



Public Report:

Where? Where? Wedgie!

2018-2020



*Bookend
Trust*





Cover images
Main image: courtesy of Nick Mooney
Inset: Peter Vaughan

► naturetrackers.com.au



Photo: David Hamilton

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In 2018, the Bookend Trust launched the citizen science project *Where? Where? Wedgie!* to monitor and guide recovery efforts for the Endangered Tasmanian wedge-tailed eagle, and involve more Tasmanians in threatened species science and conservation. This progress report presents the essential findings. More details will follow in scientific publications.



Together, more than 350 teams of volunteer 'NatureTrackers' have confirmed that the monitoring method works. After an encouraging pilot survey in May 2018, we refined the method for 2019 and repeated it for 2020. Numerous organisations have committed to participate in, promote and support the project. *Where? Where? Wedgie!* has now been discussed face to face with around 1.5% of the Tasmanian population, including 3500 school students.



Where? Where? Wedgie! provides a great opportunity to get people of all ages into birdwatching, science and conservation.

Photo: Kate Thorn



With current participation levels, we can pick up both large population changes from year to year (should something catastrophic or marvellous happen) and – most importantly – subtler changes over multiple years. Information on overall, long-term population trends is critical to deciding whether a species should be listed as threatened and needs additional conservation actions. It's too early to conclude that the Tasmanian wedge-tailed eagle population is stable, but we've learnt that the population didn't change in size substantially from 2019 to 2020.

We also surveyed other birds of prey, sulphur-crested cockatoos and long-billed and little corellas. Many more surveys are needed to monitor for between-year population changes in these birds, because they're much less 'detectable' than wedge-tailed eagles – i.e. much easier to miss. Nonetheless, we can still pick up long-term changes in their population sizes.

Team Melaleuca made a great contribution to the geographical spread of the 2020 surveys, covering two survey squares in far southwest Tasmania.



Can we retain and increase numbers of participating NatureTrackers? Retention is essential for a long-term monitoring project, and increases would enable us to detect smaller population changes more quickly. Our social science research indicates that many more people could be drawn to the project – especially by the prospects of watching and protecting birds, and contributing to science.

People are more likely to continue each year if they have an enjoyable experience during their survey; we're exploring ways to increase the chances of this! We'll keep encouraging better geographic coverage of surveys across the state, to strengthen the precision of the findings. We also hope to upgrade the technology behind signing up, booking surveys and recording data, to help more people take part, save time and reduce risk of error and frustration.

Increasing numbers of scientists, schools, conservation organisations and others are collaborating to make the most of *Where? Where? Wedgie!* (including the biggest challenge: estimating population number). There are many enjoyable ways for anyone interested to get involved – first and foremost, through a May day out in nature with your eyes to the sky.

Introduction to

Where? Where? Wedgie! – Why?

The Tasmanian wedge-tailed eagle (*Aquila audax fleayi*) was listed as Endangered in the 1990s, based on its low numbers and declining population. The population was estimated at fewer than 1000 adults, from road-based sightings and state-wide nest occupancy surveys. With no increase detected at this time, the decline was presumed, given the numerous known threats to their breeding and survival.

How is the population doing now? This information hasn't been available.

People and industries make extensive, costly attempts to limit the impacts of these threats, but it's not easy. Many of the ways we use land can gradually erode and remove eagles' breeding and foraging habitats. Eagles can also be killed by collisions with infrastructure and vehicles, electrocution, and shooting, and we're now aware of additional threats from environmental poisons.

A critical element to conservation success has been missing: consistent, regular, Tasmania-wide population monitoring. Up-to-date information on a species' population size, and rate of change, is what guides whether it should be listed as threatened. It also lets us check whether our conservation efforts are needed and working. Is the population recovering? Do we need to do more, or something different? We know that many human activities kill eagles and affect their breeding success. However, we have much less information on which of these have the greatest impacts, and whether the efforts to reduce the impacts are effective and worthwhile. There are conflicting opinions. Recent bird survey approaches have had limited use in answering these questions, due to very



Photograph by Alfred Schulte –
Taken at Inala on Bruny Island



This electrocuted wedge-tailed eagle was found during a Where? Where? Wedgie! survey. Reported to TasNetworks (lines now fitted with high visibility 'flappers'), and transported to the Tasmanian Museum and Art Gallery for research.

Photo: Michael Dempsey



House-builders, pilots, and even walkers and photographers can unknowingly disturb nesting birds, which may lead to breeding failure.

Photo: James Pay

“What gets measured, gets managed.”

Peter Drucker



low numbers of eagle records, a lack of consistency between years or biases (e.g. only certain areas, tenures or habitat types being surveyed).

In fact, fewer than 15% of Tasmania's threatened plants and animals are monitored, and a much lower proportion of our other species. If unmonitored populations are changing in size, we mightn't be aware of problems until they're too late to fix.

Monitoring species such as the wedge-tailed eagle has traditionally been costly, but it can be interesting and enjoyable. Can we address the need for monitoring this and other species with volunteers, through citizen science? Multiple eyes in the sky across the state each year could translate to useful quantities of data. Additionally, research shows that such citizen science experiences can get people more engaged with their environment.

The Tasmanian wedge-tailed eagle is considered a separate subspecies from the mainland 'wedgie', being larger and generally paler. With the thylacine extinct, and the Tasmanian devil and other mammalian carnivores threatened, this top predator is especially important for ecosystem stability.

Photo: Peter Vaughan

Aims

of Where? Where? Wedgie!

In 2018 the Bookend Trust initiated the NatureTrackers program, to set up the tools, infrastructure and collaborations needed for large-scale, volunteer-based monitoring of a broad range of species over the long term. The program's first project – *Where? Where? Wedgie!* – enables community members to monitor the Tasmanian wedge-tailed eagle annually, and to widely communicate their findings on state-wide population size and rate of change. Where possible, other birds of prey will be similarly covered. In developing a low-cost approach that multiple people and organisations help maintain over the long term, the ultimate goal is to inspire and guide effective conservation of these species across Tasmania.

The project's aims were, for the Tasmanian wedge-tailed eagle and other birds of prey where possible, to:

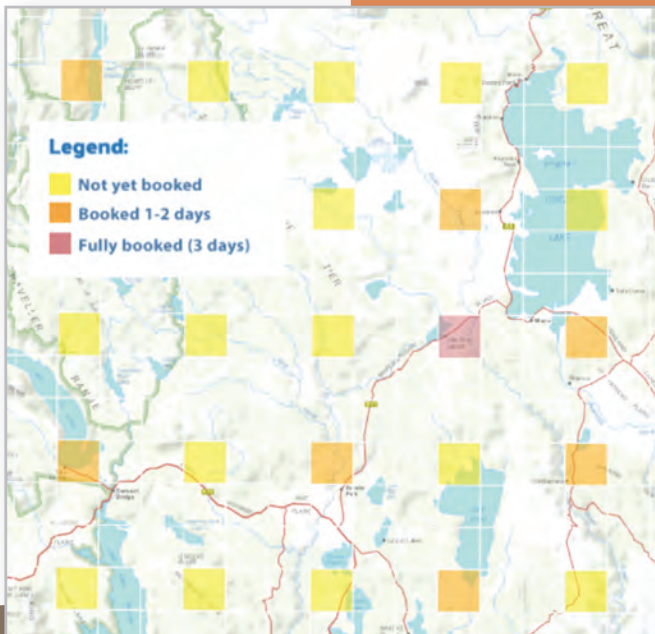
- 1 Initially, find out whether enough people are willing and available to annually monitor the population, to allow us to determine whether it is increasing, declining or remaining stable.
- 2 Establish *Where? Where? Wedgie!* as a low-cost project, attracting commitment from enough people and organisations for it to continue long-term.
- 3 Identify and include factors that attract and engage participants' long-term interest in monitoring these species, and supporting their conservation.
- 4 Estimate population size accurately – either from the survey data alone, or combined with other research data.



