St Patricks Plains Wind Farm

Threatened Avian Fauna - Site Utilisation

1 June 2023

Ark Energy Projects

Summary

Ark Energy Projects Pty Ltd, formerly Epuron Projects Pty Ltd, the proponent, has proposed a wind farm on the St Patricks Plains area of the eastern Central Plateau in Tasmania.

The Environment Protection Authority Tasmania (EPA) will oversee the assessment in accordance with a bilateral agreement between the State and the Commonwealth under section 45 of the Act. The project has been determined as a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) (EPBC 2019/8497) and will require assessment and approval under the EPBCA.

The EPA's Project Specific Guidelines (PSGs) for Preparing an Environmental Impact Statement requires the following information relevant to threatened avian fauna:

- Bird utilisation surveys
- Targeted eagle utilisation surveys
- A collision risk model for eagle species
- Eagle nest searches and productivity assessment
- Collision monitoring
- Collision management
- Carcass management
- A survey for Masked owl habitat
- Potential impact on other threatened avian species

Initially 67 turbines with a rotor sweep height of 250 m were planned. As a result of detailed investigation and assessment the initial layout has been revised to 47 wind turbines with a rotor sweep height of 70-230 m. The project requires roads to access each turbine footprint, a short section of transmission line connecting a substation to the existing transmission lines on site, met masts and other facilities.

The proponent engaged North Barker Ecosystem Services (NBES) to undertake bird utilisation surveys within the project area, and to make recommendations to minimise impacts on avifauna. In particular, the work is concerned with limiting the likelihood of significant impacts on Matters of National Environmental Significance (MNES). Accordingly, the foci are the wedge-tailed eagle and other birds listed as threatened or migratory under the EPBCA.

This report presents results of surveys undertaken from winter 2019 through to autumn 2021 in line with the PSGs summarised above.

The study area is defined by the cadastral parcels on which the turbines are proposed which include four private land owners and additional private parcels on which no turbines are proposed. The area supports extensive native forest and large areas of native non-forest and pasture.

Eagle nests

There are 17 nests known to occur within the site and a 1 km buffer. These nests have been located over some years with 5 recorded during targeted surveys in 2019 and 2020. It is likely that others occur and that nests will be lost naturally and replaced elsewhere over time.

Eagle nest productivity

In January 2020 the Forest Practices Authority (FPA) inspected the 12 nests known of at the time. Nests are considered productive if chicks reached an age of 10 weeks or more. During this survey four fledglings, approximately 10 – 11 weeks of age were observed on four nests. Two other nests were active in 2019/20 and one bird was fledged in 2019. In October 2020, 16 nests were observed and 6 nests were found to be active but by January 2021 7 were confirmed as active only 1 nest fledged a chick.

Eagle flight path analysis

Observations of eagle flight paths were made from 22 locations across the study area using 20 locations in each of the eight seasons between August 2019 and April 2021. A summary of the survey effort, and the recorded eagle observations is included. A statistical summary of the data used for analysis, and an assessment of eagle flight activity is also included. The aim of this work is to provide quantitative flight activity analysis that can be considered as part of the EIS.

Seasonal maps of eagle utilisation over the site are provided. The flight data and spatial variation measures are incorporated into a quantitative assessment of the overall collision risk.

The flight analysis is based on 3259 observer hours (80 days) of observation, from August 2019 to April 2021. A shift involved four to six observers surveying simultaneously, each observer at different sites. 3553 flight tracks were recorded and utilised in the CRM- 3596 independent Tasmanian wedge-tailed eagle tracks, and 43 independent white-bellied sea eagle tracks.

The key findings regarding activity rates are:

- The average Effective Detection Range (EDR) is 1300 metres for both species of eagles for sites in non-forested areas. For sites in forested areas, it is 1060 metres.
- Flights per hr across all observation locations were 31.4 over forest and flights per hr/ha were 0.001.
- Flights per hr across all observation locations over non-forest were 47.6 and flights per hr/ha were 0.003.

The spatial variation in activity patterns was investigated using utilisation maps. The data indicate a lower level of utilisation over forest versus non-forest. Overall, the utilisation patterns suggest a preference for the non-forested areas to the south and north-west of the site, followed by the north-east and central parts. There is lower utilisation in the north, mid-south, and south-east of the site.

Collision Risk Modelling

The flight path data, turbine locations and specifications were inputs analysed using the CRM model based off Band, Madders, and Whitfield (2007). The model estimates the number of flights that are at risk of collision under the assumption that any breeding resident bird is immediately replaced. This estimate of flight collisions may therefore be higher than the actual rate, if a struck bird is not rapidly replaced in the region.

Eagle avoidance rates used in the CRM are empirically derived. The rates are 90, 95 and 99 percent and have been accepted by regulators in other Tasmanian and Victorian assessments.

Annual estimates of unmitigated and mitigated collision rates using these avoidance rates are summarised in the table below.

Predicted annual number of collisions per target species, by avoidance rate, unmitigated

Species	Avoidance Rates		
	90 %	95 %	99 %
Wedge-tailed eagle	4.89	2.44	**0.49**
White-bellied sea eagle	**0.05**	**0.03**	**0.005**

Mitigated collision rates were estimated by using empirical data derived from modelled IdentiFlight[1] curtailment and field measured Identiflight curtailment (curtailment is turbine deceleration on the approach of a bird).

Mitigated annual number of collisions for the Wedge-tailed eagle

Species	Avoidance Rates		
	90 %	95 %	99 %
Wedge-tailed eagle	4.89	2.44	0.49
IdentiFlight modelled curtailment	1.61 – 2.45	0.80 -1.22 -	0.016 - 0.25
Identiflight field curtailment	**0.73 – 0.88**	**0.36 – 0.44**	**0.07– 0.09**

The application of other additive collision control measures, for example prey carcass management or visual noise may further reduce the annual collision rate estimated in the table above by discouraging birds from utilising the area generally and specifically the rotor swept area. There is some evidence a black blade can do this and Ark Energy Projects will consider it as an additional adaptive management measure that can be applied in the event of eagle collisions. The CRM does not include these mitigation measures and so collisions will be fewer than predicted by the CRM once one or more measures are applied.

Migratory and threatened birds

The Protected Matters Search Tool returned a number of migratory and threatened species for investigation; with a number of these species also listed on the *Tasmanian Threatened Species Protection Act 1995* (TSPA). The conservation status of each species listed under the TSPA and the EPBCA are indicated below in brackets (TSPA/EPBCA). The birds include:

- Curlew sandpiper - *Calidris ferruginea* (-/ Critically Endangered and Migratory)
- Eastern curlew - *Numenius madagascariensis* (endangered / Critically Endangered and Migratory)

[1] IdentiFlight is a bird detection system specifically designed and developed for the wind energy sector with the aim to reduce impacts to avian fauna whilst maximising energy production. This system is currently being used at Cattle Hill wind farm in Tasmania only 7 km from the St Patricks Plains site and is demonstrating efficacy.

- Latham's snipe - *Gallinago hardwickii* (- / Migratory)
- Australasian bittern - *Botaurus poiciloptilus* (- / Endangered)
- Red-capped plover - *Charadrius ruficapillus* (- / Marine)
- Double-banded plover - *Charadrius bicinctus* (- / Migratory)
- Azure Kingfisher – *Alcedo azurea* (endangered / Endangered)
- Tasmanian masked owl - *Tyto novaehollandiae castanops* (endangered / Vulnerable)
- Swift parrot - *Lathamus discolor* (endangered / Critically Endangered)
- Grey goshawk - *Accipiter novaehollandiae* (endangered / -)
- Orange-bellied parrot - *Neophema chrysogaster* (endangered / Critically Endangered)

Based on the low number of records of these species previously recorded in the vicinity over many years and the probability of occurrence, the risk of an impact is considered very low. For both curlew species no records from the vicinity were found on database searches and none were recorded during field surveys in spring, summer and autumn of 2019/20.

Latham's snipe was recorded in spring, summer and autumn in wetland and riverine habitat on the site and at Penstock Lagoon. The May record from the site is the latest known and could indicate overwintering by juvenile birds. There is only minor loss of suboptimal habitat (not wetland or riverine) and there is a low potential for collision with turbines due to this species ground level foraging nature and infrequent flight behaviour.

Wetland habitat suitable for the Australasian bittern is not present on the site but is present and occupied on adjacent land, particularly in high quality habitat at the Lagoon of Islands.

For the Latham's snipe and bittern no flight paths could be practically observed because they very rarely and unpredictably fly from the forage sites unless flushed. They may fly between suitable wetland habitats from time to time. The ground level foraging behaviour of Latham's snipe eliminates the risk of collision with turbines when foraging. The bittern may rarely fly across the site if it moves between Lagoon of Islands and suitable habitat at Penstock Lagoon although it has never been recorded at the latter.

The risk of collision in any one flight of these species is not known but is likely to be very low. The consequence of a collision is low for Latham's snipe which has a relatively high population number in Tasmania and no significant impact is anticipated. The consequence of collisions is high for the endangered bittern which has a low population number and is often solitary, particularly at nonbreeding sites.

Wetland habitat suitable for the double-banded plover and red-capped plover is present on the site in the north and at adjacent lagoons. Similarly, habitat suitable for the Azure kingfisher is present along the Shannon River and adjacent lagoons. However, records of the birds are very rare in the vicinity and so there is an extremely low potential for collision with turbines which is further reduced by this species low level foraging behaviour and infrequent flight behaviour. Consequently, a significant impact is unlikely.

Tasmanian masked owl

The site is outside of the core habitat range for this species. Nevertheless, masked owls have been recorded within the site prior to 1981. There are extensive areas of mature forest within 5 km of the site and smaller stands on the site. Trees suitable for masked owl nests occur in some of these forests.

In this study automated recording devices were placed at a number of locations for more than 200 device nights. Call back surveys were completed over 9 nights. Masked owls were heard and seen adjacent to the site near the Lagoon of Islands. Recording devices picked up masked owl screeches adjacent to the site. This was placed to also record Bitterns at an adjacent wetland.

The masked owl has a large range with only a few pairs, at most, likely to occur across the site. The strategy of hunting from perches in and around forests reduces the risk of collision for these birds by limiting the amount of time flying and by spending most time outside of the turbine areas. The likelihood of a collision is not known but for the behavioural reasons above it is likely to be low.

Nesting tree surveys will be undertaken in the nesting period (October – March) post approval to determine if nest trees are present in the vicinity of the infrastructure. If a nest tree is located within 100 m from the centre of a proposed turbine stand or 50 m from other infrastructure, it is recommended that micrositing is applied to ensure that the buffer is maintained. Micrositing will be undertaken once the final layout is determined after taking account of other relevant requirements such as geotechnical feasibility.

Swift parrot

There are no preferred forage tree species for this bird on the site or in the vicinity. There are areas of mature trees suitable for hollows. However, the lack of forage trees that could sustain a breeding effort eliminates these forests as viable breeding habitat. These are the reasons why the area is not in the swift parrot core range. No significant impact on this species is anticipated.

Grey goshawk

The St Patricks Plains site is well outside of the breeding range of this species which is limited to below 450 m asl for nesting. This is reflected in the extremely rare records in the vicinity. The extreme infrequency of flights on the site in itself demonstrates a negligible probability of a collision with a turbine blade.

The habitat is suboptimal and because of this it is unlikely to support more than an occasional bird dispersing from a territory lower in the landscape. The impacts to grey goshawks as a result of collision/habitat loss from the St Patricks Plains wind farm infrastructure is considered negligible.

Orange-bellied parrot

Old records of the orange-bellied parrot in the vicinity are potentially mis identification of blue winged parrot because they are well outside of the range of this species and its migratory route.

Conclusion and Recommendations

The EPA's PSGs have been fulfilled by the studies undertaken over the past 2 years. The findings suggest that significant impacts to MNES will be avoided or minimised and residual impacts offset.

The ability to reduce the potential for impacts to the wedge-tailed eagle reflects the evolving use of successful mitigation technology worldwide and so is a significant improvement on the management of impacts to eagles relative to existing wind farms which did not have this technology available when built.

Ongoing mitigation actions will be required to minimise the impact and these include:

1. The design and operation of the turbines as described in this assessment.
2. Identiflight curtailment technology.
3. Carcass management to decrease the number of carcasses available near turbines and therefore the flight density of eagles near turbines.

There is also a range of mitigation actions that could further minimise impacts and include:

4. Collision monitoring and adaptive management.
   - Data to be used to track performance against management triggers and offset requirements.
5. Visual deterrence through painting one blade on each turbine black.
6. Minimise loss of potential masked owl tree hollows by micro siting turbine locations away from nest trees and suitable habitat trees to the extent practicable.
7. Avoid impacts to any masked owl nest trees by determining if tree hollows within impact areas are utilised and avoid by micro siting.
8. Rehabilitate terrestrial habitat of Latham's snipe where temporarily impacted by construction activity adjacent to infrastructure.
9. Minimise impact on all avian fauna foraging and prey habitats by minimising the impact on all native vegetation as per the attendant flora and fauna habitat assessment.
   - Concentrate direct and irreversible clearance within areas of non-native vegetation (cleared land).
   - Apply a micro-siting approach (with the aid of an ecologist) to infrastructure within threatened and migratory avian habitats to make adjustments to the footprint by selecting localised areas with relatively less impact.
   - Clearly demarcate the permitted impact area on construction plans and demarcate any exclusion zones on both plans and *in situ* to minimise impacts to habitat.
   - Incorporate a revegetation plan into the post-construction requirements, covering areas where clearance of native vegetation is not required to be a permanent loss (e.g., borrow pits [if required], temporary access routes and temporary construction disturbance footprints).

Offsets

The offset strategy aims to compensate for any eagles killed by turbines by protecting eagles elsewhere. The proposal is to contribute funds and where appropriate actions to such existing efforts as:

- Contribute to mapping high risk powerlines and improving the visibility of high risk powerlines to reduce the risk of fatal collisions - retrofitting to create "bird safe power lines".
- Contribute to a State-wide educational campaign and communications strategy to reduce the use of pindone rabbit baits and other rodenticide baits.
- Contribute to a State-wide educational campaign and communications strategy to reduce the number of eagles that are shot.
- Encouragement of hunters to use no lead bullets
- Protect viable nests elsewhere that are vulnerable to disturbance to ensure nests are utilised to produce an increase in nest productivity.
- Contribution to research to devise strategies to improve breeding success everywhere and decrease eagle mortality in and around wind farms.
- Fund eagle rehabilitation at refugia, and
- Contribute to the implementation of a recovery plan.

File Control and Contributors

Project	St Patricks Plains Wind Farm	
Location	Eastern Central Plateau, Tasmania	
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Field dates	August 2019, November/December 2019, January/February 2020, April/May 2020, July 2020, October 2020, January 2021 and April 2021.	
Reporting	Philip Barker (NBES), Elizabeth Stark and Alex Jackson (Symbolix), Jason Wiersma (FPA)	
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External consultations	Jason Wiersma (FPA) – second opinion on ground versus aerial nest search suitability on site	
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Draft 0.1	05/08/2020	Philip Barker draft year 1
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Version 2.3	18/1/2023	Philip Barker (revision)
Version 2.4	1/6/2023	Philip Barker (revision)

List of Acronyms (excluding measurement units and abbreviations defined within figures or tables)

CRM – Collision risk model

DCCEEW – Department of Climate Change, Energy, the Environment and Water (since 2022)

DEWHA – Department of the Environment, Water, Heritage and the Arts (until 2022)

DPIPWE – Department of Primary Industries, Parks, Water and the Environment, Tasmania

EPBCA – *Environment Protection and Biodiversity Conservation Act 1999*

EPA – Tasmanian Environment Protection Authority

FPA – Forest Practices Authority, Department of State Growth, Tasmania

MNES – Matters of National Environmental Significance

NBES – North Barker Ecosystem Services

NCA – Tasmanian *Nature Conservation Act 2002*

NVA – Natural Values Atlas database (DPIPWE, Tasmania)

TSPA – Tasmanian *Threatened Species Protection Act 1995*

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1 INTRODUCTION

1.1 Background

A wind farm development is proposed on the St Patricks Plains area on the eastern Central Plateau in Tasmania (Figure 1). The development initially considered 67 turbines and associated access roads.. The final configuration of turbines and access follows the consideration of natural values including terrestrial flora and fauna, bird utilisation and any related mitigation measures. Further detail on the project is contained in the main body of the EIS. As a result of the detailed investigation and assessment the layout has been revised to 47 wind turbines with a rotor sweep height of 70-230 m. The project requires roads to access each turbine footprint, a short section of transmission line connecting a substation to the existing transmission lines on site, met masts and other facilities.

The proponent engaged North Barker Ecosystem Services (NBES) to undertake bird utilisation surveys within the project area, and to make recommendations to minimise impacts on avifauna, particularly regarding limiting the likelihood of significant impacts to Matters of National Environmental Significance (MNES). The study presents results from the 2019-2021 avifauna surveys of the project area.

1.2 Project Area and Existing Environment

1.2.1 Project area and location characteristics

St Patricks Plains is in the Tasmanian Central Highlands bioregion and the jurisdiction of the Central Highlands Council. The project area and the surrounding local areas have been subject to a long history of human modification and management, including land clearance/conversion, pastoral agriculture, game management, and timber harvesting and plantation establishment. Local terrestrial habitats are consequently heterogeneous with varying apparent levels of human influence.

1.2.2 Survey area

The project area is defined by the cadastral parcels of the participating properties, with the exception of an internal forest reserve, owned by Forestry (c. 275 ha) that has been excluded from consideration and investigation by the proponent (Figure 1). Figure 1 also shows areas that have been excluded by Epuron and wetlands excluded to protect migratory bird habitats. The remaining 10,035 ha represents the extent of the survey area for our investigations.

Development exclusion zones within this area were nominated by the proponent for the purposes of natural values avoidance (for previously known values), nature covenants, and buffers around incompatible land uses (e.g., neighbouring shacks/houses) – the c. 1,300 ha within these exclusion areas were included in the bird utilisation study to capture observations of bird habitat and flight paths.

1.2.3 Geology

Soils throughout the project area are primarily derived from Jurassic dolerite (geocode Jd 6499), particularly the southern sections (e.g., Christian Marsh) and the northeast (Ripple properties); soils derived from Tertiary basalt are more prominent on the properties making up the north-western corner (Wihareja, Allwrights, St Patricks Plains), including low-profile basalt outcrops emergent from broader basalt plains, which themselves are interspersed with swales of Quaternary depositions.

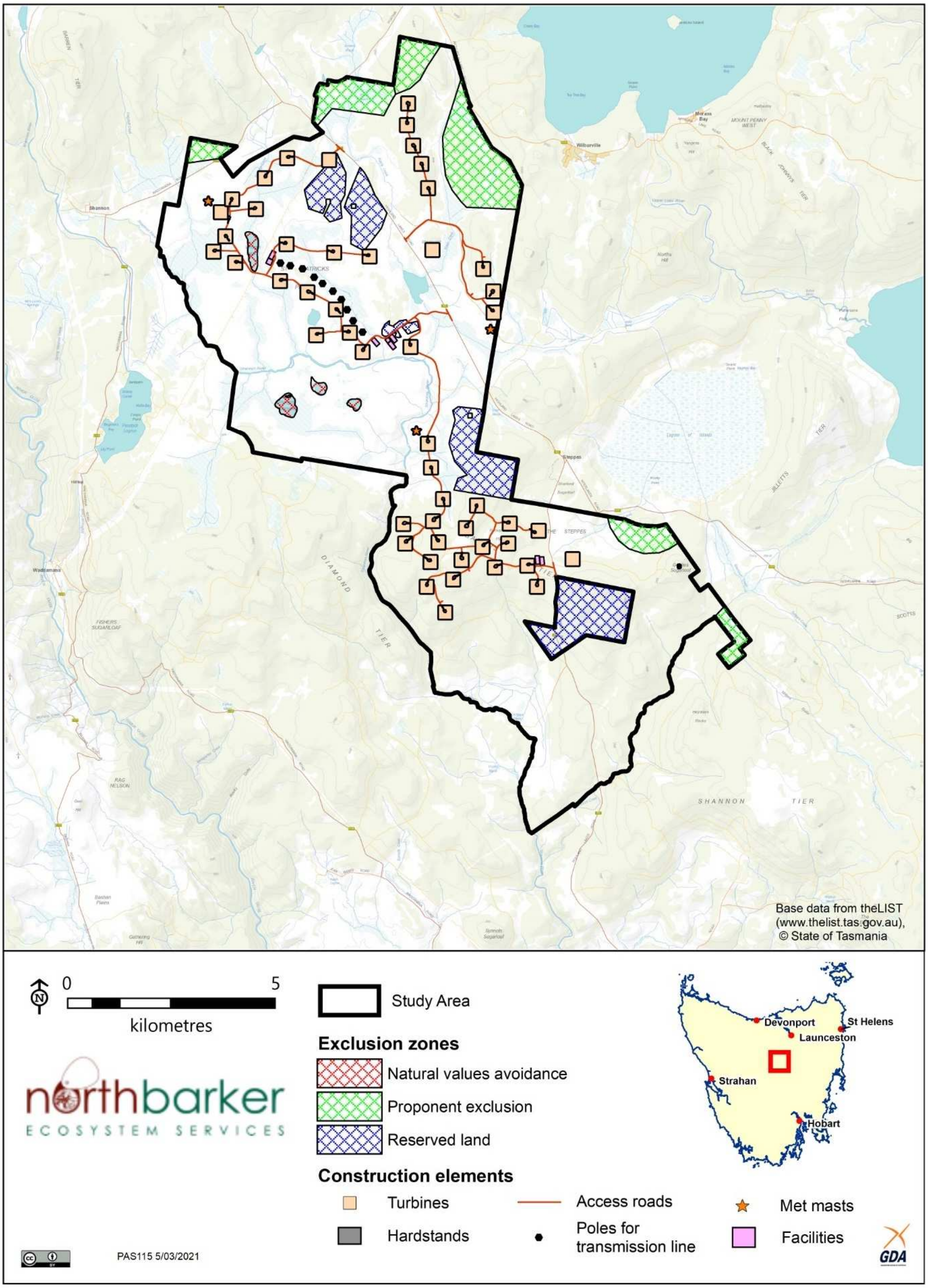

Figure 1. The study area and turbine layout

1.2.4 Topography and altitude

The project area is around 600 m a.s.l[2] at its lowest point on the section of the Shannon River in the southwest corner of Christian Marsh. The highest point is around 980 m a.s.l on the flanks of a hill in the northwest corner of Ripple South near Poatina Road. Variation in relief is greatest in the southern half of the project area, including relatively incised slopes leading down to the Shannon River, moderately steep hills (sometimes forming ridges), interjoining flats and gully bottoms. Relief is limited within the northwest part of the project area, where a large plateau (c. 900 m a.s.l) grades gently to the margins of the Shannon River (c. 880 m a.s.l) and is flanked by modest slopes of small rises (c. 920 m a.s.l).

1.2.5 Climate characteristics[3]

Mean rainfall for the area is around 1000 mm per annum, with a marked seasonal peak in precipitation from May to September. This coincides with the coldest time of year, in which average daily minimums are below 0 ° C and average daily maximum temperatures are below 10 ° C. Average daily maximum temperatures throughout the rest of the year are below 20 ° C, but temperature can be in excess of 30 ° C infrequently.

1.2.6 General Bird Habitat Characteristics

The landscape variability provides a diverse range of habitats for birds including species listed as MNES. The vegetation presents extensive areas of forest and non-forest (grasslands and heaths) as well as rivers and wetlands. These formations provide various foraging and nesting opportunities. Of particular relevance are foraging and nesting habitats for the wedge-tailed eagle, white-bellied sea eagle and the masked owl. The wetlands and waterways also provide seasonal feeding opportunities for migratory water birds discussed in Section 12.

Numerous native woodland birds, raptors and other water birds are present either seasonally or resident. These may include rare or occasional visits from threatened species and these possibilities are discussed in Section 13.

1.2.7 Context of the presence of eagles

The Tasmanian subspecies of the wedge-tailed eagle (*Aquila audax* subsp. *fleayi*) is regarded as being larger than the mainland birds with a wingspan of 2 m and a body weight up to 5.5 kg.

Although considered to be widespread but uncommon at the time of European settlement, the breeding success has decreased to a point where it is now considered that fewer than 100 pairs are successful at breeding each year with fewer than 1000 birds in total[4]. However, these estimates are a decade old and are considered to be low and are being revised for application in a population viability analysis (Dr. James Pay pers. Comm.).

Wedge-tailed eagles' prey and scavenge on a wide variety of fauna including fish, reptiles, birds and mammals. Adults are resident, highly territorial and have home ranges that vary in size depending upon prey availability.

Wedge-tailed eagles typically nest in a range of old growth native forests and the species is dependent on forest for nesting. It nests almost exclusively in mature eucalypts capable of supporting their nests. Nests can be developed over many years of use and grow to over 2 m in diameter. The eagles usually choose old growth trees in relatively sheltered sites for

[2] Above sea level

[3] Using climatological data from the nearest weather station at Liawenee Moor, 41.90°S 146.67°E 1057m AMSL

[4] DPIPWE Threatened Species Link July 2021 and Repealed Recovery Plan 2006-2010

locating their nests. But in some landscapes that lack topographic variation they sometimes choose nest sites that are more exposed or gain microhabitat protection, such as being low in the tree.

Territories can contain multiple nests and up to five alternative nests have been associated with one range. Nests within a territory are usually close to each other, particularly where habitat is spatially restricted, but may be up to 1 km apart where habitat is locally restricted. Nests in separate territories have not been recorded closer than about 1.8 km (Dr. James Pay Pers. Comm.).

While there are a number of threatening processes for the Tasmanian Wedge Tailed Eagle, the main threat to the species is the continuing decline in productivity as a result of disturbance of breeding birds and loss of nesting habitat. This is exacerbated by high levels of unnatural mortality because of persecution (illegal shooting, trapping and poisoning) and electrocution and collision (with powerlines, vehicles, fences and wind turbines) this has led to a reduction in the mean age of the population, resulting in a reduction in breeding success. They are sensitive to disturbance during the breeding season, which occurs between August and January[5].

In Tasmania, eagle habitat is very widespread covering virtually the whole State differentiated only be the density of territories between productive land and less productive land for prey species. They are rare in parts of the southwest[6]. The placement of wind farms and other infrastructure such as transmission and distribution power lines and roads is resulting in the loss of birds due to collisions.

Eagles fly throughout their territory but they utilise the territory differentially with respect to frequency of flights and the height and speed of flights. To determine the risk of an eagle colliding with a turbine it is necessary to understand the pattern and the frequency of flights throughout the year. The determination of the risk of collision is a three step process:

1. Collect sample data of flight paths and associated characteristics of a flight;
2. Collate and analyse the data to produce kernel maps[7] and summary statistics describing site utilisation; and
3. Construction of a collision risk model to estimate the frequency that birds may collide with turbine blades.

2 SCOPE

North Barker Ecosystem Services has been engaged to contribute to an Environmental Impact Statement with regard to the Project Specific Guidelines provided by the Environment Protection Authority Tasmania.

Those guidelines require:

1. Eagle nest search and productivity assessment – this survey and assessment includes the site and a 1 km buffer.
2. Eagle utilisation surveys – observation and mapping of eagle flights in each season over a two year period.
3. Collison Risk Modelling – to predict the estimated frequency of collisions and to guide the layout of turbines to reduce the risk.

[5] TSS (2006)
[6] Bell & Mooney 1998
[7] Kernel density estimation is a data smoothing process that estimates density of a variable (in this case number of flights in an area over a given time), reduces noise in individual measurements (by statistically combining individual observations) and can be represented as a contour map.

4. A collision monitoring plan – outline a detection method and management response.
5. A carcass management plan – detail how food resources will be managed to minimise and mitigate collision risk.
6. Consideration of threatened avian species – this considers potential use of the site by threatened bird species including masked owl and other MNES.
7. Bird utilisation surveys – these surveys aim to determine the general use of the site by other native birds.
8. An impact mitigation and offset strategy.

3 EAGLE NEST SEARCH

3.1 Survey area

The survey area includes both the project area and a 1 km buffer as defined in the Notice of Intent (NOI). Most of the project area was surveyed in February 2019 by Wildspot Consulting[8]. Prior to this survey the project area contained six known eagle nests, as reported on the Natural Values Atlas. During the survey conducted by Wildspot in 2019, a further three new nests were found within the project area (Appendix 1).

The following survey covered the remaining area within the project area and a 1 km buffer of the wind farm project area for which another six nests were known[9]. The area is illustrated in Figure 2. The buffer includes a large number of privately-owned properties for which permission had to be obtained, including private land, forestry land and land managed by Tasmanian Parks and Wildlife Service.

3.2 Desktop

As an exploratory desktop process, habitat within this survey area was considered according to the suitability index of the Forest Practices Authority's (FPA) eagle nest habitat model[10]. Whilst this model provides guidance for areas of eagle nesting potential, it is best practice to consider all habitat within a survey area when designing a search, to ensure the model hasn't misrepresented habitat patches and to establish if nests are likely to be present outside of areas mapped as highly suitable. The Natural Values Atlas was also utilised to gain knowledge of known nests for within the area.

The reported observations of three new nests outside of "optimal" nesting habitat during the February 2019 survey also stated that the nests were low in tree canopies and thus difficult to observe from a helicopter. Thus the search used a ground-based approach. Close inspection on ground of the characteristics of the known nests on the site indicated that they do occur in relatively protected locations. Notwithstanding the location of nests on flat land and lower exposed slopes, the locations of known nests broadly concur with typical nesting behaviour favouring relatively protected sites. Exposed slopes were excluded from the ground survey.

3.3 Methods

The ground searches were undertaken by foot over 7 days between the 6th and 16th of April 2020. The survey was undertaken by two NBES ecologists, Erin Harris and Janet Morley. Both are experienced in ground and aerial eagle nest surveying and the identification of suitable habitats (respectively, EH has a Masters degree in the management of eagle nesting habitat,

[8] Wildspot Consulting (2019)

[9] Natural Values Atlas

[10] Forest Practices Authority 2014a, Fauna Technical Note No. 6: Wedge-tailed eagle nesting habitat model, Forest Practices Authority, Hobart

and JM has over 20 years of experience as a Forest Practices Officer routinely undertaking eagle nest searches). A total of 70 hours were spent searching within the survey area. The weather was mostly optimal for the duration of the survey, with occasional showers and wind that did not hinder the search.

The survey involved walking apart parallel to one another at an appropriate distance. Where forests cover was sparse this distance was roughly 150 m where each observer could easily see 75 m either side of them. For dense forest cover (which wasn't often) transects were closer. Searchers were equipped with a UHF radio for communication and GPS to mark any nests and ensure all potential habitat was covered.

Once a nest was located, its condition and features were described *in-situ*. All nest observations were photographed using a Fujifilm HS20EXR with a 30x manual optical zoom (24-720 mm equivalent) and GPS position recorded (using a handheld non-differential GPS, Garmin Map 64s). Characteristics of the nest were recorded to describe its condition and included[11]: fresh green leaves, stick tone (brown or grey), white-wash, algal smears, nest shape (flat-topped or bowl), down/feathers, and prey remains.

3.3.1 Limitations

Disturbance levels and loss of large trees due to selective logging on a number of properties was high which may result in eagles nesting in less optimal habitat on site. Whilst all suitable habitat and marginal habitat were surveyed carefully there is always the possibility that a nest may have been missed during a survey as surveying every tree is not always practical or possible. New nests may also be built post-survey and thus new nests can appear in subsequent years. Several properties could not be surveyed due to timber harvesting operations and un-willing landholders due to concerns of Covid-19 transmission.

The areas not surveyed totalled 1175 ha (of 16000 ha). This area includes 89 ha in nest suitability class 3 or above which are the classes recommended to be searched.

3.4 Results

3.4.1 Eagle Nest habitat

Extensive forest patches within the project area were found to be potentially suitable for nests and were searched in early 2019[12]. In the extended survey area (i.e., 1 km buffer of the project area) much of the forest habitat has been intensively modified by logging, with the larger more suitable eagle nesting trees being felled over various periods. Most of the trees were either very exposed or too small to support a large nest such as eagles' nests. The most suitable mature trees were found on steep slopes, where access by machinery would have been difficult to retrieve suitable nest trees. Only those trees on flat land, lower slopes or protected slopes are suited to nesting due to reduced exposure. In addition, more extensive habitat is protected in the Steppes State Reserve.

3.4.2 Nest searches

In addition to the six known nests within the 1 km buffer of the project area, two new nests were discovered and are discussed below (nests 2755 and 2756). All previous eagle nest searches undertaken for forestry operations, incidental discoveries and targeted searches of 2019 (Wildspot Consulting) and 2020 (NBES) collectively recorded 17 eagle nests (Figure 2). The figure illustrates the extent of development exclusion areas of 1 km radius around each nest.

[11] Characteristics taken from the Forest Practices Authority's nest activity assessment forms

[12] Wildspot Consulting (2019)

Evidence of activity was noted at five nest sites during the 2020 aerial activity search conducted by the FPA (Section 4). Of these five nests, one of them was one of the new nests found in the 2020 ground search. Activity was recorded at other nests in 2019 by Wildspot Consulting including 1 fledgling (Appendix 1).

Nest ID 2755

Nest 2755 is located on the east facing slope of Goldies Sugarloaf about halfway up and was found on 15/04/2020 and its coordinates are 494297.3E, 5336421.66N (Plates 1 and 2). The nest is robust with evidence of activity, such as white-wash, brown leaves, brown sticks and bark with a wedge-tailed eagle feather below the tree. The tree species is an *E. delegatensis*.

Nest ID 2756

Nest 2756 is located on the southwest edge of the Lagoon of Islands and can clearly be seen from the Lagoon. It was found on 16/05/2020 and its coordinates are 492741.04E, 5338272.12N (Plates 3 and 4). The nest is small and bleached with no signs of recent use. Its location by the lagoon suggests it is a white-bellied sea eagle nest with two sea eagles regularly seen flying over the lagoon.

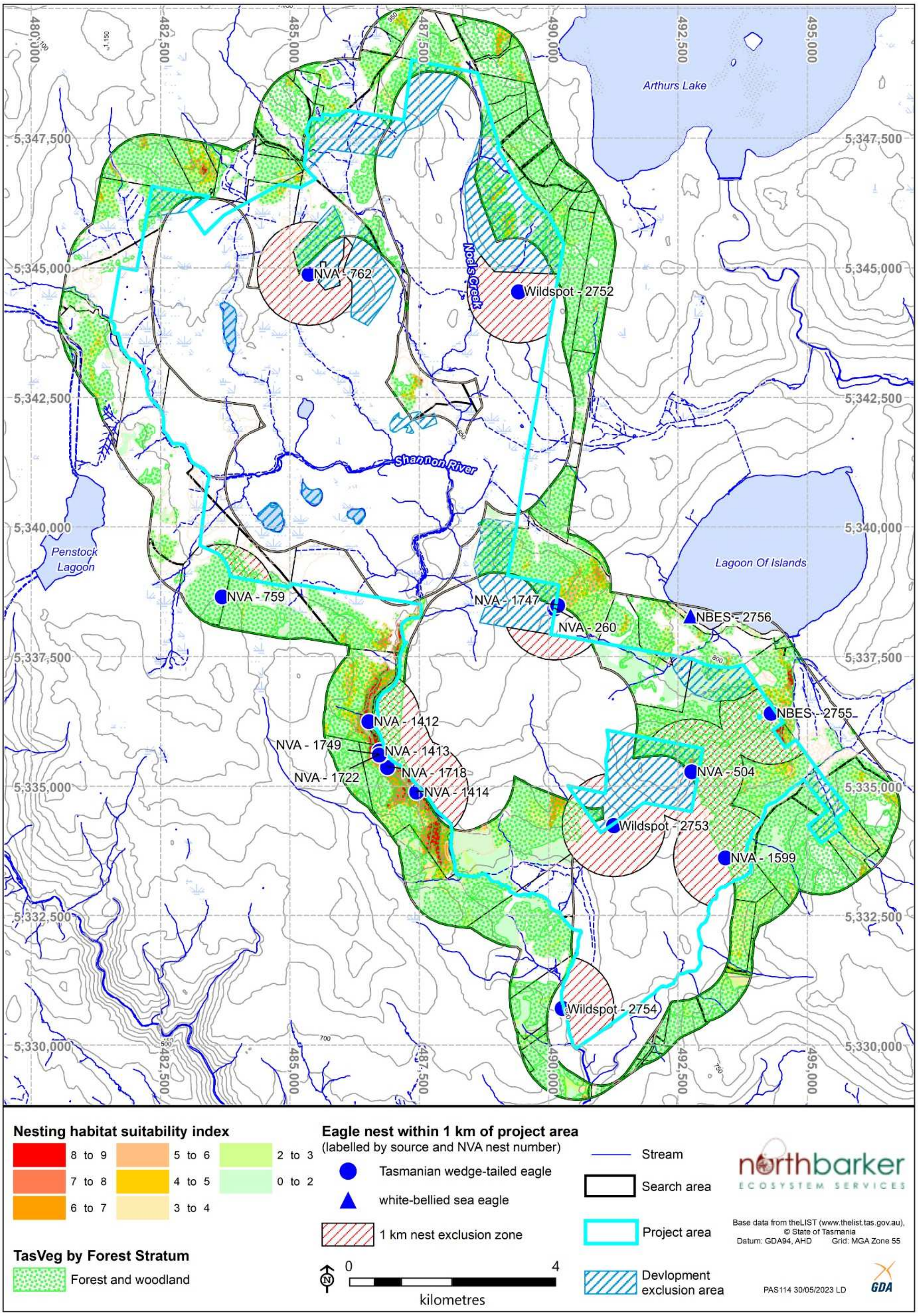

Figure 2. Eagle nest survey area and known nests

4 EAGLE PRODUCTIVITY ASSESSMENT

4.1 Methods

The FPA was engaged to assess eagle nest activity and breeding productivity. The assessment involved a helicopter-based nest activity check of 12 eagle nests[13] in January 2020 and 17 nests[14] in October 2020 and January 2021 to determine activity and count fledglings.

Eagle nests were surveyed using a Eurocopter AS350 Squirrel from Helicopter Resources Cambridge. The FPA used a newly developed standard operating procedure, designed by the FPA and endorsed by DPIPWE, to assess nests. The method involves surveying nests in a similar fashion to fixed-wings aircraft, ensuring minimum airspeed (40 – 50 knots) and altitudes are maintained whilst minimising rotor slap to reduce noise near nest sites during onsite survey. The method therefore ensured:

- forward translational movement was maintained and
- flaring, the method used to reduce excessive speed of aircraft, occurred 2 – 3 km from nests to disperse noise away from these localities.

This method allowed for aerial surveys to be conducted quickly and quietly.

Nests were considered productive if chicks reached an age of 10 weeks or more, (referred to as fledglings for the purposes of this report; eagles fledge when approximately 12.5 weeks old).

4.2 Results

The results for nest activity and nest productivity surveys are listed in Table 1 and Table 2. In 2019 no activity assessment was undertaken. In January 2020 four of 12 nests inspected supported four fledglings, approximately 10 – 11 weeks of age. Two adults were also observed, one in the air and one in a tree nearby to a nest. No birds were observed to flush from roosts or nest sites during the survey and no eagles showed aggressive behaviour toward the aircraft.

Active nests are those at which a breeding attempt has been made indicated by a bird on the nest and a productive nest produces a 10 week old fledgling.

Only eleven of the twelve nests were observed during the activity survey in January 2020 The nest that was not observed was within 80 metres of a productive nest (# 1747) and so it was assumed to be inactive and counted in the 12.

Nest observations and status are detailed in Table 1.

Subsequently, the nest ground searches in May 2020 observed that the new nest 2755 was active during the same season. So, at least five active nests can be attributed to different pairs of birds in the 2019/20 breeding season.

Inspection of 16 nests in October 2020 verified that six nests were active. Nest 2753 was noted as not active but having a bird flying nearby. In January 2021 nest 2753 was confirmed as active making a total of 7 active nests for the season. Nest 2753 was the only nest to support a fledgling. WBSE nest 2756 was not inspected.The full reports are provided in Appendix 2.

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[13] This includes six known nests within the project area and the six known nests within the 1km buffer of the project area.

[14] This includes the five new nests found during 2019/2020 by NBES and Wildspot Consulting and the 12 known nests, minus nest 2756 (white bellied sea eagle) that couldn't be found during the activity check.

Table 1. Nest activity and productivity at 12 eagle nests located at St Patricks Plains on 15/01/2020

Nest ID Number	Easting	Northing	Notes	Productive
260	490113	5338434	Not inspected	No
504	492761	5335295	Small nest no recent nesting material	No
759	483688	5338665	No recent nest material	No
762	485364	5344891	10 -11-week-old fledgling	Yes
1412	486522	5336262	Small nest	No
1413	486731	5335694	Small nest	No
1414	487444	5334900	10 -11-week-old fledgling	Yes
1599	493411	5333634	10 -11-week-old fledgling	Yes
1718	486880	5335378	Small remnant nest	No
1722	486736	5335618	Difficult to observe	No
1747	490170	5338498	10 -11-week-old fledgling	Yes
1749	486723	5335617	Difficult to observe	No

Table 2. Nest activity and productivity of 16 eagle nests from October 19th 2020 and January 2021

Nest ID Number	Easting	Northing	October Observation Notes	Productive
260	490113	5338434	No recent material	No
504	492761	5335295	Not found	No
759	483688	5338665	Adult on nest	Yes
762	485364	5344891	Adult on nest	Yes
1412	486522	5336262	Adult on nest	Yes
1413	486731	5335694	Not found	No
1414	487444	5334900	No recent material	No
1599	493411	5333634	Not found	No
1718	486880	5335378	Not found	No
1722	486736	5335618	Not found	No
1747	490170	5338498	Adult on nest	Yes
1749	486723	5335617	Not found	No
2752	489421	5344552	Adult on nest	Yes
2753	491256	533425	Adult in air	No
2754	490263	5330718	Not found	No
2755	494298	5336423	Adult on nest	Yes
Nest ID number	**Easting**	**Northing**	**January observation notes**	**Productive**
2753	491256	5334256	11 week old Wedge-tailed eagle	Yes

Plate 1. Nest 2755.

Plate 2. Nest 2755

Plate 3. Nest 2756 (WBSE)

Plate 4. Nest 2756 (WBSE)

5 FLIGHT PATH MAPPING

5.1 Methods

Flight paths of eagles were observed and mapped over eight seasons between 2019-2021. The first survey was completed in August 2019 and from then in the middle month of each season until mid-Autumn in 2021 as the PSGs required. The mid seasons roughly equate to the following breeding cycle events:

- July – August - pre breeding display
- Nov – Dec – breeding period
- Jan – foraging to feeding nestling(s)
- April – post fledging

Observation points from which flight paths were mapped were located as efficiently as possible to gain site coverage. The coverage was verified by ground truthing before the survey commenced. Based on desktop assessment of the site and comparison to survey findings of previous eagle utilisation studies, it was estimated that 20 randomly selected observation points were required for full coverage (Figure 3). An additional two sites were originally identified to provide for alternatives if access to others was prevented by prevailing conditions. Some areas are hilly and forested and so the selection of observation points accommodated this without unduly biasing the "randomness".

The site was stratified into north and south with 11 sites in each stratum. The location of six sites was adjusted after three and six seasons (Figure 3) to improve the range of visibility adjacent to those sites due to perceived potential gaps in the flight maps. The change made no substantive change to the pattern of flights observed.

Twenty of the 22 sites were used for observation in each season. The balance of sites were included by swapping 2 sites in a rotation each season if required based on accessibility (i.e., snow, flood, mud or covid limitations).

Eagle flights were observed from each point in rotating shifts over five long days (summer time) and five shorter days (winter time). The observation shifts were on average 3 * 3 hr periods per site[15] in the summer between 7 am and 7 pm and 3 * 2.5 hr periods per site in the winter between 7:30 am and 5:30 pm. The starting time at each point was rotated between points to gain full day coverage over five days at 10 of the twenty points. The 10 sites in the northern strata were generally completed first and the balance of 10 sites in the southern strata was completed the following week or as soon after as possible in similar weather conditions.

Initially in the first lot of surveys the survey shifts were 4 * 2 hr periods. Subsequently, this was changed to 3 * 3 hr periods to enhance the quality of the data by reducing the amount of travel time and maximise the amount of observation time. The 3 * 3 hr survey period was considered most appropriate as anything less would have made for an extremely long day, resulting in observer fatigue which is a significant challenge when providing long hours of full focus without moving. However, during the Covid 19 lockdown period the shifts were extended to 2 * 4 hr shifts to maximise social distancing but retain the rotation. This period is probably the maximum to avoid observer fatigue but is not ideal.

This method was devised in consultation with Symbolix to ensure that the data were ultimately suitable for collision risk modelling.

The field data collection is designed to representatively sample flight behaviour from any and all eagles across the whole site. This is the only way to derive the flight density data and complete spatial data needed to configure a collision risk model.

Independently, two birds were tracked using GPS by James Pay. His study started after the field surveys and data from the two birds were not available as an evidence base at the time of the study design. GPS data provides interesting insight into the behaviour of a specific (and biased) subset of individuals. On sites with dynamic landscapes such as extensive plantation forestry where we need to develop specific behavioural models the data collected by GPS can be included to augment the on ground data. In this case however, the St Patricks Plains landscape is far more constant than a plantation forest landscape that undergoes continuous change and so the behavioural model was not required.

[15] This includes travelling to and from Miena to St Patrick's Plains and travel time between site changes. Some sites took longer than others to get to based on the length of the roads, condition of the roads and number of gates to unlock and lock. It should be noted that where mud and flooding were excessive in the winter some sites (particularly 11 and 13) were surveyed twice per day over a longer period of time to reduce vehicle impacts to the already muddy tracks.

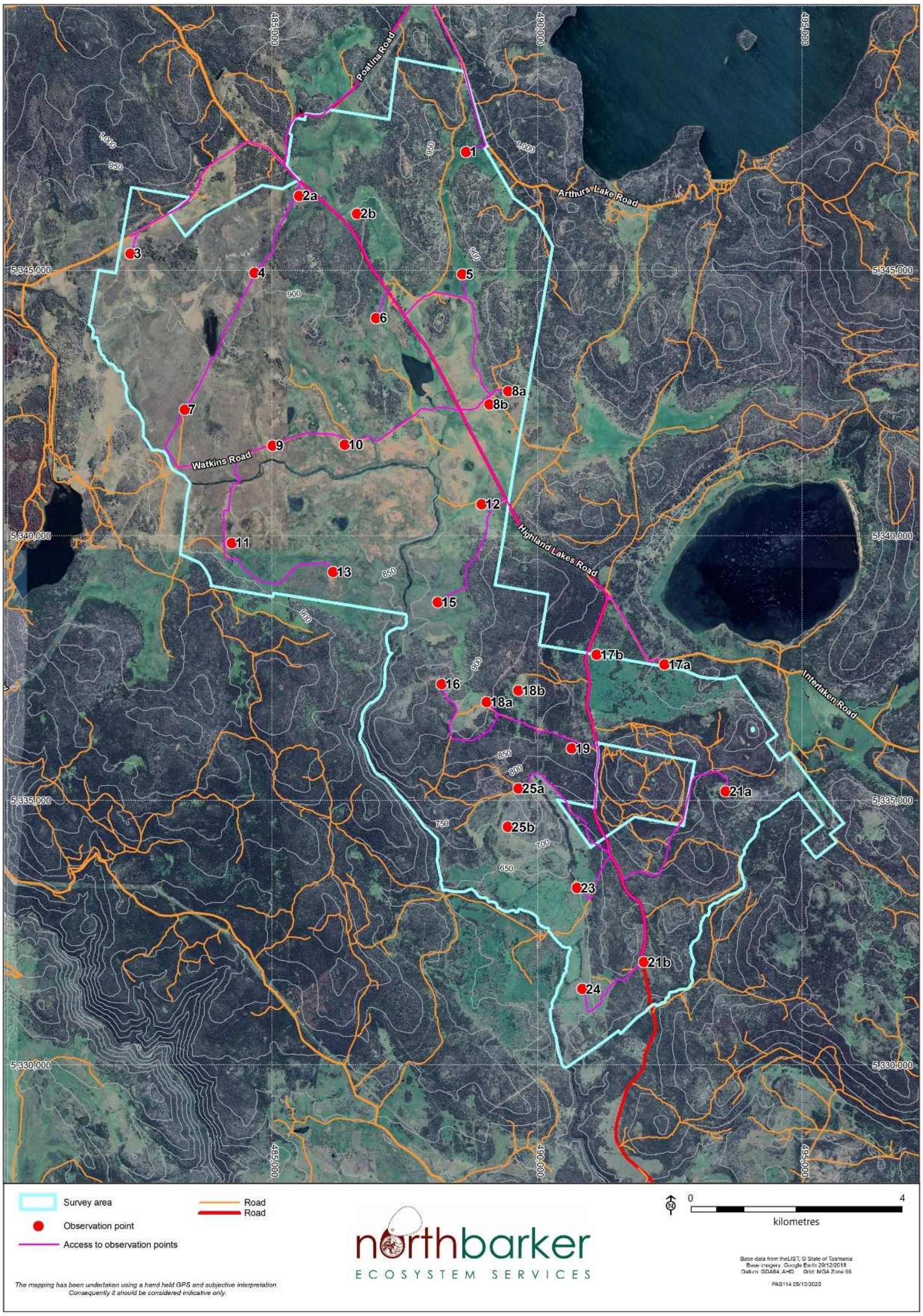

Figure 3. Overview of the entire survey area and observation points. Numbers with ‘a’ or ‘b’ signify observation points that changed during the two years of surveying. With ‘a’ being the first survey point and ‘b’ being the second

5.1.1 Data collection for each flight

Observation point ID

Flight ID

Time flight began and ended

Height class - continuous data below, above or within sweep area

Eagle species

Age class

Behaviour

Environmental observations

Without reference to an objective measure, height estimates can be grossly over or underestimated. Even experienced observers have personal error biases, and this can be amplified in landscapes with little or no reference if the experienced observer does not recalibrate their observations. This risk was managed by observers practicing estimates of known heights from known distances before the surveys and verifying estimates with each other[16]. The presence of wind monitoring towers of known heights and topographic field maps assisted in this process. Similarly, the scaled topographic maps over aerial photographs assisted with the estimate of horizontal distance.

