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

2016–17 summary report

Amelia Koch and Sarah Munks

Report to the Board of the Forest Practices Authority and the Secretary of the Department of Primary Industries, Parks, Water and Environment

Hobart

August 2017

FPA Scientific Report 21

Disclaimers

The information presented is a broad overview of information considered relevant (by the authors) to the aim of this report. Whilst the authors have 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 authors 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.

Front page photograph: FPA ecologist, Jason Wiersma (left) conducting annual eagle nest checks by fixed wing aircraft, with pilot Jesse Hawtree (right).

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 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 have allowed us to include the results from their research, undertaken independent of the Forest Practices Authority, which 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 fund the biodiversity effectiveness monitoring implementation plan for 2016–2019 (RM D16/31313).

Citation

This report should be cited as –

Forest Practices Authority 2017, *Monitoring the effectiveness of the biodiversity provisions of the Tasmanian* Forest Practices Code: *2016–17 summary report. August 2017*, FPA Scientific Report 21, report to the Board of the Forest Practices Authority and the Secretary of the Department of Primary Industries, Parks, Water and Environment.

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. Information on the effectiveness of the biodiversity provision of the *Forest Practices Code* was reviewed in 2012. The gaps identified were used to prioritise future projects. Work is done each year on a number of the priority projects. The degree of effort depends on available funds, logistic considerations and staff/student availability.
- This report summarises projects by Forest Practices Authority (FPA) staff and students (in collaboration with other research providers), carried out during the 2016–17 financial year (Section 2). It also includes projects done by other researchers (independent of the FPA) (Section 3), where the results contribute to our understanding of the effectiveness of actions taken for biodiversity values.
- Four FPA-affiliated projects current in 2016–17 contributed to our understanding of the effectiveness of code provisions that relate to the maintenance of species dependant on mature forest and freshwater habitats. FPA are working with Sustainable Timber Tasmania (SST, formerly Forestry Tasmania) to develop GIS tools for assessing landscape management recommendations delivered through FPA's Biodiversity Landscape Planning Guideline. FPA worked with STT and Australian National University (ANU) staff to explore whether LiDAR data could be used to map mature tree availability at a fine spatial scale. FPA are working with the University of Melbourne to assess the population dynamics of tree ferns in unlogged and logged forest adjacent to streamside reserves. A global literature review looked at the impacts of harvesting on stream biota and the value of stream buffers, and found considerable variability in responses.
- There were 14 FPA-affiliated projects current in 2016–17 that contributed to our understanding of the effectiveness of code provisions for threatened species. Eagle research found that the timing of the 2016–17 breeding season was later than average, preliminary data suggests that nest failure rates may be high in Tasmania, current nest management guidelines appear to be effective and juveniles largely remain close to the nest site in the six months following fledging. Preliminary results from surveys of threatened snails indicate that they are found in a wider range of habitats than previously thought and management appears to be effective. The potential range of two threatened butterflies is being field-checked and a study is looking at their response to forestry burning. Two studies explored the use of plantations by threatened carnivores (devils and quolls) and found these species use plantations in different ways, with quolls potentially responding negatively to the presence of feral cats. Projects have been initiated in 2016–17 looking at the range and habitat preference of the Lake Fenton trapdoor spider, the impact of plantation management on threatened frogs, and the effectiveness of headwater stream management for the giant freshwater crayfish.
- A range of projects done by other researchers in 2016–17 contributed to our understanding of the effectiveness of the forest practices system, with particular focus on the effectiveness of retention measures and restoration techniques. Research on threatened species was focused on hollow-using birds (swift parrots and forty-spotted pardalotes).

1. Introduction

The Tasmanian forest practices system follows an adaptive management framework which includes an emphasis on research, review and continuing improvement (FPA, 2014). It is widely recognised that ongoing research and monitoring is important for the scientific credibility of the Code's provisions applied in forest management plans (Commonwealth of Australia & State of Tasmania, 1997; Davies et al., 1999; Wilkinson, 1999). There is also a legislative requirement to monitor the effectiveness of Code provisions applied in forest practices plans (FPPs). 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 Code provisions needs to be clear.

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 were used as the basis for determining priorities for effectiveness monitoring of the *Forest Practices Code* (FPA, 2012). To identify priority monitoring projects, the management objectives and threats to values were linked with management actions. All threat/action pairs were assessed and ranked according to a range of attributes, such as the proportion of forestry operations or land area that may be affected, the effort to conduct effectiveness monitoring, the expected effectiveness of management, and degree of uncertainty about whether the management action is effective. This assessment was done both for the general *Forest Practices Code* provisions for biodiversity and the recommendations for threatened fauna delivered via the Threatened Fauna Adviser. See Box 1 for the highest priorities for each group of management actions (FPA, 2012). This prioritisation process will be repeated in 2017–18 to account for the results of recent research. Note that this assessment has not yet been undertaken for the management actions for threatened flora species or vegetation communities. This is planned for 2017–18 when standard management recommendations have been developed as part of the Threatened Plant Adviser project.

Work is done each year 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 the findings from the projects current during the 2016–17 financial year. It includes projects undertaken by FPA staff (mostly in collaboration with other research providers) (Section 2) and projects done by other researchers (independent of the FPA) (Section 3) where the results contribute to our understanding of the effectiveness of actions taken for biodiversity values, in areas covered by the forest practices system.

Box 1. Project areas identified as a priority to evaluate the effectiveness of the biodiversity provisions of the *Forest Practices Code* (FPA, 2012)**. In bold if progressed in 2016–17.**

A. The priorities identified for monitoring the effectiveness of the general biodiversity-related code provisions are:

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 the hygiene measures help prevent the 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 the 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.

B. The priorities identified for monitoring the effectiveness of the threatened fauna management provisions (note that priorities have not yet been identified for flora) are:

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

2. Summary report on FPA research and effectiveness monitoring covered in 2016–17

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

2.1. The objectives of the Tasmania's forest practices system for biodiversity

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, 2015a).

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 processes, policies and strategies involved are reviewed in Chuter and Munks (2011). These have been developed from a mixture of expert judgement, practical experience and the outcomes of research and monitoring.

The following sub-sections in this report provide a brief summary of the projects current in 2016–17 which contribute to our understanding of the effectiveness of the actions and will inform any future review of the Code provisions.

2.2. General *Forest Practices Code* provisions for biodiversity

The following summaries are for projects that contribute to project areas A2, 6, 7 and 8 (Box 1).

2.2.1. Biodiversity landscape planning on permanent timber production zone land

Effective conservation management of biodiversity, from genes to population, requires a landscape scale approach. Recently the Board of the FPA endorsed the Biodiversity Landscape Planning Guideline (the BLPG) to provide guidance on how to meet the landscape-scale goals for biodiversity in areas regulated under the forest practices system (http://www.fpa.tas.gov.au/__data/assets/pdf_file/0016/112363/Biodiversity_Landscape_Planning_Guideline_2017.pdf). Marie Yee from Sustainable Timber Tasmania (STT, formerly Forestry Tasmania) is working with FPA scientists to apply the BLPG to Tasmania's public wood production forests.

This project has used and extended the functionality of the Landscape Context Planning System, which is a relatively new conservation planning system developed by STT, to now be able to evaluate and monitor the various aspects of landscape change, in relation to past, current and proposed management at a mid-landscape scale (forest block and CFEV subcatchment scale). Work is continuing to develop a risk-based approach to applying the BLPG on Permanent Timber Production Zone land (PTPZL). Application of the BLPG will help guide longer-term forest planning to explicitly consider the cumulative effects of forest operations on habitat values and ensure biodiversity values are being managed at the most appropriate temporal and spatial scale.

2.2.2. Using LiDAR to produce a finer resolution map of mature tree (i.e. hollow) availability

Habitat models are useful as they facilitate strategic planning and can make operational planning more efficient. Tree hollows provide essential habitat for a range of fauna in Tasmania, including a number of threatened species. The FPA developed a 'mature habitat availability map', based on PI-type and other spatial data, to help manage threatened fauna dependent on mature forest features. Given the coarse resolution of the underlying data, the mature habitat availability map is not accurate at fine scales and so is of limited use for operational planning. FPA (Amy Koch) have been working with STT (Rob Musk and Daniel Hodge) and ANU (Matt Webb) to explore whether LiDAR data can be used to develop a finer resolution map of this important resource.

Previous work has shown that tree diameter is strongly related to the probability that trees will contain hollows. Therefore tree diameter thresholds currently used by the industry were used to classify trees in STT's LiDAR study plots as either 'mature', 'large mature', or not mature. These data were then used to develop a model that classified other areas mapped by LiDAR as containing habitat or not. The accuracy of the model was iteratively improved by doing field surveys in areas that were not performing well and re-running the modelling process. The final map product was validated using areas known to contain swift parrot nests. Results so far suggest that LiDAR can be used to map the location of mature trees likely to contain hollows with reasonable accuracy (Figure 1). It is hoped the map can be used for the identification of hollow-bearing trees in operational planning.

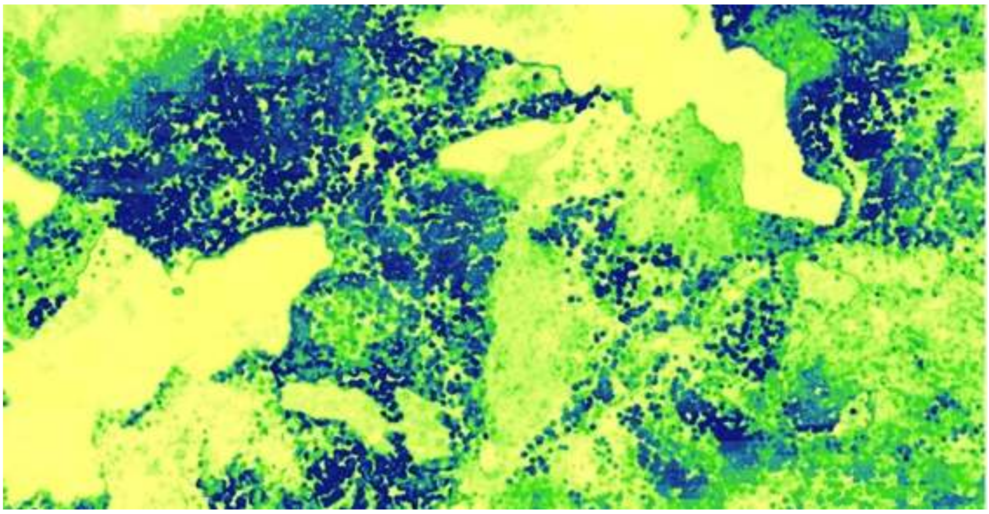

Figure 1. An example of the LiDAR mature trees map, where darker colours indicate a greater likelihood of mature (hollow-bearing) trees.

