to a social survey of participants, a majority reported subsequently being more likely to take at least one action for eagle conservation. The initial survey method was successfully adjusted to obtain more even geographic coverage for 2019, and this refined method was repeated in 2020. Both in 2019 and 2020, over 100 teams contributed good quality survey data to the project (lone individuals, groups of friends, families and school classes). Many surveyed for multiple days and in multiple squares.

A 2020 index of abundance (through occupancy modelling), to compare with that generated for 2019, will be ready later in 2020, after completion of error-checking and data-cleaning. Other analytical approaches will detect subtler changes and overall population trends over the years, and larger numbers of participants will enable swifter detection of smaller population changes. Research involving data from GPS-tagged birds will investigate ways to translate the survey data into absolute population size estimates. Note, however, that the project is unlikely to attain sufficient survey effort to provide detailed information on local population changes - the focus is on state-level population changes.

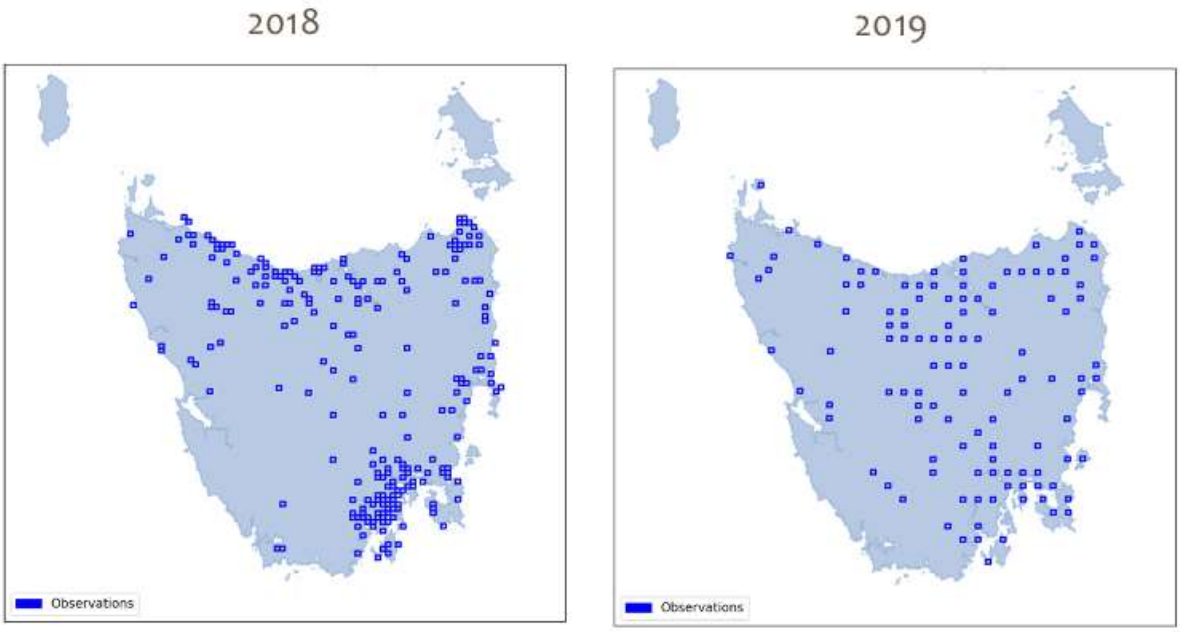

Figure 14. Survey coverage for 2018 and (under a stricter protocol, repeated in 2020) for 2019. The majority of 2020 coverage, which included King and Flinders Islands, can currently by viewed on https://naturetrackers.com.au/mapResults.php

3.2.4. Landscaping Tasmania's mammal community

PhD candidate, Antje Chiu Werner's (UTAS) research project aims to assess the changes in the mammal community structure and function along a gradient of land-use intensification in Tasmania, prioritizing native-invasive species interactions. This study is being conducted state-wide and replicated by bioregions. Within each bioregion, they have selected landscapes in each of three land-use categories (where they exist): Protected Areas (largely intact, undisturbed by anthropogenic uses), production forestry (matrix of silviculture and native eucalyptus and exotic pine plantations), and agricultural land (native vegetation remnants surrounded by large areas of farmland).