5.1.2 Field data translation

Digitised flight paths and their corresponding tabulated data that were collected from the eagle utilisation surveys were "cleaned" and provided as input data to Symbolix as shape files (digitised flight paths) or Excel files (tabulated data).

[16] At times when observers could see the same eagle they would often gauge each other's height estimates to get a more accurate estimate.

5.2 Results

A detailed coverage of flight path analysis and density is presented in Appendix 3. The following presents summary statistics and figures from Appendix 3 and interpretation.

5.2.1 Survey effort and site coverage

There were 3259 observer hours of survey effort completed by 5 observers over the period between winter 2019 to autumn 2021. Table 3 below summarises the survey effort. Fewer longer shifts and surveys were conducted in autumn and winter 2020 when strict covid restrictions were applied to minimise observer contact across the site[17]. The winter and autumn surveys had shorter durations than the spring and summer surveys due to shorter daylight hours in the cooler months.

Table 4 summarises the number of hours of survey effort per site and demonstrates that the distribution of observation effort between seasons is very even particularly when taking account of the challenges associated with field observations over two years including flooding, heavy snow and covid limitations.

A few sites (e.g., 09 and 25a) were only used in the first round of surveying as it was found that their view was adequately covered by neighbouring sites. Other sites, such as site 02a, 17a, 21a were moved (to 02b, 17b and 21b) after several seasons in order to improve visibility (i.e., areas where high tree density and topography were perceived to potentially limit the view). Figure 4 illustrates the spatial distribution and temporal coverage of the observation sites with the height of the columns proportional to the number of observer hours spent at that site.

Figure 5 shows the time of day and the frequency of surveys undertaken at those times. The relatively low coverage at the beginning and end of the day reflects the process of transporting observers to the first observation point and collecting from the last one. The first beginning observation at 7 am and the last concluding observation at 7:30 pm. The most intense period of observation being from 8 am until 5 pm with the tail after 5 pm being affected by daylight hrs in autumn and winter.

Table 3. Summary of survey effort

Season	Year	Shifts	Surveys	Duration (hrs)
Winter	2019	31	152	344
Spring	2019	30	150	482
Summer	2020	30	149	464
Autumn	2020	20	100	348
Winter	2020	20	100	363
Spring	2020	30	145	432
Summer	2021	30	150	457
Autumn	2021	30	150	370

[17] This reduced the observers contact with gates and vehicles. All gates and vehicles were wiped with disinfectant after touching.

Table 4. Hours of observation at each site

SITE_ID	Hours
01	168.2
02a	67.7
02b	103.7
03	159.1
04	163.7
05	157.0
06	165.7
07	154.7
08a	100.4
08b	66.0
09	17.8
10	147.1
11	145.2
12	165.3
13	140.9
15	154.1
16	162.3
17a	76.0
17b	109.2
18a	69.0
18b	94.0
19	65.3
21a	64.2
21b	107.0
23	151.6
24	168.5
25a	14.1
25b	101.0

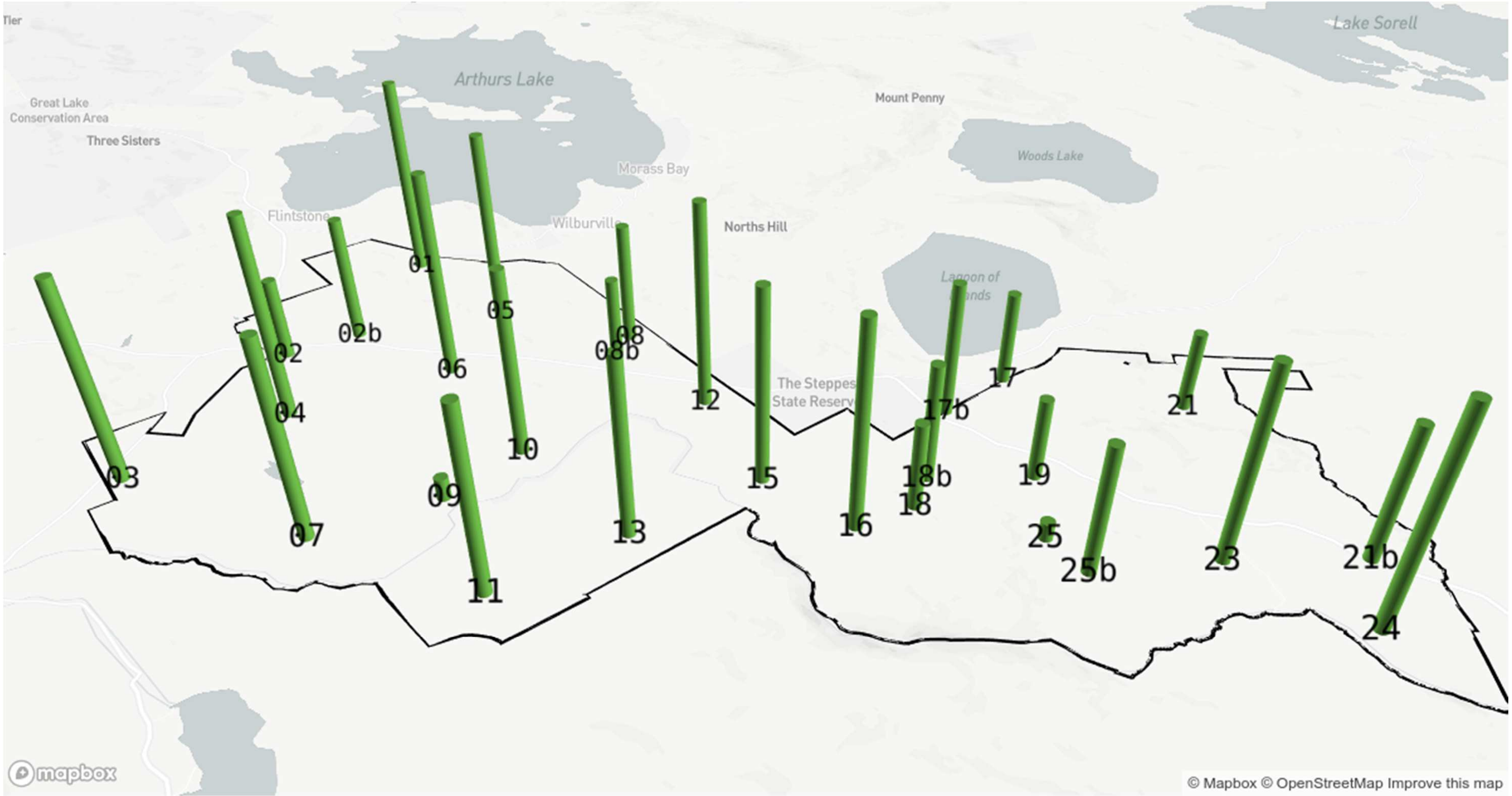

Figure 4. The spatial and temporal coverage of the observation sites.

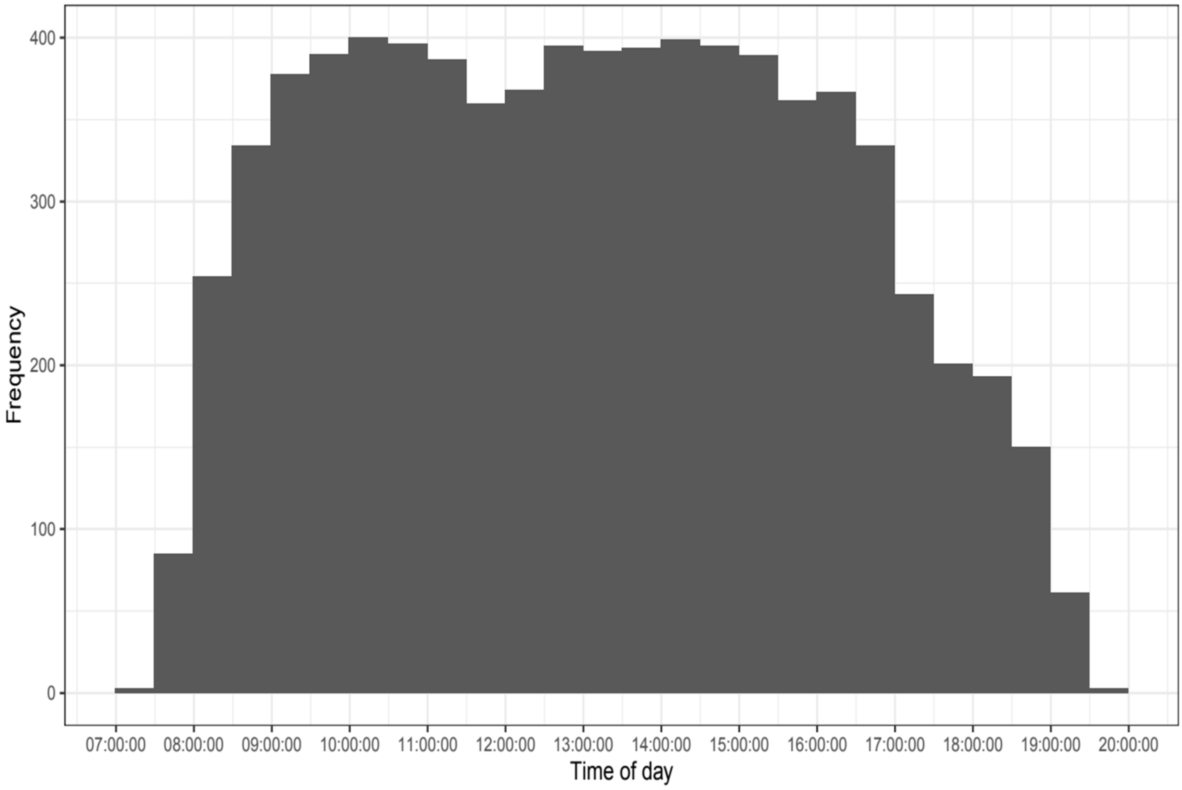

Figure 5. Time-of-day coverage of the surveys

5.2.2 Eagle observations

An example of flight paths observed in the first season of observations during August 2019 is illustrated in Figure 6. The flight paths observed and mapped in the eight seasons between August 2019 and April 2021 are illustrated in Figure 7. Figure 7 shows that seasonal flight patterns and density of flights varies considerably between seasons. The frequency of flights observed over the site was highest during spring 2019 and 2020 and least during summer and winter 2020. Both autumn observations were between the two extremes and similar in frequency (Table 5). Spring is the breeding season for eagles, where activity around active nests increases. A paper published by Braham et al. (2015) that looked at the seasonal variation in home ranges of golden eagles in California found that the eagles utilised more of their home range during spring when they were not breeding compared to when they were breeding. A larger number of flights during the spring could be related to a larger number of non-breeding sub-adults 'floaters' in the area as well as breeding adults patrolling and defending their territory. It was noted by observers that activity increased around the vicinity of nests although these flights tended to be shorter and focused on the area around the nest, likely increasing the observation count as eagles leave and return to their nest.

Table 5 summarises the number of flights observed per season, split between the two eagle species. Due to the very low counts of white-bellied sea eagles, they have been combined with the wedge-tailed eagle data throughout the utilisation modelling.

A number of sightings of perched birds were excluded from further analysis due to there being no risk of collision when stationary. However, perched birds are still reported on in Table 6 for completeness.

Figure 8 shows the distribution of times of day when flights were first observed. Given this and Figure 5, eagles appear to be more active in the late morning and afternoon, than in the late afternoon and early morning. This likely correlates with high sun and warm temperatures during midday creating thermals which are typically used by eagles[18]. The median observed flight duration was four minutes.

Figure 9 shows the flight heights (at the point of first observation) of the eagles. For both white-bellied sea eagles and wedge-tailed eagles the majority of flights were observed within the 70 m-230 m range of the rotor swept height of the turbines. These data do not estimate at what height the flight persisted nor do they suggest that a flight would continue at that height if a wind turbine was in the flight path.

Table 5. The number of eagle flights observed in each season

Season	Year	Wedge-tailed eagle	White-bellied sea eagle
Winter	2019	403	6
Spring	2019	727	3
Summer	2020	294	1
Autumn	2020	437	5
Winter	2020	288	9
Spring	2020	600	16
Summer	2021	398	1
Autumn	2021	449	2
Total flights		**3596**	**43**

[18] Murgatroyd et al (2018)

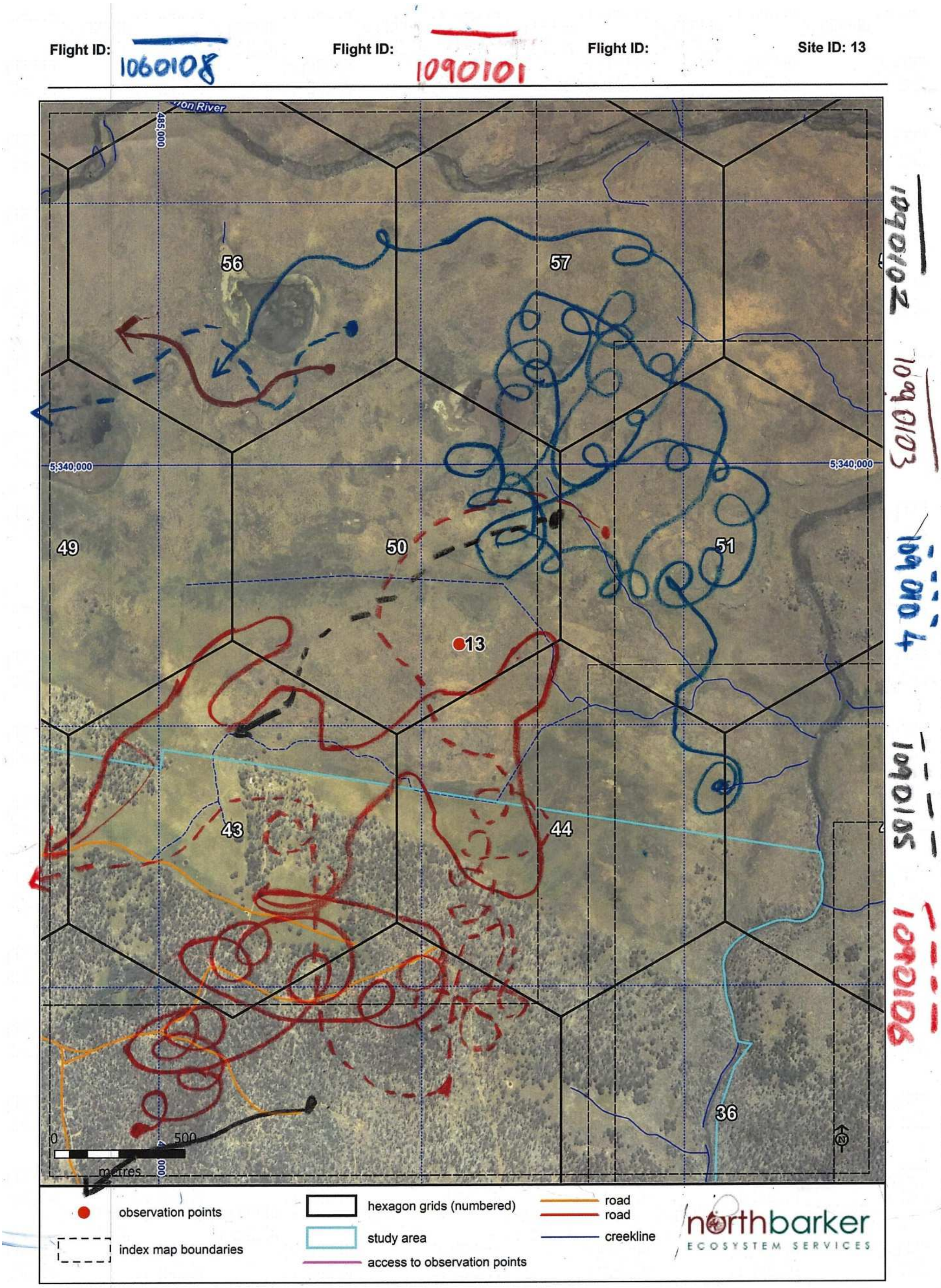

Figure 6. An example of a flight path map from observation site 13

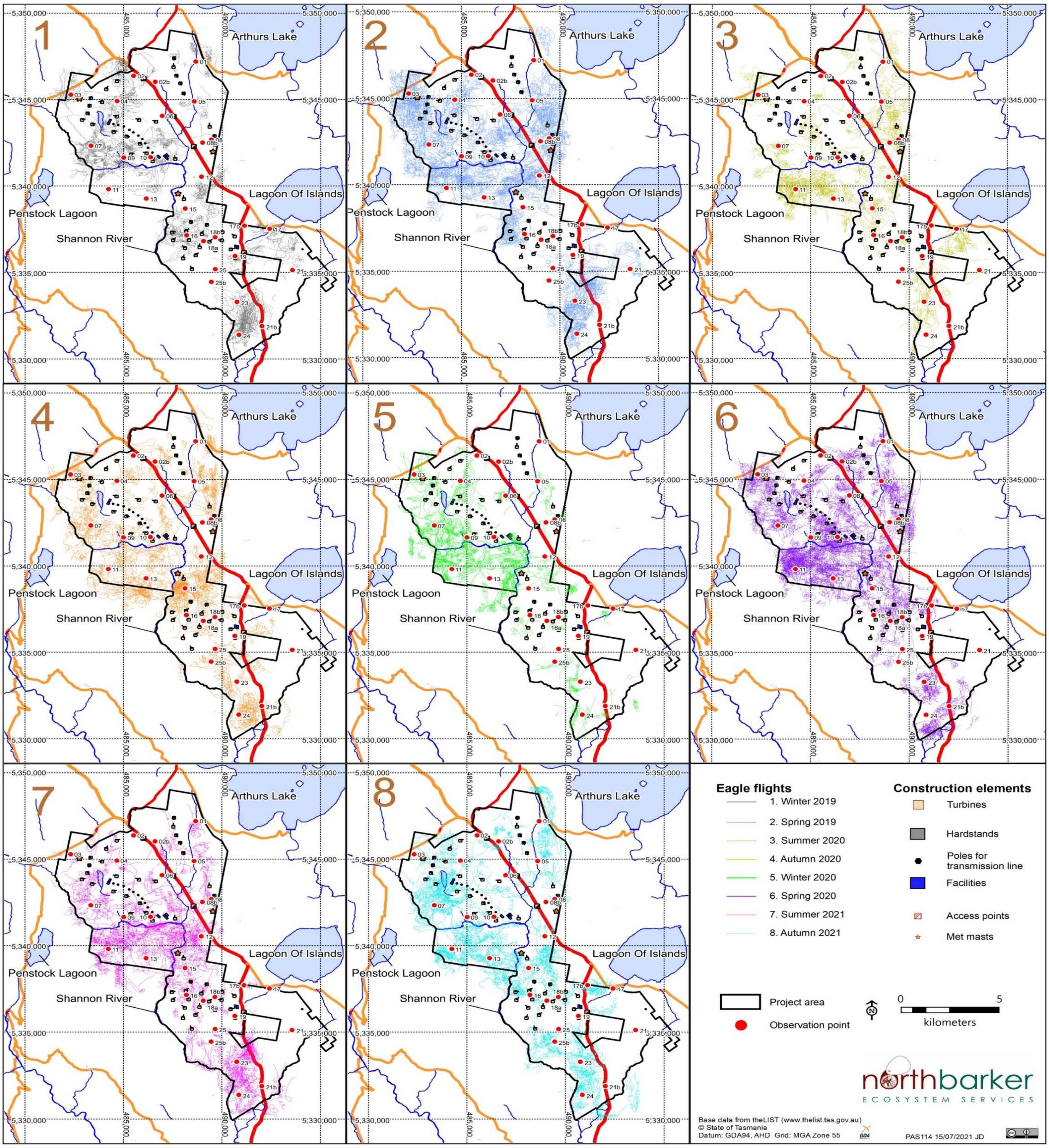

Figure 7. Flight paths observed in 8 seasons btw August 2019 and May 2020

Table 6. Perched eagle observation which are not included in formal analysis

Season	Species	Count
Spring 2019	wedge-tailed eagle	1
Summer 2020	wedge-tailed eagle	2
Autumn 2020	wedge-tailed eagle	19
Winter 2020	wedge-tailed eagle	25
Spring 2020	wedge-tailed eagle	12
Summer 2021	wedge-tailed eagle	24
Autumn 2021	wedge-tailed eagle	30
Winter 2021	wedge-tailed eagle	0

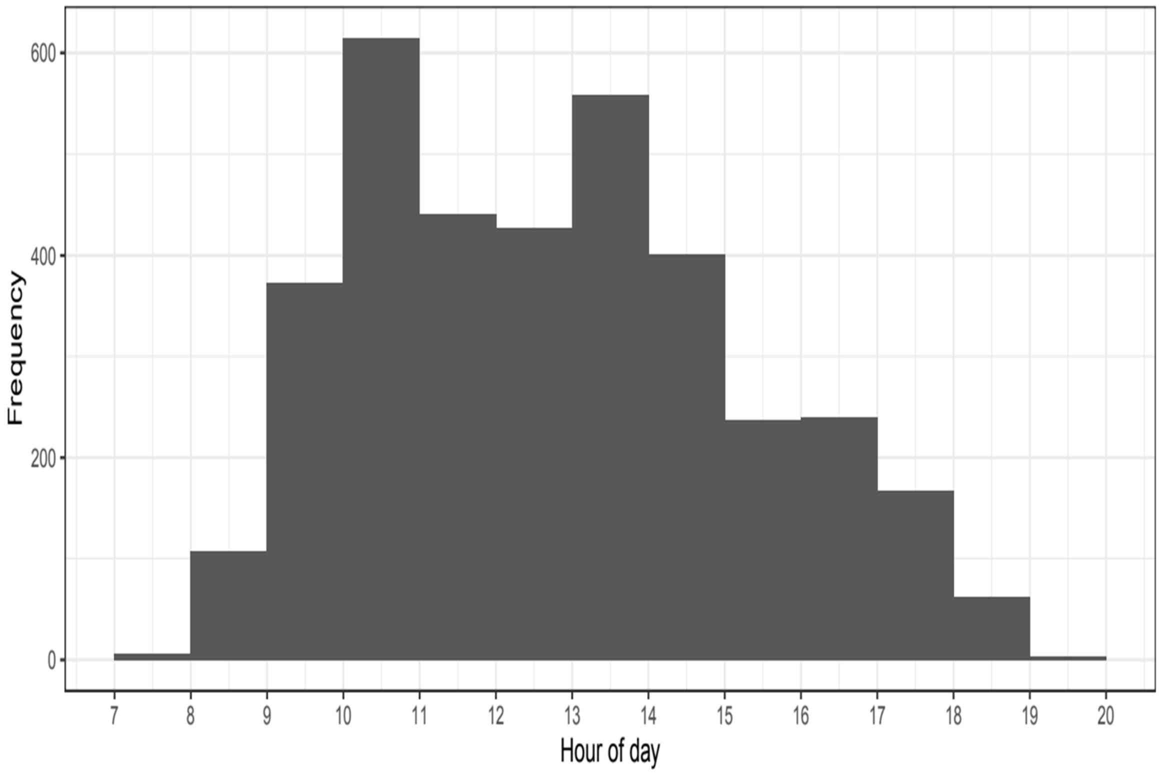

Figure 8. Time of day when eagles were first observed

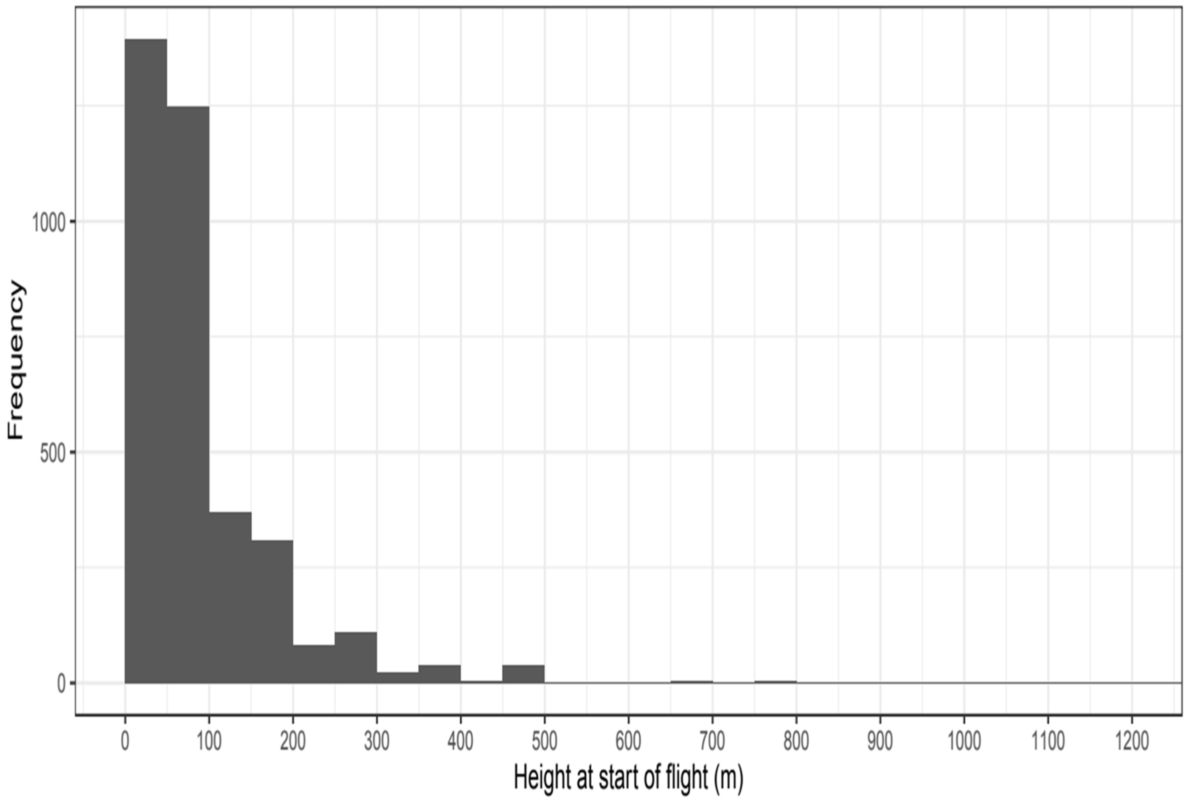

Figure 9. Frequency distribution of flight heights by species

6 TERRITORIES

6.1 Context

The nests of wedge-tailed eagle and white-bellied sea eagle breeding pairs tend to be clustered in a territory. A territory is the defended part of their home range and most territories have more than one nest. Nest clusters are generally 6-12 km apart in good-moderate habitat, potentially further in variable habitats with lower productivity, which depends on prey abundance and nesting opportunities[19]. Territories can contain multiple nests and up to six nests have been associated with one territory. Nests within a territory are usually within 1 km of each other and closest when habitat is continuous. Nests in separate territories have not been recorded closer than about 1.8 km[20].

The size of territories and home ranges varies with the quality of the habitat and the abundance of food resources. However, territory and home range boundaries are dynamic and old, disused nests can sometimes be found not associated with contemporary territories, confusing assessment.

6.2 Methods

The distribution of nests, particularly active nests provide a starting point for identifying the territories of breeding pairs. Eagles (both wedge-tailed and white-bellied sea eagle) have not been recorded breeding closer to other eagles than 1.8 km, even in very productive territories, due to territorial competition. In this case the group of nest records in the Shannon River

[19] FPA (2013)

[20] Dr. James Pay Pers. Comm (2021)

gorge area in the southwest are likely to represent only 1 pair. Similarly nest 260 and 1747 are so close as to be a single pair.

The seasonal flight path density (See section 7 for an explanation) presents the density of flight paths illustrated as kernels 'probability contours'[21] indicating decreasing density of flights from the centre outwards. These areas are essentially the most frequently used areas within the site and may indicate territorial cores; notwithstanding that they may move and vary in intensity of use with seasons.

One of the most active seasons was the spring 2019 breeding season and the distribution of the density of flight paths was used to assist the interpretation of the extent of territories. However, the widespread and spatially continuous use of the site does complicate identifying territories accurately. This is an example of where GPS tracking could assist (if all birds were tracked). Beyond 1 km of the site boundary there are no more recent nest records than those recorded on the LIST. Flight path data is only collected outside of the study area where observation is possible. The interpretation of territories is therefore limited to the available information but limitation to the information is offset to a large degree by the small kernels that fall predominantly in the site.

6.3 Results

Using the distance between nests and the seasonal flight path density and field observations a map illustrating a plausible number and size of territories was derived (Figure 10). At St Patricks Plains the density of flights observed and the number of nests that are known indicate a productive landscape. The productivity of the landscape allows pairs to establish relatively small territories. At St Patricks Plains where known nests are spaced at greater than say 3.5 km they are increasingly likely to be in separate territories.

The distribution of nests and probability contours suggests that there are perhaps 9 territories that are predominantly within the site, evident from flight path data, but they may extend beyond the site where observations were limited by topography and distance. In the habitat at the St Patricks Plains site, the density of territories is high presumably because the area is rich in food resources and sufficient nest sites occur; albeit apparently suboptimal sites. The occupation of such sites underlines the food productivity of the site.

Figure 11 illustrates the flight paths of two birds recorded continuously between April and June 2021 (Pay 2021). These "territories" accord very well with those estimated on Figure 10. Comparison should consider that the territories illustrated in Figure 10 are spatially conservative to the extent they constrain the territories to the centre of the areas of high flight density and are based on 5-day samples of flights not continuous data. The nests illustrated on Figure 11 were selected to provide context to the territories of the GPS tracked birds. These flight tracks equate to territories 4 and 5 on Figure 10 and show a very high correspondence in the context of the subsample that ground observations provide.

[21] Kernel density estimation is a data smoothing process that estimates density of a variable (in this case flights) and eliminates noise in the measurements and can be represented as a contour map.

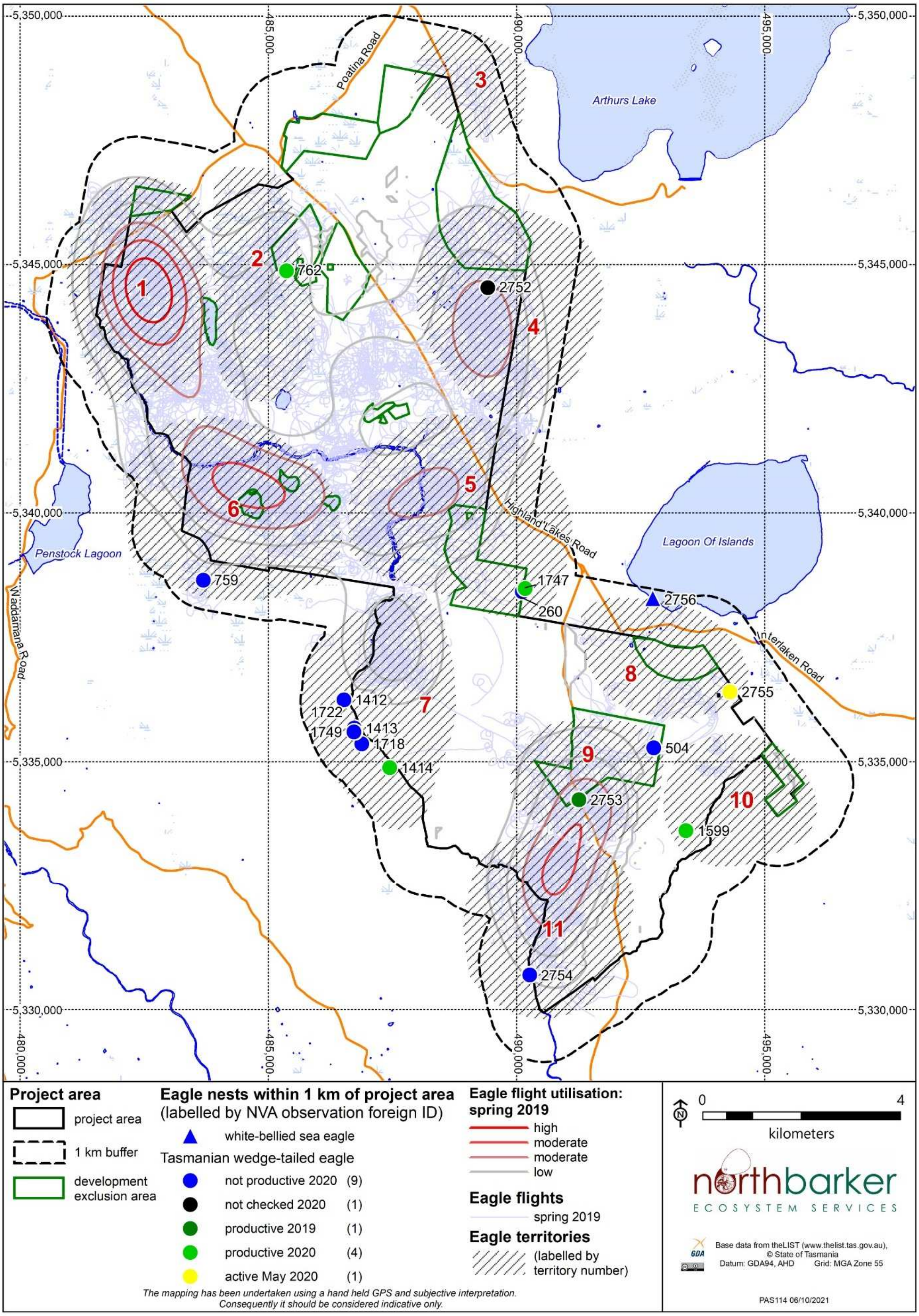

Figure 10. The possible distribution of eagle territories over spring 2020 flight paths and probability contours

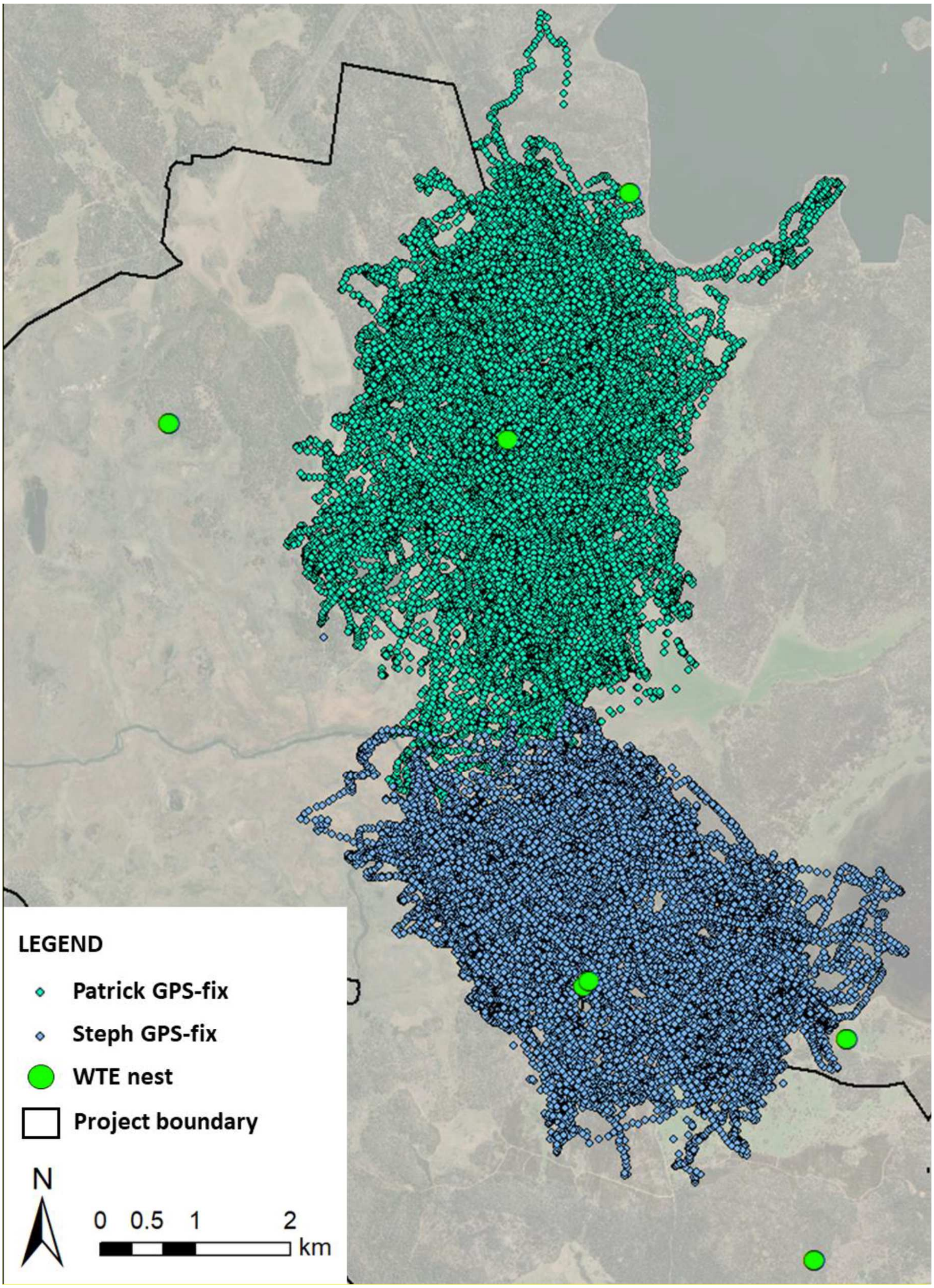

Figure 11. GPS tracks of two birds from St Patricks Plains April to June 2021 (After Pay 2021)

7 ESTIMATE OF TOTAL FLIGHT DENSITY

The estimate of flight density is a measure that can be expressed as a frequency per unit of area or simply as flights per hr that were detected. A detailed assessment of the estimation of flight density is provided in Appendix 3.

7.1 Methods

The rate at which an observer can detect an eagle in flight varies between each site and an individual's ability to spot an eagle at long range. In open landscapes such as the north of St Patricks Plains a flight is more likely to be detected at greater distances where factors such as trees and topography aren't obstructing the observers view. However, where the view isn't obstructed by trees or topography an observer is still more likely to detect a flight that is closer to their observation point than one that is at a larger distance.

7.1.1 Observer detection rate

To take account of detection rates of eagles at greater distances a statistical distance correction technique was used[22]. Distance to the bird was defined as the distance to the point at which the observer recorded the beginning of the flight path, ignoring height (see Figure 6). The data was limited to a maximum of 2500 m as an observer's ability to accurately detect distances diminishes the further away the bird is.

By applying distance models to the data[23], the Effective Detection Range (EDR) was calculated, to provide a measure of detectability in the study area. Higher EDRs suggest that detection is better at longer ranges. In this case EDR is reduced by forest, see below.

7.1.2 Modification of Buckland's method

Due to the unique site layout at St Patricks Plains, slight modification of the original method of Buckland et al. (2008) was needed.

The original method in Buckland et al. (2008) assumes each survey point is an exact replicate. Thus, each location at which observations were made (SITE_ID) is assumed to have the same visibility and the same amount of survey effort expended. This is not the case at St Patricks Plains where visibility can be obscured by forest and topography. There is also evidence to suggest[24] that observations of flight density across St Patricks Plains differs between forested and non-forested areas. To address this the Buckland's method was adjusted by stratifying observer location into forested and non forested sites (Table 7). A separate EDR was calculated for the forested sites and the non-forested sites. The majority of sites were non-forest.

[22] Buckland et al (2008)

[23] Symbolix 2021

[24] P. Barker, pers. comms

Table 7. Forest classification of sites

SITE_ID	Classification
01	Non-forest
02a	Non-forest
02b	Non-forest
03	Non-forest
04	Non-forest
05	Non-forest
06	Non-forest
07	Non-forest
08a	Non-forest
08b	Non-forest
09	Non-forest
10	Non-forest
11	Non-forest
12	Non-forest
13	Non-forest
15	Non-forest
16	Forest
17a	Non-forest
17b	Non-forest
18a	Non-forest
18b	Non-forest
19	Forest
21a	Forest
21b	Forest
23	Non-forest
24	Non-forest
25a	Forest
25b	Forest

7.2 Results

Figure 12 and Figure 13 summarise the distance at which flights were first detected (regardless of species), and a theoretical fitted curve for detection distance; for the non-forested and forested flights respectively. The effective detection range for all eagles at non-forest sites is 1300 metres with a 95 % confidence interval of (1210, 1340) metres. For observers at forested sites, the EDR is 1060 metres with a 95 % confidence interval of (833, 1350) metres. These distances support the distribution of sites across the site.

Table 8 provides distance-corrected activity rates. The activity rates are the sum of all sites in each strata, forest or non-forest. The results indicate a preference for non forest.

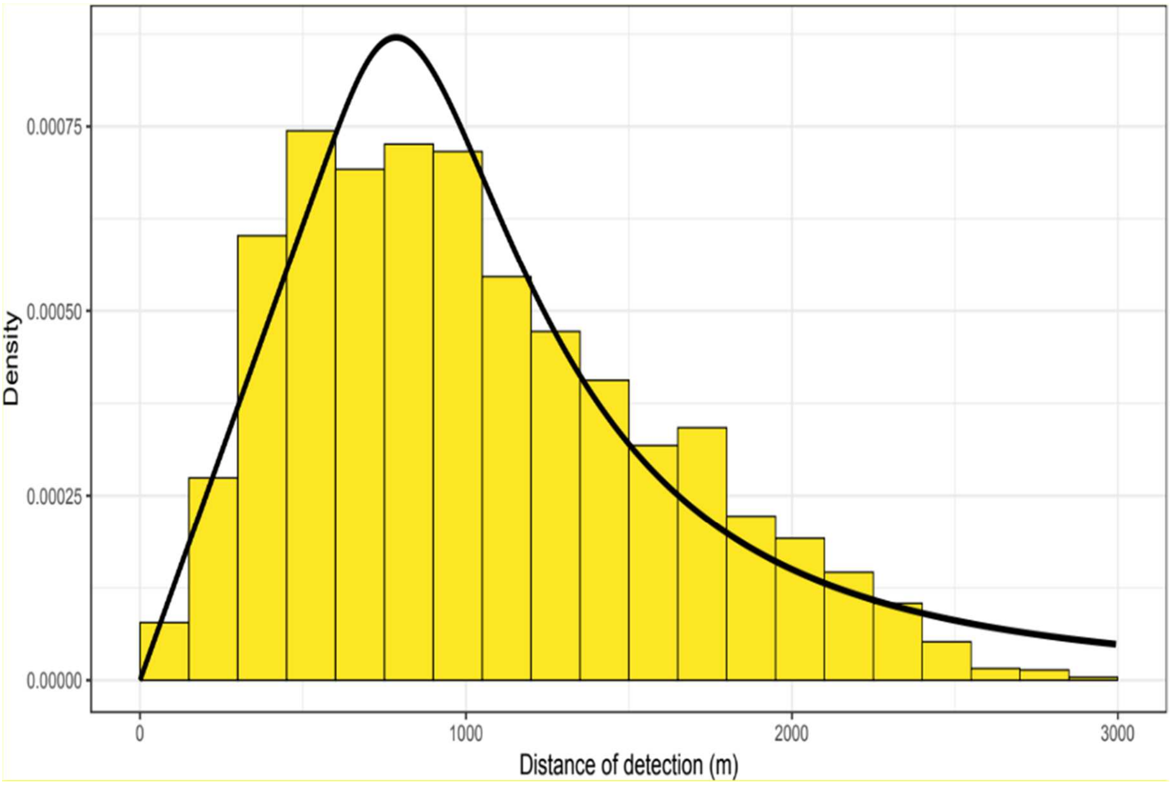

Figure 12. Non-forest observation points: histogram of (truncated) observed distances of detection. With a fitted curve overlaid for detection distance

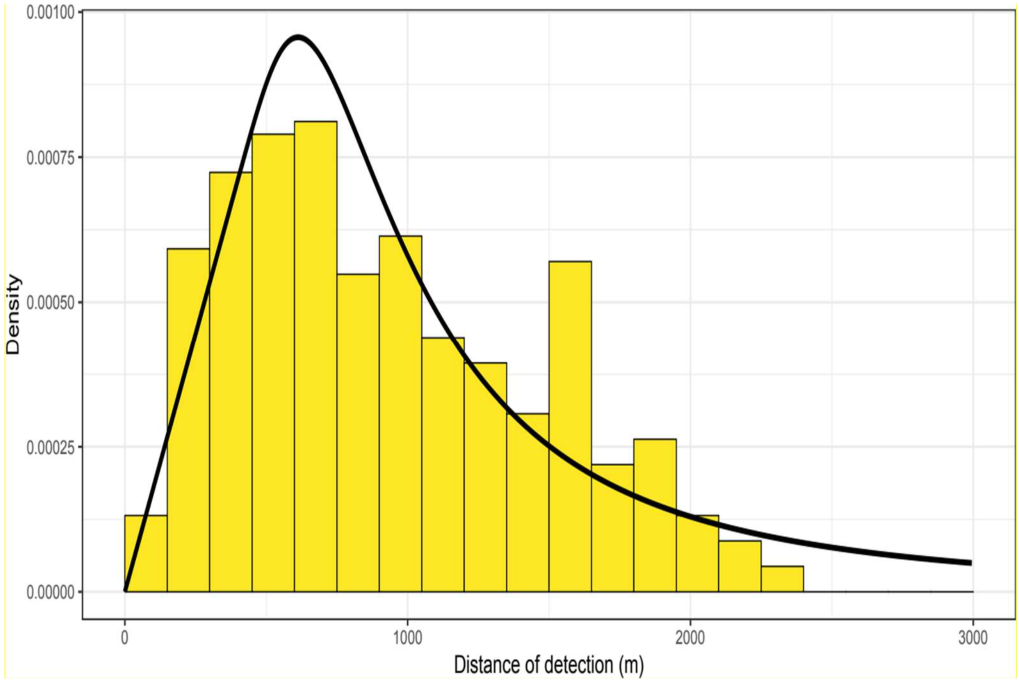

Figure 13. Forest observation points: histogram of (truncated) observed distances of detection. We have overlaid the fitted curve for detection distance.

Table 8. Counts of observed flights, and distance-corrected activity rates with corresponding 95% confidence intervals for flights per hr

Variable	Wedge-tailed eagle	White-bellied sea eagle
Valid flights observed	3594	43
Flights/hr (non-forest total)	47.6	0.723
Flights/hr (non-forest total, 95% CI)	(41, 55.1)	(0.448, 1.17)
Flights/hr (forest total)	31.4	0.0903
Flights/hr (forest total, 95% CI)	(20.2, 48.9)	(0.00555, 1.47)

8 SPATIAL MAPPING

8.1 Methods – Flight path analysis

To simplify and illustrate the spatial variation in the density of flight paths, the individual flight paths were transformed into a probability contour map (Figure 14). This was done by smoothing the data using a statistical technique called kernel smoothing, previously explained. The resulting contour maps illustrate the likelihood that a flight will occur at a particular location, in this case a m^2, relative to the other locations.

8.2 Results

Figure 14 shows the probability contours of flight density for white-bellied sea eagles and wedge-tailed eagles combined. There were insufficient white-bellied sea eagle flights to justify separation for this analysis. The green and yellow contours have the higher flight density, and the flight density decreases as the colour tends towards blue and purple.

The data indicate the highest flight density in the mid-west, and south, of the site. These areas are non forest. There are also areas in the north-west, north-east and centre of the site with high flight density, again areas of non forest are predominant. This preference is likely to be due to the higher availability of prey in non-forested areas or at least the higher likelihood of successfully feeding in non-forested areas. Nevertheless flights were observed over the majority of the site.

Figure 15 compares the seasonal differences in the flight density over 2 years.

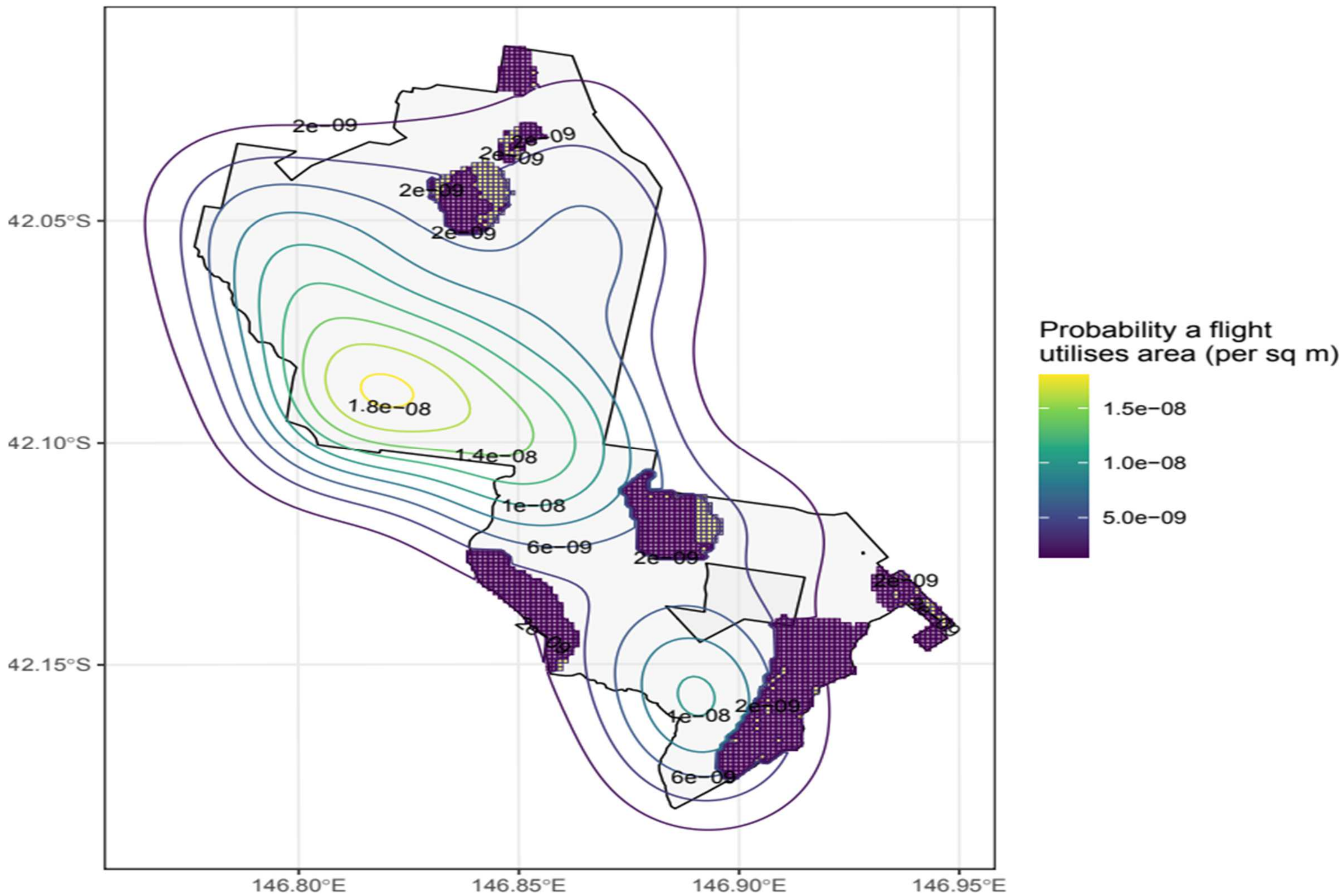

Figure 14. Contour map of eagle utilisation, overlaid on study area (boundary line). The purple blocks show areas that had limited visibility in early seasons and have been imputed by the mean of the stratum (forest or non-forest).

