

COMMUNITIES LISTENING FOR NATURE

Citizen science in the Mount Alexander Region 2017 – 2019



Tawny Frogmouth. Photo: Andrew Haysom

A REPORT ON A COMMUNITY PARTNERSHIP IN ECO-ACOUSTIC
MONITORING IN THE MOUNT ALEXANDER REGION, VICTORIA

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Victorian National Parks Association

The Victorian National Parks Association (VNPA) helps to shape the agenda for creating and managing national parks, conservation reserves and other important natural areas across land and sea. We work with all levels of government, the scientific community and the general community to achieve long term, best practice environmental outcomes. The VNPA is also Victoria's largest bush walking club and provides a range of information, education and activity programs to encourage Victorians to get active for nature.

NatureWatch

NatureWatch is a citizen science program which engages the community in collecting scientific data on Victorian native plants and animals. The program builds links between community members, scientists and land managers to develop scientific, practical projects that contribute to a better understanding of species and ecosystems, and contributes to improved management of natural areas.

Project Partners

Museums Victoria



Museums Victoria has been trusted with the collection and curation of Victoria's natural history for over 160 years and serves as a key international research institute and expert in data archiving and long-term data protection. Responding to changing intellectual issues, studying subjects of relevance to the community, providing training and professional development, and working closely with schools, communities, and online visitors, Museums Victoria works to disseminate our collective knowledge through online resources and image, audio and video databases.



Connecting Country

Connecting Country is community-operated not-for-profit organisation working to restore and enhance biodiversity and improve the productive natural environment across the Mount Alexander region in central Victoria. The organisation is led by the community and collaborates widely to achieve their vision for the people of the Mount Alexander Region to be proud of the beautiful, productive, healthy and diverse landscapes, habitats, forests, waterways, flora and fauna that we have supported and created in our region. Activities include on ground works, community engagement, flora and fauna monitoring programs and support for numerous Landcare and Friends groups.

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Helen Macpherson Smith Trust

Summary

Monitoring bird populations is an effective way to evaluate local biodiversity, and corresponding habitat condition. However, it is time-consuming to both collect and analyse bird sightings or bird call data. The study of eco-acoustics allows for the collection of bird call data across large areas of land and over an extended period with a minimal number of people in the field.

From 2017 to 2019, the Victorian National Parks Association (VNPA) partnered with Museums Victoria, local volunteers from the Mount Alexander area who are associated with the Connecting Country group, and local landholders to monitor bird populations in three forest blocks in the Bendigo Box-Ironbark Key Biodiversity Area. With many day-time surveys already being conducted in the area, it was decided to address the gap in knowledge on nocturnal bird species. An initial detectability study was conducted largely on private land in 2017, followed by a broader effort to deploy song meters in the Muckleford, Sandon and Rise and Shine areas west of Castlemaine in 2018.

Community volunteers from the Mount Alexander team provided local expertise and collected the bird song data. VNPA supported them with equipment, training and data management while experts at Museums Victoria analysed the data. Together this partnership delivered a current snapshot of the health and distribution of bird populations, especially nocturnal bird species, across many different habitat types in the Mount Alexander region.

Project outcomes:

- 5400 hours of useable recordings were collected in the Detectability study
- 5005 hours of recordings were collected during the Mount Alexander Region study
- 33 bird species were identified
- Target species that were recorded include: Barking Owl, Powerful Owl, Southern Boobook, Australian Owlet-nightjar, White-throated Nightjar and Tawny Frogmouth.
- Volunteers contributed:
 - 78 days of fieldwork
 - > 80 hours of project planning meetings
 - 72 hours towards filming the project videos
 - Numerous hours assisting with equipment and data management and reporting.

Bird species detected		
Australian Magpie	Galah	Raven species
Australian Owlet-nightjar	Golden Whistler	Red Wattlebird
Barking Owl	Grey Currawong	Rufous Whistler
Black-faced Cuckoo-shrike	Grey Fantail	Scarlet Robin
Bronzewing species	Grey Shrike-thrush	Southern Boobook
Corella species	Horsfield's Bronze Cuckoo	Spotted Pardalote
Crimson Rosella	Laughing Kookaburra	Sulphur-crested Cockatoo
Duck species	Masked Lapwing	Superb Fairy-wren
Eastern Koel	Pacific Black Duck	Tawny Frogmouth
Eastern Yellow Robin	Pied Currawong	White-throated Nightjar
Fan-tailed Cuckoo	Powerful Owl	White-throated Treecreeper

The information gathered in this project will help the local community and land managers to control threats, and work to protect threatened species. In addition, this project has been an excellent way to increase expertise in monitoring local bird species and their habitat requirements as well as increasing awareness of the value of protected areas in preserving local biodiversity.

This project has provided Museums Victoria with a new bird call data set to add to their online collection to enhance their bird call recognition software. This will improve their ability to identify bird calls quickly and accurately assess bird populations in Victoria.

A series of professional videos were created to highlight this location of the Communities Listening for Nature project. They provide an overview of the project and include insight from team leaders and landholders who participated in the study.

Video link: <http://vnpa.org.au/programs/communities-listening-for-nature/>.



Jenny Rolland and Euan Moore setting up song meters in Rise and Shine Bushland Reserve. Photo: Sera Blair

This research was conducted under DELWP research permit #10007964 and permit NW11140F. Early fieldwork in state forests was conducted in conjunction with Terri Williams, DELWP research permit #10008600.

1. Introduction

Communities Listening for Nature

Communities Listening for Nature is an exciting citizen science project, run by the Victorian National Parks Association in partnership with Museums Victoria, and local community groups and land managers. It has been run at five sites across Victoria including Brisbane Ranges National Park (Friends of Brisbane Ranges National Park), Wombat State Forest (Wombat Forestcare), Bunyip State Park (Friends of Bunyip State Park), Mount Worth State Park (Mount Worth & District Landcare & Friends of Mount Worth State Park) and around the Mount Alexander region (Connecting Country). The program involves collaborative research design and implementation utilising new acoustic technology to monitor native birds in Victoria.

The aim of Communities Listening for Nature is to engage, train and equip community groups and volunteers in Victoria as citizen scientists and to detect, record and study Victorian birds, including some of the State's threatened species. This program supports local community expertise in bird identification and habitat use, providing important knowledge of Victorian bird species to assist with active management and conservation planning.

Data collected by citizen scientists will contribute to answering the project research questions, be added to the Victorian Biodiversity Atlas, and contribute to Museums Victoria's curated sound reference library of Victorian birds. Scientists, land managers, conservation groups and the general public worldwide can use this reference library to investigate Australia's unique bird life.

The study of bioacoustics

Bioacoustics combines acoustic and biological principles to record and analyse sounds in nature. It goes beyond just species identification and can investigate how an animal relates to their environment.

Recording devices, such as Song Meters, are easy to install in the field to record bird sounds. They can be programmed to focus on recording at certain times of the day and the frequency of recording. Recordings can also be set up simultaneously at multiple locations and rotated regularly to new locations, to maximise data collection. This survey method can provide data on the presence of secretive species or species that vocalise infrequently which have a greater probability of being missed during human-based surveys.

The recordings collected from the field are analysed using specialised software that interprets bioacoustic sound frequency as visual displays called spectrograms. Spectrograms essentially graph the sound and can be annotated by bird sound identification experts to identify the species. They can also be run through auto-detection software that can extract patterns for specific species against recognisers in models developed from previous identifications. However, whilst acoustic monitoring can provide clear evidence of the presence of particular species, and presence within different habitats, it cannot give comprehensive information about how many individuals there are in an area.

Acoustic monitoring also allows the assessment of the soundscape of a site, a reliable ecological monitoring tool for biodiversity (Fuller et al. 2015) that is an indicator of the natural calling activity of species across long periods of time that may not be possible in time-restricted, human-based surveys. One way to summarise soundscape data is to calculate an Acoustic Complexity Index (ACI) at each site (Pieretti et al. 2011). This calculation measures the complexity of bird sounds in a soundscape as a way to indicate both singing activity and the diversity of birds present. Higher ACI values indicating more singing activity and greater bird diversity. ACI values can then be compared across sites to help understand how different sites compare with

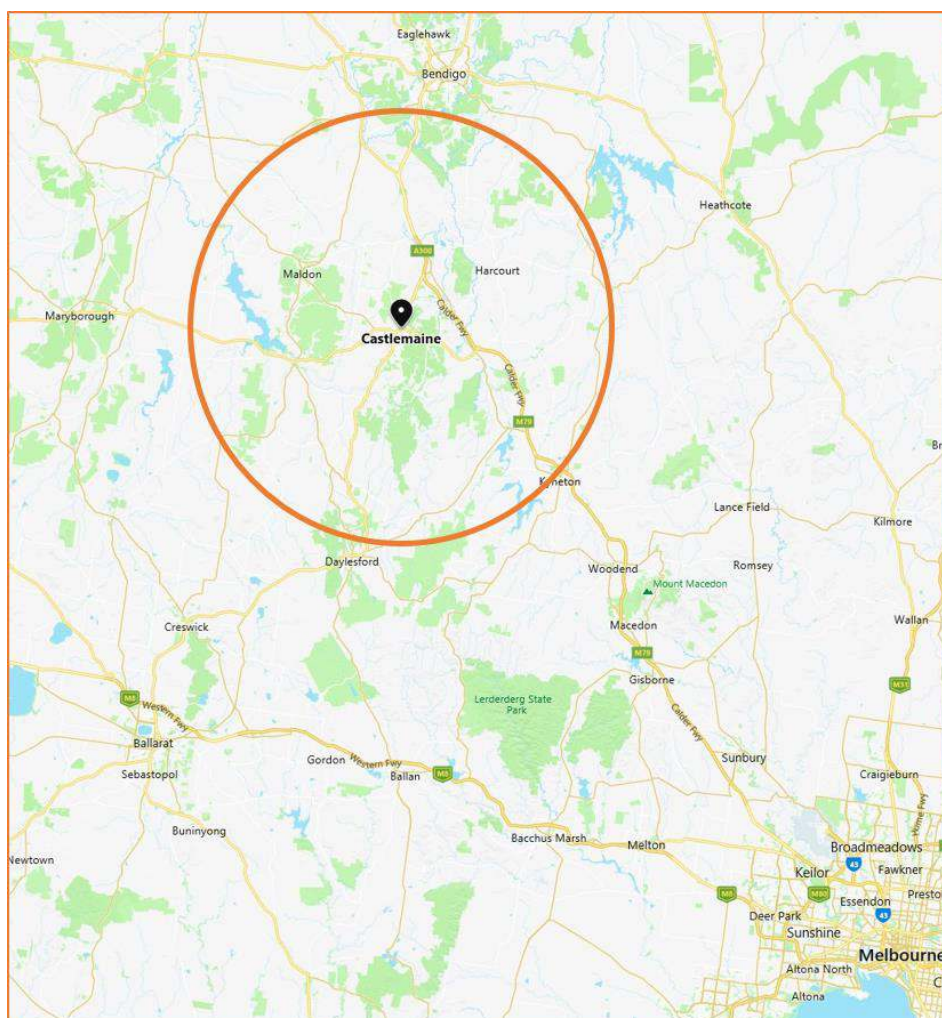
one another or are associated with different characteristics (e.g., do sites differ in their ACI in different Ecological Vegetation Classes).

Beyond drawing out ecological information from sound recordings, audio clips of local soundscapes and species are a great educational resource to present to the community. In this project, each recording is independently analysed by experts at Museums Victoria, archived digitally and stored in their collections into perpetuity. This makes them permanent, verifiable evidence of the presence of bird species at specific locations, and a valuable tool in monitoring threatened and other species.