Photo: Persia Brooks

Methods: *How?*

For 2018–2020, we've focused on aims 1–3: long-term monitoring to detect significant population changes. We trialled and honed the monitoring method, and the ways we promote it.



The online booking map ensures that NatureTrackers don't all survey in the same places, and encourages us to achieve wide geographic coverage across Tasmania (see box: The rationale behind the survey method).

A 'day' of surveying in a square consists of six 10-minute periods of observation, each at a different location within the square, and starting on the hour or half-hour between 8 am and 4:30 pm.



For each 10-minute survey, participating NatureTrackers record:

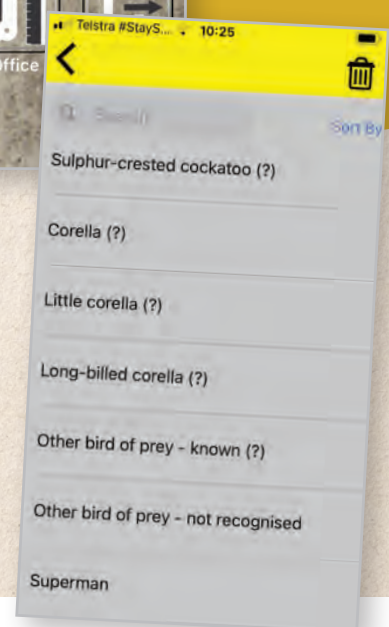
- time and location details, including whether anything (e.g. mist, hills or forest) is impeding the view – even if no birds are seen.
- details of any observed raptors or 'white cockies' (sulphur-crested cockatoos, and long-billed and little corellas) – including the distance and direction from NatureTrackers to bird, and photos where possible.
- composition of their team (number and ages)

Essential survey method

Surveys take place over 6 days – normally two long weekends in May. Volunteer participants (a.k.a NatureTrackers) sign up online and choose an area for survey via the booking map. This map divides Tasmania into 4 km x 4 km survey squares, with every third square available for booking for up to three days.



Participating NatureTrackers send in their data via the ProofSafe app, on the NatureTrackers website or on written datasheets. When recording a bird, we include an indication of how confident we were in the species identification.



Population change? Making sense of the numbers



Photo: Stephen Anstee



Photo: David Hamilton

When NatureTrackers survey a square with an eagle or other target species in it, they may not always spot it. Our analysis needs to take this into account – if no birds are observed, how sure can we be that there were really no birds there? We're using a technique called *occupancy modelling*. With repeat visits around the square, we can find out what proportion of surveys typically detect or miss the bird. The resulting *occupancy estimate* is designed to indicate what proportion of Tasmania is occupied by eagles. This measure has also been shown, for many different species, to provide a useful indicator of population abundance: an increase or decrease in occupancy corresponds to real changes in population size.

Occupancy modelling helps us get an accurate overall picture across Tasmania, and to compare years even though a slightly different combination of squares and teams are involved each time. Both the likelihood of an eagle's *presence*, and our likelihood of spotting it (*detectability*), will vary across survey squares. For example, presence is likely to depend on the habitat and levels of threat in the area. Detectability may vary with survey team size and skills, and the topography, weather and amount of forest. Even the best birder won't spot every eagle in a square. Some may be perched, hidden behind a tree, or flying behind a hill during the survey, or the view might be obscured by mist or

forest. We minimise these sources of variation where feasible, but once we have enough survey data from a range of circumstances, occupancy modelling can take the variation into account (at least for factors that we are aware of and can measure).

We also carried out *power analyses* to assess and guide the survey design, using each year's estimates and our certainties around them. These show us how great a change in overall occupancy we might still miss. They also allow us to explore how much we could improve on this if we survey more squares, or for more days per square.

THE RATIONALE BEHIND THE SURVEY METHOD

Why only survey every third square?

We don't have enough eyes in the sky to count every single eagle! Instead, we aim to survey a representative sample of areas, and multiply up for a Tasmania-wide estimate. The idea is to sample all commonly available environmental conditions, in approximate proportion of their availability – by surveying in regularly spaced-apart 4 km x 4 km squares. This reduces the risk of counting the same birds in more than one square, and helps minimise any biases (e.g. people preferring to survey near their homes). We don't want disproportionate numbers of surveys from areas where eagles are especially common or rare, or subject to much stronger drivers of population change than elsewhere. Note that survey data from Zero Heroes (who didn't see any birds) is critically important. Without it, we can't tell how the population number is changing; it will appear that eagles are everywhere that everyone looks, every year!

Why survey in May?

Those of us with less expertise in raptor identification can confuse swamp harriers with wedge-tailed eagles. The majority of swamp harriers leave Tasmania in winter.

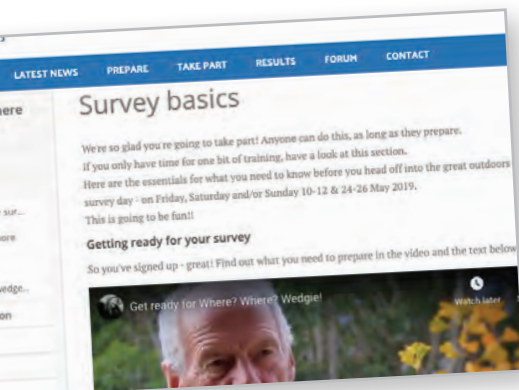
There's much more to this...

Population monitoring is a fascinating but challenging subject! Especially when the species of interest move around a lot. See Further Reading at the end of this report. The *Where? Where? Wedgie!* survey method has a 'robust' design, to fit many different analytical approaches. Our aim is to keep it very consistent over the long term. The more data we get, the more we can review, explore and learn from it. There is already plenty to investigate further, including data already collected on numbers of birds seen per survey, team size, visibility at the survey site and less confidently identified birds.

Outreach: promotion & training



People hosted community workshops in venues across Tasmania, from Woodspen farmhouse in Scamander to Inala in South Bruny, to – here – Highfield's chapel at Stanley and the Tasmanian Arboretum in Devonport.



The website presents a wealth of information to support everyone interested in taking part.

Field guide to Tasmania's birds of prey and 'white cookies' – written by Nick Mooney, using images donated by six photographers.



We first got people talking about *Where? Where? Wedgie!* with a crowd-funding campaign for state-wide community workshops. Her Excellency Professor the Honourable Kate Warner AC formally launched the project in February 2018, including a large-scale **Expedition Class** for schools. This involved over 40 school visits, Australian curriculum-based lesson plans, an online forum and a month-long series of video blogs, as Andrew Hughes and James Pay searched for James' GPS-tagged eagles around Tasmania and interviewed numerous people involved in eagle conservation. Individuals and organisations hosted community workshops on the survey method and raptor identification. The 2018 results were reported in September through expos at each of the three University of Tasmania campuses.

In 2019, we ran smaller-scale versions of the school and community outreach efforts, including eleven new educational videos, and a field guide for raptor identification. In 2020, the field guide was freely distributed by Parks & Wildlife Visitors' Centres, Council and NRM offices, retail outlets and other organisations. COVID-19 restrictions then sent us online for two weeks of daily school lessons and community workshops.

With the help of numerous collaborating individuals and organisations, we've also promoted the survey through: talks (from Rotary Clubs to TasNetworks to the Tarkine BioBlitz); displays at agricultural shows and a photographic exhibition; conferences; radio, newspaper and podcast interviews; social media; newsletter articles; emails to those who sign up on the website; flyers and car stickers.



#WhereWhereVanillaSlice highlights the attractions of heading to remote and less commonly surveyed areas, including the Midlands.



Photo: Stephen Anstee

Social science: can we retain and increase participation across Tasmania?