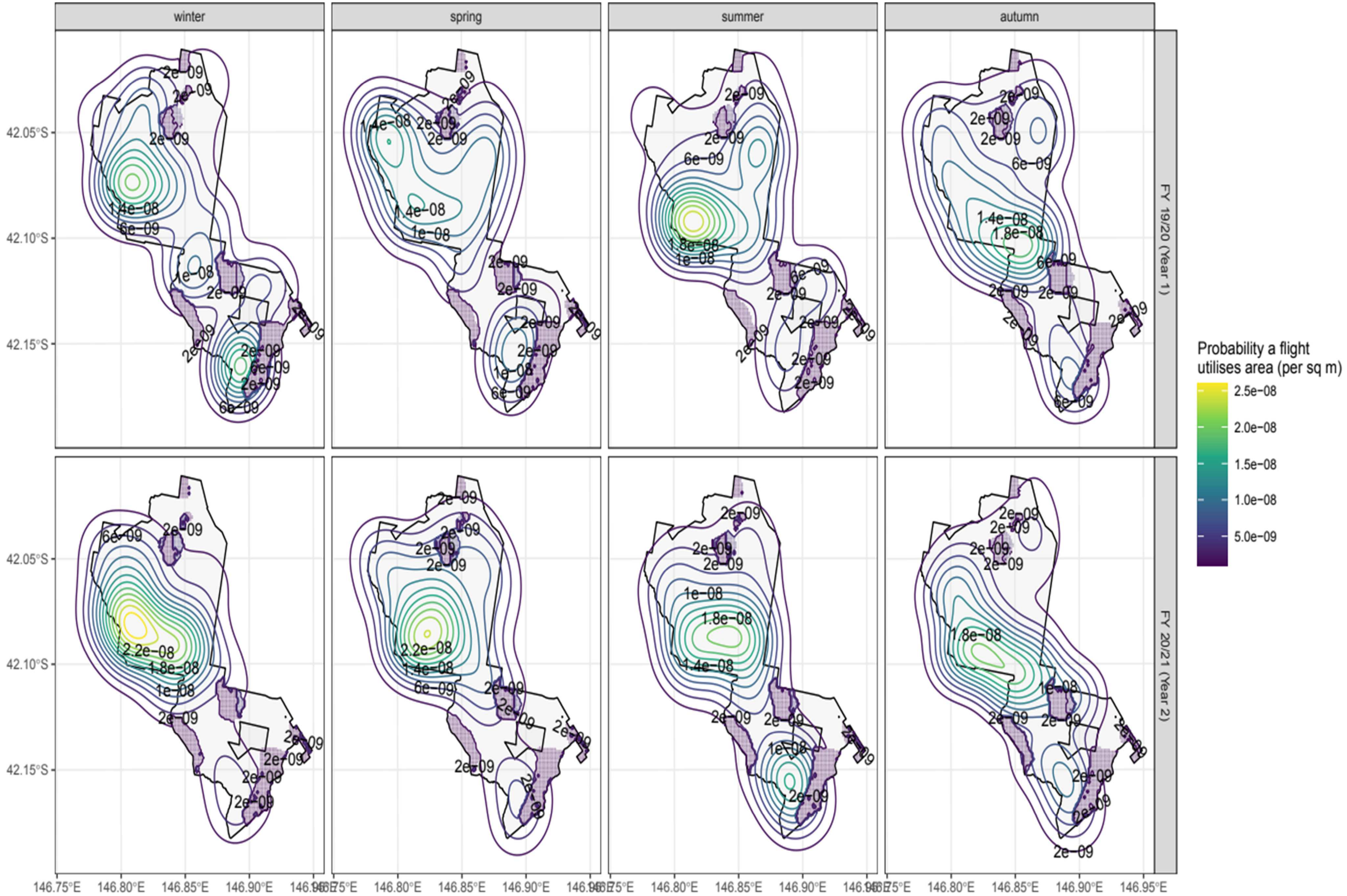

Figure 15. Contour maps of eagle flight density for each season sampled. The purple blocks show areas that had reduced visibility in year 1. These areas have been attributed the mean of the stratum (forest or non-forest).

9 ANNUAL COLLISION RATES

This analysis aims to estimate the annualised rate of incidents where eagles may collide with rotor blades of turbines. Because the turbine blades are moving at various speeds in response to wind speed, but also design and operating specifications, the risk of collision changes through time. As such the collision risk model is complicated by environmental and operating specifications. See Appendix 3 for a detailed explanation of the Collison Risk Model (CRM).

9.1 Methods

Collision risk modelling requires a model that can predict the rate of collision with one and all turbine blades. The total of all risks of collision with each turbine is presented as a combination of the risks as a probabilistic statement. The process can be summarised by the equation:

$N_{collision} = F \times P(IvF) \times P(CvI) \times (1-AR)$

where:

$N_{collision}$ is the estimated number of flights ending in collision (collisions / unit time).

F is the estimated activity rate of flights in the region (flights / unit time).

P(IvF) is the probability of a flight interacting with a turbine, given a flight in the region.

P(CvI) is the probability of collision, given an interaction occurs.

AR is the avoidance rate.

To obtain the estimated activity rate of flights in the region (*F*), the activity rate sampled at the site is extrapolated to flights over a year.

The probability of a flight interaction (P(IvF))[25] includes an assumption that every flight interacts with every turbine. The Band Model[26] was utilised for this analysis and that model requires a number of turbine-related and bird-related inputs, which are summarised in Table 9 and Table 10. The model uses these data to estimate the probability of interaction for each turbine to remove the assumption that every flight interacts with every turbine.

The probability of collision given interaction (P(CvI) is generated using the Band Model[27]. The Band Model assumes a constant number of birds i.e a struck bird is replaced immediately and behaves in the same way as indicated by the activity rate. This estimate of number of collisions may be higher than the actual collision rate, if a struck bird is not rapidly replaced. The rate of replacement is not known, particularly in the context of the variation in the number of juveniles and floaters at the site from time to time.

It is acknowledged that in this context the dynamics of the spatial use of the site may be more complex than immediate replacement following the loss of a bird. However, Symbolix (unpublished data) analysed this contention and found no such pattern (beyond random chance). This is an emerging area of interest but there are no data to inform the model of a different dynamic or quantum to that assumed here. Although it is reiterated that surveys are undertaken in all seasons and in differing weather conditions in an attempt to get coverage of a range of different behaviours and interactions.

[25] Band et al (2007)

[26] The Band Model is the most frequently used CRM for avian species. It was developed by Band et al (2007) and provides four different options for calculating collision risk.

[27] Band et al (2007); Band (2012)

Hourly data on the operating status of the wind turbines, the turbine downtime due to maintenance (3%) allows the proportion of the time the turbine is actually turning to be estimated. The operating time "uptime" for each turbine, is summarised in Table 11 (Note 47 turbines numbered between 1 – 71).

The risk of collision only occurs during "uptime" and the risk of collision is lower (all else being equal) when the turbine is spinning slowly compared to spinning faster.

To estimate turbine downtime we used maintenance and low wind estimates provided by project engineers (so as to use the same data as used for estimating project power generation). The wind turbines do not spin in low wind conditions, nor during maintenance.

The wind speed modelling was obtained from the engineering team and consisted of 10min interval wind speed for the 30 year period from 1990-2021, and the estimated generating (turning) status at each turbine location. We used this dataset (10 min resolution prediction of stationary / moving for each turbine over a 30 year period) as provided by the engineering team. Since Wedge-tailed Eagles are active only during the day, we used the day downtime value for each turbine only (day / night calculated using sunset and sunrise times for each date).

In addition to low-windspeed downtime, each turbine is estimated to require 3% downtime for maintenance, which might or might not occur when the turbine is stationary from wind speed. We assumed these two causes of downtime are statistically independent so the total proportion (*P*) of downtime (*P(D)*) is:

*P(D) = P(down-wind) + P(down-maintenance) + P(down-wind) * P(down-maintenance)*

and the uptime proportion is just *1 - P(D)*

The avoidance rates (AR) utilised in the model are 90%, 95% and 99%. The 90-95% avoidance rates have been determined empirically by Hull and Muir 2013 and by Smales et al 2013. Smales et al (2013) tested the most appropriate rate for the total avoidance rate in the collision risk modelling using eagle mortality data from 2 Tasmanian wind farms. Models with 95% avoidance rates best predicted for the mean number of collisions actually documented at these sites. Avoidance rates of 90% and 95% both predicted actual collisions within a 95% confidence interval. Based on these figures, a realistic minimum overall avoidance rate of 90% is used. These rates have been applied and accepted by the industry and regulators as evidenced by their application to CRM's at the Cattle Hill and Moorabool Wind Farms (Victoria). Additionally the Musselroe Wind Farm updated their collision risk modelling post construction, with their recorded collision numbers and determined that the collision numbers "are consistent with the modelled estimates for a 90% avoidance rate" (Musselroe Wind Farm Public Environmental Report 2019 – 2022, pg 56).

Table 9. Turbine inputs for the Band Model

Variable	Value
Rotor diameter (m)	162.0
Hub Height (m)	150.0
Maximum chord (m)	4.3
Rotation period (s)	8.0
Pitch (degrees)	10.0
Number of turbines	47.0

Table 10, Bird inputs for the Band Model.

Variable	Value
Length (m)	1.0
Wingspan (m)	2.1
Flight speed (m/s)	17.0
Flapping	1.0
% year on site	100.0
% daylight hours active	100.0
% night time hours active	0.0

Table 11. Proportion of 'uptime' for each of the 47 turbines(of 71 in original proposal), during times the eagle is active

Turbine	Uptime (%)	Turbine	Uptime (%)
1	70	**39**	50
2	87	**42**	50
3	60	**43**	49
4	60	**44**	47
6	62	**45**	51
7	69	**46**	49
8	59	**47**	70
9	69	**48**	51
11	51	**49**	50
12	61	**50**	50
13	59	**51**	49
14	60	**52**	59
15	50	**53**	58
16	52	**54**	69
17	50	**55**	85
18	49	**56**	54
19	48	**57**	85
20	50	**58**	84
25	50	**59**	64
29	62	**68**	70
30	52	**69**	62
31	54	**70**	55
32	51	**71**	84
33	52		

9.2 Impact

9.2.1 Collision with turbines

The original proposal included 67 turbines. This number has been reduced largely to mitigate the collision risk but also to reduce visual impacts. Those turbines predicted to cause the highest number of collisions were removed and the CRM rerun. Adjustments to turbine characteristics and operating conditions described above were applied which reduced the predicted impact further. The final wind farm proposal includes 47 turbines. The predicted unmitigated annual collision rates of this proposal are based on the turbine and bird parameters in Table 9, Table 10 and Table 11 and are summarised in Table 12.

Table 12. Predicted unmitigated annual number of collisions per eagle species by avoidance rate.

Species	Avoidance Rates		
	90 %	95 %	99 %
Wedge-tailed eagle	**4.89**	**2.44**	**0.49**
White-bellied sea eagle	**0.05**	**0.03**	**0.005**

9.2.2 Collision with transmission line

There are no data available on the rate of collisions with the existing transmission lines on the site and so there is no basis for extrapolation to the new line that will support the wind farm. The long-term rate of collisions is difficult to ascertain due to a likelihood of under reporting of deaths until recent improvements in monitoring and reporting by TasNetworks. High risk areas for bird collision with transmission lines include where lines are adjacent to take off and landing zones associated with wetlands and in valleys where lines cross a valley floor. The proposed location does not present this risk.

In this case the transmission line will be a 220kV line running about 3 km from a substation to the switchboard at the existing line. It will require 40-50 m in clearance for 10 towers each strung with 4 wires (Figure 16).

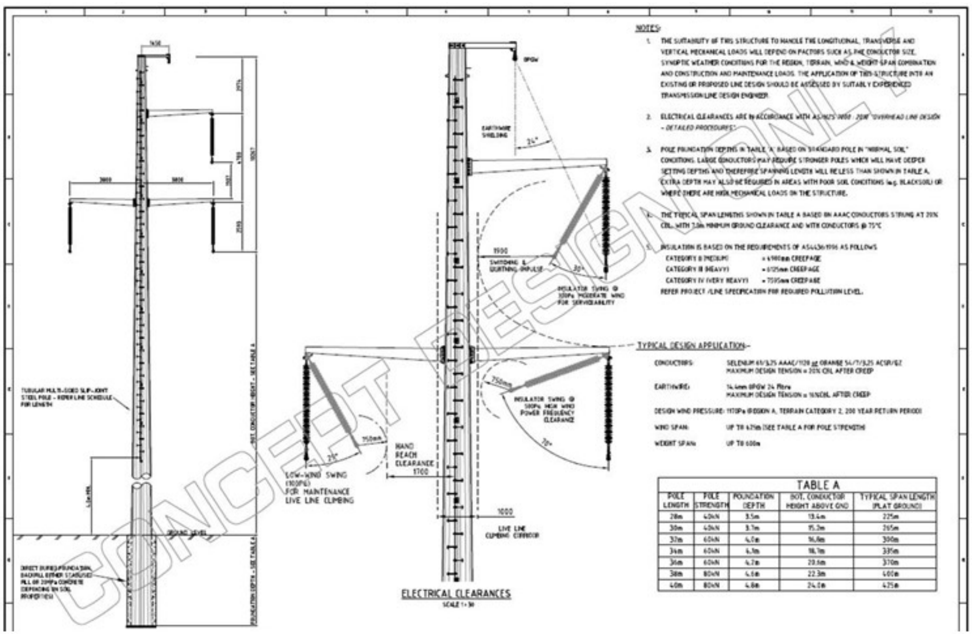

Figure 16. Concept design of transmission line towers

9.3 Mitigation Overview

The following mitigation strategy demonstrates the intention to meet the requirements of *PSG 6.1 Collision management*. Further details of each element of the mitigation strategy including the implementation of mitigation actions will be documented in the Environmental Impact Statement.

Wedge-tailed eagle mortalities are recognised as the most significant natural values impact associated with Tasmanian wind farms. The mitigation of collision risk has proven to be an extremely complex challenge where the wind farm's mitigation actions have to demonstrate tangible positive outcomes.

Various technologies and mitigation options have been proposed and tested or implemented in Tasmania. Despite Government and industry collaboration in regard to reviewing mitigation strategies (MWF PER 2016-2019) no new concepts or information gaps that could be readily filled were identified at that time. Over the same period evidence from sites across the world and summarised in published reviews such as Watson (2018) and May et al (2015) suggest that careful siting and continued research on optimising coexistence can minimise or even eliminate negative effects on raptors. The most substantial difficulty facing mitigation proposals has been the innate inability to quantify the effectiveness of any mitigation action short of complete avoidance; until recently; see Section 10.2 below.

An optimal mitigation strategy will require the implementation of a series of proven concepts with the aim of reducing the potential for collision to the minimum level enabled by the sum of the mitigation actions employed. This additive approach is supported in reviews of sustainable approaches by Marques et al (2014) and May et al (2015). The outcome relies on the utmost stringency in application of mitigants, monitoring, efficacy testing and adapting with continuous progress.

The global reviews refer to various mitigation trials but relatively few are implemented with a design required to demonstrate efficacy. However, IdentiFlight International 2019 and May et al (2020) have demonstrated through CRM models and field experimentation that very significant reductions in collision rates in the order of 50-67 % can be gained through curtailment when birds approach and 72% by visual noise enhancing the visibility of spinning rotor blades.

Most recently subsequent studies at the Top of the World Wind Farm [28] [29]in Wyoming have recorded collision reductions of 82% and 85% respectively using Identiflight.

Opportunities for mitigation on this basis are presented below.

9.4 Mitigation Strategy

In the assessment of known or potential impacts on natural values the Tasmanian EPA and the Commonwealth Department of Agriculture Water and Environment (DAWE) consider the mitigation proposal in the context of the following mitigation hierarchy.

The hierarchy requires the proponent to demonstrate the efforts made at each level.

- avoid impacts:
    - In this context avoidance means adjustment of the proposal to spatially or temporally exclude the possibility of a particular impact.
- minimise impacts:
    - Minimise means to apply mitigative actions that will reduce a particular impact.

[28] McClure *et al.* (2021)
[29] McClure *et al.* (2022)

- offset residual impacts:
    - Offsets are employed to compensate for the remaining or residual impact.
    - Offsets should ideally compensate like for like so a bird death should be replaced by a life saved.

Avoidance strategy used in this proposal

- Eliminate the turbines that present highest risk.
    - predictable outcome based on existing data and CRM.

- Turbine design and operating specifications.
    - Rotor diameter, speed of rotation, cut-in wind speed and blade pitch each contribute to the potential for collision. Shorter, slower, angled blades induce lower collision rates.

Minimise

- Employ emerging technologies to detect and respond to high risk flights by curtailment
    - IdentiFlight digital image recognition.
    - Automatic curtailment / deceleration of blades when birds approach turbines.

- *Site productivity management – reduce carcass and prey availability*
    - Continuous management effort required in a broad area.
    - Reduce shelter cover of hakea plants and other shrubs with prescribed burns (a good outcome for highland grasslands) reduces ability of wallaby and deer to graze as widely.
    - Wallaby cull based on relative abundance measurement trigger.
    - Deer cull based on relative abundance measurement trigger.
    - Rabbit control using calicivirus and warren destruction.
    - Livestock switch to cattle if cattle survival rate is higher than sheep to reduce scavenging, site productivity and hence flight density.
    - Carcass removal and disposal through prescribed culling and hunting practices and livestock monitoring.

- *Employ noise cues to reduce bird interaction*
    - "Whistling" cue in the region of best hearing for birds (2–4 kHz) help birds hear the blades while adding almost nothing to overall noise level.

- *Location of the transmission line*
    - The transmission line is located on flat land in an area where flight density was recorded as relatively low.

10 RESIDUAL IMPACTS

10.1 Avoidance

Avoidance of impacts by the removal of 20 turbines from the proposal has resulted in the predicted number of collisions reported in Table 12 above for the 47 turbine layout.

10.2 Minimisation

Recent research on two elements in the minimisation strategy has provided empirical evidence of the scale of reduction in collisions that can be predicted through the application of:

- IdentiFlight driven automatic curtailment when high risk flights approach; and
- 'Visual noise' enhancing the visibility of turbine blades (e.g., painting one turbine black).

10.2.1 IdentiFlight Curtailment

IdentiFlight (cameras) (IDF) detect and identify birds at sufficient distance from specific wind turbines to be able to initiate a shutdown ("curtailment") of the turbine in order to reduce the risk of a bird colliding with that wind turbine. The curtailment rules are coded into software that automatically controls the relevant turbine. Curtailment can be blade feathering through to shut down. Two IdentiFlight International research papers demonstrate the outcomes of simulations of IdentiFlight initiated turbine curtailment. The simulation process utilised the same Band CRM model as was used for the St Patricks Plains CRM but without any avoidance rate such that the predicted collision rate is the maximum estimate.

Based on the estimated time for an eagle to fly from the point it was detected by IdentiFlight to the rotor-swept area of a turbine the collision probability was calculated using the Band CRM with a lower turbine speed. That is, a slower turbine rotation speed reduces the Band CRM's predicted rate of collisions. This allowed collision estimates to be reduced by an increment attributable to blade deceleration.

As a function of the blades deceleration rate, the predicted collisions were reduced by between 50 % and 67 % by the time of complete shutdown; taking between 30 – 70 seconds from initiation. A 2.3 MW Siemens turbine returned a 50-67 % reduction within 20 - 50 seconds of deceleration. The longer the bird takes to approach the lower the probability of collision.

There are other technologies operating around the world and these were reviewed by Joule Logic in 2018 (cited in Goldwind 2022). They found that that IDF performed well in comparison by being effective at collision minimisation as well as efficient with regard to generation loss, being around 0.6%. In Tasmania, the Cattle Hill IDF implementation is the most relevant experience with IDF to predict the efficacy most likely to be experienced at St Patricks Plains.

IDF technology is being trialled at the Cattle Hill wind farm by Goldwind who have reported on an assessment of the effectiveness between August 2020 and February 2022 (Goldwind 2022). One of the benefits of using IDF is the continuous monitoring of avifauna activity which adds to the understanding of TWTE behaviour. The continuous monitoring allows for automated curtailment outside of the hours that manual curtailment using human observers is undertaken; particular in Tasmania where long daylight hours occur in summer.

At Cattle Hill wind it was reported that IDF operated on a partial basis during 8.5 months of commissioning and 18 months at full operation of 48 turbines. During this time 3 TWTE deaths occurred.

Goldwind argues that all 3 mortalities could have been avoided and ascribes them to human error. One mortality involved the human operator overriding the IDF automatic curtailment that had already been initiated because the human could not see the eagle. This resulted in a modified procedure whereby IDF initiated curtailment cannot be overridden for any reason so that the error cannot happen again. The second mortality occurred in a dense forest location. Review of the incident found that a stand of trees created an IDF blind spot below 70 m in that direction. The death was attributed to insufficient clearance around the turbine and has been rectified. The third death was also attributed to occlusion of IDF view by vegetation. While vegetation clearance resolved the field of view issue on these occasions, Goldwind suggest an alternative is to raise the height of the IDF tower, relocation or removal of perch branches.

Adaptation to St Patricks Plains

At St Patricks Plains forested landscapes with the potential to occlude vision occur near some turbines. The designers and operators will have the benefit of the Cattle Hill learning experience and will implement the operational measures of:

- No human overriding of IDF curtailment for any reason.
- Assessment and zones of occlusion – the range of angles that identification is possible and the occlusion of birds above the IDF station will be considered in designing the IDF layout and turbine micrositing. The location and tower design will maximise field of view for IDF cameras and where necessary include neighbouring cameras triggering curtailment where the zone of occlusion of the local camera does not allow detection.
- Adequate clearance around turbines - This will require field assessment of each tower that has potential occlusion due to vegetation. An optimal occlusion distance and height will ensure that the IDF technology has ample time to curtail in response to all approaching eagles.
- Topographic limitations to visibility – the potential for the "pop up" effect whereby a bird only becomes visible once it emerges from behind a hill close to a turbine (or from lower land near to a turbine location from where the eagle is not able to be seen by the camera technology until close to the impact zone) will be investigated for each turbine at St Patricks Plains. If the topographic screen is closer than the minimum distance for effective curtailment then IDF or turbine micrositing will be undertaken to reduce the risk.

It is not possible to predict what the reduction in collisions would be following these mitigation efforts other than to say it will reduce these known risks so presumably reduce the residual impact.

10.2.2 Visual Noise

A recent paper by Nygard et al. (2020) has demonstrated that painting one of three rotor blades black reduced motion smear and so made the blade more visible to birds. At the Smola wind farm in Norway a Before After Control Impact (BACI) investigation was carried out between 2006 and 2016. Carcasses of all bird species including the white-tailed eagle (*Haliaeetus*- same genus as white-bellied sea eagle) were counted at a sample of turbines before the treatment was applied. The treatment affect across all species was measured by counting carcasses at treated and untreated (control) turbines. The analysis of the BACI model indicated that the annual fatality rate was significantly reduced for the painted turbines versus the controls. Overall, there was an average reduction of 71.9 % (95 % Confidence Interval and a range in reduction of 61.8 %-79.1 %).

This experiment has not been repeated elsewhere and so there remains some uncertainty in the potential benefit at St Patrick Plains Wind Farm. If a significant beneficial effect can be demonstrated then it can be applied as a multiplier to the calculation of the cumulative mitigation effect. To that end use of black blades is an optional additional mitigation measure that could be applied in the event of eagle collisions and, if applied, it would be implemented in a scientifically robust manner including suitable monitoring to determine efficacy.

10.2.3 Mammal Carcass management

The St Patricks Plains site is highly productive with regard to the biomass of mammals including wild, pest and livestock mammals. The high productivity is a major contributing factor to the number of eagles that the site supports. As a consequence of a high number of animals there is almost certainly a proportionately high natural mortality of these animals which contributes to a food resource for scavengers, including eagles and other raptors.

In addition to the natural mortality there is a high rate of hunting and culling of deer and wallaby respectively. The habits of the hunters and cullers (hunters) with regard to the treatment and disposal of waste and carcasses is not known. Nevertheless, it remains important to reduce the proportion of the site's productivity presented to scavengers as a result of hunting and culling.

Natural mortality, hunting and culling occurs on all the properties on which turbines are proposed. Hunting practices have been in place for many years. While the practice may continue in a similar form there should be arrangements agreed upon in order to ensure safety of people on the site and protocols developed to minimise the amount of meat left for scavengers and the location at which it is left.

In particular, no carcass produced by hunting should be left where shot. Either whole carcasses should be removed from the site by hunters or all parts of a carcass that are not to be utilised as meat should be disposed of at approved disposal areas located across the site and not within 500 m of a turbine. There will need to be at least one disposal site on each of the four properties supporting turbines and if necessary more disposal sites to provide for practicalities of each property.

The disposal method should be determined in consultation with the relevant authorities and landowners.

Searches for carcasses due to natural mortality of mammals will be undertaken at the same time as the collision monitoring for birds. However, it will be extended to all turbines where livestock have been grazing in any particular monitoring period (Section 11.4).

Carcasses of birds recovered from around turbines during the collision monitoring searches should also be disposed of unless required for another legitimate purpose (legitimate being contributing to the management of the site or species conservation).

A record or at least an estimate of the number of animals shot, the location and number of carcasses collected and disposed of, and the number and species of natural mortalities removed from around turbines should be recorded. These numbers and any change in number over time and an estimate of biomass and the locations from which they were removed should be analysed with respect to the location of any eagle collisions and eagle nest productivity.

10.3 Estimated Residual Impact

The implementation of any or all of the elements listed in the mitigation strategy (Section 9.4) will contribute to mitigation of collision risk.

The CRM predictions are based on very thorough sampling of flights across the whole site. This comprehensive data set provides a very high degree of confidence in our understanding of the site utilisation. The application of the model to these data provides a transparent defendable prediction of collision rates. The application of the predicted rate of mitigation due to IdentiFlight curtailment at the St Patricks Plains CRM reduces the 90 % avoidance collision rate of 4.89 predicted by the CRM to between 1.61 and 2.45 birds per annum.

The application of other additive collision control measures, for example prey carcass management, will reduce the annual collision rate further by discouraging birds from utilising the area. While the treatment effects of this and other measures have not been measured so cannot be quantified, it is well supported by ecological theory and knowledge that sites of low productivity have fewer predators present and so fewer collisions would occur.

As mention above, since IdentiFlight reported the results of curtailment simulation in 2019, subsequent studies at the Top of the World Wind Farm [30] [31]in Wyoming have recorded collision reductions of 82% and 85% respectively. If this were achieved at St Patricks Plains the residual collision rate calculated as described above would be 0.73 and 0.88 birds per annum respectively. Applied to the Cattle Hill Wind Farm the predictions of the CRM would have been almost identical at 0.90 and 0.75 birds based on the unmitigated predicted 5 bird deaths in the first year. In fact these estimates are close to the 3 deaths recorded in 18 months during commissioning and before mitigative adjustments to IDF operation protocols were made.

Table 13 lists the collision rate predicted by the CRM as well as the mitigated rates of 50 – 67% from curtailment modelling and the mitigated collision rates reported from the Top of the World Wind Farm studies. The calculations to arrive at the mitigated rates are CRM rate * (1-0.67 and 1- 0.5) and CRM rate * (1-.82 and 1-.85).

Table 13. Mitigated collision rates

Species	Avoidance Rates		
	90 %	95 %	99 %
Wedge-tailed eagle	4.89	2.44	0.49
IdentiFlight modelled curtailment	1.61 – 2.45	0.80 -1.22 -	0.016 - 0.25
Identiflight field curtailment	**0.73 – 0.88**	**0..36 – 0.44**	**0.07– 0.09**

10.4 Cumulative Impacts

The St Patricks Plains site is more than 10 km east of the Cattle Hill Wind Farm. Of the nests between the two sites, the nests nearest St Patricks Plains are about 9.5 km km east of the Cattle Hill Wind Farm and the nearest nests to Cattle Hill Wind Farm are about 7 km east of the Cattle Hill turbines and 7 km west of St Patricks Plains proposed turbines. Based in typical and estimated territory sizes at St Patricks Plains and generally for Wedge-tailed Eagles these birds are highly unlikely to forage within the alternative respective wind farm sites i.e. none of the known nests between the two sites are likely to occupy territories that span both sites.

Any mortality of eagles at St Patricks Plains will be additional to those at Cattle Hill. However, for the reasons stated above it is highly unlikely that a breeding bird from Cattle Hill will die as a result of collision with a turbine at St Patrick Plains.

Additional to consideration of cumulative impacts at the individual territory level, it is also important to acknowledge that any impact to eagles at the Project Site is in the context of cumulative impacts from all other impacts to eagles both locally and across Tasmania (i.e. cumulative impact on the regional and state-wide population level). This includes other wind farms (both regionally and across the state) as well as other impacts such as shooting, poisoning, collision with other structures (power lines, vehicles), electrocution from power lines, habitat loss and nest disturbance. It is not possible to quantify the extent to which the

[30] McClure *et al.* (2021)
[31] McClure *et al.* (2022)

Project has a cumulative impact (combined with these other impacts) as there is limited holistic information on impacts from these other sources. Although this potential cumulative impact on regional and state-wide populations cannot be readily quantified, it does emphasise the importance of minimising impacts at the Project level, given the overall threat to the species from other wind farms and other activities regionally and across the state. The management, mitigation and monitoring measures aim to achieve this goal, including the commitment to mortality reporting and adaptive management in response to any listed avifauna mortality.

10.5 Offset

The offset strategy described here is based on the principals of saving the lives of eagles that may otherwise be killed elsewhere and by increasing the breeding success at nests. As such the offsets directly compensate for the residual rate of loss to collisions at St Patricks Plains.

Compensating for eagles killed by turbines by saving eagles elsewhere is best achieved by mitigating threatening processes that are known to present the highest risk to individuals. Examples of actions aimed at this outcome include:

- Contribute to mapping high risk powerlines and improving the visibility of high risk powerlines to reduce the risk of fatal collisions - retrofitting to create "bird safe power lines".
- Contribute to a State-wide educational campaign and communications strategy to reduce the use of pindone rabbit baits and other rodenticide baits.
- Contribute to a State-wide educational campaign and communications strategy to reduce the number of eagles that are shot.
- Encouragement of hunters to use no lead bullets
- Protect viable nests elsewhere that are vulnerable to disturbance to ensure nests are utilised to produce an increase in nest productivity.
- Contribution to research to devise strategies to improve breeding success everywhere and decrease eagle mortality in and around wind farms.
- Fund eagle rehabilitation at refugia, and
- Contribute to the implementation of a recovery plan.

These actions could be funded by contributing a sum of money to a suitable organisation tasked with implementing outcomes based projects.

11 AVIFAUNA COLLISON MONITORING

11.1 Context

Mortality monitoring is required to estimate the actual rate of mortality of eagles compared to the predicted rate of mortality. Measuring the actual rate of collision is an important undertaking for all bird species to gain an understanding of the impact of the operation of the wind farm. This section outlines best practice for manual bird carcass detection and mortality estimation at St Patricks Plains Wind Farm.

Mortality searches and estimation are an area of ongoing research worldwide. This proposal was founded on a combination of statistical tests, current best practice, and practices on-ground at other Australian wind farms. This will also allow a comparison of data to other sites.

The site-specific application of the strategy is proposed to be detailed in a site specific monitoring plan on finalisation of an approved wind farm design. The details of the proposed collision monitoring method and statistical justification are provided in Appendix 4. A summary is provided here.

11.2 Objectives

The objectives of the monitoring plan are:

1. **Avifauna mortality estimation.** To track site impacts on local avifauna through collision counts and estimated rates.
2. **Adaptive management monitoring.** To inform adaptive management through targeted monitoring of species of interest. These data would be used to track performance against management triggers and will focus on Tasmanian wedge-tailed eagles.

11.3 Methods

Avifauna mortality estimation

This objective requires a valid survey program to sample turbines for carcass searches. This enables an estimate of collision mortality that can be compared with other sites. The method also relies on

- Searcher efficiency trial – this indicates detection rates
- Scavenger rate trial - This determines how quickly carcasses are lost to scavengers

Adaptive management monitoring

To collect the data required to achieve this objective a complete scan of the area around each turbine on a regular basis is recommended. The aim is to detect all threatened avifauna carcasses but with a particular focus on eagles to inform a comparison with the predicted number of mortalities.

Adaptive management triggers will be based on the time and number of eagles killed. They will be determined based on the count of carcasses found, prior to any estimate of total mortality. Detail of survey period and the frequency and intensity will be included in a monitoring plan following approval of the project. The triggers and the management response will also be included in the monitoring plan.

Mortality estimation

To detect any collision requires a number of factors to align.

1. First, there must be a collision at the site;
2. The collision must be at a turbine included in the carcass searches;
3. The carcass must land inside the searched area (noting the total 'fall zone' differs depending on the size of the turbine and size of the carcass and assumes the bird lands and dies in the fall zone). Undetected mortalities are not estimated or accounted for;
4. The carcass must not be removed (by decay and/or scavenge) from the search area prior to the search; and
5. The observer must observe the carcass (i.e. not miss it because of obstruction or imperfect vision).

The carcasses found in formal surveys are a sample of all carcasses and an estimation of total carcasses is drawn from the sample.

The application of the method detailed in Appendix 4 will help ensure that even if not all carcasses are detected, the mortality estimates will be close to the true number of mortalities.

Number and location of turbines

Highest risk turbines have been eliminated from the layout and although the remaining turbines do pose different risks based on the two years of data the method assumes that remaining turbines each poses an equal risk and so the whole site should be sampled. If different vegetation types are suspected to result in practical differences in the ability to find a carcass at different turbines then the site should be stratified based on the vegetation cover.

Ultimately, the number of turbines that can be consistently and meaningfully surveyed within a reasonable time would be constrained by resourcing and logistics. For this site with 47 turbines, selecting 20 for survey would provide adequate coverage across the site.

Survey frequency and timing

The survey timing must be similar to or less than the expected scavenge time. This is manageable for larger birds like wedge-tailed eagles where evidence can remain in place for weeks or even months, as such, monthly searches would be sufficient. This is supported by evidence from 4 locations in the USA[32] where mean carcass persistence time varied between 28 and 76 days for raptors. This research estimated that 95% of large avian carcasses fall within 100 m of turbine bases, and 99% fall within 150 m of turbines with heights of about 125 m. At SPP the turbine heights will be 250 m.

Appendix 4 details the calculation used here to arrive at the proposed search area for eagle mortalities of 120 m radius around each turbine with a tip height of 230 m.

- Searches for carcasses will be undertaken monthly at all turbines.
- The search will be based on a 12 m concentric radius to 120 m from the turbine tower.
- The frequency and distance will be reconsidered after 12 months data collection and analysis.

It is recommended that details of the search strategy including the commencement date, survey duration, a surveyor fatigue management plan and consideration of inclusion of met masts and the transmission line be included in a carcass management plan after project approval.

Searcher efficacy trials

Detectability trials provide an estimate of surveyor effectiveness under the carcass search conditions. Searcher efficacy trials aim to determine the proportion of carcasses that are present that are likely to be found during searches. To achieve this a trial would:

- Randomly select turbines at which to place carcasses to account for possible variation in detectability between the locations.
- Be carried out using the same method as used for the mortality surveys
- Use bird carcasses of different sizes if mortality estimates for bird species in different size classes are required.

Scavenger efficiency trials

Scavenger efficiency trials allow us to estimate the average time until complete loss from scavenge and this time is an input to the final design of the monitoring plan. Detail of survey period and the frequency and intensity should be included in a monitoring plan following approval of the project.

[32] Hallingstad et al 2018.

11.4 Monitoring plan

The considerations and methods described above should be incorporated into a carcass monitoring plan for application during the operation of the approved wind farm. The monitoring plan will detail location and extent, duration and frequency of monitoring. The number of turbines to be monitored will depend on the outcome of the trials and will be as few as required to be statistically valid. Details of design for searcher efficiency and scavenger detectability trials will also be included in the monitoring plan.

Formulation of adaptive management triggers for an adaptive management response and potential actions will be detailed in the plan.

12 MIGRATORY AND THREATENED WETLAND AVIFAUNA

12.1 Context

Australia and Tasmania provide important habitat for migratory birds. Threatened migratory visitors to Tasmania are protected under *Tasmania's Threatened Species Protection Act 1995* (TSPA). The Australian Government's fundamental piece of environmental legislation, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) protects migratory species listed under international agreements to which Australia is a party[33]. All species that are considered Matters of National Environmental Significance (MNES)[34] under the EPBCA are reviewed below and their geographic migratory details are listed in Table 14. Appendix 5 illustrates the local and state-wide distribution of records of each of the species listed below.

12.2 Migratory and wetland birds

The wind farm proposal requires consideration of the potential risk of:

- impacts to habitat from infrastructure; and
- collision with turbines for listed threatened and migratory bird species

Due to seasonal variations in migrating populations, rainfall and consequent wetland conditions, species for which habitat is suitable may be seasonally absent during surveys. To compensate for these limitations, data from the field surveys are supplemented with data from the:

- Atlas of Living Australia (ALA)[35]
- Tasmanian Natural Values Atlas (NVA)[36]
- Birdlife Tasmania[37]
- EPBCA Protected Matters Search tool[38]
- Previous natural values assessments in the local area by NBES[39]
- Published bird sightings (Birdata[40] and eBird[41])

The list of species below includes species not found during surveys (apart from Latham's snipe) and was derived from the EPBCA Protected Matters Search Tool and data purchased from Birdlife Tasmania.

- Curlew sandpiper, *Calidris ferruginea* (-/ Critically Endangered and Migratory)
- Eastern curlew, *Numenius madagascariensis* (endangered / Critically Endangered and Migratory)
- Latham's snipe, *Gallinago hardwickii* (- / migratory)
- Australasian bittern, *Botaurus poiciloptilus* (- / Endangered)
- Red-capped plover, *Charadrius ruficapillus* (- / Marine)
- Double-banded plover, *Charadrius bicinctus* (- / Migratory)
- Azure kingfisher, *Ceyx azureus* subsp. *diemenensis* (endangered / Endangered)

[33] Australian Government – Migratory species in Australia (2020)

[34] The conservation status of each species under the Tasmanian TSPA, and the EPBCA. Under the TSPA these are: r = rare, v = vulnerable, e = endangered and x = extinct. Under the EPBC these are: VU = Vulnerable, CR = Critically Endangered, EW = Extinct in the wild, EX = Extinct.

[35] Atlas of Living Australia (2020), available at: https://www.ala.org.au

[36] DPIPWE (2020),

[37] Includes data not held in any other database and made available for sale

[38] Department of Environment and Energy (2020), available at: http://www.environment.gov.au/epbc/pmst

[39] Including the bird surveys conducted hourly during targeted eagle surveys.

[40] Birdlife Australia (2020) available at: https://birdata.birdlife.org.au

[41] The Cornell Lab of Ornithology (2020), available at: https://ebird.org

Buffers of 500 m and 5 km[42] were used for identifying previous observations of natural values stored in these sources. A 5 km buffer around the site was assessed for habitat suitability. Areas of suitable habitat were then subsequently surveyed during spring, summer and autumn to determine utilisation of habitat by migratory birds.

12.3 Wetland bird habitat

Habitat suitability was initially conducted using remote sensing techniques, combining satellite imagery of apparently suitable habitat with published habitat types and previous sightings of each species. Field surveys to ground-truth habitat suitability were conducted in November 2019.

Visual and auditory surveys were carried out over five consecutive days in spring, summer and autumn, a minimum of 10 hours per day (two four-hour surveys spanning across dusk and dawn, and two 1-hour daytime surveys) was allocated per survey. A minimum of eight hours per day (four hours in the morning and four hours in the evening, including masked owl call-backs) were allocated during Autumn. Additional survey effort included travelling between sites and other opportunistic circumstances. Five ecologists rotating in shifts between 20 randomly located sites across the study area also recorded observations over 10 days per season.

The dawn and dusk targeted surveys were biased toward suitable habitat. An ecologist would alternate between stationary observations and a meandering search pattern through suitable habitat, ensuring the area was sufficiently covered. Each survey covered the most suitable habitats for the targeted species, with the order in which they were searched randomised between surveys.

Surveys for migratory birds were conducted following the methods outlined in "Industry guidelines for avoiding, assessing and mitigating impacts on EPBCA listed migratory shorebird[43] species"[44]. Survey timing was conducted following guidelines for non-tidal areas:

Surveys coincided with the period when the majority of migratory shorebirds are present in the area to obtain data on the total population (in addition to this an autumn survey was conducted to determine whether all birds had migrated or not. A winter survey is not necessary for these species).

- Surveys were not undertaken during periods of high rainfall or strong winds.
- Surveys were not undertaken when activities were taking place that cause migratory disturbance.
- Surveys were conducted when habitat conditions were suitable for migratory birds. Typically, when water is present with a minimally vegetated, exposed margin.
- Targeted surveys for nocturnal birds (Australasian bittern, *Botaurus poiciloptilus*) included visual surveys and auditory surveys adjacent to suitable habitat

12.3.1 Curlew Sandpiper (*Calidris ferruginea*) and Eastern Curlew (*Numenius madagascariensis*)

These species are listed as critically endangered, marine, and migratory under the EPBCA, with the eastern curlew also being listed as endangered under the TSPA. Habitat destruction, the reclamation of tidal flats and disturbance are the biggest threats to these species[45]. The curlew

[42] These are the numbers recommended when using the Natural Values Atlas Reports Tool

[43] Shorebirds are birds that inhabit the shorelines of coasts and inland water bodies during most of their life cycles

[44] Commonwealth of Australia (2017)

[45] Lilleyman and Garnett et al (2016)

sandpiper and Eastern curlew were once a common visitor to Tasmania, but their numbers have declined significantly since the 1950s[46]

Curlew sandpiper and Eastern curlew frequent intertidal mudflats in sheltered coastal areas, with the most important sites for them in Tasmanian centred on the north and east coast of Tasmania[47](Appendix 5). However, they are also occasionally recorded inland, along the open edges of ephemeral and permanent lakes and other water bodies[48] (Plate 5).

Plate 5: Potentially suitable habitat for curlew sandpiper / eastern curlew (and Latham's snipe/Australasian bittern) at Penstock Lagoon within a 5 km buffer of St Patricks Plains (January 2020).

12.3.2 Latham's Snipe (*Gallinago hardwickii*)

Latham's snipe is listed under the EPBCA as migratory / marine and is a non-breeding migrant to south-eastern Australia and Tasmania. Major threats to this species include habitat loss and disturbance. It utilises a broad range of habitats from coastal / inland lakes and wetlands to rivers and wet grassland (Plate 6). Around wetlands Latham's snipe favour a variety of vegetation cover such as sedges, lignum, grasses, rushes and reeds[49]. Whilst they were once widespread throughout Tasmania's coastline and inland lakes in the early 80s[50], there are fewer recent records which may reflect a declining abundance and distribution throughout the state (Appendix 5).

[46] Cooper and Clemens et al. (2012); Reid and Park (2003)

[47] Bryant (2002)

[48] Higgins & Davies (1996); and Bryant (2002)

[49] Birdlife Australia – Latham's Snipe

[50] DPIPWE (2020)

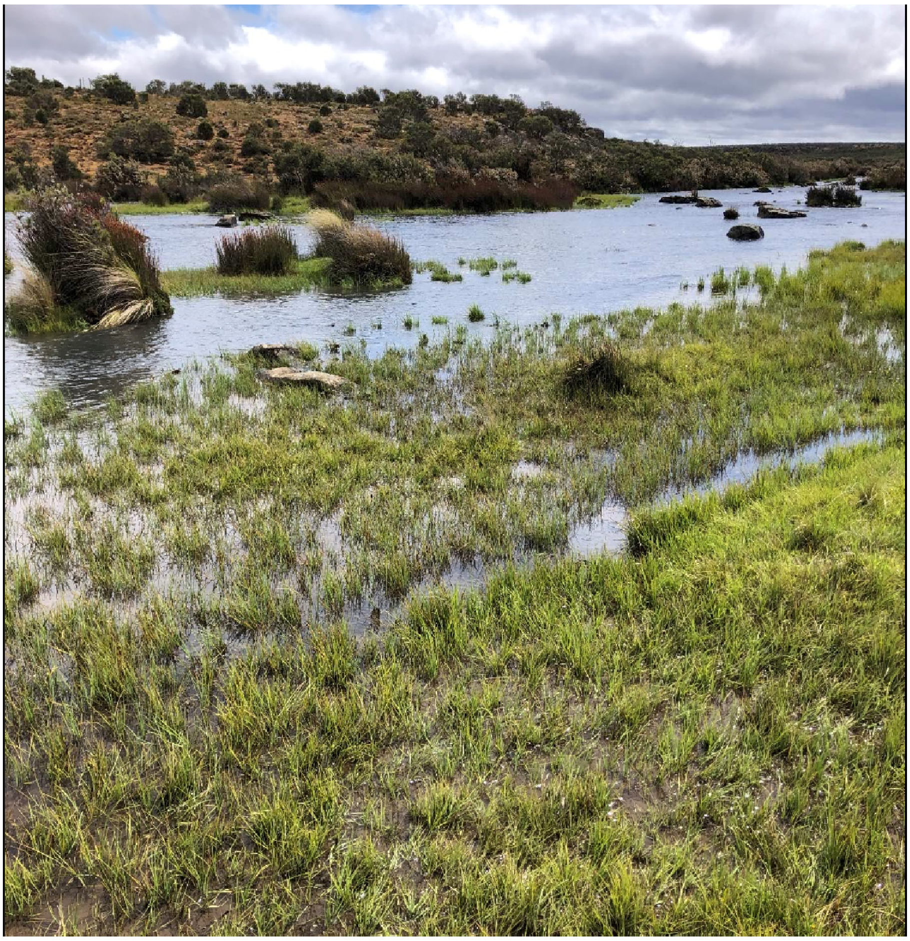

Plate 6: Habitat used by Latham's snipe (and potentially suitable for curlew sandpiper/eastern curlew) on the Shannon river on St Patricks Plains (January 2020).

12.3.3 Australasian Bittern (*Botaurus poiciloptilus*)

Australasian bitterns are listed under the EPBCA as endangered. Australasian bitterns are a highly cryptic species, utilising wetlands and lakes with a dense cover of vegetation[51] (Plate 7). Plate 7 represents habitat from which an Australasia bittern was recorded in 2020. Whilst once common on Tasmania's north/east coasts, the numbers of Australasian bitterns in the state during the last two decades have declined significantly in both their range and numbers[52] (Appendix 5). Habitat loss, wetland alteration such as draining and extended periods of dryness are major threats to this species.

[51] Commonwealth Listing Advice on *Botaurus poiciloptilus* (Australasian Bittern), Threatened Species Scientific Committee (2011)

[52] Threatened Species Section (2019) Australasian Bittern.

Plate 7: Habitat utilised by Australasian bitterns at Lagoon of Islands (January 2020).

12.3.4 Red-capped plover (*Charadrius ruficapillus*) and Double-banded plover (*Charadrius bicinctus*)[53]

These species are both listed as marine under the EPBCA with the double-banded plover also listed as migratory. The red-capped and double-banded plovers are generally found along the north and east coastlines of Tasmania inhabiting the littoral zone of estuaries, fresh and saline terrestrial wetlands, grasslands, saltmarshes and grazed open pastures (plate 8) (Appendix 5).

Red-capped plovers typically nest on sandy open beaches or stony areas near waterways, with the double-banded plover breeding along inland riverbeds or coastal lagoons and estuaries in New Zealand alone. Due to their exposed nesting behaviour both species are at risk of habitat degradation from sea level rise, storms and coastal development/engineering and are constantly under threat from human recreation and domestic animals such as dogs and cats.

[53] Griffin (2013); Birdlife (2018) Beach-nesting Birds Management; SPRAT (2020) *Charadrius bicinctus*

Plate 8. Potential moderately suitable habitat for the double-banded plover and low suitability for the red-capped plover along the pasture and grasslands surrounding Allwrights Lagoons.

12.3.5 Azure Kingfisher (*Ceyx azureus* subsp. *diemenensis)*[54]

The Tasmanian azure kingfisher is a subspecies of *Ceyx azureus* and is listed as endangered both under the EPBCA and TSPA. It is found along rivers in the south, west, north and northwest of Tasmania with outlying occurrences in the northeast, east, centre and Bass Strait islands. This species occurs in the forested margins of major river systems where it perches on branches overhanging rivers waiting for prey items such as small fish, insects and freshwater crayfish to come down the river (Plate 9).