Monitoring in the Mount Alexander Region

The Mount Alexander Region of central Victoria occurs in the lower foothills on the north side of the Great Dividing Range, approximately midway between Kyneton and Bendigo (Figure 1). The region is broadly defined as an area with a 30km radius around the township of Castlemaine. Semi-arid climate influences the region from the north, with milder and wetter climate pushing up from the more mountainous south. The area is classified as the Central Victorian Uplands Bioregion. Volcanic plains are on the western edge of the region, sedimentary sandstones occur broadly, and granitic country occurs to the north-east with scattered outcrops throughout.

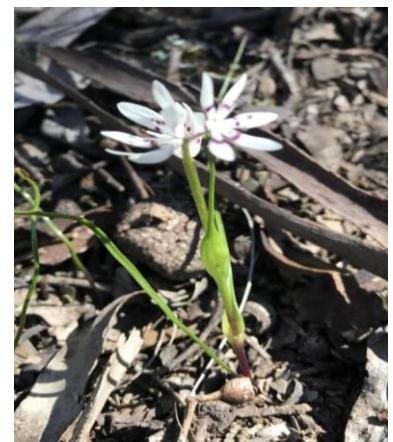
Figure 1: Map of the project region within a 30km radius of Castlemaine.



The Mount Alexander region is traditionally home to the Jarra people, also known as the Dja Dja Wurrung. With European settlement in the late 1830s, squatters commenced sheep and cattle grazing in the area and the area was the site of one of the first major gold rushes in Victoria from the mid-1850s. These two activities massively altered the vegetation, habitats and wildlife of the region before they were ever properly documented in their original condition.

While there are some individual trees remaining on private and public land that pre-date European colonisation, there are effectively no areas of native vegetation in the region that could be considered 'old growth' or 'largely intact and unaltered'. Fortunately, there are now extensive areas of forest and woodland protected within parks and reserves in the region, but these are mostly on infertile soils and comprise regrowth vegetation following decades of disturbance from activities such as mining, agriculture and forestry. The more fertile soils are mostly on private land, where the majority of vegetation has been cleared and agricultural activities still dominate. However, even within the more fertile areas, many are only semi-viable for profitable agriculture, and increasingly these are being sub-divided for hobby farmers and low-density 'tree-changers' properties. The region is increasingly well known for the environmental consciousness, knowledge and actions of its communities with a high level of Landcare participation.

Influenced by all the factors outlined above, plus others, and also factors beyond the boundaries of the region (e.g. changing climate, introduced species), the vegetation and wildlife of the region is interesting, diverse and continues to alter. Some fauna species have disappeared since European colonisation (e.g., most medium-sized mammals, Grey-crowned Babblers, emus), some are threatened (e.g. Swift Parrot, Barking Owl), many appear to remain relatively secure (e.g. a moderate proportion of the small-to-medium sized woodland birds; frogs; wallabies), and others are arriving and/or thriving (e.g. ravens, currawongs, magpies, cockatoos, kangaroos). While there is reasonable knowledge of the extent and status of many fauna in the region, there is also much that is uncertain. The night birds of the region are one group where this information is scant and unreliable.



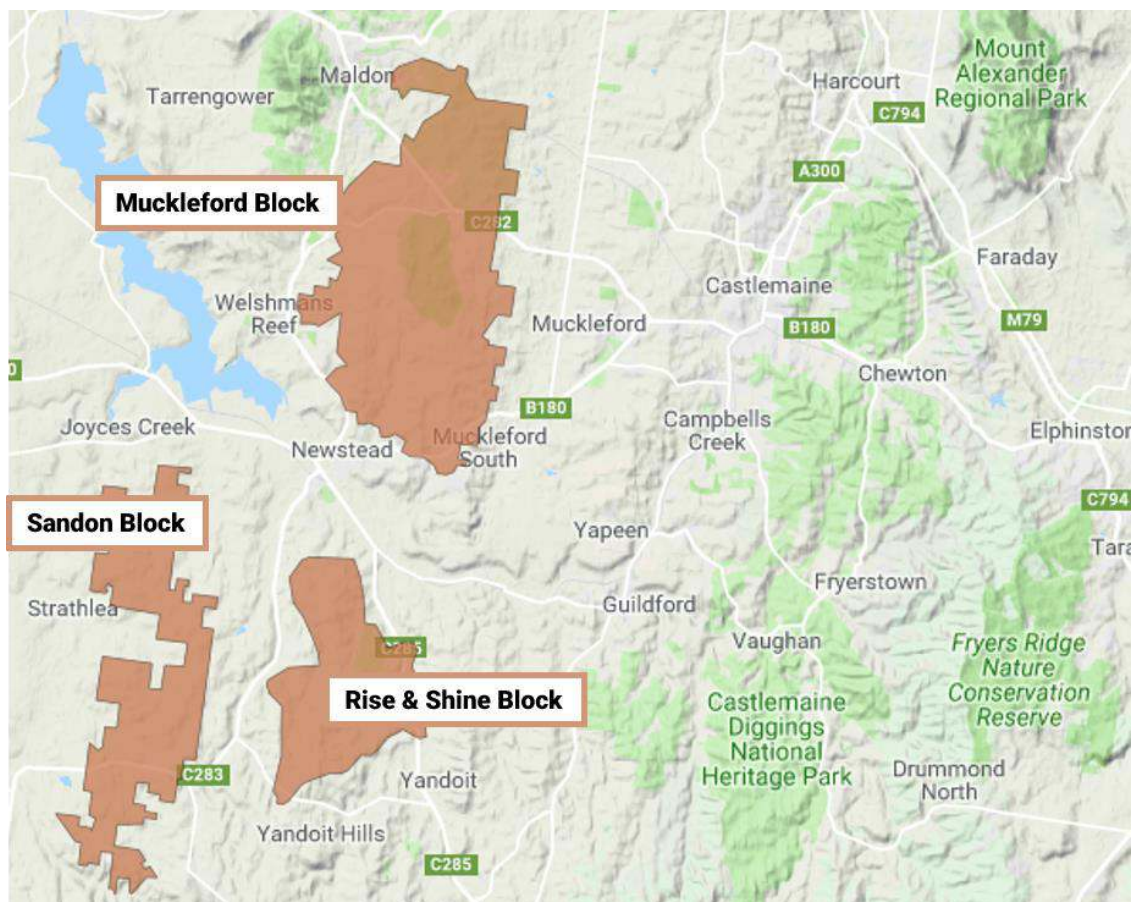
Early Nancy Lily in Rise & Shine
Nature Conservation Reserve.

Key Biodiversity Areas

This project focused on three forest blocks that are part of Birdlife International's Bendigo Box-Ironbark Key Biodiversity Area (KBA) (Figure 2). KBAs are part of a global network of sites where bird conservation is being monitored largely by community-driven projects.

- Muckleford Block – Muckleford State Forest, Muckleford Nature Conservation Reserve and Maldon Historic Reserve
- Sandon Block – Sandon State Forest
- Rise & Shine Block – Rise and Shine Bushland Reserve (Pickpocket Diggings Historic Reserve) and adjacent private property.

Figure 2: Map of the three forest blocks in the Bendigo Box-Ironbark Key Biodiversity Area used in this research.



Project Design

Prior to the planning workshop, three meetings and one training session were held between 23 June and 25 September, 2017. These were attended by representatives from Connecting Country, project partners from Museums Victoria and VNPA, local community volunteers and land holders. These meetings were used to discuss potential project aims, song meter methodology and parameters of the technology and key target areas.

It was agreed that due to the extensive local knowledge on diurnal birds and the flexibility of the song meter technology, the study would focus on addressing the local knowledge gap around nocturnal birds. Table 1 outlines the target species of nocturnal bird for the study, ranging from common species that were expected to be found, to rarer species with little evidence of local populations. Three additional species, Bush Stone-curlew, Eastern Barn Owl and Australian Masked Owl, were initially considered for inclusion in the study. However, given the lack of recent verified records of Bush Stone-curlews, detection of the species was unlikely and efforts would be more beneficial spent looking for other species likely to be found within the study areas. For Eastern Barn Owl and Australian Masked Owl, the confidence of the volunteers and Museums Victoria experts to distinguish between the calls of these species within field recordings was low, making it difficult to create an accurate call recogniser or be able to confidently evaluate the output from the recogniser. We therefore chose to focus on seven target species for this project.

Table 1: Target bird species for the study

Common Name	Scientific Name	Conservation Status in study sites
Powerful Owl	<i>Ninox strenua</i>	Relatively common
Barking Owl	<i>Ninox connivens</i>	Rare
Southern Boobook	<i>Ninox boobook</i>	Common
Tawny Frogmouth	<i>Podargus strigoides</i>	Common
Australian Owlet Nightjar	<i>Aegotheles cristatus</i>	Relatively common
White-throated Nightjar	<i>Eurostopodus mystacalis</i>	Relatively common
Spotted Nightjar	<i>Eurostopodus argus</i>	Rare

To refine the project aim further and develop the study design, a planning workshop was held on 9 October 2017 with representatives from Connecting Country, local project volunteers, local land holders, Museums Victoria and VNPA.

Project Aim: To determine the distribution of night birds across the Mount Alexander region.

Due to the agreed difficulty in detecting the target night birds through recordings, the project team agreed on an initial Detectability Study. This was undertaken to determine the optimal deployment duration and recording schedule for target species and to increase the likelihood of detecting them using automated recognition software. We selected the Powerful Owl as a focus for estimating a detection probability (i.e., the likelihood of detecting the species on any given day) to develop our recording protocol as this species is rare, but highly detectable when present and a call recogniser already existed that could be used to determine presences. This calculation provides an estimate of the number of nights recorders should be placed at a site to have confidence of detecting them if they are present.

The following parameters were applied to the Detectability Study:

- Song meters deployed for one-week intervals across the remaining spring season
- Sites located on public and private land across the region in areas where target species were known to occur to maximise the likelihood of capturing their sounds.
- Sites were a minimum of 1 km apart to ensure they represented independent sites. For Powerful Owls, with a long ranging call, a minimum of 2 km was agreed to avoid recording the presence of the species at a site when the bird was not actually nearby.
- Where possible, song meter recorders were placed away from other potential noise sources, roads, farms or running water, to reduce competing sounds on recordings.
- Song meters were placed on trees at head height to closely mimic how bird sounds would naturally be detected by observers.

Learnings from the Detectability Study were integrated into the Mount Alexander Region Study within the three Key Biodiversity Area blocks. Similar parameters to the Detectability Study were adopted except for dusk to dawn recording times. Sites were selected across a range of Ecological Vegetation Classes in each area to provide the opportunity to monitor birds in different habitat types.

2. Methods

Song Meter Methodology

Communities Listening for Nature uses 'Song Meter SM4' devices from Wildlife Acoustics. Each Song Meter contains two built-in microphones for multidirectional recording and two 64 GB SD cards, all contained within a weatherproof protective case.

At each site, volunteers located the center of the site (using GPS coordinates) and used the nearest suitable tree to set up the Song Meters. Song Meters were fixed to a tree trunk at approximately ear height (about 150 cm) above the ground with an elastic strap and secured with a cable-lock to prevent damage and theft. Locations were recorded with GPS. Recording began on the day they were set-up and stopped either when the SD cards were full or when the Song Meter was retrieved. Recording was continuous from dusk to dawn and saved as a consecutive series of .wav files of no more than 1 hour each. This is a standard procedure on the SM4 to reduce the risk of file writing failure when converting the sounds into a .wav recording.



Song Meter SM4 acoustic recording device. Photo: Sera Blair

Site Selection

Sites were selected across a range of Ecological Vegetation Classes (EVCs) to represent the diversity of habitat in the area (Table 2). Sites were predominantly Box-Ironbark Forest and Heathy Dry Forest.