Through questionnaires and interviews, NatureTrackers' social scientist Dr Angela Dean and colleagues have been exploring how best to inspire people to take part and continue each year.

We explored three questions:

1

How does taking part in *Where? Where? Wedgie!* generate environmental engagement?

At the NatureTrackers website sign-up, we asked people a few questions about themselves and what had motivated them to get involved. Following each year's surveys, signed-up NatureTrackers were also invited to respond to social science questionnaires about their eagle surveying experiences.

2

What components of school outreach for *Where? Where? Wedgie!* contribute most to environmental engagement?

We interviewed nine class groups and eight teachers who had participated in our large-scale schools education program for *Where? Where? Wedgie!* in 2018.

3

What might lead to stronger engagement from the broader community in threatened species monitoring?

An Australia-wide social survey investigated the general public's perception of citizen science and their potential willingness to participate in this type of program.

Results:

What have we found so far?

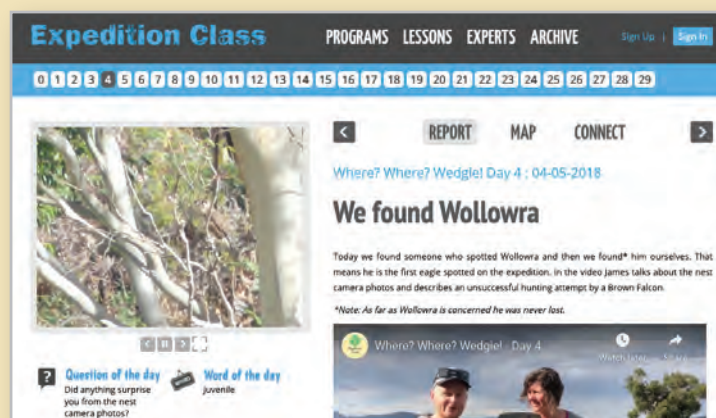
“Awesome adventure for our students and an increased awareness of birds of prey. Also an increased capacity for students and teachers to correctly identify birds of prey.”

Outreach

Members of NatureTrackers' expert team have now discussed *Where? Where? Wedgie!* face to face with an estimated 1.5% of the Tasmanian population.

This included, in 2018 and 2019, more than 3500 students from over 65 schools who were involved in the *Where? Where? Wedgie!* Expedition Classes. Over 380 bookings were made for the 2020 online classes.

Over 1000 people have signed up to the NatureTrackers website. The Facebook page has over 1000 followers, and the Twitter page has over 300 followers. *Where? Where? Wedgie!* has been covered by more than 25 radio, newspaper, newsletter and podcast interviews and articles, 20 community workshops and 15 additional talks to a wide range of groups. Many more NatureTrackers, Expedition Class students and others involved are also likely to have talked about it with family, friends and colleagues.



“The online resources provided are exceptional, easy to follow and required little forward planning from me. The daily reports, with a combination of reading and video, in addition to daily research assignments, stem activities and student interaction opportunities, made it a superbly simple cross curriculum adventure for all of us to undertake. Add to that, the opportunity to become citizen scientists and undertake our own adventure in the footsteps of Andrew and James’ example, was a great finale to Where? Where? Wedgie!”

Teacher feedback on the 2018 Expedition Class



Photo: Jim Lovell

Survey numbers: squares and birds

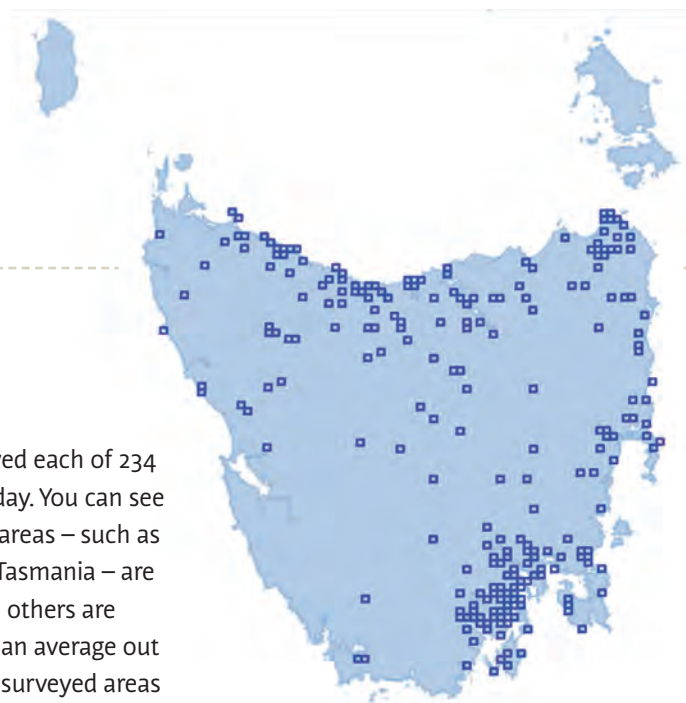
Hundreds of NatureTrackers have taken part in each year's surveys. In 2019 and 2020, participation was lower than during the 2018 pilot, but the quality of the data improved. The geographic coverage was much more representative of the state (including the Bass Strait islands in 2020), and higher proportions of squares were surveyed on more than one day: 63% in 2019 and 62% in 2020, versus 43% in 2018 (multi-day surveys having been found to be especially valuable by the power analyses; see below).

2018 PILOT:

GOOD PARTICIPATION,
CLUSTERED RECORDS

In 2018 – our first ever year – we trialled surveying for three days: 25 to 27 May. We highlighted the value of surveying 'priority squares' (every 10th square) but gave participants the option of surveying any square. Two-thirds of the 196 NatureTrackers responding to our social science questionnaire had never carried out a citizen science project before. They comprised a wide range of ages, from primary school to 86 years of age. Most carried out the raptor survey with family members.

Over 170 teams surveyed each of 234 squares for at least a day. You can see in the map that some areas – such as the Midlands and SW Tasmania – are hardly surveyed, while others are heavily surveyed. We can average out the results for heavily surveyed areas (note that each NatureTracker's effort in these areas is less valuable), but in the other areas, which may cover very good or bad conditions for eagles, we have no information. We need more even geographic coverage to be confident that we're getting a good picture of overall numbers.



