Is the Bush Stone-curlew about to become extinct in the Hunter Region?

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Records of Bush Stone-curlew *Burhinus grallarius* in the Hunter Region were reviewed and population trends established for the period 1998-2021. A small population was previously widely dispersed across a broad area of near-coastal habitat in the region. Peak numbers were 20-23 birds in 2010-11 which corresponded with the implementation of a recovery plan. Since then, numbers have declined rapidly and in 2021 only six birds could be accounted for – five around Port Stephens and one at Dora Creek. