Corella, 2025, 49: S1-S10

BANDING PROJECT REPORT No. 11

Bournda, New South Wales

(Supplementary Data)

Aim: Avian research at Bournda commenced in May 2005 and was initiated when a local landholder raised concerns about Bell Miner associated dieback (BMAD) impacting his property and adjacent areas. This research was part of a broader study seeking to gain a better understanding of BMAD through the active management and removal of Bell Miners *Manorina melanophrys* and to identify if it resulted in: (a) reduced effects of BMAD, (b) changes to the populations of other local forest bird species and (c) recovery of the vegetation communities. Comparisons were made between treatment sites (Bell Miner removal) and nil treatment sites (monitoring only).

The importance of conducting the Bournda study is highlighted given

- BMAD is listed as a key threatened process under the Biodiversity Conservation Act 2016 (New South Wales) and is known to impact threatened vegetation communities and threatened fauna species.
- The study site at Bournda includes two Plant Community Types (PCT 3272 and 3185) that form part of the endangered ecological community 'River-flat eucalypt forest on coastal floodplains of NSW North Coast, Sydney Basin and South East Corner bioregions' (Department of Planning and Environment 2022).

Location: 'Bournda', 36º 50′ 31.47″ S; 149º 54′ 42.71″ E., elevation between 30 and 150 m asl, is the collective name attributed to three BMAD study sites described below. The study sites encompassed the *Mandeni* and *Manna Park* properties, both owned at the time by Rob High. *Mandeni* (Lot 471 and Lot 472 DP1043030) is located 4.9 km north of Merimbula NSW, along Sapphire Coast Drive. *Manna Park* (Lot 1 DP859074) is adjacent to *Mandeni*, located 5.9 km north of Merimbula, north-west of Red Hill Road, off Sapphire Coast Drive. The project was expanded in 2010 to include the nearby *Tura Beach Flora Reserve* (Lot 1195 DP 255196), located 2.5 km north of Merimbula, bounded by High Crescent and Nolan Drive (Fig. 1).

Description: *Mandeni* is adjacent to Sapphire Coast Drive and covers an area of 218 ha. (Fig. 2) The site is partially developed including resort accommodation, bike tracks, golf course and driving range, with several large dams. Grazing of livestock occurred until recently (2020) across two large cleared paddocks in the northern part of the property. Much of the native vegetation has been retained, interspersed between these facilities, but also includes large tracts of generally undisturbed vegetation. The site is undulating but generally flat overall.

The drier forest community occurring on the more elevated parts of *Mandeni* is typical of the South Coast Lowland Blackbutt Forest (Plant Community Type (PCT) 3662). This community

Figure 1. *Bournda Study site showing Mandeni (outlined in white), Manna Park (outlined in yellow) and Tura Brach Flora Reserve (outlined in orange) boundaries.*

Figure 2. *Mist net placement at Mandeni with X indicating location of banding stations.*

Figure 3. *Mist net placement at Manna Park with X indicating location of banding stations.*

consist of Red Bloodwood *Corymbia gummifera*, Blackbutt *Eucalyptus pilularis*, Silvertop Ash *E. sieberi*, White Stringybark *E. globoidea*, with an understorey of Black She-oak *Allocasuarina littoralis* and Saw Banksia *Banksia serrata*. The shrub layer is typically diverse with a Bracken *Pteridium esculentum* or sedge-dominated groundcover, dictated by the fire history from place to place (Local Environmental Solutions 2022).

The Far South Lowland Creekflat Forest (PCT 3184) is found in areas of higher soil moisture levels across the South Coast Lowland Blackbutt Forest, typically in small patches on upper drainage lines within *Mandeni*. These areas are dominated by Red Bloodwood with a sparse shrublayer and the groundlayer dominated by the fern *Calochlaena dubia* and Gristle Fern *Blechnum cartilagineum* (Local Environmental Solutions 2022).

The low-lying areas of *Mandeni* consist of South Coast Lowland Creekflat Forest (PCT 3272) dominated by Woollybutt *E. longifolia*, Rough-barked Apple *Angophora floribunda* and Monkey Gum *E. cypellocarpa* with occasional Coast Grey Box *E. bosistoana* and Swamp Gum *E. ovata*. The understorey varies considerably from patches of dense Swamp Paperbark *Melaleuca ericifolia* through to a more open and fern or sedge dominated patches. Small patches are developing the beginnings of a rainforest understorey characterised by Muttonwood *Myrsine howittiana*, Common Silkpod *Parsonsia straminea* and Jasmine Morinda *Gynochthodes jasminoides* (Local Environmental Solutions 2022).

The unnamed tributaries of Sandy Beach Creek to the north are characterised by narrow belts of Far South River-flat Wet Forest (PCT 3185), which includes River Peppermint *E. elata*, Rough-barked Apple, occasional Ribbon Gum *E. viminalis* and Black Wattle *Acacia mearnsii*. Along the edges of cleared land, most of the understorey species are absent due to past grazing pressure. Here the vegetation consists largely of remnant or regrowth eucalypts, dense stands of Black Wattle and a low diversity groundcover of native grasses (Local Environmental Solutions 2022).

Past vegetation management of *Mandeni* has included hazard reduction burning every one to three years, which is reflected in the variation of the composition of the understory. The most recently burnt area is in the eastern portion of *Mandeni* below the bend in Sapphire Coast Drive (Local Environmental Solutions 2022).