The azure kingfisher nests in holes along the top of riverbanks or nearby and is therefore susceptible to clearing and modification of river-side vegetation. There is thought to be fewer than 250 mature individuals left in Tasmania with the overall distribution of Tasmania's azure kingfisher reflecting the higher rainfalls in the west and north-west regions of Tasmania (Appendix 5).

[54] Threatened species link (2020) *Ceyx azureus* subsp.*diemenensis;* Department of the Environment (2020) *Ceyx azureus* subsp.*diemenensis*

Plate 9. Suboptimal but potential habitat of the Azure kingfisher along the Shannon River

Table 14. Summary of each threatened migratory and wetland bird's temporal and spatial distribution

Species	Breeding site	Flyway[55]	Migratory route stop-over	Non-breeding grounds	Tasmanian populations
Eastern Curlew[56] (***Numenius madagascariensis***)	North-eastern China and Russia	East Asian-Australasian flyway [57] Passing through the Yellow Sea/Bohai Sea region	Coastal areas of China, Japan, Korea and Borneo. Sometimes small numbers visit New Zealand	Widespread in coastal regions of north-eastern and southern Australia	Bass Strait islands, northeast and north west coast and south east coast
Curlew Sandpiper[58] (***Calidris ferruginea***)	Russian Arctic, Chukchi Peninsula and the New Siberian Islands	East Asian-Australasian flyway and East Atlantic Flyway	Passage migrant though Europe, North Africa, Kazakhstan, west and south-central Siberia, China, Japan, Taiwan, Philippines and Papua New Guinea	Australian Coastal and inland regions. South of southern Mauritania, Ethiopia and the Nile valley in Madagascar. The Arabian Peninsula, Pakistan, India, south China, Indonesia and Malaysia.	King Island and Furneaux Group. South-east and north-west Tasmania.
Latham's snipe [59] (***Gallinago hardwickii***)	Northern Japan	East Asian-Australasian Flyway	North New Guinea, Philippines and Taiwan	North east and south east Australia	Coastal and Inland Tasmania and Islands.
Australasian Bittern[60],[61] (***Botaurus poiciloptilus***)	South-eastern Australia, with a small population in the south west, New Zealand and New Caledonia during summer	N/A	N/A	Likely undertakes seasonal population shifts within its breeding range associated with the wet and dry seasons with winter influxes along the coasts of Australia and New Zealand	East and north coast. Flinders and King Island and some east-central lakes.
Red capped plover[62]	Australia, typically along	N/A	N/A	Australia, typically along	East and South-east coastlines as

[55] A 'flyway' is and identifiable migratory route that include specific flight routes, stopover sites, and destinations. Flyways are used by numerous species to travel between breeding and non-breeding areas. For example, The East Asian-Australasian flyway is a route travelled by migratory birds travelling between their breeding sites in the northern hemisphere and feeding sites in the southern hemisphere.

[56] Threatened Species Section (2020) *Numenius madagascariensis* – Eastern Curlew

[57] EAAFP (2020) – Saving a migratory icon: Recovering the Far Eastern Curlew.

[58] Bamford et al (2008).

[59] SWIFT (2020) - Latham's Snipe Project

[60] SWIFT (2020) – Australasian Bittern

[61] Heron Conservation (2020) – Australasian Bittern

Species	Breeding site	Flyway[55]	Migratory route stop-over	Non-breeding grounds	Tasmanian populations
(*Charadrius ruficapillus*)	the south-eastern coastlines.			the south-eastern coastlines. Also, a vagrant species to southern New Zealand, last seen in NZ in 1981.	well as populations along the north coast
Double banded plover[63] **(*Charadrius bicinctus*)**	New Zealand	Utilised the East Asian-Australian Flyway	Vagrant to Norfolk Island Lord Howe, FIJI, Vanuatu and New Caledonia.	Australia, common in eastern and southern Australia, occasionally found in northern Queensland and Western Australia.	Common on King island and Perkins island with significant populations along the Derwent River, Pittwater Reserve and Cape Portland-Musselroe Bay.
Tasmanian Azure kingfisher (*Ceyx azureus* subsp. *diemenensis*)	Tasmania	N/A	N/A	Tasmania	West and north coast large rivers. Former range contraction. There is no migration between Tasmanian and mainland populations.

12.4 Suitability of habitat

The Shannon River and seven small lagoons exist within the study area that provide various levels of potential suitable habitat for wetland birds. The lagoons are known as; Wihareja lagoon, Allwrights lagoons (east, west and middle), Ripplecreek lagoon and two smaller unnamed lagoons. Within the 5 km buffer are three larger lagoons and lakes; Penstock Lagoon, the Lagoon of Islands and Arthurs Lake. Figure 17 to Figure 22**.** illustrate the distribution of the habitats within the site and the 5 km buffer.

The habitats within the project area are on private property and are not as accessible to the public as areas outside the project area such as Penstock Lagoon, Arthurs Lake and Lagoon of Island. This is likely why the public areas have more recorded observations than private properties.

Habitat assessments of the site indicate that potentially suitable habitat exists for all species within the study area and surrounding buffer. Habitat mapping[64] and ground surveys suggest low and moderate quality potential habitat occurs for the curlew sandpiper and Eastern curlew within the study area (Figure 17) but that no habitat constitutes high habitat suitability for these species.

[62] Griffin (2013) Red-capped plover. *In* Miskelly, C.M. (ed.) *New Zealand Birds Online*. www.nzbirdsonline.org.nz

[63] SPRAT (2020) *Charadrius bicinctus* – Double-banded plover

[64] Tasmanian Natural Values Atlas, nvr_1_31-Oct-2019

All the wetlands, rivers, and wet grassy areas within the study area constitute potential high and moderately suitable habitat for Latham's snipe (Figure 18). The study area contains only low quality wetland habitats for the Australasian bittern. These wetlands are potentially suitable for foraging but not nesting due to the highly disturbed nature of the dams and waterbodies and their lack of dense vegetation. However, some suitable habitat exists within the 5 km buffered area, notably the Lagoon of Islands and small sections of Penstock Lagoon (Figure 19). Suboptimal habitat is present for the double banded and red-capped plover and the azure kingfisher (Figure 20 and Figure 21).

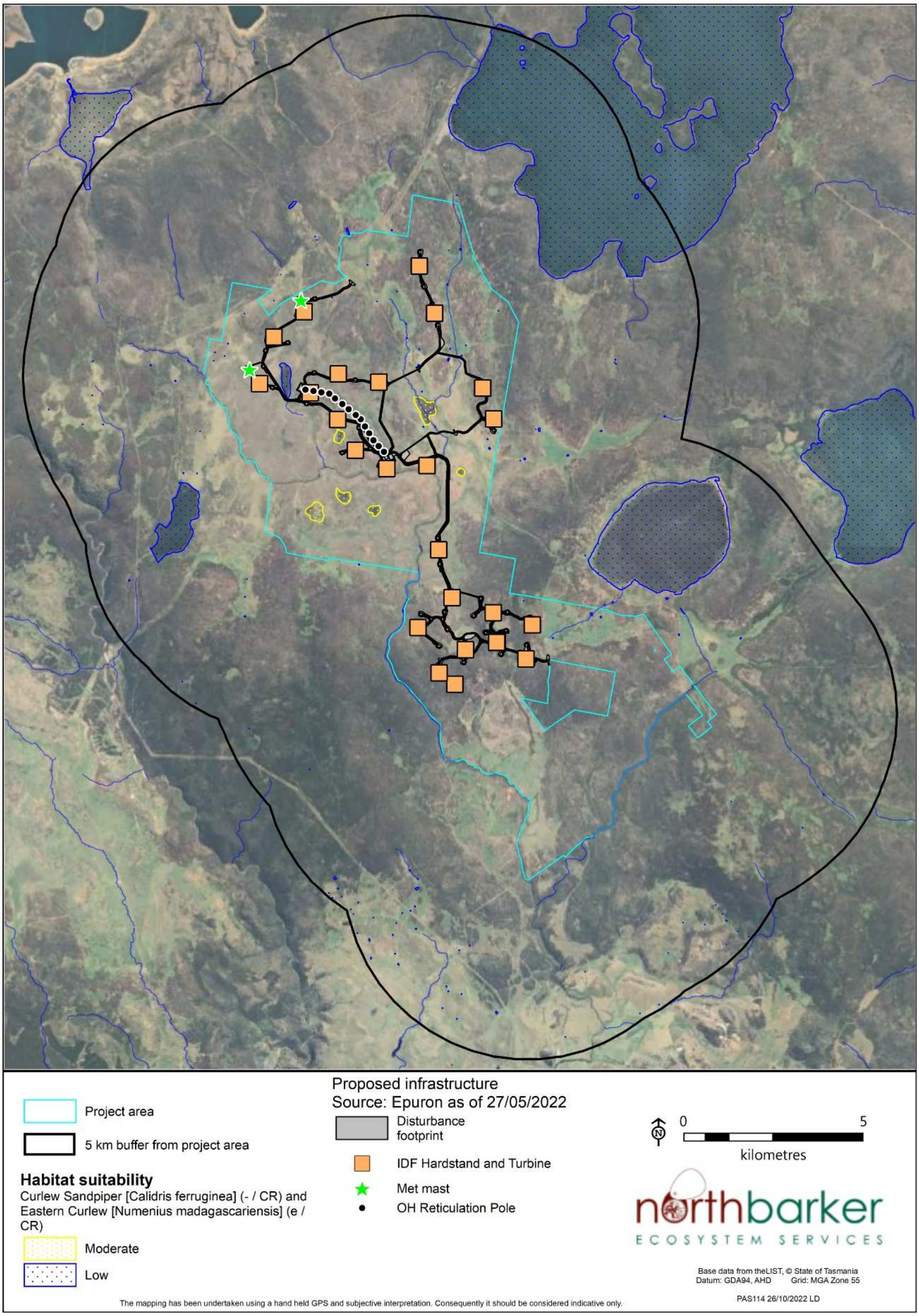

Figure 17. Habitat suitability of curlew sandpiper and eastern curlew within 5 km of the study area – no records are known from within 5 km for these two species

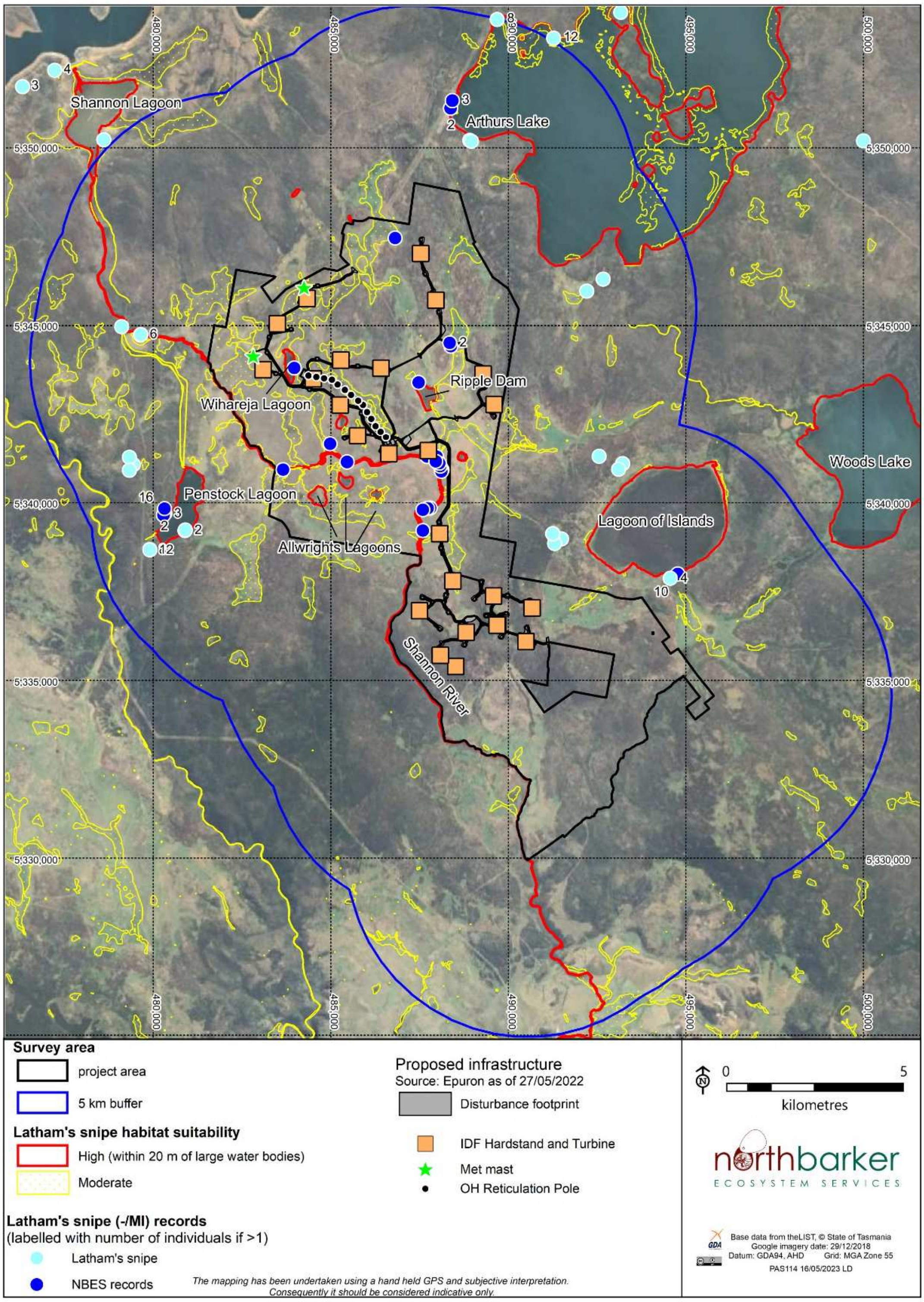

Figure 18. Habitat suitability and records of Latham's Snipe within 5 km of the study area

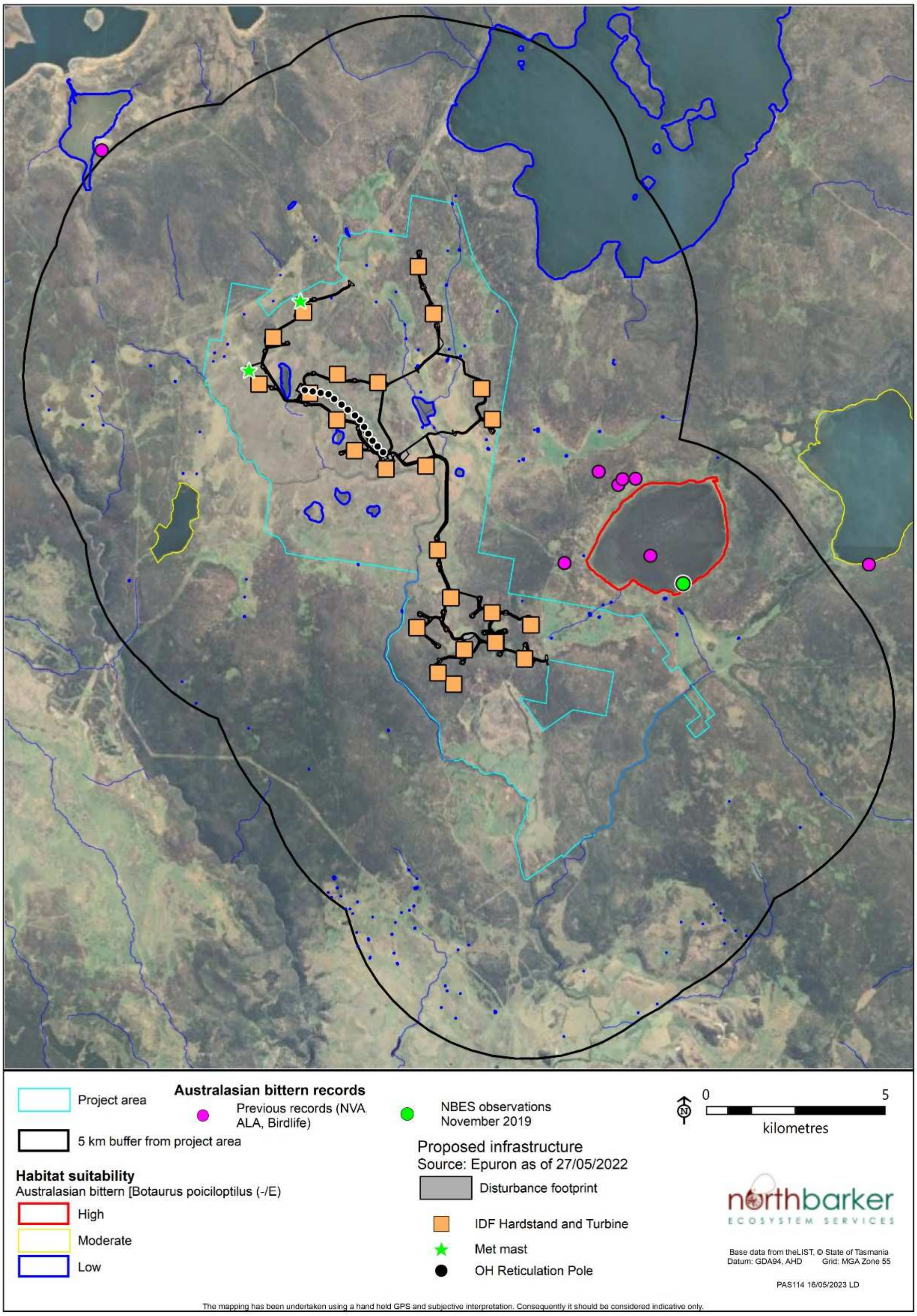

Figure 19. Habitat suitability and records of the Australasian bittern within 5 km of the study area

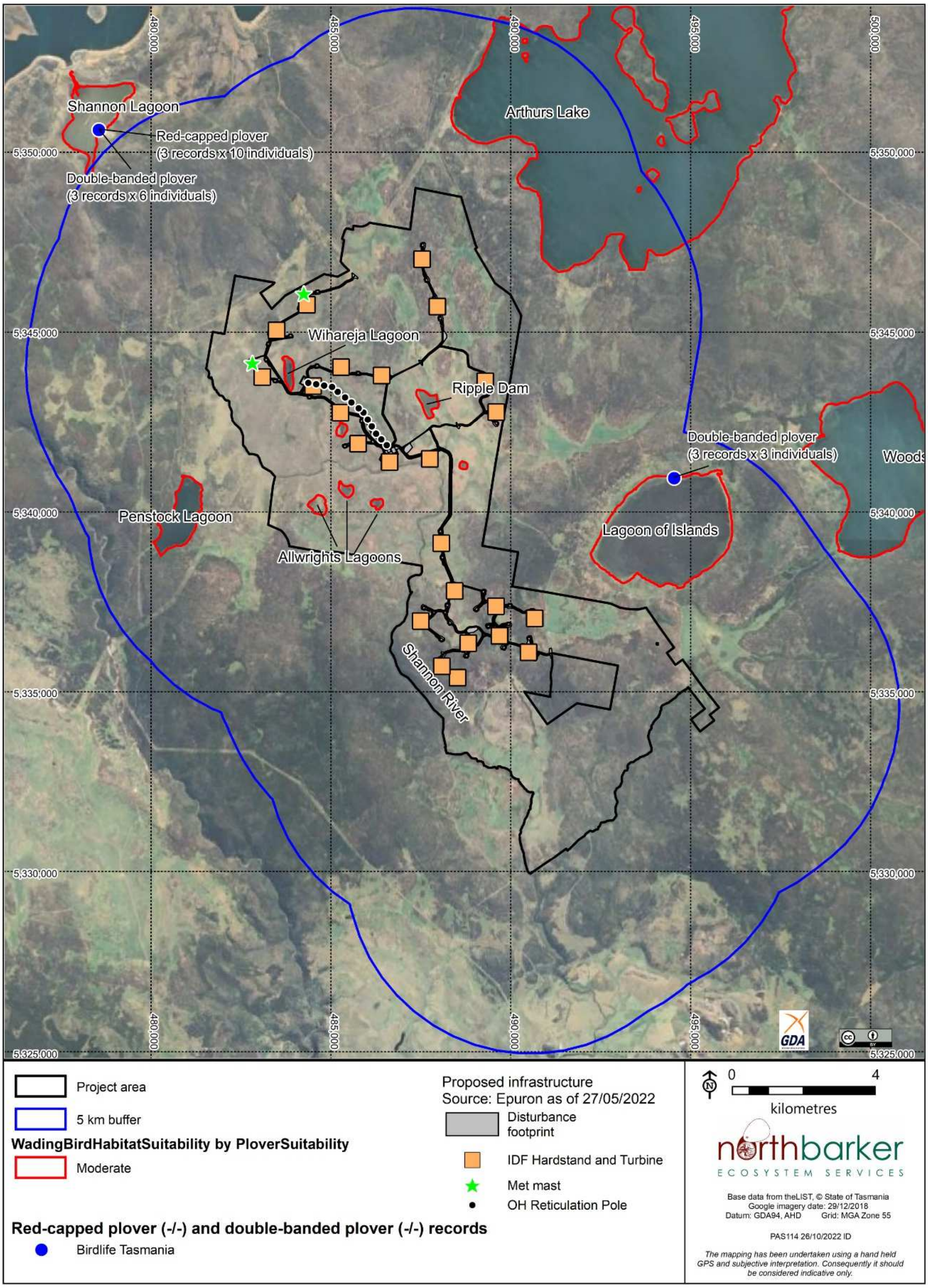

Figure 20. Habitat suitability and records of the double banded plover and red capped plover within 5 km of the study area

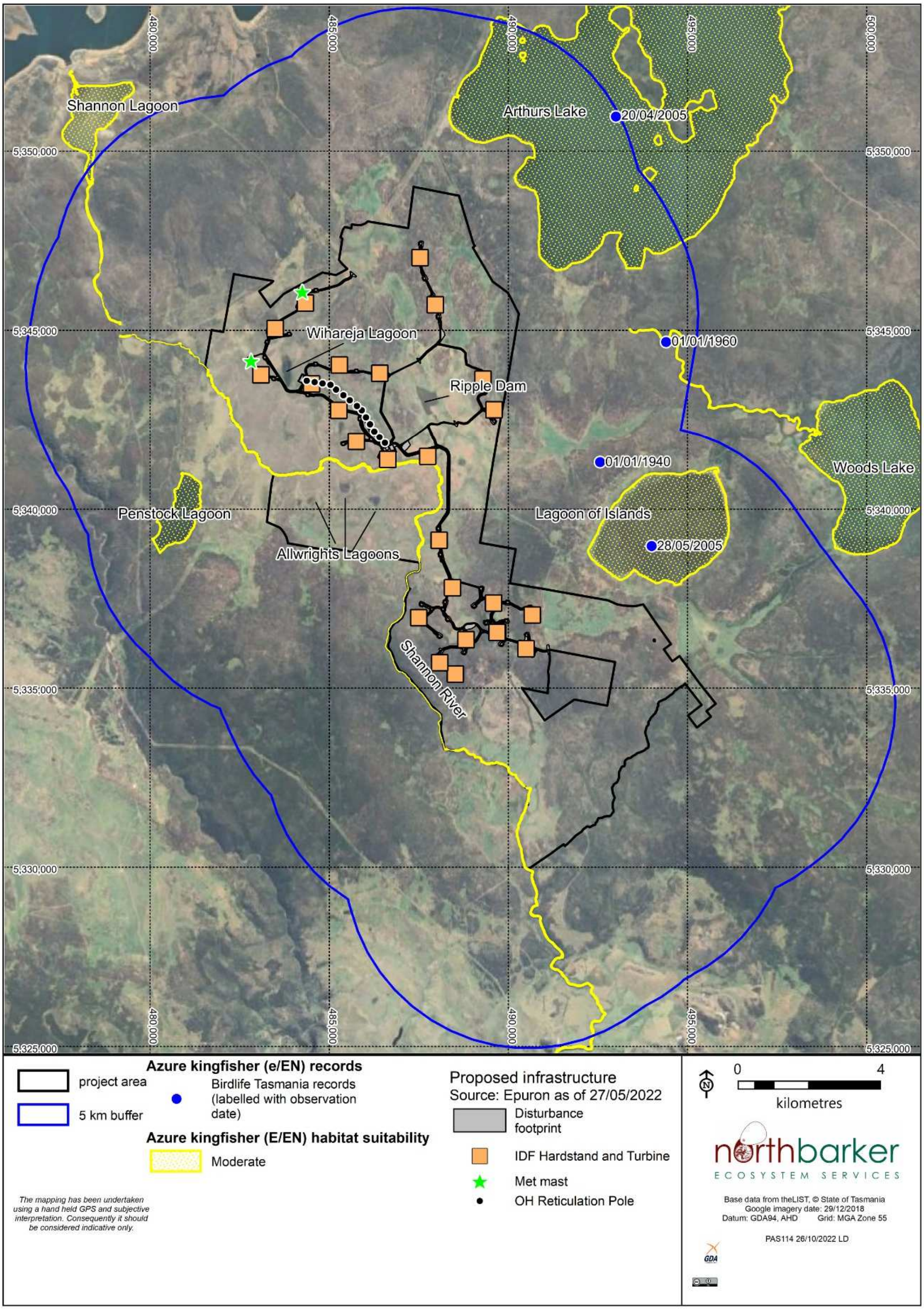

Figure 21. The distribution of records and habitat of the Azure kingfisher within 5 km of the site

12.5 Results – Field surveys

Field surveys of the lagoons and rivers within the study area by NBES ecologists as well as previously recorded sightings (NVA, ALA, Birdlife etc..) revealed that only one species, the Latham's snipe has been seen within the actual proposed study area (Figure 18) with records of Australasian bitterns, double-banded plover and azure kingfisher occurring within 5 km of the proposed study area. The survey counts over the three seasons listed in Table 15 indicate that there were no observations of curlew sandpipers or eastern curlew, nor have they been recorded within 5 km of the proposed site. Latham's snipe was observed on 41 occasions and the bittern on one occasion by NBES ecologists as well as an audio recording on another occasion.

Curlew sandpipers and eastern curlew

Neither curlew sandpipers nor eastern curlew species were observed during the three seasonal field surveys (Table 15). Eastern curlews have never been recorded within the site or central highlands or previously recorded within 25+ km of the study area[65]. Only two curlew sandpiper sightings have ever been recorded in the highlands, both sightings were near the Great Lakes in the late 70's. No curlew sandpiper has been recorded in the central highlands since.

Latham's snipe

Latham's snipe were observed within the study area in small numbers around the Shannon River over the warmer months (spring and summer), with the occasional flocks of 10 - 16 at individual wetlands within the site or at all three lagoons/lakes adjacent to the site (Penstock Lagoon, Lagoon of Islands and Arthurs Lake). This constitutes approximately 15 - 24 birds regularly utilising the site (Table 15). The autumn survey reported no Latham's snipe within the proposed study area, with two Latham's snipes recorded together within the 5 km buffer at Penstock Lagoon. Based on previous record dates the snipe has typically migrated from the site by early march.

Australasian Bittern

The Lagoon of Islands has had previous sightings of the Australasian bittern from other documented sources prior to 1983 and one recorded sighting in 2005 by Birdlife Tasmania. NBES ecologists sighted one and recorded audio of another Australasian Bittern during the spring surveys but no Australasian Bitterns were seen or heard during the summer and autumn (Figure 19 and Table 15). Any habitat that supports this species in Tasmania should be considered to be important simply due to the rarity of the bird and the consequent stochastic risks that are associated with rarity.

Double-banded plover and red-capped plover

Neither red-capped nor double-banded plover species were observed during the three seasonal field surveys (Table 15). Only 3 sightings of the red-capped plovers and 6 sightings of double-banded plovers have ever been recorded within the 5 km buffer and 10 km radius, these sightings were all recorded during a single survey in 1984 (Figure 20). The site does not exhibit important habitat for these species.

Azure kingfisher

The Azure kingfisher was not observed during the three seasons of field surveys (Table 15). This species has been observed within 10 km of the proposed site and buffer in previous years, with the last known sightings occurring in April and May of 2005 where three

[65] Previous records refer to those held by the Tasmanian Natural Values Atlas, the Atlas of Living Australia, and the databases of Birdata, eBird and Birdlife Tasmania.

observations were made, two at the Lagoon of Islands and one near Arthurs Lake (Figure 21). The kingfisher is an obvious bird and so the infrequency of records suggest that it may be an occasional visitor to the area or else there is a very small resident population in the vicinity.

Table 15. Survey results over three seasons

Species	Status TSPA / EPBCA[66]	Recorded individuals[67] (within study area and 5 km buffer)		
		November 2019	January 2020	April 2020
Calidris ferruginea Curlew Sandpiper	- / Critically Endangered	0	0	0
Numenius madagascariensis Eastern Curlew	endangered / Critically Endangered	0	0	0
Gallinago hardwickii Latham's snipe	- / Endangered	15	24	2
Botaurus poiciloptilus Australasian bittern	- / Endangered	2	0	0
Charadrius bicinctus Double-banded plover	- / Endangered	0	0	0
Charadrius ruficapillus Red-capped plover	- / Marine	0	0	0
Alcedo azureus diemenensis Azure kingfisher	endangered / Endangered	0	0	0

12.6 Importance of the site for migratory and wetland birds

The importance of the site for threatened birds listed in this report can be gauged through the results of habitat assessments and past and present bird surveys.

Important habitats in Australia for migratory shorebirds under the EPBCA include those recognised as nationally or internationally important[68]. Accordingly, an area[69] is considered **internationally** important if it regularly supports[70]

- At least 1 % of the individuals in a population of one species or subspecies of waterbird
- A total abundance of at least 20,000 waterbirds

[66] Tasmanian TSPA and Commonwealth EPBCA

[67] Estimates derived only from field surveys conducted by North Barker Ecosystem Services

[68] Commonwealth of Australia (2017)

[69] "A shorebird area is defined as: the geographic area that had been used by the same group of shorebirds over the main non-breeding period" Commonwealth of Australia (2017)

[70] 'Support' is defined differently depending on whether the habitat is considered permanent or ephemeral. For permanent wetlands, 'support' is defined as: migratory shorebirds that are recorded during surveys and/or known to have occurred within the area during the previous five years. For ephemeral wetlands, 'support' is defined as: habitat that migratory shorebirds have ever been recorded in, and where that habitat has not been lost permanently due to previous actions." Commonwealth of Australia (2017)

And a **nationally** important area is one that regularly supports

- At least 0.1 % of the flyway population of a single migratory shorebird species
- At least 2,000 migratory shorebirds
- At least 15 migratory shorebird species

Table 16. Importance of study area to migratory shorebirds based on thresholds[71]

Species	Status TSPA / EPBCA[72]	Population Estimate [73]	1% threshold [74]	0.1% threshold [75]	Study area as important habitat
Calidris ferruginea Curlew Sandpiper	- / Critically Endangered	90 000	900	90	No
Numenius madagascariensis Eastern Curlew	endangered / Critically Endangered	35 000	350	35	No
Gallinago hardwickii Latham's snipe*	- / Migratory	30 000	300	30	Likely[76]
Charadrius bicinctus Double-banded plover	-/ Migratory	19,000	190	19	No

* "Latham's snipe does not commonly aggregate in large flocks or use the same habitats as many other migratory shorebird species. Consequently, habitat important to Latham's snipe is not regularly identified using the process outlined above and different criteria are therefore necessary. Threshold criteria are still considered the best way to identify important sites in the absence of data sufficient for more rigorous methods. Important habitat for Latham's snipe is described as areas that have previously been identified as internationally important for the species, or areas that support at least 18 individuals of the species".[77]

[71] This table only includes migratory birds.

[72] Tasmanian TSPA and Commonwealth *EPBCA*

[73] Hansen et al. (2016) - East Asian-Australasian Flyway Population Estimates.

[74] 1 % of the flyway population. If an area holds 1 % of the flyway population, then it is considered an internationally important population in Australia

[75] 0.1 % of the flyway population. If an area holds 0.1 % of the flyway population, then it is considered an nationally important population in Australia

[76] Results suggest the area supports the threshold of ≥18 individuals.

[77] Hansen et al. (2016)

Curlew sandpiper, eastern curlew and double-banded plover

These species were not recorded in spring, summer nor autumn surveys of potentially suitable habitat on and adjacent to the site (Table 15). Table 16 indicates the numbers that represent important thresholds for the number of birds recorded at a site regularly. Consequently the site is not attributed a national or international level of importance for these species.

Latham's snipe

Latham snipe are treated differently with thresholds, as they tend to not aggregate in large flocks and use a wider range of habitats[78]. This makes the definition of a distinct important site challenging[79]. Important habitat for this species is recommended to be:

- *An area that has previously been identified as internationally important for the species, OR*
- *An area that supports at least 18 individuals.*

DAWE recommends that important sites for Latham's snipe should be based upon their abundance within an area rather than the extent of suitable habitat, stating that a 'site' where at least 18 individuals have been consistently recorded over the previous five or more years, is considered important for this species[80]. Identifying a 'site' is therefore important and can be defined for Latham's snipe as "all the contiguous and non-contiguous areas of habitat between which there is a frequent interchange of birds"[81]. The study area along with the 5 km buffer has been defined as the 'site' for Latham's snipe to reduce the risk of breaking down the landscape into individual lakes and wetlands, which will hamper the determination of the site's importance.

Sightings in the general area of Latham's snipe have not been consistent over the previous five years, which is probably a reflection of a lack of purpose-designed comprehensive survey rather than the lack of the area's importance to Latham snipe. This lack of previous data is typical of the datasets used to designate significant shorebird areas but will improve with the ongoing surveys conducted as part of this project.

The results and previous recommendations[82] suggest that the study area is likely to be important for the Latham's snipe.

[78] Commonwealth of Australia (2017)

[79] EPBC Act Policy Statement 3.21, Commonwealth of Australia (2017)

[80] EPBC Act Policy Statement 3.21, Commonwealth of Australia (2017)

[81] Clements *et al.* 2010

[82] Naarding (1983)

12.7 Impact

The risk of collision for the migratory and wetland birds is very low and is described for each species below. The physical disturbance to potential habitat is restricted to Latham's mod and that is described below for each element of the wind farm.

Curlew sandpiper and eastern curlew

The distribution records show the birds tend to keep to the east and north coasts of the state[83]. Consequently, there is a very low probability that curlew sandpiper and eastern curlew would pass through the study area during migration, and should they do so it would be in very low numbers. Although even infrequent utilisation would place birds at risk of collisions with turbines, the lack of any records in the area suggests that the risk is very low and the impact is unlikely to have a significant impact upon either species.

Latham's snipe

The results and previous recommendations[84] suggest that the study area may be important for the Latham's snipe. It is likely that Latham snipe will continue to utilise the study area and surrounding landscape, particularly the wetlands, rivers, and wet grasslands. While they may be at risk of collision, the impact level is likely to be low for this species due to the relatively short time that they are flying when they arrive, their natural ground level foraging behaviour, their short low flights between habitats[85] and low evidence of turbine collisions in the past. The lack of turbines in the areas where Latham's snipe frequents, such as the Shannon River and the wetland margins mapped as a 20 m zone around the wetlands (Figure 18), minimises the risk and aids in protecting the birds and their habitat. Based on mapping of potential foraging habitat which is predominantly away from where most birds were recorded in wet grasslands the impact of infrastructure is as indicated in Table 17. The indirect impacts referred to are those of assembly and working areas that will recover after construction. Table 17 indicates the areas of habitat to be impacted and the total area in the study area inclusive of the impact as well as the area of habitat exclusively in the 5 km buffer.

Table 17. The area (ha) of the impact of infrastructure on the potential habitat of *Latham's snipe*

Infrastructure	Access Rd	Access buffer	Turbine stands	Turbine buffer	Met masks	Total impact	Total Study Area	Total 5km buffer
Moderate quality habitat	6.49	2.55	0.02	0.02	0.10	9.19	1139	1487
High quality habitat	0	0	0	0	0	0	76	130

Australasian bittern

Australasian bittern undertake flights of considerable distance when exploring for suitable habitat. Flight paths potentially cross the study area between the Lagoon of Islands and

[83] Threatened Species Section (2020) *Numenius madagascariensis* – Eastern Curlew

[84] Naarding (1983)

[85] High aerial display flights occur during the breeding season in Japan and thus this behaviour is unlikely to occur on site.

Penstock lagoon. Additionally, we would expect birds from further afield (e.g., Lake Crescent) to pass through the site when undertaking longer distance flights between habitats. However, such exploratory flights are likely to be relatively rare, particularly given the low numbers of this species in Tasmania. These factors and the absence of quality habitat in the wind farm site suggest that although the risk of collision with turbines is present the potential frequency would be very low[86]. The continuing restoration of the Lagoon of Islands could provide better quality habitat in the future. If the restoration increases carrying capacity the number of this species could grow; producing a higher risk of collision due to more birds.

Double-banded plover and red-capped plover

These species both tend to aggregate around the coastlines of Tasmania with only a small number ever being recorded inland. Whilst there is a small chance that both of these species could fly over the site, they are more likely to fly along the coastlines. Small numbers of both these species have been recorded in the past around the central highland lakes so it is possible that small numbers of both these species, particular the double-banded plover may briefly stop over on the open pastures and grasslands for short periods of time however the populations of these species would be at a low risk from collision due to their low frequency of occurrence on the site and ground feeding behaviour.

Azure kingfisher

Suitable habitat for this species on site is very limited, with little vegetation cover offering perches around the site's rivers, lagoons and lakes. It is very unlikely this species occurs on site and if it were to occur its behaviour would likely restrict it to the minimal vegetation that does exist around the waterways. The probability of this species being impacted by the turbines is very low.

12.8 Mitigation

The direct physical impacts of construction in migratory and wetland birds habitats are not able to be avoided. The area of direct physical impact has been minimised, in part through a reduction in number of turbines and attendant roads, as a result of minimising eagle collision risk.

Temporary impacts such as ground disturbance associated with works areas will recover over time. The rate of recovery will be enhanced by replacement of original landform to enhance regeneration. Where rehabilitation through replanting and weed control is required it will be identified and scoped in an environmental management plan.

13 THREATENED AVIFAUNA

13.1 Context

The wind farm proposal requires consideration of the potential risk of impacts to habitat and collision with turbines for threatened bird species listed on the TSPA and the EPBCA as MNES. The list of species below was derived from the EPBCA Protected Matters Search tool and Birdlife Tasmania records.

- Tasmanian masked owl, *Tyto novaehollandiae castanops* (endangered / Vulnerable)
- Swift parrot, *Lathamus discolor* (endangered / Critically Endangered)
- Orange bellied parrot, Neophema chrysogaster (endangered / Critically Endangered)
- Grey goshawk Accipiter novaehollandiae (endangered/-)

[86] Threatened Species Scientific Committee – *Botaurus poiciloptilus*

13.1.1 Tasmanian Masked Owl (*Tyto novaehollandiae castanops*)

Tasmanian masked owls are listed under the EPBCA as vulnerable and as endangered under Tasmania's TSPA. Loss of nesting habitat in the form of hollow-bearing trees is a major threat to the species along with secondary poisoning[87]. Masked owls are a nocturnal species that favour the edges of dry forests, utilising nearby hollows $\geq$15 cm in diameter for nesting. Their core foraging habitat includes mature native forests and woodlands typically below 600 m altitude as well as mosaics of both native vegetation and agricultural patches (Appendix 5).

13.1.2 Swift Parrot (*Lathamus discolour*)

Swift parrots are listed as critically endangered and marine (due to migration across Bass Strait) under the EPBCA, with the species also being listed as endangered under Tasmania's TSPA. Loss of foraging habitat, nesting trees and collision with "invisible" infrastructure are major threats to the species[88]. Swift parrots are a migratory species, undertaking annual flights from Tasmania to the mainland of Australia. When in Tasmania they are semi-nomadic, crossing much of the state to coincide with the erratic and patchy flowering patterns of their preferred food plants, *Eucalyptus globulus* and *Eucalyptus ovata* (Appendix 5). Neither is found on the site.

13.1.3 Grey Goshawk (*Accipiter novaehollandiae*)[89]

This species is listed as endangered under TSPA due to low densities and limited breeding distribution in the state, however it is not listed under the EPBCA. Unlike their mainland counterparts, all Tasmanian grey goshawks are white. The core habitat for this species is generally below 600 m with high priority nesting habitat occurring along watercourses in old growth wet forests (Appendix 5). This species inhabits large tracts of wet and swamp forest, particularly patches with closed canopies above an open understorey and with dense stands of prey habitat nearby. Mature blackwood (*Acacia melanoxylon*) is reported as the preferred nesting tree for this species but it is known to nest in eucalyptus, Acacia dealbata and myrtle (pers. Obs. P. Barker).

Recent unpublished research (David Young pers. comm.) indicates the abundance of birds is higher than previously estimated and the habitat more varied and widespread than previously reported. However nests have not been recorded above 450 m asl which is considerably lower than the turbine locations which are generally above 700 m.

Just 1 goshawk was observed during the surveys at observation sites and from extensive incidental observation when traversing the site. This bird is likely to have been a dispersing juvenile which may be observed from time to time traversing habitat outside of the breeding range.

13.1.4 Orange-Bellied Parrot (*Neophema chrysogaster*)[90]

The Orange-bellied parrot is listed as Critically Endangered under the EPBCA and endangered under the TSPA. Numbers of this species have declined significantly since the late 1800's, with 2020 being a historic year for this species with their population exceeding 100 individuals for the first time in a decade[91]. This species only occurs in coastal south-west Tasmania and spends winter in coastal Victoria and South Australia. The current breeding range is a narrow strip of south-west Tasmania near Melaleuca. Nesting takes place in hollows of eucalyptus

[87] Threatened Species Section (2019) *Tyto novaehollandiae castanops* Tasmanian Masked Owl

[88] Threatened Species Section (2019) *Lathamus discolor* – Swift Parrot

[89] Threatened species link (2020) *Accipiter novaehollandiae* - Grey Goshawk

[90] Threatened Species Section (2020) *Neophema chrysogaster* - Orange-bellied Parrot

[91] Birdlife (2020) Orange-bellied Parrot Recovery Program.

trees. After breeding, birds return to mainland Australia via the west coast of Tasmania (incl. King Island).

The orange-bellied parrot is not considered further in this report due to the records in the vicinity being very old (dating back to the 20s), extremely disjunct from the core habitat and quite likely to be erroneous with sightings often mistaken for the similar blue winged parrot, which has been recorded regularly on site.

13.2 Methods

13.2.1 Masked owl habitat:

. To assess the potential areas and quality of habitat for this species within the Project Site, remote assessment was undertaken using the FPA 'mature habitat availability map'[92] of the Project Site and a ~5 km buffer area, which uses mature canopy cover as a proxy for determining potential hollow-bearing tree density. Significant habitat was considered to be all areas of dry forest with at least 20% mature eucalypt crown cover. Patches with >40% crown cover of mature eucalypts were classified as having high potential to support suitable hollows and patches with between 20% and 40% cover as medium potential to support suitable hollows.

The habitat identified within the study area was then ground-truthed. This involved inspection of representative areas of the mapped habitat types within the impact areas and where owl surveys were undertaken to verify the maturity class and classification of habitat suitability. Due to the size of the project site and number of potential habitat areas, this ground truthing focused on confirmation of mapping classification, rather than full ground coverage, as further outlined in NBES (2023a). No counts of individual hollow-bearing trees were undertaken during these surveys.

Subsequently the area of mature habitat with high, medium or low cover of mature trees was intersected with the infrastructure layout to indicate the area of disturbance to potential nesting habitat (Appendix 7, Plate 10).

Inspection of trees for suitable hollows will be undertaken prior to construction as part of a micrositing process for all natural values and other site constraints.

13.2.2 Masked owl call-back and call recording surveys

Survey guidelines have been developed for Australia's threatened birds listed under the EPBCA[93]. Although the Tasmanian masked owl is not included in these guidelines, its Species Profile and Threats Database (SPRAT) profile[94] suggests that the recommendations for the northern Australian subspecies, *T. n. kimberli*, may be relevant. Guidelines for the northern subspecies suggest that broadcast (playback) surveys are effective in suitable habitat, especially in the lead up to breeding season. Whilst the Department of Climate Change Energy the Environment and Water (DCCEEW)[95] guidelines suggest that playback surveys are most likely to be effective in the lead up to the breeding season[96], in Tasmania there is no peak survey period recommended[97], with the entire year considered viable for surveying[98]. This is

[92] Forest Practices Authority (2016)
[93] DEWHA (2010)
[94] Department of the Environment (2020)
[95] Now known as DAWE
[96] DEWHA (2010)
[97] Threatened Species Section (2020) – Tyto novaehollandiae castanops Tasmanian Masked Owl
[98] Threatened Species Section (2020) – Tyto novaehollandiae castanops Tasmanian Masked Owl

supported by the complete lack of seasonality in the effectiveness of the playback method in Tasmania[99], which is consistent with the limited effect of season on owl calling or response to playback noted in other Australian large forest owls, including other subspecies of *T. novaehollandiae*[100].

Nine twenty-minute masked owl call-back surveys were conducted after sundown across the site (five locations were chosen based on their habitat for these surveys). Each twenty-minute survey was broken down into five-minute blocks. For the first five minutes a selection of masked owl recorded noises (screech's and chattering) was broadcast on a Boom 3 bluetooth speaker. Recorded noises were played intermittently to replicate a more natural regularity of calls. The second five minutes of the survey consisted of silent listening in complete darkness for wild owl calls and watching for silhouettes (if moonlight permitted). For the third five minutes of the survey, the recorded sounds were then played again as per the first five minutes, with the additional use of a spotlight to observe any owls that may be perched in nearby trees. The final five minutes of the survey was completed in silence and dark, again listening out for wild owl sounds and looking for any owl silhouettes.

In conjunction with the call-back surveys, audio surveys were conducted. Three automatic audio-recording devices (One Song Meter SM3 Bioacoustics Recorder and two SM4 Bioacoustics Recorders) were placed on site during summer/start of autumn for 115 nights (SM3 between the 20th of December 2019 and the 14th of April 2020) and 90 nights (both SM4s between the 15th of January 2020 and the 14th of April 2020) (Figure 22). For a further 11 nights between the 20th of April 2020 and 1st of May 2020 the same three song meters were placed in three new locations (Figure 22). The devices were placed in a stand of dry forest with mature habitat elements, which can be high quality potential habitat[101], but in this case lacked suitable hollow-bearing trees. The audio-recording device was programmed to record from half an hour before sunset and continue for two and half hours after sunset, and then to record again for half an hour each side of sunrise[102] – i.e., a total of four hours of recording were completed each night. The recordings were wave files using a 48 kHz sampling rate to cover the maximum frequency of the call of the Tasmanian masked owl.

The audio-recordings from the survey were analysed using Song Scope software and a call recogniser compiled from calls collected across Tasmania[103]. This process identifies sounds that correspond to the call signature of the Tasmanian masked owl only.

With the combination of these survey methods, plus the masked owl habitat surveys the total survey effort of the Tasmanian masked owl was in excess of 85 hours over 4 days and 126 nights, which well exceeds the DCCEEW recommended survey effort (8 hours over 4 days).

13.2.3 Other threatened avifauna

Surveys for swift parrot, orange bellied parrot and grey goshawk were undertaken broadly across the site over four seasons as described below in Section 13.2.

13.3 Results

Tasmanian Masked Owl

The site is above 600 m altitude and so is not within the core range of the Tasmanian masked owl which covers all habitat below 600 m. Significant habitat is dry forests within the core

[99] Todd (2012)

[100] Kavanagh and Peake (1993); Debus (1995); Kavanagh (1997)

[101] FPA (2016)

[102] Todd (2012)

[103] Todd (2012)

range[104]. The ground surveys confirmed the presence of suitable habitat, with scattered hollow-bearing trees found to be consistent with mapping of mature forest.

Masked owls have been recorded within the study area prior to 1981 but no records have been lodged to the Natural Values Atlas since then. There are very few records of the birds in the vicinity.

The habitat adjacent to the site is known to be utilised by masked owls based on recent observations by NBES ecologists (Figure 22). However, no masked owls have been recorded on the site. Figure 22 illustrates the distribution of mature forest and the location of observations and audio surveys. Table 18 lists the areas (ha) of each maturity class reflecting an estimate of potential hollow bearing tree density of forest within 1 km of the study area. .

Masked owls have been heard and sighted on adjacent land near the Lagoon of Islands by NBES ecologists. Song meters have also picked up masked owl screeches. It is unlikely that the site could support more than a few pairs given the large home range (>1000 ha in core habitat) and the suboptimal or non-core habitat that is present. The expanses of non-forest may also be limiting to a perch hunter due to the lack of perches.

Given that any masked owls that occur on the site are not within core range nor are they in significant habitat, as defined by the Forest Practices Authority (2016), we deem them to not be part of an important population. The notion of an important population is not clearly defined. The notion however implies an important population is not the whole of the population.

The EPBC significant impact criteria define an 'important population' as a population that is necessary for a species' long-term survival and recovery. This MAY include populations identified as such in recovery plans, and/or that are:

• key source populations either for breeding or dispersal

• populations that are necessary for maintaining genetic diversity, and/or

• populations that are near the limit of the species range.

While the EPBC definition MAY include populations that are near the limit of ranges, those near the limit but continuous with main population are less likely to afford the greater population advantages such as a source populations or for gene flow due to the existing connectivity. Populations near the ecological limits of ranges such as at the altitudinal limits are more likely to be sinks rather than important source populations necessary for the species long term survival. In this case St Patricks Plains is outside of core range and at the altitudinal limit of the forest habitat on the site but not necessarily the ecological limit of the Masked owl. In fact suitable habitat in Eucalyptus forests occurs up to more than 1200 m asl in *Eucalytpus dalrympleana, E. delegatensis and E. coccifera* forests. For example, old growth forest at 1100 m on the slopes of Macs and Walled Mountain in the Cradle Mountain National Park. The windfarm is between 800 and 1000 m asl.

In Tasmania the most productive habitat with highest densities of Masked owl referred to above as core and significant habitat is clearly the preferred lowland habitat. The habitat outside of the core range above 600 m supports lower densities of Masked owl (FPA 2017). In comparison, the St Patricks Plains population is not as important because it is less likely to be a source of birds to maintain the broader range and thus be necessary for the species long term survival.