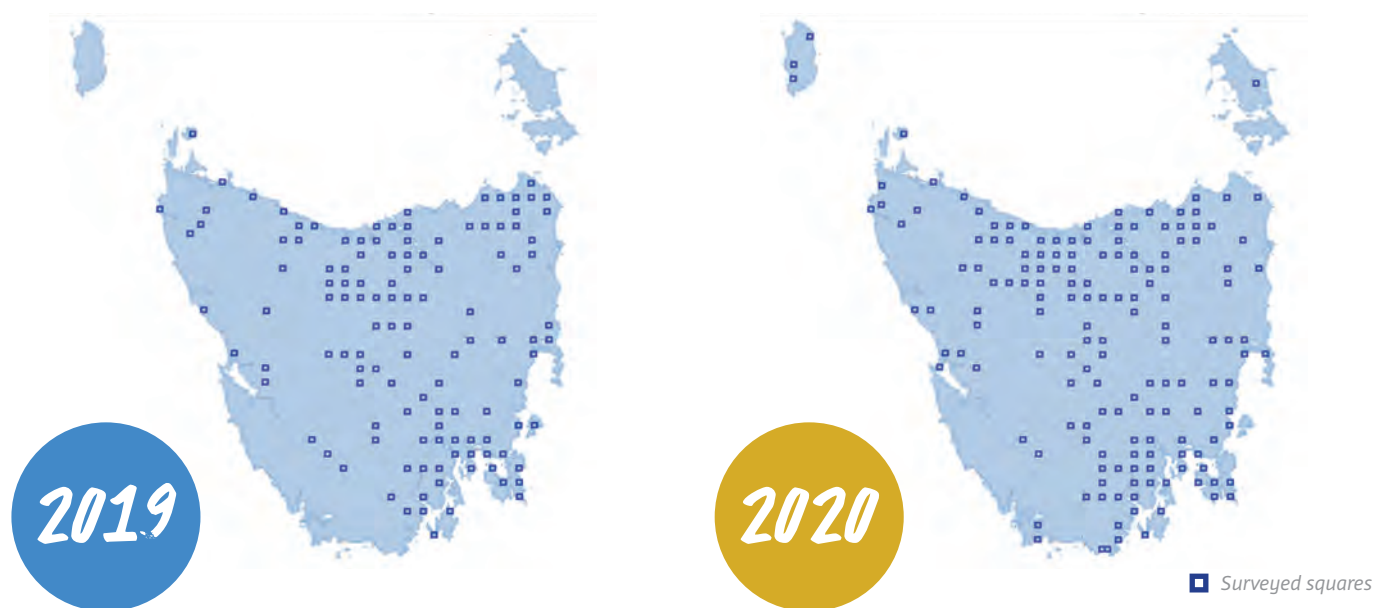
2018

■ Surveyed squares

For 2019 and beyond, we therefore restricted surveys to every third square, but increased the potential dates to six days.

2019-2020:

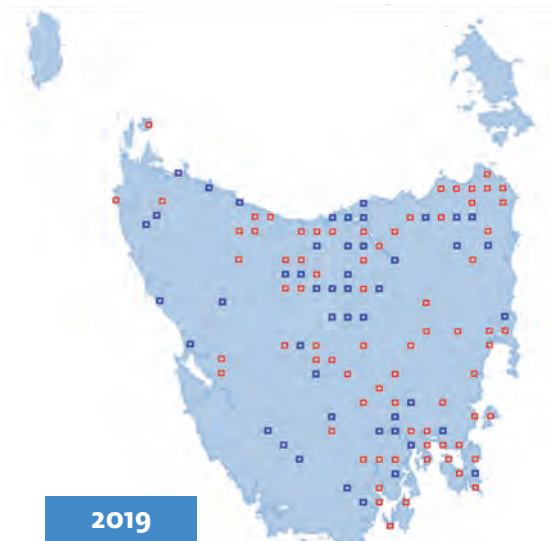
an increasingly even spread of surveys across Tasmania



102	teams submitted good data from...	121
123	survey squares	146
78	of which were surveyed for 2-3 days	90

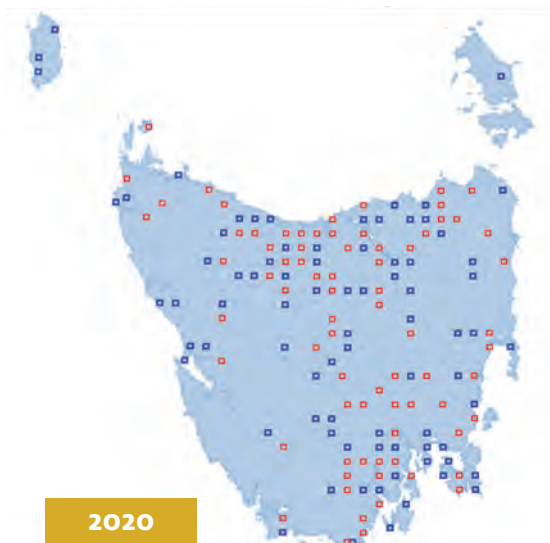
Number of survey squares in which each of the target species was recorded, in 2019 and 2020		
Number of squares (10-12 & 24-26 May 2019)	Species confidently identified	Number of squares (29-30 May & 19-21 June 2020)
74	wedge-tailed eagle	76
24	white-bellied sea-eagle	27
19	brown falcon	23
24	sulphur-crested cockatoo	26
9	swamp harrier	1
3	brown goshawk	3
5	grey goshawk	8
2	collared sparrowhawk	2
2	peregrine falcon	3
0	Australian hobby	0
0	nankeen kestrel	2
2	long-billed corella	1
0	little corella	1

Wedge-tailed eagles were recorded widely across Tasmania.



2019

- No wedge-tailed eagle
- Wedge-tailed eagle



2020

- No wedge-tailed eagle
- Wedge-tailed eagle

Due to COVID-19 restrictions, we postponed one of the 2020 survey weekends to mid-June, and were granted special permission for NatureTrackers to travel to areas beyond the standard 30 km limit in place through COVID-19 restrictions for the last weekend in May.

SPECIES IDENTIFICATION

To support confidence in the results, we ask people to send in photos of the birds they saw during their surveys. We've now run photos of 53 bird observations, submitted from the 2020 surveys via the ProofSafe and iNaturalist apps, past three raptor experts. Identifications can be difficult without seeing the birds' behaviours and contexts, but the experts were able to provide 'confident' or 'likely' identifications for 43 photos. Of these, 95% were consistent between these experts and with the NatureTrackers' identifications. Considering each expert's identifications separately, 94% of 126 confident expert identifications of the photos were consistent with the NatureTrackers' identifications. And specifically, for 96% of 25 photos that NatureTrackers were confident were of wedge-tailed eagles, the experts agreed with this identification.

Encouraging results so far! More photos will be checked, and we also plan to build up more video and photo material for training and testing, to ensure every NatureTracker is well prepared for their surveys.

Population change? Making sense of the numbers

Our surveys found no evidence of a change in occupancy (which we're using as an indicator of population size) between 2019 and 2020. In both years, the estimates indicate approximately a 70% chance of any of the survey squares being occupied by a wedge-tailed eagle during the time of the survey.



Even if an eagle's in our square, we have a 40% chance of missing it during a single day of surveying. But we can still have a great day!

For wedge-tailed eagles, we checked whether detectability and occupancy varied between survey squares, with environmental features we suspect could be important for eagles or ease of view (length of forest edge; forested area; agricultural area; plantation area; heath and grassland areas; mature forest area; and lengths of sealed and unsealed road). For both years, probability of detection was influenced by the amount of agricultural area in each survey square. Occupancy wasn't found to vary with any of the features considered.

Occupancy measures were similar for the two years:

2019		2020
123	Number of squares used in analysis	146
1386	Number of surveys used in analysis	1564
0.15	Average probability of detection	0.13
0.73	Estimated probability of occupancy	0.71
0.59	- 95% confidence interval	0.57
0.83	+ 95% confidence interval	0.83

"I feel like I see eagles all the time, but after doing Where? Where? Wedgie! I realised: you notice when you see an eagle, but you don't notice when you don't see one!"

Ed Parker



It's important to understand the uncertainties here! The essential finding is that 'no significant change' to the population over the two years was detected. You can see in the table that the estimated probabilities of an eagle occupying a survey square were 73% in 2019, and 71% in 2020. The two values are very similar, but this may be a matter of chance. The key information is that the two year's **confidence intervals** overlap. There's a 95% probability that the true values lie within the pairs of confidence intervals.

Another useful insight into our survey results: calculations from each year's detectability estimates indicate that if we surveyed a square that was occupied by an eagle six times (ie one day of surveying), we had around a 40% chance of missing it. However, if we surveyed the square for two days, this dropped to around 16%, and lower still (roughly 6%) with three days of surveying.



Power analyses, wedge-tailed eagle and white-bellied sea-eagle

We're only surveying a sample of the population. So how sure are we that, overall, there was 'no significant change in occupancy' (our indicator of population size), between years? How many surveys in how many squares do we need in order to confidently detect changes of a certain magnitude? What about for other species?