Manna Park (Fig. 3) is adjacent to *Mandeni*, on the western side of Red Hill Road, and covers an area of 63 ha. *Manna Park* adjoins other private properties to the north but is bounded by Bournda Nature Reserve to the west and south. This site consists of mostly intact native forest with a single large clearing and associated buildings. The site is undulating with steeper hills in the north leading into the adjacent nature reserve and tends towards creek flats to the east. Vegetation across *Manna Park* includes areas of South Coast Lowland Creekflat Forest, Far South River-flat Wet Forest and Far South Lowland Creekflat Forest (Local Environmental Solutions 2022).

Mandeni and *Manna Park* both adjoin Bournda Nature Reserve to the west and south. There is extensive private timbered land adjoining both properties to the east and north.

The soil landscape for both sites was described by Tulau (1997) as Tertiary sediments (‘Pambula soil landscape’), with the possibility of more recently deposited Quaternary sediments along the tributary of Sandy Beach Creek to the north. Soils in the lower parts of the two sites appear to be quite clayey and poorly drained. The elevated area in the south-east corner (*Mandeni*) has very sandy soil, while the lower ridges are intermediate between the two.

Both sites were cleared and farmed for maize between 1890 and 1910. At *Mandeni*, these areas have been grazed continuously for the last 90 years until some areas of grazing lands were converted to recreational facilities. At *Manna Park*, cleared areas were allowed to regenerate back to the original bushland (R. High *in litt.*). Timber harvesting historically occurred across both sites, primarily targeting eucalyptus for railway sleepers, but there have been no logging activities in the last 20 years. Although *Mandeni* has more vegetation disturbance compared with *Manna Park*, fauna surveys undertaken concurrently with this project (J. Shields, unpublished) showed that both sites have retained a high level of biodiversity. Several tracks for walking and mountain biking have been constructed across both sites.

Figure 4. *Mist net placement at Tura Beach Flora Reserve with X indicating location of banding stations.*

Tura Beach Flora Reserve, 4.5 ha, is located within the suburban area of Tura Beach and is encompassed by High Crescent on the north, west and southern sides and Nolan Drive to the east (Fig 4.). Surrounding land consists primarily of large residential blocks, with an area of undeveloped bushland ~150 m to the west and south. The Reserve consists of South Coast Lowland Blackbutt Forest, with a mixed sub-canopy of casuarinas, banksias and acacias. Several walking tracks are maintained across the site (TBFRC 2011, Local Environmental Solutions 2022).

Status of Site: At the time of this project, both *Mandeni* and *Manna Park* were privately owned. *Mandeni* was operated as a holiday destination and resort while *Manna Park* provided group accommodation in a bushland setting. Since this project ended, the commercial operations of *Mandeni* have ceased pending redevelopment, while *Manna Park* was gifted by the previous owner (now deceased) to the Anglican Diocese of Canberra and Goulburn and has continued to be operated as a hostel offering group accommodation.

Tura Beach Flora Reserve was gazetted by Bega Valley Shire Council as a flora reserve in 1992. The site is managed for passive recreation and protects a small remnant of coastal vegetation within the developing suburb of Tura Beach (BVSC 2024).

Previous Ornithological Records: Few ornithological records exist for the three sites prior to this study. Data collected from this project was also used for teaching students enrolled in the Master of Wildlife Management (Habitat) at Macquarie University.

Duration of Project: May 2005 – December 2013. Banding was carried out every two months for the first two years and then within spring and autumn each year thereafter, with at least one banding session held in September each year. No banding sessions were undertaken in 2012.

Meteorological Data: Temperature and rainfall data for the period of banding study has been taken from the automated Bureau of Meteorology Weather Site (No. 069147) located at Merimbula Airport (BOM 2024a).

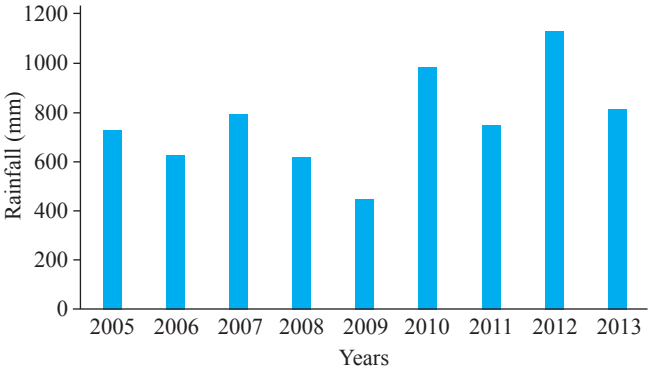

Figure 5. *Annual rainfall totals (mm) recorded from 2005 to 2013 at Merimbula Airport weather site.*

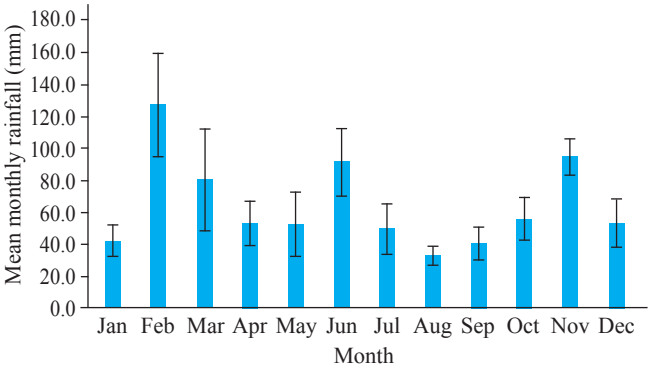

Figure 6. *Mean monthly rainfall (± standard error) for the period 2005 to 2013.*

Mean temperatures ranged from 15.5ºC to 24.8ºC in January through to 4.2ºC to 16.7ºC in July. The mean yearly rainfall over the 8-year study period was 765 mm (Fig. 5). Average rainfall for the years 1970-2013 was slightly higher than this mean with 797 mm. The study area experienced seasonal variation in monthly rainfall (Fig. 6) with the first half of the study period (2005-2009) coinciding with the Millenium drought, which was characterised by long periods without major rainfall events (BOM 2024b). This is reflected in the rainfall totals with 2009 the driest year during the study period, receiving only 56% of the annual mean.