Table 2: Ecological Vegetation Classes (EVCs) represented in this project and their conservation status (DELWP 2018).

EVC Name	EVC Number	Conservation Status	Number of sites
Heathy Dry Forest	20	Least Concern	9
Wet Forest	30	Least Concern	1
Floodplain Riparian Woodland	56	Endangered	1
Box-Ironbark Forest	61	Vulnerable	20
Creekline Grassy Woodland	68	Endangered	1
Grassy Woodland	175	Endangered	7
Hillcrest Herb-rich Woodland	70	Depleted	1

Data analysis

Acoustic field recordings were sent to Museums Victoria for analysis where species-specific recognisers were generated for commonly detected and threatened bird species previously recorded at different sites.

Recognisers are a type of model created based on available, pre-existing high quality vocalisations ('template vocalisations') for a species. Individual recognisers were created for each species based on their most diagnostic and common call to maximise the likelihood of their detection. Once created, recognisers were used in an automated process to scan the acoustic field recordings collected by Song Meters and detect vocalisations ('candidate vocalisations') that matched the template vocalisations. Candidate vocalisations were then manually checked to verify species presence as false positive detections are commonly encountered with all types of automated species recognisers. Species-specific recognisers were used to produce a general species list for research sites.

Acoustic Complexity Index (ACI) was calculated for each of the three blocks in the Key Biodiversity Area to allow for comparison between blocks. Individual recordings were clipped into consecutive and non-overlapping 10-min clips to reduce computational requirements and to improve the resolution of the daily patterns in ACI. Daily patterns in ACI were then calculated for each block to compare complexity throughout the recording period (1 hour before dusk to 1 hour after dawn).



Australian Owlet-nightjar in tree hollow.
Photo: Damian Kelly

3. Results

A: Detectability Study

The Detectability Study collected audio recordings between: 16 October 2017 and 23 February 2018.

It was run largely on private land due to a lack of some permits for public land use at that stage. Many local landowners were generous enough to allow the song meters to be installed on their properties. Song meters were deployed for one-week intervals and set to record continuously through the day and night.

Additional information collected at detectability study sites:

- GPS location on song meters
- Date and time of deployment
- General habitat description (e.g. open woodland, shrubby understory with closed canopy, grassland with scattered shrubs)
- Photographs of the study sites for additional representation of the habitat values.
- General weather conditions
- Any incidental bird sightings while managing the song meters in the field
- Names of people who set up and retrieved the song meters.

Results of the Detectability Study:

Over 1.7 TB of audio data was collected over 91 days of recording during the Detectability Study. This dataset included 28,724 usable audio files totaling over 5400 hours of recordings. On average, 180 hours of audio were recorded at each site, with individual sites varying from 65 h to 542 h (Table 3).

Preliminary analysis of the audio files was restricted to the hours between sunset and sunrise to limit the effort required of volunteer listeners. Five species of night bird and a variety of other birds and animals were detected including:

- **Powerful Owl:** detected by Museums Victoria software recogniser
- **Southern Boobook:** detected by volunteer listener and Museums Victoria listener
- **Tawny Frogmouth:** detected by volunteer listener and Museums Victoria listener
- **White-throated Nightjar:** detected by volunteer listener and Museums Victoria listener
- **Australian Owlet Nightjar:** detected by volunteer listener and Museums Victoria listener
- Additional sounds detected: various diurnal birds, Koala, Common Brush-tailed Possum, Sugar Glider, kangaroos (hopping), Fox, Dingo (from nearby dingo farm), frogs, domestic animals, vehicles and aeroplanes.

Table 3: Summary of the number of 10-min recordings and total duration of recordings from the detectability study including land tenure and EVC.

Site name	Land Tenure	EVC	Number of 10-min recordings	Duration of recordings (hours)
BS	Private	Wet Forest	990	164
CT1	Private	Box-Ironbark Forest	924	153
CT2	Private	Box-Ironbark Forest	1004	166
EW	Private	Box-Ironbark Forest	437	72
EW2	Private	Box-Ironbark Forest	1002	166
HAL	Private	Box-Ironbark Forest	1268	210
IG	Private	Hillcrest Herb-rich Woodland	995	164
JE	Private	Box-Ironbark Forest	1584	263
JE01	Private	Creekline Grassy Woodland	73	198
JE02	Private	Box-Ironbark Forest	90	243
JE06	Private	Floodplain Riparian Woodland	174	65
KJ	Private	Grassy Woodland	1099	182
KP	Private	Grassy Woodland	511	84
NS	Private	Grassy Woodland	991	164
PAN	Private	Heathy Dry Forest	1268	210
RU01	Private	Heathy Dry Forest	1195	198
RU02	Private	Heathy Dry Forest	3270	542
SK01	Private	Box-Ironbark Forest	582	96
STO (GR01)	Private	Grassy Woodland	1196	198
WAR	Private	Box-Ironbark Forest	1268	210
FF1	Public	Heathy Dry Forest	1018	168
FF2	Public	Heathy Dry Forest	1009	167
FF3	Public	Heathy Dry Forest	1010	167

The Detectability Study demonstrated that the target species could be detected by the group using song meters, and provided data on the best times of the night in which to detect different local night birds. Table 4 outlines the breeding season of the key nocturnal bird species in the study area, indicating the best times of the year to conduct audio surveys for these species as this is when they are most vocal. The information in Tables 4 and 5 was compiled by Damian Kelly of the Mount Alexander project team from available literature (e.g. HANZAB) and databases (see also Appendix A).

Table 4: Breeding seasons of key nocturnal species in the Mount Alexander Region.

Species	Breeding Season											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Powerful Owl												
Barking Owl												
Southern Boobook												
Tawny Frogmouth												
White-throated Nightjar												
Owlet Nightjar												
Spotted Nightjar												

Table 5 shows the time of the night when different target night bird species call most reliably to assist with detectability. Previous research combined with knowledge of the detection distance of Powerful Owl calls (~1-2 km) suggested sites should be placed at least 2 km apart to avoid recording the same individuals at multiple sites within the study. Results of the Detectability Study also suggested the likelihood of detecting a Powerful Owl on any given night (if present at a site) was 11%. However, given that the Detectability Study took place during the non-breeding season for Powerful Owls, we determined a recording duration of 7-14 days was likely to detect Powerful Owls if they were present.

Table 5: Call times of key nocturnal species in the Mount Alexander Region.

Species	Call Times							
	Before dusk	Dusk	After dusk	Night	Before dawn	Dawn	After dawn	Daytime
Powerful Owl								
Barking Owl								
Southern Boobook								
Tawny Frogmouth								
White-throated Nightjar								
Owlet Nightjar								
Spotted Nightjar								

B: Mount Alexander Region Study

After the success of the Detectability Study, the information learned was applied to the design of the more extensive distribution of night birds study. Project partners met several times to discuss the research parameters for the study.

Key considerations included:

- Monitoring sites should be a minimum of 2 km apart and as far away from roads and houses as possible.
- Study sites were to be in the Bendigo Box-ironbark Key Biodiversity Area. Initially six blocks were considered and then narrowed to three in the Mount Alexander region to compliment diurnal bird studies being conducted by Connecting Country. Selected blocks include:
 - Muckleford (MU sites)
 - Sandon (SA sites)
 - Rise & Shine (RS sites)
- Song meters to be set to record continuously from one hour before dusk to one hour after dawn. Recordings taken for seven days at each site.
- Data is to be shared between project partners, VNPA and Museums Victoria.
- Song meters to be deployed between May and December 2018.
- Sites will be recorded three times, with a one-month gap between each round.

Results of the Mount Alexander Region Study

Nearly 1.6 TB of audio data was collected over 76 days from 17 sites. This included 30,253 usable audio files totaling more than 5005 hours of recordings. On average, 208 hours of audio were recorded at each site, with individual sites varying from 181 h to 383 h (Table 6).

Song meters were deployed in three rounds:

- Round 1: 21 May to 20 June 2018
- Round 2: 11 September to 10 October 2018
- Round 3: 23 November to 19 December 2018

Table 6: Summary of recordings from the Mount Alexander Region Study. (Note: Sites RS1 and RS3 are different to the sites of the same name in the Detectability Study. Site RS2 is the same in both studies).

Site Name	Land Tenure	EVC	Number of recordings	Duration of recordings (hours)
MU01	Public	Box-Ironbark Forest	1735	288
MU02	Public	Box-Ironbark Forest	2316	383
MU03	Public	Grassy Woodland	1689	279
MU04	Public	Heathy Dry Forest	1091	181
MU05	Public	Grassy Woodland	1634	270
MU06	Public	Box-Ironbark Forest	1672	277
MU07	Public	Box-Ironbark Forest	1092	181
MU08	Public	Heathy Dry Forest	1786	296
SA1	Public	Box-Ironbark Forest	2081	343
SA2	Public	Box-Ironbark Forest	2083	345
SA3	Public	Box-Ironbark Forest	2083	345
SA4	Public	Box-Ironbark Forest	2093	345
SA5	Public	Box-Ironbark Forest	2092	345
SA6	Public	Heathy Dry Forest	1604	265
RS1	Private	Box-Ironbark Forest	1734	287
RS2	Public	Box-Ironbark Forest	1734	287
RS3	Private	Grassy Woodland	1734	287

Bird species List:

The presence of six of target species was detected - Powerful Owl, White-throated Nightjar, Australian Owlet-nightjar, Barking Owl, Tawny Frogmouth and Southern Boobook. Spotted Nightjar was not detected at any of the sites.

Powerful Owls were detected at 12 sites, including sites within each of the three main study areas (Muckleford, Rise and Shine and Sandon).

Barking Owls were detected in four sites: RS2, RS3, SA1 and SA2. While the number of recordings where Barking Owls were detected was small (7 recordings), both males and females were recorded based on differentiation by call, with male(s) detected in RS2, a duetting male and female and a single female in RS3, and female(s) in SA1 and SA2.

An additional 27 species that were not part of the target species list were detected with recognisers (Table 7), including Eastern Koel, Fan-tailed Cuckoo, and Horsfield's Bronze Cuckoo. Further effort to review more of the recordings will likely result in a greater number of species identifications for the area.

Table 7: Bird species identified in acoustic data in relation to number of recordings at each research site in the Mount Alexander Region Study.

Common Name	M U 1	M U 2	M U 3	M U 4	M U 5	M U 6	M U 7	M U 8	R S 1	R S 2	R S 3	S A 1	S A 2	S A 3	S A 4	S A 5	S A 6
Australian Magpie									2						1		
Australian Owllet-nightjar	2	28	18	38	4	41	7	4	21	9	26	11	45	23	27	7	12
Barking Owl										2	3	1	1				
Black-faced Cuckoo-shrike			1										1	1			
Bronzewing species															4		
Corella species															1		
Crimson Rosella				1							1						
Duck species						1											
Eastern Koel						2											
Eastern Yellow Robin		2									6						
Fan-tailed Cuckoo			1			2										1	1
Galah				1													
Golden Whistler									1								
Grey Currawong						1											
Grey Fantail									1				1				
Grey Shrike-thrush													1				
Horsfield's Bronze Cuckoo			1									1					
Laughing Kookaburra										2				2	2		
Masked Lapwing		2										1	1				
Pacific Black Duck										1							
Pied Currawong								2									
Powerful Owl	10	20			2		4		4		3	1	16	40	22	3	3
Raven species												2			2		
Red Wattlebird						1						1					1
Rufous Whistler									2						1		
Scarlet Robin				1										1		1	
Southern Boobook	4	15	3	1	4	1	1	1	12	13	19	26	29	17	36	11	4
Spotted Pardalote					1	1										1	
Sulphur-crested Cockatoo														1			
Superb Fairy-wren										1							
Tawny Frogmouth									19			6		1		1	32
White-throated Nightjar		1	4	2	1	1	5	6	2		2					1	
White-throated Treecreeper			2		2					2							

Target species

The six target night bird species that were detected were in five EVCs (Table 8). All target species were detected in Box-Ironbark Forest, a common EVC across the Mount Alexander region. Powerful Owls were distributed widely across the research sites, in all three Key Biodiversity Area blocks and on private properties studied (Figure 3). Southern Boobooks were detected across all five EVCs, while Barking Owls were only detected in Box-Ironbark Forest and Red Gum dominated Grassy Woodland (Figure 4).