Using each year's estimates of detectability and occupancy, a power analysis allows us to answer these questions, to assess and guide the survey design. Our power analyses found that with current participation

The power analysis based on the 2020 estimates indicates that:

<i>For a good chance of picking up a change in occupancy of as little as:</i>	<i>We need to survey for at least:</i>	<i>Across at least this number of squares:</i>
42%	nearly 2 days (11 surveys)	90*
30%	2 days	100
25%	2 days	120
25%	3 days	100
20%	3 days	150

*2020 survey results




Photo: Kavinwit Kitiapalawatatanapol

levels, we can pick up large between-year changes for wedge-tailed eagles and, with small increases in effort, we can also pick up smaller changes. This is more challenging for other species (but see the Discussion).

Detectability is low, but if we visit squares for two to three days, we can potentially pick up fairly small changes from year to year for wedge-tailed eagles. This was apparent from our first power analyses in 2018, and so we

emphasised the importance of multi-day surveys for 2019 and 2020. In 2020, 90 squares were surveyed for at least 2 days; this level of effort is likely to detect a change in occupancy of 42% or greater. But with more survey effort, we can pick up smaller changes – if we survey 150 squares for three days each, we could reliably pick up a 20% change.

However, the survey data indicate that other species are much less detectable, which makes the process much more difficult. Power analysis of the 2020 white-bellied sea-eagle data found that, to pick up a 50% change, either 150 squares need to be surveyed for five days, or 120 squares for six days.



Finding low-cost fixes to data errors and technical hitches that work for everyone isn't always simple; but solving them is an ongoing high priority for the project. Over the three years we've been tweaking and testing the sign-up and booking process, the data collection app and web data entry forms (generously provided free of charge by ProofSafe), and the datasheets and the instructions, to reduce risks of these issues.

REDUCING DATA ERRORS & TECHNICAL HITCHES

Data errors

Many errors can be tidied up through a data-cleaning process (e.g. switching all 'midnight' surveys to midday). Data manager Dr Jim Lovell has created thousands of lines of code to cover these. Others are easier for the human eye to pick out and correct, but when large amounts of data are involved, this can become especially time-consuming. For example, someone might record their survey location as somewhere outside their booked square. This could be a typo, if they're copying out GPS coordinates, or perhaps they uploaded their data from home and recorded their location from there by mistake. If we work through the data, we may be able to spot the typo, or figure out from other surveys whether they normally go to their booked square. However, it isn't always clear, and the observer can't necessarily remember the details by the time we've picked this up and emailed them. Also, detailed location data is important for some of the future analyses. Other common errors are survey time and order typos, and missing data.

We will keep and use all possible data at least for some analyses. Some analyses have less strict requirements than occupancy modelling, and we may explore these in future as the dataset grows. However, we don't use data that could bias the results. For example, we are very cautious where people have supplied fewer than six surveys for a square in a day; if people often give up because they haven't seen any eagles, or after they've seen one eagle, this could lead to confusing results.

Technical hitches

Some participants reported challenges with sign-up, the booking map and data entry. In 2018 in particular, these were often due to teething problems with the newly designed website and app forms. Another common challenge arises from older software versions and slow internet speeds, which can make map-viewing off-puttingly difficult. We are seeking funding to address these issues.

Social science: can we retain and increase participation across Tasmania?

So far, 1046 people have signed up to *Where? Where? Wedgie!* on the NatureTrackers website. Top reasons for their interest included a desire to help protect eagles (73%), enjoyment of birdwatching (46%) and wanting to help scientists (39%).

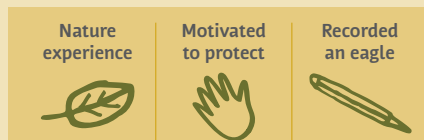
How does taking part in *Where? Where? Wedgie!* generate environmental engagement?

From May 2018 to August 2020, signed-up NatureTrackers sent in 323 responses to social science questionnaires, providing information on how their eagle surveying experiences had made them feel, including their likelihood of continuing with the annual survey.

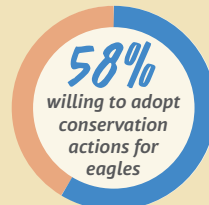
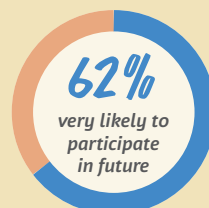
Where? Where? Wedgie! survey data was submitted by 89% of questionnaire respondents. Respondents were more likely to submit data if they had used the online training information, or if they appreciated time in nature. However, people who mentioned working with others as a positive for them were less likely to have submitted data (perhaps someone else in the team had done this). More information came from the NatureTrackers' online sign-up data: those who submitted data were more likely to be motivated by helping scientists, and less likely to be motivated by protecting eagles or learning about their local area.

The majority of questionnaire respondents were very likely to participate again (see the infographic), and also willing to adopt new conservation actions for eagles. Some participants had specifically learnt something new that they could do to help eagles, that they were very likely to do in future. Factors affecting these responses included good experiences during the survey, workshop attendance, feeling empowered by science and having learnt new things, but also feeling sad about environmental issues.

Elements of the *Where? Where? Wedgie!* experience associated with positive outcomes



Outcomes reported by *Where? Where? Wedgie!* surveyors



What are the outcomes of schools outreach for *Where? Where? Wedgie!*

From the 2018 Expedition Class program, we identified several ingredients for successful environmental engagement in children.

Teachers valued its capacity to link with a range of curriculum areas, and to cater for different learning styles. Both teachers and students said they particularly appreciated: a) opportunities to be in nature which generated surprise and excitement, b) personal connections to wedge-tailed eagles and the program presenters, and c) humour, enjoyment and other positive emotions associated with Expedition Class.

What might lead to stronger engagement from the broader community in threatened species monitoring?

Across Australia, 3946 people took part in the social survey. From their responses, only 6.6% had helped monitor nature as part of a community program. Almost one third (30%) were willing to find out more about these sorts of programs.

People who were younger, with greater educational attainment, and with stronger connection to where they lived were more willing to participate in citizen science, especially if the program focused on a threatened species. In particular, people said they'd be more likely to participate if they could take part near home (51%), do it in their own time (33%) or if it was in a beautiful location (25%).

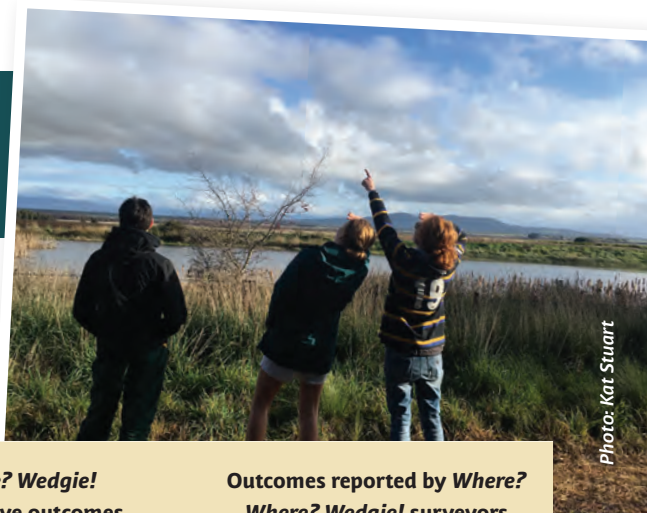


Photo: Kat Stuart

Discussion:

Implications – now & future

Progress so far is encouraging. Together, NatureTrackers have confirmed that this method is repeatable (essential for good science) and works in a practical sense. Enough people are willing and available to survey across Tasmania to detect any major change in the size of the Tasmanian wedge-tailed eagle population. Numerous individuals and organisations have also committed to help promote and support the project. It's early days to conclude that the population is stable, but we've learnt that the population didn't substantially change in size between 2019 and 2020. That's a start. Importantly, we've also learnt quite a lot about what's needed to attract and maintain people's interest in participating.



Dr James Pay with GPS-tagged wedge-tailed eagle.

Is the population changing in size?