Bell Miner Management: Following initial baseline data collection during 2005, management and removal of Bell Miners was undertaken across the *Mandeni* site under a licence issued by the NSW National Parks and Wildlife Service (NPWS). After baseline data collection in 2005, any Bell Miners captured in mist nets across the *Mandeni* site were not banded but humanely culled from the population, limited to 1500 birds annually for 2005 and 2006 only. The *Manna Park* and *Tura Beach Flora Reserve* sites were retained as nil treatment areas for comparison, and any Bell Miners captured were banded and released at the site of capture.

Assessment of Vegetation: The assessment of any recovery of the vegetation communities across the *Mandeni* site was undertaken as part of a broader study conducted by other researchers separately (J. Shields, J. Dare and T. Hastings), with their results published elsewhere.

Table 1

Banding effort at Bournda from 2005 to 2013. Banding sessions in 2005 and 2006 include the capture effort of Bell Miners removed under license issued by NPWS

Year	No. of banding sessions	Average no. of nets (range)	Average total length of nets erected (range)	Average hrs nets open (range)
2005	10	3.5 (1-9)	42m (12-108m)	4.6 (1.5 – 9.5)
2006	11	3.5 (3-6)	42m (36-72m)	2.4 (1.5 – 4.0)
2007	2	9.0 (3-15)	108m (36-180m)	3.4 (1.5 – 4.0)
2008	2	7.0 (3-11)	84m (36-132m)	3.6 (2.0 – 6.0)
2009	2	8.0 (6-10)	96m (72-120)	3.4 (1.5 – 6.0)
2010	2	7.5 (7-8)	90m (84-96m)	3.3 (1.5 – 4.5)
2011	6	5.3 (3-12)	63.6m (36- 144m)	4.3 (1.5 – 6.0)
2013	4	4.5 (3-6)	54m (36-72m)	4.7 (1.5 – 6.0)

METHODS

Birds were captured in mist nets carefully placed to minimise habitat disturbance. Banding was carried out every two months for the first two years and then within spring and autumn each year thereafter, with at least one banding session held in September each year. No banding sessions were undertaken in 2012. A total of 39 banding sessions was conducted between 2005 and 2013 (Table 1). The number of banding days for each session ranged from between one and ten days (mean 3.075). Nets were 12 m in length, mesh size 32 mm and the number of nets set depended on location but varied between one and 15 for each session, giving a total average length of 72.5 m (range 12-180 m). Nets were open from 30 minutes before sunrise for an average of 3.7 hours (range 1.5 to 9.5 hours).

Across *Mandeni*, netting targeted areas with large concentrations of Bell Miners around the property. As the Bell Miner populations contracted following culling, netting targeted the remaining core population, with additional follow-up netting at other key sites. Note that in 2006 the focus of mist netting was on Bell Miner removal and few other species were banded at this site during this year. At *Manna Park*, netting was undertaken around the hostel, community vegetable garden and trails across the property. At *Tura Beach Flora Reserve*, netting was undertaken within set net lanes off available access trails.

Wherever possible, the same netting positions were used for each subsequent session although targeted areas were shifted in response to property management as required and to specifically target Bell Miner populations. The capture sites for all individual birds were recorded on banding data sheets. Additionally, the number of Bell Miners removed from *Mandeni* were recorded on license return data sheets, required as part of reporting requirements to NPWS. Banded birds were individually marked using bands supplied by the Australian Bird and Bat Banding Scheme (ABBBS). Morphometric data (weight, head-bill, tarsus, tail length, etc.) were collected along with estimated age and sex where possible.

The capture rate measurements are calculated to include both the banded birds and Bell Minors removed and are presented as the number of birds trapped (both new captures and recaptures) per 100 m of net erected per hour. Any bird recaptured after it had been banded was considered a recapture, irrespective of the number of times it was captured or length of time between banding and recapture. The percentage recapture rate for each species was calculated as a proportion of recaptured individuals from the total number of individuals of that species banded.

RESULTS

A total of 1,659 birds of 57 species (Table 2) was trapped and banded during the 8-year study period, with 270 being recaptured 328 times, a recapture rate of 16.3%. The most numerous species banded were Bell Miner (424), Red-browed Finch *Neochmia temporalis* (161), Eastern Spinebill *Acanthorhynchus tenuirostris* (134), Superb Fairy-wren *Malurus cyaneus* (126), White-browed Scrubwren *Sericornis frontalis* (122), Brown Thornbill *Acanthiza pusilla* (973), New Holland Honeyeater *Phylidonyris novaehollandiae* (89), Eastern Yellow Robin *Eopsaltria australis* (62) and Satin Bowerbird *Ptilonorhynchus violaceus* (51) (Table 2 and 3).

The mean capture rate (number of birds/100m net/hour) for all years of the study was 13.97 (range 2.05-62.10) (Table 2). The maximum capture rate for a single banding session was 57.08 and the minimum for a single capture session was 0.25. Captures of a large number of Bell Miners in the first two years of the project contributed to high capture rates but yearly capture rates varied (Fig. 7). Of the 57 species captured, 15 accounted for 94.73% of total captures throughout the study (Table 3).

Recaptures

Over the study period, 23 of the 57 species banded were re-trapped, with 14 species re-trapped outside of the same banding session (Table 4). There were no recoveries outside of the three study sites. However, a small number of individuals (Table 5) were recorded to have moved a distance of ~2 km from *Mandeni* to *Tura Beach Flora Reserve* towards the end of the study, with the distance calculated between the net locations at which they were captured at *Mandeni* and *Tura Beach Flora Reserve*.

Threatened and Introduced Species

Two threatened species listed as vulnerable on the *NSW Biodiversity Conservation Act 2016* were captured during this study. A Dusky Woodwallow *Artamus cyanopterus* was captured once in September 2007 while an Olive Whistler *Pachycephala olivacea* was captured once in September 2009.

Table 2

Species banded at Bournda from 2005 to 2013, showing the annual capture rate, total birds captured, banded and recaptures. Threatened species listed on *NSW Biodiversity Conservation Act* 2016 are highlighted in bold..

Species		Capture Rate								Total Birds Caught	No. Banded	Trapped but not Banded	Individuals Re-Trapped		
		2005	2006	2007	2008	2009	2010	2011	2013				No.	%	No. Times
Peaceful Dove	*Geopelia placida*	0.1				0.07				6	6				
Masked Lapwing	*Vanellus miles*			0.04						1	1				
Rainbow Lorikeet	*Trichoglossus moluccanus*	0.1						0.01	0.03	6	6				
Australian King Parrot	*Alisterus scapularis*	0.05								2	2				
Crimson Rosella	*Platycercus elegans*	0.12	0.03							6	6				
Eastern Rosella	*Platycercus eximius*	0.02	0.03							2	2				
Laughing Kookaburra	*Dacelo novaeguineae*	0.07			0.07				0.03	5	5				
Sacred Kingfisher	*Todiramphus sanctus*					0.04				1	1				
Fan-tailed Cuckoo	*Cacomantis flabelliformis*	0.02	0.03					0.01	0.03	4	4				
Shining Bronze-Cuckoo	*Chalcites lucidus*								0.03	1	1				
Welcome Swallow	*Hirundo neoxena*	0.02						0.01		2	2				
Grey Fantail	*Rhipidura alisteri*	0.12		0.04		0.11		0.04	0.07	14	14				
Rufous Fantail	*Rhipidura rufifrons*	0.02	0.26					0.04		12	10		2	20	2
Willie Wagtail	*Rhipidura leucophrys*	0.02			0.14				0.03	4	4				
Black-faced Monarch	*Monarcha melanopsis*		0.03							1	1				
Jacky Winter	*Microeca fascinans*			0.09						2	2				
Rose Robin	*Petroica rosea*	0.1				0.07		0.01		7	6		1	16.7	1
Eastern Yellow Robin	*Eopsaltria australis*	0.17	0.33	0.17	0.68	0.37	0.04	0.19	0.61	77	62		12	19.4	15
Golden Whistler	*Pachycephala pectoralis*	0.22	0.33	0.13	0.14	0.04		0.04	0.1	31	28		3	10.7	3
Rufous Whistler	*Pachycephala rufiventris*	0.02								1	1				
Olive Whistler	***Pachycephala olivacea***					0.04				**1**	**1**				
Grey Shrike-thrush	*Colluricincla harmonica*	0.1	0.03							5	5				
Magpie-lark	*Grallina cyanoleuca*	0.02								1	1				
Eastern Whipbird	*Psophodes olivaceus*	0.3	0.03	0.09				0.01		16	12		4	33.3	4
Brown Gerygone	*Gerygone mouki*				0.07				0.13	5	5				
Striated Thornbill	*Acanthiza lineata*	0.12			0.14	0.15		0.22	0.07	32	27		5	18.5	5
Brown Thornbill	*Acanthiza pusilla*	1.41	0.36	0.17	1.02	0.45	0.04	0.3	0.27	134	97	2	29	29.9	35
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*								0.03	1	1				
White-browed Scrubwren	*Sericornis frontalis*	1.65	0.36	0.26	0.88	0.71	0.13	0.35	0.54	165	122	2	33	27	41
Large-billed Scrubwren	*Sericornis magnirostra*		0.03							1	1				
Australian Reed-Warbler	*Acrocephalus australis*	0.02								1	1				
Superb Fairy-wren	*Malurus cyaneus*	1.83	0.65	0.43	1.36	0.11	0.35	0.28	0.24	166	126		31	24.6	40
Variegated Fairy-wren	*Malurus lamberti*	0.22	0.03	0.04		0.04		0.06	0.03	18	17		1	5.9	1
Dusky Woodswallow	***Artamus cyanopterus***			0.04						**1**	**1**				
White-throated Treecreeper	*Cormobates leucophaeus*	0.02	0.13	0.04		0.04		0.04		10	9		1	11.1	1
Spotted Pardalote	*Pardalotus punctatus*							0.12		10	9		1	11.1	1
Silvereye	*Zosterops lateralis*	0.81				0.15	0.26		0.07	45	44		1	2.3	1
White-naped Honeyeater	*Melithreptus lunatus*	0.02				0.07		0.05	0.13	11	11				
Eastern Spinebill	*Acanthorhynchus tenuirostris*	2.64	0.23	0.04	0.2	0.45	0.31	0.12	0.44	160	134		22	16.4	26
Lewin's Honeyeater	*Meliphaga lewinii*	0.52	0.2	0.04	0.07		0.09	0.04	0.03	35	28		7	25	7
Yellow-faced Honeyeater	*Caligavis chrysops*	0.22	0.07		0.14	0.19			0.17	23	23				
Yellow-tufted Honeyeater	*Lichenostomus melanops*	0.02	0.03			0.56				17	14		3	21.4	3
White-plumed Honeyeater	*Ptilotula penicillata*								0.03	1	1				
Crescent Honeyeater	*Phylidonyris pyrrhoptera*	0.25	0.1							13	10		2	20	3
New Holland Honeyeater	*Phylidonyris novaehollandiae*	1.18	0.1	0.09	0.14	1.04	0.09	0.04	0.4	100	89	1	10	11.2	10
Bell Miner	*Manorina melanophrys*	44.44	28.95	0.13	3.81		1.13	0.67	0.4	2,842	424	2,326	70	16.5	92
Red Wattlebird	*Anthochaera carunculata*	0.02					0.04			2	2				
Red-browed Finch	*Neochmia temporalis*	3.23	0.13	0.04	0.48	1	0.13	0.14	0.24	192	161		26	16.1	31
Olive-backed Oriole	*Oriolus sagittatus*	0.07								3	3				
Satin Bowerbird	*Ptilonorhynchus violaceus*	0.64	0.03	0.17	0.68		0.17	0.08	0.03	53	51		2	3.9	2
Pied Currawong	*Strepera graculina*	0.12	0.07							7	7				
Grey Butcherbird	*Cracticus torquatus*	0.05	0.07							4	3		1	33.3	1
Australian Magpie	*Gymnorhina tibicen*	0.17								7	7				
Little Wattlebird	*Anthochaera chrysoptera*	0.64	0.03			0.15		0.07	0.13	41	37	1	3	8.1	3
Bassian Thrush	*Zoothera lunulata*	0.07	0.1						0.03	7	7				
Spotted Dove	*Spilopelia chinensis*	0.05								2	2				
Common Blackbird	*Turdus merula*				0.07			0.01		2	2				
Birds/100m net/hour		62.1	32.78	2.05	10.07	5.84	2.79	2.93	4.38	4,319	1,659	2,332	270	16.3	328
Banding Sessions per year		10	11	2	2	2	2	6	4						
Mean number of birds per visit		101	16	24	74	79	32	41	33						
Number of species per year		44	27	18	17	21	12	25	27						

Table 3

Fifteen most common species caught at Bournda from 2005 to 2013 showing the percentage of the total number of captures throughout the study.

Species	% of total catch
Bell Miner	65.8
Red-browed Finch	4.45
Superb Fairy-wren	3.84
White-browed Scrubwren	3.82
Eastern Spinebill	3.7
Brown Thornbill	3.1
New Holland Honeyeater	2.32
Eastern Yellow Robin	1.78
Satin Bowerbird	1.23
Silvereye	1.04
Little Wattlebird	0.95
Lewin's Honeyeater	0.81
Striated Thornbill	0.74
Golden Whistler	0.72
Yellow-faced Honeyeater	0.53
	94.73

Table 4

Oldest individual of fourteen species re-trapped at Bournda, calculated from the initial capture to the final capture, with the number of times re-captured, from 2005 to 2013.

Species	Age	No time recaptured
White-browed Scrubwren	5 years 5 months	3
Brown Thornbill	3 years 4 months	1
Eastern Spinebill	2 years 5 months	1
Eastern Yellow Robin	2 years 2 months	1
Superb Fairy-wren	2 years 4 months	1
Eastern Whipbird	2 years 1 month	1
Bell Miner	2 years 1 month	2
White-throated Treecreeper	6 months	1
Crescent Honeyeater	3 months	2
Red-browed Finch	3 months	2
Little Wattlebird	3 months	1
Lewin's Honeyeater	2 months	1
New Holland Honeyeater	2 months	1
Golden Whistler	2 months	1

Table 5

Number of individuals recorded to have moved from Mandeni to Tura Beach Flora Reserve locodes including the longest elapsed time between banding and re-capture.

Species	No of individuals that moved sites	Elapsed time between banding and final capture at TBFR
White-browed Scrubwren	3	3 years 2 months
Brown Thornbill	2	3 years 4 months
Eastern Spinebill	2	2 years 5 months
New Holland Honeyeater	1	2 months
Lewin's Honeyeater	1	2 months
Superb Fairy-wren	1	15 days

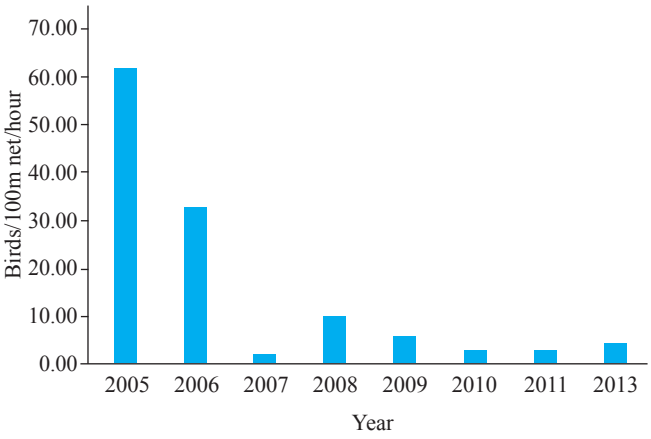

Figure 7. *Yearly capture rate for all sites (2005-2013) at Bournda.*

Two introduced species, Spotted Dove *Spilopelia chinensis* and Common Blackbird *Turdus merula* were captured within the study area during this project.

Bell Miner Management

During 2005 and 2006, 2,326 Bell Miners were removed from across the *Mandeni* site. Capture rates show a corresponding decrease in the population at *Mandeni*, which remained at low levels until the end of the study, in comparison with the adjacent nil treatment site *Manna Park*, as shown in Figure 8. Comparing the capture rates of the most common species caught between sites with consistent annual data suggests an increase in capture rate at *Mandeni* when compared with *Manna Park* for Red-browed Finch (Fig. 9), White-browed Scrubwren (Fig. 10) and Eastern Spinebill (Fig. 11) following Bell Miner removal. Note that the consistent drop in other species capture rates in 2006 at *Mandeni* is the result of a targeted focus of Bell Miner removal from that site and for that year.

A similar comparison using Superb Fairy-wren (Fig. 12) and Brown Thornbill (Fig. 13) captures indicates no obvious trend in capture rates for these species following Bell Miner removal.

Migratory species

Six summer migrants were recorded at the banding site (Table 6). Captures of Silvereyes *Zosterops lateralis* showed a distinct increase between May and August, reflecting the passage of migrants, while captures of Rufous Fantails *Rhipidura rufifrons* showed their presence between December and March. The small number of captures ($n \leq 4$) for other summer migrants (Sacred Kingfisher *Todiramphus sanctus*, Shining Bronze-cuckoo *Chalcites lucidus*, Fan-tailed Cuckoo *Cacomantis flabelliformis*, Olive-backed Oriole *Oriolus sagittatus* and Black-faced Monarch *Monarcha melanopsis*) did not allow clear patterns of movement to be identified. Winter altitudinal migrants included the Rose Robin *Petroica rosea*, recorded in the study area between May and September, and the Crescent Honeyeater *Phylidonyris pyrrhopterus*, recorded in the study area primarily between May and August.

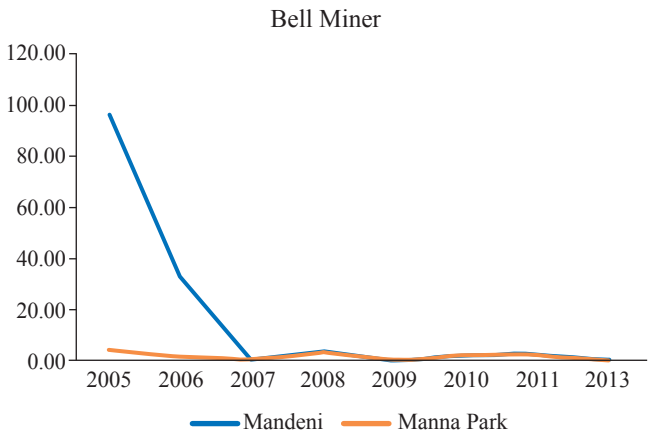

Figure 8. *Comparison of yearly capture rate of Bell Miners* Manorina melanophrys *between* Mandeni *(treatment) and* Manna Park *(nil treatment) sites (2005-2013) at Bournda.*

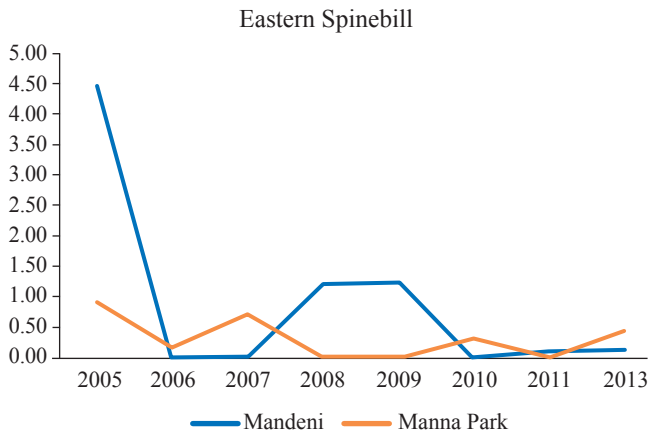

Figure 11. *Comparison of yearly capture rate of Eastern Spinebill Acanthorhynchus tenuirostris between* Mandeni *(treatment) and* Manna Park *(nil treatment) sites (2005-2013) at Bournda.*

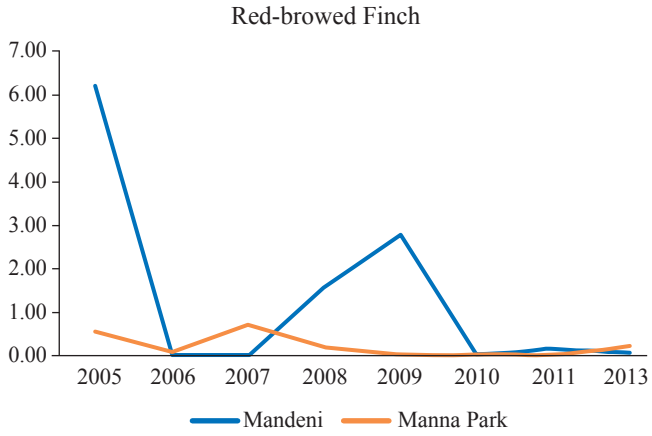

Figure 9. *Comparison of yearly capture rate of Red-browed Finch* Neochmia temporalis *between* Mandeni *(treatment) and* Manna Park *(nil treatment) sites (2005-2013) at Bournda.*

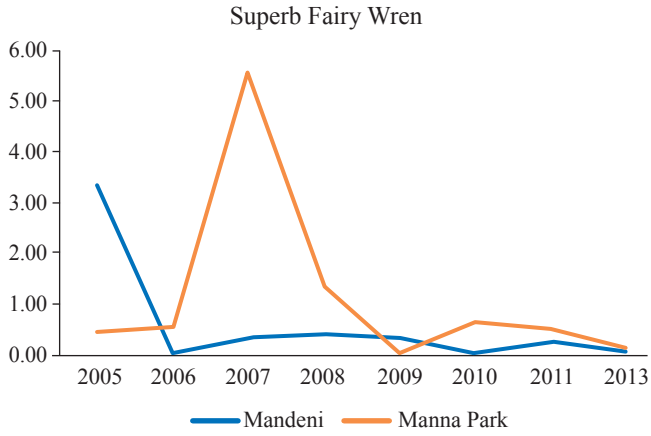

Figure 12. *Comparison of yearly capture rate of Superb Fairy-wren* Malurus cyaneus *between* Mandeni *(treatment) and* Manna Park *(nil treatment) sites (2005-2013) at Bournda.*

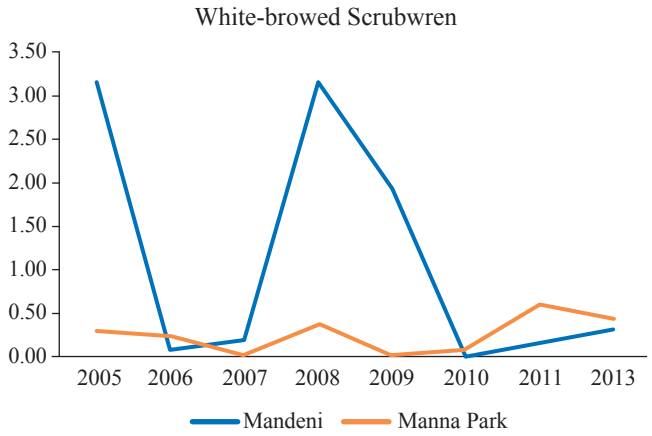

Figure 10. *Comparison of yearly capture rate of White-browed Scrubwren* Sericornis frontalis *between* Mandeni *(treatment) and* Manna Park *(nil treatment) sites (2005-2013) at Bournda.*

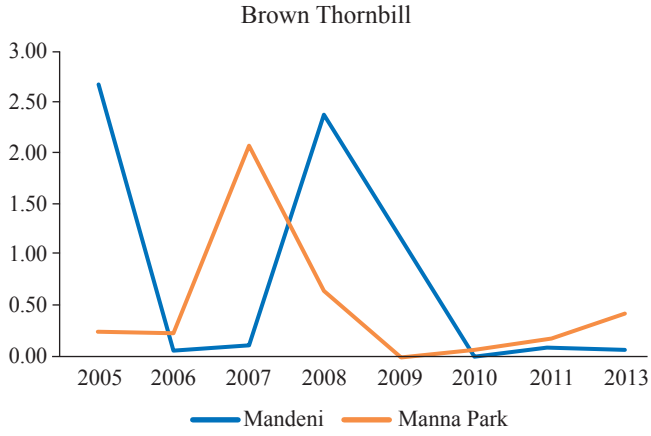

Figure 13. *Comparison of yearly capture rate of Brown Thornbill* Acanthiza pusilla *between* Mandeni *(treatment) and* Manna Park *(nil treatment) sites (2005-2013) at Bournda.*

Table 6

Species caught and banded per month including recaptures at Bournda from 2005 to 2013, showing number of individuals caught per month.

Species	J	F	M	A	M	J	J	A	S	O	N	D
Peaceful Dove	2					1		3				
Masked Lapwing									1			
Rainbow Lorikeet	1							2	2	1		
Australian King Parrot						2						
Crimson Rosella	1				2	1		2				
Eastern Rosella						1						1
Laughing Kookaburra						1		1	1			2
Sacred Kingfisher	1											
Fan-tailed Cuckoo					1				2	1		
Shining Bronze-Cuckoo									1			
Welcome Swallow									1	1		
Grey Fantail	1				4			4	4	1		
Rufous Fantail	5	1	3			1						2
Willie Wagtail								1	3			
Black-faced Monarch		1										
Jacky Winter									2			
Rose Robin					1		1	3	2			
Eastern Yellow Robin	10	5		8	6	1	7	2	28	2	1	7
Golden Whistler	1			1	1		3	5	12	5		3
Rufous Whistler										1		
Olive Whistler									1			
Grey Shrike-thrush								2	1	1		1
Magpie-lark										1		
Eastern Whipbird					1	1		6	2	5		1
Brown Gerygone		1							4			
Striated Thornbill	4	2				3	19	2	2			
Brown Thornbill	8	6		2	10	10	22	31	34	9		
Yellow-rumped Thornbill									1			
White-browed Scrubwren	13	8	2	3	10	2	12	28	63	21		1
Large-billed Scrubwren							1					
Australian Reed-Warbler										1		
Superb Fairy-wren	5	1		5	16	10	5	39	64	17		4
Variegated Fairy-wren	1		1					6	7	3		
Dusky Woodswallow									1			
White-throated Treecreeper	3			1			4	1	1			
Spotted Pardalote							10					
Silvereye	4				1	24	6	8				2
White-naped Honeyeater	1				2	1	2		4	1		
Eastern Spinebill	10	3	2		22	4	11	35	23	41	2	7
Lewin's Honeyeater	1		1		6		1	13	6	1		6
Yellow-faced Honeyeater	6					2		5	7	2		1
Yellow-tufted Honeyeater	6					1			10			
White-plumed Honeyeater									1			
Crescent Honeyeater					3	1		6				3
New Holland Honeyeater	25	2	1	1	1	1	2	4	19	42		1
Bell Miner	25	9			116	19	5	122	156	13	21	30
Red Wattlebird							1			1		
Red-browed Finch	27	4	1	2	18	22	8	73	9	20		8
Olive-backed Oriole										2		1
Satin Bowerbird		1			13	3	1	6	25	3		1
Pied Currawong	2							4		1		
Grey Butcherbird							2	2				
Australian Magpie					3	1		3				
Little Wattlebird	9			1	2			6	4	17		1
Bassian Thrush	1							1	3			2
Spotted Turtle-Dove								2				
Common Blackbird	1	1										
Total caught per month	**174**	**45**	**11**	**24**	**239**	**113**	**123**	**428**	**507**	**214**	**24**	**85**
No. species per month	27	14	7	9	21	23	20	32	36	27	3	21
No. days banding (Total = 127)	13	6	2	5	7	6	11	9	6	6	5	19

Local species Winter migrants Summer migrants

DISCUSSION

Capture rates from this project demonstrated that the active management and removal of Bell Miners at *Mandeni* resulted in the collapse of the colony. The number of Bell Miners encountered remained at low levels for the duration of the study, in comparison with the nil treatment sites. These results are similar to other studies that have found that active removal or exclusion of Bell Miners may be an effective management tool for the control of BMAD (Clarke and Schedvin 1999, Loyn *et al.* 1983, Pearce et al 1995, Stone 1996).

While this is a positive result for the Bournda site, Lambert *et al* (2022) highlighted that interventions to manage BMAD, including the removal of Bell Miners, have not been universally effective. In a review of BMAD studies, Lambert *et al* (2022) noted that a) psyllid numbers do not always decline when Bell Miners are removed, b) Bell Miners can occur in healthy forest and c) psyllid-mediated dieback can occur in the absence of Bell Miner colonies but within the species' range. This suggests the cause of BMAD is more complex than a simple positive feedback between Bell Miners, psyllid abundance and declining tree health. Additional site-specific factors are likely to be critical drivers of Bell Miner occurrence and psyllid outbreaks, and management responses need to be adjusted on a site-by-site basis (Lambert *et al* 2022).

It should be noted that Bell Miners in the Bournda study were not completely removed from the treatment site, with a very small population (~≤10 birds) remaining in one localised area. There was a chance that this small nucleus colony could have started to expand and colonise now vacant areas given time as experienced in other studies (Clarke and Schedvin 1999, Dare *et al*. 2008). However, at the completion of this project this colony remained within the same location and there was no evidence that Bell Miners had started to expand into other areas of the treatment site (J. Shields, unpublished data, A. Fawcett, pers. obs., K. Woodhouse, pers. comm.).

Bell Miners are well known to aggressively exclude other avian species from their colonies (Bower 1998, Clarke and Schedvin 1999, Dare *et al* 2007, Kemmerer *et al* 2008). Changes in the populations of other avian species in response to Bell Miner removal across *Mandeni* were harder to determine from banding data alone. Capture rates for some of the most commonly recorded species tended to show an increase following removal of Bell Miners at *Mandeni* in comparison with the nil treatment sites. However, this result was variable over time, possibly as a result of banding effort. In contrast, capture rates for the Brown Thornbill supported the findings of Leseberg *et al* (2014), which found that understory dwelling species persisted within Bell Miner colonies.

Recovery of vegetation, particularly the dominant tree species, was also assessed as part of the broader study of the effects of Bell Miner management (J. Shields, unpublished data). Initial results indicated that tree health had not improved within 12 months of Bell Miner removal, with no difference in the number of lerps between the treatment and nil treatment sites (Dare 2010). However, reassessment of tree health five years following treatment found there had been a significant improvement (Hastings 2012). These results demonstrated the benefits of long-term monitoring given the recovery time for tree species (Silver and Carnegie 2017).

The results of this study suggest that the removal of Bell Miners at the Bournda site may have contributed to the long-term recovery of Bournda vegetation. Whilst this study has contributed to further ecological understanding of BMAD, the project would have benefitted from increasing the banding effort to at least one session every quarter following Bell Miner removal. Analysis of the capture rates from the annual September sessions was undertaken but were inconclusive in isolation of other data. While the inclusion of the *Tura Beach Flora Reserve* provided an additional nil treatment site, data comparison was not undertaken for this site due to the late inclusion and a small dataset. Additionally, this project would have benefitted from including comparative plot-based bird surveys at removal sites, similar to other banding studies (e.g. Farrell *et al* 2020).

CONCLUSION

Our results suggest that the active management and removal of Bell Miners may have been an effective approach to mitigating one of the causes of BMAD at the Bournda site. Changes in the populations of other avian species were harder to detect but there was some evidence of increase in a number of species over time from recapture rates and casual observations. Unlike other studies, Bell Miners did not re-colonise the treatment site within the five years following culling, which may have allowed the vegetation across the site to recover.

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This project was approved by the ABBBS which also supplied the bands used. Culling of bell miners was approved by the NSW NPWS under non-commercial occupiers license RH2005. All other procedures were licensed and approved by the NSW NPWS (scientific licenses S12838 and SL100751) and Macquarie University Animal Ethics Committee (animal research authority 2012/004-3).

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