[104] FPA (2016)

Figure 22 illustrates the extent of mature forest types in the disturbance footprint.

Table 18: Summary of potential hollow-bearing tree density (FPA 2016) as determined from forest maturity (H class) within the study site

Potential hollow-bearing tree density	Area within the study area (% of study area)	Area within the disturbance footprint (% of total area)
High (>40% crown cover is mature eucalypts)	281 ha (2.8%)	12.31 ha (0.12%)
Medium (20-40% crown cover is mature eucalypts)	821 ha (8.2%)	15.86 ha (< 0.16%)
Low (<20% crown cover is mature eucalypts)	2120 ha (21.11%)	132 ha (1.31%)
Negligible (none to patchy mature eucalypt cover)	6821 ha (67.9%)	320 ha (3.19%)
Total area	**10 043 ha**	**481.22 ha**

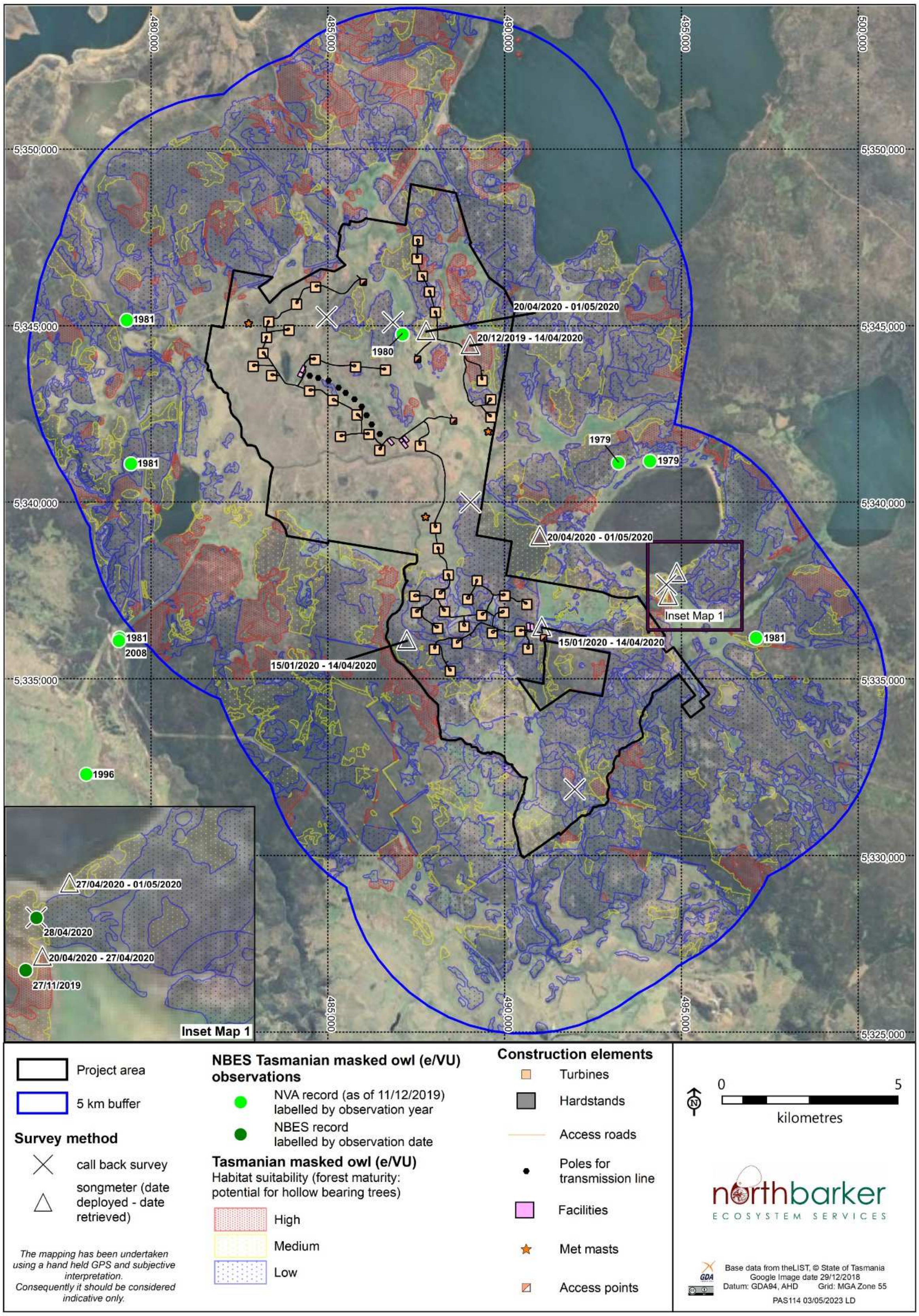

Figure 22. The extent of mature forest, observation records and audio survey locations for the Masked owl

Plate 10: Suitable hollow for Tasmanian masked owls on Saint Patrick's Plains (January 2020)

Swift parrots

No swift parrots were recorded during the three seasonal surveys by NBES ecologists within the study area. There are very few records of the bird in the vicinity. They were not recorded during the 15-minute surveys conducted hourly by NBES ecologists over 10 days during each season as part of the two years of eagle utilisation surveys, nor as an incidental sighting. There have only ever been four sightings of swift parrots within the site, these sightings were all prior to 1988. The parrot is highly unlikely to utilise the site habitually.

Whilst the site contains scattered hollow-bearing mature eucalyptus trees the study area is not considered as providing important nesting habitat for swift parrots. The absence of any optimal foraging habitat that could sustain breeding means that hollows suitable for nesting would not be utilised.

It is possible that swift parrots may occasionally occur within the study area during their migration, but such flight paths will be unpredictable due to a dearth of focal points (food plants) and the nomadic nature of the species. Swift parrots rely heavily on mass nectar producing trees such as *E. globulus* and *E. ovata* for feeding on during the breeding season and generally fly from canopy to canopy and not at turbine height when foraging. This species is not known to utilise this site and although smaller marginal post season dispersal habitat is present on the site it is highly unlikely this species will be affected significantly by this wind farm proposal.

Grey goshawk

One grey goshawk was observed on site. No nests of this species have previously been recorded above 450 asl (David Young Pers. Comm.) which is lower than the study area. The single observation is likely to have been a foraging adult or a dispersing juvenile traversing non breeding habitat. Given the rarity of sightings of this species on site, the risk to this species population from the wind farm is extremely low with no risk of disturbing nests

13.4 Impact and mitigation

Tasmanian masked owls

Some Owl species have suffered very high levels of collision mortality elsewhere in the world on wind farms where the number of birds is high, and the turbine sweep is low enough to engage the low flying habit[105]. However, many owls occur at much higher density than the Tasmanian masked owl for which a breeding pair occupies a large territory resulting in a low density of birds even across core habitat. The St Patricks Plains Wind Farm site is a high-altitude habitat that is outside of the core range of the owl. As such it is described as suboptimal habitat.

At St Patricks Plains there is likely to be a relatively low risk of collision due to the low density of birds in suboptimal habitat in large home ranges. Risk is further reduced by the short amount of time on the wing as a result of their predominantly perch based foraging strategy or prey being taken from and among trees, which places them below the sweep of turbines around forests and forest edges.

Table 19 indicates the area of mature forest that will be converted for infrastructure. About 96 % of high, 98% of medium maturity classes are not being impacted and 94% of forest with low and 95% of negligible cover of mature trees are not being impacted.

A high proportion of disturbance is attributed to the construction disturbance buffer in Table 19. This buffer is not necessarily utilised during construction and much may remain undisturbed. The other elements in the construction footprint including IDF radial clearing and overhead reticulation will have vegetation maintained at a low height but will not be converted to non native vegetation.

Nesting tree surveys will be undertaken in the nesting period (October – March) after approval and prior to finalising the design of the wind farm to determine if nest trees are present in the vicinity of the infrastructure. Micrositing will be undertaken once the final layout is determined after taking account of other relevant requirements such as geotechnical feasibility. If a nest tree is located within 100 m from the centre of a proposed turbine stand or 50 m from other infrastructure, it is recommended that localised micrositing is applied to maintain the buffer.

[105] Moorman, C.E. Grodsky, S.R. and Rupp, S. (2019) Renewable energy and wildlife conservation 280 pp, JHU Press.

Table 19. The area of forest by maturity class (ha) that will be converted or disturbed to allow construction

Mature forest class	Construction footprint (ha) Vegetation Clearance				Operational footprint (ha) Vegetation Conversion						Total impact	Extent on site (ha)	% Remaining after total impact
	Construction Disturbance Buffer	IDF Radial Clearing	OH Retic.	Validation Mast	BESS	Hardstands	IDF Hardstand	Road	UG Retic.	All other elements			
High	4.88	5.58				1.36	0.07	0.31	0.10	0.00	12.31	280.91	95.62%
Medium	7.40	4.71				2.58	0.06	0.85	0.25	0.00	15.86	820.88	98.07%
Low	60.34	48.07	0.00	0.00	0.00	14.33	0.36	7.40	2.18	0.00	132.68	2120	93.77%
Negligible	214.30	28.79	3.94	0.32	0.30	24.99	0.39	32.30	9.23	5.81	320.37	6821.78	95.30%
Total	**286.93**	**87.15**	**3.94**	**0.32**	**0.30**	**43.26**	**0.89**	**40.85**	**11.77**	**5.81**	**481.22**	**10043.32**	

The potential impact on the Masked Owl is not likely to be a significant one evidenced by the following criteria. The potential impact is unlikely to;

- Lead to a long-term decrease in the size of an important population. This is supported by the very low fraction of potential nesting habitat affected and the low probability of collision.
- Reduce the area of occupancy of an important population because the entire area is likely to continue to be occupied in the context that Masked owls are rare in the landscape with large ranges with potentially just 1 to a few ranges within the site.
- Lead to a long-term decrease in the size of an important population because it would not result in repeated losses of breeding birds to the extent that they are eliminated from the site and the site is not reoccupied by dispersing juveniles from elsewhere.
- Fragment an existing important population into two or more populations because the central highlands habitat/population is extensive and not able to be fragmented by even the unlikely loss of habitat from the site.
- Adversely affect habitat critical to the survival of a species because the habitat has not been determined to be critical habitat and is not likely to be such given that it is not in the productive core range.
- Disrupt the breeding cycle of an important population because at worst if a nest tree were disturbed during a breeding cycle it would affect the individual with a negligible impact on the population.
- Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline because the disturbed habitat is a very small fraction of potential nesting and foraging habitat in the vicinity.
- Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat because there are no invasive species that are known to be harmful to the Masked owl.
- Introduce disease that may cause the species to decline because there are no diseases that threatened the Masked owl.
- Interfere with the recovery of the species because the area of habitat in the central highlands is very extensive and impacts to it and to the Masked owl are negligible in comparison.

Swift parrot

The St Patricks Plains site is well outside of this species core foraging and breeding range and this is reflected in the extremely rare records in the vicinity. The extreme infrequency of flights on the site in itself demonstrates a near zero probability of a collision with a turbine blade.

The foraging habitat is suboptimal and because of this it is unlikely to support breeding and hence the impacts to swift parrots as a result of collision/habitat loss from the St Patricks Plains wind farm infrastructure is considered negligible.

Grey goshawk

The St Patricks Plains site is well above the known breeding range of this species which is limited to below 450 m asl for nesting. This is reflected in the extremely rare records in the vicinity. The extreme infrequency of flights on the site in itself demonstrates a near zero probability of a collision with a turbine blade.

The habitat is suboptimal and because of this it is unlikely to support more than an occasional bird dispersing from a territory lower in the landscape. The impacts to grey goshawks as a result of collision/habitat loss from the St Patricks Plains wind farm infrastructure is considered negligible.

14 GENERAL BIRD UTILISATION SURVEYS

Birds other than eagles and targeted threatened and migratory birds were specifically targeted to gain an understanding of the site's avifauna and the seasonal frequency and occurrence of species across the site.

14.1 Methods

General bird surveys were conducted at the same randomly selected sites as the eagle flight path observations. All birds that were heard or seen were recorded hourly during each of the observation shifts in 2019/2020. The number of shifts ranged between 4 and 2 per day; the latter reduction in shifts was due to shared vehicle constraints imposed to manage the risk posed by Covid 19. Birds of some sort of significance (e.g., threatened, migrant, vagrant or considered rare) that were flushed on arrival at a site and birds that were incidentally observed when moving between sites were also recorded.

All data were added to an excel spread sheet and analysed and summarised through pivot tables. The species data are summarised and reported by shift.

14.2 Results

The stratified distribution of the observation sites in forest and non-forest and the association of incidental observations with specific habitats provides a very strong coverage of the site.

14.2.1 Characterisation of the site's avifauna

The general bird surveys returned 67 species of which six are exotic including the common black bird, common starling, European greenfinch, European goldfinch, Eurasian skylark and the laughing kookaburra. A list of species recorded in each season is in Table 20. The native species are typical of each of the habitats that are present on the site including forest and woodland species, grassland and wetland species. The data indicate the percentage of total observations represented by each species. It is clear that the easily observed ravens and currawong are an important part of the avifauna. Including them, 51 % of observations are made up of the eight most frequent species while the least frequent 23 species make up just 2 % of observations.

Eleven species were observed just once or twice including diurnal raptors (other than the wedge-tailed eagle); nankeen kestrel, collared sparrowhawk white goshawk and peregrine falcon. Swamp harrier and the brown goshawk were observed just six times.

The lowest number of observations was in autumn; nearly double the autumn count were recorded in winter. This result would be unlikely over the long term. More than 60 % of observations were made in spring and summer (Table 20).

14.2.2 Species richness

Species richness ranged between 20 and 42 species at sites observed during all seasons. The combined number of species observations per shift has been standardised for the number of shifts in Table 21. The seasonal and standardised data reveal that sites 17a and b, 21a and b and 23 regularly returned more observations than all other sites. The same sites have the highest species richness of all sites. These sites are all in the southern part of the study area and each has extensive forest adjacent. Species that forage and roost in and near the edge of forest have a low likelihood to be at risk of collision with turbines because they remain lower than the swept path of the rotor most of the time.

Sites 4, 7 and 10 returned the fewest records and had the lowest species richness of all sites. These sites all occur in open heath and grassland and are further from forest than any other sites. The most frequent birds in grasslands and heath lands are the smaller birds including

Eurasian skylark and striated fieldwrens while the larger woodland birds such as magpie and currawong occurred less frequently in the heaths and grassland. The smaller birds do not typically fly at the height of turbine blades and so collision risk is low.

The larger birds may occasionally fly at the height of the rotor swept area (RSA) but typically fly below that height. Ravens are likely to be at the highest risk due to their frequency of occurrence and relatively common flight height within the RSA. They are however ground foragers and so flight time is relatively low. Other far less frequent birds, such as white-faced heron, also fly in the RSA on occasion but again the ground foraging behaviour of many birds reduces the time spent at that height to a small fraction of the time they are on the site. The rarest birds including the diurnal raptors excluding eagles may also fly within the RSA but in this case their extremely low frequency presents a very low risk of collision and certainly a very low impact at the whole of species level.

14.3 Impact and mitigation

The general bird data were not collected to measure collision risk based on frequency of flight paths interacting with turbines. The potential for collision with turbines is therefore reflected in the species flight and foraging behaviour. The RSA is between 70 and 230 m above the ground. The minority (20 of 67) of the species listed in Table 22 would regularly fly more than 70 m above the ground. However, the majority of their time is not spent flying above 70 m. The flights above 70 m are more likely to be relatively infrequent transitory flights in comparison to the more frequent foraging flights closer to the ground and time spent on the ground. As such interaction with the turbine blades is likely to be a relatively rare event.

The potential impacts other than collision are displacement due to disturbance and loss or degradation of habitat from turbines and associated infrastructure. An analysis of the impact on vegetation types in Table 22 demonstrates that the impact on these bird habitats is a very small percentage of the area present on the wind farm site. The loss of habitat at this scale is negligible and so a change in the number of birds due to habitat loss may not be measurable. A reduction in species richness is highly unlikely due to the maintenance of more than 98 % of the habitat area and no significant loss of a single habitat to which any of the species is restricted. As such the diversity and number of birds is likely to be sustained by the continued productivity of the site.

The direct impact on each habitat will be restricted to the footprint of the infrastructure and this is reported in Table 23. No additional targeted mitigation actions will be applied in these habitats other than rehabilitation of areas disturbed incidentally during construction. These will be limited by identifying the limits of works by marking them in the field before construction begins.

Table 20. List of species and number of records recorded in each season

Bird Species	Winter 2019	Spring 2019	Summer 2020	Autumn 2020	Grand Total	% of observations
Total count	**891**	**1142**	**1080**	**477**	**3590**	**100.00**
Forest raven	116	99	124	87	426	11.87
Black currawong	100	102	101	47	350	9.75
Australian magpie	68	68	69	53	258	7.19
Yellow wattlebird	65	57	64	23	209	5.82
Yellow-throated honeyeater	54	43	46	29	172	4.79
Grey butcherbird	29	31	59	30	149	4.15
Green rosella	26	32	60	24	142	3.96
Laughing kookaburra	41	31	54	8	134	3.73
Noisy miner	30	32	45	27	134	3.73
Welcome swallow	3	53	54		110	3.06
Striated pardalote	28	65	13	3	109	3.04
Flame robin	41	38	5	24	108	3.01
Spotted pardalote	23	39	21	10	93	2.59
Striated fieldwren	25	30	22	9	86	2.40
Black-faced cuckoo-shrike	0	33	46	4	83	2.31
Australasian pipit	9	41	28	4	82	2.28
Superb fairy wren	24	28	24	6	82	2.28
Brown thornbill	29	26	13	2	70	1.95
European starling	22	26	13	6	67	1.87
Black-headed honeyeater	25	18	10	7	60	1.67
Eurasian Skylark	8	34	16	0	58	1.62
Brown falcon	9	17	20	8	54	1.50

Bird Species	Winter 2019	Spring 2019	Summer 2020	Autumn 2020	Grand Total	% of observations
Tree martin	1	20	18	0	39	1.09
Grey currawong	4	10	14	10	38	1.06
Grey strike-thrush	5	19	7	2	33	0.92
Eastern rosella	5	6	11	9	31	0.86
Masked lapwing	4	15	7	4	30	0.84
Dusky robin	12	10	4	3	29	0.81
European goldfinch	3	12	13	1	29	0.81
Dusky woodswallow	1	7	17	0	25	0.70
Little wattlebird	1	3	15	2	21	0.58
Crescent honeyeater	15	2	3	0	20	0.56
Australian shellduck	16	2	0	1	19	0.53
Pallid cuckoo	0	17	1	1	19	0.53
Tasmanian thornbill	3	2	10	4	19	0.53
Grey fantail	1	16	1	0	18	0.50
Yellow-tailed black cockatoo	3	5	5	3	16	0.45
Bronzewing	1	6	5	3	15	0.42
White-faced heron	3	6	1	3	13	0.36
Yellow-rumped thornbill	4	0	6	3	13	0.36
Blue-winged parrot	0	6	5	0	11	0.31
Tasmanian native hen	1	4	6	0	11	0.31
Australian wood duck	5	3	1	1	10	0.28
Black swan	4	2	1	3	10	0.28
Tasmanian scrubwren	3	2	5	0	10	0.28
Horsefield's bronze cuckoo	3	5	0	1	9	0.25

Bird Species	Winter 2019	Spring 2019	Summer 2020	Autumn 2020	Grand Total	% of observations
Scarlet robin	3	1	4	1	9	0.25
Brown goshawk	2	3	1	0	6	0.17
Pacific black duck	4	0	0	2	6	0.17
Silvereye	2	1	1	2	6	0.17
Swamp harrier	3	2	1	0	6	0.17
Fantailed cuckoo	0	4	1	0	5	0.14
New Holland honeyeater	1	0	2	0	3	0.08
Olive whistler	0	1	0	2	3	0.08
Tasmanian scrubtit	0	1	2	0	3	0.08
Nankeen kestrel	0	1	1	1	3	0.08
Banded plover	0	1	0	1	2	0.06
Common Blackbird	0	2	0		2	0.06
Great cormorant	1	0	0	1	2	0.06
European greenfinch	0	1	1	0	2	0.06
Golden whistler	0	0	2	0	2	0.06
Collared sparrowhawk	0	0	0	1	1	0.03
Pink robin	0	0	0	1	1	0.03
Peregrine falcon	1	0	0	0	1	0.03
Strong-billed honeyeater	0	1	0	0	1	0.03
White goshawk	1	0	0	0	1	0.03
White-fronted chat	0	0	1	0	1	0.03

Table 21. The seasonal count of birds recorded at each site and species richness

	Sites[106]																					
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**10**	**11**	**12**	**13**	**15**	**16**	**17**	**18**	**19**	**21**	**23**	**24**	**25**	**Total**	**% obs**
Winter 2019	57	28	36	21	50	56	-	33	11	9	49	6	41	29	104	44	46	80	71	69	51	891	24.8
Spring 2019	71	55	51	31	55	57	9	33	28	62	52	29	56	50	111	55	55	90	106	86	-	1142	31.8
Summer 2020	60	42	42	23	43	61	20	59	21	47	32	63	39	73	83	53	71	85	83	80	-	1080	30.1
Autumn 2020	20	27	25	12	46	32	10	17	10	22	13	11	19	23	37	24	-	36	38	25	30	477	13.3
Grand Total	**208**	**152**	**154**	**87**	**194**	**206**	**39**	**142**	**70**	**140**	**146**	**109**	**155**	**175**	**335**	**176**	**172**	**291**	**298**	**260**	**81**	**3590**	**100**
% 0bs	**5.8**	**4.2**	**4.3**	**2.4**	**5.4**	**5.7**	**1.1**	**4.0**	**1.9**	**3.9**	**4.1**	**3.0**	**4.3**	**4.9**	**9.3**	**4.9**	**4.8**	**8.1**	**8.3**	**7.2**	**2.3**	**100.0**	
Species richness	**29**	**35**	**31**	**25**	**32**	**30**	**17**	**31**	**20**	**26**	**34**	**24**	**32**	**29**	**41**	**29**	**24**	**39**	**42**	**36**	**20**		

[106] See Figure 3 for an overview of site locations

Table 22. The estimated frequency of birds flying in the rotor swept area of turbines (RSA) as r – regular, o – occasional, ra – rare and n – never

Species	above 70 m	Species	above 70 m
Forest raven	r	European greenfinch	o
Black currawong	r	Dusky robin	ra
Welcome swallow	r	Flame robin	ra
European starling	r	Brown thornbill	ra
Eurasian Skylark	r	Tasmanian thornbill	ra
Brown falcon	r	Golden whistler	ra
Grey currawong	r	White-fronted chat	ra
Australian shellduck	r	Yellow wattlebird	ra
Yellow-tailed black cockatoo	r	Yellow-throated honeyeater	ra
White-faced heron	r	Grey butcherbird	ra
Brown goshawk	r	Laughing kookaburra	ra
Swamp harrier	r	Noisy miner	ra
Great cormorant	r	Striated pardalote	ra
Nankeen kestrel	r	Spotted pardalote	ra
Collared sparrowhawk	r	Black-headed honeyeater	ra
Peregrine falcon	r	Grey strike-thrush	ra
White goshawk	r	Eastern rosella	ra
Masked lapwing	r	Crescent honeyeater	ra
Black swan	r	Scarlet robin	ra
Pacific black duck	r	New Holland honeyeater	ra
Dusky woodswallow	o	Strong-billed honeyeater	ra
Australian magpie	o	Striated fieldwren	n
Green rosella	o	Superb fairy wren	n
Black-faced cuckoo-shrike	o	Little wattlebird	n

Species	above 70 m	Species	above 70 m
Banded plover	o	Grey fantail	n
Australasian pipit	o	Yellow-rumped thornbill	n
Tree martin	o	Tasmanian nativehen	n
European goldfinch	o	Tasmanian scrubwren	n
Pallid cuckoo	o	Silvereye	n
Bronzewing	o	Olive whistler	n
Blue-winged parrot	o	Tasmanian scrubtit	n
Australian wood duck	o	Common Blackbird	n
Horsefield's bronze cuckoo	o	Pink robin	n
Fantailed cuckoo	o	**Total – f = 20, o = 15, r = 20, n=12**	

Table 23. The vegetation/habitat types areas (ha) in project area and the area of each impacted and % impacted

Community/ unit	Extent in project area (ha)	Total loss in impact area (ha)	Total loss % of extent in project area
(AHF) Fresh water aquatic herbland	70.1	0.17	0.17
(AHL) Lacustrine herbland	2.13	0	0
(DAD) *Eucalyptus amygdalina* forest and woodland on dolerite	344.95	0	0
(DDE) *Eucalyptus delegatensis* dry forest and woodland	1071.21	14.36	1.68
(DDP) *Eucalyptus dalrympleana - Eucalyptus pauciflora* forest and woodland	530.92	14.92	3.76
(DGW) *Eucalyptus gunnii* woodland	21.69	0.41	1.7
(DPD) *Eucalyptus pauciflora* forest and woodland on dolerite	1687.22	13.56	0.87
(DRO) *Eucalyptus rodwayi* forest and woodland	134.3	0.66	0.48
(GPH) Highland Poa grassland	2703.93	69.05	2.21
(MGH) Highland grassy sedgeland	1082.77	11.7	0.87
(MRR) Restionaceae rushland	3.28	0.6	13.1
(NLE) *Leptospermum* forest	6.69	0.26	0.7
Total areas and %	7659.19	160.7	2.09

15 CONCLUSION AND RECOMMENDATIONS

The EPA's PSGs have been fulfilled by the studies undertaken over the past 2 years. The findings suggest that significant impacts to MNES will be avoided, or minimised and residual impacts offset.

The ability to significantly reduce the potential for impacts to the wedge-tailed eagle reflects the evolving use of successful mitigation technology worldwide and so is a significant improvement on the management of impacts to eagles relative to existing wind farms which did not have this technology available when built.

Nevertheless, further and ongoing mitigation actions should be required to minimise the impact. These actions include the implementation of:

1. The layout and operation of the turbines as described in this assessment.
2. Curtailment technology.
3. Collision monitoring and adaptive management.
    a. Data to be used to track performance against management triggers and offset requirements.
    b. Implementation of a BACI experiment to measure the effectiveness of visual deterrence through painting one blade on each turbine black
4. Carcass management to decrease the availability of carrion.
5. Minimise loss of potential masked owl tree hollows and/or potential hollows by micro siting turbine location to the extent practicable.
6. Avoid impacts to any masked owl nest trees by determining if tree hollows within impact areas are utilised and avoid by micrositing.
7. Rehabilitate terrestrial habitat of Latham's snipe where temporarily impacted by construction activity adjacent to infrastructure.
8. Minimise impact on all avian fauna foraging and prey habitats by minimising the impact on all native vegetation as per the attendant flora and fauna habitat assessment.
    - Concentrate direct and irreversible clearance within areas of non-native vegetation (cleared land).
    - Apply a micro-siting approach (with the aid of an ecologist) to infrastructure within avian habitat to make adjustments to the footprint by selecting localised areas with relatively less impact.
    - Clearly demarcate the permitted impact area both *in situ* and on construction plans and specify on all contractor agreements that works, vehicles and materials must be confined within the designated impact areas.
    - Incorporate a revegetation plan into the post-construction requirements, covering areas where clearance of native vegetation is not required to be a permanent loss, for example, temporary access routes and temporary construction disturbance footprints.

Offsets

The offset strategy aims to compensate for any eagles killed by turbines by protecting eagles elsewhere. The proposal is to contribute funds and where appropriate actions to:

1. Contribute to mapping high risk powerlines and improving the visibility of high risk powerlines to reduce the risk of fatal collisions - retrofitting to create "bird safe power lines".
2. Contribute to a State-wide educational campaign and communications strategy to reduce the use of pindone rabbit baits and other rodenticide baits.
3. Contribute to a State-wide educational campaign and communications strategy to reduce the number of eagles that are shot.
4. Encouragement of hunters to use no lead bullets
5. Protect viable nests elsewhere that are vulnerable to disturbance to ensure nests are utilised to produce an increase in nest productivity.
6. Contribution to research to devise strategies to improve breeding success everywhere and decrease eagle mortality in and around wind farms.
7. Fund eagle rehabilitation at refugia, and
8. Contribute to the implementation of a recovery plan.

These actions could be funded by contributing a sum of money to a suitable organisation tasked with implementing outcomes based projects.

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ST PATRICKS PLAINS

Wedge-tailed eagle nest search

and assessment

Central Highlands

Tasmania

Prepared by

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Introduction

Wind farms may have an impact on bird populations through direct (collision) or indirect (habitat disturbance and other disturbance effects) impacts. Wildspot Consulting was commissioned by Epuron Projects Pty Ltd to conduct Wedge-tailed eagle nest surveys at a proposed wind farm site in the Central Highlands of Tasmania. These assessments are considered a necessary part of a wind farm development proposal by the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBCA)* and the Tasmanian *Threatened Species Protection Act 1995 (TSPA).* The Tasmanian Wedge-tailed eagle (*Aquila audax fleayi)* is listed as Endangered under the TSPA. The scope of work included searching suitable habitat for unknown nests and checking the status of existing nests listed on the *Natural Values Atlas* (*NVA*).

The Objectives

The objectives of the nest search survey is, to provide an overview of where eagles might breed each season. Wedge-tailed eagles in the central Highlands will often have multiple nests within their territory and any of these nests have the potential to be used in any given breeding season. At the commencement of a breeding season, which nest they will choose to use within the territory cannot be predicted. This can present problems when considering wind turbine placement, this is the primary reason, all eagle nests, actively used or not, are considered equally important. The knowledge of where all nest are located is vital in order to minimise impact on this threatened species. Knowing where existing nests are will provide, buffered limitation guidelines for the design and placement of wind farm infrastructure. At this time a one kilometre non disturbance buffer is considered adequate at a nest site.

Nest habitat mapping will provide an insight into possible future nest locations should current nests sites change significantly.

Site description

The proposed site is located in the Central Highlands of Tasmania and covers an area from ST Patricks Plains through Bakers Tier to Blackburn Creek in the south, a north to south distance of approximately 20 kilometres. The site primarily spans six different privately owned properties, with the Highland Lakes Road dissecting the site from north to south. The landscape varies considerably ranging from wide open treeless plain to remnant optimum nesting habitat. Extensive areas in the southern part of the site have either been selectively logged or clear felled and turned into plantation forestry. The total area of interest for this survey was 8,871 hectares which included the proposed turbine placement zones and a buffer of one kilometre beyond each turbine placement zone.

There are six wedge-tailed eagle nests listed on the *NVA* which occur in the search area.

Figure 1. ST Patricks Plains study area

Methodology

The field survey was undertaken over a five day period in late February 2019. Potential nesting habitat was identified utilising current aerial imagery and desktop GIS analysis. GIS limitations prevent accurate identification of optimum habitat therefore any clearly defined old growth forested areas were picked to be included into the ground search. These areas were categorised into three different habitat types during the ground search.

Wedge-tailed eagles are known to prefer certain site conditions to establish nests, they include slopes which provide shelter from prevailing winds, or a clump of forest which might also provide shelter and an aspect which may provide warmth instead of cold, however a significant number of nests fall outside of these preferred conditions. The nests that fall outside of preferred areas are likely a result of territorial limitations, caused by adjacent pairs of eagles and or the shortage of optimum nest habitat within an area where prey availability is beneficially high. Eagles can also be forced into nesting in unusual places by loss of habitat due to timber harvesting activity. As such all habitat was ground searched, regardless of forest type, shelter provided or aspect. It is extremely important to survey all habitat capable of supporting a nest when considering the installation of a permanent source of disturbance such as a wind farm.

Figure 2. Example of Wedge-tailed eagle nest in an exposed location on a nearby property

The entire study area including the one kilometre buffer of turbine placement zones is approximately 8,871 hectares. During the GIS habitat identification process approximately

4000 hectares (31 individual patches) were identified as requiring ground searching and habitat assessment. Each of the 31 patches had transects drawn over them at 130 metre spacing. Transects were drawn automatically by GIS software to ensure accurate spacing. We consider 130 metre spacing to be adequate in the open forest types found in the Central Highlands. Searchers walking transects, can easily see 65 metres each side of their transect as they progressed along it.

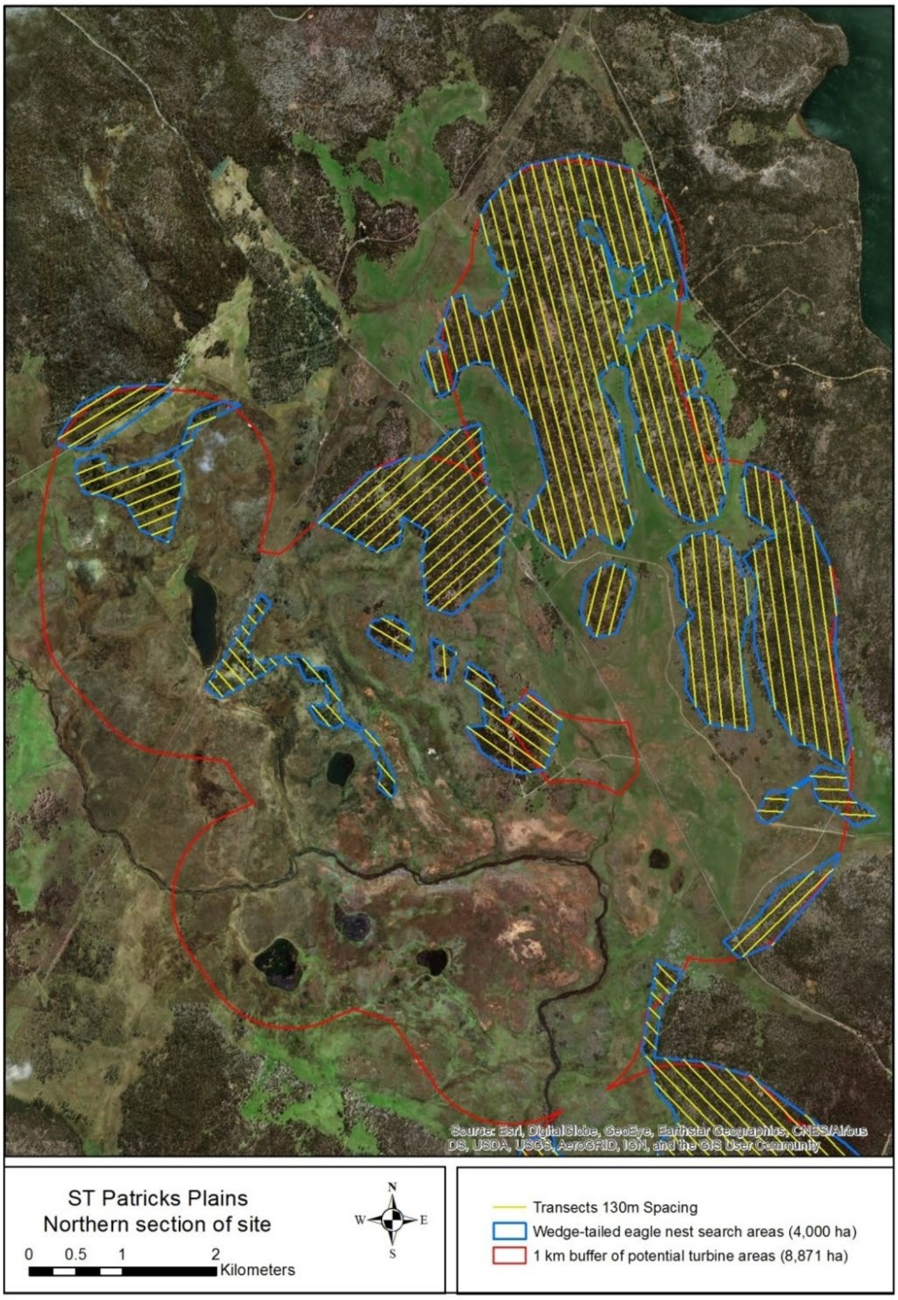

Figure 3. Search areas and transect on northern section of the proposed site

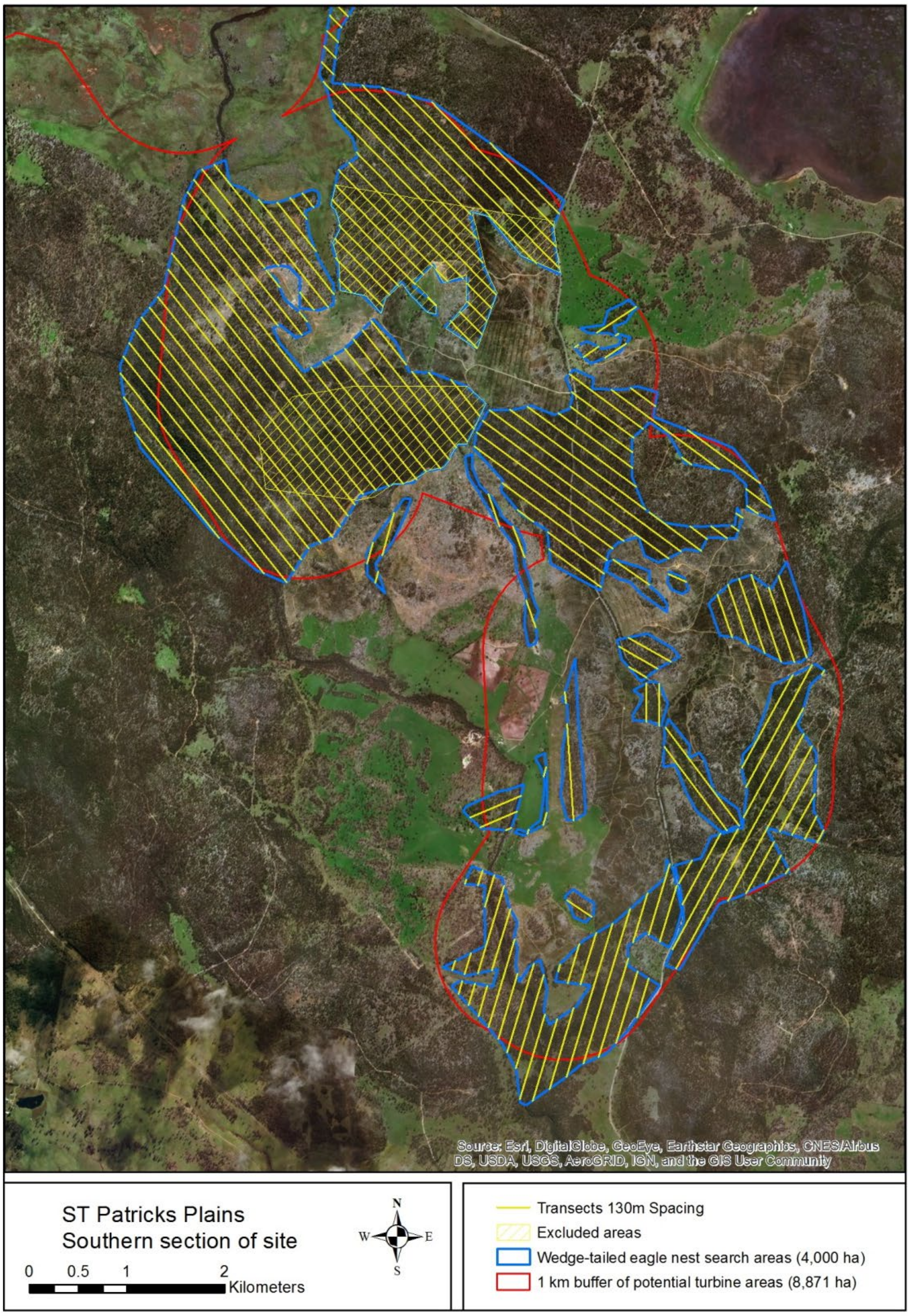

Figure 4. Search areas and transects on southern section of the proposed site

An experienced team of five personnel were assigned to walk along transects and each searcher was provided with a two way radio and GPS unit to keep on track. Tracks were produced in GIS software and loaded onto GPS units, which allowed each observer to keep on a defined line. This method ensures observers keep a methodical search pattern.

Personnel remained in contact with the use of UHF radio communication and conducted each search in a side-by-side line pattern to ensure accurate coverage and safe work practices. If a nest like structure was found, other members of the team would also investigate the find including the team leader Simon Plowright. As the search of each area concluded, all devices would be synced to check that good coverage was achieved on the ground and if a section had been missed for some reason, searchers would rectify the problem before moving on to the next patch.

In open areas where small clumps of forest had been identified, 4x4 quad bikes were used for access. Quad bikes provide good visibility and ease of travel over often, very rough terrain.

Some areas which were scheduled to be searched during the surveys were excluded due to timber harvesting being in progress. These areas are shown in figure 4 and described as excluded areas.

Limitations

Areas of young re-growth forest or naturally shorter stunted eucalypt forest would be avoided when found whilst walking transects. Trees of this nature are not able to support a large nest structure. Though all suitable areas were surveyed carefully and methodically, it is never possible to be 100 percent sure a nest has not been missed during a survey. Disturbance levels and loss of habitat is particularly high in the survey area which may result in a nest being placed in an unusual location. It is impossible to search every tree on the landscape however we encourage anyone who is working on this proposed site for whatever reason to always be looking out for eagle nests. Nests can be missed during surveys, but also new nests can be built from July onwards. The proposed eagle utilisation surveys at the site are an effective tool in establishing high use areas, which can sometimes point to a new nest or an existing unrecorded nest. Any highly utilised areas revealed during utilisation surveys should be investigated.

Results

Habitat Categories

The forested areas on the proposed wind farm site in general have all been disturbed by logging at some stage over the years. Very small patches here and there have not been disturbed and appear to be due to extremely rocky, steep and inaccessible ground which makes retrieving logs very difficult. Where appropriate these areas have been included into the optimum nest habitat category.

Optimum nest habitat

This was defined as forest that contained multiple trees of adequate size and type to support a Wedge-tailed eagle nest. The topography comprised mostly east southeast facing slope, or an alternative shelter of dense forest was present to protect a nest from the local prevailing wind. The location was also considered to have characteristics similar to that found at the majority of known nest sites in the greater area. However the mapped optimum areas should be considered the best available sites in the study area rather than perfect eagle habitat.

There was 533 hectares of optimum habitat identified during the surveys. This represents approximately 6% of the total survey area. There are 19 fragmented patches distributed across the entire site with the greatest concentration occurring in the southern section (68.5%) of the proposed wind farm.

Secondary nest habitat

This was defined as forest that contained several trees of adequate size and type to support a Wedge-tailed eagle nest. The topography may slope in any direction or indeed be flat but there is some shelter provided by either re-growth forest or stands of older trees.

There was 1,777 hectares of secondary habitat identified which represents 20% of the total survey area. There are 37 fragmented patches distributed across the entire site with the greatest concentration occurring in the southern section (73.5%) of the proposed wind farm.

Degraded nest habitat

This is the balance of the survey area and is made up of open exposed highland farmland or open native vegetated plain with scattered old growth eucalypts, to logged forest areas containing young re-growth or plantation forestry. Of the 31 original patches identified for nest searching a significant number of these occur as natural clumps of forest on the plains. In this situation the patches have a natural profile of short stunted trees on the outer edges and taller more suitable trees for eagles in the centre or on the wind sheltered side of the clump. In most cases these outer edges of clumps have been included in the degraded category.

This remaining balance of degraded habitat is approximately 6,561hectares which represent approximately 74% of the total study area. Its unlikely Wedge-tailed eagles will choose to nest in any of this area but certainly not impossible as shown from other locations in Tasmania.

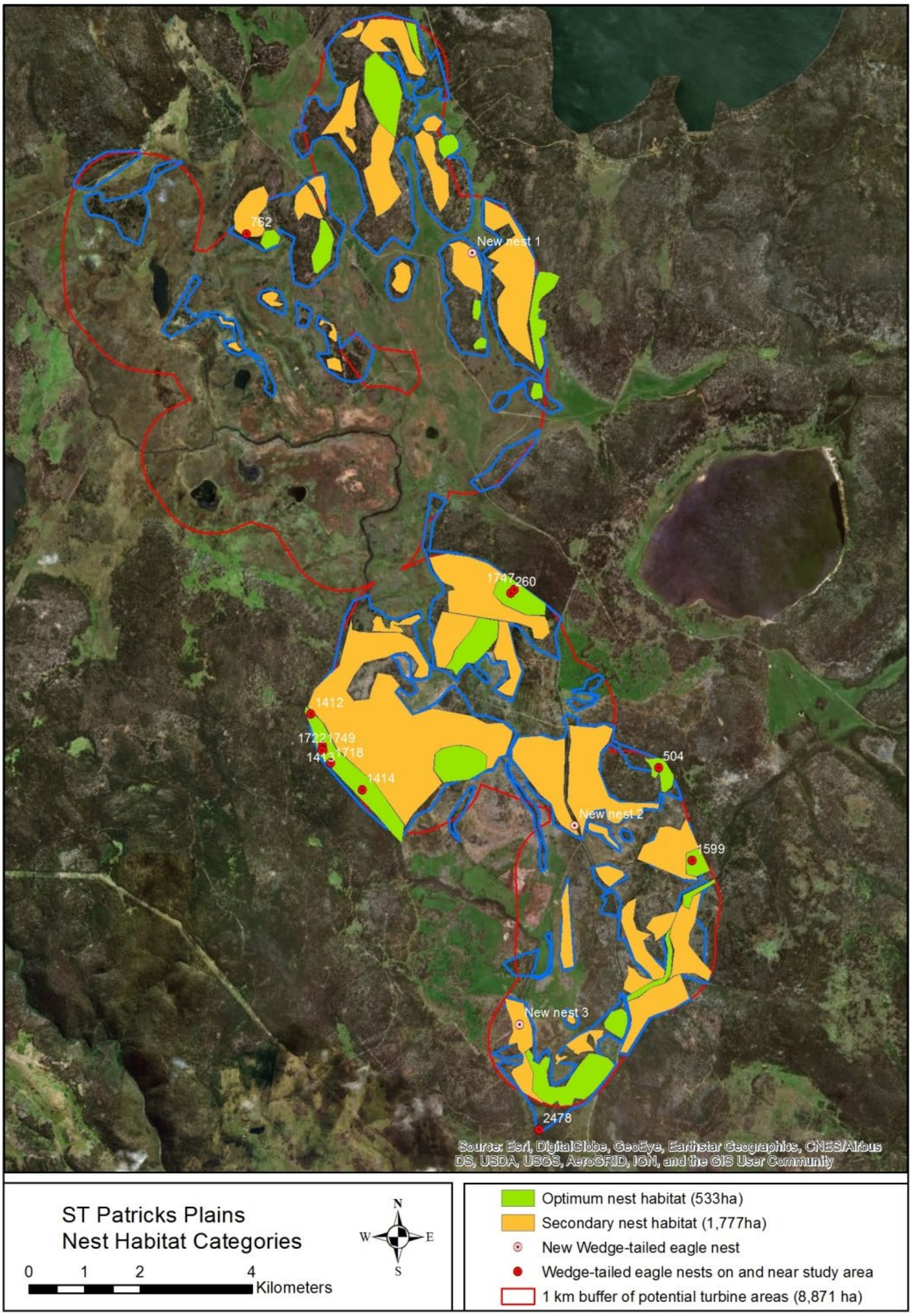

Figure 5. Nest habitat categories

Wedge-tailed eagle nests listed on the *NVA*, (known nests)

There are six registered wedge-tailed eagle nests located inside the survey area. In addition to these nests, another six are located just outside but within 500 metres of the survey area boundary. It should be noted, that five of these nest are located very close together which would suggest they belong to one pair of eagles with multiple nests in the territory.

In the summer of 2018-19 there was an extensive wildfire to the west of the study area and the status of the known nests on the western side of the Shannon river were considered important in relation to the wind farm proposal, had the nests been destroyed the birds may have chosen to rebuild on the proposed site. Though the nests are located just outside the study area we ventured as close as we could and viewed the area from vantage points on the opposing hillside. The Shannon River was flowing fast and deep and we were unable to cross to the nests, however in general a good view is possible from the western side.

By mid February when this survey was undertaken fledglings have normally left the nest and checking nests after the breeding season is not an effective way of determining breeding activity and success. Once a chick has fledged the evidence left at the nest can often be variably subjective and inconclusive. The focus of this survey was to find new nests and this activity needs to be undertaken outside of the breeding season. Known nests were visited, more with the intent of clarifying nest existence rather than an assessment of the 2018 breeding season.

Figure 6. Old and new Wedge-tailed eagle nests

Wedge-tailed eagle nests inside the study area

Nest 762

This nest is located very high up in the largest eucalypt in the area and looked in very good order and was probably used this breeding season (2018). There was a lot of fresh prey scraps found around the base of the nest tree, these included rabbit, hare, Tasmanian pademelon, Bennetts wallaby and echidna. This nest is in secondary grade habitat and is quite exposed to prevailing winds as the tree is the largest in the area and emerges above the smaller surround trees. The land slope provides almost no shelter as the area is relatively flat.

Figure 7. Nest 762, largest tree in the patch

Nest 260

This nest could not be located and undoubtedly had been a secondary nest for the eagles occupying Nest 1747 as both nest locations are very close together.

Nest 1747

This nest was occupied with a large ready to fledge chick. Once observers were spotted, it crouched down in an attempt to hide. Two adults were also seen. The nest was visited on February the 18th 2019 and it's unusual to find a chick hiding in the nest this late in the breeding season.

Figure 8. Nest 1747 with large chick visible

Nest 504

This nest appears to be in quite good order but didn't seem like it was used this season (2018). There was some faecal whitewash around the base of the tree and a few feathers however the general impression was of a nest that's visited by birds rather than a breeding site. It can be quite difficult to determine activity levels when a nest is this high above ground. There were no birds present. The nest tree is very exposed and would have to be classed as a poor site at this time.

Figure 9. Nest 504 very high and exposed

Nest 1599

This nest is in good order and may have been used this season as there was a lot of faecal whitewash and prey item scraps together with a few regurgitated pellets. If not used for breeding it is certainly visited often.

Figure 10.Nest 1599 in good condition

Nest 1414

This nest was found and looked in relatively good order. An estimated one hectare of land around this nest was saved from the fire. This location was where the fire first crossed to the eastern side of the Shannon River and everything all around had been burnt except for the nest area. No assessment of breeding activity could be made without crossing the river.