2.2.3. Influence of site and disturbance history on tree fern dynamics in Tasmania and Victoria: implications for epiphyte and plant diversity

The FPAs tree fern research program aims to inform the future management of tree ferns as a forest resource and to assess the effectiveness of the tree fern management provisions in Tasmania. There exists a gap in the research undertaken to date that complements the FPA's tree fern research program; what are the population dynamics of tree ferns in unlogged and logged forest (retention harvesting/clearfell) adjacent to streamside reserves, overtime?

To address this gap, Clare Duck, a MSc student from the School of Ecosystem and Forest Science at the University of Melbourne, co-supervised by Craig Nitschke (UMelb) and Perpetua Turner (FPA), undertook field work in north-west Tasmanian wet eucalypt forest to look at the epiphytic diversity on treeferns (height, density and surrounding forest vegetation), in a range of forest types regenerating after clearfelling and aggregated retention. Clare has repeated the fieldwork in the Central Highlands of Victoria, including wildfire regeneration and excluding aggregated retention. Preliminary results include: bryophyte and epiphytic fern diversity is richer and more diverse on *Dicksonia antarctica* in Tasmania than in Victoria; the epiphytic diversity on *D. antarctica* is more diverse than that found on *Cyathea australis* (no *C. australis* was sampled in Tasmania). Clare's records of the heights of *D. antarctica* and *C. australis* will be used to estimate tree fern ages using an in-preparation height-age mode (Fedrigo et al. in prep). It is also hoped that the data collected in Tasmania will be useful in Victoria for informing and understanding the possible effects of variable retention harvesting, a method which has only recently begun there. This knowledge will be useful for determining the best silvicultural approach for managing tree fern populations and maintaining their ecological function in the forests of Victoria and Tasmania.

2.2.4. The impacts of harvesting on stream biota

University of Tasmania (UTas) Honours student, Tamika Lunn, together with supervisors Sarah Munks (FPA) and Scott Carver (UTas) have just had a manuscript accepted reviewing the impacts of timber harvesting on stream biota (Lunn et al. 2017). The systematic global literature review found few consistent responses of taxa to forestry, with variation in the direction and magnitude of observed responses across studies. The majority of studies were on invertebrates in North America, were retrospective surveys, lasted less than five years and only considered impacts at a stream reach scale. The authors suggest that more research is required in understudied areas and on a greater diversity of taxa at broader spatial and temporal scales, and that greater focus should be placed on understanding the mechanistic reasons why stream biota respond to forestry.

2.3. Threatened species management

The following summaries are for projects current in the 2016–17 financial year that looked at the effectiveness of the provisions for threatened fauna species. They contribute to threatened fauna project areas B1, 2, 4, 5 and 8 (Box 1).

2.3.1. Wedge-tailed eagle management actions

The Tasmanian wedge-tailed eagle (*Aquila audax fleayi*) is an endemic subspecies that is listed as endangered at both a state and federal level. The primary threats to this species are loss of nesting habitat, disturbance at the nest site, mortality due to collisions with man-made structures and persecution (Threatened Species and Marine Section, 2017). Three projects were current in 2016–17 which contribute to our understanding of the effectiveness of management actions for this species.

FPA annual nest monitoring

FPA initiated a research program in 2007 to monitor wedge-tailed eagle nests. Data were collected between 2007–08 and 2014–15 on the rate of nest success and timing of breeding season events. The objectives and outcomes from the FPA eagle nest monitoring project were reviewed in 2015 and it was determined that the scale of the project would be reduced due to limited FPA resources. Since this time the project aims only to establish the timing of the breeding season to assist with management decisions. Similar to 2015–2016, survey nests were selected from a targeted group of nests confirmed as ‘active’ during activity nest checks conducted in October. During the 2016–2017 breeding season 23 of the nests surveyed had chicks that could be aged. Data from these surveys allowed the timing of the breeding season to be evaluated (Figure 2). The results showed eagles laid later than average in 2016–17.

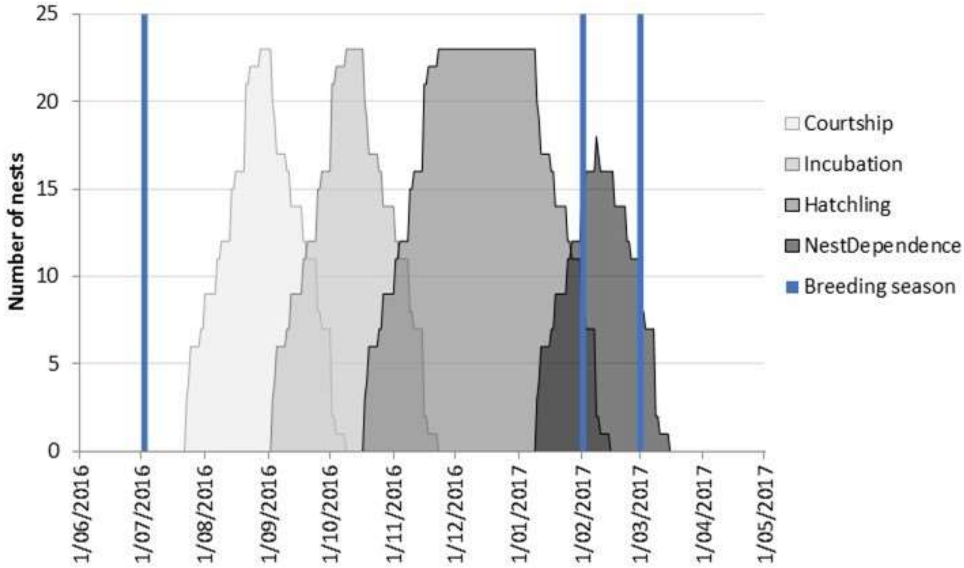

Figure 2. The timing of the 2016–2017 breeding season, extrapolated from the estimated age of chicks at 23 nests. The blue lines indicate the eagle management constraint period, with the two lines on the right indicating the end of the constraint period for a standard (middle bar) and a late season (furthest right).

Given that some nests are now surveyed twice in a season, first for the industry checks and then later to assess the timing of the breeding season, this has allowed us to get an indication of breeding failure rates. These data suggest that more than half of breeding attempts have failed in the last two seasons (Table 1) which is considered high compared to other *Aquila* eagles. However it should be noted that results from the first survey in a season are often simply that an adult is observed on a nest and it is usually not confirmed whether an egg has been laid, so these results should be interpreted with caution.

Table 1. Estimated breeding season failure rates from aerial nest surveys conducted during November 2015–2016 and 2016–2017[a].

Result of nest survey in November	Number (and percent) of nests surveyed in November*	
	2015	2016
Successful	16 (36%)	15 (42%)
Failed	29 (64%)	21 (58%)
Total	45	36

[a] Nests were selected for survey in November if they were assessed as being 'active' in October because an adult, egg or chick was seen on the nest. Nests were classified in November as being successful if a chick was observed in a nest or a fledgling seen in the territory (usually with parents) or evidence (whitewash, prey remains and down) from the nest strongly indicates that fledging was successful. All other nests were classified as having failed.

Behaviour of breeding eagles and the impact of disturbance

In March 2015 an FPA-supported PhD candidate, James Pay, commenced research with the aim of studying the behavioural ecology of the Tasmanian wedge-tailed eagle and quantifying the impacts of human disturbance. During the 2016 breeding season field work was carried out to assess how effective the current management prescriptions are at protecting nesting eagles from the impacts of human disturbance. Aerial nest surveys conducted in October were used to identify 44 nests for this study. The researchers conducted ground-visits to these nests during October 2016, introducing a disturbance at the limit of the current exclusion zone (500m out of line-of-sight from the nest). The disturbance involved audial and visual aspects that were carried out at a similar level to a standard harvesting operation (e.g. a speaker played audio at a comparative volume and frequency of the sounds created by forestry machinery). The nests were resurveyed aerially in November 2016 to determine if the eagles were still nesting. The results from this work found a high nest failure rate in both control and experimental nests, but suggest that the disturbance did not cause an increase in nest failure rates (see Figure 3).

The project is also investigating the spatial ecology of the Tasmanian wedge-tailed eagle using GPS telemetry. In January 2017 the research team attached GPS transmitters to eight sub-adult eagles. The transmitters record the location of the birds every 15 minutes, providing detailed data on how the eagles are moving around the landscape (see Figure 4). Initial analysis of the data has revealed that juvenile wedge-tailed eagles stay within their natal territory for at least five months after fledging. The project aims to attach a further 10 transmitters in January 2018. These transmitters are expected to last five years and will provide valuable information on the dispersal patterns, causes of mortality and habitat requirements of the species.

Results of this project will improve understanding of the species and may result in a review of current recommended management. The project is being supervised by Elissa Cameron

(School of Biological Sciences, UTAS), Amelia Koch (FPA) and Clare Hawkins (Threatened Species Unit, DPIPWE). Expert advice on Tasmanian wedge-tailed eagle ecology and guidance on the project design are being provided by Jason Wiersma (FPA), Nick Mooney and Bill Brown (DPIPWE). Current funding for the project has been provided through New Forests through Timberlands Pacific, the Holsworth Wildlife Research Endowment, Woolnorth Windfarms, TasNetworks, Birdlife Australia, the FPA and Norske Skog.