Table 8: Site EVCs where target bird species were detected in the acoustic data (both studies).

Common Name	Box-Ironbark Forest	Heathy Dry Forest	Grassy Woodland	Hillcrest Herb-rich Woodland	Wet Forest
Powerful Owl	x	x	x		
White-throated Nightjar	x	x	x		
Australian Owlet-nightjar	x	x	x		
Southern Boobook	x	x	x	x	x
Tawny Frogmouth	x	x			x
Barking Owl	x		x		
Spotted Nightjar	No detections				

Figure 3: Locations of sites where Powerful Owls were detected on audio recordings for Detectability Study (site name_D) and Mount Alexander Region Study.

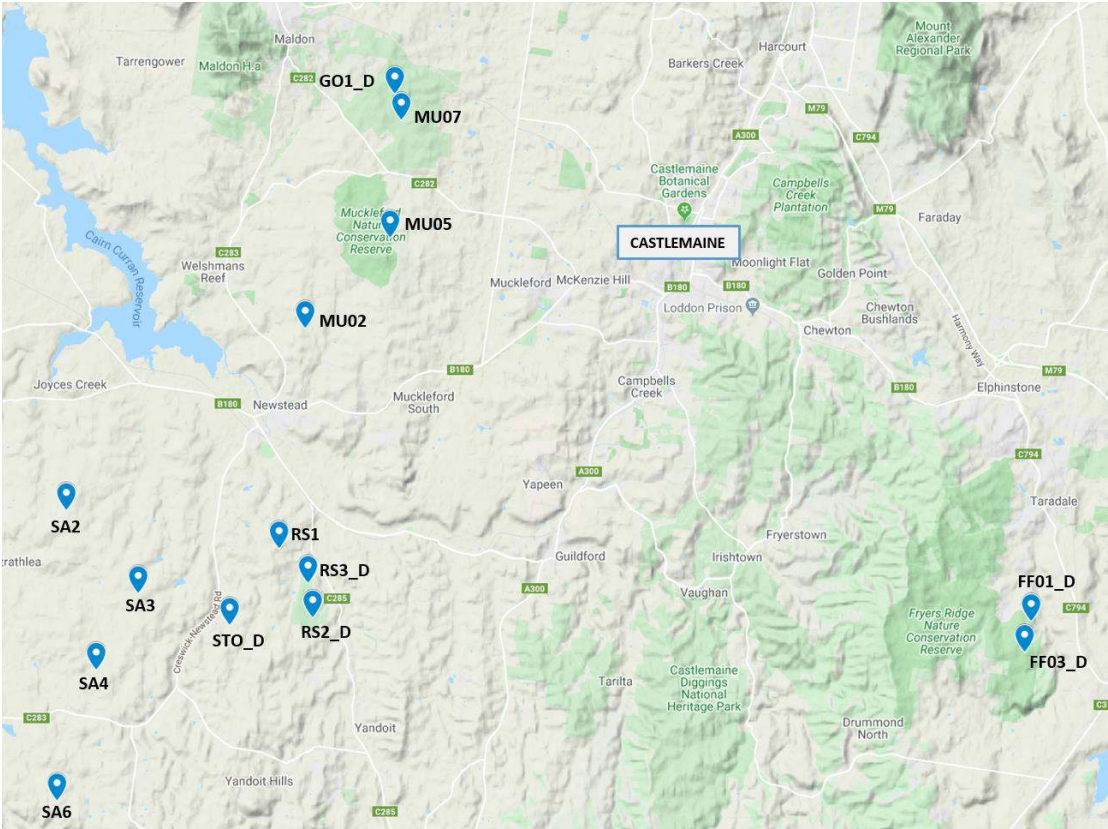
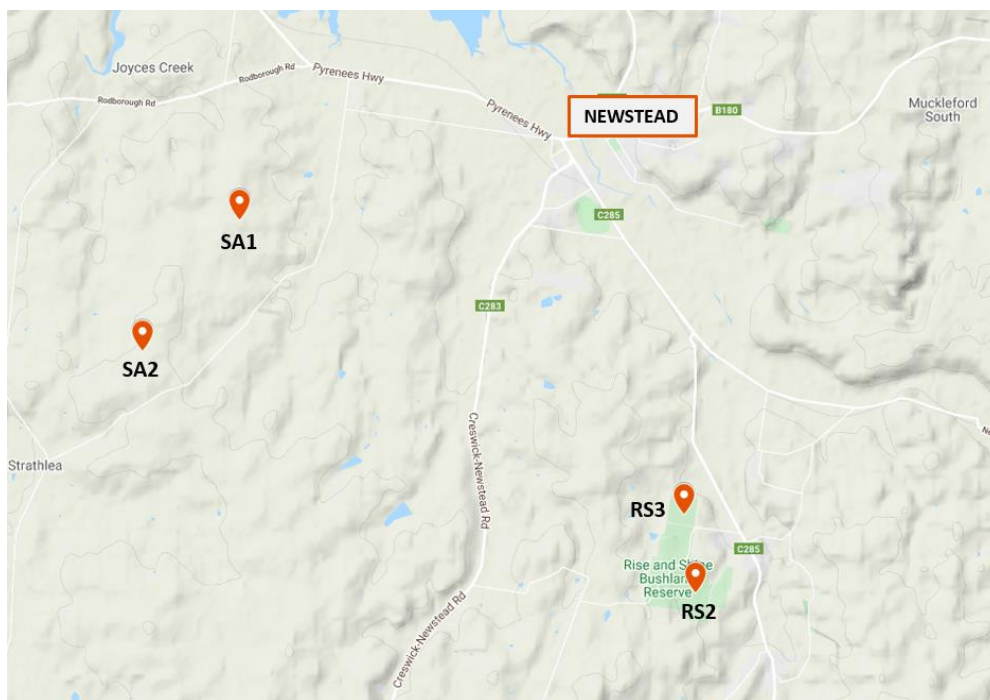


Figure 4: Locations of sites where Barking Owl were detected on audio recordings for Detectability Study and Mount Alexander Region Study.



To complement the targeted species in this study, a list of species occurrences from the Global Biodiversity Informatics Facility (www.gbif.org) was generated for the three regions (Muckleford, Rise and Shine and Sandon) (Appendix B). A total of 215 species have been recorded within these areas; 33 of these are listed as threatened. Of the seven species targeted, two – Barking Owl and Powerful Owl – are listed as Endangered and Vulnerable, respectively.

Spectrograms for target bird species detected.

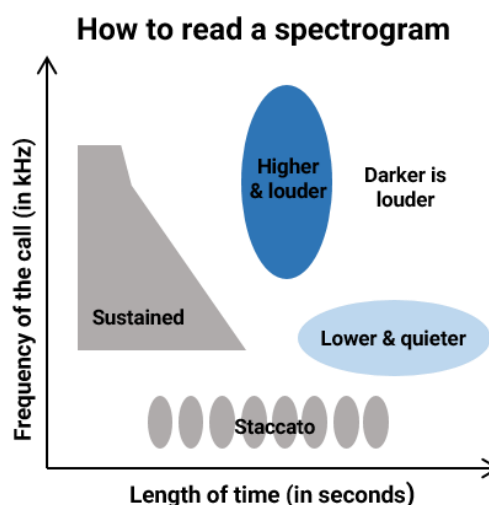


Figure 5: Spectrogram of Powerful Owl call.

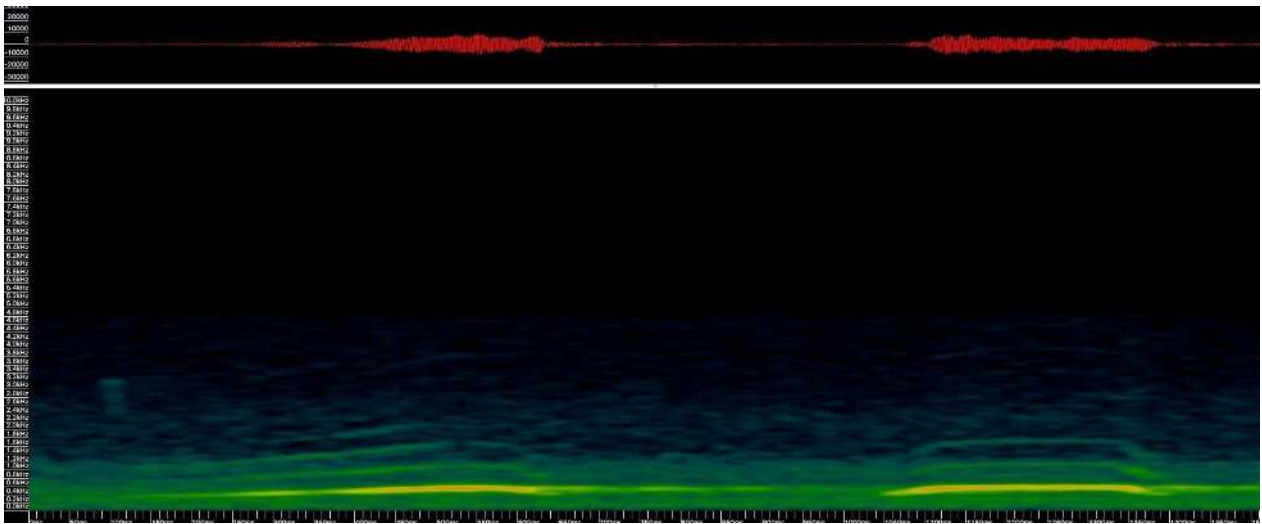


Figure 6: Spectrogram of White-throated Nightjar call.

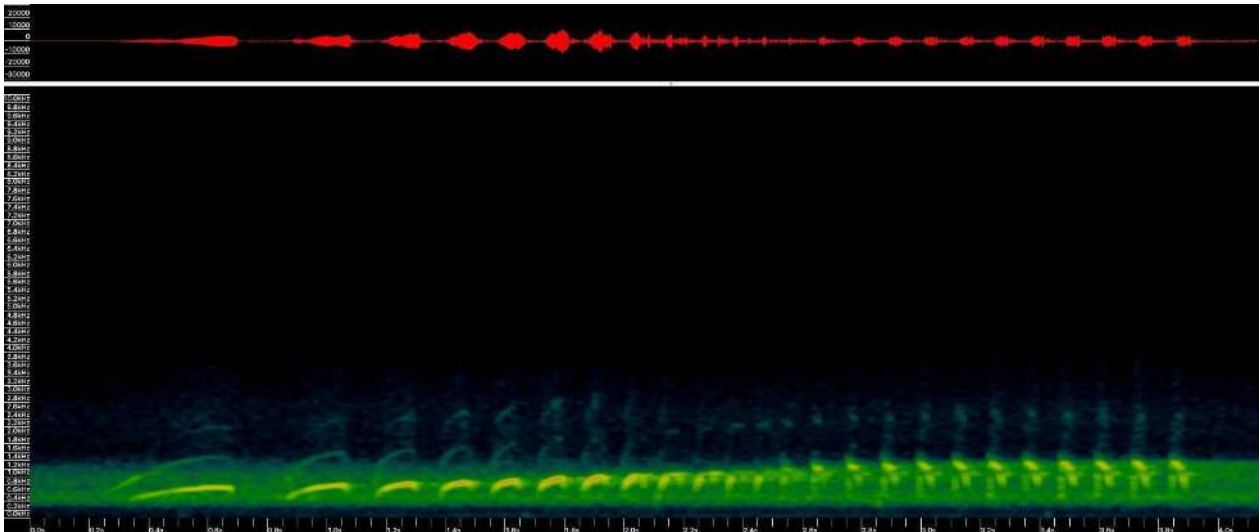


Figure 7: Spectrogram of Australian Owlet-nightjar call.