Wedge-tailed eagle nests outside the study area

Nest 1412

This nest was visible from the eastern side of the Shannon River and appeared to be in good order. No fire damage occurred near the nest. No assessment of breeding activity could be made without crossing the river.

Nest 1413

Could not locate this nest, there was a place in a large tree which possibly could have originally contained the nest. The canopy was untouched by the fire however it had burnt all the understory and stems of the larger trees with the one large tree showing signs of a very hot fire in a likely nest position.

Nests 1722 and 1749

One nest could be seen however as these two nests were so close together it is difficult to determine which one was observed. The canopy was mostly untouched by the fire however all the understory and stems of large trees were burnt. No assessment of breeding activity could be made without crossing the river.

Nest 1718

We were unable to find this nest from our position on the eastern side of the Shannon River. We did find that many of the nest coordinates were incorrect in this area. This does not necessarily mean the nest has gone. The fire had also burnt the understory and stems of eucalypts in this area but in general the canopies all looked fine and a nest should have survived the fire.

New wedge-tailed eagle nests located during the survey

There were three new eagle nests found during the surveys. All nests were found in the secondary habitat type.

New nest 1

Grid reference: GDA 489421-5344552

This nest was found on the north western part of the proposed site in an area which had been timber harvested in the past. The nest tree is very large and may have been left as a seed tree during the timber harvesting process. There was no sign of any recent activity, although the nest looked in fairly good condition. The site is now quite exposed however; the nest is micro sheltered by the thick canopy and limbs of the tree. Based on the aspect and old tree stumps, the area pre logging, would have been classed as optimum habitat. The nest may pre date the timber harvesting activity.

Figure 11. New nest 1

Figure 12. Wider view of new nest 1

New nest 2

Grid reference: GDA 491256 533425 (this is approximate as birds were on nest).

This is a very large nest located in an old growth eucalypt. This nest is in secondary category habitat. There are several reasons why this location is classed as secondary. The nest is about 100 metres from the Highland Lakes Road and the road at this location is very noisy. The highway runs in a tunnel of overhanging trees and is on a hill. This means trucks going uphill are very noisy and just as noisy coming down and the sound is trapped in the tunnel where the nest is. In addition, the nest on its western side is exposed to the full brunt of the prevailing winds. This is yet another example of a nest found outside of preferred habitat. Despite the seemingly problematic nest location there was a large chick present. When first observed it hid in the nest bowl but on another occasion when we looked it was out perching on a limb adjacent to the nest.

Figure 13. New nest 2 with large chick visible

New nest 3

This nest is located in the south of the site on the western side of the Shannon River. We were unable to get to the nest as the river was flowing heavily. Three eagles were observed in the same patch of trees, we were unable to tell if there was any connection to the nest or if the bird presence was a coincidence. The nest is in secondary category habitat as the area is very open with little protection from the elements, though the hill to west would provide some shelter from prevailing winds.

Figure 14. New nest 3 visible from the eastern side of the Shannon River

Conclusion

Of the six registered Wedge-tailed eagle nests listed to occur within the study area, we were only able to find five. Three new nests were found, one of these in particular (New nest 2) highlights the importance of searching in all locations rather than only where habitat modelling may suggest. The five nests which occur just outside the study area on the western side of the Shannon River were checked to see if they had survived the 2018-19 summer wildfires. We could only locate two out of the five nests however we were unable to approach the nest areas as the Shannon River was flowing too heavily to cross safely. The unaccounted for nests could easily remain intact, on the whole the nest areas along the western side of the river had received a cool fire which at the most appeared to burn the undergrowth and none of the canopy of the larger trees.

There were at least two successful breeding events in the study area as the chicks were still present at the nests. These chicks were both very late in the breeding season and we are unsure whether this represents a late season for all nests in the greater area or whether these two nests were an anomaly. There were signs of breeding activity at other nests on site and in a normal year by mid-February the chicks would have fledged therefore, we cannot confirm successful breeding as there were no birds present.

The site appears to have a high population of eagles as many birds were seen during the week long survey. In a landscape where prey species are in abundance, territories may be quite small which equates to the potential for many nests on the landscape and will likely be one of the contributing factors to what appears to be, less than ideal nest site selection. The proposed eagle utilisation surveys if undertaken will clarify how many breeding pairs are using the survey area and may also help to highlight any new nests which may get built in the 2019 breeding season.

In an environment where frequent timber harvesting activities are being undertaken, as witnessed at the study area, eagles will be under pressure to build nests in new locations. This can happen during late winter in any breeding season. It is crucial that continual nest searching be carried out even if an area was checked previously.

Wedge-tailed Eagle Nest Activity Assessment October 2020

St Patricks Plains

Jason Wiersma, Raptor Biologist,

Forest Practices Authority, December 2020

A Report to *Epuron Projects Pty Ltd*

Ver 3.0   15 Dec 2020   *HPRM D20/325370*

FOREST PRACTICES AUTHORITY

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Background

Each year FPA conduct aerial surveys of a large number of eagle nests to determine if they are being used for breeding. The surveys are conducted in October, and this snap shot nest assessment allows a specialist observer to identify whether a chick, egg or adult is present on the nest. Evidence of such would determine that a nesting attempt had been made.

The FPA were contracted by Epuron to assess if any of the wedge-tailed eagle nests within the St Patricks Plains proposed windfarm footprint were used for breeding during the 2020/21 breeding season. St Patricks Plains is located approximately 10 km south-south-west of Arthurs Lake in the Central Highlands Tasmania. In total 16 nest checks were requested.

Aim

The aim of this nest survey was to establish whether there were signs of wedge-tailed eagle breeding activity at any of the 16 nests identified.

Methods and Results

Nests were flown on the 19 October 2020. Surveys were done using an AS350 B3 Eurocopter from Helicopter Resources Cambridge. Nests were flown using a newly developed standard operating procedure, designed by the Forest Practices Authority and endorsed for use by DPIPWE. During the survey an orbit flight pattern was taken, at airspeeds no less than 50 knots. Surveys were generally completed within 1–2 orbits of a nest and in less than 1 minute to ensure the least disturbance. If a nest could not easily be located or if an adult eagle showed aggression towards the aircraft, the survey at that nest was terminated. To reduce disturbance from the aircraft to any breeding eagles we ensured the following:

- Altitudinal nest–aircraft separation of 300 ft was maintained
- To reduce rotor-clap commute speed (100 knots) was reduced to survey speed (~ 50 knots) by flaring (slowing) the aircraft two miles from a nest.
- Forward translational movement was maintained (no hovering or slowing of aircraft when surveying nests).
- All nests surveyed by a highly experienced specialist.

The methods detailed allowed for aerial surveys to be conducted quickly, efficiently and relatively quietly.

Nests were considered active if an adult(s) was observed in a sitting/brooding pose on the nest, or if a chick or egg was noted. Eggs are heavily pirated by scavengers if left unattended, so we assumed any egg observed on the nest was from the current breeding season.

During the October survey at St Patricks Plains, 6 nests were active, 2 nests showed no signs of activity and 7 nests were not located. An aggressive adult exhibited aggressive behaviour over another nest, thus preventing the nest contents from being observed during October (See Table 1).

Table 1 Nest activity assessment results of 16 eagle nests surveyed at St Patricks Plains on the 19th of October 2020.

Nest Number	UTM E	UTM N	October Observation	Location
260	490113	5338434	No Recent Material	St Patricks Plains
504	492761	5335295	Not Found	St Patricks Plains
759	483688	5338665	Adult on nest	St Patricks Plains
762	485364	5344891	Adult on nest	St Patricks Plains
1412	486522	5336262	Adult on nest	St Patricks Plains
1413	486731	5335694	Not Found	St Patricks Plains
1414	487444	5334900	No Recent Material	St Patricks Plains
1599	493411	5333634	Not Found	St Patricks Plains
1718	486880	5335378	Not Found	St Patricks Plains
1722	486736	5335618	Not Found	St Patricks Plains
1747	490170	5338498	Adult on nest	St Patricks Plains
1749	486723	5335617	Not Found	St Patricks Plains
2752	489421	5344552	Adult on nest	St Patricks Plains
2753	491256	533425	Adult in air	St Patricks Plains
2754	490263	5330718	Not Found	St Patricks Plains
2755	494298	5336423	Adult on nest	St Patricks Plains

As part of FPA's annual chronology assessments that were undertaken in southern Tasmania, nine nests in St Patricks Plains were re-surveyed on November 18 2020. Of these, 5 had failed since the October flight (See Table 2).

Table 2. Nest activity assessment results of 9 eagle nests re-flown at St Patricks Plains on the 18 November 2020 as part of a southern chronology survey by FPA.

Nest Number	UTM E	UTM N	October Result	November Result	Location
759	483688	5338665	Adult on nest	No Recent Material	St Patricks Plains
762	485364	5344891	Adult on nest	No Recent Material	St Patricks Plains
1412	486522	5336262	Adult on nest	No Recent Material	St Patricks Plains
1599	493411	5333634	Not Found	No Recent Material	St Patricks Plains
1747	490170	5338498	Adult on nest	No Recent Material	St Patricks Plains
2752	489421	5344552	Adult on nest	No Recent Material	St Patricks Plains
2753	491256	533425	Adult in Air	Chick 3 weeks	St Patricks Plains
2754	490263	5330718	Not Found	Not Found	St Patricks Plains
2755	494298	5336423	Adult on nest	Poor view	St Patricks Plains

An evaluation of the spacing of eagle nests that were originally active during the October nest assessment at St Patricks Plains defines a mean active nest spacing of 5.7 km with the nearest and furthest active nests being 3.8 and 8.0 km apart respectively (Figure. 1).

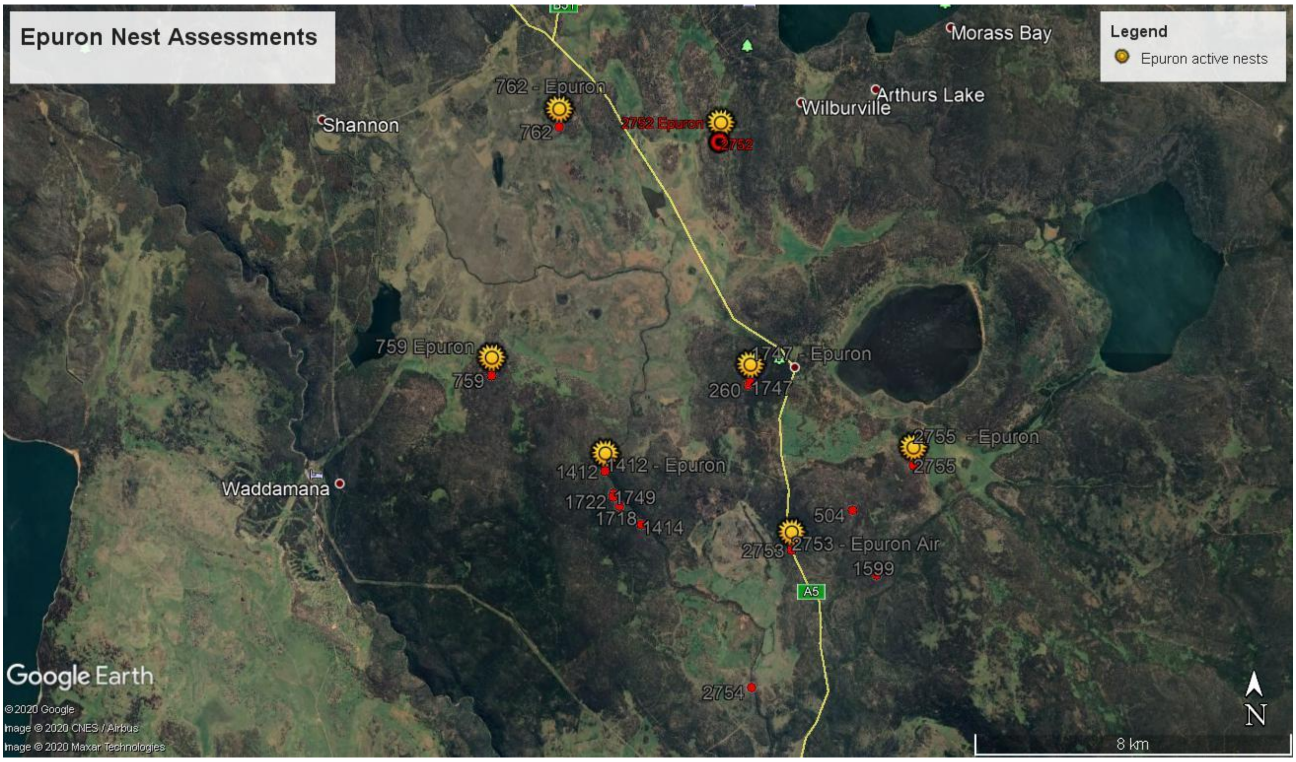

Figure 1. Spacing of active eagle nests during October at St Patricks Plains, Central Tasmania.

Discussion

Of the 16 nests surveyed, 6 were confirmed active in October, with the November checks identifying one additional active nest (a nest (2753) not located during October) but five nests that had failed. Of the remaining nests, five were confirmed as not being active in October, with one other nest confirmed as being not active in November.

Six nests were not found. However, the density of birds that attempted to breed at St Patricks Plains in October is considered high. A number of active nests were only 3.8 – 4.1 km apart. All except two (2754 & 504) of the nests within the St Patricks Plains area that were not located during the October survey, were located within a few hundred metres of a nest recorded as active. Eagles (both wedge-tailed and white-bellied sea eagle) have not been recorded breeding closer than 1.8 kilometres, even in very productive territories, due to territorial competition. Hence it's unlikely the nests not located (1413, 1718, 1722, 1749) would have been used this season.

Results from the second *ad hoc* November survey identified a large number of failures within the St Patricks Plains area, a trend also observed across southern Tasmania. We conclude that approximately 70% of nests failed in the early part of this year's breeding season in Tasmania. Results from previous years concluded that average failure rates may be around 63%, indicating failure rates this year are higher than usual (although the sample size was notably small so this conclusion is only tentative).

This years observed failure rates at St Patricks Plains is high when compared to last year's January flights which identified that 4 birds had successfully fledged.

Wedge-tailed Eagle Nest Activity Assessment January 2021

St Patricks Plains Region

Jason Wiersma, Raptor Biologist,

Forest Practices Authority

A Report to *Epuron Projects Pty Ltd*

FOREST PRACTICES AUTHORITY

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Background

The FPA was contracted by Epuron in October 2020 to determine if any of the wedge-tailed eagle nests within the St Patricks Plains proposed windfarm footprint were used for breeding during the 2020/21 breeding season. Of the nests checked, six were identified as active in October 2020. A follow-up survey in November could confirm only one nest as active.

The FPA was then contracted in January 2021 to determine whether any chicks successfully fledged from the active nest in the St Patricks Plain area, which is located approximately 10km east of Waddamana in the Central Highlands of Tasmania. This report details the results of that survey. For the purposes of this report nestlings were considered successfully fledged if they reached an age of 10 weeks or more, a period shorter than the actual fledging period of 12.5 weeks. Surveys are done at this time as nestlings are large enough to survive and fledge, but it would be nearly impossible to observe a nestling actually fledge. This approach is commonly applied in raptor research.

Aim

The aim of this survey was to determine whether the nest at St Patricks Plains contained a nestling at least 10 weeks old, which is old enough that it is likely to fledge successfully.

Methods

An aerial survey was conducted on the 19th January 2021.

The eagle nests were surveyed using a Eurocopter AS350 B3 Squirrel from Helicopter Resources Cambridge. The survey was done using a standard operating procedure designed by the FPA and endorsed by DPIPWE. The method involves surveying nests while ensuring minimum airspeed (40 – 50 knots) and altitudes are maintained, minimising rotor slap near nest sites to reduce noise. The method used ensured:

- forward translational movement was maintained and
- flaring, the method used to reduce excessive speed of aircraft, occurred 2 – 3 kms from nests to disperse noise away from these localities.

This method allowed for the aerial survey to be conducted quickly and quietly.

Results

During this survey one fledgling, approximately 11 weeks of age was observed at nest 2753. No birds were flushed from roosts or nest sites during the survey and no eagles showed aggressive behaviour toward the aircraft. Nest observations and status are detailed in Table 1.

Table 1 Nest activity assessment results of 1 eagle nests located at St Patricks Plains on 19/01/2021

Nest Number	UTM E	UTM N	October Observation	Location
2753	491256	5334256	11 Week old Wedge-tailed eagle	St Patricks Plains

Nest 2753 is located below a very dense canopy and fairly close to a main dirt road (see Figure 1 detailing the general nest location).

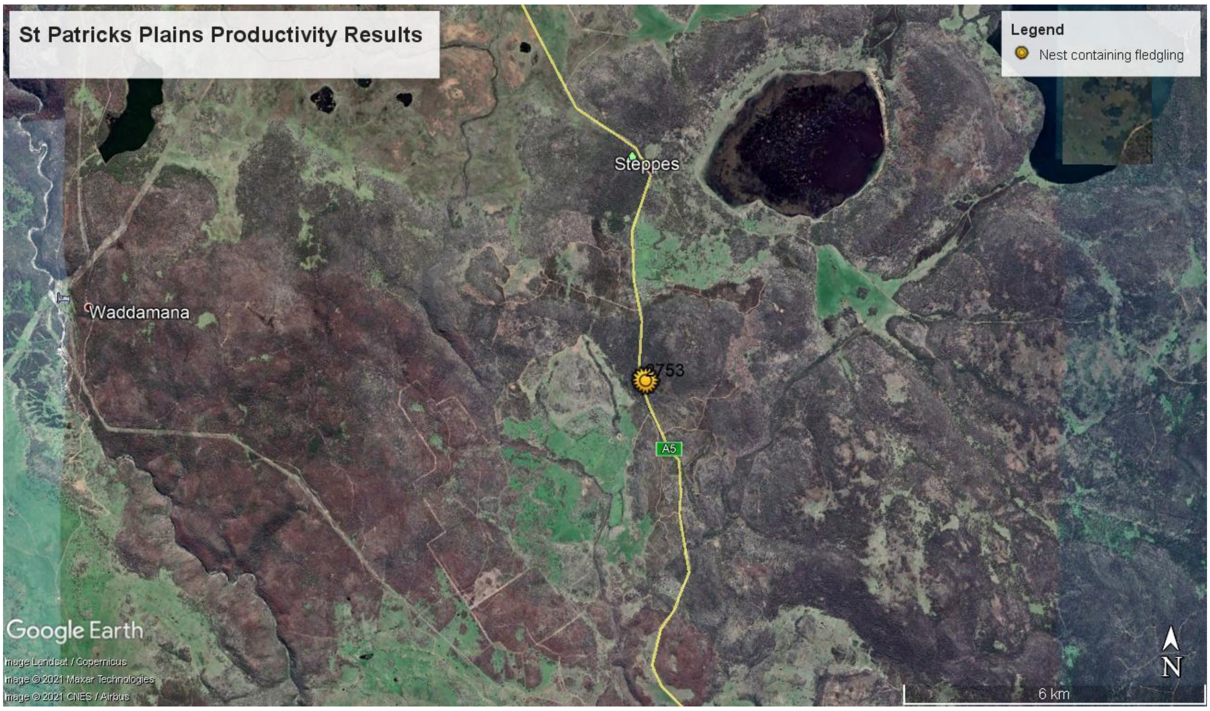

Figure 1 Map detailing 1 productive nest surveyed at St Patricks Plains January 2021

The timing of this year's survey was fortunate and happened to observe chicks at the best time to assess productivity. This was due in part to the FPA undertaking a November chronology flight which allowed this survey to be conducted at the best period.

Discussion

The results of this survey suggest that one wedge-tailed eagle nest (2753) in the St Patricks Plain survey area will have a chick successfully fledge in the 2020/21 breeding season.

St Patricks Plains Wedge-tailed Eagle Nest Activity Assessment 2020

Introduction

The FPA were contracted by Ephron to complete an eagle productivity assessment. The agreed assessment involved a rotor-wing nest activity check of 12 eagle nests to count fledglings, within the St Patricks Plains region. St Patrick's plains is located approximately 10km south-south-west of Arthurs Lake in the central highlands, Tasmania.

Methods

Aerial survey were conducted on the 15th January 2020.

Eagle nests were surveyed using a Eurocopter AS350 Squirrel from Helicopter Resources Cambridge. We used a newly developed standard operating procedure, designed by the Forest Practices Authority and endorsed by DPIPWE, to assess nests. The method involves surveying nests in a similar fashion to fixed-wings aircraft, ensuring minimum airspeed (40 – 50 knots) and altitudes are maintained whilst minimising rotor slap near nest sites during onsite survey to reduce noise. Our method therefore ensured:

- forward translational movement was maintained and
- flaring, the method used to reduce excessive speed of aircraft, occurred 2 – 3 km's from nests to disperse noise away from these localities.

This method allowed for aerial surveys to be conducted quickly and quietly.

Results

Nests were considered productive if chicks reached an age of 10 weeks or more, (referred to as fledglings for the purposes of this report, although note that eagles fledge when approximately 12.5 weeks old). During this survey four fledglings, approximately 10 – 11 weeks of age were observed. Two adults were also observed, one in the air and in a nearby tree to a nest. No birds were observed to flush from roosts or nest sites during the survey and no eagles showed aggressive behaviour toward the aircraft. Nest observations and status are detailed in Table 1.

Table 1.0 Nest activity assessment results of 12 eagle nests located at St Patricks Plains on 15/01/2020

Nest Id Number (NVA RND no.)	Location (UTM) Eastings	Location (UTM) Northings	Observation	Productive
260	490113	5338434	Not Found	No
504	492761	5335295	Small nest no recent nest material	No
759	483688	5338665	No Recent nest material	No
762	485364	5344891	10 – 11 week fledgling	Yes
1412	486522	5336262	Small nest	No
1413	486731	5335694	Small nest	No
1414	487444	5334900	10 – 11 week fledgling	Yes
1599	493411	5333634	10 – 11 week fledgling	Yes
1718	486880	5335378	Small remnant nest	No
1722	486736	5335618	Difficult to observe	No
1747	490170	5338498	10 – 11 week fledgling	Yes
1749	486723	5335617	Difficult to observe	No

Only eleven of the twelve nests were observed during the survey (figure 2). While nest number 260 was not located we conclude this nest could not have been productive as it was located within 80 metres of a productive nest (1747). Eagles (both wedge-tailed and white-bellied sea eagle) have not been recorded breeding closer than 1.8 kilometres, even in very productive territories, due to territorial competition. Hence it’s not likely nests as close as 80m could be productive and be from two separate territories.

Recommendations for future surveys: Timing of the activity survey

The timing of this survey was estimated from the average fledging times of chicks from past breeding events whilst factoring in a slightly later season based on expert opinion. The timing of this year’s survey was fortunate and happened to observe chicks at the very best time to assess productivity. Future annual surveys may require a more detailed assessment of timing in order to undertake nests checks when chicks are the same age to provide comparable data.

Survey and Report conducted and written by Jason Wiersma, Raptor Specialist/Biodiversity Section, Forest Practices Authority

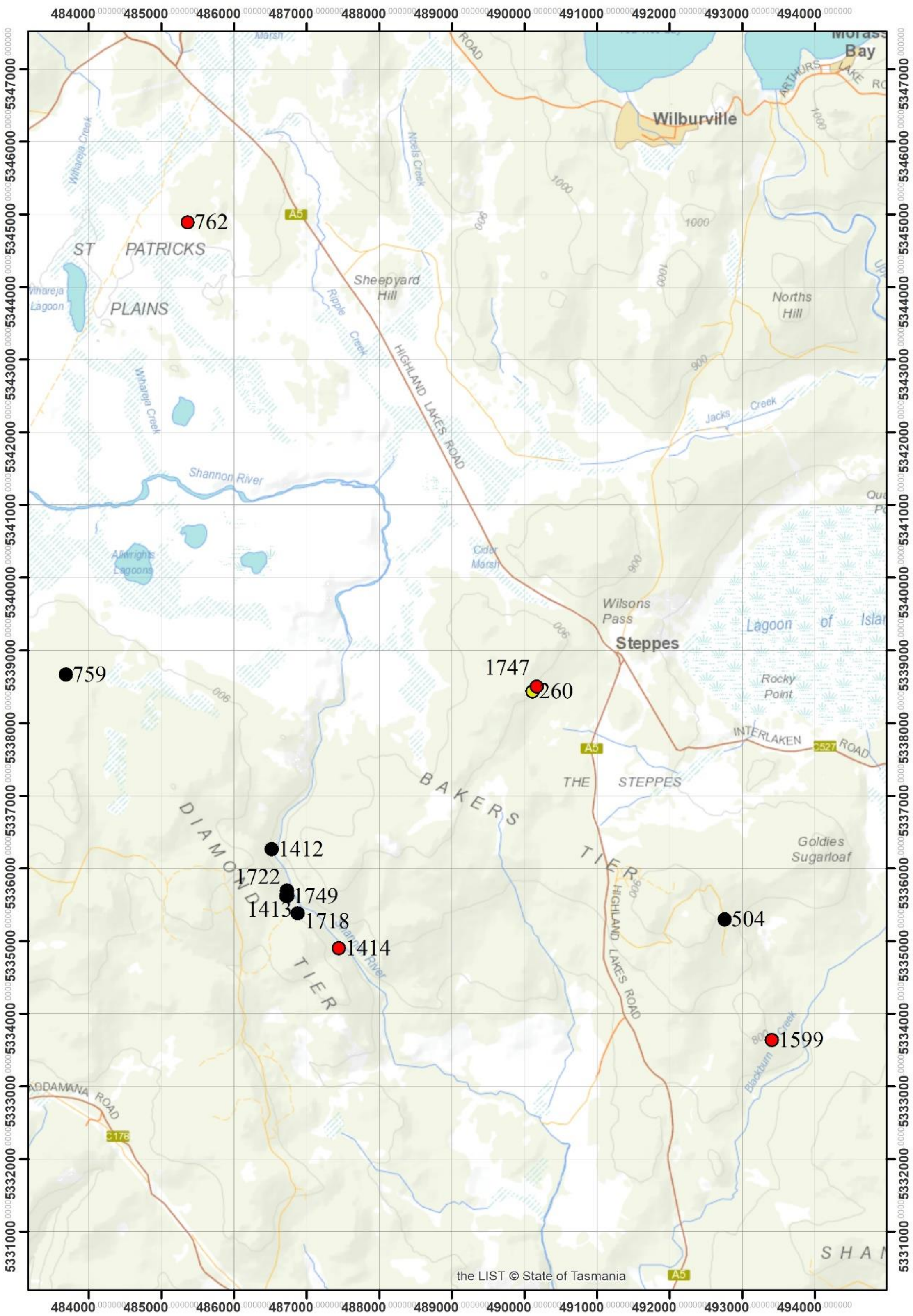

Figure 2.0 Map detailing productive/unproductive nests and nests located

St Patricks Plains Wind Farm Eagle Flight Analysis

Ver. 1.6

Submitted to North Barker

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Version Control

Version	Status	Date	Approved For Release	Issued To	Comments
0.1	Draft	2020-03-19	Internal	Internal	-
1.1	For release	2020-05-21	E. Stark	P. Barker	-
1.2	For release	2020-06-17	E. Stark	P. Barker	Prelim. CRM draft
1.3	Draft	2021-05-14	Internal	Internal	Y2 data update
1.4	For release	2021-06-11	E. Stark	P. Barker, D. Bolton	Final data/params
1.5	For release	2021-06-22	E.Stark	P. Barker, D. Bolton	Minor grammar and sense edits
1.6	For release	2021-06-24	E.Stark	P. Barker, D. Bolton	Minor edits

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Elizabeth Stark Date

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Summary

This report summarises our analysis of eagle flight path data at St Patricks Plains Wind Farm, Tasmania. North Barker collected Tasmanian Wedge-tailed Eagle (TWTE) and White-bellied Sea Eagle (WBSE) flight tracks from Aug 2019 to Apr 2021 over all eight seasons at 28 locations around the site.

This report provides an overview of the data used for analysis, and an assessment of eagle flight activity. The aim of this work is to provide quantitative flight activity analysis that can be considered as part of an ecological risk analysis.

To do this, we provide the following:

- A summary of the survey effort, and the recorded eagle observations (Section 1).
- A distance-corrected flight activity rate, in flights per hectare per hour. We use distance correction models (Buckland et al. 2008) to obtain an overall estimate of eagle flight density, accounting for the fact that it's harder to spot flights that are further from the observer (Section 2.1). This measure does not take into account spatial variation in activity, but provides a measure of average activity over the whole study area.
- A spatial map of eagle utilisation over the St Patricks Plains site (Section 3). This complements the previous measure by providing information on the spatial variation, but not on the likelihood of a flight in the first place.
- Results of predicted collisions of eagles with turbine, using the Nature Advisory BAND collision risk model. This model combines the distance-corrected activity rate, the spatial map, a geometric model incorporating physical turbine and bird parameters, and modelled turbine operational data.

Summary of results

This analysis is based on 3259 person hours (136 days) of observation in 222 shifts, from Aug 2019 to Apr 2021. A *shift* involved four to six observers going into the field simultaneously, each observer at a different site. We call the combination of a shift and an observer a *survey* (i.e. one observer at one site during a shift). 3639 valid flight tracks were recorded - 3596 independent Tasmanian Wedge-tailed Eagle tracks, and 43 independent White-bellied Sea Eagle tracks. Five shifts (and 309 surveys) did not record a flight track.

The encounter rate (number of observations per observer-hour before distance correction) was 1.104 flights per hour for Tasmanian Wedge-tailed Eagles.

The encounter rate for White-bellied Sea Eagles was 0.013 flights per hour.

The key findings regarding activity rates (see Section 2.2) are:

- The average effective detection radius (EDR) is 1273 metres for both species of eagle, for sites in non-forested areas. For sites in forested areas, it is 1060 metres.
- For flights in the *non-forested* region of the site, the overall, distance-corrected activity

on-site is in the interval:
  - (0.0027, 0.00363) flights per hectare per hour, with a point estimate of 0.00313 for Tasmanian Wedge-tailed Eagles. These values are reported to 95% confidence.
  - (2.95e-05, 7.69e-05) flights per hectare per hour, with a point estimate of 4.76e-05 for White-bellied Sea Eagles.
- For flights in the *forested* region of the site, the overall, distance-corrected activity on-site is in the interval:
  - (0.000801, 0.00194) flights per hectare per hour, with a point estimate of 0.00125 for Tasmanian Wedge-tailed Eagles.
  - (2.21e-07, 5.83e-05) flights per hectare per hour, with a point estimate of 3.59e-06 for White-bellied Sea Eagles.
- The weighted (overall) flight rate on the site is in the interval:
  - (0.00165, 0.00232) flights per hectare per hour for Tasmanian Wedge-tailed Eagles with a point estimate of 0.00196.
  - (1.29e-05, 3.15e-05) flights per hectare per hour for White-bellied Sea Eagles with a point estimate of 2.01×10^{-5}.

The spatial variation in activity patterns was investigated using utilisation maps (Section 3). Overall, the utilisation patterns throughout the site suggested a preference for the mid-west and south of the site. There is lower utilisation in the north, mid-south, and south-east of the site.

The expected (long-term average) number of Tasmanian Wedge-tailed Eagle collisions in a year is 4.89 at 90% avoidance, while for White-bellied Sea Eagles the expected number of collisions is 0.0503. For results relative to other avoidance rates refer to Table 10 in Section 4.3.

1 Data overview

In this section, we describe the survey effort. This provides an independent validation of the survey methodology provided by North Barker. We also provide a summary of the field data (pre-analysis).

Note that if figures or text refer to “Wedge-tailed Eagle” or “WTE,” we refer specifically to the Tasmanian Wedge-tailed Eagle.

All analysis in this report is based off the full two year dataset.

1.1 Pre-processing

Shift and observation data was provided by North Barker in multiple Excel files, and raw flight tracks were provided as shape files.

We briefly outline pre-processing steps taken:

- **Shift / survey sheet**: surveys (a unique combination of `SHIFT_ID` and `OBSERVER_ID`) with `COMMENT` containing the string `"did not look"` were flagged as not held, and removed from the analysis dataset.
- **Shift / survey sheet**: some `SITE_ID` variables were left-padded with a single `"0"`, for consistency and keying with the provided observer locations shapefile.
- **Shift / survey sheet**: the spring 2019 and 2020 files were missing the `SEASON` variable for some records. They were filled with the string `"spring"`.
- **Observation sheet**: 113 records were not valid flights as the bird was perched. These were flagged by the North Barker team in their provided `points` shapefiles. We removed these records from the analysis datasets[1].
- **Observation sheet**: reporting of eagle species names was made consistent.
- **Flights shape file**: the spacing between points on the flight traces was re-sampled so each GPS point was approximately 10 metres apart, while maintaining the same line shape.

1.2 Survey effort

Table 1 summarises the survey effort. The observer hours per season are roughly equal in Spring 2019 and Summer 2020, and lower in Winter 2019 and Autumn 2020 as they aligned with daylight hours.

[1] Note - it was assumed that belonging to the `points` shapefile is the master record of whether a flight was perched or not. If inconsistent with the `FLIGHT_BEHAVIOUR` field , the `points` shapefile was assumed to be correct (Harris 2021).

Table 1: Summary of survey effort.

Season	Year	Shifts	Surveys	Duration (DD:HH:MM)	Start	End
Winter	2019	31	152	14:08:31	2019-08-12	2019-08-30
Spring	2019	30	150	20:02:31	2019-11-18	2019-12-10
Summer	2020	30	149	19:08:06	2020-01-28	2020-02-13
Autumn	2020	20	100	14:11:54	2020-04-20	2020-05-01
Winter	2020	20	100	15:04:20	2020-07-06	2020-07-17
Spring	2020	30	145	17:19:34	2020-10-12	2020-10-23
Summer	2021	30	150	19:01:01	2021-01-11	2021-01-22
Autumn	2021	30	150	15:10:38	2021-04-19	2021-04-30

Rounding to the nearest hour, there were 3259 survey hours over the period from 2019-08-12 to 2021-04-30.

Figure 1 shows the locations of the different observation points. They are spread evenly across the study area. Note that some of the sites were moved (e.g. “18” to “18b”). All adjustments and additions were done to improve overall visibility (including forested areas) and to remove areas of duplicated visibility.

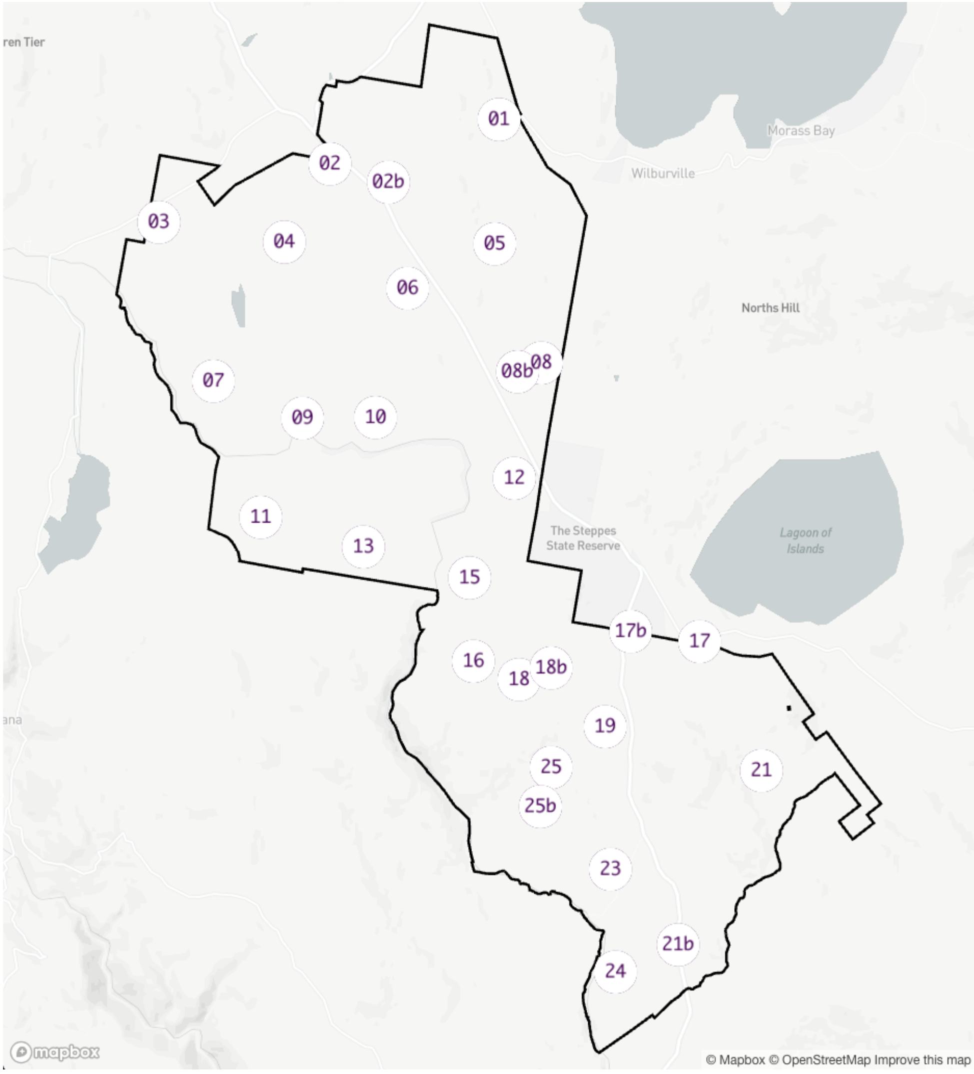

Figure 1: Observer locations (numbers) overlaid on the study area (boundary line).

Table 2 summarises the number of hours of survey effort per location.

Table 2: Hours by observer location. 'Start date' and 'End date' refer to the first / last time that location was used.

Site	Hours	Start date	End date
01	168.2	2019-08-12	2021-04-23
02	67.7	2019-08-12	2020-02-04
02b	103.7	2020-04-20	2021-04-23
03	159.1	2019-08-12	2021-04-23
04	163.7	2019-08-12	2021-04-23
05	157.0	2019-08-12	2021-04-23
06	165.7	2019-08-12	2021-04-23
07	154.7	2019-08-25	2021-04-23
08	100.4	2019-08-12	2020-07-10
08b	66.0	2020-10-19	2021-04-23
09	17.8	2019-08-25	2019-08-30
10	147.1	2019-08-26	2021-04-23
11	145.2	2019-08-25	2021-04-30
12	165.3	2019-08-12	2021-04-23
13	140.9	2019-08-25	2021-04-30
15	154.1	2019-08-25	2021-04-30
16	162.3	2019-08-25	2021-04-30
17	76.0	2019-08-25	2020-02-13
17b	109.2	2020-04-27	2021-04-30
18	69.0	2019-08-25	2020-04-28
18b	94.0	2020-04-29	2021-04-30
19	65.3	2019-08-25	2020-02-13
21	64.2	2019-08-25	2020-02-13
21b	107.0	2020-04-27	2021-04-30
23	151.6	2019-08-25	2021-04-30
24	168.5	2019-08-25	2021-04-30
25	14.1	2019-08-26	2019-08-30
25b	101.0	2020-04-27	2021-04-30

In Figure 2, we take Table 2 and cast it onto the site map. The height of the columns is proportional to the number of observer hours spent at that site. We can see that the spatial coverage of the site, via the surveys, is flat.

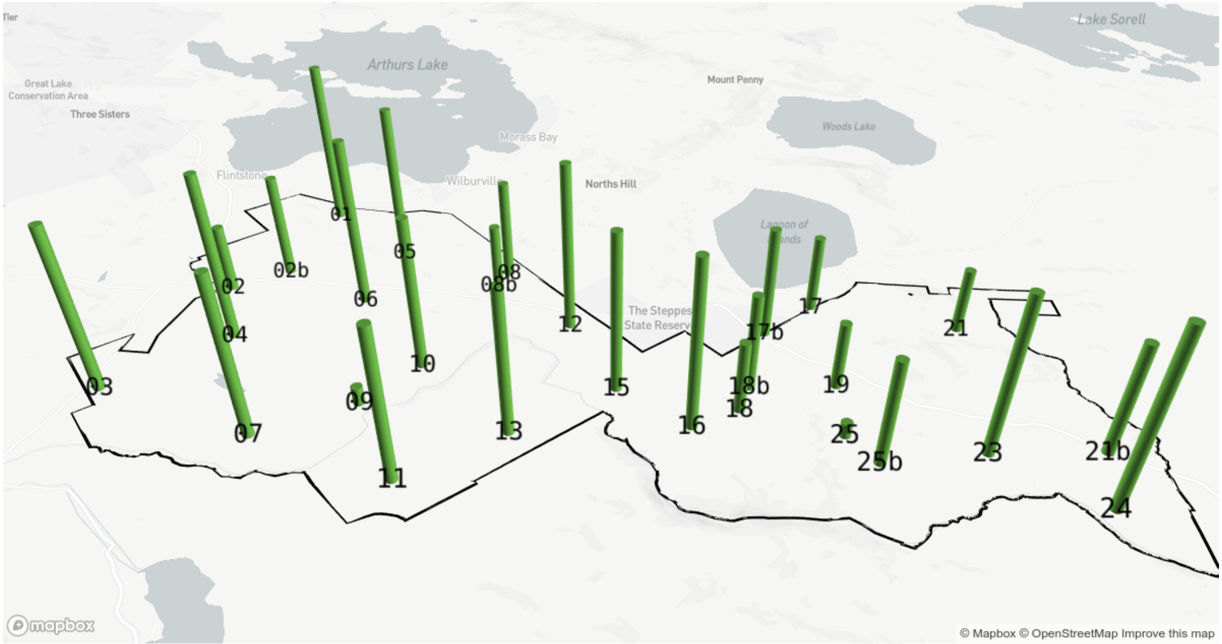

Figure 2: Spatial coverage of the sites. Note this map is rotated, as compared to Figure 1 - we are viewing from the west side.

Figure 3 shows the coverage by time of day, where the frequency is the number of surveys (shift + observer combinations) which fall into the time bin. We can see from this plot that the coverage between 8:30 am and 7:00 pm is good, and demonstrates adequate coverage of daylight hours.

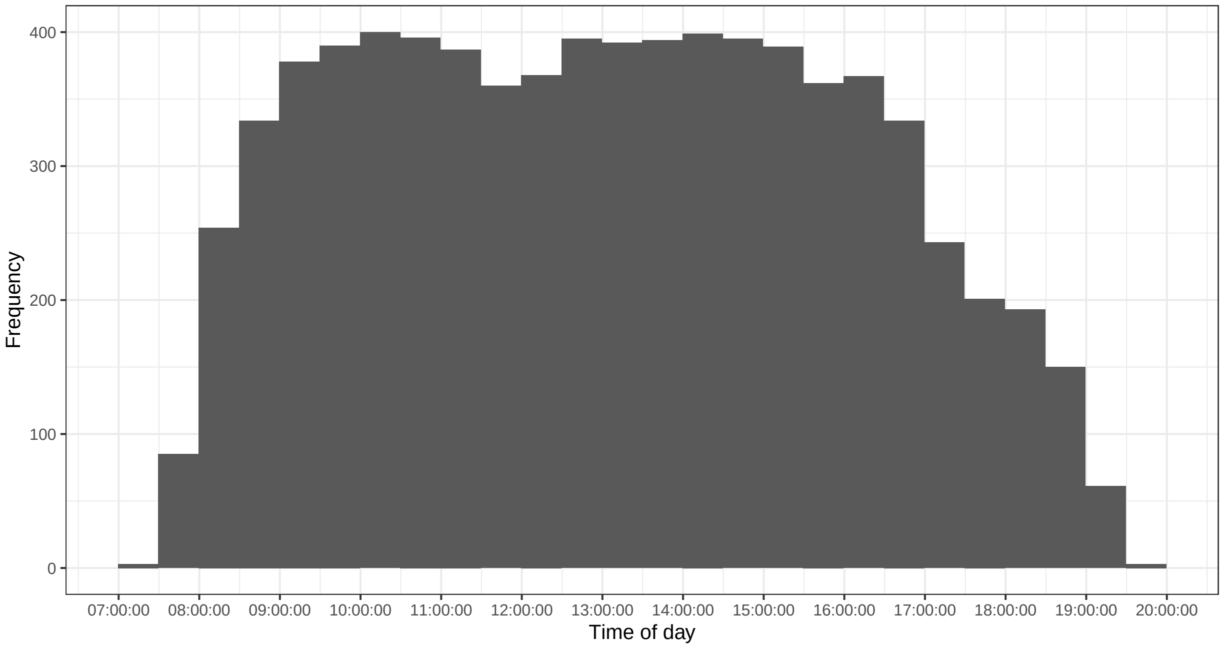

Figure 3: Time-of-day coverage of the surveys (using 30 minute bins).

1.3 Observations

Table 3 summarises the number of formally observed flights per season, split by species. As there were very low counts of White-bellied Sea Eagles, we have treated both them and Tasmanian Wedge-tailed Eagles as a combined set, and haven't attempted to differentiate the species, during the distance modelling.

Table 3: Flights observed per season in formal surveys.

Season	Year	Wedge-tailed eagle	White-bellied sea eagle
Winter	2019	403	6
Spring	2019	727	3
Summer	2020	294	1
Autumn	2020	437	5
Winter	2020	288	9
Spring	2020	600	16
Summer	2021	398	1
Autumn	2021	449	2

There were also a number of excluded sightings (usually because the bird was perched). These were not included in any further analysis, but are reported here for completeness in Table 4.

Table 4: Sighted (perched) eagles which are not included in formal analysis.

Season	Species	Count
Spring 2019	Wedge-tailed eagle	1
Summer 2020	Wedge-tailed eagle	2
Autumn 2020	Wedge-tailed eagle	19
Winter 2020	Wedge-tailed eagle	25
Spring 2020	Wedge-tailed eagle	12
Summer 2021	Wedge-tailed eagle	24
Autumn 2021	Wedge-tailed eagle	30

Figure 4 shows the distribution of times of day when flights were first observed. Given this and Figure 3, eagles appears to be more active in the morning and early afternoon, than in the late afternoon.

The median observed flight duration was four minutes.

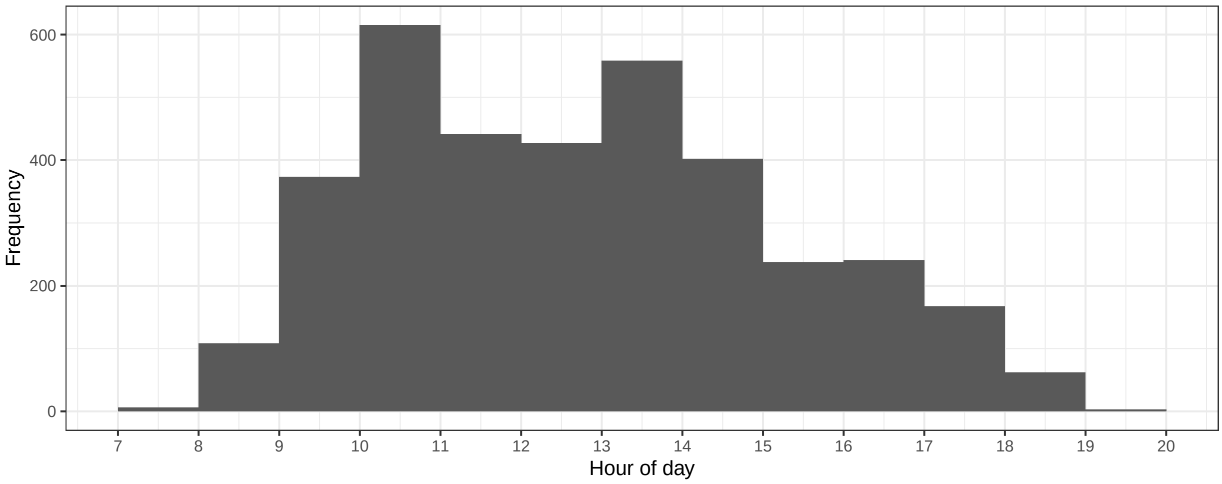

Figure 4: Time of day when eagles were first observed.

Figure 5 shows the flight heights (at point of first observation) of the eagles. For both WBSEs and TWTEs, 90% of flights were initially detected at between 12 and 300 metres high.

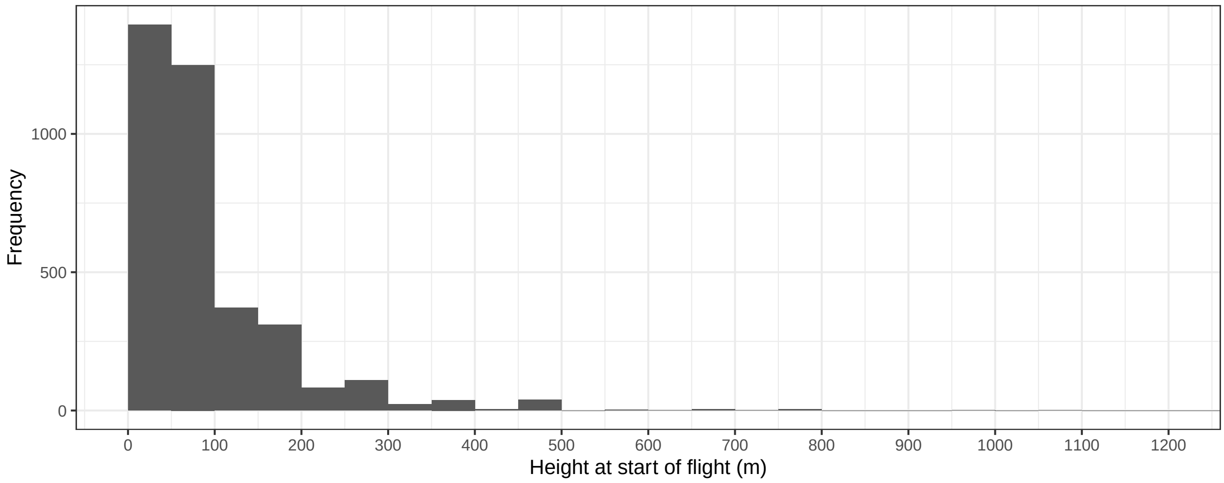

Figure 5: Distribution of flight heights (species combined)

The survey has produced flight data across all times of day, and sampled a selection of flight heights and locations. We are satisfied it is fit for the purpose of site utilisation analysis, and collision risk modelling.