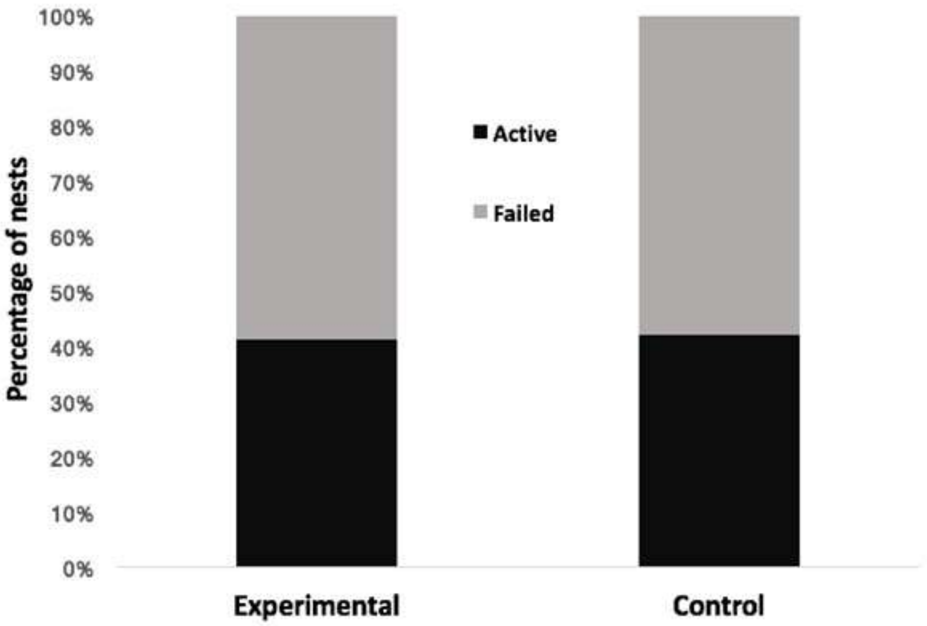

Figure 3. Percentage of nests that were still active or had failed between a survey early in the breeding season (October) and a repeat survey later in the season (November). Experimental nests are those where an activity that mimicked audio and visual disturbance caused by forest harvesting was introduced at 500m from the nest. Control nests did not have an activity event introduced. The results indicate that there is a very similar nest failure rate between both samples; 58% of control nests and 59% of experimental nests had failed in the month between the two surveys.

Strategic eagle nest management 2016 – 2017

A project was initiated to develop a method for identifying important nest sites for wedge-tailed eagles to assist with strategic nest management in production forests. This project is being carried out by FPA Scientific Officer, Jason Wiersma. Field survey work was undertaken in northeast Tasmania during April 2016. A total of 110 nest sites (and their reserves) were flown during the survey period using rotor-wing aircraft. These flights collected aerial data on nest and reserve characteristics, including images. Ground verification surveys of these nests also collected nest characteristic data and further reduced the number or nests to 64 due to natural attrition and/or missing data.

Data from the 64 nests are being analysed to test the feasibility of developing a method to rank a nest based on a suite of explanatory variables, so that eagle nests in production forests can be strategically managed into the future. Regression models (boosted regression trees: decision trees and boosting [iteratively building a model]) are being used as a tool to quantify the relationship between a nests rank (by an expert) and associated nest characteristics. Preliminary analyses have found that of the top 6 nest characteristics with greatest relative influence for determining a primary or secondary nest for Expert A, four of these characteristics (nest condition, average nest depth, % canopy cover above the nest, and number of large mature trees) are also in the top 6 for Experts B and C. Experts A and B were most similar in their ranking of nest characteristics for primary and secondary nests. A draft report is currently being produced to summarise preliminary findings. Further work is planned to increase the sample size to better ascertain the usefulness of the key findings considered important in establishing a new approach to prioritise nests.

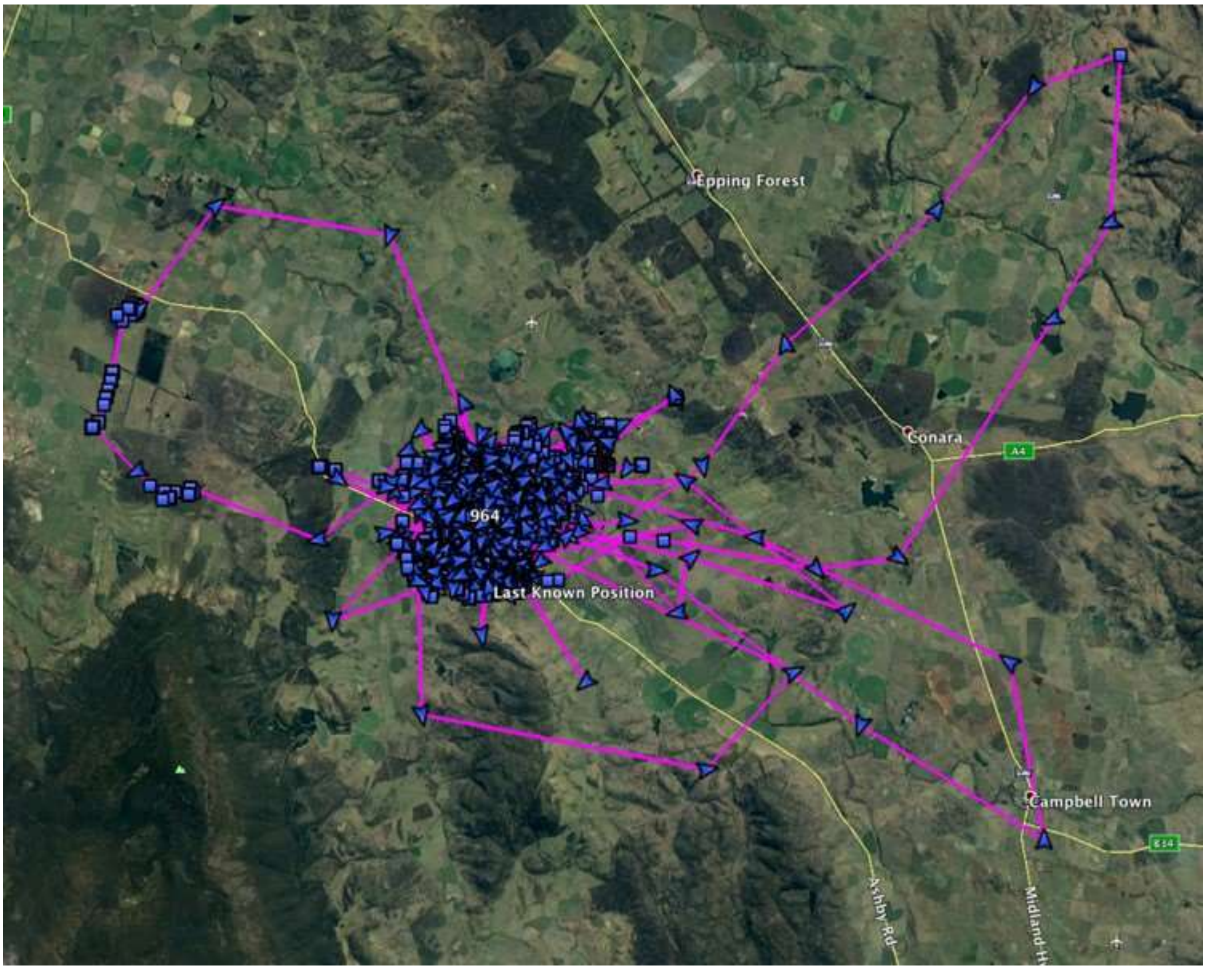

Figure 4. **GPS data received from a wedge-tailed eagle tracked since January 2017. The GPS transmitter has been recording the location of the eagle every 15 minutes. Each location fix is represented by a blue square or blue arrow (dependent on if the eagle was moving or stationary). The data shows that the eagle has predominantly stayed within 4 km of its nest. Between 17 April and 16 May the eagle took four exploratory flights ranging from 10 to 25 km from the nest location. However, the eagle has remained within 4 km of the natal nest from 16 May until the first week of July.**

2.3.2. Monitoring management actions for the protection of masked owl roost and nest sites

The Tasmanian masked owl (*Tyto novaehollandiae castanops*) is an endemic subspecies that is listed as vulnerable under federal legislation and endangered under the Tasmanian *Threatened Species Protection Act 1995.* The Threatened Fauna Adviser recommends that if an operation is to occur near a known masked owl nest or roost site, the FPA be contacted for advice and as a guide the FPA might recommend a 100 m radius reserve be retained around such as site.

In 2016 a project was initiated to assess the efficacy of these management prescriptions for protection of masked owl nest and roost sites within the forest practices system. The project involves annual monitoring of reserves and management actions that have been implemented in FPPs for the protection of nest and roost sites. Only a few sites have been managed specifically for the protection of masked owls through the forest practices system. Initial attention was focused on reviewing locality records from across Tasmania both from within and outside the forest practices system. All confirmed nest and roost sites will be surveyed in 2017 to establish baseline environmental data on general habitat and critical habitat features, local landuses and disturbance, and evidence of use of sites by masked owls. The project will reassess nest and roost sites on an annual basis and any newly recorded nests and roosts will be added to the annual monitoring schedule.

2.3.3. Skemps snail management strategy

As set out in the Threatened Fauna Adviser, the current management prescriptions for the rare-listed Skemps snail (*Charopidae* sp ‘Skemps’) (TSPA 1995) include the requirement 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. Coupe based surveying for this species is conducted on an as-required basis. However, comprehensive information on habitat requirements for the species is lacking. To address the effectiveness of retaining areas of varied age and forest production type to achieve levels of presence and abundance of the species throughout the Skemps snails’ known range (in accordance with management prescriptions), four weeks of sampling targeted at different ages and types of forest retention were conducted. Habitat types were either riparian or non-riparian and were surrounded by production forest of different types (mature, 20 yrs old, plantations). Skemps snail was patchy in its distribution and was predominantly present: at riparian sites surrounded by mature forest; in habitat supported by manferns, rainforest or wet eucalypt forest; in multi-aged wet forest; under rocks and woody debris of various sizes. Where it was found, it was fairly common. Skemps snail was absent: at non-riparian sites surrounded by plantations; at narrow (<40 m) retained riparian areas irrespective of surrounding forest type; where fire and other disturbance affected wood quality/quantity. The data set is currently being analysed to further investigate these findings.