In the second half of 2019, they deployed 200 camera traps in 20 sites across Tasmania to determine the species composition and relative abundance in each landscape. The second phase (which has been postponed until 2021 due to COVID restrictions) involves live-trapping to obtain faecal and blood samples of several native and invasive species. These samples will be analysed to measure chronic stress levels, disease spillover and spillback, and diet across the gradient. They aim to understand how different mammal populations respond to changes in landscape and the mechanisms that underlie such responses. Finally, as each landscape represents a mosaic of different land uses, Antje aims to further identify which combination of land uses favour native over invasive species.

3.2.5. Assessing habitat requirements of the threatened eastern barred bandicoot in Tasmania

The eastern barred bandicoot (*Perameles gunnii*) is extinct in the wild in mainland Australia. In Tasmania the species was previously widespread over northern and eastern Tasmania, but in recent years the population has declined although it is still relatively common within the northern part of the Northern Midlands and West Tamar municipalities. Key threats include loss of refuge and foraging habitat via a decrease in structural complexity in the understorey, as well as a higher incidence of the predatory and disease carrying feral cats in the landscape. Climate change with expected hotter and drier conditions is also likely to affect the conditions within the understorey, perhaps influencing the availability of particular invertebrates or the structure and complexity of the understorey. Management of this species under the forest practices system includes retaining wildlife habitat clumps focusing on areas of significant habitat for the species.

A new PhD project, being done by UTAS student Jo Lyall, will use wildlife cameras, trapping and movement tracking techniques to determine what constitutes good habitat for bandicoots, the drivers of bandicoot abundance, and whether bandicoots respond to restoration interventions. This research may be used to review the habitat definitions for this species delivered by the FPA.

3.2.6. Claws on the Line - monitoring Tasmania's burrowing crayfish

Five species of burrowing crayfish are managed under the forest practices system. A program aiming to map and monitor Tasmania's burrowing crayfish populations, Claws on the Line, was launched in November 2019 by the Bookend Trust. Additional aims are to improve public understanding of the science and to unite threatened burrowing crayfish recovery efforts. The initial focus is on the endangered central north burrowing crayfish (*Engaeus granulatus*), which is endemic to a small region surrounding Devonport and Latrobe, through which it is very thinly scattered. The species' area of occupancy is estimated as less than 100 ha and shrinking. Much of this area is on privately-owned properties, so mapping and monitoring requires sensitive outreach efforts to obtain the assistance of many people. The project invites participants to share burrow location records via the app iNaturalist (on which precise locations can be hidden). Questionnaires and other public engagement efforts provide additional avenues for reporting locations and recognising crayfish burrows (including the website naturetrackers.com.au). The results, supported by visits to assist with species identification, will provide accurate, up-to-date information on this species' area of occupancy, and enable detection of any significant changes (initially with the aid of MaxEnt modelling). The project has identified a number of enthusiasts but relatively few records as yet – perhaps because promotion of the project in 2019 was primarily around a BioBlitz in Devonport. A more sustained effort is planned around schools and the community in spring 2020 (when the species becomes more active and apparent), in collaboration with governmental and non-governmental organisations, corporates and interested individuals.

Figure 15. Current records Claws on the Line project records on iNaturalist (https://www.inaturalist.org/projects/claws-on-the-line). Note that these include a range of crayfish taxa, and that accurate records of threatened species are not visible to the general public (so that Central North burrowing crayfish may appear to have been recorded in the sea).