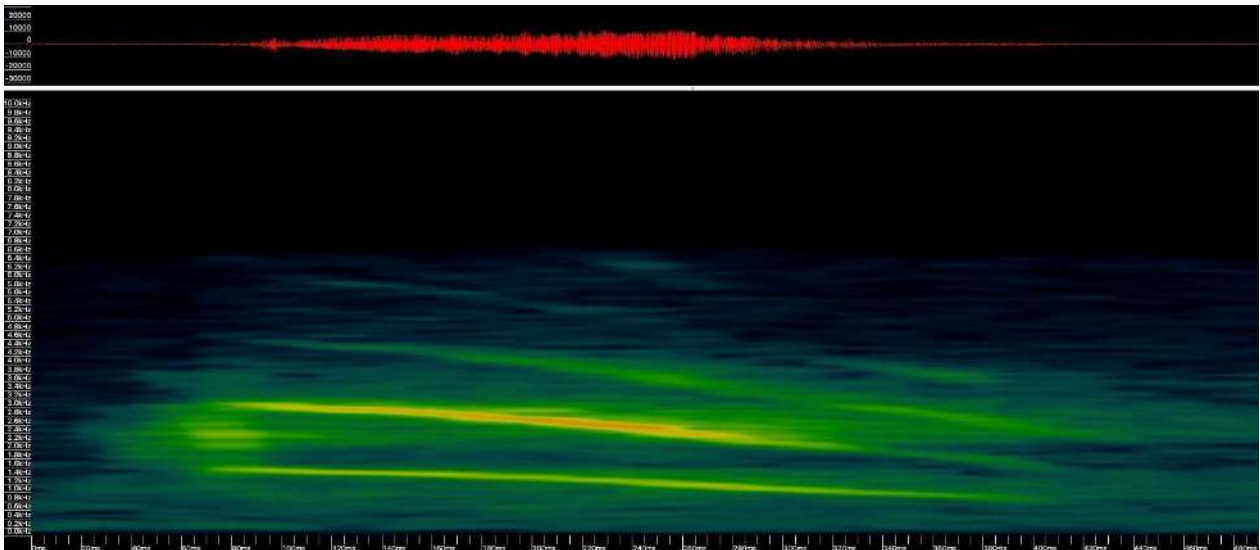


Figure 8: Spectrogram of Southern Boobook call.

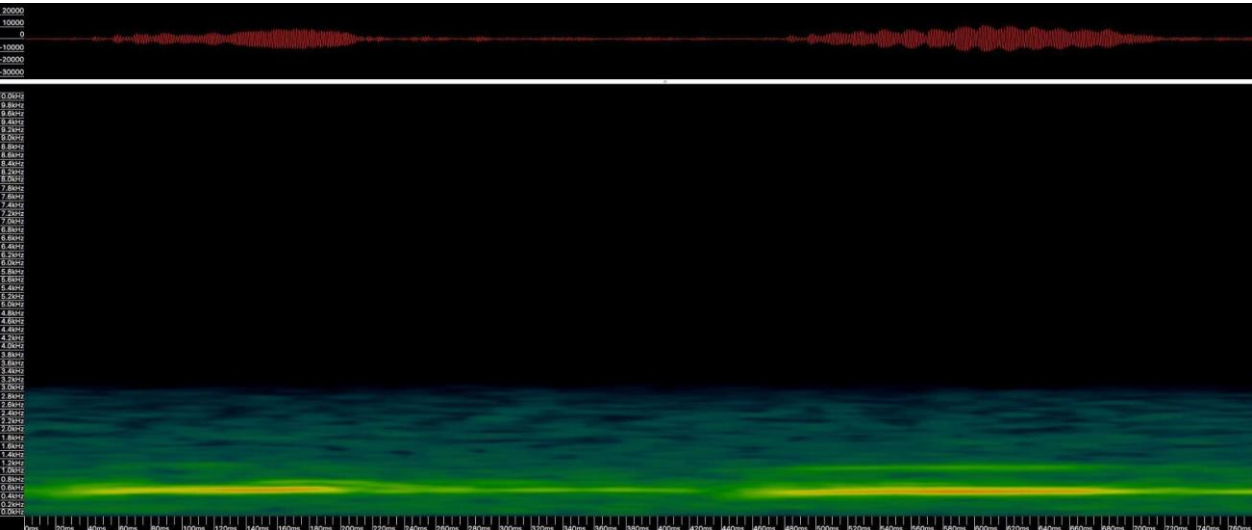


Figure 9: Spectrogram of Tawny Frogmouth call.

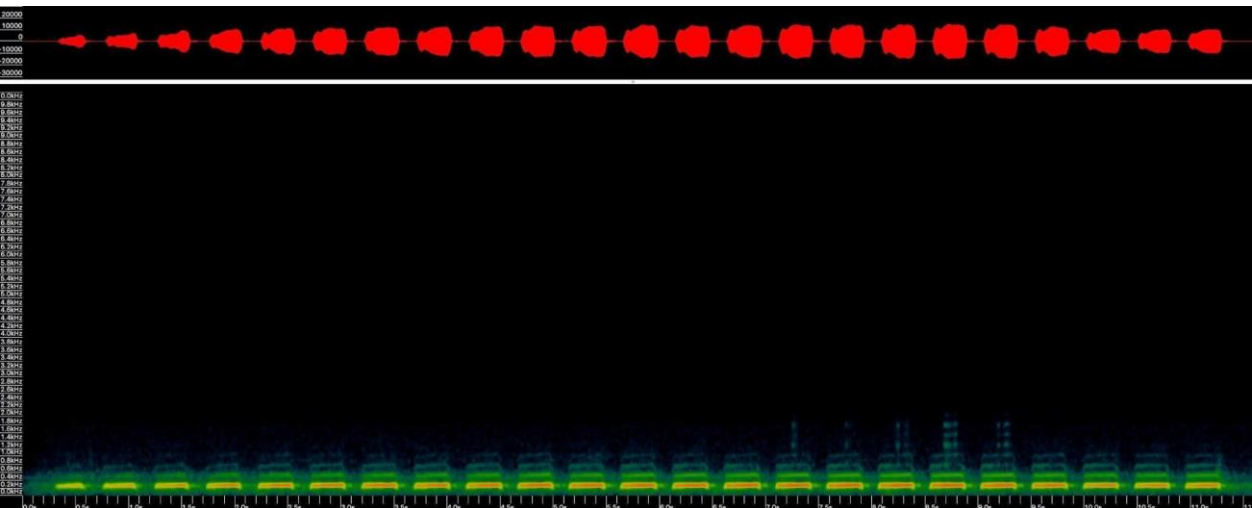


Figure 10: Spectrogram of Barking Owl (Site RS3). The first call is the female and the male responds with the lower frequency call (three female calls and two male calls).

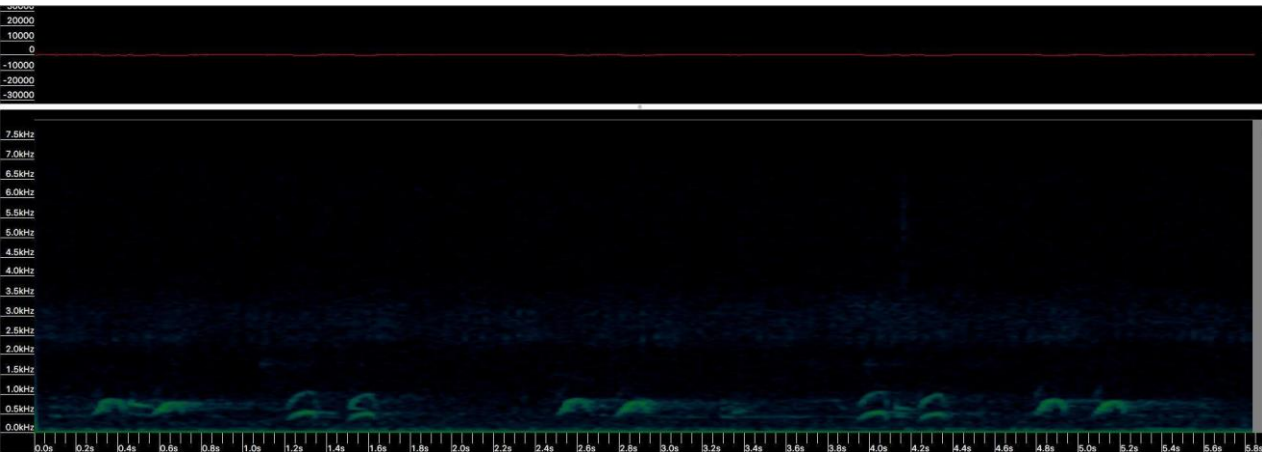
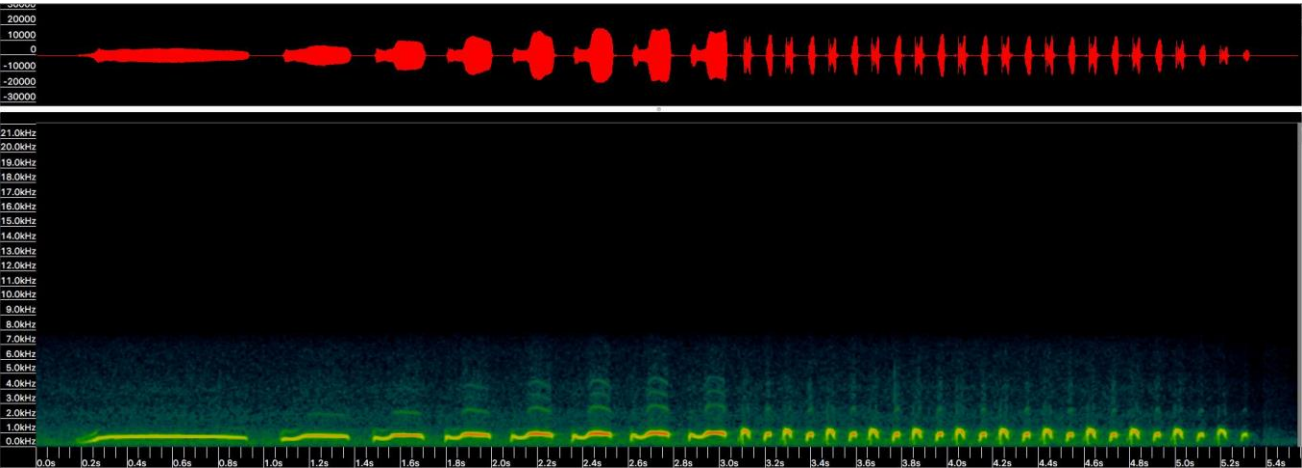


Figure 11: Spectrogram of Spotted Nightjar call.



Acoustic Complexity Index (ACI) comparisons

Soundscape data were compared between sites by calculating an Acoustic Complexity Index (ACI) for each site. Higher ACI values indicate a higher complexity of both singing activity and the diversity of birds present at a site. ACI values varied across the three regions with the values for Rise and Shine slightly greater than Muckleford and Sandon (Figure 12). ACI values also varied across seasons. Overall, ACI values were greatest during Round 3 (late spring into summer), but also most variable, particularly for Rise and Shine (Figure 13). While there appears to be an increase in ACI values from Round 1 (May/June) to Round 3 (November/December) for Muckleford and Sandon, Rise and Shine appeared to be similar through the seasons. While these patterns may reflect differences in species richness across sites and over time, a closer examination of the recordings to explore which species are present within each round will be required to confirm.

Figure 12. Average values for Acoustic Complexity Index (ACI) as a representation of acoustic activity across Muckleford Block (purple), Rise and Shine Block (green) and Sandon Block (yellow). These values represent an average of the daily 95th percentile value with 95% confidence intervals around the means.

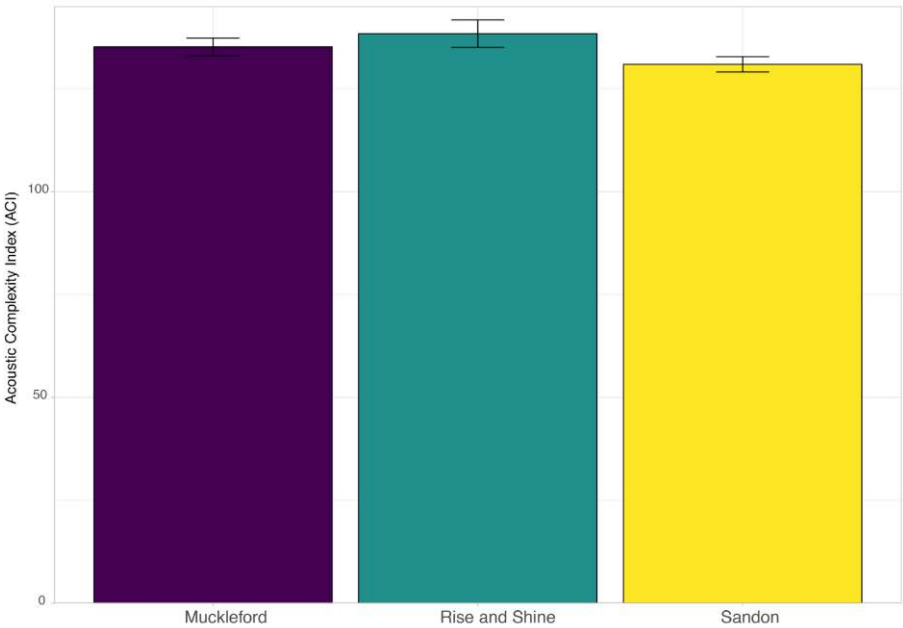
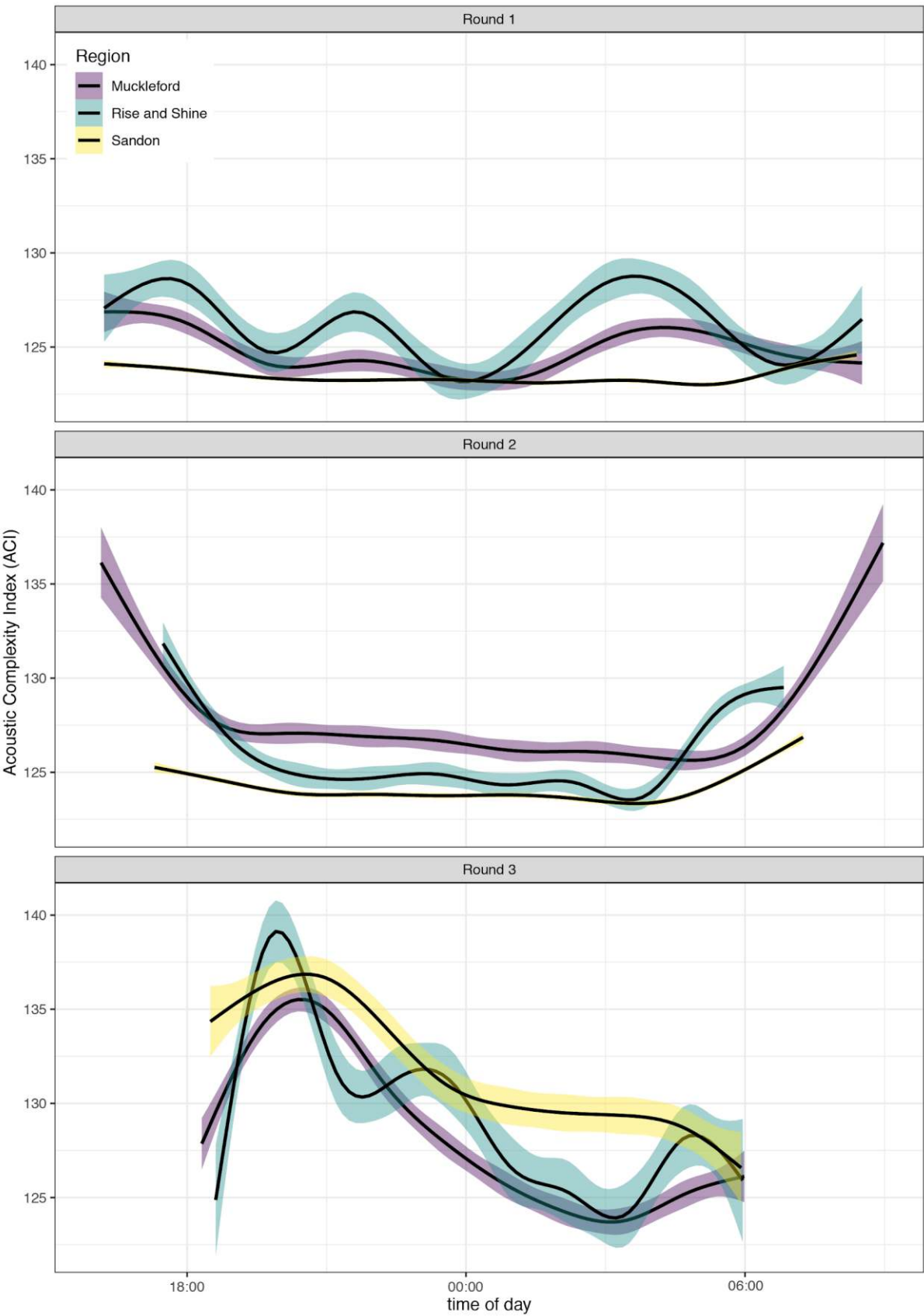


Figure 13. Overnight (4pm to 9 am) and seasonal pattern of acoustic activity (as Acoustic Complexity Index) across Muckleford (purple), Sandon (yellow), and Rise and Shine (green). Higher values represent greater acoustic activity. Black lines represent smoothed 10-minute interval 95th percentile values across nights with coloured shading representing 95% confidence intervals around those values.



Overnight patterns of acoustic complexity varied between regions and among rounds (Figure 13), with an overall pattern of lower activity overnight during Round 2 (September/October). With the exception of Round 3, overall acoustic activity was lower in Sandon. Activity was greater at the beginning (dusk) and end (dawn) of the recording period except for a marked post-dusk increase in activity during Round 3 (November/December), a steady decline overnight, then a short increase pre-dawn. Large confidence intervals around the mean values (represented by the wide shading around the black lines) indicates the ACI values at each time interval were most variable during Round 3. Given that recording periods within each site only lasted for seven days, it's likely a longer recording duration (more nights recording) may clarify the trends within these regions.

Issues with the data

There were some common challenges with the data in this project. A large volume of data made analysis difficult to store and time consuming to analyse. One song meter did not have the prefix changed creating multiple data sets with the same prefix making it difficult to know which site names it related to; however we were able to resolve these issues by rechecking with the community group and the original data sheets. Finally, a few recordings were corrupted, likely due to battery power loss or file writing errors on the SD cards, making them unable to be analysed.



Australian Owlet-nightjar. Photo: Damian Kelly

4. Discussion

Overall, this Communities Listening for Nature project has fulfilled its aim of determining the distribution of night birds across the Mount Alexander region. The initial detectability study was an excellent opportunity to engage local landholders in acoustic monitoring of local bird species. An interesting assemblage of birds was detected across the landscape within the research area and landholders are now more aware of the habitat value their properties provide to a range of night birds. This information informs landholders of the type of vegetation and habitat values that are needed for these bird species to persist in their area which may be able to guide habitat restoration activities across the landscape. Lack of night bird detection may also indicate a lack of habitat values on private properties that may be able to be re-established to provide improved habitat values in the future.

The detectability study also provided valuable knowledge to help guide the region study and appropriate recording design, providing insight into efficient acoustic monitoring of Powerful Owls in this region. For example, survey protocols would benefit from including the recommended 2 km distance between monitoring sites and minimum 3 weeks of acoustic recording outside of the breeding season to ensure reliable Powerful Owl detection.

The Mount Alexander Region study provided a large amount of acoustic data on night birds within the Bendigo Box-Ironbark Key Biodiversity Area. We detected the presence of six of the target night bird species from this study: Powerful Owl, White-throated Nightjar, Australian Owlet-nightjar, Barking Owl, Southern Boobook and Tawny Frogmouth. This project provides new information on habitat use for these species associated with Ecological Vegetation Class that may assist future monitoring or habitat restoration efforts. Five species were detected in the endangered Grassy Woodland EVC (Powerful Owl, White-throated Nightjar, Australian Owlet-nightjar, Southern Boobook and Barking Owl) indicating the value of protecting these woodland areas for night bird populations. Six night bird species were detected in vulnerable Box-Ironbark Forest EVC sites highlighting the need to protect habitat values in these forests.

In addition to new insights into the current night bird populations and their habitat use in the Mount Alexander area, this project has delivered a large data set that will be preserved into perpetuity in the Museums Victoria online Digital Wildlife Sounds Library Collection (<https://collections.museumvictoria.com.au/articles/16435>). It can be revisited in future to check for changes in species presence or habitat use and is publicly available for non-commercial use worldwide and will help scientists, land managers, conservation groups and the public connect with Australia's unique and charismatic bird life. The annotated data collected in this project will also be incorporated into Museums Victoria's species recognizers to improve digital species recognition in future project. Using the same recordings, future analysis can also provide more detailed data on seasonality of species presences at each of these sites and improve understanding of the value of both public and private land in this region and to promote better land management practices.

All project partners retain copies of the acoustic recordings which can be used to create sample spectrograms for different species to use in landholder and community education as well as soundscape for each site. A short soundscape compilation of their property has been provided to each landholder who assisted with data collection in this project, which was received with much enthusiasm. Soundscapes have also been uploaded to the VNPA YouTube site to provide tools for community educational programs and to assist with future bird identification.

The Mount Alexander Communities Listening for Nature project also produced an educational video of the project to be used by Museums Victoria, VNPA, Connecting Country and the Mount Alexander team (https://www.youtube.com/watch?v=xIPnvzAS_7U). It was produced by Museums Victoria with the assistance of project coordinators and private landholders. The Mount Alexander location was chosen for the project video due to the incredible enthusiasm for the project by the local team leaders and land holders, and their ability to demonstrate the greater value of community-driven acoustic monitoring projects to a broad audience. They dedicated many days to the creation of the video and now have a fantastic tool to share with their community and landholders to engage them in understanding local bird populations and their habitat needs.