2.3.4. How effective are management strategies for the threatened keeled snail?

The Tasmanian *Threatened Species Protection Act 1995* rare-listed keeled snail (*Tasmaphena lamproides*) occurs only in far north-western Tasmania and southern Victoria. The management plan for keeled snail in Tasmania's public production forests (where it predominantly resides) incorporates data from initial surveys for the species and information on species biology. The management plan identified four key management strategies aimed at limiting the conversion of potential habitat for the species (wet forest and rainforest) and managing the age structure and distribution of habitat.

In 2013, 28 sites from the initial 1992 surveys were revisited, and in 2016 new data (31 sites) on the snail were collected to examine if management strategies have been effective in maintaining viable breeding populations of the species across its range. The data suggest that there has been an overall decrease in the abundance of keeled snails across their range. However, this decrease is less than predicted by previous population viability analysis modelling investigating impacts of logging. Effective management was evident where keeled snails were confidently and consistently found in older logging regeneration and mature forest. Unexpectedly the keeled snail was also present in young plantation and 20–39 year-old logging regeneration, in similar numbers to mature forest albeit with larger variance (Figure 5). The degree to which the management strategies have been implemented (using GIS spatial analyses) is being analysed. Modelling of species data is suggesting that management to date has been effective.

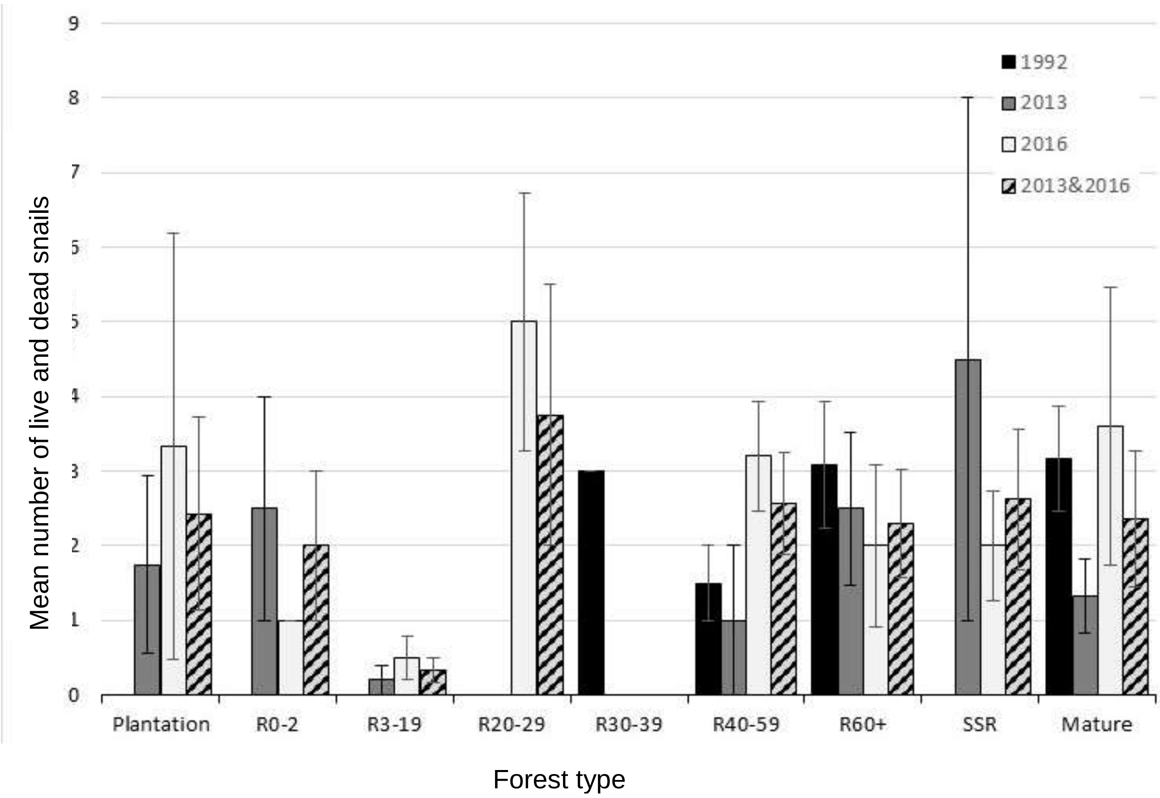

Figure 5. Mean and standard error of the combined surveys for keeled snail surveys done in 1992, 2013 and 2016. Surveys were done in mature, plantation, regrowth of different ages and streamside reserves (regrowth ages indicated are correct for 2016).

2.3.5. Tasmania's threatened frogs

Tasmania has two species of threatened frog; the green and gold frog (*Litoria raniformis*) and the striped marsh frog (*Limnodynastes peroni*). The main threats to these frog species are loss and fragmentation of habitat, predation on eggs and tadpoles by introduced fish species, and infection by pathogens (particularly chytrid fungus). In June 2017 a Deakin University student, Tim Garvey, started a PhD looking at the spatial ecology and impact of timber harvesting on Tasmania's threatened frogs and the effectiveness of current management recommendations delivered through the Threatened Fauna Adviser. This project is being supervised by Don Driscoll (Deakin University) and Amy Koch (FPA) and will be used to review current management of these species.

2.3.6. Lake Fenton trapdoor spider

The Lake Fenton trapdoor spider was first collected from the Mt Field National Park in the 1920s. For over 50 years, it was only ever known from a very small area at the outflow of Lake Fenton, but in 1992 it was discovered by chance in Forestry Tasmania's (now STT) pitfall trapping samples in the Central Highlands around Tarraleah, extending its known range by 60 kilometres. In a recent survey in the Wentworth Hills, Dydee Mann (FPA) and Dave Kyte (STT) discovered a spider in the same genus (Plesiothele) that looked similar to a female Lake Fenton Trapdoor Spider but may be a new species. FPA is hoping to do more work looking at the distribution and habitat preferences of Plesiothele spiders in Tasmania, and potentially assess the effectiveness of different management options. This project will progress in an *ad hoc* manner as opportunities are presented.

Figure 6. Lake Fenton Trapdoor Spider hole, Tarraleah (Dydee Mann).

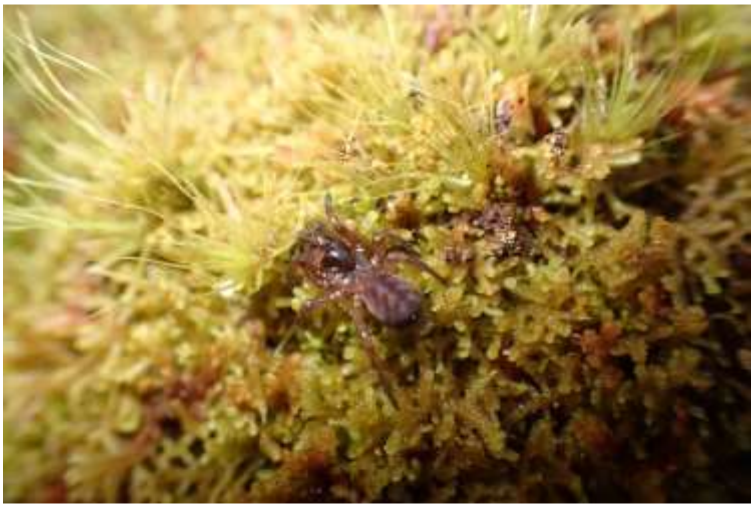

Figure 7. Lake Fenton Trapdoor Spider on moss (Karen Richards).

2.3.7. Threatened butterflies

Tasmania has several species of threatened butterfly, of which three are included in the FPA monitoring program; Chaostola skipper (*Antipodia chaostola subsp. leucophaea*), the Tasmanian hairstreak butterfly (*Pseudalmenus chlorinda myrsilus*) and Marrawah skipper (*Oreisplanus munionga subsp. larana*). Three projects have been initiated by the FPA acting ecologist Phil Bell in 2016–17: assessing the distribution of two species, and the response to fire and habitat disturbance for two species

Response of threatened butterflies to fire and habitat disturbance

Initiated in 2016, this project aims to develop effective management prescriptions for chaostola skipper and Tasmanian hairstreak for forestry planned burning and development activities and is jointly supported by FPA, TSS, PWS and TFS. The project monitors butterfly habitat and populations in two conservation reserves before, and in the years following planned burns.

The distribution and abundance of chaostola skipper was determined for Peter Murrell Reserve, near Kingston. Attempts were made to assess the distribution and abundance of Tasmanian hairstreak within Lime Bay Nature Reserve, although the surveys were problematic due to the large extent of the food plant (silver wattle) within the reserve. Both reserves were subsequently burnt in autumn 2017 and will be surveyed annually to assess re-establishment or re-colonisation by Tasmanian hairstreak.

Systematic survey for chaostola skipper in Tasmania

The current potential range boundary for chaostola skipper used in forestry planning covers an extensive area along the east coast from the Huon valley up to the north coast and as far west as the Tamar valley. The use of this large potential range for planning is the result of a precautionary approach in the absence of systematic surveys for this species.

The project was initiated in 2017 and will be completed by August. Known records and locations of chaostola skipper were reviewed and a simple habitat and distribution model developed to guide the surveys. The model was mainly based on known locations of the food plants (*Gahnia radula* and *G. microstachya*) but also on the distribution of associated forest communities including *Eucalyptus tenuiramis* forest on granite, and *Eucalyptus amygdalina* forest on sediments. Fortunately we can identify chaostola skipper at any time of the year, not just when adults are flying, as the caterpillars build characteristic shelters in the food plant that are present year round (Figure 8).

Previously chaostola skipper was known only from a few sites between Hobart and Freycinet Peninsula. However, it was discovered in a proposed coupe near Bridport last year (100 km outside the known range). The systematic survey, almost completed, has rediscovered the species in the Huon valley (where it was previously recorded in the 1960s but thought to be extinct due to clearing for agriculture and residential development) and adjacent to Mt William National Park in the far north east of the state (over 60 km from the nearest known location). Habitat for chaostola skipper was also found to be broader than is currently defined and includes coastal *E. amygdalina* forest.

The results of the survey so far suggest that chaostola skipper is more common than previously thought. This new information will be used to review the conservation status, potential range boundary, potential habitat description and management prescriptions for the species delivered through the FPA's Threatened Fauna Adviser.

Figure 8. Caterpillar/pupal shelter of Chaostola skipper in thatch sawsedge (*Gahnia radula*). The shelter is made by joining several leaves of the sedge together with silk - the caterpillar rests in the shelter with its head downwards with the shelter opening at the bottom.

Systematic survey for Marrawah skipper in Tasmania

The current potential range boundary for Marrawah skipper used in forestry planning extends from the far northwest of Tasmania, east along the coast as far as Penguin. The use of this large potential range for planning is the result of a precautionary approach in the absence of systematic surveys for this species.

The project was initiated in 2017 and will be completed in August. Known records and locations of Marrawah skipper were reviewed and a simple habitat and distribution model was developed to guide the surveys. The model was mainly based on known locations of the foodplant (*Carex appressa*) but also on the distribution of associated forest communities, mainly *Melaleuca ericifolia* coastal swamp forest. Fortunately we can identify the species at any time of the year, not just when adults are flying, as the caterpillars build characteristic shelters in the foodplant that are present year round.

The systematic survey for Marrawah skipper targeted the current potential range between Stanley and Penguin and the far northwest region that supports the bulk of the known records. The Penguin record extends the potential range of Marrawah skipper by over 65 km from the nearest known record. Its presence at Penguin raises speculation that the species was more widely distributed in coastal northwest Tasmania and eliminated in the wake of a history of extensive land clearing for agriculture. The systematic survey was completed in June 2017 and failed to find the species at Penguin or in any potential habitat surveyed between Penguin and Stanley – the most easterly confirmed site now being at Roger River. The survey discovered several new populations for Marrawah skipper, all within the existing known range and an inland range extension to the Arthur River near Kanunnan Bridge.

The results of the survey suggest a large easterly range contraction for Marrawah skipper of about 90 km, however more sites have been found for the species within its core range in the far northwest. These results will be used to review the potential range boundary, potential habitat description and management prescriptions for Marrawah skipper delivered through the FPA’s Threatened Fauna Adviser.

2.3.8. Habitat use in plantations by Tasmanian devils and spotted tailed quolls

Carnivores play an important ecological role and many species have been shown to be sensitive to habitat change. Two of the marsupial carnivores managed under the forest practices system are the Tasmanian devil (*Sarcophilus harrisii*) and the spotted tailed quoll (*Dasyurus maculatus*). The Tasmanian devil is listed as Endangered at both the state and federal level, and the spotted tailed quoll is listed as Rare under state legislation and Vulnerable under federal legislation. Two studies that contribute to our understanding of habitat use in plantations by these species were current in 2016–17.

Factors in plantations in north-west Tasmania influencing usage by spotted-tailed quolls, devils and cats

Loss and fragmentation of habitat are key factors causing decline in many native species worldwide. Carnivores often require large areas of habitat, and so are particularly vulnerable to habitat loss. Habitat loss and fragmentation have occurred on a large scale in Tasmania since European settlement due to the conversion of native forest to both agricultural land and forest plantations. These changes, combined with the recent decline in the abundance of the Tasmanian devil due to Devil Facial Tumour Disease (DFTD), are likely to have influenced the distribution and abundance of the guild of mammalian carnivores in Tasmanian forests.

This study was part of Joanna Lyall's Masters project through the University of Tasmania, co-supervised by Menna Jones, Chris Johnson and Sarah Munks. The aim was to quantify the use of different types and elements of plantations in north-west Tasmania by native and invasive mammalian carnivores: the Tasmanian devil, spotted-tailed quoll and domestic/feral cat (*Felis catus)*. The goal was to gather information of use to forest managers to enable them to manage plantations to increase their value for the native carnivores and thus reduce the effects of habitat loss associated with conversion to plantations. Forty-five sites were surveyed in plantations, in winter and in summer, and the landscape and site-specific factors were recorded. The results indicate that the three species are influenced by different factors, between winter and summer, and at site and landscape levels. Spotted-tailed quolls were found in more open plantations, suggesting they travel through plantations rather than use them for hunting or denning. Devils were found in dense understorey during winter but in more open plantations in summer except where there are windrows, indicating possible use for denning. Cats mainly occupied plantations in close proximity to agricultural land where there are high rabbit populations. These results reflect the different and varying requirements for each species during the year for breeding and hunting. Our results indicate that it should be possible to enhance the habitat value of plantations for the two native predators by focussing on their site-level requirements at critical times in their annual life-cycle. Improving habitat for the two native predators is likely to reduce the habitat suitability for feral cats.

In the wider landscape study, there are seasonal differences that drive the habitat and land use, of the three species, influenced by breeding cycles, prey preferences and availability. Both devils and quolls appeared to favour native forest while feral cats were more likely to be found in agricultural areas. Spotted tailed quolls appeared to be more specialised in their habitat requirements than the other two species, with taller forests and understorey qualities influencing their occurrence. Elevation, forest cover and prey emerged as factors influencing the abundance of the Tasmanian devil. Feral cats were abundant on the edges of agricultural land with cover, including trees and undergrowth, for concealment during hunting.

There are relationships between all the species. Spotted-tailed quolls and devils are more abundant at the same sites, and cats and devils have no adverse influence on each other's presence. However there was some evidence that spotted-tailed quolls and cats avoid each other or choose different habitats.

Use of devil dens in plantations before and after harvest

A small cave in a Norske Skog pine plantation was recognised by planners in 2014 as a potential den site for the Tasmanian devil. This was confirmed by FPA ecologist, Dydee Mann, through the use of a remote camera. The video footage of the cave showed a female devil with young entering, then later leaving without the young. Management prescriptions were developed to protect the site and the devils occupying it, during a harvest operation planned for 2015, including a speed limit for passing vehicles. Harvesting of the 110 ha coupe began in the furthest end of the coupe in late 2015, with the trees around the den site itself harvested in February 2016.

Monitoring of the den site to evaluate the effectiveness of the management prescriptions by Dydee Mann pre- and post-harvest involved collecting data at monthly intervals using cameras to record observations of fauna visiting the site. Nearly all of Tasmania's larger terrestrial mammals were recorded at the site - including echidna, brushtail and ringtail possum, pademelon, wombat, devil (Figure 9), eastern and spotted tailed quoll, feral cat, introduced rats, introduced mice, antechinus and swamp rat. Individual devils have been recorded returning to the site over multiple months within the same year, in two successive years, and one individual was recorded in 2014, 2015 and 2016. This indicates some devils are resident and others passing through. Although observed species diversity declined post-harvest, species diversity returned to pre-harvest levels within 4–5 months, including observations of a Tasmanian devil with pouch young entering the den. The first devil with visible signs of DFTD was detected in August 2016. The quality of the camera footage has declined post-harvest with the sudden increase in exposure (leading to weathering of camera units), resulting in more 'false triggers' of the cameras and sudden increases in weed growth in front of the PIR sensors.

Additional monitoring sites were established at potential den sites within a pine plantation at Hollow Tree and a thinned hardwood plantation in Mathinna in 2016. Initial footage from these sites has not yet provided strong evidence of denning devils, but one site has shown use by multiple individual spotted tailed quoll. FPA has contracted biologist Fiona Hume to assist with this camera surveillance project through 2017–18.

Figure 9. A devil investigating the Norske Skog den being monitored by camera trap (Photo: D. Mann).

2.3.9. Giant freshwater crayfish

The giant freshwater crayfish (*Astacopsis gouldi*) is listed as vulnerable under both state and federal legislation. In the new draft recovery plan for this species, habitat disturbance by forestry is listed as a threatening process. One of the main ways forestry may impact the species is by increasing sedimentation levels downstream. The Threatened Fauna Adviser recommends that the GFC 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. However 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.).

FPA and UTas are in the early stages of initiating a long-term project to assess the efficacy of riparian buffers on class 4 streams for mitigating the impacts of sedimentation on this species.

3. Other Tasmanian project outcomes that contribute to our understanding of the effectiveness of *Forest Practices Code* provisions for biodiversity in 2016–17

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. Effectiveness of forest retention measures to promote recolonisation

Forests of different ages provide habitat to different species, and promoting landscape heterogeneity is seen as one of the key strategies for maintaining biodiversity in production forestry landscapes (Lindenmayer and Franklin, 2002). It is particularly important that mature forest is maintained throughout the forest estate as older forests provide special structural features, take long times to develop and therefore are more difficult to replace (Munks et al., 2007). The *Forest Practices Code* and associated planning tools recommend retention of forest patches within a production landscape for a variety of reasons, including to maintain biodiversity. Understanding the amount and distribution of older forests and the spatial requirements of species (particularly in relation to mature forest), can inform both stand and landscape level management to help maintain habitat for biodiversity.

Landscape structure in Tasmania and Victoria

A spatial analysis compared the structure of wet forest landscapes in southern Tasmania, northern Tasmania and the Central Highlands of Victoria based on GIS layers derived from aerial photographs (Wood et al., 2017). Variables considered were structural maturity within the landscape (the proportion of patches with >5% mature crowns), edge influence (percentage of mature forest patches at different proximities to road or harvesting edges), mature forest influence (proportion of harvested patches within specified proximities to mature forest) and landscape context (cover of forest with at least 5% mature crowns within 1 km of harvested patches). These metrics indicated there is more structurally mature forest in Tasmania compared to Victoria, although in recent years the three areas have experienced similar levels of harvesting. This paper discusses the importance of retaining mature forest in the landscape. For more details see Wood et al. (2017).

Bird acoustic monitoring on Permanent Timber Production Zone land

Hollow-using fauna are a group particularly vulnerable to native forest harvesting, and their conservation management warrants a landscape approach. Sustainable Timber Tasmania has developed a pilot project to establish effectiveness monitoring procedures using bioacoustic technology and help monitor the biological responses to cumulative landscape change. This pilot project will focus on hollow-using birds to assess the effectiveness of mature habitat management at the landscape scale. Bioacoustic technology has the potential capacity to provide a smart and cost-efficient tool for land managers to monitor the effectiveness of their management on biodiversity conservation.

The pilot project will use 12 bioacoustic recorders, deployed this coming Spring at 24 study sites, in landscapes of different amounts of mature habitat availability (high, medium and low). Recorders will be left in the field for two weeks and programmed to record the morning and afternoon bird chorus, and a nocturnal sample. The project leverages off existing collaborations with University of Tasmania, where ornithologist Andrew Hingston, PhD student Scott Whitemore and forest scientist Tim Wardlaw from the ARC Centre for Forest Value will validate, process (using machine-learning software), and analyse the data recordings. Results of this monitoring will be used to help guide forest-block scale mature-forest habitat retention and management on PTPZ land for maintaining hollow-using bird populations. Outputs from this work will also contribute to building a statewide ornithologist-reviewed bird-call library to enable efficient processing of bioacoustic data for future projects.

Recovery of beetle communities after logging in wet forest

A study using a chronosequence of forest ages in the southern forests assessed the extent to which the taxonomic, functional and phylogenetic composition of beetles recovered after logging (Fountain-Jones et al., 2017). This study concluded that beetle predator functional composition had recovered ~45 years after logging, and this recovery preceded taxonomic recovery. Neither taxonomic nor functional composition had recovered for the decomposer/primary consumer communities by this time. This suggests that studies should include multiple functional groups and that just relying on predatory carabid beetles as indicators would give misleading results. Trait syndromes were identified that characterise forest recovery stages as a basis for future work on community re-assembly following disturbance.

Implementing aggregated retention

A recent paper provides an overview of the process adopted to trial and subsequently adopt aggregated retention on public land. Clear goals for the silvicultural system were identified early in the process which provided a clear benchmark for success (or otherwise). Early in the project there were unacceptable levels of fire damage to retained trees while wide firebreaks damaged soils, meaning the retained patches were not performing their role effectively. However there have been considerable improvements over time meaning that current coupes rate well against the objectives of this type of silviculture (Baker et al., 2017). This implementation monitoring ties with previous effectiveness monitoring research that shows good biodiversity outcomes from aggregated retention when coupes are carefully planned and harvested with ecological goals in mind.

3.1.2. Effectiveness of forest restoration measures

The *Forest Practices Code* recognizes the importance of forest restoration in some areas, acknowledging that restoration of habitat can assist conservation of flora and fauna (Section D3). A considerable amount of work is being done on restoration in Tasmania, of which two key projects are outlined below.

A review of forest restoration projects in Tasmania

Michael Schofield from Norske Skog received a Gottstein Trust which allowed him to do a review of forest restoration projects in Tasmania. The aim of the study was to review and document the various Tasmanian restoration projects and gain an understanding of what motivated people to undertake them, the scale and methods used, with the intent that this may lead to improved co-operation, knowledge and field outcomes. The report covers the organisations visited, forest restoration processes, summaries of individual projects, discussion and recommendations.

Forest restoration works are occurring in a range of environments throughout Tasmania that span the spectrum of sites from high inherent resilience to virtually no resilience. Silvicultural treatments, costs per hectare and timeframes vary considerably across projects. The motives for forest restoration can broadly be summarised as (i) financial (ii) environmental gain (iii) requirements under the FPC and (iv) forest certification. The scale of forest restoration being carried out in Tasmania has increased from a base of virtually zero hectares in the early-2000s to an annual program of more than 400+ hectares per year over the past decade. Forest restoration is set to become an increasingly visible part of forest management in Tasmania. There are a wide range of silvicultural techniques used to achieve forest restoration and in most instances a combination of techniques is required, including retention of native vegetation, unassisted natural regeneration, scarification, burn and sow, planting, direct seeding, weed control, browsing control and fire. Across all projects Michael found there was considerable effort made to assess and document the reforestation standard achieved. The report concluded that a more co-ordinated approach including a wider field of individuals and organisations would provide a better opportunity to share expertise across technical, marketing and research disciplines. This could provide an opportunity to set forest restoration standards, conduct research across a wider range of sites and strengthen funding applications.

This review also identified that the *Forest Practices Code* (FPC) will need to consider forest restoration in any future reviews. Future reviews of the FPC will need to be flexible in prescribing the standards and location of forest restoration, and should at a minimum consider the constraints around harvesting near riparian zones and formally incorporate the class 4 guidelines. Currently there is no specific operational code that FPOs can use when certifying FPPs that identifies forest restoration.

Key recommendations from the review were:

1. Forest restoration should be targeted and not result in unnecessary loss of productive plantation.
2. Organisations carrying out forest restoration should consider drawing on a wider range of skills, across technical, marketing and research disciplines.
3. Forest restoration and associated guidelines should be considered in future revisions of the FPC.
4. A risk based ‘case by case’ approach to forest restoration should be adopted adjoining Class 4 streams, and other riparian zones.
5. Forest restoration should be added as an operational code to the Forest Practices Regulations 2017 to enable FPOs to identify forest restoration in FPPs.

Landscape scale restoration planting in the Tasmanian Midlands

The Restoration Ecology Research group in the ARC Centre for Forest value, along with Greening Australia are doing considerable research related to landscape scale restoration plantings in the Tasmanian Midlands. A brief outline of some of the related projects is provided below.

- Developing a genetic framework to inform resilient ecological restoration focusing on local native *Eucalyptus* species (Brad Potts, René Vaillancourt, Tanya Bailey, Peter Harrison PhD).
- Developing seed collection strategies to take into account current and future climate change and testing these strategies in common garden experiments imbedded in Greening Australia’s restoration plantings (Brad Potts, René Vaillancourt, Tanya Bailey, Peter Harrison PhD, Akira Weller-Wong Honours study).
    - A recent publication provides a synopsis of recent and ongoing research on climate adaptation in eucalypts. Results to date suggest that eucalypts have some capacity to respond to future environmental instability although they may still be vulnerable to change. This paper suggests considering non-local sources of seed to confer greater climate resilience in ecological restoration plantings (Prober et al., 2016).
    - The survival and growth of 5–6 year old *E. pauciflora* over an altitudinal gradient was used to test if local seed or whether non-local seed could be used to pre-adapt to climate change. It was found that trees from mainland seed did not grow as well as trees from local seed in Tasmania, however they have still become established. Trees from seed collected from across Tasmania have all

established well suggesting there is scope for implementing a climate-adjusted provenancing strategy in Tasmania (Akira Weller-Wong Honours study).

    - A recent publication demonstrates the use in the Midlands of a framework that integrates the principles of climate-adjusted provenancing strategy with concepts from population genetics (i.e. potential inbreeding in small fragmented populations) as both a research and operational-ready tool to guide the collection of nonlocal seeds (Harrison et al., 2017).

- Undertaking direct seeding trials across the Midlands to help understand the constraints on the success of this method and to develop techniques to improve species mixtures and survival (Collaboration with CSIRO, GA, Polymer CRC. Brad Potts, Tanya Bailey, Claire Ranyard PhD study, Yolanda Hanusch Honours study).
    - Application of insecticide reduced seed removal by ants and significantly increased plant emergence compared to untreated controls (Yolanda Hanusch Honours study). *Eucalyptus* seeds were particularly prone to predation and predation was reduced if seeds were sown subsurface.
- Trialling methods of establishing understorey species within abandoned eucalypt plantations on farms to convert monoculture plantings to more diverse ones (Claire Ranyard PhD study).
- Investigating techniques for remote sensing of restoration plantings and remnant dry forests that may be useful to assess structural complexity, carbon sequestration and provision of habitat for animals (Nicolo Camarretta PhD study).
- Developing models of habitat suitability and connectivity in Tasmania using remote sensing techniques (Nicolo Camarretta PhD study).
- Investigating the soil microbiota in forest, restoration plantings and pasture soils (Stuart MacDonald PhD study).

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.

A population monitoring program was established by DPIPWE in 2007 (Webb et al. 2007) and has been continued and the research expanded upon by Australian National University researchers Rob Heinsohn, Dejan Stojanovic and Matthew Webb. Recent work includes the impact of wildfire on nest site availability, the importance of cavity morphology for breeding success, and the population size and geographic range of the species.

Fire is important in the long-term dynamics of cavity creation and loss, but there are few data on how fire impacts nesting resource availability for animals. Stojanovic et al. (2016)

assessed the survival of 189 trees and 191 cavities used for nesting by swift parrots over a decade. A subset of monitored trees were burned in an uncontrolled fire. Modelled persistence of unburned swift parrot nest cavities was more than twice that of scorched cavities over ten years. Likewise, unburned nest trees were more likely to still be standing at the end of the ten years than scorched trees. Fire caused an acute local increase in cavity and tree collapse. At the site of the fire, 62.8% of scorched nest cavities were destroyed compared to only 9.1% over the unburned remainder of the study area. Likewise, 48.6% of scorched nest trees collapsed at the fire affected site, compared to only 3.8% of unburned trees elsewhere. Burning associated tree collapse led to a significant decrease in tree diameter at breast height and number of potential cavities at monitored plots. This destroyed most of the existing nest cavity resource for swift parrots at the local scale and cavity abundance is unlikely to be replenished quickly. For more information see Stojanovic et al. (2016).

Stojanovic et al (2017) considered the importance of cavity morphology in limiting the breeding success of swift parrots. Swift parrots select nest cavities where the minimum entrance diameter is positively associated with cavity depth, floor diameter and maximum entrance diameter. These cavity characteristics are adaptive because they exclude native predators by physically preventing access to the nest chamber; only one introduced nest predator is able to overcome this passive nest defence. Introduced sugar gliders prey on swift parrot nests irrespective of nest cavity morphology. The study found no effect of cavity morphology on the number of eggs laid or fledglings reared by swift parrots. This suggests that fine-scale nest cavity characteristics do not influence the nest success of swift parrots beyond their effectiveness in excluding native Tasmanian predators. For more information see Stojanovic et al. (2017).

A paper was recently published estimated the population size and geographic range of the swift parrot (Webb et al., 2017). The abstract is provided below.

> The distribution of mobile species in dynamic systems can vary greatly over time and space. Estimating their population size and geographic range can be problematic and affect the accuracy of conservation assessments. Scarce data on mobile species and the resources they need can also limit the type of analytical approaches available to derive such estimates. We quantified change in availability and use of key ecological resources required for breeding for a critically endangered nomadic habitat specialist, the Swift Parrot (*Lathamus discolor*). We compared estimates of occupied habitat derived from dynamic presence-background (i.e., presence-only data) climatic models with estimates derived from dynamic occupancy models that included a direct measure of food availability. We then compared estimates that incorporate fine-resolution spatial data on the availability of key ecological resources (i.e., functional habitats) with more common approaches that focus on broader climatic suitability or vegetation cover (due to the absence of fine-resolution data). The occupancy models produced significantly ($P < 0.001$) smaller (up to an order of magnitude) and more spatially discrete estimates of the total occupied area than climate-based models. The spatial location and extent of the total area occupied with the occupancy models was highly variable between years (131 and 1498 km^2). Estimates accounting for the area of functional habitats were significantly smaller (2–58% [SD 16]) than estimates based only on the total area occupied. An increase or decrease in the area of one functional habitat (foraging or nesting) did not

> necessarily correspond to an increase or decrease in the other. Thus, an increase in the extent of occupied area may not equate to improved habitat quality or function. We argue these patterns are typical for mobile resource specialists but often go unnoticed because of limited data over relevant spatial and temporal scales and lack of spatial data on the availability of key resources. Understanding changes in the relative availability of functional habitats is crucial to informing conservation planning and accurately assessing extinction risk for mobile resource specialists.

The results of this and previous research on swift parrots highlights the scarcity and vulnerability of the nesting resource and the need for effective landscape-scale management of habitat for this species. The management recommendations delivered through the Threatened Fauna Adviser are supported by this research.

3.2.2. Forty-spotted pardalote

The forty-spotted pardalote (*Pardalotus quadragintus*) is a cryptic sedentary potential refugee species endemic to Tasmania. Forty-spotted pardalotes are dependent on white gum (*Eucalyptus viminalis*) where they forage for arthropods and manna (sugary exudates produced at damage points of branches). Historically, the species was widely distributed across Tasmania, but is believed to be extinct across most of its former range and is now largely confined to a few small islands of Tasmania. Forty-spotted pardalotes are threatened by habitat loss and degradation, introduced predators, competitors, drought, poor dispersal ability and a screw worm fly larvae which is a major cause of nestling mortality. Management recommendations for this species in areas covered by the forest practices system are provided in the Threatened Fauna Adviser.

An ANU PhD student, Fernanda Alves, has just commenced research into the conservation of the forty-spotted pardalote. A summary of the research planned as part of this PhD is outlined below.

- Assess the availability of critical resources (tree cavities, food) and threats (competitors, introduced predators, parasitic flies) for forty-spotted pardalotes across their current and historical range across south-eastern Tasmania.
- Use an existing network of nest boxes already occupied by pardalotes in their current range to investigate breeding success and sensitivity to different management interventions (fly control, predator exclusion) and experimentally deploy nesting boxes into relict populations of unmanaged pardalotes to establish whether they respond to management intervention.
- Collect blood samples to assess genetic structure and diversity across the remaining populations.
- Compare characteristics of occupied and unoccupied pardalote habitat across their range, and investigate why some populations are declining and why others appear stable.

- Analyse a long term, landscape scale existing data set to evaluate baseline population size and trajectory for the species across its range, and expand the monitoring program to account for experimental manipulation of populations.
- Identify what habitat characteristics are most important for supporting pardalote populations, and identify ways to make new populations safe (e.g. sugar glider safe next boxes).
- Survey historical parts of the range of forty-spotted pardalotes, and develop a framework and feasibility analysis of the potential for experimental reintroduction of the species to parts of its historical range.

3.3. Other miscellaneous projects relating to Tasmanian forests

A range of other projects occurring in Tasmania 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

- In 2016 the FPA in collaboration with DPIPWE and ECOtas completed a review and update of the habitat descriptions for all Tasmanian threatened flora species. The review was based on relevant literature as well as expert opinion, and the habitat descriptions were peer reviewed by experts in field botany. The habitat descriptions are available in a PDF table format to download via the FPAs website. The table includes the following information: species name (including common name), conservation status, life form, and habitat description and distribution notes.
- In 2017 the FPA completed a set of survey guidelines for all Tasmanian threatened flora species. They survey guidelines built on work by DPIPWE with input from ECOtas, using the most up-to-date information available (e.g., listing statements, recovery plans, published and unpublished papers etc) and expert advice. The guidelines were reviewed by DPIPWE and peer reviewed by experts in field botany. The survey guidelines help with decisions such as what time of year a survey should be done, do you need flowers to identify a species, and who should conduct a survey (i.e., is the species highly distinctive or is a specialist required to identify). These guidelines do not prescribe when a survey is required. The survey guidelines are available in a PDF table format to download via the FPAs website.
- Conventional intensive logging promotes loss of organic carbon from the mineral soil (Dean et al., 2016).
- Forest succession in Tasmania’s wet forests (from mixed forest to rainforest) results in trees becoming smaller and wood carbon stocks reducing (Moroni et al., 2017).

General

- A recent review looked at the ecology and conservation of Australian urban birds and report the results of the first Australian study on the relationship between avifauna and habitat variation in exurbia, which is the low-density zone of development on the outer margins of a city (Daniels and Kirkpatrick, 2017).
- Owlet-nightjar found roosting in forestry boom-gate (Wapstra, 2016).
- A recent study assessed the ectomycorrhizal fungal communities in Tasmanian temperate high-altitude *E. delegatensis* forest (Horton et al., 2017).
- A genetic approach was used to investigate the potential influence of landscape on dispersal of Tasmanian wedge-tailed eagles. Results suggest that the Tasmanian *A. audax* population is a recent founding by a small number of mainland Australian individuals, and that historically the species has generally remained in a particular area with only occasional dispersal (Kozakiewicz et al., 2017).
- Tasmanian devils (*Sarcophilus harrisii*) translocated to Maria Island appear to be thriving and show a positive association with agricultural and urban habitats, and an avoidance of wet eucalypt forest (Thalmann et al., 2016).
- A recent study determined throughfall, measured its local spatial variation, and tested its relationships with rainfall, rainfall intensity, wind speed, canopy dryness, canopy cover, and other structural variables in a cool- temperate callidendrous rainforest in Tasmania. Throughfall was related to rainfall amount and intensity, but not to canopy cover and other structural variables (Styger et al., 2016).

Weeds and diseases

- A new technique based on Landsat imagery was found to be suitable for detecting defoliation caused by leaf beetles in *E. nitens and E. globulus* plantations (Anees et al., 2016).
- A study looked at the genetic variation in seedling recovery following decapitation (as may occur from browsing mammals) in two *E. globulus* populations (wet forest and dry forest *E. globulus).* They found that early-age decapitation had little long-term impact on the expression of inherent population differences in growth strategies and foliar chemistry (Borzak et al., 2016).
- A recent paper assessed the risk myrtle rust (*P. psidii*) poses to the eucalypt flora of Tasmania. They tested the relative importance of phylogenetic history, habitat, endemism, and range size in predicting host susceptibility. They found significant genetic-based variation in response among host species and populations within the species (Potts et al., 2016).
- A recent study looked at the current and projected global distribution of *Phytophthora cinnamomi* (Burgess et al., 2017).

Climate change

- A recent paper investigated changes in the treeline and vegetation immediately above it by resampling quadrats and rephotographing from set points on Mount Rufus. No change in the tree line was detected over the 10 year period although *E. coccifera* height and density above the treeline did increase (Harrison-Day et al., 2016).
- Well-drained, aerated soils are important sinks for atmospheric methane. Soil methane uptake showed substantial temporal variation and increased as soil moisture decreased at both a dry and a wet temperate eucalypt forest (Fest et al., 2017).
- A study in the Tasmanian midlands found that eucalypts in dry forests are more tolerant of fire than the obligate seeder eucalypts in wet forests. However, there were few live mature stems remaining in some burnt plots, suggesting that dry eucalypt forests could be vulnerable to increasingly frequent, severe fires (Prior et al., 2016).

4. Discussion and 2017–18 priorities

The outcomes of the FPA supported studies covered in this 2016–17 report contribute to our understanding of the effectiveness of the general biodiversity code provisions (priority projects A2, 6, 7 and 8, Box 1) and the threatened fauna management provisions (priority projects B1,2,4, 5 and 8, Box 1). This year has seen the start of a number of new projects, as well as the continuation of other existing projects.

The projects from this year highlight the need to identify clear objectives for our management and research, which facilitates a process of continual review and adjustment (as required). Managers need to be flexible to new ideas and new information, whether it be back to basics of ‘where is the species?’ or bigger ideas of ‘how will this environment be different in 50 years?’. New tools, such as spatial mapping and genetics work, allows consideration of issues at larger spatial scales and in more detail than has been possible in the past, providing important tools for the future.

In terms of fine scale considerations, the research this year has focused on whether management is being applied in the right areas. Reviews of the range boundaries (or effective range boundaries) and attempts to increase our understanding of habitat use have been done, are underway or are planned for butterflies, Lake Fenton trapdoor spiders, forty-spotted pardalotes and swift parrots. In addition, a new project will consider whether the area to which management is applied for the giant freshwater crayfish needs review, and the use of plantation areas by threatened carnivores (Tasmanian devils, spotted-tailed quolls and keeled snails) has been highlighted. Tools are also being developed to help with these questions, such as the LiDAR mature trees map which provides a fine-scale indication of hollow-bearing tree availability.

In terms of broad scale considerations, climate change and land clearance (historic and current) provide particular challenges. This is resulting in increased focus on the importance of retaining forest patches and restoring forest, thereby maintaining landscape heterogeneity. Areas with different histories (e.g. Victoria, north-west Tasmania and southern Tasmania) have different levels of forest retention and mature forest availability which are important for a range of biota. Restoring degraded landscapes and improving linkages should help native biota recolonise these areas, but under climate change we may need to re-think our standard practices, such as using local seed sources, to ensure we achieve the long-term outcomes we seek.

The monitoring program for 2017–18 will continue to focus on the priority project areas in Box 1, part-funded through the FPAs effectiveness monitoring program. In addition, on completion of the Threatened Plant Adviser, priorities for the monitoring of management actions for threatened plants will be determined following a similar process to that taken in Forest Practices Authority (2012).

5. Bibliography

Anees, A, Aryal, J, Reilly, MMO, Gale, TJ & Wardlaw, T 2016, 'A robust multi-kernel change detection framework for detecting leaf beetle defoliation using Landsat 7 ETM + data', *ISPRS Journal of Photogrammetry and Remote Sensing* 122, 167–178.

Baker, SC, Grove, SJ, Wardlaw, TJ, McElwee, DJ, Neyland, MG, Scott, RE & Read, SM 2017, 'Monitoring the implementation of variable retention silviculture in wet eucalypt forest: A key element of successful adaptive management', *Forest Ecology and Management* 394, 27–41.

Borzak, CL, Potts, BM & O'Reilly-Wapstra, JMO 2016, 'Survival and recovery of *Eucalyptus globulus* seedlings from severe defoliation', *Forest Ecology and Management* 379, 243–251.

Burgess, TI, Scott, JK, McDougall, KL, Stukely, MJC, Crane, C, Dunstan, WA & Brigg, F 2017, 'Current and projected global distribution of *Phytophthora cinnamomi*, one of the world's worst plant pathogens', *Global Change Biology* 23, 1661–1674.

Chuter, A & Munks, SA 2011, *Developing a framework for the conservation of habitat of RFA priority species - Background Report 2. A review of the approach to the conservation of RFA priority species in areas covered by the Tasmanian Forest Practices System,* Forest Practices Authority, Hobart, Tasmania.

Commonwealth of Australia & State of Tasmania 1997, *Tasmanian Regional Forest Agreement between the Commonwealth of Australia and the State of Tasmania*, Commonwealth of Australia and State of Tasmania, Canberra.

Daniels, G & Kirkpatrick, J 2017, 'Ecology and conservation of Australian urban and exurban avifauna, In: Murgui, E & Hedblom, M (Eds.), *Ecology and conservation of birds in urban environments,* Springer International Publishing, pp. 343–370.

Davies, PE, Hart, R, Mitchell, C, Laffan, MD, Wright, D & Smethurst, P 1999, *Forest Practices Code: Review of soil and water provisions*, Final report to the Forest Practices Advisory Council and Forest Practices Board, Hobart, Tasmania.

Dean, C, Kirkpatrick, JB & Friedland, AJ 2016, 'Conventional intensive logging promotes loss of organic carbon from the mineral soil', *Global Change Biology* 23, 1–11.

Fest, BJ, Hinko-Najera, N, Wardlaw, T, Griffith, DWT, Livesley, SJ & Arndt, SK 2017, 'Soil methane oxidation in both dry and wet temperate eucalypt forests shows a near-identical relationship with soil air-filled porosity', *Biogeosciences* 14, 467–479.

Forest Practices Authority 2015, *Forest Practices Code*, Forest Practices Authority, Hobart, Tasmania.

Fountain-Jones, NM, Jordan, GJ, Burridge, CP, Wardlaw, TJ, Baker, TP, Forster, L, Peters, M & Baker, SC 2017, 'Trophic position determines functional and phylogenetic recovery after disturbance within a community', *Functional Ecology* 31, 1441–1451

FPA 2014, *Guiding policy for the operation of the Forest Practices Code*, Forest Practices Authority, Hobart, Tasmania.

FPA 2012, *Developing a framework for the conservation of habitat of RFA priority species – Developing a biodiversity effectiveness monitoring program for the forest practices system: identifying priority projects*, Scientific report 17, Forest Practices Authority, Hobart, Tasmania.

FPA& DPIPWE 2014, *Procedures for the management of threatened species under the forest practices system*, Forest Practices Authority and Department of Primary Industries, Parks, Water and Environment, Hobart Tasmania.

Harrison-Day, V, Annandale, B, Balmer, J & Kirkpatrick, JB 2016, 'Decadal-scale vegetation dynamics above the alpine study area', *Papers and Proceedings of the Royal Society of Tasmania* 150, 9–18.

Harrison, PA, Vaillancourt, RE, Harris, RMB & Potts, BM 2017, 'Integrating climate change and habitat fragmentation to identify candidate seed sources for ecological restoration', *Restoration Ecology* 25, 524–531.

Horton, BM, Glen, M, Davidson, NJ, Ratkowsky, DA, Close, DC, Wardlaw, TJ & Mohammed, C 2017, 'An assessment of ectomycorrhizal fungal communities in Tasmanian temperate high-altitude *Eucalyptus delegatensis* forest reveals a dominance of the Cortinariaceae', *Mycorrhiza* 27, 67–74.

Koch, AJ, Chuter, A & Munks, SA 2012, *A review of forestry impacts on biodiversity and the effectiveness of “off-reserve” management actions in areas covered by the Tasmanian forest practices system*, Forest Practices Authority report to the Independent Verification Group, Hobart.

Kozakiewicz, CP, Carver, S, Austin, JJ, Shephard, JM & Burridge, CP 2017, 'Intrinsic factors drive spatial genetic variation in a highly vagile species , the wedge-tailed eagle *Aquila audax*, in Tasmania', *Journal of Avian Biology* 48, 1025–1034.

Lindenmayer, DB & Franklin, JF 2002, *Conserving forest biodiversity. A comprehensive multiscaled approach*, Island Press, Washington DC.

Lunn, T, Munks, SA & Carver, S 2017, 'The impacts of timber harvesting on stream biota – An expanding field of heterogeneity', *Biological Conservation* 213, 154–166.

Moroni, MT, Musk, R & Wardlaw, TJ 2017, 'Forest succession where trees become smaller and wood carbon stocks reduce', *Forest Ecology and Management* 393, 74–80.

Munks, S, Wapstra, M, Corkrey, R, Otley, H, Miller, G & Walker, B 2007, 'The occurence of potential tree hollows in the dry eucalypt forests of south-eastern Tasmania, Australia', *Australian Zoologist* 34, 22–36.

Potts, BM, Sandhu, KS, Wardlaw, T, Freeman, J, Li, H, Tilyard, P & Park, RF 2016, 'Evolutionary history shapes the susceptibility of an island tree flora to an exotic pathogen', *Forest Ecology and Management* 368, 183–193.

Prior, LD, Williamson, GJ & Bowman, DMJS 2016, 'Impact of high-severity fire in a Tasmanian dry eucalypt forest', *Australian Journal of Botany* 64, 193–205.

Prober, SM, Potts, BM, Bailey, T, Byrne, M, Dillon, S, Harrison, PA, Hoffmann, AA, Jordan, R, McLean, EH, Steane, DA, Stock, WD & Vaillancourt, RE 2016, 'Climate adaptation and ecological restoration in eucalypts', *The Royal Society of Victoria* 128, 40–53.

Stojanovic, D, Rayner, L, Webb, M & Heinsohn, R 2017, 'Effect of nest cavity morphology on reproductive success of a critically endangered bird endangered bird', *Emu - Austral Ornithology* 117, 247–253.

Stojanovic, D, Webb nee Voogdt, J, Webb, M, Cook, H & Heinsohn, R 2016, 'Loss of habitat for a secondary cavity nesting bird after wildfire', *Forest Ecology and Management* 360, 235–241.

Styger, J, Kirkpatrick, JB & Unwin, G 2016, 'Throughfall and its spatial variability in a temperate rainforest of simple structure', *Physical Geography* 37, 251–263.

Thalmann, S, Peck, S, Wise, P, Potts, JM, Clarke, J & Richley, J 2016, 'Translocation of a top-order carnivore: tracking the initial survival, spatial movement, home-range establishment and habitat use of Tasmanian devils on Maria Island', *Australian Mammalogy* 38, 68–79.

Threatened Species and Marine Section 2017. *Threatened Species Link: wedge-tailed eagle* http://www.threatenedspecieslink.tas.gov.au/Pages/Wedge-tailed-Eagle.aspx

Wapstra, M 2016, 'Two records of an Australian owlet-nightjar *Aegotheles cristatus* roosting in forestry boom-gates in Tasmanian forests', *Australian Field Ornithology* 33, 156–158.

Webb, MH, Terauds, A, Tulloch, A, Bell, P, Stojanovic, D & Heinsohn, R 2017, 'The importance of incorporating functional habitats into conservation planning for highly mobile species in dynamic systems', *Conservation Biology* doi:10.1111/cobi.12899.

Wilkinson, GR 1999, 'Codes of forest practice as regulatory tools for sustainable forest management', In: Wllia, EX & Amwrhuear, PJ (Eds.), *Practicising Forestry Today,* Proceedings of the 18th Biennial Conference of the Institute of Foresters of Australia, Hobart Tasmania.

Wood, SW, Wardlaw, TJ, Pryde, EC & Baker, SC 2017, 'Landscape structure and mature forest biodiversity in wet eucalypt forests: A spatial analysis of timber production areas in south-eastern Australia', *Forests* 8, 1–22.