3.2.7. *Hoplogonus simsoni* (Simsons stag beetle)

Hoplogonus simsoni (Simsons stag beetle) is a threatened species of stag beetle listed as vulnerable on both the Tasmanian *Threatened Species Protection Act 1995* and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. It is found in the leaf litter of rainforest, damp forest, mixed forest and wet eucalypt forests in the Blue Tier area in north-eastern Tasmania. While the majority of known records of this species are from former production forest areas (FPPF land) and formal reserves, forestry operations do still occur within the species range.

One of the areas of highest elevation within the range of the species is a Poimena, an area significantly impacted by anthropogenic disturbance (tin mining, fire, agriculture) from 1875 to the 1960s. Vegetation in this area is slowly recovering, so a recent study used a novel technique to investigate a high-elevation population of *H. simsoni* at Poimena. Exoskeletal material found in regurgitated pellets of black currawongs and forest ravens, as well as presence of intact beetles and larvae were used to confirm the existence of a population of *H.*

simsoni on the slopes of Mt Poimena, an area predicted to be unsuitable for the species in 2004. Regenerating native vegetation leading to improved soil condition is considered essential for the continuance and expansion of the beetle population at this location. [Modified from Richards and Spencer, 2019].

3.3. Other miscellaneous projects relating to Tasmanian forests

A range of other Tasmanian projects relate to forest ecology and management, but not to the effectiveness of the biodiversity provisions of the forest practices system. A subset of these projects is listed below.

Forest management

- The contribution of the Tasmanian forest practices system to biodiversity conservation is described by Munks et al. (2020). The paper is framed through, 1) legislative and policy context, 2) areas where the approach applies, 3) biodiversity provisions, 4) planning and implementation, 5) research, monitoring and continual improvement. Case studies of specific values highlight examples of practice. The swift parrot is one example, where a history of policy changes is detailed alongside practical constraints of poor reservation, variable patterns of foraging resource, predation (e.g. sugar gliders), alternative management approaches for nesting habitat and socioeconomic factors. With few published accounts of 'off-reserve' conservation systems in practice, the synopsis by Munks et al. (2020) provides a sound account of the past 30 years of practice and delivers direction for effective 'off-reserve' conservation for the future.

- Liu et al. (2020a) use nonparametric machine learning techniques to project the spatial distribution of forest cover and identify its drivers using Tasmania as a case study. One approach (RF) required less computational costs and outperformed the other three models (both in fitting and projection accuracy), but did exhibit serious overfitting. Although each model gave different influence rankings on explanatory variables, land tenure type and rainfall were identified among the top four for all. Topographic feature variables such as those associated with land clearing and production (elevation and distance to timber facilities) were most influential for the RF model.
- A comparison of the structure of overstorey *Eucalyptus* species and midstorey tree genera for private (covenant) reservation and public reserves found little tree recruitment on private lands (Romanin et al., 2019). On these lands, exotic pasture species were common. Tree recruitment on public lands was abundant with no pasture improvement. Recommendations to private reserves include reinstating fire disturbance, reducing exotic pasture, and management of domestic, feral and native herbivores.
- A recent study by Camarretta et al. (2019) examined how differences in species and provenance performance are affected by plant community composition in a dry sclerophyll forest restoration experiment. *E. tenuiramis* was more susceptible to

insects and frost, and had poorer establishment but greater growth of the survivors than *E. pauciflora*. Generally, nonlocal provenances were more susceptible to insect herbivory and frost damage and had higher mortality than local provenances.

Fire

- Using pollen, charcoal and dendrochronological analyses from sites at Surrey Hills, Tasmania, Fletcher et al. (2020) demonstrate that prior to British invasion, the burning regimes of Aboriginal Australians heavily influenced the species composition of the landscape. Landscapes were largely constructed prior to European influence. They previously maintained as eucalypt-savanna by frequent, low-intensity burns, thus discouraging the late successional wet forest and rainforest communities that since have encroached on grasslands under a post-Aboriginal burning suppression regime. The authors also challenge the view of Indigenous Australian's as 'hunter-gatherers'.

- Kirkpatrick et al. (2020) compared floristic and environmental data from 1994 to that of 2016–17 at Surrey Hills Tasmania. They found a high frequency and cover of native shrubs in unburned areas for the 20 years before 2017 but not for unburned areas in the 20 years before 1994. Without fire, a) shrub cover increased strongly, and was greater on larger plains and b) there is a high potential of species loss at the landscape scale. Current fire intervals (10 years) are maintaining grassiness and native species richness of treated plains.

- With data from 2010–2019, Borchers-Arriagada et al. (2020) present the first study to quantify health impacts attributable to biomass smoke for Tasmania. Woodheater smoke was attributed to 74% of impacts, and had average yearly costs 18 times higher than that for landscape fire smoke (AUD $16 million). Replacement heating technologies, improvement in fire management and integrated strategies are suggested to deliver important and cost-effective health benefits.

Climate change

- Iglesias and Whitlock (2020) look at past forest histories in north-western USA, Patagonia, Tasmania and New Zealand. They report on how a narrow view on only present forest conditions overlooks the conditions that have shaped forests of today, such as biophysical, disturbance, climate, ecological response and thresholds. Future strategies to address climate change should be framed with a perspective of ecological resilience.

Threatened or 'special' species

- A series of papers were published in the last financial year on the threatened orange-bellied parrot (*Neophema chrysogaster*) (Stojanovic et al., 2019a,b; Stojanovic et al., 2020a,b). Stojanovic et al. (2019a) found that removing the nests of the competing tree martin (*Petrochelidon nigricans*) was ineffective management action for alleviating nest competition for orange-bellied parrots. Stojanovic et al. 2020a concluded that fire alters the availability of key resources needed by breeding orange-bellied parrots, and ongoing manipulation of fire regimes may relieve limitation of natural foods for this species.

- Cunningham et al. (2020) examined whether Tasmanian devils limit abundance of invasive feral cats and in turn protect smaller native prey. They found cat abundance was about 58% higher where devils had declined, which in turn negatively affected a smaller native prey species. Devils had a stronger limiting effect on cats than on a native mesopredator, suggesting apex predators may have stronger suppressive effects on evolutionarily naive species than coevolved species.

- Anderson et al. (2020) used GPS collars and cameras and found little spatial segregation of home range and core area placement between Tasmanian devils and spotted-tailed quolls. Quolls showed more spatial segregation within the sexes than between them. Devils had larger home ranges than quolls. Male devils had larger home ranges than females, but there was no difference in home range size between the sexes of quolls. Females of both species travelled significantly further per night than did males. There was moderate temporal partitioning between the two species: devil activity peaked after dusk and devils remained active until the early morning, while quoll activity showed distinct peaks around dusk and dawn.

- The long-lived, endemic Tasmanian conifer *Athrotaxis selaginoides* (King Billy pine) is integral to many Tasmanian threatened vegetation types. Holz et al. (2020) document a landscape-scale population collapse of King Billy pine in remote montane catchments in southern Tasmania. Fire events were infrequent prior to European colonisation, and stands persisted during this time with irregular, widespread forest fires. Fire increased quickly after colonisation with near total tree mortality of King Billy pine, changes in vegetation structure and fuel loads. Current distributions reflect survival in refugia.

- A recent study by Dean et al. (2020) sampled soil organic carbon and soil bulk density under large tree trunks, inside tree trunks, in the humus mounds in the buttress region and under the humus mounds of *Eucalyptus regnans* mixed forest. They estimated that 90% of the total soil organic carbon was within ~ 2.6 m of the surface, that soil organic carbon was four times more concentrated under large tree trunks, and that at the stand level there was about 7% more soil carbon than previously estimated.

Social science

- Yasue et al. (2019) explored the psychological and management impacts of financial incentives for enabling landowners to engage in conservation activities. Landowners indicated that neither the payments to create a covenant, nor the conservation covenant made any significant impact on how they managed the land. However landowners receiving stewardship payments reported that the payments enabled the conservation actions they valued, helped build relationships and promoted favourable attitudes towards conservation.

- A survey-based study found that private land conservation programs supported autonomy by helping landowners align private land management decisions with deeply held environmental values. These programs also fostered competence and relatedness by developing trust and shared purpose amongst people engaged, enabling personal and social learning and enhancing life purpose and belonging (Yasue et al., 2020).
- Banham (2020) explore the concept of 'ontological security' i.e. the 'trust individuals have that the world, their lives, and self-identity are fundamentally stable and predictable'. Banham (2020) remodels this concept through a case-study interviewing 27 Tasmanians about their concerns, feelings etc. relating to Tasmania's forests. The paper focuses more on the concept of 'ontological security' than the case study findings. However, some findings include: forests are the foundation of routine life events; forests are a sense of refuge; events in forests contextualise hopes and fears of the future.
- A paper by Woo et al. (2020) presents modelling of the potential socio-economic impacts from a proposed co-generation bio-energy plant (under 50 MW) in the Valley Central Industrial Precinct (VCIP) in northern Tasmania. Conclusions reached were that feedstock availability is a critical factor in the biomass energy industry. A combined heat and power plant is the best option for the dried biomass feedstock. Under 25 MW biomass plant is the best option for the local industry in this area.

Miscellaneous

- A recent study by Smith et al. (2020) found the incidence and severity of bark damage in 12 Tasmanian radiata pine plantations was influenced by site-factors. They found that the likelihood of bark stripping increased with percentage of bare ground, bracken and moss and grass. The difference between mean minimum soil and air temperatures in spring was also related to the extent of bark stripping.
- A recent study by Krisanski et al. (2020) presents results from a study of a consumer-grade Unmanned Aircraft System (UAS) flown under the forest canopy in challenging forest and terrain conditions. The results demonstrate that under-canopy UAS photogrammetry shows promise in becoming a practical alternative to traditional field measurements, however, these results are currently reliant upon the operator's knowledge of photogrammetry and his/her ability to fly manually in object-rich environments.

4. Discussion and 2020–21 priorities for biodiversity monitoring

The FPA-supported studies current in 2019–20 continue to contribute to our understanding of the effectiveness of the *Forest Practices Code* provisions for biodiversity. There have not been as many projects initiated this year as the emphasis has been on progressing existing projects, while a number of the projects funded by industry and Forest and Wood Products Australia (FWPA) have taken a new direction.

Major projects by external research providers continue to tackle important areas relevant to the work of the FPA. The focus on improving survey techniques has continued this year, but with an increased emphasis on collecting baseline and trend monitoring data. These data are extremely important for setting the context for the status of biodiversity values in Tasmania. Efficient and effective survey techniques and baseline trend monitoring data facilitate the interpretation of other studies examining the impact of forestry.

While trend monitoring is extremely important, assessing the effectiveness of management practices needs to remain a key focus for the FPA research program. A number of projects are progressing that will make important contributions to our understanding of the impact of forestry on high profile, threatened species.

One other theme alluded to by a number of studies, but not addressed directly by any of the studies reported on, was the impact of climate change on the effectiveness of the forest practices system. The fires that occurred on mainland Australia in the summer of 2019–20 were a reminder of the considerable impact that climate change and associated disturbances such as wildfire can have on our forests. Addressing the impact of climate change was identified as a priority by the Biodiversity Expert Review Panel in 2008 (BERP, 2008). To ensure the FPA remains responsive to emerging issues, we need to ensure that management considers the impact of climate change and responds accordingly. Therefore a priority for 2020–21 should be to progress existing projects and review the impact of climate change and associated disturbances on the forest industry.

5. References

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