

Re-connecting Thunderbolt Country for Threatened New England Woodland and Wetland Biodiversity

Avifaunal Survey Report 2: 2022



InSight Ecology
for
Southern New England Landcare Ltd.

September 2023





This report was prepared by InSight Ecology for Southern New England Landcare Ltd. This work is funded by NSW Environmental Trust (Project 2019/RR/0041). The project is supported by NSW Local Landcare Support Program (Local Land Services and Landcare NSW).

Recommended citation: InSight Ecology, 2023b. Re-connecting Thunderbolt Country for Threatened New England Woodland and Wetland Biodiversity – Avifaunal Survey Report 2: 2022. InSight Ecology for Southern New England Landcare Ltd., Armidale, NSW.

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Photographic credits: Front page - main photograph: view over Salisbury Water from Top Spring Paddock, 'Taylor's Run', Kentucky South (InSight Ecology, 5/8/20). Front page, smaller images - clockwise from left to right (upper row): Site prepared for planting at 'Big Ridge', Uralla (InSight Ecology, 31/8/22); recently planted Far Dip Paddock at 'Taylor's Run' (InSight Ecology, 4/1/22); Billabong wetland at 'Salisbury Court', Salisbury Plains (InSight Ecology, 13/1/22). Front page (bird images): Scarlet Robin (aussiebirding.wildlaries.com 2012), Diamond Firetail (Neville Bartlett), Latham's Snipe (Jason Girvan and en.wikipedia.org), Blue-billed Duck (Spikerccs, commons.wikimedia.org). Inside front page – view south from Stringybark Hill remnant, 'Big Ridge' (InSight Ecology, 13/8/20); Pink-eared Duck (Melbourne Water), recorded at Dangar's Lagoon.

Acknowledgements

InSight Ecology acknowledges that field surveying and community field events for the Thunderbolt Project, Closing The Gap Project, and all other fieldwork completed by InSight Ecology on the NSW northern tablelands have been undertaken on the traditional lands of the Anaiwan People. InSight Ecology recognises the Anaiwan People as the Traditional Custodians of these lands and offers respect to the Elders, past, present and emerging.

This project was funded by the NSW Environmental Trust (2019/RR/0041) and NSW Local Landcare Support Program from 2019-2023. This funding was provided to Southern New England Landcare (SNEL) which contracted InSight Ecology to undertake and report on systematic bird surveys and participate in field events.

This project took place during the Covid19 pandemic. This required additional project planning and some initial meetings were undertaken online or re-scheduled. The summer 2022 fieldwork program was affected due to a decision not to survey on one property where Covid19 was present. Strict Covid19 protocols including full vaccination for InSight Ecology staff were observed.

InSight Ecology gratefully acknowledges the support, interest, and assistance from:

- SNEL – Karén Zirkler and Struan Ferguson. Karén supported my work as did Struan who managed the project from its inception. SNEL also provided access to previous related studies and avifaunal survey reports for the area and organised the 12 May 2023 project field day.
- NSW Environmental Trust for funding the project and Local Land Services and Landcare NSW for supporting the project.
- The participating landholders who kindly provided access to their properties – Gordon and Wendy Williams (also for accommodation during the surveys), Kath Taylor and Hamish Caddy, Michael and Milly Taylor and family, Richard Munsie and family (and for hosting the project field day), Garry and Beatrice Bashford, Trish and Peter Rasmussen, Andrew Eichorn (CSIRO 'Chiswick'), Catherine Wright and Andrew Douglas-Menzies, Bridgett and Adam Hone, NPWS (Dangar's Lagoon Wildlife Refuge/Nature Reserve) and Northern Tablelands Local Land Services (Dangar's Lagoon TSR), and Uralla Shire Council (Mt. Mutton Reserve and Racecourse Lagoon Reserve). Gordon, Hamish, Kath, Michael, Richard, Catherine and Andrew accompanied me during field surveys on their properties and at other sites.
- Allison and Phillip Attard for permitting survey access to 'No Man's Land' remnant woodland and shrubland.
- Brad Spalding and Michael Taylor for providing recent photographs of birds on 'Taylor's Run'. Michael kindly provided a kayak for a water-based survey of Dangar's Lagoon in January 2022.
- Hugh and Shelley Cordingley also provided survey access to remnant Blakely's red gum and yellow box woodland on their property.
- David Carr from Stringybark Ecological for botanical and revegetation information.
- Dr Michael Drielsma and the University of New England for landscape connectivity modelling information and access to scientific reports and papers.

Executive summary

The ecological footprint of about 180 years of European settlement on New England Tableland has been substantial. About 70% of the region's native vegetation has been removed for agriculture, housing and urban infrastructure. This has caused the widespread loss, fragmentation and degradation of habitat and, consequently, the removal or disruption of wildlife corridors. Remaining native animal populations have become highly isolated, leading to the decline and local extinction of many native species. Remnant habitat in the region is now confined to a small number of nature reserves and national parks, narrow and often degraded road reserves and, importantly, bushland on privately-owned properties.

Efforts to reduce these impacts have been underway since the 1970s through a series of revegetation and remnant regeneration projects in the region. These have focused on planting trees and shrubs on farms and along roadsides and waterways to control soil erosion, establish windbreaks, provide wildlife habitat and improve aesthetics. More recent Landcare-related work has recognised the importance of re-connecting wildlife corridors through targeted plantings in key locations, widening and extending existing revegetation, and improving the condition of woodland/forest remnants.

Two recent Southern New England Landcare (SNEL) projects have focused on strategic revegetation and protection of remnant native vegetation in a key gap (about 35 km long by 23-25 km wide) in habitat connectivity between Armidale in the north and Uralla and Salisbury Plains/Kentucky in the south. This gap is preventing and/or inhibiting the movement and dispersal of 19 threatened fauna species and 7 threatened plant species between the eastern and western sides of the tableland.

The first project - *Closing the Gap: Functional Habitat for Threatened New England Fauna (2016-2019)* - surveyed woodland birds in revegetation and remnant woodland/forest at 36 sites on 15 properties in the northern section (Dangarsleigh and Kellys Plains to Uralla and Mihi) of the gap zone. The second project (reported on here) - *Re-connecting Thunderbolt Country for Threatened New England Woodland and Wetland Biodiversity (2019-2023)* - surveyed woodland/forest and wetland birds in revegetated woodland/forest, grassland, and aquatic habitats at 21 sites on 14 properties in the southern section of the gap zone, between Uralla, Enmore, Salisbury Plains and Kentucky South.

This report presents the results of the third and fourth bird surveys completed under this second project, in summer 2022 and winter 2022. It also discusses changes that occurred in surveyed bird communities over the study period (2020-22) and likely reasons for these changes. Four variables were targeted at each surveyed site in woodland/forest and wetland habitats – bird species presence, species richness, individual abundance, and habitat use. Five of these properties have been surveyed for birds by InSight Ecology during previous SNEL, Local Land Services, and CSIRO projects in the area. Sites were also assessed for their habitat and landscape connectivity, habitat condition, and land management and revegetation histories. A separate report presents the results of the first two Thunderbolt Project bird surveys (InSight Ecology 2023a).

A total of 2,382 individual birds from 98 species and 44 families was recorded during the summer 2022 and winter 2022 surveys in the study area. About 60% or 1,452 of these birds (71 species) were recorded foraging, sheltering and/or breeding in woodland/forest remnants. These

remnants supported 5 threatened (in NSW) species including Speckled Warbler, Scarlet Robin, Varied Sittella, Dusky Woodswallow, and Little Eagle.

Seven (7) species of local conservation significance were recorded in some of these remnants including Satin Flycatcher, White-browed Scrubwren, Eastern Yellow Robin, Double-barred Finch (declining nationally), Fuscous Honeyeater, Buff-rumped Thornbill, and Wedge-tailed Eagle. These species occurred in the larger, higher quality stringybark, Yellow Box, New England Peppermint and Blakely's Red Gum remnants. These were, in order of highest quality of remnant and the number of threatened bird species detected - 'Mihi Station', 'Spring Camp', CSIRO 'Chiswick' – 'Stringybark Paddock', 'Eastlake Geen Camp Peppermint Block', and Mt Mutton Reserve.

Freshwater wetlands surveyed in the study were utilised by 930 birds from 41 species and 18 families across both survey periods. The summer survey recorded 420 birds from 33 species while the winter survey detected 510 birds from 28 species. In the summer survey, the three main wetlands surveyed were between 60% (Racecourse Lagoon) and 80% full (Dangar's Lagoon and 'The Billabong' at 'Salisbury Court'). In the winter survey, Dangar's Lagoon was 100% while Racecourse Lagoon and 'The Billabong' were each at 80% capacity. More birds were recorded at these wetlands in winter (510) than summer (420) although the number of species present was less than in summer (28 in winter, 33 in summer).

One threatened species, the Blue-billed Duck (25 birds including 15 young), was recorded at Dangar's Lagoon in summer. Racecourse Lagoon was utilised by 5 Latham's Snipe in summer. This species is an intercontinental migratory wader protected under conservation agreements between Australia, China, Japan and South Korea. Ten wetland species of local conservation significance were also recorded at these sites and at Lambing Gully and 'Benambra'. They included Great Crested Grebe, Hoary-headed Grebe, Black Swan, Black-fronted Dotterel, Black-winged Stilt, Lewin's Rail, Australian Reed-Warbler, Little Grassbird, Tawny Grassbird, and Golden-headed Cisticola.

The total number of birds recorded during the four field surveys completed for the Thunderbolt Project (2020-2022) was 5,148 from 104 species and 47 families. Of this total, 3,027 birds from 73 species and 36 families were detected at woodland/forest sites while 2,121 birds (51 species from 25 families) were recorded at wetland sites.

Recommendations are provided to help protect, conserve, and re-establish key habitat for woodland/forest and wetland bird communities in the study area. These actions target the restoration and rehabilitation of foraging, refuge, and breeding habitat for threatened and declining bird species within the connectivity gap zone. The actions focus on completing the current project's funded program of revegetation, remnant protection and enhancement, recording progress on achieving goals at project-participating properties, running community information and demonstration site workshops on participating farms in the study area, securing significant ongoing funding to support the continuation of revegetation and restoration work commenced under the Thunderbolt Project, potentially in similarly cleared districts such as Walcha and Guyra, and monitoring and reporting on bird communities at each site in 3-5 years' time.

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1. Introduction

1.1 The woodland bird conservation crisis

The ecological footprint of about 180 years of European settlement on the native forests, woodlands and wetlands of New England Tableland has been substantial. About 60% of the region's native vegetation has been removed for farming and urban development. This has caused the widespread loss, fragmentation, and degradation of habitat and, as a result, the removal or disruption of wildlife corridors. Remaining animal populations have become highly isolated and this has led to the decline and local extinction of many native species. Remnant habitat in the region is now confined to some nature reserves and national parks, narrow and often degraded road reserves and, importantly, bushland on privately-owned properties.

Woodland birds and mammals have been particularly hard hit by these changes to the amount, condition and connectivity of habitat in the region. Hugh Ford and his colleagues have shown that small woodland bird species have been declining in abundance and disappearing at an alarming rate across southern Australia (Ford et al. 2001). This has also been occurring in other highly fragmented landscapes such as the sheep-wheatbelts of NSW (Reid, 1999 and Seddon et al. 2003) and Western Australia (see Saunders 1989; Saunders et al. 1991; Huggett et al. 2004; InSight Ecology et al. 2015).

It is also likely that woodland birds of New England Tableland are continuing to pay an extinction debt imposed by this large-scale land clearing and fragmentation (Ford et al. 2009; Kuussaari et al. 2009). This has involved the gradual disappearance of a suite of woodland birds from the region as patches have become increasingly isolated, smaller in size, degraded, and often heavily predated. Species-specific mechanisms have also been implicated in this process. These include, for example, the inability or unwillingness of the female Brown Treecreeper to disperse between isolated patches leaving remaining males to eventually die out (Cooper et al. 2002; Ford et al. 2009). High nest predation in isolated patches experienced by another ground-foraging woodland insectivore that has declined markedly across the region – Hooded Robin – has resulted in inadequate recruitment rates to replace losses caused by adult mortality (Fitri and Ford 2003; Debus 2006; Ford et al. 2009). The outcome has been the eventual extinction of this species from many small remnants across the tableland (Ford et al. 2009).

1.2 Re-connecting Thunderbolt Country Project

Since the 1970s, a series of revegetation projects have re-introduced vegetation into parts of the New England landscape. Livestock grazing pressure on woodland remnants has been reduced in some areas through fencing and improved stock management and pest control practices. While these efforts have helped to reduce soil erosion, provide shelter for livestock, establish habitat for some wildlife and improve local aesthetics, gaps in native vegetation cover between the eastern and western sides of the tableland still remain. Also, these plantings have often been too narrow, short or isolated within paddocks to act as functional corridors or stepping stones for area-sensitive and dispersal-limited native fauna species (see InSight Ecology 2012a, b, 2018a, b; Southern New England Landcare [SNEL] 2015).

A new project proposal, *Re-connecting Thunderbolt Country for Threatened New England Woodland and Wetland Biodiversity* (termed Thunderbolt Project), was developed by SNEL to address this key conservation issue in the region. This drew on the results of previous fauna

surveys and Landcare-based revegetation projects undertaken in the southern New England, particularly work completed under the Closing the Gap Project (2016-2019) (InSight Ecology 2018a, b). The Thunderbolt Project is funded by the NSW Environmental Trust under its Restoration and Rehabilitation Program for the period, 2019-2023.

The Thunderbolt Project targets the southern section of a key gap in habitat connectivity on the southern New England Tableland (termed the “study area”). This gap is about 35 km long by 23-25 km wide and occurs between Uralla in the north, Dangar’s Gorge and Enmore in the east, and Kentucky South and Salisbury Plains in the south. This area represents a significant gap in connectivity that is preventing and/or inhibiting threatened and declining fauna moving between habitats on the western and eastern sides of this part of New England Tableland. Previous SNEL projects (e.g. InSight Ecology 2018a), wildlife corridor mapping (Scotts 2003), habitat connectivity modelling projects (Mackey et al. 2010; Office of Environment and Heritage 2010, 2016; Smith 2018; Harwood et al. 2022), a local strategic plan (Local Land Services 2021), and a State of the Environment report (Uralla Shire Council 2017-2021) have identified the study area as a high priority for ecological restoration.

Key conservation management actions that are in progress or planned for the study area include the protection of 18 ha of remnant woodland and wetland using 6 km of fencing, planting 36 ha of new future habitat with 12,000 local native trees, shrubs and ground cover species, and managing key threats. This work is targeting a total of 18 sites on 12 private properties in the study area. In addition, a total of 10,000 community members in the Uralla, Walcha and Armidale LGAs have been reached via an online training workshop and articles in the local media and on SNEL’s website. A well-attended project field day was held on 12 May 2023 at ‘Big Ridge’, Uralla. Another local community event is planned for November 2023.

This report presents the results of the third and fourth avifaunal surveys conducted under the Thunderbolt Project. This work was undertaken in summer 2022 and winter 2022 at 21 sites on 14 properties across the study area. Six (6) of these sites comprised remnant and/or constructed wetland habitats, 9 sites supported remnant eucalypt woodland/forest, and 6 sites were proposed to be revegetated with native flora. Remnant woodland/forest sites were designated as reference sites to allow comparison of bird response to revegetation and remnant protection over time. The results of the first and second bird surveys, conducted in winter 2020 and summer 2021, are reported separately (InSight Ecology 2023a).

1.3 Objectives

The Thunderbolt Project aims to increase habitat connectivity and improve habitat condition for threatened fauna and flora in the study area.

Specifically, the project will:

- Establish 36 ha of new functional habitat for woodland birds and other fauna;
- Protect 18 ha of remnant woodland/forest and grassland;
- Erect 6 km of fencing to protect remnants and new revegetation;
- Increase community awareness, skills and knowledge of functional habitat connectivity and its importance for threatened New England flora and fauna among 10,000 community members in the Uralla, Armidale, Walcha and Guyra LGAs.

This report:

- Describes the species composition, relative abundance, habitat use and conservation significance of bird communities surveyed in remnant and planted native vegetation in the study area;
- Provides new data to allow monitoring of the performance of revegetated and remnant woodland and wetland sites as functional faunal habitat and help inform their conservation management over time;
- Contributes to our current knowledge of the ecology and conservation of woodland and wetland birds in remnants and revegetation on the southern New England Tableland;
- Provides recommendations to protect, enhance, increase and re-connect habitat for threatened birds and other fauna in the study area.

2. Location and methods

2.1 Location

The study area is located between 18 km south-west (CSIRO 'Chiswick', north of Uralla) and 51 km south (Hillview Road at 'Eastlake') of Armidale on the NSW northern tablelands. Figure 1 (next page) shows the location of surveyed properties and sites in the study area and the distribution of vegetation across the landscape. Table 1 lists the properties and sites surveyed for avifauna in the Thunderbolt Project.

2.2 Methods

2.2.1 Literature and data review

A review of existing literature and data on avifauna and revegetation of the study area and southern Australia generally was undertaken before and during the project. This included published research papers in ornithological science and ecological restoration journals, reports of previous bird surveys and revegetation projects, field data from past bird surveys and habitat assessments in the study area, NSW Wildlife Atlas (BioNet, under licenced access to InSight Ecology) and Landcare funding applications, and verified bird records held by individual landowners. Regional and sub-regional connectivity modelling work undertaken by NSW Department of Planning and Environment and University of New England was also reviewed.

2.2.2 Site selection

A total of 21 survey sites were selected across 14 properties in the study area. The selection of these sites was based on proposals submitted to SNEL for on-ground habitat protection and revegetation works by individual landholders under the Thunderbolt Project. Works plans for each property were prepared by landholders in consultation with the SNEL project officer and commitment to plans secured through landholder management agreements. Recommendations from previous surveying in and near the study area helped guide the design of proposed revegetation and remnant protection actions, particularly concerning the connectedness, width and length of plantings, and their functional habitat value for woodland and wetland birds.

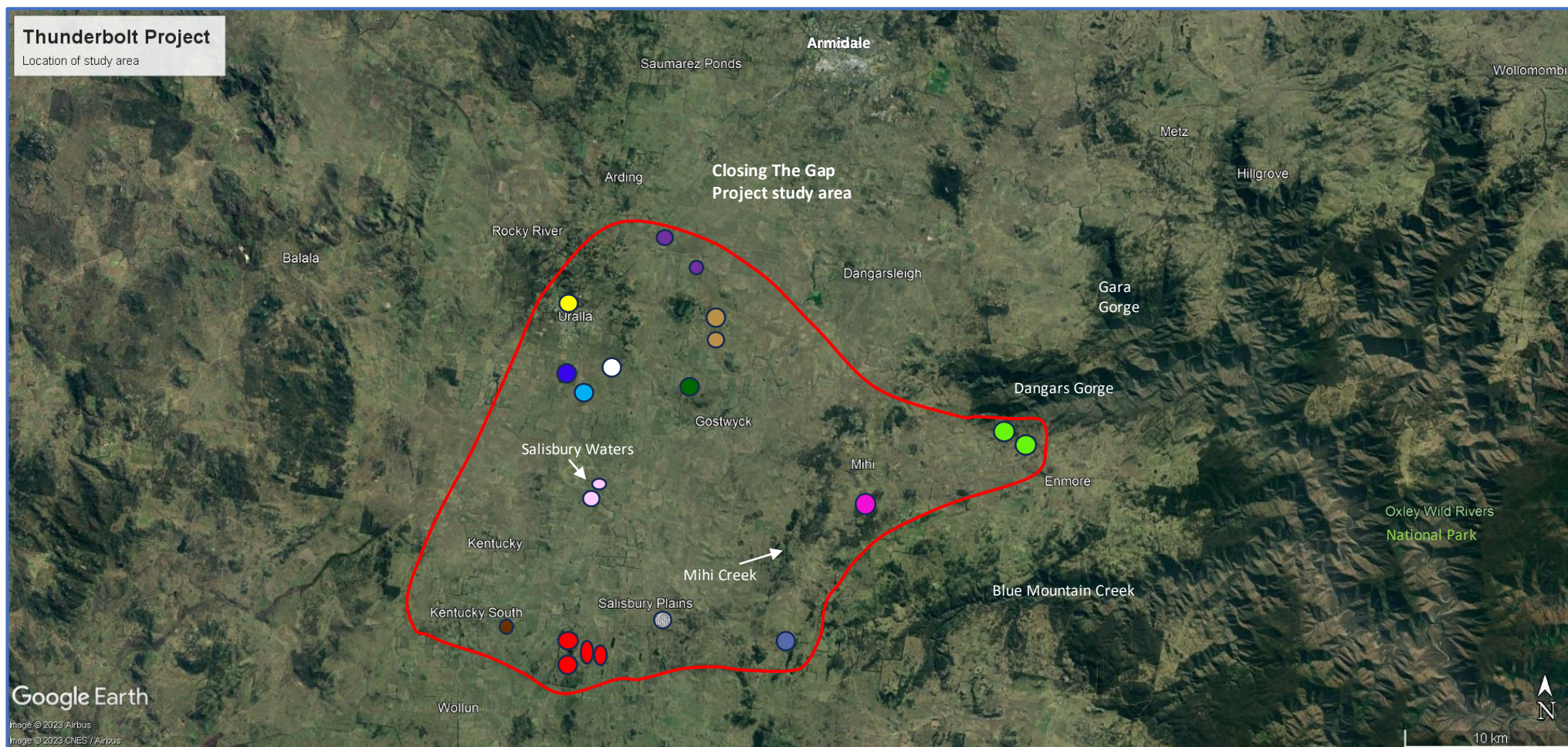


Figure 1: Location of the Uralla to Kentucky South and Salisbury Plains connectivity gap (the study area). Red line denotes the Thunderbolt Project study area boundary. Key to properties and surveyed sites: purple = 'Chiswick', yellow = Mt Mutton Reserve, brown = 'Big Ridge', dark green = 'Gostwyck', white = 'Benambra', dark blue = Racecourse Lagoon Reserve, light blue = Dangar's Lagoon NR, light green = 'Spring Camp', magenta = 'Mihi Station', dark grey = 'Eastlake', light grey = 'East Oaks', red = 'Taylor's Run', dark brown = 'Woodstock', light pink = 'Salisbury Court'.

Table 1: List of properties and sites surveyed in the Thunderbolt Project. Sites previously surveyed by InSight Ecology (between 2011 and 2018) are indicated. The location of sites is shown in Figure 1.

Property name	Site number	Site name	Description	Site previously surveyed by InSight Ecology
CSIRO 'Chiswick'	1	Lambing Gully	Remnant wetland	yes
CSIRO 'Chiswick'	2	Stringybark Paddock	Remnant woodland/forest	yes
Mt Mutton Reserve	3	Mt Mutton Reserve	Remnant woodland/forest	no
'Big Ridge'	4	Corridor planting Site 3	Proposed woodland planting	No (yes, other sites on 'Big Ridge')
'Big Ridge'	5	Corridor planting Site 4	Proposed woodland planting	no
'Gostwyck'	6	'No Man's Land'	Remnant woodland and shrubland on rocky ridge	yes
'Benambra'	7	Wetland Paddock Site 3	Remnant wetland in drainage line connected to Dangar's Lagoon	no
Dangar's Lagoon Nature Reserve	8	Dangar's Lagoon	Remnant wetland	no
Racecourse Lagoon Reserve and Wildlife Refuge	9	Racecourse Lagoon	Remnant wetland	no
'Salisbury Court'	10	'Rock quarry'	Scattered remnant woodland on rocky knoll east of Salisbury Waters	no
'Salisbury Court'	11	'The Billabong' wetland	Remnant wetland	no
'Spring Camp'	12	'Fairy Glen' and 'Hill of Birds'	Remnant forest and shrubby woodland on rocky knolls and gullies	yes
'Spring Camp'	13	'Dam wetland'	Fully vegetated old dam	no
'Mihi Station'	14	'Lower Ram Paddock' and part of 'Trig Reserve' (contiguous site)	Remnant grassy woodland	no
'Eastlake'	15	'Green Camp Peppermint Block'	Remnant grassy woodland to Jack's Creek	no (yes - other sites on 'Eastlake' since 2011)
'East Oaks'	16	'Lower Hill Planting' and 'Lower Hill Enhancement'	Proposed woodland corridor planting and remnant woodland enhancement	no
'Taylor's Run'	17	'Top Spring'	Remnant woodland/forest and planted pines	no
'Taylor's Run'	18	'Wallaby Paddock'	Remnant woodland/forest and planted pines	no
'Taylor's Run'	19	'Corner Paddock'	Remnant grassy woodland	no
'Taylor's Run'	20	'Far Dip Paddock'	Proposed woodland corridor planting	no
'Woodstock'	21	Woodstock dam	Proposed wetland fencing and woodland strip planting	no

2.2.3 Field surveying

Terrestrial and aquatic bird species were surveyed by InSight Ecology during the day at each site in the study area in summer 2022 (4-7 and 11-14 January) and late winter 2022 (29 August-2 September). InSight Ecology has previously surveyed bird communities on 5 of the properties

that participated in the Thunderbolt Project – ‘Eastlake’, ‘Big Ridge’, CSIRO ‘Chiswick’, ‘Gostwyck’ (at ‘No Man’s Land’), and ‘Spring Camp’.

Bird species that utilised wetland habitats present at 7 surveyed sites were also recorded. These included open or standing water, floating vegetation on lake and dam surfaces, reedy margins, fringing trees, shrubs and grasses, fallen logs and rocky embankments along creeks and farm dams, and wet paddocks/grassy creeks.

The area search technique (InSight Ecology 2012a, b, 2018a, b) was used to sample bird communities present in woodland remnants. This involved surveying by steadily walking a loop route in which different forward and return legs, separated where possible by a distance of at least 100 metres, were taken through the main habitats present at each site. In revegetation, point-count line transects were used to sample bird species present in typically narrow planted strips. Both techniques avoided recording the same bird twice, particularly flocking, group-foraging, and fast or very frequently moving species such as Noisy Miner, Yellow-faced Honeyeater, Welcome Swallow, and Eastern Rosella. This also helped to avoid committing the same error with more sedentary species such as Australian Magpie and Grey Butcherbird. These species tend to remain in specific areas for periods of time, scanning for ground-based prey in grass or leaf litter.

Wetland sites were surveyed for birds by walking slowly around a lake, billabong or dam’s dryland perimeter or walking a transect through reeds, grasses and other wetland vegetation at ‘Benambra’, CSIRO ‘Chiswick’, ‘Salisbury Court’ (‘The Billabong’ wetland), Dangar’s Lagoon, Racecourse Lagoon, ‘Spring Camp’, and ‘Woodstock’. In addition, a 2.5-hour, kayak-based survey of Dangar’s Lagoon was conducted on 12 January 2022. This allowed access to open water, reedbeds, and floating aquatic vegetation without disturbing nesting birds or adults with fledged young. This approach improved the survey count accuracy for larger groups of waterbirds such as Grey Teal, threatened Blue-billed Duck (25 birds – 15 young, 10 adults), Eurasian Coot, and Australasian Grebe. It also assisted in detecting and counting species that were difficult to record and count accurately from the shore such as diving species Hoary-headed Grebe and Musk Duck, and Golden-headed Cisticola (in fringing reedbeds and rushes).

All birds observed or heard at a site were recorded, including individuals flying over the site. Data recorded included the species present, number of individuals observed, date, time, behaviour (ie. foraging/feeding, courting, calling, mobbing, resting, flying), use of habitat, and other relevant information such as age, species composition and condition of revegetation and remnants, weather, and interactions with other birds. Nomenclature used was consistent with Christidis and Boles (2008). All observations were made by the same experienced ornithologist (A.H.) using a pair of Zeiss 10x40BT® binoculars fixed to a Pro-Harness® chest strap. Several landholders accompanied A.H. during surveys on their properties.

Surveys were generally conducted in the main morning (c. 0700-1030 hours) and afternoon (c. 1600-1930 hours in summer and 1400-1700 hours in winter) bird foraging periods (survey sessions) on each survey day. No surveying occurred in windy or wet weather.

A total of 16 field survey sessions were conducted in summer 2022 (total of 18 hours and 50 minutes) and 21 survey sessions in winter 2022 (total of 21.5 hours). The fewer sessions completed in summer reflected a decision not to survey sites on one property where Covid19 was reported by the landowner to be present. A total of 40 hours was therefore spent surveying

birds in the study area. This effort was similar to that invested in the first two bird surveys (2020-21, total of 40.5 hours).

2.2.4 Habitat assessment

The biophysical attributes of each surveyed site were assessed. These included location and area of woodland remnants, woodland revegetation and wetland remnants, geology, broad habitat type - forest, woodland, grassland, pasture or wetland, type of native vegetation present - mature trees, young trees, grasses, herbs/forbs, moss/fungi/lichens, leaf litter and bare soil, habitat and habitat condition features – standing dead trees, trees with hollows, trees with mistletoe, fallen timber and rocks, open water, wetland vegetation, unhealthy habitat features – dead/dying/mistletoe-infested trees, introduced shrubs and grasses, soil erosion, feral animals and excessive grazing, main tree, shrub and grass/forb species present, observations of other fauna, and land management information including land use types, native vegetation connectivity and owner’s perspectives.

Still photographs were taken of the surveyed sites using a Nikon D3200 (Nikkor 55-300 mm lens) digital SLR camera. These provided reference points for future monitoring of revegetation and remnant enhancement sites as well as habitat condition in remnant and planted sites. They also captured some birds present and their use of habitat and provided a landscape-scale perspective of vegetation distribution within the gap zone. All images were stored on a standard 500GB ATA HDD and backed up to a 500GB external HDD.

2.3 Community engagement and education

Several activities were designed and implemented by SNEL and InSight Ecology to engage landholders and local communities in the Thunderbolt Project. These aimed to increase community awareness, skills and knowledge of functional habitat connectivity and its importance for threatened New England fauna. This work targeted reached out to 10,000 community members in the Uralla, Walcha, Armidale and Guyra LGAs. Landholders were also invited to accompany the ornithologist on surveys of sites on their properties.

Activities conducted during 2022-23 included continued promotion of the project through the local print media, Landchat newsletter, and SNEL eNewsletter and website. A well-attended field workshop was held on 12 May 2023 at ‘Big Ridge’ in which presentations on the Koala conservation project and the woodland and wetland bird project were delivered, followed by an inspection of on-farm revegetation and a visit to ‘No Man’s Land’ remnant woodland. A new pocket booklet about the project and bird species and habitats recorded was prepared by InSight Ecology and distributed to each workshop participant by SNEL (booklet available from SNEL).

3. Results

3.1 Overview

A total of 2,382 birds from 98 species and 44 families were recorded at woodland and wetland sites during the summer 2022 and winter 2022 surveys in the study area. Slightly fewer birds were recorded in summer (1,156) than in winter (1,226). During the summer 2022 survey, Dangar’s Lagoon was 80% full while in the winter 2022 survey the lagoon was 100% full. Racecourse Lagoon was at 60% capacity during the summer 2022 survey and 80% full in the

winter 2022 survey. 'The Billabong' wetland at 'Salisbury Court' was 80% full in both the summer 2022 and winter 2022 surveys.

A total of 5,148 birds from 104 species and 47 families was recorded across all 4 surveys for the project (see also InSight Ecology 2023a). This included 3,027 woodland birds from 73 species and 36 families and 2,121 wetland birds from 51 species and 25 families.

3.1.1 Woodland birds

A total of 1,452 woodland birds from 71 species and 35 families was recorded during the summer 2022 and winter 2022 surveys in the study area.

Most woodland birds were recorded in eucalypt remnants and mixed eucalypt remnant/old pine plantings. These provided important foraging, refuge and/or breeding habitat for 67 bird species in summer 2022 (736 birds) and 56 bird species (716 birds) in the winter 2022 survey. Some species occurred in both surveys.

Woodland bird species of State conservation significance recorded in the surveys were the threatened Speckled Warbler, Scarlet Robin, Dusky Woodswallow, Little Eagle, and Varied Sittella. Woodland birds of local conservation significance in the highly fragmented southern New England landscape detected were White-browed Scrubwren, Eastern Yellow Robin, Buff-rumped Thornbill, Satin Flycatcher, Double-barred Finch, Fuscous Honeyeater, and Wedge-tailed Eagle (see Section 3.3).

Surveying of existing woodland revegetation in this project was limited to two sites, both on 'Taylor's Run' – 'Top Spring' and 'Wallaby Paddock'. The former site was a mix of remnant New England Stringybark and Blakely's Red Gum and old planted Radiata Pine while these pines dominated much of 'Wallaby Paddock'. Bird species recorded in these sites included nesting Brown Goshawk ('Top Spring'), White-throated Treecreeper, Crimson Rosella, Brown Thornbill, Buff-rumped Thornbill, Superb Fairy-wren, White-browed Scrubwren, Eastern Yellow Robin, Yellow-faced Honeyeater, and Red Wattlebird. Summer breeding migrants recorded at these sites were Satin Flycatcher and Dollarbird.

Five sites proposed for woodland revegetation in the project were also surveyed for birds. These included two sites at 'Big Ridge' and one each at 'East Oaks', 'Taylor's Run', and 'Salisbury Court'. Birds recorded at these sites were open country species, typically Australian Magpie, Eastern Rosella and Crested Pigeon as well as birds flying between remnants and paddocks such as Red-rumped Parrot and Torresian Crow.

3.1.2 Wetland birds

A total of 930 wetland birds from 41 species and 18 families was recorded during the summer 2022 and winter 2022 surveys in the study area. Wetlands provided important foraging, refuge and/or breeding habitat for 33 bird species in summer 2022 (420 birds) and 28 bird species (510 birds) in the winter 2022 survey. Some species occurred in both surveys. Some families comprised species that utilised both wetland and woodland habitats such as White-faced Heron (Ardeidae), Brown Falcon (Falconidae), Welcome Swallow (Hirundinidae), Superb Fairy-wren (Maluridae), and Willie Wagtail (Rhipiduridae).

Lagoons and dams with open water supported common residents such as Australian Wood Duck, Pacific Black Duck, Grey Teal, Australasian Grebe, Eurasian Coot and Welcome Swallow. Dangar’s Lagoon, Racecourse Lagoon and ‘The Billabong’ at ‘Salisbury Court’ provided expanses of open water and some aquatic floating vegetation for Musk Duck, Hoary-headed Grebe, Great Crested Grebe, Australasian Shoveler, and Black Swan. The threatened Blue-billed Duck was recorded at Dangar’s Lagoon (breeding) and Sailsbury Court’s ‘The Billabong’.

Reedy and muddy margins of wetlands were utilised by White-faced Heron, Purple Swamphen, Eurasian Coot, Black-winged Stilt and Masked Lapwing. Black-fronted Dotterel was recorded foraging along the exposed muddy shores of Dangar’s Lagoon in winter 2022.

A seasonally wet grassland along Lambing Gully at ‘Chiswick’ provided rank foraging, refuge and nesting habitat for Tawny Grassland, Golden-headed Cisticola and Brown Quail. Lewin’s Rail was detected in rank grasses and pools along Chiswick’s Lambing Gully wetland in winter 2022. The intercontinental migratory wader, Latham’s Snipe, was observed foraging in rank grasses and along the shoreline of Racecourse Lagoon.

Wetland bird species of State conservation significance was the threatened Blue-billed Duck. Also recorded was the international migratory wader, Latham’s Snipe. The latter species is protected under migratory bird agreements between the governments of Australia, China, Japan, and South Korea. Wetland bird species of local conservation significance detected were Lewin’s Rail, Black Swan, Great Crested Grebe, Hoary-headed Grebe, Black-winged Stilt, Black-fronted Dotterel, Australian Reed-Warbler, Tawny Grassbird, Little Grassbird, and Golden-headed Cisticola.

3.2 Birds recorded at each surveyed site

All bird species recorded during both surveys are listed in Tables 2-22, together with the number of individual birds detected for each species in each survey period, their behaviour/habitat use, and the total number of species and individuals recorded at each site. Species of local, regional or State conservation significance are highlighted in bold. Species classified as threatened under NSW Biodiversity Conservation Act 2016 and Latham’s Snipe are indicated in bold and italics. Introduced species are shown by an asterisk.

Table 2: Birds recorded at Lambing Gully remnant wetland, CSIRO ‘Chiswick’ (Site 1)

Species and survey date - summer 2022 (11/1/22)	Species and survey date – winter 2022 (31/8/22)
Golden-headed Cisticola 6 (called breeding territory)	Golden-headed Cisticola 14 (used blackberry clump)
Tawny Grassbird 6 (along wet channel, 4 males, 2 females)	Welcome Swallow 2
Brown Quail 1 (called)	Galah 1 (flew over)
Superb Fairy-wren 7 (near powerline)	Superb Fairy-wren 5
Common Starling* 30 (flushed from plantings by 12 cows)	Lewin’s Rail 1 (flushed from pool 10 m N powerline)
Australasian Pipit 3 (perched on fencelines)	Common Starling* 40 (in plantings, W bank of ck)
	Pacific Black Duck 4 (flushed from N long pool)
	Brown Quail 1 (called N end)
	Australasian Pipit 1 (called)
	Nankeen Kestrel 1 (on powerline)
<i>Total birds 53. Total species 6</i>	<i>Total birds 70. Total species 10</i>

Table 3: Birds recorded at 'Stringybark Paddock' forest remnant, CSIRO 'Chiswick' (Site 2)

Species and survey date – summer 2022 (11/1/22)	Species and survey date – winter 2022 (31/8/22)
Torresian Crow 4 (near 12 sheep)	Common Starling* 12
Eastern Rosella 7	Striated Pardalote 1
Australian Magpie 2	White-throated Treecreeper 1
Rufous Whistler 3 (2 males, 1 female)	Noisy Friarbird 1
White-throated Treecreeper 1	Australian Magpie 2
Superb Fairy-wren 6 (E side hawthorn)	Eastern Rosella 7
Striated Pardalote 2	Crimson Rosella 6
Yellow-rumped Thornbill 12	Superb Fairy-wren 5
Grey Fantail 8	Black-faced Cuckoo-shrike 1
Crimson Rosella 2	Yellow Thornbill 2
Black-faced Cuckoo-shrike 2 (nesting)	Grey Fantail 2
Laughing Kookaburra 2	Varied Sittella 4 (foraged in stringybarks)
Brown Thornbill 1	Striated Thornbill 2
Scarlet Honeyeater 2	Yellow-rumped Thornbill 4
Yellow Thornbill 3 (adult fed 2 young, in blackthorn)	Golden Whistler 1
Striated Thornbill 1	Willie Wagtail 1
Silvereeye 3	Galah 2
White-throated Gerygone 1	
Galah 2	
Dusky Woodswallow 2 (nesting, repelled crow)	
Brown Falcon 1	
White-faced Heron 1	
<i>Total birds 68. Total species 22</i>	

Table 4: Birds recorded at Mt Mutton Reserve - grassy woodland and shrubland remnant (Site 3)

Species and survey date – summer 2022 (12/1/22)	Species and survey date – winter 2022 (1/9/22)
Grey Fantail 3	White-throated Treecreeper 1
Silvereeye 5	Red Wattlebird 2
White-throated Treecreeper 4	Noisy Friarbird 1
Superb Fairy-wren 8	Yellow-faced Honeyeater 3
Dollarbird 1	Double-barred Finch 4
Yellow-faced Honeyeater 4	Grey Fantail 2
Buff-rumped Thornbill 7	Superb Fairy-wren 17 (cotoneasters, blackthorn)
Red-browed Finch 2 (foraged in seeding grasses)	Spotted Pardalote 2
Brown Thornbill 2	Australian Magpie 1
White-browed Scrubwren 5 (foraged thick blackthorn, likely nested with young)	Silvereeye 60 (flock moved through site on migration)
Spotted Pardalote 2	Brown Thornbill 2
Eastern Koel 1 (call)	Striated Thornbill 2
Double-barred Finch 3 (foraged in seeding grasses)	Buff-rumped Thornbill 5
Pied Currawong 1	Crimson Rosella 3
Crimson Rosella 2	Golden Whistler 2
Eastern Spinebill 2	Brown-headed Honeyeater 3 (foraged W slope stringys)
Olive-backed Oriole 1 (call)	Eastern Spinebill 2
Spangled Drongo 2	White-browed Scrubwren 2 (W side blackthorn)
Black-faced Cuckoo-shrike 2	
Red Wattlebird 1	
Rufous Whistler 1	
Striated Thornbill 6 (E side upper slope)	
<i>Total birds 75. Total species 18</i>	<i>Total birds 114. Total species 18</i>

Table 5: Birds recorded at ‘Big Ridge’ – proposed corridor planting site 3 (Site 4)

Species and survey date – summer 2022	Species and survey date - winter 2022 (31/8/22)
Not surveyed	Black-faced Cuckoo-shrike 1 (flew over beds)
	Tree Martin 6 (foraged above prepared beds)
	Yellow-rumped Thornbill 6 (near Blakely’s RG isolate)
	<i>Total birds 13. Total species 3</i>

Table 6: Birds recorded at ‘Big Ridge’ – proposed corridor planting site 4 (Site 5)

Species and survey date – summer 2022	Species and survey date - winter 2022 (31/8/22)
Not surveyed	Welcome Swallow 3
	Australian Magpie 1
	<i>Total birds 4. Total species 2</i>

Table 7: Birds recorded at ‘No Man’s Land’ remnant woodland/shrubland, ‘Gostwyck’ (Site 6)

Species and survey date – summer 2022	Species and survey date – winter 2022 (31/8/22)
Not surveyed – but surveyed in autumn, winter & late spring 2016-17 (see InSight Ecology 2018a, b, 2019). Additional conservation-significant species recorded in 2016-17: Common Bronzewing, Rufous Fantail, Scarlet Honeyeater, Eastern Yellow Robin & Satin Flycatcher.	Golden Whistler 2
	Noisy Friarbird 9
	Buff-rumped Thornbill 11 (foraged in <i>Cassinia quinquefaria</i> , mate pursuits)
	Superb Fairy-wren 7
	Grey Fantail 3
	Yellow-faced Honeyeater 3
	Striated Pardalote 2 (call)
	Grey Butcherbird 1 (call E edge)
	Striated Thornbill 6
	Torresian Crow 2
	Varied Sittella 5 (foraged snow gum & angophoras)
	White-throated Treecreeper 2
	Laughing Kookaburra 2
	Black-faced Cuckoo-shrike 2
	Crimson Rosella 1
	Brown Thornbill 2
	White-browed Scrubwren 3 (breeding, W sector)
	<i>Total birds 63. Total species 17</i>

Table 8: ‘Benambra’, Wetland Paddock Site 3 (Site 7)

Species and survey date – summer 2022 (6/1/22)	Species and survey date – winter 2022 (7/1/21)
Australian Reed-Warbler 1 (in cumbungi around small dam, 60% of the site was very water-logged)	Grey Teal 6 (in pooled section, cattle currently grazing site)
Tawny Grassbird 4 (responded to call playback, called in rank rushland)	Masked Lapwing 3
Magpie-lark 1 (flew over)	Purple Swamphen 4
	Pacific Black Duck 8
	Welcome Swallow 3
	Magpie-lark 1
	Australian White Ibis 3
	Superb Fairy-wren 2 (in rushes at small dam)
	Tawny Grassbird 2 (in untrampled grassland at W end – 1 in breeding plumage, early return)
	Willie Wagtail 1
<i>Total birds 6. Total species 3</i>	<i>Total birds 33. Total species 10</i>

Table 9: Dangar’s Lagoon Nature Reserve wetland (Site 8)

Species and survey date – summer 2022 (12/1/22)	Species and survey date – winter 2022 (29/8/22)
Great Crested Grebe 7 (foraged in submerged reeds)	Masked Lapwing 3
Eurasian Coot 17	Black Swan 14
Musk Duck 8	Pacific Black Duck 30
Pacific Black Duck 26 (15 fledglings)	Black-fronted Dotterel 3 (muddy shoreline)
Grey Teal 14 (nesting & young)	Chestnut Teal 16
Dusky Moorhen 2	Grey Teal 16
Golden-headed Cisticola 2 (called, grassy margins)	Purple Swamphen 19
Blue-billed Duck 25 (10 adults, 15 young)	Welcome Swallow 9
Hoary-headed Grebe 2	Australasian Grebe 7
Welcome Swallow 15	Eurasian Coot 35
White-faced Heron 2	Hoary-headed Grebe 13 (with young)
Masked Lapwing 2	Dusky Moorhen 1
Australian White Ibis 1	Great Crested Grebe 1
Purple Swamphen 1	Superb Fairy-wren 3 (foraged reedy margins)
Little Grassbird 2 (fringing grassland)	Musk Duck 1
Australasian Grebe 14 (8 young)	
Australasian Shoveler 5 (3 young)	
Pied Cormorant 2 (flew over lagoon)	
<i>Total birds 147. Total species 18</i>	<i>Total birds 171. Total species 15</i>

Table 10: Racecourse Lagoon Reserve and Wildlife Refuge wetland (Site 9)

Species and survey date – summer 2022 (6/1/22)	Species and survey date – winter 2022 (29/8/22)
Black Swan 27 (incl. 6 fledglings & 2 nests)	Black Swan 3
Black-winged Stilt 2	Pacific Black Duck 12
Tawny Grassbird 1	Eurasian Coot 154
Little Grassbird 1	Purple Swamphen 3
Superb Fairy-wren 5	Masked Lapwing 1
Chestnut Teal 5	
Eurasian Coot 6 (& 2 nests)	
Pacific Black Duck 18	
Australasian Grebe 25	
Australasian Shoveler 4	
Latham’s Snipe 5 (flushed from N end shallows)	
White-faced Heron 2	
Grey Teal 9	
<i>Total birds 110. Total species 13</i>	<i>Total birds 173. Total species 5</i>

Table 11: ‘Salisbury Court’ rock quarry remnant woodland with exotic/native grass swards and located on the eastern side of Salisbury Water to the old cottage (Site 10)

Species and survey date – summer 2022 (12/1/22)	Species and survey date – winter 2022 (30/8/22)
Tawny Grassbird 1 (aerial displays)	Crimson Rosella 2
Silverye 7	Grey Butcherbird 2
European Goldfinch* 11	Common Starling* 4
Superb Fairy-wren 5	Superb Fairy-wren 3
Black-shouldered Kite 1	Brown Falcon 1 (perched in dead tree)
Grey Shrike-thrush 1	Tree Martin 2
Grey Fantail 1	Welcome Swallow 2
Tree Martin 4	
Common Starling* 3 (flew over)	
Striated Pardalote 1 (nested in dead branch)	
Australian Reed-Warbler 2 (rushes nr Salisbury Water)	

Species and survey date – summer 2022 (12/1/22)	Species and survey date – winter 2022 (30/8/22)
Brown Thornbill 1 (foraged in hawthorn)	
<i>Total birds 38. Total species 12</i>	<i>Total birds 16. Total species 7</i>

Table 12: ‘Salisbury Court’ – ‘The Billabong’ remnant wetland (Site 11)

Species and survey date – summer 2022 (13/1/22)	Species and survey date – winter 2022 (30/8/22)
Eurasian Coot 20	Tree Martin 2
White-faced Heron 1	Welcome Swallow 6
Pied Cormorant 1	Brown Quail 1
Black Swan 2	Tawny Grassbird 1 (fringing grass swards)
Pacific Black Duck 8	Pacific Black Duck 21
Australasian Grebe 31 (incl young, nested in coot nests)	Australasian Grebe 18
Blue-billed Duck 4 (2 pairs)	Hoary-headed Grebe 4
Masked Lapwing 2	Eurasian Coot 4
Australian Wood Duck 4	Chestnut Teal 1
Purple Swamphen 1	
Magpie-lark 1	
Australasian Shoveler 2	
Dusky Moorhen 4 (incl. 2 young)	
<i>Total birds 81. Total species 13</i>	<i>Total birds 58. Total species 9</i>

Table 13: ‘Spring Camp’ – ‘Fairy Glen’ and ‘Hill of Birds’ remnant grassy woodland/forest (Site 12)

Species and survey date – summer 2022 (7/1/22)	Species and survey date – winter 2022 (2/9/22)
Welcome Swallow 2	Yellow-faced Honeyeater 13
Grey Shrike-thrush 3	Red Wattlebird 2
Crimson Rosella 10	White-browed Scrubwren 9 (nested/nesting)
Grey Fantail 2	White-throated Treecreeper 1
Red-browed Finch 4 (building nest in dead wattle)	White-naped Honeyeater 6 (in flowering stringybark)
Superb Fairy-wren 17	Grey Shrike-thrush 1
Brown Thornbill 4	Pied Currawong 2
White-browed Scrubwren 4	Grey Butcherbird 2
Silvereye 11	Golden Whistler 2
Australian King-Parrot 4 (breeding)	Eastern Spinebill 9 (in flowering stringybarks)
Yellow-faced Honeyeater 5	Grey Fantail 4
Dollarbird 1	Brown Thornbill 9 (incl. juvenile)
Red Wattlebird 5	Superb Fairy-wren 12
Satin Bowerbird 3	Noisy Friarbird 4
Pied Currawong 2	Australian Wood Duck 1 (nesting)
Spotted Pardalote 1	Laughing Kookaburra 2
White-throated Treecreeper 2	Australian King-Parrot 2
Eastern Spinebill 3	Speckled Warbler 1 (male called in olearia, acacia)
Rufous Whistler 4	Varied Sittella 7 (upslope stringybark near house)
Torresian Crow 4	Brown-headed Honeyeater 9
Noisy Friarbird 2	Buff-rumped Thornbill 2
Striated Thornbill 4	Red-browed Finch 4 (foraged upslope grassy spur near Speckled Warbler)
Grey Butcherbird 1	Crimson Rosella 2
Mistletoebird 1 (called)	
Laughing Kookaburra 4 (breeding)	
White-naped Honeyeater 4	
White-throated Gerygone 2	
Satin Flycatcher 1	
Striated Pardalote 1	
Willie Wagtail 1	
Tree Martin 4	

Species and survey date – summer 2022 (7/1/22)	Species and survey date – winter 2022 (2/9/22)
Yellow-rumped Thornbill 2	
Total birds 118. Total species 32	Total birds 106. Total species 23

Table 14: ‘Spring Camp’ – Dam wetland (Site 13)

Species and survey date – summer 2022 (7/1/22)	Species and survey date – winter 2022 (2/9/22)
Superb Fairy-wren 3	Superb Fairy-wren 4
Welcome Swallow 2	Willie Wagtail 1
Pacific Black Duck 1 (flew over)	
Rufous Songlark 1 (called rank grasses)	
Willie Wagtail 1	
Total birds 8. Total species 5	Total birds 5. Total species 2

Table 15: ‘Mihi Station’ – ‘Lower Ram Paddock’ and part of ‘Trig Reserve’ remnant grassy woodland (Site 14)

Species and survey date – summer 2022 (14/1/22)	Species and survey date – winter 2022 (1/9/22)
Rufous Whistler 5	Red Wattlebird 4 (in flowering yellow box)
Grey Fantail 4	Rufous Whistler 2
Scarlet Honeyeater 10	Noisy Friarbird 14 (in flowering yellow box)
Black-faced Cuckoo-shrike 2	Grey Fantail 5
White-throated Gerygone 1	White-throated Treecreeper 2
Laughing Kookaburra 2	Buff-rumped Thornbill 4
Crimson Rosella 4	White-naped Honeyeater 7 (flowering yellow box)
Varied Sittella 5 (foraged yellow box and BRG upper)	Fuscous Honeyeater 12 (mate pursuits, yellow box starting to flower, upper-mid slopes)
Brown-headed Honeyeater 4 (foraged budding BRG)	Yellow-faced Honeyeater 3
Grey Shrike-thrush 4	Striated Pardalote 2
Red Wattlebird 1	Spotted Pardalote 2 (inspected BRG nest hollow?)
Noisy Friarbird 5 (nesting, conflicts with miners)	Grey Shrike-thrush 2 (called)
Fuscous Honeyeater 16 (with young birds in BRG foliage)	Satin Flycatcher 1
Mistletoebird 1	Golden Whistler 2 (m and f)
Willie Wagtail 2 (nested)	Torresian Crow 2
Tree Martin 2	Eastern Spinebill 1
Red-rumped Parrot 8	Willie Wagtail 2
Yellow-faced Honeyeater 4	Crimson Rosella 1
White-throated Treecreeper 1	Dusky Woodswallow 2 (called, mate pursuit)
Buff-rumped Thornbill 7	Brown-headed Honeyeater 8 (foraged upslope BRG)
Dusky Woodswallow 5 (likely nested, with fledglings)	
Australian Magpie 7	
Red-rumped Parrot 4 (nesting in BRG stags)	
White-naped Honeyeater 2 (foraged in mistletoe)	
Noisy Miner 7	
Grey Butcherbird 1	
Total birds 114. Total species 26	Total birds 78. Total species 20

Table 16: ‘Eastlake Green Camp Peppermint Block’ remnant grassy woodland (Site 15)

Species and survey date – summer 2022 (6/1/22)	Species and survey date – winter 2022 (29/8/22)
Yellow-tailed Black-Cockatoo 2 (flew over)	Red Wattlebird 12
Noisy Friarbird 2	Australian Magpie 9
Satin Flycatcher 4 (2 m, 2 f)	Grey Fantail 6
Australian Magpie 2	Spotted Pardalote 8 (males calling for mates)
Grey Fantail 3	Yellow-faced Honeyeater 5
White-naped Honeyeater 13 (in flowering yellow box)	Superb Fairy-wren 8

Species and survey date – summer 2022 (6/1/22)	Species and survey date – winter 2022 (29/8/22)
Eastern Spinebill 6 (flowering mistletoe & yellow box)	Eastern Spinebill 9
Red Wattlebird 7	White-throated Treecreeper 3
Yellow-faced Honeyeater 2	Mistletoebird 1
Noisy Friarbird 3	Australian Wood Duck 2
Black-faced Cuckoo-shrike 1	Galah 2
White-throated Treecreeper 3	Little Eagle 1 (immature bird soared)
Rufous Whistler 4 (2 pairs)	Torresian Crow 4
Buff-rumped Thornbill 7	Grey Butcherbird 2
Striated Pardalote 3	Noisy Friarbird 2
Spotted Pardalote 2	Crimson Rosella 3
Willie Wagtail 6 (incl. 2 fledglings)	Rufous Whistler 4 (males calling for mates)
Olive-backed Oriole 2 (likely pair, mobbed by fantails)	Striated Thornbill 3
Dusky Woodswallow 4 (2 along Jacks Ck, 2 upper slope)	Brown Thornbill 2
Brown Thornbill 4	Yellow-rumped Thornbill 1
Crimson Rosella 12	Satin Flycatcher 1 (called, E side stringybarks)
Grey Shrike-thrush 2	Noisy Miner 8
Red-rumped Parrot 11	Willie Wagtail 1
White-throated Gerygone 3 (foraged in <i>E. radiata</i>)	Red-rumped Parrot 2 (flew over)
Noisy Miner 10 (mostly lower W slope to Jacks Ck)	Black-faced Cuckoo-shrike 2
Dollarbird 1 (in lower W slope peppermints)	Wedge-tailed Eagle 1 (flew over upslope)
Fuscous Honeyeater 6 (incl. young birds along Jacks Ck)	Fuscous Honeyeater 4
Pacific Black Duck 2 (flushed from pool in Jacks Ck)	White-naped Honeyeater 3
	Varied Sittella 4 (foraged <i>E. radiata</i> & stringybarks)
	Welcome Swallow 2
	Grey Shrike-thrush 1
	Scarlet Robin 2 (pair on fence upslope E side nr start)
	Golden Whistler 1
<i>Total birds 127. Total species 28</i>	<i>Total birds 119. Total species 33</i>

Table 17: ‘East Oaks’ – Proposed ‘Lower Hill Planting’ and ‘Lower Hill Enhancement’ (Site 16)

Species and survey date – summer 2022 (5/1/22)	Species and survey date – winter 2022 (30/8/22)
Rufous Whistler 2	Straw-necked Ibis 2 (flew over)
Crested Pigeon 4	Eastern Rosella 6
Common Starling* 4	Australian Magpie 4
Australian Raven 1	Striated Pardalote 4
Stubble Quail 3 (called & flushed from tall grasses)	Noisy Miner 5
Eastern Rosella 6	Australian Raven 2
Crimson Rosella 2	Sulphur-crested Cockatoo 1
Australian Magpie 4	Nankeen Kestrel 1 (likely nesting in BRG hollow)
Swamp Harrier 1	
Noisy Miner 4	
Red-rumped Parrot 4	
Dollarbird 2 (perched on stag nr hollow, likely nesting)	
<i>Total birds 37. Total species 12</i>	<i>Total birds 25. Total species 8</i>

Table 18: ‘Taylor’s Run’ – ‘Top Spring’ remnant woodland/forest and planted pines (Site 17)

Species and survey date – summer 2022 (5/1/22)	Species and survey date – winter 2022 (30/8/22)
White-throated Treecreeper 4	Brown Thornbill 4
Red Wattlebird 1	Yellow-rumped Thornbill 7
Rufous Whistler 4 (3 calling males)	Buff-rumped Thornbill 5
Satin Flycatcher 4 (3 males, 1 female, in tall pines)	Superb Fairy-wren 10
Buff-rumped Thornbill 8 (in pines & stringybarks)	Yellow-faced Honeyeater 13 (in flowering stringybarks)
Silvereye 4	Golden Whistler 4 (incl. 1 pair in N sector stringybarks)
Superb Fairy-wren 3 (sheltered in pines)	White-throated Treecreeper 2

Species and survey date – summer 2022 (5/1/22)	Species and survey date – winter 2022 (30/8/22)
White-browed Scrubwren 2 (pair sheltered)	Grey Fantail 4
Yellow Thornbill 10 (in pines & stringybark)	Pied Currawong 2
Yellow-tailed Black-Cockatoo 2	Grey Shrike-thrush 2
Eastern Rosella 1	Australian Raven 2
Brown Thornbill 4 (E side pines & stringybark)	Mistletoebird 1
Yellow-faced Honeyeater 2	Torresian Crow 4
Pied Currawong 1	Brown Goshawk 1 (perched nr previous nest)
Pied Butcherbird 1	Laughing Kookaburra 2 (nr E side poplars)
Grey Fantail 1	Red Wattlebird 1
Brown Goshawk 2 (nesting pr 30 m in mountain gum)	Yellow Thornbill 1 (flew from E to W stringybarks)
Dollarbird 1	Eastern Yellow Robin 2 (obs. in pines & mt gum)
Crimson Rosella 2	White-browed Scrubwren 2 (foraged in fallen stringy)
Spotted Pardalote 2	Striated Thornbill 6 (foraged W ridge stringybarks)
White-naped Honeyeater 2 (in flowering mistletoe)	
<i>Total birds 61. Total species 21</i>	<i>Total birds 49. Total species 21</i>

Table 19: ‘Taylor’s Run’ – ‘Wallaby Paddock’ remnant woodland/forest and planted pines (Site 18)

Species and survey date – summer 2022 (5/1/22)	Species and survey date – winter 2022 (30/8/22)
Rufous Whistler 2	Spotted Pardalote 1 (called)
White-browed Scrubwren 4 (2 adults, 2 juveniles – in upper slope’s thick and tall inkweed patch)	Brown Thornbill 9
Grey Fantail 4	Yellow Thornbill 1
Brown Gerygone 1	Torresian Crow 1
Silvereye 4	Pied Currawong 4
Grey Shrike-thrush 1	Grey Shrike-thrush 1
Dollarbird 1	Australian King-Parrot 2 (male and female)
Satin Flycatcher 2 (male and female)	Eastern Yellow Robin 1 (called, upper & lower slopes)
Australian King-Parrot 1	White-browed Scrubwren 2 (still good inkweed cover)
Yellow-faced Honeyeater 4	
White-throated Treecreeper 1	
Brown Thornbill 4	
Eastern Yellow Robin 2 (nr W end fence with pines)	
<i>Total birds 31. Total species 13</i>	<i>Total birds 22. Total species 9</i>

Table 20: ‘Taylor’s Run’ – ‘Corner Paddock’ remnant grassy woodland (Site 19)

Species and survey date – summer 2022 (4/1/22)	Species and survey date – winter 2022 (30/8/22)
Torresian Crow 2	Spotted Pardalote 1
Galah 2	Noisy Miner 8
Striated Pardalote 1 (nested in Blakely’s RG stag)	Australian Magpie 2
Eastern Rosella 16	Common Starling* 6
Grey Butcherbird 1	Eastern Rosella 14
Red-rumped Parrot 7	Crimson Rosella 2
Red Wattlebird 2	Pied Butcherbird 1
Noisy Miner 5 (incl. fledgling fed by adult in BRG)	Little Corella 8 (likely nesting in BRG hollows)
Sulphur-crested Cockatoo 2 (flew over)	Red-rumped Parrot 2
Crimson Rosella 1	Galah 5 (nesting in dead BRG)
<i>Total birds 39. Total species 10</i>	<i>Total birds 49. Total species 10</i>

Table 21: ‘Taylor’s Run’ – ‘Far Dip Paddock’ proposed woodland corridor planting (Site 20)

Species and survey date – summer 2022 (4/1/22)	Species and survey date – winter 2022 (30/8/22)
Torresian Crow 2	Australian Magpie 2
Australian Magpie 6	Galah 2 (site planted May-Sept 2021)

Species and survey date – summer 2022 (4/1/22)	Species and survey date – winter 2022 (30/8/22)
Mistletoebird 1 (flew over – site planted May-Sept 21)	
Sulphur-crested Cockatoo 2	
Australian White Ibis 2 (flew over)	
Galah 2 (flew over)	
Eastern Rosella 1 (flushed from ground-foraging)	
Red-rumped Parrot 12	
<i>Total birds 28. Total species 8</i>	<i>Total birds 4. Total species 2</i>

Table 22: ‘Woodstock’ – proposed wetland fencing and woodland strip planting at a dam (Site 21)

Species and survey date – summer 2022 (5/1/22)	Species and survey date – winter 2022 (29/8/22)
Australian White Ibis 1	Intermediate Egret 1
Australian Magpie 2	White-faced Heron 1
European Goldfinch* 3 (flew over)	Welcome Swallow 1
Willie Wagtail 1	Australian Wood Duck 6
White-faced Heron 2	Pacific Black Duck 3
Pacific Black Duck 2	Yellow Thornbill 4 (in planted strip W of dam)
Black-faced Cuckoo-shrike 1	Grey Fantail 1 (as above)
Common Starling* 2 (flew over)	Grey Shrike-thrush 1 (as above)
Australian Wood Duck 1 (flushed N end of wetland)	Red Wattlebird 1 (as above)
	Yellow-faced Honeyeater 2 (as above)
<i>Total birds 15. Total species 9</i>	<i>Total birds 21. Total species 10</i>

3.3 Birds of conservation significance and their habitats

A total of 28 bird species of conservation significance was recorded during the surveys. These included 6 species listed as Vulnerable under the NSW Biodiversity Conservation Act 2016 – Scarlet Robin, Speckled Warbler, Varied Sittella, Dusky Woodswallow, Little Eagle, and Blue-billed Duck. Diamond Firetail was not recorded in either survey.

Other conservation-significant species were the intercontinental migrant Latham’s Snipe which is listed under the Australian Environment Protection and Biodiversity Conservation Act 1999 and migratory bird protection agreements that Australia hold with Japan (JAMBA), China (CAMBA), and Republic of Korea (ROKAMBA). A further 21 species were of local conservation importance in the highly fragmented southern New England landscape. They included Eastern Yellow Robin, Double-barred Finch, White-browed Scrubwren, Eastern Yellow Robin and Satin Flycatcher which are members of a suite of declining woodland birds on New England Tableland (see Reid et al. 2006; InSight Ecology 2012a, 2018a, b, 2023a; Southern New England Landcare 2015), aquatic species such as Black-winged Stilt, Black Swan, Great Crested Grebe, Lewin’s Rail and Black-fronted Dotterel, and grassland/reedland specialists – Little Grassbird, Tawny Grassbird, Australian Reed-Warbler and Golden-headed Cisticola. Plates 1-25 depict some of these species including the habitats they utilised.



Plate 1: The threatened Varied Sittella *Daphoenositta chrysoptera*– main photo: foraging for insects in a decaying branch at Chiswick’s Stringybark Paddock remnant (12/6/19, InSight Ecology). Smaller image: drawing by Nicholas Day



Plates 2-3: Speckled Warbler *Chthonicola sagittata* – showing blackthorn and Cassinia thicket at Stringybark Paddock remnant on Chiswick – threatened in NSW. Photo: Iestyn Taylor & InSight Ecology (site photo)



Plate 4: Dusky Woodswallow *Artamus cyanopterus* – threatened in NSW. Photo: Greg Clancy



Plate 5: Little Eagle *Hieraetus morphnoides* - threatened (NSW). Photo: mountainsbeyond.org



Plate 6: Latham’s Snipe *Gallinago hardwickii*. Photo: Jason Girvan, en.wikipedia.org. See [Latham's Snipe Project \(swift.net.au\)](http://Latham's Snipe Project (swift.net.au))



Plate 7: Blue-billed Duck *Oxyura australis* - Threatened (NSW). Photo: Spikerccs, commons.wikimedia.org



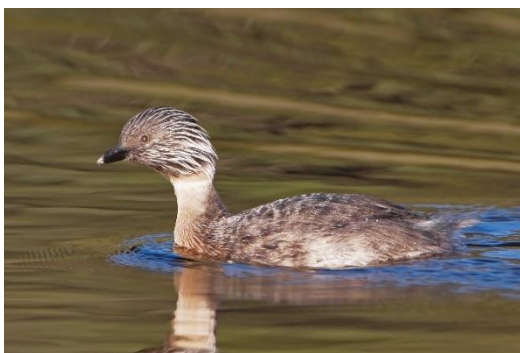
Plate 8: Stringybark and peppermint grassy woodland foraged in by Scarlet Robin *Petroica boodang* at Eastlake's Green Camp Peppermint Block. Photo: InSight Ecology, 29/8/22



Plate 9: Lewin's Rail *Lewinia pectoralis* recorded at Chiswick's Lambing Gully pools in winter 2022. Photo: birdsinbackyards.net (dmp)



Plate 10: Great Crested Grebe *Podiceps cristatus*. Foraged in small numbers after good rainfall in reeds and open water on Dangar's Lagoon NR. Photo: JJ Harrison, en.wikimedia.org



Plates 11-13: Hoary-headed Grebe *Poliiocephalus poliocephalus* (above), photo JJ Harrison, en.wikipedia.org –foraged in small flocks on Dangar's Lagoon NR (Jan. 2021). Black Swan foraged with Eurasian Coot and other aquatic birds and nested on Dangar's Lagoon NR after good rainfall (Jan. 2021). Swan photos at Dangar's Lagoon NR: InSight Ecology.

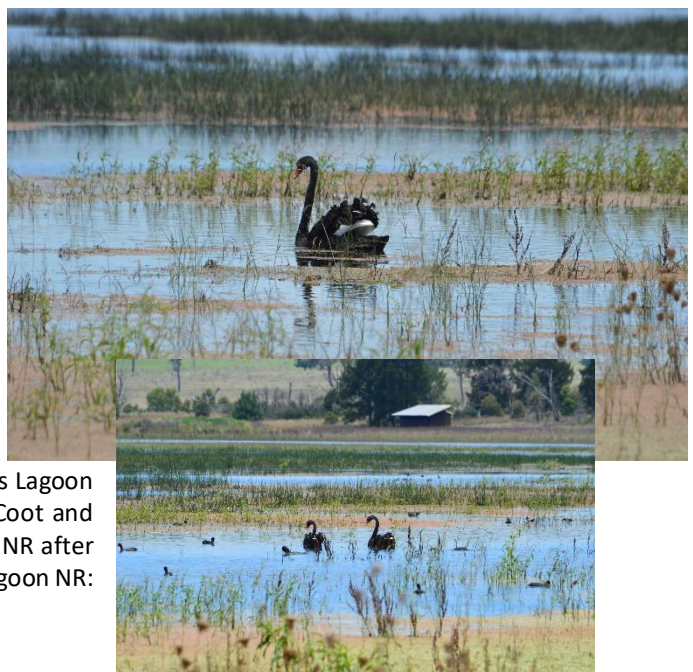




Plate 14: Australian Reed-Warbler *Acrocephalus australis* foraged and nested in rank Phragmites and other rushes along Salisbury Water. Photo: birdlife.org.au



Plate 15: Tawny Grassbird *Megalurus timoriensis* bred at Chiswick's Lambing Gully Photo: aviceda.org



Plate 16: Golden-headed Cisticola *Cisticola exilis* defended breeding territories at Chiswick's Lambing Gully. Photo: aviceda.org



Plate 17: Little Grassbird *Megalurus gramineus* foraged in fringing rushes and reedbeds at Dangar's & Racecourse Lagoons. Photo: scienceimage.csiro.au



Plate 18: Black-fronted Dotterel *Euseyornis melanops* foraged along muddy shorelines at Dangar's Lagoon & Woodstock dam in both winters. Photo: Steve Scalise



Plate 19: Black-winged Stilt *Himantopus himantopus* foraged for small invertebrates in the shallows of Dangar's Lagoon NR in January 2021. Photo: InSight Ecology



Plate 20: Purple Swamphen *Porphyrio porphyrio* foraged along muddy edges and in the shallows of Dangar's Lagoon, Racecourse Lagoon, 'Benambra' wet paddock and 'The Billabong' wetland. Photo: InSight Ecology



Plate 21: An adult male Brown Goshawk *Accipiter fasciatus* was recorded calling near a nest in 'Top Spring' remnant and old pines, 'Taylor's Run', January 2021. Photo: InSight Ecology



Plate 22: Adult male White-browed Scrubwren *Sericornis frontalis* foraged and nested in tall thistle, 'Wallaby Paddock' and 'Top Spring' at 'Taylor's Run', Mt Mutton Reserve, 'No Man's Land', 'Chiswick' And 'Spring Camp'. Photo: Iestyn Taylor



Plate 23: Eastern Yellow Robin *Eopsaltria australis* - recorded at 'Mihi Station', 'Taylor's Run' and 'Eastlake'. and 'No Man's Land'. Photo: Iestyn Taylor (Summer Hill)



Plate 24: Double-barred Finch *Taeniopygia bichenovii* was recorded at Mt Mutton Reserve in summer & winter 2022. Photo: Glen Fergus, commons.wikimedia.org



Plate 25: Dollarbird *Eurystomus orientalis* a summer migrant recorded at Taylor's Run, Eastlake, East Oaks, Spring Camp & Mt Mutton Res. Photo: Brad Spalding

4. Discussion

4.1 Patterns and processes in bird communities of the study area

4.1.1 Woodland avifauna

About 180 years of native vegetation removal on the New England Tableland has substantially reduced the diversity of woodland bird communities and confined remaining populations to small isolated patches of bush surrounded by cleared land. Often these patches have declined in condition under weed incursion and livestock and hare grazing pressure.

Despite five decades of Landcare on the tablelands, we are still losing iconic woodland bird species. Recent examples of this loss between Armidale and Kentucky are the Hooded Robin and Brown Treecreeper (Ford et al. 2009; InSight Ecology 2019). This suggests that the tablelands are indeed continuing to pay the extinction debt proposed by Ford et al. (2009) and Ford (2011). It also highlights a potential time lag effect in the development of planted habitat to reach the stage where they can be utilised by birds for food, breeding and refuge, particularly hollow-dependent species. As a guide, repeated surveys of 23 revegetated and remnant sites on CSIRO 'Chiswick' by InSight Ecology since 2018 have demonstrated that planted exotic and native trees and shrubs have taken about 25 years to provide suitable foraging and nesting habitat for woodland species such as the threatened Flame Robin (non-breeding) and Scarlet Robin, Striated Thornbill, Rufous Whistler, Grey Shrike-thrush, Grey Fantail and Yellow Thornbill.

Bird communities surveyed in the current study reflected these historical and ongoing patterns of habitat loss and condition decline. The larger remnants surveyed in the study – Mihi Station's Lower Ram Paddock and Trig Reserve (2 threatened species – a high quality remnant), Eastlake's Green Camp Peppermint Block (3 threatened species – also a high quality remnant), Mt Mutton Reserve (4 species of local conservation significance), Top Spring Paddock (Taylor's Run), Spring Camp (2 threatened species), and Chiswick's Stringybark Paddock (2 threatened species) – supported some of the core group of woodland birds described in previous studies and surveys (see Reid 2006; Ford et al. 2009; Ford 2011; InSight Ecology 2018a, b, 2019, 2023a). These are species requiring canopy cover, foliage, bark, shrub and leaf litter food resources (invertebrates),

nest sites, and vegetated linkages with other remnants within a 200 m – 1 km radius. They included Eastern Yellow Robin, Scarlet Robin, Varied Sittella, Dusky Woodswallow, White-browed Scrubwren, Double-barred Finch, Satin Flycatcher, Buff-rumped Thornbill, and Fuscous Honeyeater.

Not detected in the summer and winter 2022 surveys was the threatened Diamond Firetail *Stagonopleura guttata*. This species forages for seasonally available grass seeds often along paddock and remnant edges and road verges. It has been previously recorded at 'Mihi Station' in the Thunderbolt Project's winter 2020 survey (InSight Ecology 2023a), 'Summer Hill' remnant (Uralla) and 'Eastlake' (InSight Ecology 2012a, 2018b, 2019).

In contrast, smaller remnants and planted strips supported a depauperate range of woodland bird species, relative to the larger and better-connected remnants. Small remnants surveyed at Taylor's Run (Corner Paddock), 'East Oaks' and 'Salisbury Court' (rock quarry site) typically supported 7-13 species such as Eastern Rosella, Noisy Miner, Galah, Australian Magpie, Torresian Crow, and Superb Fairy-wren. These are common species able to forage and in some cases nest in more disturbed sites where canopies have been generally reduced to under 25% projective foliage cover, weedy grasses and forbs dominate the ground layer, and alternative habitat such as blackberry and hawthorn thickets occur.

Six woodland bird species of conservation significance were detected breeding, mostly in the summer 2022 survey. These included Dusky Woodswallow (at Chiswick's Stringybark Paddock and Mihi Station remnants), Scarlet Robin ('Eastlake' Green Camp), Eastern Yellow Robin (Wallaby Paddock at 'Taylor's Run'), White-browed Scrubwren (Mt Mutton Reserve, No Man's Land, 'Spring Camp' and Wallaby Paddock), Buff-rumped Thornbill ('No Man's Land' remnant), and Satin Flycatcher (Wallaby Paddock). Twenty-one (21) relatively common woodland bird species were also recorded breeding, again mainly during the summer 2022 survey.

4.1.2 Wetland avifauna

Wetland bird communities surveyed in the study area were relatively species-rich, reflecting significant rainfall received during spring and summer 2021. Dangar's Lagoon was at 80% capacity in the summer survey and 100% in winter 2022. Racecourse Lagoon was 60% full in summer and 80% full in winter 2022. 'The Billabong' wetland at 'Salisbury Court' was at 80% capacity in both summer and winter 2022. This supported lush aquatic vegetation and fringing reed, rush and grass growth. This habitat provided suitable conditions for nesting by the threatened Blue-billed Duck, Black Swan, Hoary-headed Grebe, Australasian Grebe, Australasian Shoveler, and Tawny Grassbird at 'Benambra' wetland site.

As the water level rose at Dangar's Lagoon, remaining Black Swan nests were inundated and thus deserted. However, high water levels provided protection from European Red Fox and helped trigger breeding by the threatened Blue-billed Duck as well as Australasian Shoveler, Hoary-headed Grebe, Australasian Grebe and Eurasian Coot at Dangar's Lagoon. Racecourse Lagoon supported small breeding populations in summer of Black Swan (2 nests and 6 fledglings), Eurasian Coot, Pacific Black Duck and Australasian Grebe. 'The Billabong' also supported summer breeding populations of Eurasian Coot, Australasian Grebe and Pacific Black Duck as well as two pairs of Blue-billed Duck. However, these populations were markedly smaller in size than those recorded at these three wetlands in the summer 2021 survey.

Other changes that were evident between the two surveyed summers (2021 and 2022) were the absence of Pink-eared Duck, Plumed Whistling-Duck and Hardhead and much lower numbers of Black-winged Stilt and Black Swan in summer 2022. This was because other inland freshwater wetlands, recharged by substantial rainfall that occurred between Surveys 2 (January 2021) and 3 (January 2022), supplied adequate foraging and breeding resources for these highly mobile species. Therefore, their reliance on Dangar’s and Racecourse Lagoons was not as strong as during the preceding year (2020) of drought conditions, particularly in inland NSW and Queensland.

Tall rushland, reedbeds, and dense grassy swards adjoining wetlands provided food, shelter and nest sites for summer breeding migrants, Australian Reed-Warbler, Rufous Songlark and Tawny Grassbird and the residents/nomads, Golden-headed Cisticola and Little Grassbird. The latter species was not recorded in Thunderbolt Project surveys 1 and 2. Sites utilised for breeding by Tawny Grassbird included Salisbury Court’s rock quarry and ‘The Billabong’, Chiswick’s Lambing Gully, Racecourse Lagoon, and Benambra’s wetland paddock. Little Grassland was likely nesting at Racecourse Lagoon and in thick fringing reedbeds around Dangar’s Lagoon. Golden-headed Cisticola bred in Lambing Gully’s thick grassland. The intercontinental migratory wader, Latham’s Snipe (5 birds), was recorded foraging along a muddy shoreline with reeds at Racecourse Lagoon in summer 2022.

4.2 Changes in surveyed bird communities between 2020 and 2022

There were some inter-annual and inter-seasonal differences in the relative abundance and species composition of woodland and wetland bird communities surveyed in the study area. These related to variation in the total number of birds and species composition of bird communities recorded over the project’s 2020-22 survey period (Table 23).

Moderate increases occurred in the number of woodland and wetland birds recorded in summer relative to winter. This was particularly noticeable in summer 2021, following good spring-early summer rainfall in 2020.

The total number of bird species recorded was substantially higher in 2022 than in 2020-21. This was largely attributable to woodland birds - 67 species in summer and 56 species in winter. The number of woodland bird families was also greater in summer 2022 (34) than in summer 2021 (20). Wetland bird families, in contrast, increased only moderately between these periods (16 in summer 2021, 22 in summer 2022).

Survey period	Number of individual birds			Number of bird species			Number of bird families		
	WOOD	WET	Total	WOOD	WET	Total	WOOD	WET	Total
Winter 2020	734	489	1,223	30	22	82	19	13	45
Summer 2021	841	702	1,543	37	30		20	16	
Summer 2022	736	420	1,156	67	33	98	34	22	44
Winter 2022	716	510	1,226	56	28		25	18	
Study total	3,027	2,121	5,148	73	51	104	36	25	47

Table 23: Changes in the relative abundance (number of birds), species richness (number of bird species), and taxonomic diversity (number of bird families) of woodland (WOOD) and wetland (WET) birds recorded over four Thunderbolt Project Avifaunal Survey Report 2: 2022 – InSight Ecology – September 2023

seasons and two equivalent years in the Thunderbolt Project. The total numbers of bird species and families for all 4 survey periods is not additive because some species (and their families) were recorded in more than one survey period at woodland and wetland sites.

A strong driver of these changes related to seasonal variation in rainfall and an associated increase or decrease in food availability, availability of mates, and suitable nest and refuge sites. Birds tracking the availability of these resources particularly in woodland sites in the summer surveys included nomadic species such as Spotted Pardalote, Fuscous Honeyeater and Silvereye. Summer breeding migrants including Satin Flycatcher, Scarlet Honeyeater, Horsfield's Bronze-Cuckoo, Shining Bronze-Cuckoo, Dusky Woodswallow, White-throated Gerygone, and Dollarbird contributed to the higher number of species recorded in woodland sites, particularly in summer 2022 than winter 2022. The summer 2022 influx of woodland bird species was in part due to substantial rainfall received in the study area (and regionally) in the preceding winter and spring.

The woodland/forest sites that supported many of the resident and migratory/nomadic bird species recorded during the project were, expectedly, the higher quality, larger and often more contiguous patches. These were, in order of the number of woodland/forest bird species recorded over the study, Mihi Station', 'Spring Camp', CSIRO 'Chiswick' – 'Stringybark Paddock', 'Eastlake Green Camp Peppermint Block', and Mt Mutton Reserve. Most of these sites occur in relatively close proximity to larger continuous tracts of woodland/forest along the eastern ('Spring Camp', 'Mihi Station', 'Eastlake') and western (Mt Mutton Reserve) edges of the southern New England tableland (see Figure 1). This means that a fuller complement of core woodland/forest bird species could forage and breed in these remnants.

The exception was Chiswick's 'Stringybark Paddock', an isolated 9 ha stringybark forest patch on a small hilltop about 1.5 km north-east of another stringybark forest patch at 'Kelvin Grove' and about 3.5 km east/north-east of patches of remnant woodland/forest near Uralla and Rocky River (Figure 1). Some woodland bird species recorded at 'Stringybark Paddock' such as Yellow-faced Honeyeater, Spotted Pardalote, Varied Sittella and White-throated Treecreeper could be expected to commute between these remnant patches in the local landscape. Others, however, such as Brown Thornbill, White-browed Scrubwren, and Superb Fairy-wren, are likely to be confined to 'Stringybark Paddock' remnant in which they were recorded breeding during the study. This heightens the importance of protecting and enhancing existing Australian Blackthorn and Dead Finish shrub habitat for these species including excluding sheep to allow adequate site regeneration (see Section 5).

Two sites on 'Taylor's Run' – 'Wallaby Paddock' and 'Top Spring' containing a mix of old planted pines and remnant New England Stringybark, Blakely's Red Gum, and Ribbon Gum supported smaller samples of woodland bird communities. Importantly, they provided habitat for breeding pairs of Eastern Yellow Robin, White-browed Scrubwren (in tall inkweed patches in late winter/early summer), Rufous Whistler, Yellow-faced Honeyeater, Superb Fairy-wren, and Brown Goshawk (at 'Top Spring').

Wetland bird communities surveyed during the project generally displayed less variability in terms of the relative abundance of birds than woodland sites. This was because the two wetlands that contained standing bodies of water throughout the project – Dangar's Lagoon and 'The Billabong' at 'Salisbury Court' - supported a core group of residents (ducks, swans, coot, swamphen, moorhen, grassbirds and cisticola) that maintained similar population levels across all seasons. The exception was summer 2021 when more birds (702) were recorded following good rainfall in the preceding spring. Racecourse Lagoon when near-capacity in winter 2022

provided additional open water and fringing reedbeds and wet grassland habitats for a similar but smaller complement of aquatic bird species to those recorded at nearby Dangar's Lagoon.

No changes occurred in the amount of bird habitat that was lost or degraded due to land clearing, wetland drainage or heavy livestock grazing at any of the surveyed sites during the study.

4.3 Targeting functional habitat

Re-connecting native fauna and flora isolated by habitat loss, fragmentation, and degradation is a key goal of biodiversity conservation programs worldwide (see IUCN 2007; Mackey et al. 2010; Saura et al. 2014; Correa Ayram et al. 2016). In highly fragmented landscapes such as New England Tableland and in the face of the current woodland bird crisis (Bennett and Watson 2011; Ford 2011), effective restoration action is urgently needed. This work must target specific parts of landscapes where key taxa still occur and beneficial outcomes for their conservation are achievable – areas where new habitat for threatened and declining species can be successfully established and remnant habitat better protected and enhanced.

The emphasis in these areas needs to be on providing **functional** habitat for species still present and those that could be reasonably expected to return over time in response to these interventions. Functional habitat is habitat of sufficient size, structure and condition to allow target taxa – woodland birds in this project – to survive, successfully reproduce and disperse.

The site-specific knowledge needed to inform this work was the focus of the surveying component of this project - determining what woodland and wetland bird species still persist, where they occur and their habitat restoration requirements in the connectivity gap zone. The four Thunderbolt Project bird surveys determined the composition and abundance of bird communities present at 21 sites in this zone and their use of remnant woodland/forest and wetland habitats. This has built on the survey results of the adjoining Closing The Gap Project and contributed important baseline data for this section of the southern New England region. Baseline data are essential for monitoring of bird responses to restoration actions including remnant protection and enhancement and strategic revegetation over time.

5 Recommendations

The key objective of the Thunderbolt Project is to plant new habitat to re-connect fragmented woodland and forest for threatened fauna and flora in the gap zone. A related goal is to improve habitat condition for a suite of threatened fauna and flora species. Actions to achieve these goals are recommended below, together with priorities for their implementation. While the focus is primarily on birds, other threatened native species such as Koala, Spotted-tailed Quoll, Bell's Turtle, Bluegrass, and Narrow-leaved Black Peppermint, as well as a range of other flora and fauna species should also benefit from this work.

5.1 Complete the current program of project works on each property (Priority 1)

This work should align with the Landholder Management Agreement that SNEL holds with each participating property owner in the project. Key components and relevant project sites include:

- **Strategic revegetation** to increase habitat area and improve local connectivity, targeting:
 - 'Big Ridge' (Sites 3 and 4), noting planting of these sites has been completed.
 - 'Benambra' wetland paddock using suitable native wetland plant species (planting yet to commence). Suggest consulting Armidale Tree Group or Kentucky Tree Nursery.

- ‘Salisbury Court’ rock quarry woodland restoration – check current status of planting and fencing.
- ‘East Oaks’ Lower Hill planting and Lower Hill enhancement - check current planting and fencing status.
- ‘Taylor’s Run’ ‘Far Dip Paddock’ planting – planting and fencing completed in 2022.
- ‘Woodstock’ dam planting to connect with an existing planted strip and enhance wetland function. Suggest contacting Armidale Tree Group for suitable species. Check current planting and fencing status.
- **Protection and enhancement of remnant woodland/forest:**
 - Exclude sheep from Chiswick’s ‘Stringybark Paddock’ remnant (eastern and western knoll sections) by installing appropriate fencing (must be rabbit-proof). This will protect existing Australian Blackthorn (*Bursaria spinosa*), Dead Finish (*Cassinia quinquefaria*) and other shrubs present as well as eucalypt and other native flora regrowth so as to conserve and improve woodland bird habitat. As a priority, fence out the western knoll that contains the blackthorn and dead finish patch. This is where InSight Ecology recorded a female Speckled Warbler (threatened in NSW) in a separate survey of ‘Chiswick’ on 12 June 2019. Allow inter-paddock fenced stock access through the gully forming the central part of the patch (ie. between the eastern and western knolls) which is cleared;
 - Replace old fencing around the high quality No Man’s Land remnant with new rabbit-proof fencing and gates. This could be outside the current project’s scope but should be pursued with the owners of ‘Gostwyck’ and ‘Big Ridge’ as a high priority given the high quality of this important remnant and its avifauna and plants.
 - Fence (rabbit-proof if possible) off the upper section of Lower Ram Paddock adjoining Trig Reserve at ‘Mihi Station’ to protect naturally regenerating Blakely’s Red Gum, White Box and Yellow Box endangered ecological community from livestock grazing. This site supported more threatened woodland bird species than any other site in the study and its habitat condition was generally high.
 - Protect and enhance remnant Blakely’s Red Gum regrowth at ‘East Oaks’ from damage by livestock – fence out livestock from the area of naturally regenerating Blakely’s Red Gum; in other parts of the site, continue managing grazing with a focus on long spelling to allow native grass recovery and light, short-period stocking, if required.
 - Continue protecting peppermint regrowth, trees, forbs and shrubs including planted acacias from livestock grazing at Eastlake’s Green Camp Peppermint Block and maintain fencing.
 - Limit sheep grazing in ‘Top Spring’ remnant and planted pines at ‘Taylor’s Run’ to encourage regeneration of the currently sparse shrub and ground cover layers. Retain storm-blown tree branches and trunks within the site to provide microhabitat for ground foraging birds such as White-browed Scrubwren and Superb Fairy-wren and reptiles.
 - Consider planting native shrubs such as Australian Blackthorn *Bursaria spinosa* and Dead Finish *Cassinia quinquefaria* and ground covers to provide cover and foraging and breeding habitat for White-browed Scrubwren, Brown Thornbill, and Superb Fairy-wren in Wallaby Paddock remnant at ‘Taylor’s Run’.
 - Undertake best-practice weed and feral animal management programs on most of the properties surveyed. Immediate action is needed at Chiswick’s Stringybark Paddock remnant, ‘Top Spring’, ‘Wallaby Paddock’ (staged removal of stinging nettles and inkweed and replacement with *Bursaria spinosa* and *Cassinia quinquefaria*), and Corner Paddock remnants at Taylor’s Run, Mt Mutton Reserve (staged removal of cotoneaster

and other woody weeds, followed by replacement with *B. spinosa* and *C. quinquefaria* for small bird cover and nest sites), and the rock quarry site at 'Salisbury Court' (removal of rank exotic grasses and removal of hawthorn, replacement with *B. spinosa* and *C. quinquefaria*).

- **Protection of freshwater wetlands:**

- Replace old fencing with new rabbit-proof fencing and gates at Chiswick's Lambing Gully to prevent livestock entering the wetland. Ensure maintenance of these fences.
- Encourage either fencing or limiting/reducing stock access to Salisbury Court's 'The Billabong' wetland.
- Work with Uralla Shire Council to revegetate the dryland northern fringe of Racecourse Lagoon Reserve as a buffer to the wetland itself and to link with older existing plantings along the site's north-western and western borders.
- Continue liaison with NPWS and LLS to protect and, where necessary, revegetate Dangar's Lagoon and its margins. Access to the lagoon itself should continue to be prevented, except for scientific studies and surveys. A new or renovated bird hide is needed at the lagoon's southern end.
- Limit livestock access to 'Woodstock' dam to protect its muddy banks as foraging substrate for Black-fronted Dotterel and other birds. Install logs as perches for cormorants and ducks and plant native reeds and rushes for cover along the dam's northern, eastern and western margins. This would enhance the value of the site for other aquatic species such as Purple Swamphen, Black-winged Stilt, Latham's Snipe, Eurasian Coot and egrets. Advice from Armidale Tree Group and/or Kentucky Tree Nursery would assist in the selection of appropriate native wetland plant species and their planting and maintenance.
- Exclude current livestock access to the wetland paddock site at 'Benambra'. This is needed as a high priority to help reedbeds and *Phragmites australis* patches recover from past livestock trampling. Some sections will need to be revegetated (see above). Maintain existing fencing as required – there may be a need to install rabbit-proof fencing at the wetland revegetation locations.

5.2 Record progress toward achieving project goals (Priority 1)

Implement photo points and establish a simple project database to ensure accurate and timely recording and measuring of project progress over time. With some training, this work could be undertaken by landholders participating in the project and should include observations of bird and other fauna species utilising project sites.

This information would be helpful in reporting the project's achievements against specific goals to the funding body – NSW Environmental Trust. It would also add to the knowledge gained and lessons learnt from other similar projects completed by SNEL and their project partners such as *Closing The Gap Project: Functional Habitat for Threatened New England Fauna* (2016-19) and *Moths, Magpies and Marsupials: Promoting On-farm Biodiversity* (2014-15).

5.3 Run on-farm education and information events (Priority 2)

These events could be run as education and knowledge-sharing workshops/field days by SNEL on selected properties participating in the project. They should aim to help educate local landholders and communities about the presence and conservation requirements of threatened

and declining woodland and wetland birds, their habitat types, strategic revegetation and restoration actions, and on-farm monitoring and data recording over time (see also Section 5.2).

A further benefit of these events would be the communication and sharing of knowledge between other habitat connectivity and biodiversity-focused restoration projects completed or in-progress in other parts of the Northern Tablelands, North West Slopes and North Coast regions. The value-adding potential of these events to conservation and sustainable farm management projects and on-ground restoration actions across these regions would be considerable.

5.4 Identify and secure significant ongoing project funding (Priority 2)

Work with project partners and local communities to identify and secure significant and appropriate ongoing project funding. This would allow progress made and knowledge gained by habitat connectivity and biodiversity monitoring-focused projects such as the Thunderbolt Project and Closing The Gap Project to be used in other parts of the southern New England landscape. One area that could benefit would be the Walcha and Guyra districts where significant habitat and landscape connectivity gaps occur.

Additional funding would also allow for the maintenance of revegetation and remnant enhancement programs commenced under the Thunderbolt Project and Closing The Gap Project. This would demonstrate to funding bodies such as NSW Environmental Trust the ongoing commitment of SNEL and project partners in working to address key ongoing ecological challenges such as increasing habitat connectivity and the woodland bird crisis on the tablelands.

Applications for funding from the NSW Environmental Trust should preferably target periods of 3-4 years with project-specific budgets of at least \$170,000. This would allow for more realistic resourcing of projects that could potentially achieve better on-ground results in key target areas.

5.5 Monitor and report on bird communities at project sites over time (Priority 1)

Repeat bird surveys at the same sites using the same methods during the same seasons as those undertaken for this project at 3–5-year intervals. This is essential to be able to assess the performance over time of revegetation and remnants in providing functional (especially breeding) habitat for threatened and declining bird species. Data collected should be stored in a central project database that can be readily accessed for project review, management, and on-ground application purposes by SNEL and project partners. These data should also be made available to each participating landholder holding a Thunderbolt Project and Closing The Gap Project Landholder Management Agreement with SNEL.

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