2 Estimate of total eagle flight density

This section aims to understand the eagle activity over the site.

2.1 Methods - distance corrections

To provide a robust estimate of the rate of flight activity onsite, one must adequately account for the possibility that an observer will be more likely to detect a flight that is overhead, than one that is a large distance away. This was done using standard distance correction techniques (Buckland et al. (2008)). It requires GIS analysis, and so is only performed on flight tracks with full GIS associated data.

We used a hazard-rate distribution to model the detection function. Other shapes (uniform with a cosine series expansion, and half-normal) models were also explored. The hazard-rate was chosen for its alignment with the shape of the data. We used the Akaike Information Criterion (AIC) (Akaike 1974) to compare models. There was no evidence (using AIC) that adding covariates, such as species, season, or radio handover status, nor using a cosine series expansion on the hazard-rate shape, resulted in an improved model.

Here, "distance" was defined as the GIS-calculated straight line distance between the observation point (`SITE_ID`), and the first recorded eagle point on each flight path, ignoring height. We truncated the data at 3000 metres to remove the effects of outliers. Truncating for point transects is recommended by Buckland et al. (2008) (p151). We believe this is a sensible value, as not truncating results in a detection function which fits poorly (the curve fits to the long tail, rather than the main body). It's unrealistic that flights are observed at greater than roughly 3 km from the survey point - meaning that the distances greater are potentially outlier values.

From the distance models, we obtain the *effective detection radius* (EDR), which provides a measure of the detectability in the study area. Larger EDRs suggest that detection is good at large distances, and the activity rate requires a smaller correction for undetected flights. Given that the detection efficiency decreases as we increase the distance, we can equivalently re-state the detectability as "100% of flights are observed within the EDR."

The EDR collapses an extended curve, which has decreasing detection with greater distance, into an equivalent, confined circular radius with 100% detectability. Given this area, the time spent at each site, and the observed flights, we can then project flights over the whole site, to assess eagle activity rates. Due to the unique site layout at St Patricks Plains, we have slightly modified the original methodology of Buckland et al. (2008), which is expanded upon in Section 2.1.1

To obtain a measure of uncertainty on the EDR, we use the bootstrap (Buckland et al. 2008). The bootstrap is a stochastic technique involving resampling of the dataset in order to obtain "replicate" sets. The variation in replicate sets can be used to estimate the population variance.

2.1.1 Modification of Buckland's method

The original methodology in Buckland et al. (2008) assumes each survey point is exchangeable. In other words, each `SITE_ID` is assumed to have the same visibility, the same amount of survey effort expended, and is sampling the same underlying flight rate. This is not the case in St Patricks Plains, where some site visibilities are obscured by forest, and different surveys have different time spent. There is also evidence to suggest (P. Barker, *pers. comms*) that flight density differs between forested and non-forested areas.

We have therefore developed an extension to Buckland's method. Our underlying assumption is there is a flight density (being flights per unit area per unit time) α for non-forested regions, and another density β for forested regions. We are expecting that $\alpha > \beta$ (P. Barker, *pers. comms*). However, this is not a constraint in the modelling - only the data determines α and β. We stratify, by observer location (`SITE_ID`) depending on whether a site is in forest or not. This is summarised in Table 5.

From our models, we obtain an EDR for the forested region, and an EDR from the non-forested region. Each EDR expands from a radial distance to a circular area[2] (called the EDA, *effective detection area*) which can be similarly interpreted: "100% of flights are observed within the EDA." We then overlay the provided forest / non-forest layers onto these circular areas, to account for the proportion of area which has a different visibility. This partitions the site into two strata - forest, and non-forest.

Each survey's observed flight density is estimated, using a modification to Equation 2.19 from Buckland et al. (2008). Our modified equation for flight density in survey k is $\hat{D}_k = n/\left[(\text{EDA})_k t_k\right]$, where n is the number of observed flights, and t_k is the time spent on that survey k.

Then, for each site i (and therefore each survey), we have a proportion F_i (the proportion of the EDA falling in forest) and a proportion P_i (the proportion of the EDA falling in non-forest)[3]. We expect the observed flight density $\hat{D}_i$ to be a weighted average of the true flight densities, where the weights are the proportions of the two strata, plus random noise (ϵ). Stated as an equation, this is

$$\hat{D}_i = \alpha P_i + \beta F_i + \epsilon.$$

We can solve for α and β using standard linear regression techniques. Scaling these flight density values by the amount of forest and non-forest area in the whole site gives an overall site flight rate.

[2]Via the usual equation for the area of a circle: $\text{EDA} = \pi(\text{EDR})^2$

[3]Because we stratify, any piece of land on-site falls in either the forest or non-forest, i.e. for each site i, $P_i + F_i = 1$.

Table 5: Forest classification of sites.

SITE_ID	Classification	SITE_ID	Classification
01	Non forest	13	Non forest
02	Non forest	15	Non forest
02b	Non forest	16	Forest
03	Non forest	17	Non forest
04	Non forest	17b	Non forest
05	Non forest	18	Non forest
06	Non forest	18b	Non forest
07	Non forest	19	Forest
08	Non forest	21	Forest
08b	Non forest	21b	Forest
09	Non forest	23	Non forest
10	Non forest	24	Non forest
11	Non forest	25	Forest
12	Non forest	25b	Forest

2.2 Results

Figures 6 and 7 summarise the distance at which flights were first detected (regardless of species), and a theoretical fit from a hazard-rate distribution, for the non-forested and forested flights respectively.

This is a good fit, for distance data. We don't plot any of the truncated upper part of the data, which were not used in the modelling.

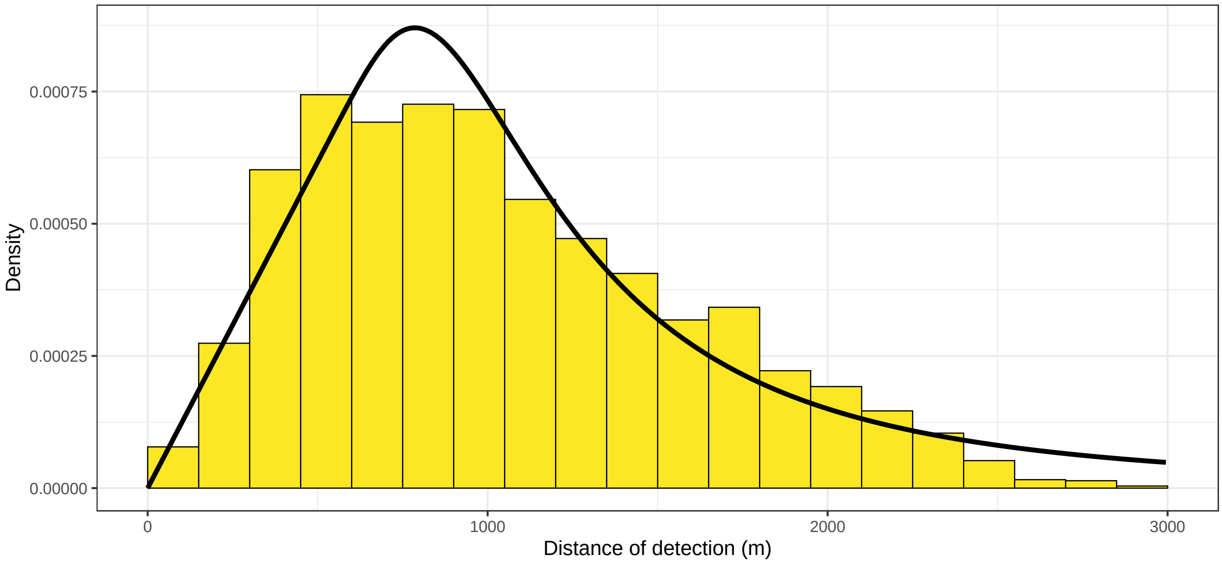

Figure 6: Non-forest observation points: histogram of (truncated) observed distances of detection. We have overlaid the fitted curve for detection distance.

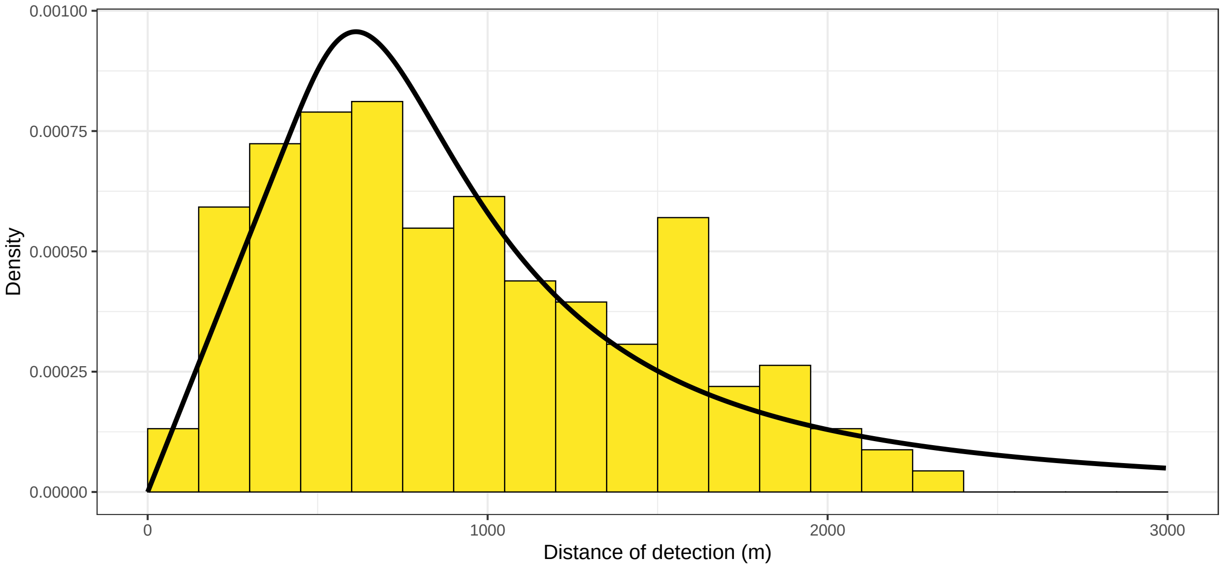

Figure 7: Forest observation points: histogram of (truncated) observed distances of detection. We have overlaid the fitted curve for detection distance.

The effective detection radius for all eagles (for observers at non-forested sites) is 1270 metres with a 95% confidence interval of (1210, 1340) metres. For observers at forested sites, the EDR is 1060 metres with a 95% confidence interval of (833, 1350) metres.

Table 6 provides distance-corrected activity rates. The site is defined to be area in which flights were observed, with a four km buffer[4]. The "forest" or "non-forest" status and areas was defined

[4]Technical note: we define the site dependent on the flights, rather than the provided wind farm spatial layer. This

by overlaying the study area with the appropriate layers in the provided forest shape file[5].

2.2.1 Summary of activity rates

Table 6 summarises the distance-corrected activity rates.

Table 6: Raw counts of (valid) observed flights, and distance-corrected activity rates with corresponding 95% confidence intervals. Valid flights are those which could be used in distance modelling.

Variable	TWTE	WBSE
Valid flights observed	3594	43
Flights/hr/ha (non-forest)	0.00313	4.76e-05
Flights/hr/ha (non-forest, 95% CI)	(0.0027, 0.00363)	(2.95e-05, 7.69e-05)
Flights/hr (non-forest total)	47.6	0.723
Flights/hr (non-forest total, 95% CI)	(41, 55.1)	(0.448, 1.17)
Flights/hr/ha (forest)	0.00125	3.59e-06
Flights/hr/ha (forest, 95% CI)	(0.000801, 0.00194)	(2.21e-07, 5.83e-05)
Flights/hr (forest total)	31.4	0.0903
Flights/hr (forest total, 95% CI)	(20.2, 48.9)	(0.00555, 1.47)
Flights/hr/ha (aggregated)	0.00196	2.01e-05
Flights/hr/ha (aggregated, 95% CI)	(0.00165, 0.00232)	(1.29e-05, 3.15e-05)

We note that this is applicable only to daylight hours when eagles are active on-site, which averages to 12 hours per day over the year.

is because our probability map of eagle flights allows flights to vary by chance, e.g. a flight which went from A to B one day is "smeared" as to allow the birds to take varying routes. The expanded boundary is required to make the equations align. More about the kernel smoothing can be found in Section 3.1.

[5] `TasVegAOI_ForestvNonForest_region.shp`. The forest area was taken to be 2.5164×10^4 ha, and the non-forest areas was taken to be 1.5179×10^4 ha.

3 Spatial mapping

Flight tracks were recorded by North Barker and provided as GIS set. The tracks were then "smoothed" over the surrounding area using kernel functions, which then provides a two-dimensional probability map over the study area.

3.1 Methods - kernel smoothing

To understand the relative spatial patterns in flight density we need to transform the individual flight tracks into a smoothed probability map for the whole area. The flight points are "smoothed" using a kernel function (Figure 8 illustrates the concept with a simpler 1-dimensional method, whereas our method operates in 2 dimensions)[6]. For an introduction to kernel methods in ecology see Worton (1989) or Fulk and Quinn (1996) for more detailed mathematics.

The resulting maps are a visualisation of the conditional likelihood that a flight will be seen at a particular location, relative to the other locations. That is, it answers the question: "if a flight exists in the study area, where is it likely to be?"

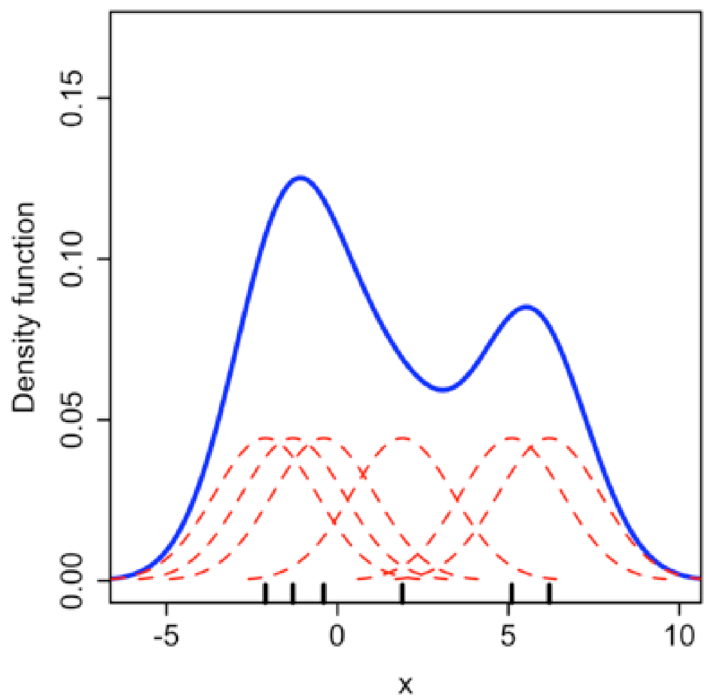

Figure 8: Schematic of kernel methods. The contributions of individuals points (small vertical lines along the x axis) are smoothed using a kernel (red dashes curves). The overall density is the combination of all the kernels (blue curve).

We used a W4 kernel function with smoothing parameter $h = 2000$ metres. This kernel function

[6] "Comparison of 1D histogram and KDE". Created by Drleft and edited by A. Jackson (Symbolix). Available under the Creative Commons Attribution-Share Alike 3.0 Unported license.

has a Gaussian-like shape, but compact support - a single point on a flight path is smoothed to no more than $2 \times h$ metres away from the original point. While the smoothing, to some degree, provides a safety buffer to account for the difficulty of recording exact flight tracks, mostly we smooth to account for natural flight variability, to answer: “even though an eagle flew here today, if it flew again, where is it likely to be?”

Prior to smoothing, we re-spaced the points on the flight path to a consistent distance (10 metres). The raw flight paths had point spacing from anywhere between 0.88 and 507 metres, which meant that if we smoothed on the raw data, some flight paths would erroneously contribute more weight to the spatial map than others. Once re-spaced, the contribution of each flight to the spatial map was proportional to its length.

3.2 Low visibility areas

Some areas of the site were noted as having low visibility to the observers. These areas were provided as a shapefile[7].

For these areas, we imputed an activity rate based upon whether that part of the low visibility area fell into the forest or non-forest stratum. The imputed value was taken to be the mean utilisation value of that stratum.

The imputed rates can be seen in Figure 9 as hatched areas.

3.3 Results

Figure 9 plots the contours of utilisation for WBSEs and TWTEs combined (we did not think there was enough WBSE data to justify separating the kernel analysis). The green and yellow contours have the higher levels of utilisation, and the utilisation level decreases as the colour tends towards blue and purple.

[7] DataGapvsFewFlights_region.shp.

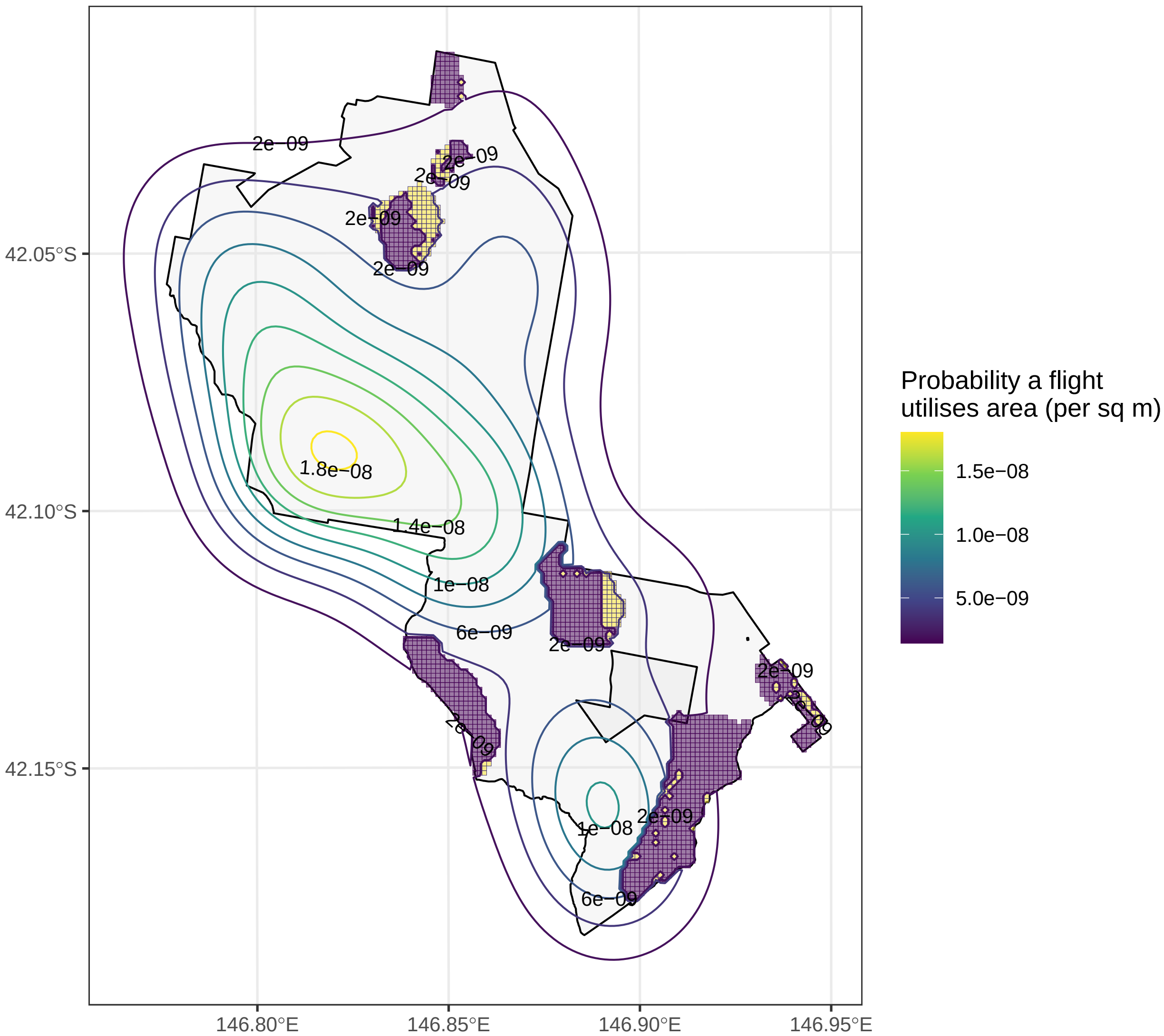

Figure 9: Contour map of eagle utilisation, overlaid on the study area (boundary line). This combines the spatial mapping / kernel smoothing with the observed metres of eagle flights over the whole farm. We note that the cross-hatched areas were flagged by North Barker as having limited visibility, and have been imputed by the mean of the stratum (forest or non-forest).

In Figure 9, we can see that eagles have the highest flight density in the mid-west, and south, of the site. We observed some level of utilisation over most of the site.

In Figure 10, we can see there are some seasonal differences in the contour maps.

Year 1: The first season (Winter 2019) sees most eagles in the northwest and south of the site. The second season (Spring 2019) see the majority of flights in the north of the site, particularly in the west of the site. There's a secondary high flight density zone in the south. The third season (Summer 2020) sees the most flights in the mid-west. The fourth season (Autumn 2020) has the highest concentration of flights in the centre of the site.

Year 2: Winter 2020 has the highest concentration of flights in the mid-west of the site. This is also the case for Spring 2020, although the spread in Spring 2020 is greater compared to that of Winter 2020. In Summer 2021 and Autumn 2021, we see that while the centre of the site is still being utilised, the south also sees some utilisation (particularly Summer 2021).

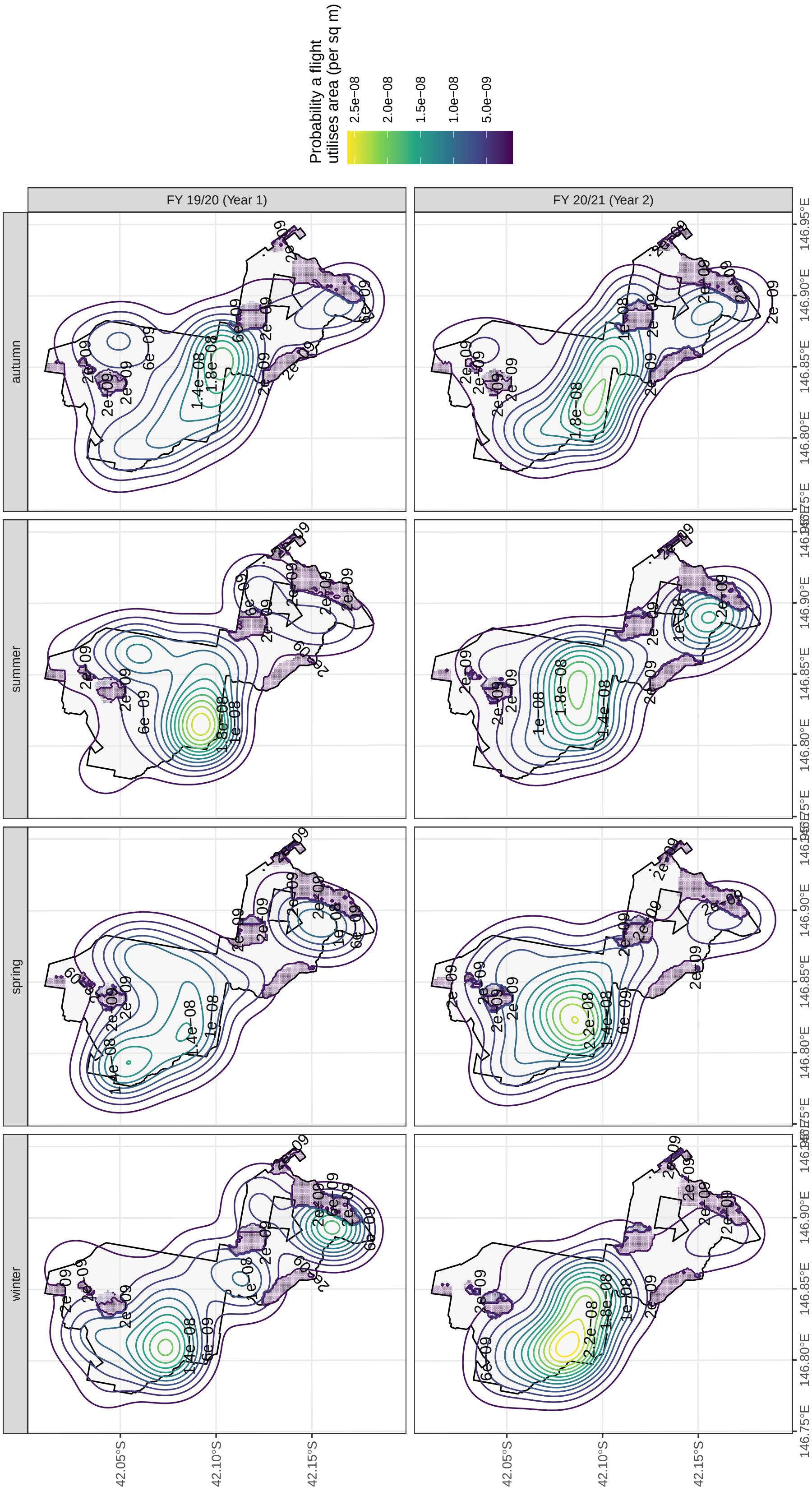

Figure 10: Contour maps of eagle utilisation, overlaid on the study area (boundary line), and split by season.

4 Annual collision rates

4.1 Methods - collision risk modelling

Collision risk modelling (CRM) requires a step-wise risk model (Reason (1997)), where the total risk is the probabilistic combination of the risk of each step in the process. The process can be summarised by the equation:

$$N_{\text{collision}} = F \times P(I|F) \times P(C|I) \times (1 - \text{AR})$$

where:

- $N_{\text{collision}}$ is the estimated number of flights ending in collision (collisions / unit time)
- F is the estimated activity rate of flights in the region (flights / unit time)
- $P(I|F)$ is the probability of a flight interacting with a turbine or powerline, given a flight in the region
- $P(C|I)$ is the probability of collision, given an interaction occurs
- AR is the avoidance rate

To obtain the F term in the equation (that is, the estimated activity rate of flights in the region), we take the activity rate and expand it to flights over a year, accounting for the proportion of time the bird is on-site during the year, and the proportion of time that the bird is active. This is discussed in Section 2.

The probability of interaction component (the $P(I|F)$ term) in W. Band, Madders, and Whitfield (2007) includes an unreasonable assumption that every flight interacts with every turbine. The NA-BAND model used here uses spatial statistics to estimate the probability of interaction for each turbine, removing the reliance on that assumption. Additionally, at this site we also account for the predicted turbine downtime (which is due both to wind speed and maintenance).

The probability of collision given interaction (the $P(C|I)$ term) is generated using the exact model published by Band et al. (W. Band, Madders, and Whitfield (2007), B. Band (2012)).

An important note is that the NA-BAND model has no assumption about the likelihood that an individual bird would be replaced in the local area if it is struck. The model estimates the number of flights that are at risk of collision under the assumption that any breeding resident bird is immediately replaced. This estimate of flight collisions may be higher than the actual individual collision rate, if a struck bird is not rapidly replaced in the region.

4.2 Model inputs

The NA-BAND model requires a number of turbine-related and bird-related input parameters, which are summarised in Table 7 and 8 respectively. The turbine locations were provided in a spatial layer[8].

[8] 20210604 47WTG Layout.shp

Table 7: Turbine inputs for the NA-BAND model.

Variable	Value
Rotor diameter (m)	162.0
Hub Height (m)	150.0
Maximum chord (m)	4.3
Rotation period (s)	8.0
Pitch (degrees)	10.0
Number of turbines	47.0

All values in Table 7 (except hub height) inform the NA-BAND model's $P(C|I)$ term. The hub height, in conjunction with the rotor diameter, informs the rotor swept height. In combination with the set of empirical heights from the survey, this provides a scaling factor for the proportion of flights which could interact with the rotor. This scaling factor is 47%.

Table 8: Bird inputs for the NA-BAND model.

Variable	Value
Length (m)	1.0
Wingspan (m)	2.1
Flight speed (m/s)	17.0
Flapping (0 = flapping, 1 = gliding)	1.0
% year on site	100.0
% daylight hours active	100.0
% night time hours active	0.0

Furthermore, we were provided hourly data on the predicted operating status of the wind turbines[9], and the predicted turbine downtime due to maintenance (3%). Combining these values, during eagle active hours[10], allowed us to predict the "uptime" (the proportion of the time the turbine is actually turning). This provides a scaling factor for each turbine, which is summarised in Table 9.

[9] 20210531_SPP_eagle_data_update.zip - this depends on the cut-in speed of each turbine.
[10] Defined here as 6am to 6pm.

Table 9: Proportion of 'uptime' for each turbine, during times the eagle is active.

Turbine	Uptime (%)	Turbine	Uptime (%)
1	70	39	50
2	87	42	50
3	60	43	49
4	60	44	47
6	62	45	51
7	69	46	49
8	59	47	70
9	69	48	51
11	51	49	50
12	61	50	50
13	59	51	49
14	60	52	59
15	50	53	58
16	52	54	69
17	50	55	85
18	49	56	54
19	48	57	85
20	50	58	84
25	50	59	64
29	62	68	70
30	52	69	62
31	54	70	55
32	51	71	84
33	52		

4.3 Results - annual collision rates

Annual collision rates (based on the turbine and bird parameters in Tables 7 and 8, (predicted) operational data in Table 9, and activity rates in Table 6) are summarised in Table 10.

Table 10: Predicted annual number of collisions per target species, by avoidance rate.

Species	0.9	0.95	0.99
Wedge-tailed eagle	4.8900	2.4400	0.48900
White-bellied sea eagle	0.0503	0.0252	0.00503

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Carcass monitoring – statistical considerations

Prepared for North Barker, 13 July 2020, Version 0.9 For Review

This document outlines suggested best practice for manual carcass detection and mortality estimation at Patricks Plains Wind Farm, Tasmania.

We note that mortality searches and estimation is an area of ongoing research worldwide. As such our advice is guided by a combination of statistical tests, current best practice, and practices on-ground at other Australian wind farms (as this increases the ability to compare sites in future).

Symbolix has delivered carcass monitoring design (and analysis of results) at wind farms in Tasmania, Victoria and NSW. In addition to published literature, we draw on these results and data to inform the recommendations below. Unfortunately, the design and results of these studies are not always publicly available, so not everything in this memo can be directly referenced to literature. Where references are not provided, the recommendations are based on unpublished data from other Australian sites. We also note that we are willing to provide further details and discussion on any of these points, to assist in developing robust a survey program for Patricks Plains Wind Farm.

Objectives of the monitoring program

The objectives of the plan are two-fold:

1. **Adaptive management monitoring.** To inform adaptive management through targeted monitoring of species of interest. This data would be used to track performance against management triggers. This would focus on Tasmanian Wedge-tailed Eagles.
2. **Avifauna mortality estimation.** To track site impacts on local avifauna through collision counts and estimated rates. For this objective it is beneficial to choose methods that allow comparison with other sites.   To enable comparison (and ensure sufficient data for analysis) we recommend that this objective requires data on the entire cohort of species subject to turbine collision (not just species of concern).

In designing a mortality monitoring program, we attempt to make choices that provide the most precise estimate of overall mortality, within the logistic constraints of time, observer fatigue and OH&S.

Study program components

Adaptive management monitoring

To achieve the first objective listed above whilst acknowledging physical resource limitations (i.e. how much ground an observer team can reliably, regularly survey) we recommend a complete scan of the area around each turbine on a regular basis.

This would complement the more formal search program for objective two.

The scan would achieved through a single drive around of all turbines during the formal survey period, or ATV searches (if the roads do not provide adequate access). Raptors are large, visible birds and this sort of informal survey has detected carcasses at other Australian sites.

It should also involve training of onsite staff to recognise and record raptor carcasses.

Adaptive management triggers will be associated with the count of carcasses found, prior to any estimate of total mortality. It is common in Australia that management actions commence after finding a small number of carcasses of species of interest.

Avifauna mortality estimation

This component requires a structured, statistically designed survey program to sample random turbines for carcass searches. This enables an estimate of collision mortality that can be compared with other sites, provided two adjunct studies are carried out to enable estimates of undetected mortality.

- Searcher efficiency trial. This determines the average efficiency of the observer team
- Scavenger rate trial. This determines how quickly carcasses are lost to scavenge.

Statistical mortality estimation

To detect any collision requires a number of factors to align.

1. First, there must be a collision at the site;
2. The collision must be at a turbine included the carcass searches;
3. The carcass must land inside the searched area (noting the total 'fall zone' differs depending on the size of the turbine and size of the carcass);
4. The carcass must not be removed (by decay and/or scavenge) from the search area prior to the search; and
5. The observer must observe the carcass (i.e. not miss it because of obstruction or imperfect vision).

The schematic in figure 1 demonstrates the complexity involved in step 4 and 5 (carcass loss vs searcher efficiency and survey timing).

Each row presents a single carcass scenario. **A** and **B** show a simple competition between scavenger and observer. **A** is lost in the time between collision and survey, but **B** is not.

In **F**, **G** and **H** the survey is scheduled almost immediately after the collision. **F** is found, **G** is lost to scavenge immediately and **H** is lost later, due to being missed in the first survey. Because of the inherent statistical uncertainty it's quite plausible a carcass will be lost very quickly (even if the average time to loss is days or weeks).

The carcasses found in formal surveys can be thought of as a sample of the (initially unknown) population of all carcasses. A good program offers randomly sampled, representative observations of the site area where collisions might land, times, and conditions.

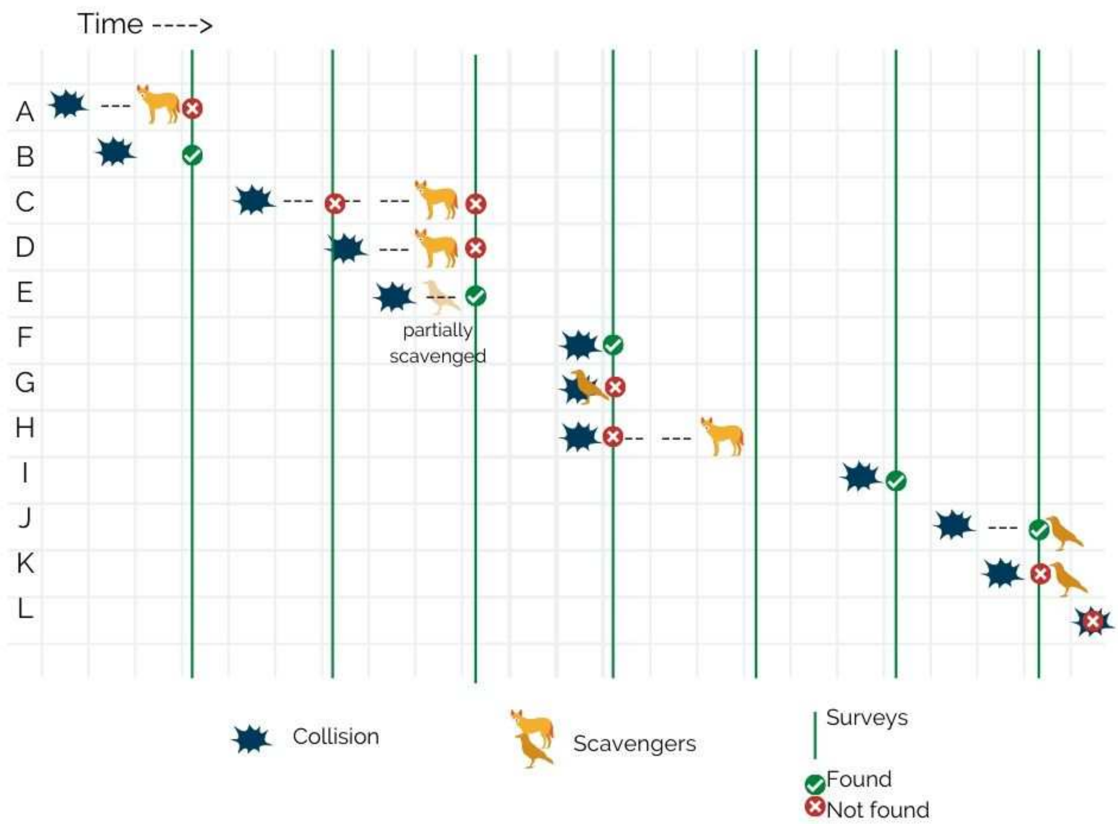

Figure 1: Schematic showing different scenarios of scavenger loss, searcher efficiency and survey timing

Estimating total mortality due to collision

Mortalities at turbine ***i*** during search ***j*** ($\hat{M}_{ij}$) are estimated by (Huso, Dalthorp, and Korner-Nievergelt (2015) and references therein)

$$\hat{M}_{ij} \sim C_{ij} / (\hat{g}_{ij}) \qquad (1)$$

where

• C_{ij} is the number of carcasses found

• $\hat{g}_{ij}$ is the estimate of the detection probability for that search and turbine

For a given turbine, $\hat{g}_{ij}$ is a function of

$$\hat{g}_{ij} \sim a_i \, r_{ij} \, p_{ij} \qquad (2)$$

• a_i is the fraction of total carcasses within the searched area

• r_{ij} is the fraction of the carcasses that arrived at turbine ***i*** but have not been lost to scavenge or decay before search ***j***

• p_{ij} is the probability that an existing carcass will be detected by the searcher

Through field surveys we can estimate $\hat{a}$, $\hat{r}$ and $\hat{p}$. ***C*** is given by the field observation data. It's important to highlight that this approach does not require that all or even most carcasses are found. We allow for loss of carcasses through scavenge and some carcasses not being detected during surveys through $\hat{r}$ and $\hat{p}$. So, this approach depends upon scavenger efficiency trials and searcher efficiency trials being performed in accordance with best practices as outlined below to obtain good estimates of scavenge rate and detectability. Additionally, appropriate survey design is important so that we can be confident that the carcasses found are a representative sample of the population of all carcasses.

Equation 1 can be estimated using an analytical method (e.g. Huso 2011) or using hybrid simulation algorithms (*GenEst* or Stark & Muir 2020 in prep). Any method must account for

- the fraction of the carcass distribution searched,
- the fraction of turbines searched,
- the searcher efficiency,
- the rate of scavenge relative to the search interval.

The use of the best practices given below will help ensure that even if not all carcasses are detected, the mortality estimates will be close to the true number of mortalities. Unavoidably, mortality estimates for species with lower collision rates where few or no carcasses may be found (e.g. threatened species with low local populations) have wider confidence bands. This means that there is greater uncertainty around them because the proportion of carcasses detected is more variable when the numbers are very low. That is why we recommend a backup site 'scan' for Tasmanian Wedge-tailed Eagles to maximise detection. We also recommend that adaptive management triggers are based on carcasses found, not estimates.

The turbine area to be searched

Using the methods in Hull and Muir (2010) we assessed the fall zone estimate using the expected turbine parameters (maximum hub height of 150m, with a maximum blade length of 90m).

A search radius of 120m around each turbine will cover 87% of the fall zone for birds (73% for WTEs) and give 100% coverage for small birds/bats. We account for the proportion of the fall zone that isn't surveyed in the a_i expansion factor in Equation (2).

Transect spacing

Transect spacing should be decided based on your assessment of visibility and time constraints, and final turbine size. We recommend smaller transects in the inner zone and larger in the other zone. For example:

- 5m transects to 60m from the turbine base and
- 12m transects from 60m to 110m

Would cover the majority of the fall zone for all sizes of bird. Assuming circular transects, this results in around 4.5 – 5km of walking for each turbine. At a walking pace of 3km/hour it would take around two hours to survey a turbine. These numbers would differ if quad bikes or dogs are used, but this is a realistic baseline for calculating the survey resources required.

Number and location of turbines

Turbines to be surveyed should be selected at random (assuming all turbines are accessible). This is the only way to enable an unbiased estimate of mortality. Prior to surveying,we cannot determine if certain turbines have a higher risk than others.

If different vegetation types are suspected to result in different searcher efficiency the site should be stratified based on the vegetation cover. Searcher efficiency and scavenger trials should be replicated within each stratum. We recommend the number of turbines searched in each stratum be a constant proportion of the total turbines in that stratum (e.g. 25%).

We do not specify that all turbines be searched, nor suggest a specific set fraction, as there exist standard techniques to account for the fact that a subsample was selected (including all modern mortality estimators, back to seminal texts such as Kish 1965).

Ultimately, the number of turbines that can be consistently and meaningfully surveyed within a reasonable time would be constrained by resourcing and logistics. For a site with 50 turbines, selecting 20 for survey would provide coverage across the site and balance resources. If it takes two hours to survey a turbine, then 20 turbines should be measurable in 3-4 human days of survey.

We recommend the same turbines be visited each time. This allows for any seasonal patterns to emerge, and is a required for accurate mortality estimation for some of the modern estimators.

The simplest design is to randomly select turbines throughout the site. If the site contains different habitat (e.g. cleared pasture and long grass) it can be stratified. In order to determine an overall mortality rate, it is important that the turbines be randomly selected within each stratum. You could choose an equal number, or equal proportion of turbines in each land type, but this is not critical. Statistically, we would require a barest minimum of 3-4 turbines per stratum.

Survey frequency and timing

For reliable mortality estimates, it is preferable that the survey timing be similar or less than the expected scavenge time (see below). This is managable for larger birds like Tasmanian Wedge-tailed Eagles (where evidence can remain in place for weeks or even months), but is difficult to achieve for micro-bats and smaller birds, which can be completely scavenged within a few days.

If large birds are the primary focus of the mortality estimates, monthly searches are sufficient. To estimate mortality of all sizes, we would recommend a pulsed monthly survey, where:

- The entire search region for each turbine in the sample is surveyed once per month. They are searched out to 120m.
- Two to three days later a targeted bat/small bird survey is done, where each turbine is revisited and only the inner-most region done (so this is a quicker survey).

This balances the need to obtain coverage of the larger region to ensure that large birds are detected, with the need to 'beat the scavengers' by surveying more frequently surveying for bats.

The search strategy and commencement date / Survey duration / Inclusion of met masts / fatgue management plan etc

Carcass searches

• Either human of dog observers can be used. Detection of birds is not significantly differently between human and dog observers, whereas dogs are better at finding bats (Stark and Muir (2020)).

Searcher efficiency trials

Detectability trials provide an estimate of surveyor efficiency under the carcass search conditions.

We suggest 20 replicates per carcass size class per stratum per year (10 in spring, 10 in autumn), which will provide a reasonable detectability estimate after one year, and optimal after two.

Even with 20 replicates per season, it is unlikely that a statistically significant difference between two groups (e.g. season groups, ground type, carcass size etc.) can be determined unless the difference is 20 to 30 percentage points.

- We suggest randomly selecting turbines at which to place carcasses to account for possible variation in detectability between them.
- These trials must be carried out using the same methodology as used for the mortality surveys. For example, if circular transects are used in the main survey, the detectability trials must also use circular transects with the same spacing etc. If two surveyors undertake the surveying, they should both be represented in the detectability trial.
- We would advise using both birds and bats in the trials if mortality estimates for both are required. Birds, particularly medium and larger species, are generally easier to observe.
- If (for example) only bats were used in the detectability trial, this would likely result in an under-estimate of the bird detectability, and thus give an over-estimate of the total bird mortality. If mortality estimates for bird species in different size classes are required, trials should use bird carcasses of different sizes.
- If it is difficult to source real bat carcasses (for example), surrogates such as mice are an option.

Scavenger efficiency trials

Scavenger efficiency trials allow us to estimate the average time until complete loss from scavenge.

Often, we may only know the time period during which a scavenger took the carcass instead of a precise time. This could be a specific night, or maybe a few days. At other times, the carcass may remain within the test area at the end of the trial. We accommodate this by using a survival analysis (Kaplan & Meier, 1958 or Miller 1997 for a more recent reference) to estimate time to scavenge. This approach can mathematically account for the fact that you never know the time of loss exactly, only to within a "window".

Note that data from sites that employed cameras (thus giving exact time of loss) can also be incorporated into this method.

- We recommend a minimum sample size of 10 replicates carcass size class per stratum per season.
- Running scavenger trials concurrently with detectability trials (10 replicates, twice per year) is reasonable to establish the rate and "shape" of scavenge for the purpose of mortality estimation.
- Carcasses should be checked more frequently earlier in the trial and less frequently towards the end. This is because we will typically only know the time period during which a scavenger took the carcass instead of a precise time, and having a large interval early in the trial increases the uncertainty around estimates of scavenge rate.

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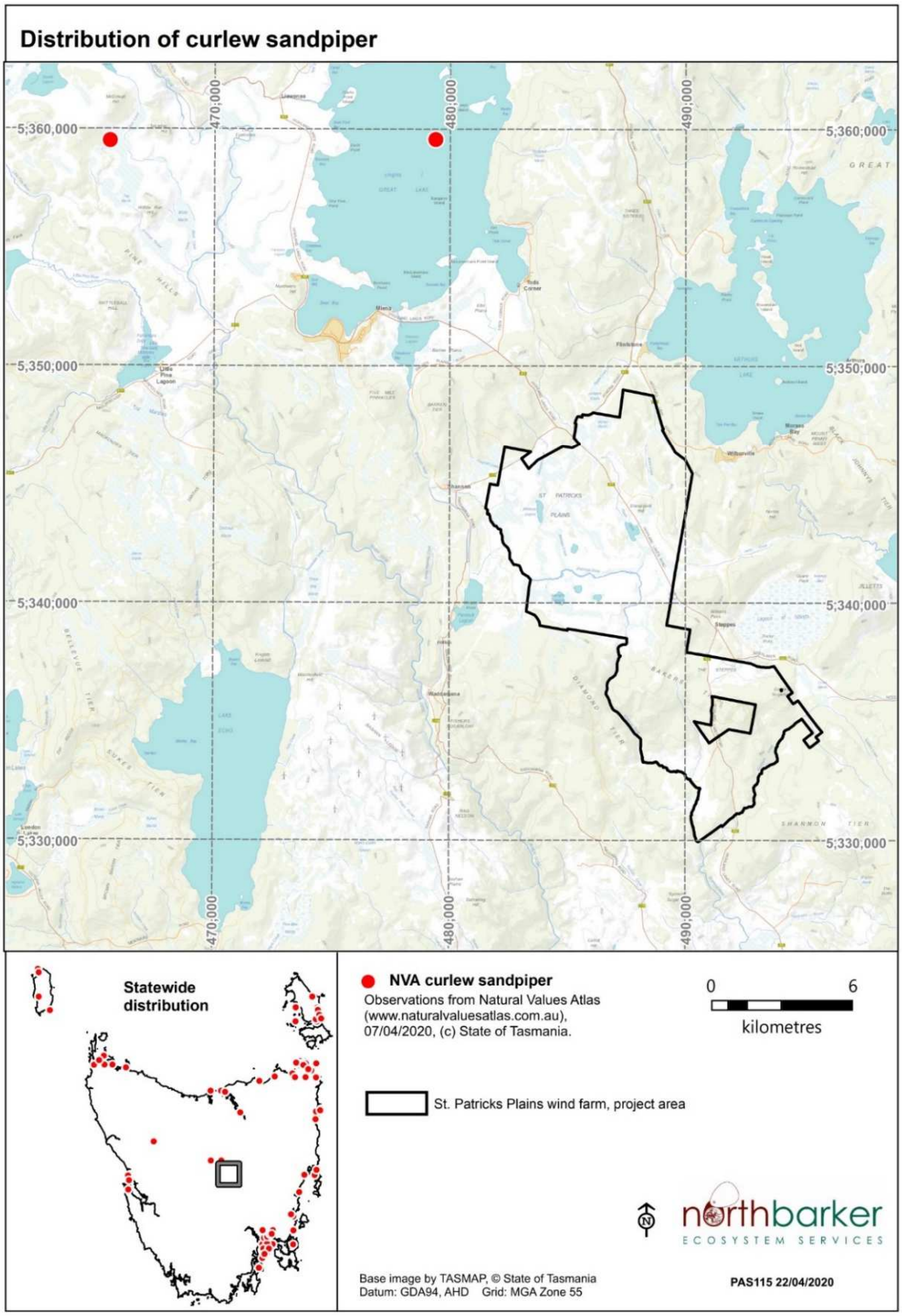
Distribution of curlew sandpiper
5,360,000
5,350,000
5,340,000
5,330,000
470,000
480,000
490,000
Statewide distribution
NVA curlew sandpiper
Observations from Natural Values Atlas
(www.naturalvaluesatlas.com.au),
07/04/2020, (c) State of Tasmania.
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St. Patricks Plains wind farm, project area
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Base image by TASMAP, © State of Tasmania
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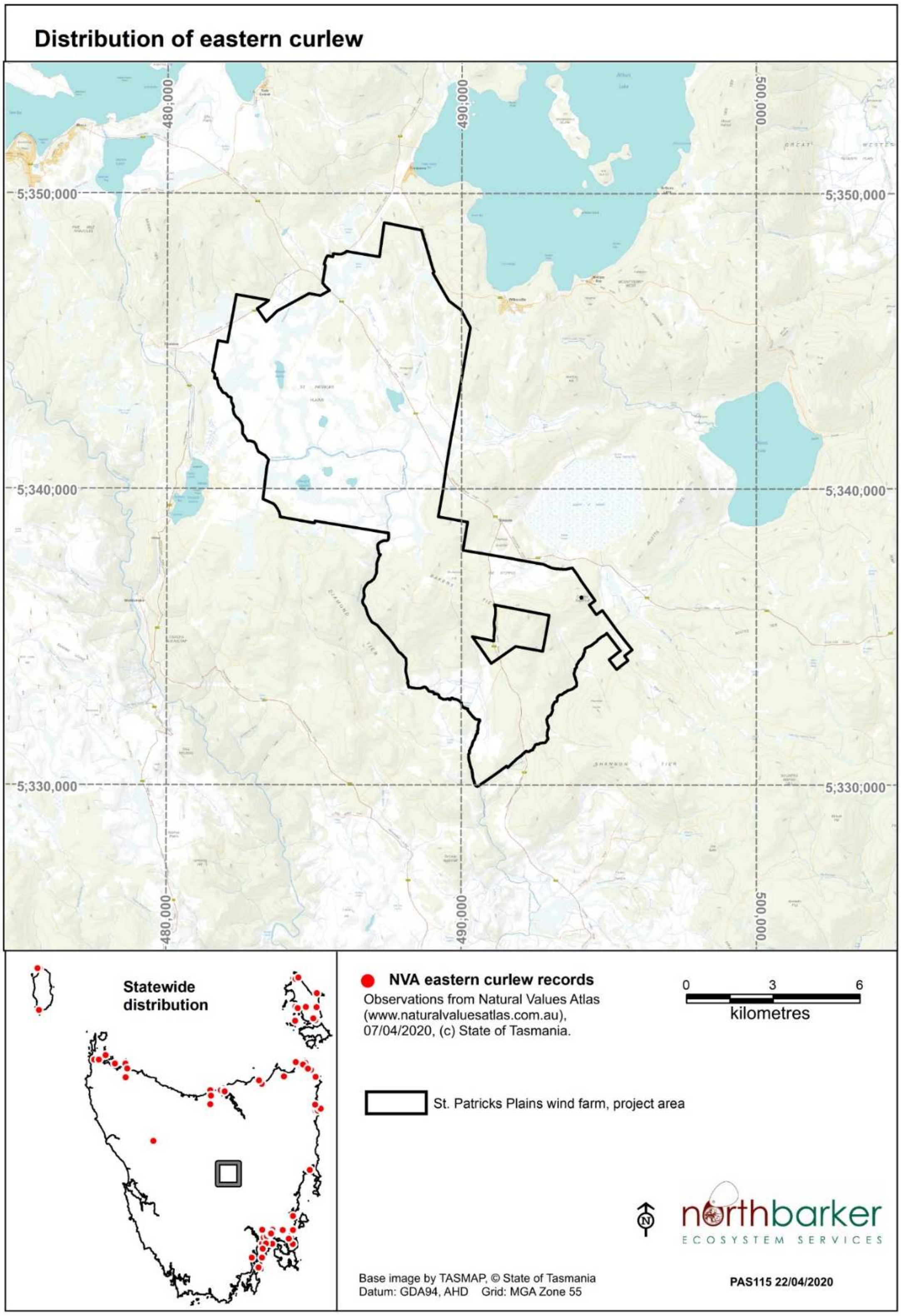
Distribution of eastern curlew
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Statewide distribution
NVA eastern curlew records
Observations from Natural Values Atlas (www.naturalvaluesatlas.com.au), 07/04/2020, (c) State of Tasmania.
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St. Patricks Plains wind farm, project area
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Base image by TASMAP, © State of Tasmania
Datum: GDA94, AHD Grid: MGA Zone 55
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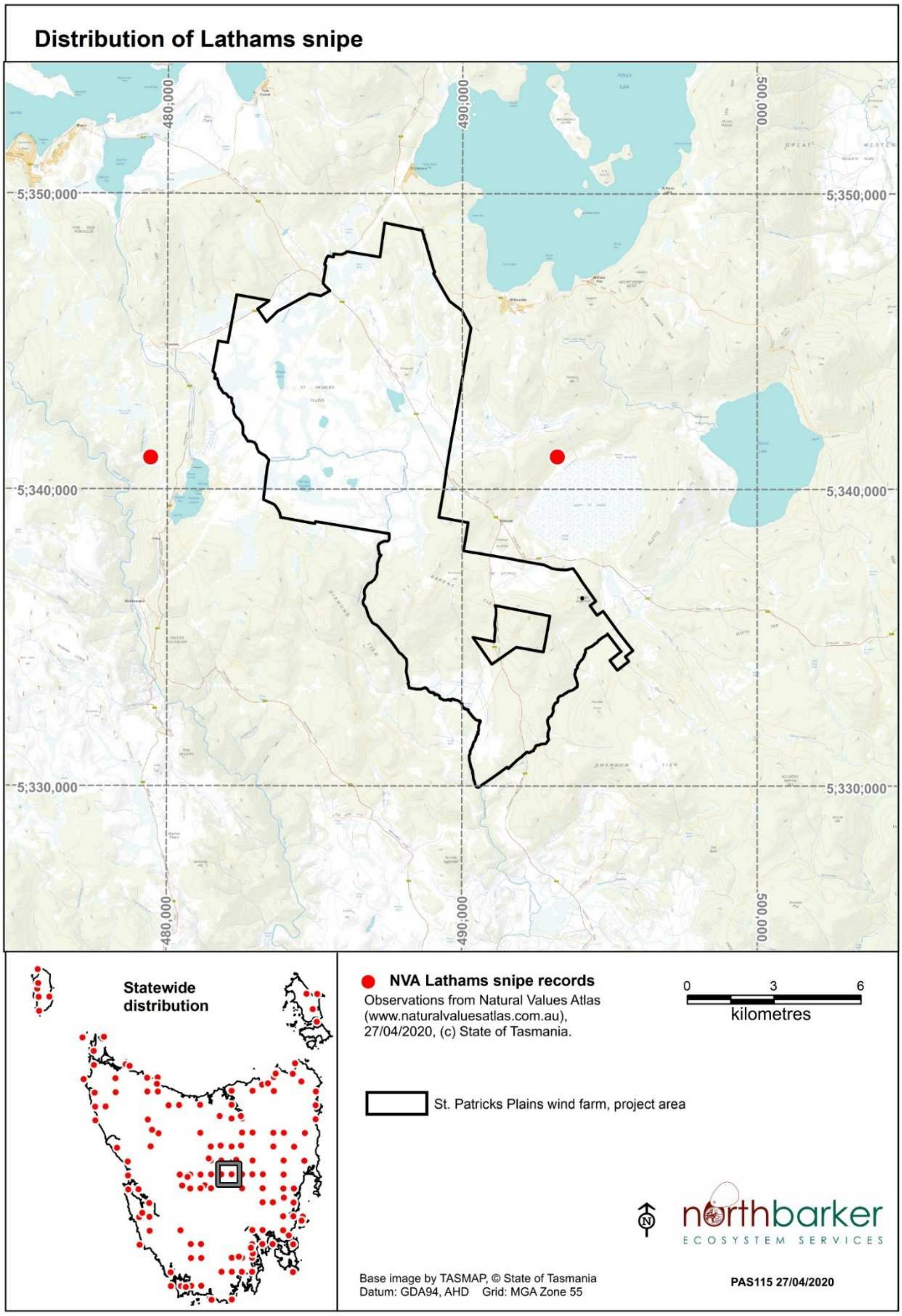
Distribution of Lathams snipe
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Statewide distribution
NVA Lathams snipe records
Observations from Natural Values Atlas (www.naturalvaluesatlas.com.au), 27/04/2020, (c) State of Tasmania.
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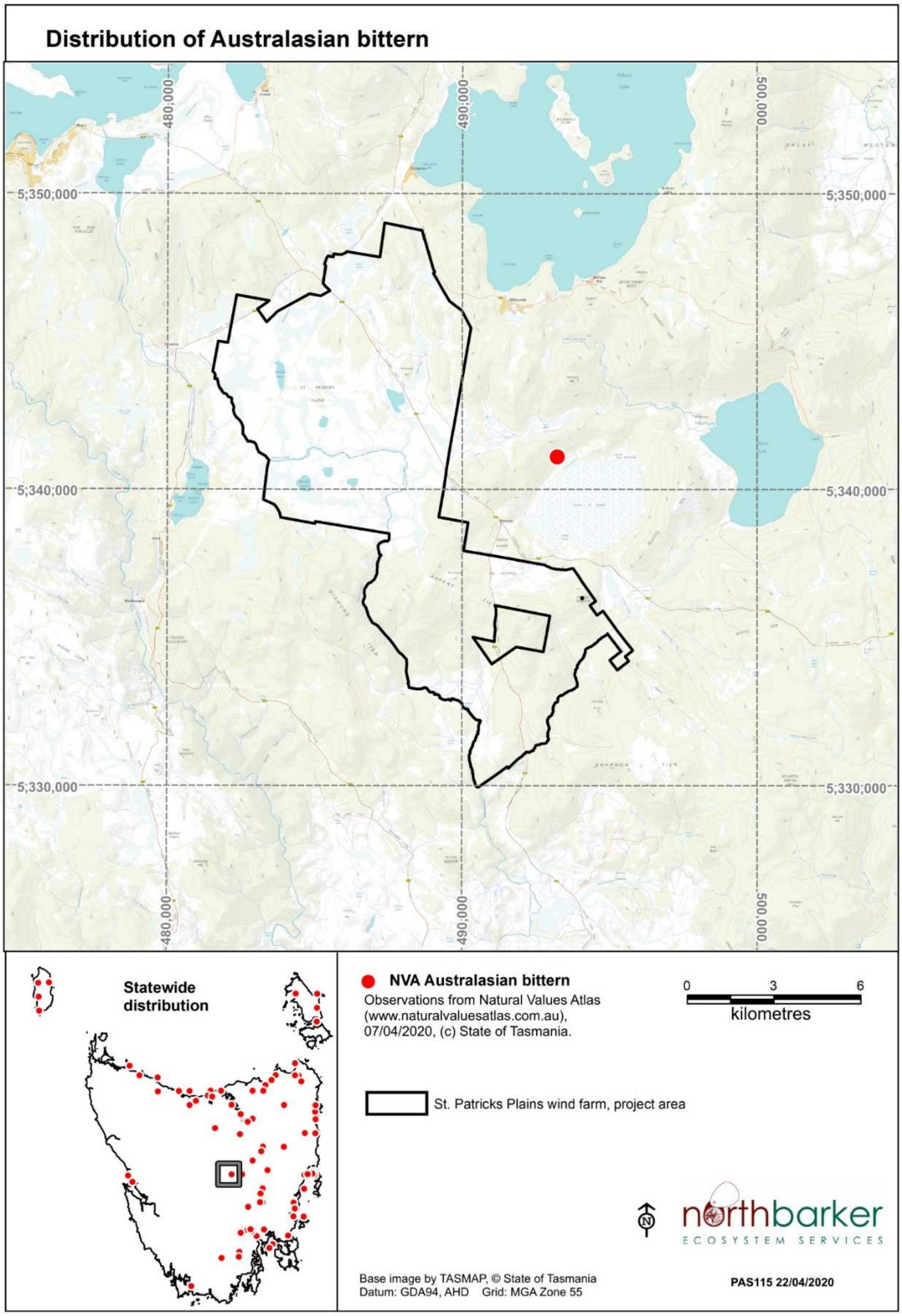
Base image by TASMAP, © State of Tasmania
Datum: GDA94, AHD Grid: MGA Zone 55
PAS115 27/04/2020


Distribution of Australasian bittern
480,000
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5,350,000
5,340,000
5,330,000
Statewide distribution
NVA Australasian bittern
Observations from Natural Values Atlas (www.naturalvaluesatlas.com.au), 07/04/2020, (c) State of Tasmania.
0 3 6
kilometres
St. Patricks Plains wind farm, project area
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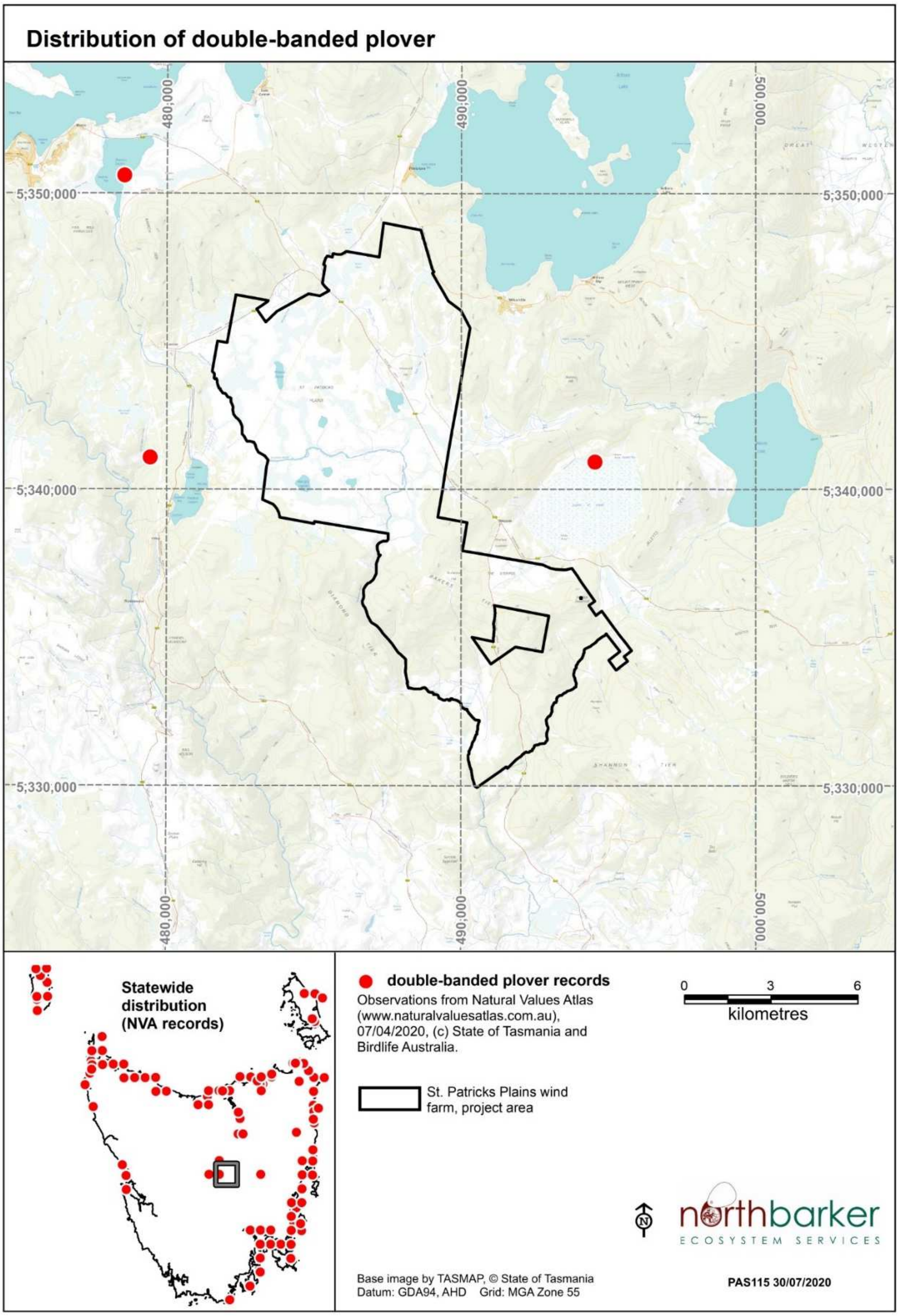
northbarker
ECOSYSTEM SERVICES
Base image by TASMAP, © State of Tasmania
Datum: GDA94, AHD Grid: MGA Zone 55
PAS115 22/04/2020


Distribution of double-banded plover
480,000
490,000
500,000
5;350,000
5;340,000
5;330,000
Statewide distribution (NVA records)
double-banded plover records
Observations from Natural Values Atlas (www.naturalvaluesatlas.com.au), 07/04/2020, (c) State of Tasmania and Birdlife Australia.
St. Patricks Plains wind farm, project area
0
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kilometres
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ECOSYSTEM SERVICES
Base image by TASMAP, © State of Tasmania
Datum: GDA94, AHD Grid: MGA Zone 55
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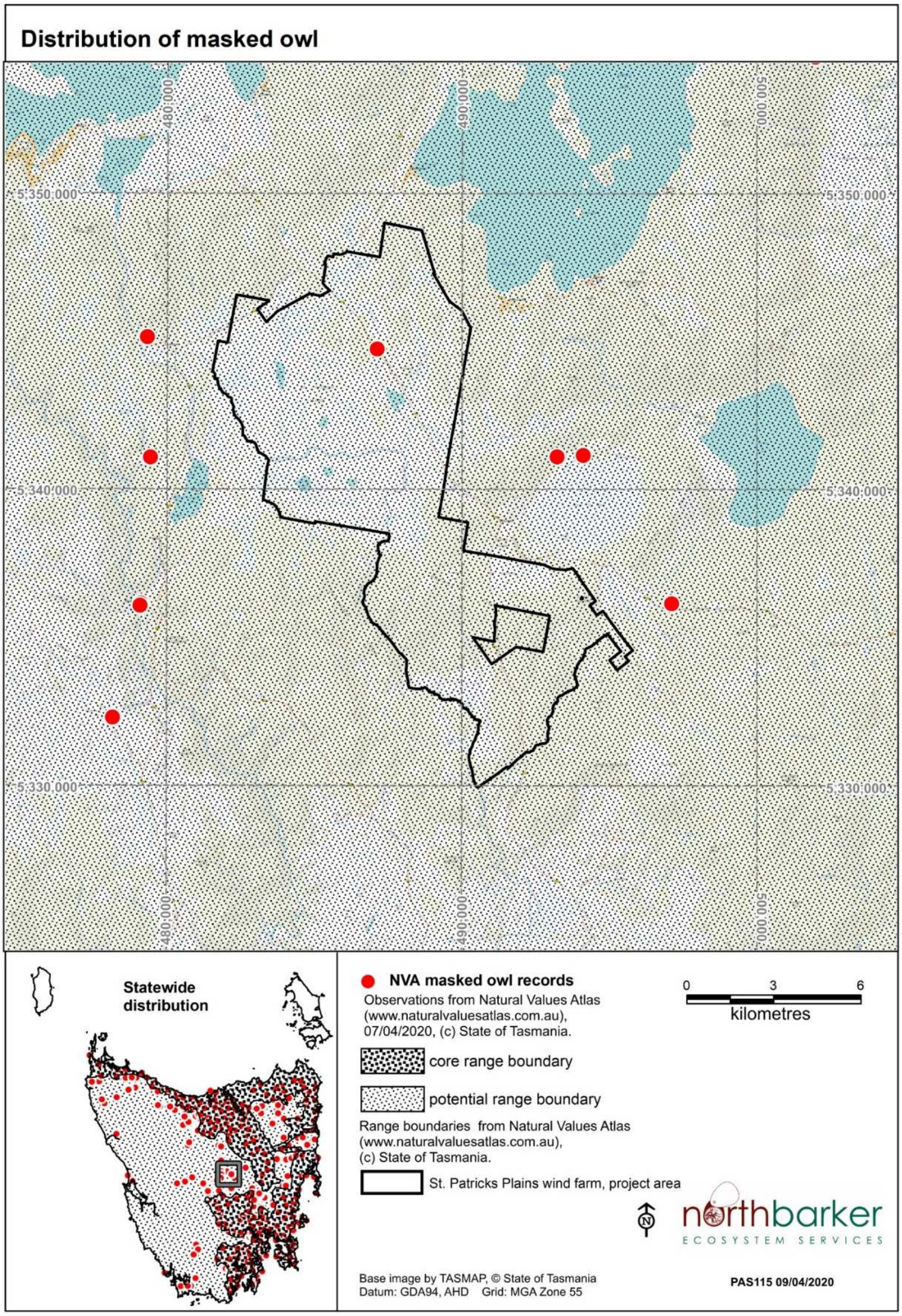
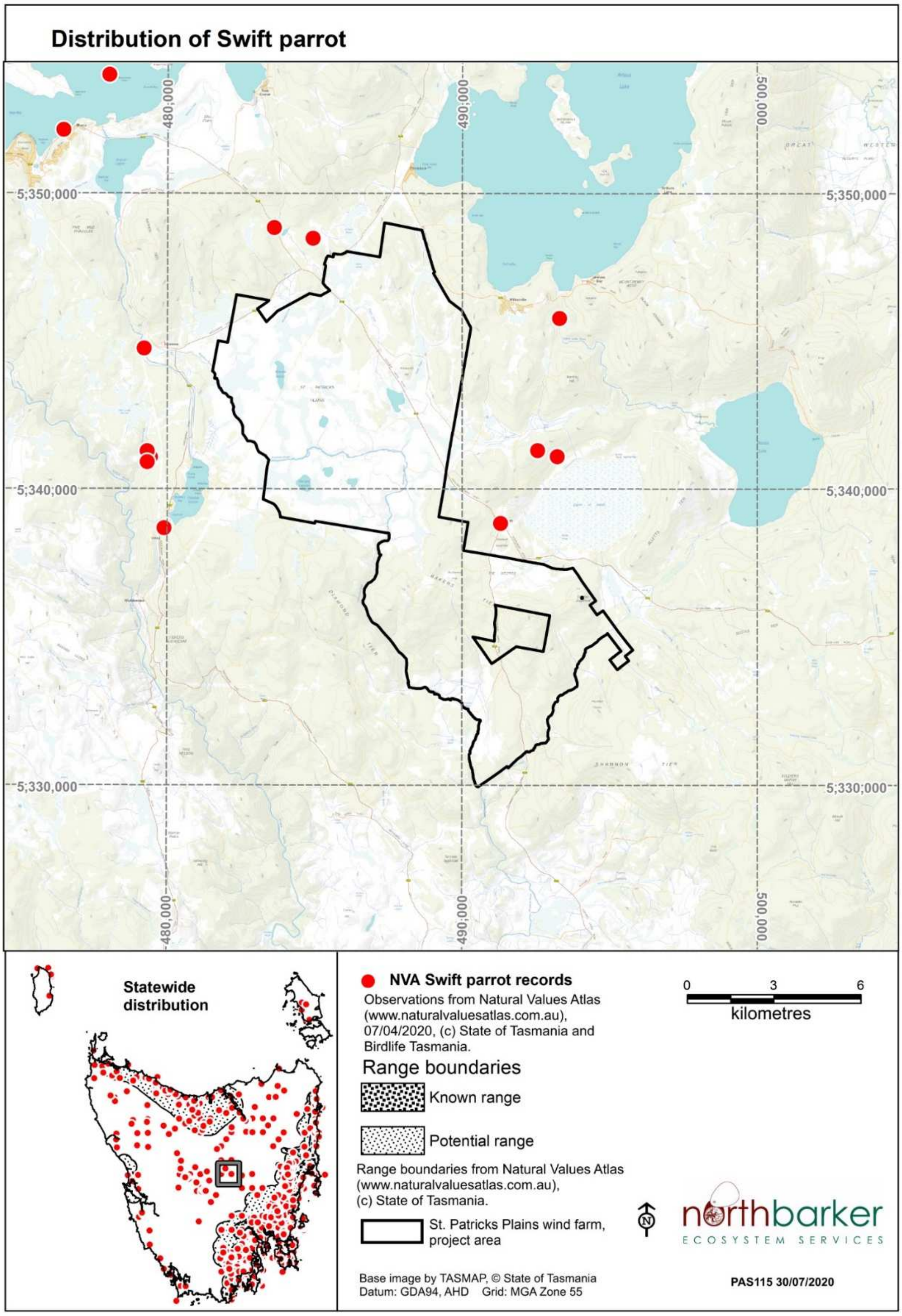
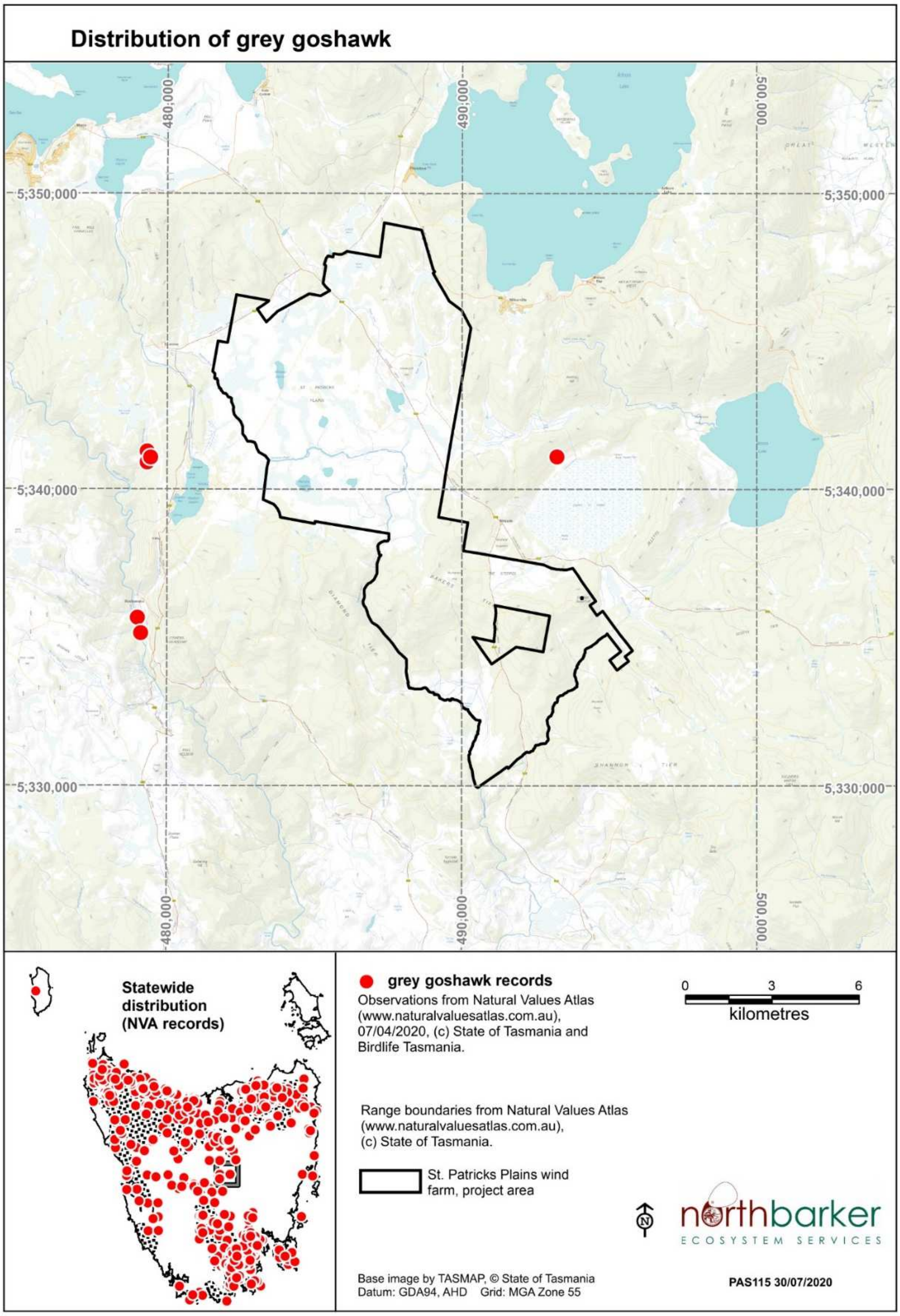
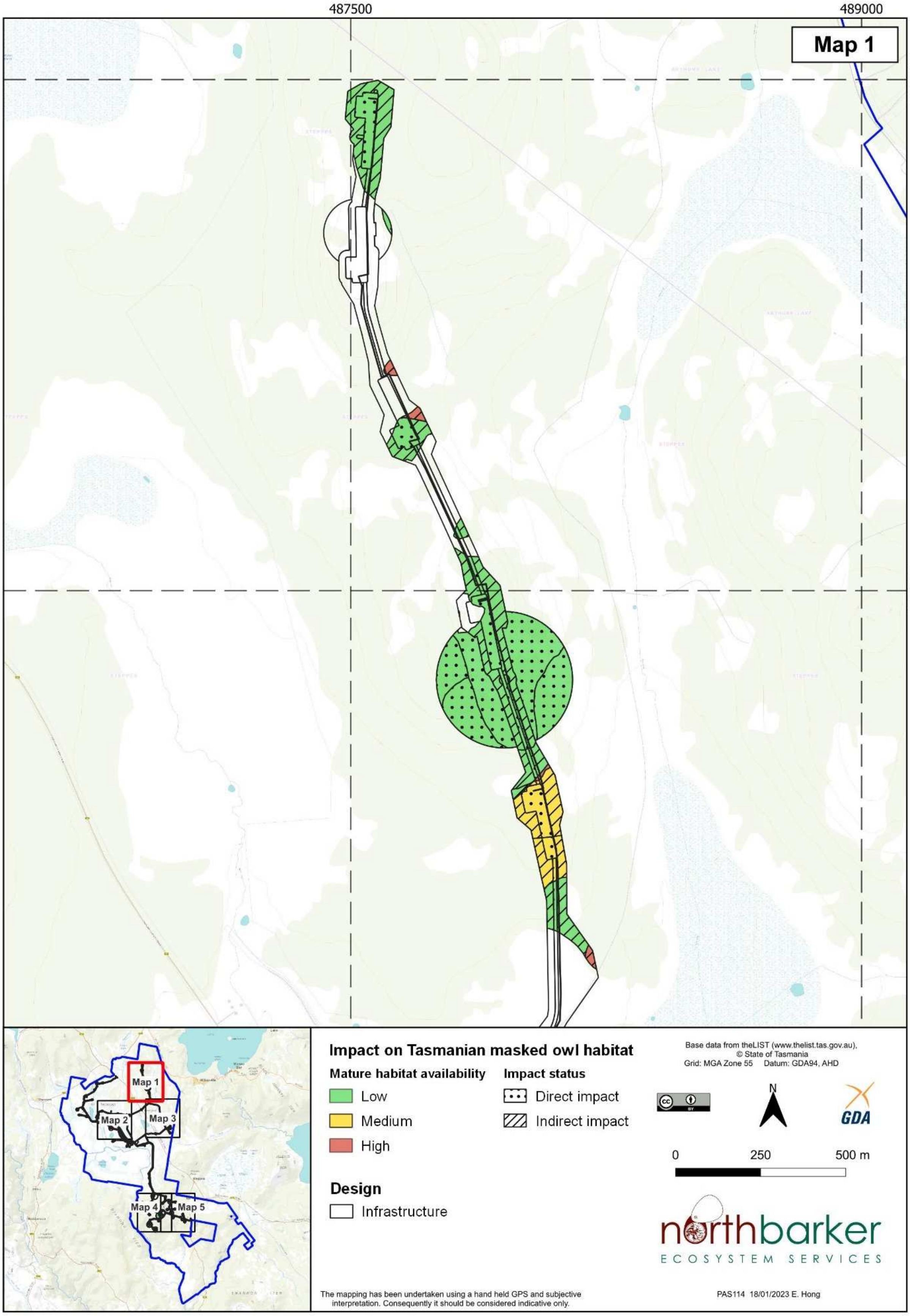
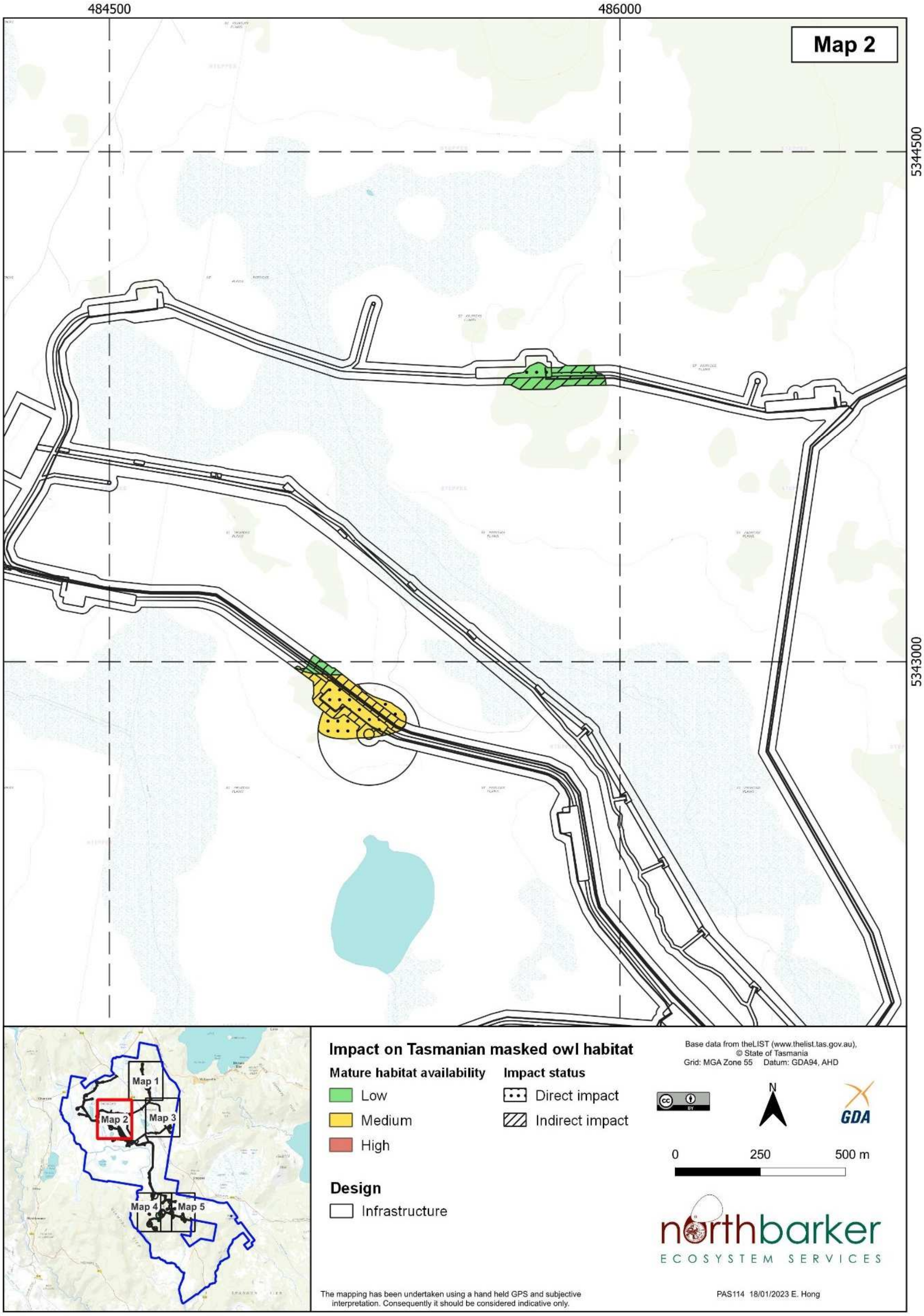

Distribution of masked owl
480 000
490 000
500 000
5 350 000
5 340 000
5 330 000
Statewide distribution
NVA masked owl records
Observations from Natural Values Atlas (www.naturalvaluesatlas.com.au), 07/04/2020, (c) State of Tasmania.
core range boundary
potential range boundary
Range boundaries from Natural Values Atlas (www.naturalvaluesatlas.com.au), (c) State of Tasmania.
St. Patricks Plains wind farm, project area
0 3 6
kilometres
northbarker
ECOSYSTEM SERVICES
Base image by TASMAP, © State of Tasmania
Datum: GDA94, AHD Grid: MGA Zone 55
PAS115 09/04/2020

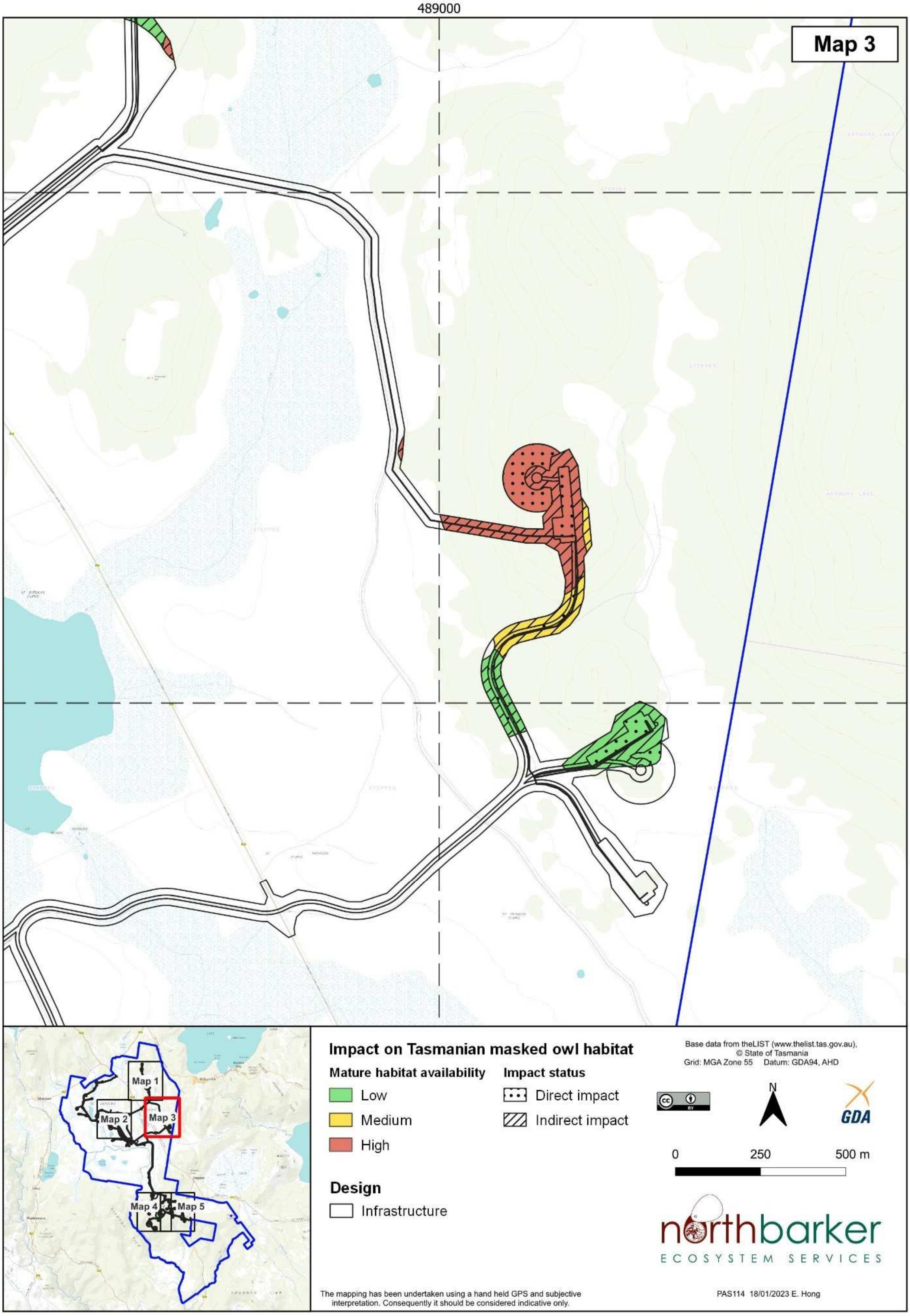

Distribution of Swift parrot
480,000
490,000
500,000
5,350,000
5,340,000
5,330,000
Statewide distribution
NVA Swift parrot records
Observations from Natural Values Atlas (www.naturalvaluesatlas.com.au), 07/04/2020, (c) State of Tasmania and Birdlife Tasmania.
0
3
6
kilometres
Range boundaries
Known range
Potential range
Range boundaries from Natural Values Atlas (www.naturalvaluesatlas.com.au), (c) State of Tasmania.
St. Patricks Plains wind farm, project area
northbarker
ECOSYSTEM SERVICES
Base image by TASMAP, © State of Tasmania
Datum: GDA94, AHD Grid: MGA Zone 55
PAS115 30/07/2020


Distribution of grey goshawk
480,000
490,000
500,000
5,350,000
5,340,000
5,330,000
Statewide distribution (NVA records)
grey goshawk records
Observations from Natural Values Atlas (www.naturalvaluesatlas.com.au), 07/04/2020, (c) State of Tasmania and Birdlife Tasmania.
Range boundaries from Natural Values Atlas (www.naturalvaluesatlas.com.au), (c) State of Tasmania.
St. Patricks Plains wind farm, project area
0
3
6
kilometres
northbarker
ECOSYSTEM SERVICES
Base image by TASMAP, © State of Tasmania
Datum: GDA94, AHD Grid: MGA Zone 55
PAS115 30/07/2020

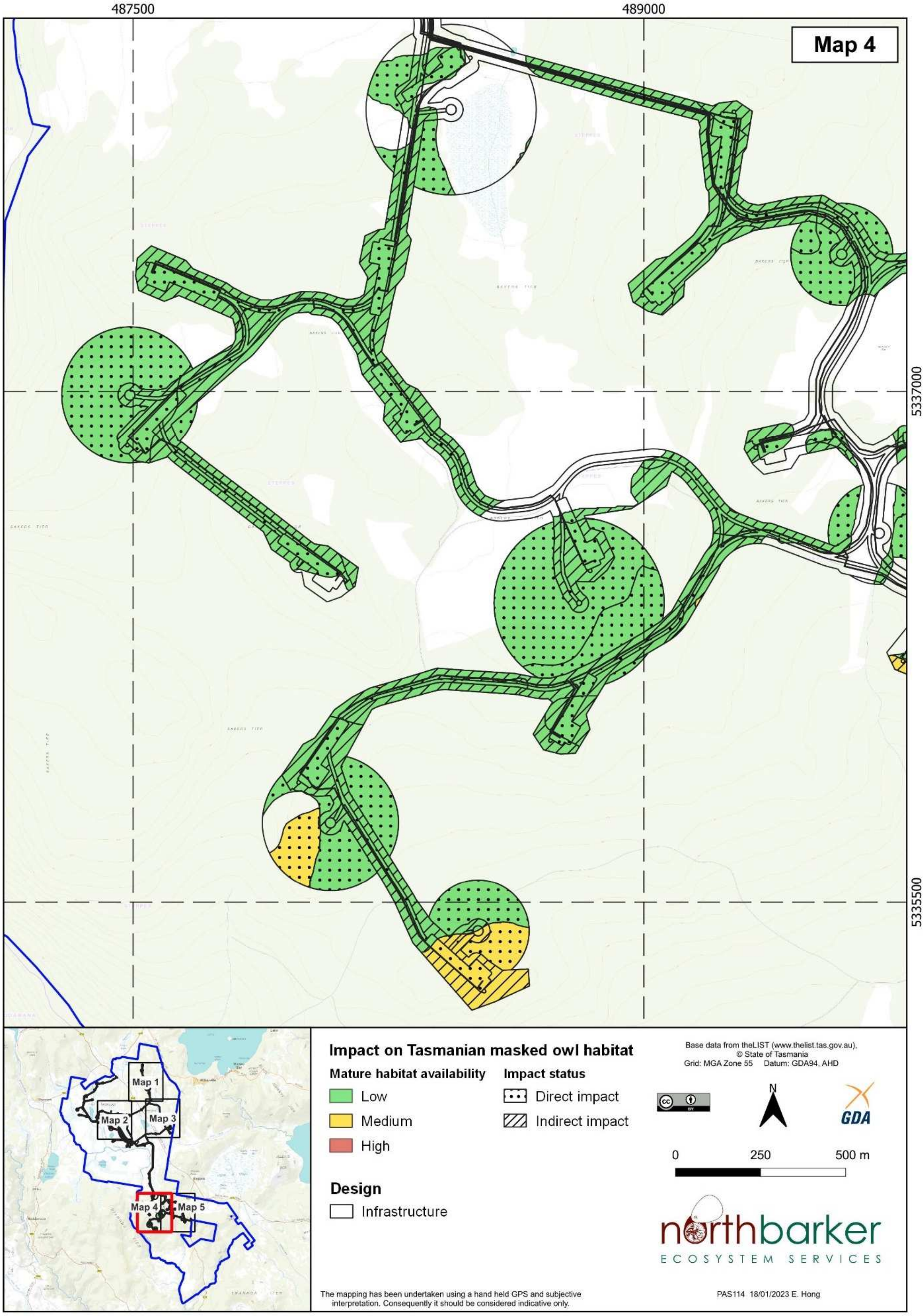
Appendix 7. The distribution of mature forest in the disturbance footprint



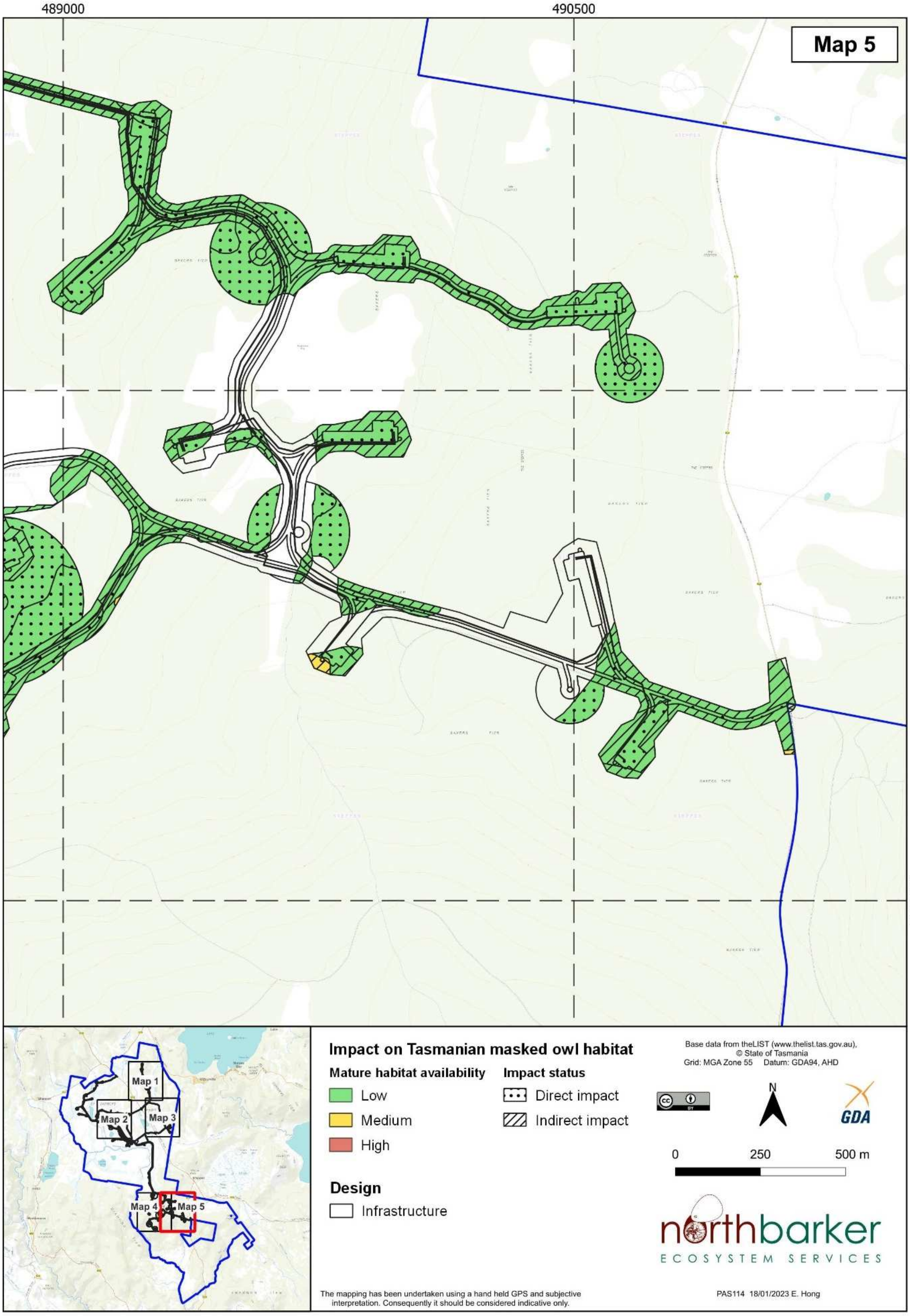

484500
486000
5344500
5343000
Map 2
Map 1
Map 2
Map 3
Map 4
Map 5
Impact on Tasmanian masked owl habitat
Mature habitat availability
Low
Medium
High
Impact status
Direct impact
Indirect impact
Design
Infrastructure
Base data from theLIST (www.thelist.tas.gov.au), © State of Tasmania
Grid: MGA Zone 55 Datum: GDA94, AHD
N
GDA
0
250
500 m
northbarker
ECOSYSTEM SERVICES
The mapping has been undertaken using a hand held GPS and subjective interpretation. Consequently it should be considered indicative only.
PAS114 18/01/2023 E. Hong



489000
Map 3
5344500
5343000
Map 1
Map 2
Map 3
Map 4
Map 5
Impact on Tasmanian masked owl habitat
Mature habitat availability
Low
Medium
High
Impact status
Direct impact
Indirect impact
Design
Infrastructure
Base data from theLIST (www.thelist.tas.gov.au), © State of Tasmania
Grid: MGA Zone 55 Datum: GDA94, AHD
N
GDA
0 250 500 m
northbarker
ECOSYSTEM SERVICES
The mapping has been undertaken using a hand held GPS and subjective interpretation. Consequently it should be considered indicative only.
PAS114 18/01/2023 E. Hong



487500
489000
Map 4
5337000
5335500
Map 1
Map 2
Map 3
Map 4
Map 5
Impact on Tasmanian masked owl habitat
Mature habitat availability
Low
Medium
High
Impact status
Direct impact
Indirect impact
Design
Infrastructure
Base data from theLIST (www.thelist.tas.gov.au),
© State of Tasmania
Grid: MGA Zone 55 Datum: GDA94, AHD
N
GDA
0
250
500 m
northbarker
ECOSYSTEM SERVICES
The mapping has been undertaken using a hand held GPS and subjective interpretation. Consequently it should be considered indicative only.
PAS114 18/01/2023 E. Hong


489000
490500
Map 5
5337000
5335500
Map 1
Map 2
Map 3
Map 4
Map 5
Impact on Tasmanian masked owl habitat
Mature habitat availability
Low
Medium
High
Impact status
Direct impact
Indirect impact
Design
Infrastructure
Base data from theLIST (www.thelist.tas.gov.au), © State of Tasmania
Grid: MGA Zone 55 Datum: GDA94, AHD
N
GDA
0
250
500 m
northbarker
ECOSYSTEM SERVICES
The mapping has been undertaken using a hand held GPS and subjective interpretation. Consequently it should be considered indicative only.
PAS114 18/01/2023 E. Hong