Apparently not so far, but we have to wait a few more years. Decisions about whether a species should be listed as threatened, and its category (Endangered, Vulnerable etc.), mostly rest on whether its population has changed in size by at least 30% over at least a decade. The numbers of any wild population are likely to bounce around by a certain amount from year to year, so it's important to assess the significance of any changes over a multi-year time-scale.

The two years' results seem remarkably similar, but it's important to understand the context of the confidence intervals and the power analysis. This year's effort was enough for us to pick up a change of 42% or greater.

We could pick up smaller annual changes with just a slight increase in the number of squares surveyed for two days.

However, once we have several years of data, we will also be able to carry out additional types of analysis to detect any continuing, subtler change in one direction.

What does 'occupancy' really mean?

Researcher Dr James Pay is currently GPS-tagging Tasmanian wedge-tailed eagles. His information is likely to help us understand how our occupancy estimates really translate to the biology of the bird.

Occupancy estimates are designed to relate to the proportion of an area that the study species occupies, and can also provide a useful indicator of population abundance. However, at this stage we're taking care over our exact interpretation of these estimates. Taken literally, our findings suggest that eagles inhabit around 70% of Tasmania – at least in May – and that their occupancy doesn't vary with the different habitat features we considered.

So how many eagles are there now?

We can't say for sure yet! It's particularly challenging in such a mobile species as the Tasmanian wedge-tailed eagle. To estimate specific population numbers from our occupancy results, we need

more information. Data from Dr James Pay's GPS-tagged birds should provide such information, and allow us to better interpret our survey data in the coming years.

We understand that a territory typically contains a pair of adult birds and often one young one, and that older sub-adult birds leave their parents' territory and fly widely across Tasmania. It would also be very helpful to know the distances the birds move, and to what extent their movements overlap.

The tagging data may also be used to generate separate estimates of population size for some years, against which the long-term *Where? Where? Wedgie!* survey results can be calibrated.

Another potential option involves gathering data on how detectability varies with distance between eagle and surveyor. Multiple 'bonus surveys' using the *Where? Where? Wedgie!* approach in the vicinity of GPS-tagged eagles may provide this information.

What about other species?

We probably won't be able to compare individual years' results for any of the other surveyed species' populations (raptors, and white cockatoos and corellas), but there are other options.

The power analyses found that we aren't gathering enough data on the white-bellied sea-eagle to detect population size changes even of 50% or more between years. This species is the second most commonly seen bird during the surveys, after the Tasmanian wedge-tailed eagle.

However, the *Where? Where? Wedgie!* method has a 'robust' design, which allows many options for analysis. With more years of data, we may detect the overall population changes important for threatened species listing and other key conservation decisions. The less commonly seen the species, the more data required before we pick up these changes. We can build up our data more swiftly by surveying more squares each year. For the least common species, we can also consider adding targeted surveys in their preferred habitats.

Where? Where? Wedgie! can't always meet all the elements that attract people, like providing the option to do it around their home or in their own time, but it shines in other areas, such as opportunities for surveying beautiful places.

Stephen Anstee and Heidi Krajewsky were well equipped for an enjoyable day in nature, whether or not they saw any birds.



Photo: Heidi Krajewsky



Photo: Keith Martin-Smith

Where? Where? Wedgie! can't always meet all the elements that attract people, like providing the option to do it around their home or in their own time, but it shines in other areas, such as opportunities for doing it in beautiful places.

How can we attract and maintain people's interest in surveying?

The more participants, the more useful the resulting survey data is likely to be. And to ensure that the survey remains effective long-term, we need to maintain people's interest in continuing to participate. Many more Tasmanians might enjoy *Where? Where? Wedgie!* The Australia-wide social survey found around a third of respondents are interested in citizen science nature-monitoring surveys, especially if a threatened species was involved, but that a much smaller proportion have actually taken part as yet.

We attracted the largest numbers of participants in 2018. This could at least partly be due to the huge scale of the 2018 schools program, and also its novelty value in this first year. We also had higher participation in 2020 than in 2019. Perhaps this was helped by our reaching lots of parents through the online student program during the COVID-19 lockdown, and also the May 2020 participants being allowed to travel to reserves beyond the 30 km restriction in place at the time for the general public.

The sign-up information indicates that people are motivated to take part by their interests in helping protect eagles, birdwatching and helping with

science. This can guide our promotion of the project in future. We are excited that the project will continue to work closely with Dr James Pay, thereby connecting everyone with fascinating findings emerging from his GPS-tagged eagles.

We found that people's interest in continuing to participate also relates, unsurprisingly, to their experiences during their surveys, which can be hard to guarantee! But our survey preparation advice will increasingly highlight features to help with this for a diverse range of people, and also recognise the achievements of those who have carried out many surveys.

What else for the future?

TECHNICAL IMPROVEMENTS

Participation may also increase if more people can easily use the sign-up, booking and data entry processes, as detailed in the box 'Reducing errors and technical hitches'.

TRAINING

More training materials can accelerate NatureTrackers' raptor spotting and identification abilities, and thereby confidence in participating. Videos of the birds can be particularly effective for this.

COLLABORATIONS & VOLUNTEERING

To help with all of the above and much more, and to guarantee the long-term viability of the project, we need the involvement of multiple individuals and organisations. See 'How can I help' for more ideas...

FORMAL PUBLICATIONS

Where? Where? Wedgie! findings have been and will continue to be presented at various scientific meetings, including the Ecological Society of Australia conference 2020. We are also preparing scientific papers to be formally published in peer-reviewed journals, which will be made available for anyone to read.



Photo: Nick WooneJ

How can I help?

SOME OPPORTUNITIES FOR YOU TO GET MORE INVOLVED:



Photo: Rosemary Lyne

- Sign up & take part in the survey each year.
- Assist survey teams to get to remote areas (e.g. boats to west coast, bushwalking expeditions).
- Donate (to support project coordination, website upgrade and maintenance, promotional materials, further data management and analyses).
- Write newsletter, blog and media articles inspiring others to take part in the survey.
- Teach survey methods (from data entry to raptor identification), to young and old, invite others to join you on your surveys and ensure they have a great time.
- Go into the field with experienced birdwatchers to improve your skills.
- Share inspiring photos and stories of your surveys.
- Find ways to ensure landowners can feel comfortable with allowing surveys on their properties.
- Encourage schools to follow *Where? Where? Wedgie!* activities and learn the relevant skills.
- Assist with checking for data errors and following up queries with NatureTrackers.
- Share ideas on how to make the surveys easier and more enjoyable, to get more people involved and in the less-surveyed areas.
- Share videos of raptors and similar-looking birds for use in training NatureTrackers.
- Distribute field guides and promotional materials for display in shops and other organisations where they can inspire survey participation.
- Encourage your friends and your organisations to assist with all of the above.

Contributors



Many people and organisations have contributed to Where? Where? Wedgie! so far – here, we have listed many but not everyone, and not all of their contributions. If you were missed out and are happy for us to mention you, please let us know so that we can acknowledge you in future accounts of the work.