Finally, the Mount Alexander Communities Listening for Nature Project provided an excellent example of the NatureWatch model, bringing together the local community with scientists and land managers to improve our collective understanding of species and ecosystems and to inform management of natural areas. Because of this partnership, we now know more about the night bird species and their distribution in the Mount Alexander region and have a set of skilled citizen scientists who are now deeply embedded contributors to the development of bioacoustic monitoring and the on-going management of the area. The enthusiasm for this knowledge is only growing in this region with strong support for a next phase of the project. This would include coordinating a network of community volunteers to listen through the audio data, providing a more detailed analysis of species presences through the seasons and across sites as well as adding more support to the Museums Victoria recognisers and broadening community engagement across the region more generally.

Recommendations

Connecting Country and the Mount Alexander study team continue a night bird monitoring program across the Bendigo Box-Ironbark Key Biodiversity Area, targeting the best times of year and habitat values to try and monitor the presence of species in the area.

Extend the study to include other public land in the Mt Alexander region as well as private land with remnant or restored vegetation through seeking additional funding to acquire their own equipment and project management. More detailed analysis of the existing data will also provide a more fine-scaled seasonal and spatial understanding of habitat and site occupancy by each species.

Results of this study be circulated within the community to provide important community education about the species of night birds in the area and the need to protect their habitat. A peer-reviewed publication of the findings should be prepared to bolster support for a community-based approach for monitoring as well as providing the species occupancy data to the broader scientific community.

Results of this study should be presented to the Victorian Government to assist with land management planning within the Bendigo Box-Ironbark Key Biodiversity Area.

5. References

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Handbook of Australian, New Zealand & Antarctic Birds 1999, vol 4, Ed PJ Higgins, Oxford University Press

Pieretti, N., Farina, A. and Morri, D. 2011. A new methodology to infer the singing activity of an avian community: The Acoustic Complexity Index (ACI). *Ecological Indicators*, 11: 868-873.



Powerful Owl and chick. Photo: Damian Kelly

Appendix A:

Analysis of target night bird distribution, habitat, seasonality and calls across the study area. This information was compiled by Damian Kelly to inform both studies in this project.

Southern Boobook

Distribution	Whole region
Habitat	Most habitats including wooded farmland and near habitation
Recent records	Kalimna, Central Castlemaine, Botanic Gardens, Mount Alexander
Breeding	Hollows in large trees. September – November
Home range	Resident. Little evidence of long distance movement, may be winter migration
Movement	Banding studies show >75% less than 10km from banding site
Calls	May start late afternoon, and occasionally anytime during day. Carries 1km+
Call season / time	Well-known “boo-book” call by both sexes. Most vocal at start of breeding season. May call from nest hollow. Range of squeals, trills, growls and screams. Widest range of calls of any Australian owl.
Food	Small birds and mammals, amphibians, insects
Notes	May feed 1 hour before sunset and sometimes before dusk in cloudy weather. Will roost in buildings.

Barking Owl

Distribution	Whole region.
Habitat	Open forest, particularly near water.
Recent records	Barker’s Creek, Muckleford, Vaughan Springs, Welshman’s Reef, Campbell’s Creek
Breeding	Hollows in large trees, usually near water. Occasionally in dense vegetation. Mid-winter to spring.
Home range	Resident. No evidence of long distance movement. Defended home range often < 2 km ²
Movement	May range up to 5 km from feed.
Calls	Double bark. Sometimes duet. Carries 1km or more. Screaming call, rarely heard, appears to be alarm call. More common in autumn, by both sexes.
Call season / time	More common in breeding season. May commence late afternoon, and occasionally anytime during day.
Food	Insects, birds (Rosella, Currawong, Magpie, finches, Grey Shrike-Thrush), Sugar Gliders Most feeding along edge of habitat and clearings in forest.
Notes	Most crepuscular of Australian owls often feeding 1 hour before sunset and sometimes during day.

Tawny Frogmouth

Distribution	Whole region.
Habitat	Most wooded areas with open clearings including wooded farmland and near habitation.
Recent records	Muckleford, Newstead
Breeding	Nests in trees
Home range	Small territories / home ranges throughout the year. Often returns to same nest site.
Movement	Some evidence of movement away from colder areas in winter. Banding – 87% recovered with 10 km.
Calls	Low pitched and soft. “Ooom” calls. Carries < 100 m.
Call season / time	Dusk – dawn. Mostly spring / summer.
Food	Insects, worms, small vertebrates.
Notes	Roosts in trees.

White-throated Nightjar

Distribution	Northern part of region. At edge of range.
Habitat	Forests, rocky ridges, often near water.
Recent records	Muckleford, Gowar, Strangways, Mandurang, Paddy’s Ranges (Maryborough), Talbot, Lerderderg.
Breeding	Nests on ground among leaf litter. No nest. Often near conspicuous marker such as fallen log, prominent stone, burnt log. August – Feb.
Home range	Unknown.
Movement	Summer migrant to area.
Calls	Distinctive “laugh” that carries 1 km or more.
Call season / time	Mainly during breeding season at just after dusk.
Food	Nocturnal flying insects.
Notes	Some recent evidence of range extension (Chris Tzaros). Can be confused with Spotted Nightjar.

Australian Owlet-nightjar

Distribution	Whole region.
Habitat	Diverse habitats including forests and farmland and near habitation.
Recent records	Kalimna, Walmer, Campbell's Creek.
Breeding	Hollows and nest boxes used.
Home range	Mostly sedentary. Banding 100% recovered with 10 km of site.
Movement	After breeding dispersal of young.
Calls	Chirring, squeaking, yelping.
Call season / time	More common during breeding season. Mainly dusk / dawn.
Food	Nocturnal flying insects.

Powerful Owl

Distribution	Whole region.
Habitat	Variable. Large trees with hollow, dense cover.
Recent records	Muckleford, Barker's Creek, Metcalfe, Newstead, Botanic Gardens, Chewton, Maldon.
Breeding	May – June, but occasionally earlier or later. Hollows in large trees. Winter.
Home range	3 - 15 km ²
Movement	Resident, but seasonal movement within range. Radio tracked up to 4.1 km.
Calls	May start 30 min before dusk. Woo-hoo alone or duet. Often carries 1.5 km or more depending on habitat. Sometimes call breaks down after ~10 min and becomes shorter/sharper, more like Barking Owl. Various softer nest/feeding calls, squealing may be associated with conflict or mating. Females tend to call dusk/dawn, males middle of the night. Male call slightly deeper and shorter, female slightly higher and rising in pitch, especially second Woo-hoo.
Call season / time	More common at dusk/dawn, but may occur during night. More common during breeding season.
Food	Mount Alexander Pellet study: Magpie 45%, Sugar Glider 44.5%, Ringtail 18%, Tuan 11.5%, various small birds and insects, rabbit 1.5%

Spotted Nightjar

Distribution	Edge of range
Habitat	Diverse habitats including wooded farmland and near habitation, swamps and heathland
Recent records	Pilcher's Bridge, Kamarooka, plus road kills at Moolort (Clarke's Lane) and Joyces Creek (Cairn Curran railway bridge)
Breeding	Nests on ground among leaf litter. No nest. Often near conspicuous marker such as fallen log, prominent stone, burnt log. August-January
Home range	Unknown
Movement	Little known. Partly nomadic
Calls	Distinctive "laugh" that carries 1 km or more
Call season / time	Mainly breeding season. From dusk onwards
Food	Nocturnal flying insects
Notes	Call can be confused with White-throated Nightjar

Appendix B:

Species list for Mount Alexander Region generated from the Global Biodiversity Informatics Facility (www.gbif.org). Conservation status listed in the Advisory List of Threatened Vertebrate Fauna in Victoria (DSE 2013): CE = Critically Endangered, E = Endangered, NT = Near Threatened, V = Vulnerable. **Species listed in bold were detected in this study at the genus or species level.**

Common name	Species name	# GBIF occurrences	Conservation Status		
			Advisory List	EPBC	FFG
Asian Koel	<i>Eudynamys scolopaceus</i>	3			
Australasian Bittern	<i>Botaurus poiciloptilus</i>	1	E	EN	L
Australasian Darter	<i>Anhinga novaehollandiae</i>	14			
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>	85			
Australasian Pipit	<i>Anthus novaeseelandiae</i>	54			
Australasian Shoveler	<i>Anas rhynchotis</i>	1	V		
Australian Hobby	<i>Falco longipennis</i>	16			
Australian Magpie	<i>Gymnorhina tibicen</i>	523			
Australian Owlet-nightjar	<i>Aegotheles cristatus</i>	83			
Australian Pelican	<i>Pelecanus conspicillatus</i>	27			
Australian Pied Cormorant	<i>Phalacrocorax varius</i>	8			
Australian Raven	<i>Corvus coronoides</i>	757			
Australian Reed Warbler	<i>Acrocephalus australis</i>	21			
Australian Shelduck	<i>Tadorna tadornoides</i>	78			
Australian White Ibis	<i>Threskiornis molucca</i>	45			
Australian Wood Duck	<i>Chenonetta jubata</i>	300			
Barking Owl	<i>Ninox connivens</i>	34	E		L
Barn Owl	<i>Tyto alba</i>	3			
Bassian Thrush	<i>Zoothera lunulata</i>	1			
Black Falcon	<i>Falco subniger</i>	2	V		
Black Honeyeater	<i>Sugomel nigrum</i>	2			
Black Honeyeater	<i>Certhionyx niger</i>	2			
Black Kite	<i>Milvus migrans</i>	25			
Black Swan	<i>Cygnus atratus</i>	55			
Black-chinned Honeyeater	<i>Melithreptus gularis</i>	312	NT		
Black-eared Cuckoo	<i>Chrysococcyx osculans</i>	30	NT		
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>	516			
Black-fronted Dotterel	<i>Elseya melanops</i>	66			
Black-shouldered Kite	<i>Elanus axillaris</i>	39			
Black-tailed Native-hen	<i>Gallinula ventralis</i>	5			
Blue-faced Honeyeater	<i>Entomyzon cyanotis</i>	9			
Blue-winged Parrot	<i>Neophema chrysostoma</i>	1			
Brown Falcon	<i>Falco berigora</i>	200			
Brown Goshawk	<i>Accipiter fasciatus</i>	99			
Brown Quail	<i>Coturnix ypsilophora</i>	9			
Brown Songlark	<i>Megalurus cruralis</i>	3			
Brown Thornbill	<i>Acanthiza pusilla</i>	277			
Brown Treecreeper	<i>Climacteris picumnus</i>	961	NT		
Brown-headed Honeyeater	<i>Melithreptus brevirostris</i>	718			
Brush Bronzewing	<i>Phaps elegans</i>	3			
Brush Cuckoo	<i>Cacomantis variolosus</i>	1			
Budgerigar	<i>Melopsittacus undulatus</i>	1			
Buff-banded Rail	<i>Rallus philippensis</i>	1			
Buff-rumped Thornbill	<i>Acanthiza reguloides</i>	571			
Cattle Egret	<i>Bubulcus ibis</i>	4			
Chestnut Teal	<i>Anas castanea</i>	8			
Chestnut-rumped Heathwren	<i>Calamanthus pyrrhopygius</i>	53	V		L
Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>	1			
Collared Sparrowhawk	<i>Accipiter cirrocephalus</i>	59			
Common Blackbird	<i>Turdus merula</i>	387			

Common name	Species name	# GBIF occurrences	Conservation Status		
			Advisory List	EPBC	FFG
Common Bronzewing	<i>Phaps chalcoptera</i>	599			
Common Myna	<i>Acridotheres tristis</i>	75			
Common Starling	<i>Sturnus vulgaris</i>	80			
Crescent Honeyeater	<i>Phylidonyris pyrrhopterus</i>	8			
Crested Bellbird	<i>Oreoica gutturalis</i>	170	NT		L
Crested Pigeon	<i>Ocyphaps lophotes</i>	347			
Crested Shrike-tit	<i>Falcunculus frontatus</i>	242			
Crimson Rosella	<i>Platycercus elegans</i>	1205			
Diamond Dove	<i>Geopelia cuneata</i>	2	NT		L
Diamond Firetail	<i>Stagonopleura guttata</i>	203	NT		L
Dollarbird	<i>Eurystomus orientalis</i>	3			
Dusky Moorhen	<i>Gallinula tenebrosa</i>	44			
Dusky Woodswallow	<i>Artamus cyanopterus</i>	404			
Eastern Great Egret	<i>Ardea alba</i>	14	V		L
Eastern Rosella	<i>Platycercus eximius</i>	971			
Eastern Spinebill	<i>Acanthorhynchus tenuirostris</i>	142			
Eastern Yellow Robin	<i>Eopsaltria australis</i>	570			
Eurasian Coot	<i>Fulica atra</i>	64			
Eurasian Skylark	<i>Alauda arvensis</i>	6			
Eurasian Tree Sparrow	<i>Passer montanus</i>	4			
European Goldfinch	<i>Carduelis carduelis</i>	128			
European Greenfinch	<i>Chloris chloris</i>	2			
Fairy Martin	<i>Petrochelidon ariel</i>	64			
Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>	92			
Flame Robin	<i>Petroica phoenicea</i>	226			
Fuscous Honeyeater	<i>Lichenostomus fuscus</i>	1233			
Galah	<i>Cacatua roseicapilla</i>	1329			
Gang-gang Cockatoo	<i>Callocephalon fimbriatum</i>	1			
Gilbert's Whistler	<i>Pachycephala inornata</i>	2			
Golden Whistler	<i>Pachycephala pectoralis</i>	347			
Golden-headed Cisticola	<i>Cisticola exilis</i>	3			
Great Cormorant	<i>Phalacrocorax carbo</i>	26			
Great Crested Grebe	<i>Podiceps cristatus</i>	4			
Grey Butcherbird	<i>Cracticus torquatus</i>	17			
Grey Currawong	<i>Strepera versicolor</i>	457			
Grey Falcon	<i>Falco hypoleucos</i>	1	E		L
Grey Fantail	<i>Rhipidura albiscapa</i>	662			
Grey Goshawk	<i>Accipiter novaehollandiae</i>	7	V		L
Grey Shrike-thrush	<i>Colluricincla harmonica</i>	1315			
Grey Teal	<i>Anas gracilis</i>	44			
Grey-crowned Babbler	<i>Pomatostomus temporalis</i>	4	E		L
Hardhead	<i>Aythya australis</i>	24	V		
Hoary-headed Grebe	<i>Poliocephalus poliocephalus</i>	16			
Hooded Robin	<i>Melanodryas cucullata</i>	119	NT		L
Horsfield's Bronze Cuckoo	<i>Chrysococcyx basalis</i>	161			
Horsfield's Bushlark	<i>Mirafrja javanica</i>	2			
House Sparrow	<i>Passer domesticus</i>	383			
Intermediate Egret	<i>Egretta intermedia</i>	2	CE		L
Jacky Winter	<i>Microeca fascinans</i>	516			
Latham's Snipe	<i>Gallinago hardwickii</i>	1	NT		N
Laughing Kookaburra	<i>Dacelo novaeguineae</i>	670			
Leaden Flycatcher	<i>Myiagra rubecula</i>	6			
Little Bittern	<i>Ixobrychus minutus</i>	1	E		L
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>	23			
Little Corella	<i>Cacatua sanguinea</i>	35			
Little Eagle	<i>Hieraetus morphnoides</i>	93			
Little Grassbird	<i>Megalurus gramineus</i>	1			
Little Lorikeet	<i>Parvipsitta pusilla</i>	115			
Little Lorikeet	<i>Glossopsitta pusilla</i>	39			
Little Pied Cormorant	<i>Microcarbo melanoleucos</i>	110			

Common name	Species name	# GBIF occurrences	Conservation Status		
			Advisory List	EPBC	FFG
Little Raven	<i>Corvus mellori</i>	338			
Little Wattlebird	<i>Anthochaera chrysoptera</i>	12			
Long-billed Corella	<i>Cacatua tenuirostris</i>	494			
Magpie-lark	<i>Grallina cyanoleuca</i>	409			
Masked Lapwing	<i>Vanellus miles</i>	360			
Masked Woodswallow	<i>Artamus personatus</i>	35			
Mistletoebird	<i>Dicaeum hirundinaceum</i>	300			
Musk Duck	<i>Biziura lobata</i>	9	V		
Musk Lorikeet	<i>Glossopsitta concinna</i>	424			
Nankeen Kestrel	<i>Falco cenchroides</i>	30			
Nankeen Night Heron	<i>Nycticorax caledonicus</i>	12	NT		
New Holland Honeyeater	<i>Phylidonyris novaehollandiae</i>	367			
Noisy Friarbird	<i>Philemon corniculatus</i>	11			
Noisy Miner	<i>Manorina melanocephala</i>	118			
Olive Whistler	<i>Pachycephala olivacea</i>	2			
Olive-backed Oriole	<i>Oriolus sagittatus</i>	146			
Pacific Black Duck	<i>Anas superciliosa</i>	169			
Pacific Swift	<i>Apus pacificus</i>	4			
Painted Button-quail	<i>Turnix varius</i>	69			
Painted Honeyeater	<i>Grantiella picta</i>	26	V		L
Pallid Cuckoo	<i>Cuculus pallidus</i>	173			
Peaceful Dove	<i>Geopelia placida</i>	159			
Peregrine Falcon	<i>Falco peregrinus</i>	16			
Pied Currawong	<i>Strepera graculina</i>	43			
Pink Robin	<i>Petroica rodinogaster</i>	5			
Powerful Owl	<i>Ninox strenua</i>	54	V		L
Purple Swamphen	<i>Porphyrio melanotus</i>	4			
Purple-crowned Lorikeet	<i>Parvipsitta porphyrocephala</i>	103			
Purple-crowned Lorikeet	<i>Glossopsitta porphyrocephala</i>	43			
Rainbow Bee-eater	<i>Merops ornatus</i>	88			
Rainbow Lorikeet	<i>Trichoglossus haematodus</i>	22			
Red Wattlebird	<i>Anthochaera carunculata</i>	1506			
Red-browed Finch	<i>Neochmia temporalis</i>	303			
Red-capped Robin	<i>Petroica goodenovii</i>	75			
Red-kneed Dotterel	<i>Erythronyx cinctus</i>	2			
Red-rumped Parrot	<i>Psephotus haematotus</i>	675			
Regent Honeyeater	<i>Xanthomyza phrygia</i>	9	CE	EN	L
Restless Flycatcher	<i>Myiagra inquieta</i>	390			
Rock Dove	<i>Columba livia</i>	15			
Rose Robin	<i>Petroica rosea</i>	18			
Royal Spoonbill	<i>Platalea regia</i>	3	NT		
Rufous Songlark	<i>Megalurus mathewsi</i>	70			
Rufous Whistler	<i>Pachycephala rufiventris</i>	533			
Sacred Kingfisher	<i>Todiramphus sanctus</i>	118			
Scarlet Honeyeater	<i>Myzomela sanguinolenta</i>	16			
Scarlet Robin	<i>Petroica boodang</i>	554			
Shining Bronze Cuckoo	<i>Chrysococcyx lucidus</i>	87			
Silver Gull	<i>Larus novaehollandiae</i>	9			
Silvereye	<i>Zosterops lateralis</i>	235			
Singing Honeyeater	<i>Lichenostomus virescens</i>	2			
Southern Boobook	<i>Ninox novaeseelandiae</i>	66			
Southern Whiteface	<i>Aphelocephala leucopsis</i>	66			
Speckled Warbler	<i>Pyrholaemus sagittatus</i>	127	V		L
Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>	4			
Spotted Dove	<i>Streptopelia chinensis</i>	3			
Spotted Harrier	<i>Circus assimilis</i>	5	NT		
Spotted Pardalote	<i>Pardalotus punctatus</i>	1006			
Spotted Quail-thrush	<i>Cinclosoma punctatum</i>	23	NT		
Square-tailed Kite	<i>Lophoictinia isura</i>	28	V		L
Straw-necked Ibis	<i>Threskiornis spinicollis</i>	57			

Common name	Species name	# GBIF occurrences	Conservation Status		
			Advisory List	EPBC	FFG
Striated Pardalote	<i>Pardalotus striatus</i>	797			
Striated Thornbill	<i>Acanthiza lineata</i>	406			
Stubble Quail	<i>Coturnix pectoralis</i>	4			
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>	581			
Superb fairy-wren	<i>Malurus cyaneus</i>	1352			
Swamp Harrier	<i>Circus approximans</i>	4			
Swift Parrot	<i>Lathamus discolor</i>	119	E	EN	L
Tawny Frogmouth	<i>Podargus strigoides</i>	73			
Tawny-crowned Honeyeater	<i>Gliciphila melanops</i>	1005			
Tree Martin	<i>Petrochelidon nigricans</i>	51			
Turquoise Parrot	<i>Neophema pulchella</i>	1	NT		L
Varied Sittella	<i>Daphoenositta chrysoptera</i>	288			
Wedge-tailed Eagle	<i>Aquila audax</i>	174			
Weebill	<i>Smicrornis brevirostris</i>	726			
Welcome Swallow	<i>Hirundo neoxena</i>	867			
Western Gerygone	<i>Gerygone fusca</i>	3			
Whistling Kite	<i>Haliastur sphenurus</i>	216			
White-backed Swallow	<i>Cheramoeca leucosterna</i>	11			
White-bellied Cuckoo-shrike	<i>Coracina papuensis</i>	97			
White-breasted Woodswallow	<i>Artamus leucorhynchus</i>	3			
White-browed Babbler	<i>Pomatostomus superciliosus</i>	507			
White-browed Scrubwren	<i>Sericornis frontalis</i>	179			
White-browed Woodswallow	<i>Artamus superciliosus</i>	158			
White-eared Honeyeater	<i>Lichenostomus leucotis</i>	300			
White-faced Heron	<i>Egretta novaehollandiae</i>	269			
White-fronted Chat	<i>Epthianura albifrons</i>	18			
White-fronted Honeyeater	<i>Phylidonyris albifrons</i>	2			
White-naped Honeyeater	<i>Meliphaga lunata</i>	625			
White-necked Heron	<i>Ardea pacifica</i>	43			
White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>	654			
White-shouldered Triller	<i>Lalage sueurii</i>	40			
White-throated Gerygone	<i>Gerygone olivacea</i>	5			
White-throated Needletail	<i>Hirundapus caudacutus</i>	11	V		
White-throated Nightjar	<i>Eurostopodus mystacalis</i>	3			
White-throated Treecreeper	<i>Cormobates leucophaea</i>	555			
White-winged Chough	<i>Corcorax melanoramphos</i>	857			
White-winged Triller	<i>Lalage tricolor</i>	28			
Willie Wagtail	<i>Rhipidura leucophrys</i>	1025			
Yellow Thornbill	<i>Acanthiza nana</i>	351			
Yellow-billed Spoonbill	<i>Platalea flavipes</i>	22			
Yellow-faced Honeyeater	<i>Lichenostomus chrysops</i>	175			
Yellow-plumed Honeyeater	<i>Lichenostomus ornatus</i>	21			
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>	332			
Yellow-tailed Black-Cockatoo	<i>Calyptorhynchus funereus</i>	10			
Zebra Dove	<i>Geopelia striata</i>	232			



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