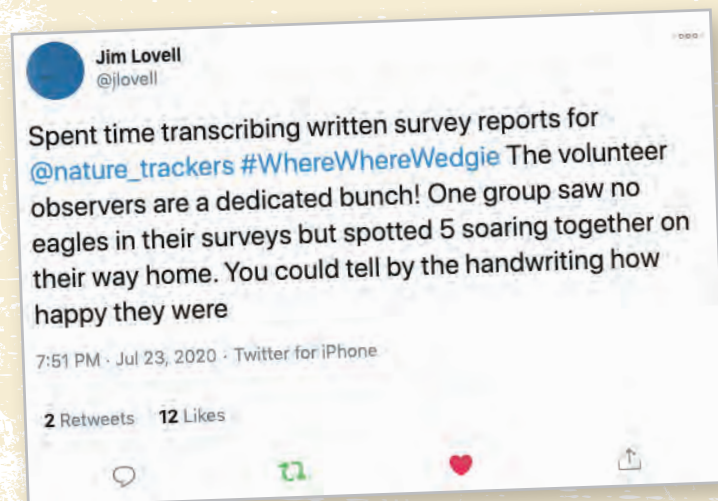
Where? Where? Wedgie! 2018-2020 was created, designed, administered and coordinated by the following people, many of whom have donated substantial time to the project: the Bookend Trust's Clare Hawkins (coordinator), Andrew Hughes (educator), Alastair Richardson (academic director) and Niall Doran (director); Joanne Potts (wildlife statistician, The Analytical Edge); Nick Mooney (scientific advisor, BirdLife Australia Raptor Group), James Pay (scientific advisor and Expedition Class educator, University of Tasmania), Stuart Newson (scientific advisor, British Trust for Ornithology), Jim Lovell (data manager, University of Tasmania) and Angela Dean (environmental social scientist, University of Queensland/Queensland University of Technology). Doug Mutch developed and maintains the website, while the ProofSafe team (including Mark Cashmore and Hans Strazdauskas) developed and maintain app and web data entry forms.

Matt Webb (Australian National University) provided additional scientific advice on the survey design and analysis. Kara Spence (Nature. Be in it) created the Expedition Class lesson plans while the Bookend Trust's Justin Smith edited the online videos. Ingrid Albion and John Bowden, assisted with education and promotion through community outreach efforts, especially WildSCOOL, within Tasmania's Parks & Wildlife Service, DPIPWE (Department of Primary Industries, Parks, Water & Environment). Stewart Huxtable and other staff from DPIPWE's Natural & Cultural Heritage Division collected 'bonus survey' data on James Pay's GPS-tagged eagles. Sue Drake assisted with community participant liaison, while our University of Tasmania TrailBlazer student Katherine Stuart assisted with data entry and ran user-testing of the data entry systems. Steve Greig directed us to a GPS app to guide NatureTrackers to their survey squares, providing a supporting layer and instructions. Woolnorth Wind Farm Holdings contributed significant support to participants in preparing them for their surveys and subsequently uploading their data. TasNetworks assisted with promotion, including hosting talks to all their staff,

and scientists' presence at their AgFest marquee and their stalls at other shows. Other collaborations also include the University of Tasmania, the Department of Primary Industries, Parks, Water & Environment (both through WildSCOOL within the Parks & Wildlife Service, and the Natural & Cultural Heritage Division), the Forest Practices Authority and BirdLife Tasmania, field naturalists' and outdoor activities groups, more than 65 schools, consultants and local experts.

Community, corporate and government workshops and talks were hosted by Inala Nature Tours, Woolnorth Wind Farms, Cradle Coast Authority NRM, WILDCARE Inc. Roaring Beach Wildlife Rescue, City of Hobart Bushcare, Glamorgan Spring Bay Council, Kingborough Council, Devonport City Council, Waratah-Wynyard Council, Circular Head Council, Zeehan Neighbourhood Centre, Department of Primary Industries, Parks, Water and Environment, Forest Practices Authority, Central North Field Naturalists, Launceston Field Naturalists, Kentish Field Naturalists, Friends of Triabunna, Bob Brown Foundation and BirdLife Tasmania. TasNetworks hosted us at all of their Zero Harm workshops that we could fit in; these are attended by all of their employees. Much of this was organised by Catherine Young, Cat Davidson, Chris Sims, Iona Flett, Anna Wind, Ange Anderson, Nicole Gill, Nicky Meeson, Rosie Jackson, Mel Kelly, Bridget Jupe, Phil Hrstich, Bill Walker, Kim Dunstan, Liese and Paul Fearman, Peter Tenni, Stewart Huxtable, Amy Koch, Sue Gebicki, Jill Spencer, Helen Tait, Phil Brumby, Leoni Read, Maggie Mars, Jenny Weber, Molly Coburn and Sue Drake. Many of these people, as well as Iona Mitchell and Sharon Moore, have also edited and written newsletter articles on the project. The following people have presented information at these workshops and talks, online lessons and schools: Clare Hawkins, Andrew Hughes, Alastair Richardson, Joanne Potts, Nick Mooney, James Pay, Jim Lovell, Angela Dean, Peter Vaughan, Angela Anderson, John Bowden, Simon Plowright, Peter Tonelli, Ramit Singal, Catherine Young, Alastair Richardson, Vanessa Thompson, Thomas Webster and Kelsey Picard.

Over 350 teams contributed survey data from 2018 to 2020, including the following people. We've starred some of the bigger hitters – each responsible for 36 or more surveys – and double-starred those who achieved over 90. Some people on this list also assisted with bonus surveys and entered others' data: Ainslie & Ashley Cooper, Alastair, Jean & Marty Richardson, Alice Grieve, Amanda Wilson, Andrea Hay, Andrea McQuitty, Ange Anderson, Anna Guegan Rahmah, Anna Povey, Anna Wind, Annie Leschen, Anthony Houston, Anthony Mann, Arthur Clarke, Barbara Alsop, Bill Brown, Bob Given, Brett Miller, Bruce Cameron, C Goodwin*, Carly Lambert, Carol Ann, Caroline & Aidan Smith, Caroline Haigh, Cat Davidson (Inala Nature Foundation), Catherine Murdoch, Catherine Young & David Hamilton, Cathie Plowman & David Butler, Chris Sims**, Christine Fialho, Clare Lawrence, Clare Lond-Caulk, Coral Saward & Riley Gaylor, Craig Searle**, Daniel Hackett, Dannielle Denning, David Dieckfoss*, David Mason, David Sledge, David Zendwalewicz, Deborah Taylor, Dinah Woods, Dr Gary Luck, Dr Nikki den Exter, Earth Ocean Network Inc. Bicheno, Emma Egan, Emma Godden & James Green, Erik Hayward, Eve Hayden, Fiona Loughran, Frank Wilson*, Gareth & Beverley Matthews, Geoff Shannon, Gill Basnett, Heidi Krajewsky, Hemraj, Iona Flett*, Jen Calder, Jewell family, Jill Hammond & Family, Jill Harris, Jillian Lyall, Jim Lovell, Jenny Lovell, Sarah Lovell, Patrick Lovell, Jo Voller*, Joan Ward, Joanne Potts, Joh Bloomberg, John & Ann Hughes, John & Jennifer Davey, Josephine Murray, K Green, K Robke, Kath Fleming, Kathleen Nolan, Kathy Gatenby & Tom Dunbabin, Keith Martin-Smith*, Kim & Rob Scanlon, Lawrence family, Lee Navickas, Leoni Read, Lisa & Michael Mahoney, Lisa Walkden & Saskia, Louise Brooker*, Lucy Landon-Lane, Luke Rowden, Lyle Ground, Maggie



Mars, Mandy Nelson, Marg Fitzgerald, Margaret Woodward & Justy Phillips, Mark Fowkes, Mark McCormack*, Marlene & Brendan Schmidt, Maryanne Young, Matthew Fielding, Michael & Grainne Hendrey, Michael & Sally Simco, Michael Dempsey*, Mick Brown, Mira Corry, Mrs Kym N Matthews, Naomie O'Loughlin Scotch Oakburn College, Nick Mooney**, Nicole Gill, Nicole I. Anderson, Paige Eveson, Patrice Baxter, Patricia Shires, Paul Brooks, Peter D Moore, Peter Hefferon, Peter Vaughan, Ray Turnbull, Rob & Lisa Hopwood*, Robbie Gaffney, Robert Masterman, Robert Read*, Robyn Tuft, Rosie Long, Sally Hildred, Samantha Bailey, Shelley Graham, Shaun Thurstans & Dydee Mann, Sofia Lundy, Steve Greig* & Sharyn Jackson, Stewart Huxtable*, Sue Gebicki, Suyanti Winoto-Lewin, Suzanne Betts, Tahlia & Lily, The O'May Family, Tony Thiele, Trowunna Wildlife Sanctuary, Wade Bone & Rachel Lynch, Wendy Armstrong.

Major funders

Major funders for Where? Where? Wedgie! 2018-20 were the Tasmanian Community Fund, the Tasmanian Government Department of Education and Woolnorth Wind Farm Holding. The project was also supported by the Pennicott Foundation and TasNetworks. ICS created and supported the NatureTrackers website throughout 2018. ProofSafe volunteered their time to create survey forms for Where? Where? Wedgie! on their app, and provided personal support throughout the surveys. DPIPWE and the University of Tasmania also provided in-kind support, and additional funding was provided by Inspiring Australa, Kingborough Council and Pozible supporters.



Glossary & FAQs

Analysis, analyses, data analysis – any calculations carried out – from averages and percentages to complex mathematical models – to make sense of the data (here, *Where? Where? Wedgie!* survey information).

Bonus surveys involve NatureTrackers carrying out *Where? Where? Wedgie!* surveys outside the official survey dates, in the vicinity of GPS-tagged eagles, to learn how distance between observer and eagle affects detectability. This may assist with population size estimate.

The **Bookend Trust** is a not-for-profit education initiative that seeks to inspire students and their communities with positive environmental engagement that helps make the world a better place. These endeavours include coordinating the NatureTrackers and Expedition Class programs.

Confidence intervals – Estimates are only estimates! They're commonly provided with a pair of 95% confidence intervals. There's a calculated 95% chance that the true value lies within these confidence intervals.

Detectability of a bird is the likelihood of spotting it, if it's present in the area being surveyed. See *Methods: Making sense of the numbers*.

Expedition Class was created by Andrew Hughes in 2007 to inspire and motivate school students in science and environmental education, specialising in a unique model of adventure learning. It continues with the Bookend Trust, and includes a huge range of free online learning resources, school visits, and professional learning for teachers. Andrew is pursuing new educational projects but regularly works with the Bookend Trust on elements relating to NatureTrackers, Extinction Matters BioBlitzes and more.

Monitor (population monitoring) – The repeated measurement of population size or extent (or indicators of these) over time, to detect significant changes. See the Introduction.

NatureTrackers – coordinates citizen science species monitoring projects including *Where? Where? Wedgie!* and also describes everyone who participates in these projects.

Occupancy, occupancy modelling, occupancy estimate – Occupancy modelling estimates are designed to relate to the proportion of an area that the study species occupies, and has been shown for many species to provide a useful indicator of population size: an increase or decrease in occupancy corresponds to real changes in population size. See *Methods: Making sense of the numbers*.

Population trend – the overall direction, over time, of a change in population size (i.e. increase or decrease in number or geographic extent). Population decline: a general decrease in population size over time.

Power analysis – from our estimates of detectability and occupancy, a power analysis allows us to calculate how certain we can be that there was no significant change in occupancy (our indicator of population size) between years. We can find out how many surveys in how many squares are needed for us to confidently detect changes of a certain magnitude.

Survey squares – *why can I only survey in the selected squares?* I want to survey on my own property where I know there are eagles! We need surveys from a wide range of environmental conditions – both good and bad for eagles. See the box on the 2018 Pilot, and the Glossary definition of Zero Heroes.

Tasmanian wedgies – are they different from mainland wedgies? Tasmanian wedgies are a little larger and paler. Some mainland wedgies are not nearly as sensitive to disturbance when breeding as Tasmanian wedgies.

Threatened species – a species that has been placed on a formal threatened species list (e.g. the International Union for the Conservation of Nature's Red List, or within State or Commonwealth legislation). This involves a process to assess the risk of extinction it is facing, on the basis of its population number, extent, and past or expected decline in either of these. Each species is assigned a category, such as Endangered or Vulnerable.

Threats in my area – *I'm concerned that something happening near me might cause problems for eagles. Can Where? Where? Wedgie! pick this up?* This survey is designed to detect state-wide population changes, and so would pick up any major impacts on the species. With enough data over long periods, it may detect regional impacts.

Zero Hero

This term was coined by the British Trust for Ornithology to highlight how essential it is to complete and report on all your surveys, whether or not you saw any birds. Our estimates are all about the proportion of surveys during which birds were seen. If some people don't report their 'zeros', it could seem that the birds are more common or detectable than they really are. It can feel disappointing not to find any birds during your surveys, so Zero Heroes deserve a special cheer. But if you set your day up to make sure you have a great time regardless, you'll be able to celebrate being a Zero Hero!

Further reading

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Eric Woehler

Sulphur-crested Cockatoo



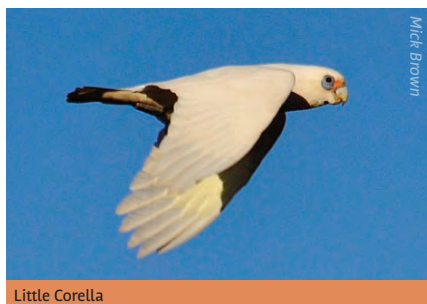
Mick Brown

Grey Goshawk



Keith Martin-Smith

Long-billed Corella, aka Slender-billed Corella



Mick Brown

Little Corella



Elaine McDonald

Peregrine Falcon



Mick Brown

Australian Hobby, aka Little Falcon (adult)



Elaine McDonald

Brown Falcon (adult)



Mick Brown

Brown Goshawk, aka Australian Goshawk (juvenile)



Mick Brown

Collared Sparrowhawk (adult)



Eric Woehler

Nankeen Kestrel, aka Australian kestrel (adult)



Elaine McDonald

Swamp Harrier



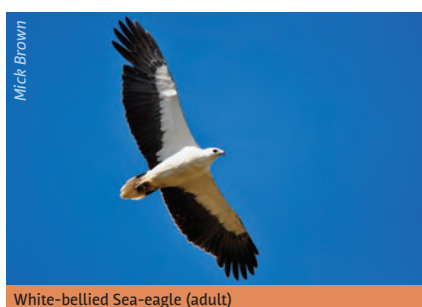
Elaine McDonald

Wedge-tailed Eagle (adult)



Keith Martin-Smith

Wedge-tailed Eagle (juvenile)



Mick Brown

White-bellied Sea-eagle (adult)



Jacqui Gardner

White-bellied Sea-eagle (juvenile)



WHY SURVEY FOR ALL RAPTORS AND WHITE COCKIES?

We'd like to look out for all these species. Some people believe that brown falcons are becoming rarer, and that sulphur-crested cockatoos are becoming problematically numerous – let's do the science on this. It's also important for NatureTrackers to carefully check any white birds they see, to make sure that they're not Endangered grey (white) goshawks.

Report authors: Clare Hawkins, Angela Dean, Andrew Hughes, Jim Lovell, Nick Mooney, Stuart Newson, James Pay and Joanne Potts.

An earlier draft was edited by Eve White (White Editing).

Design: by Patrick Badger.

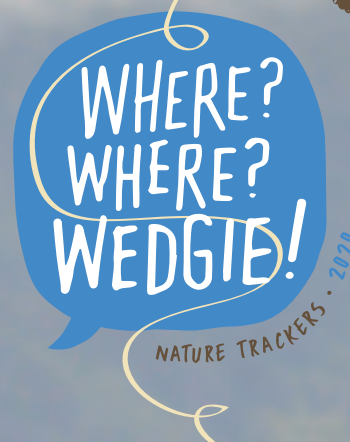


Photo: Peter Vaughan



Photo: Stephen Anstee





Photo: Persia Brooks

2018-2020



Photo: Bridget Jupe

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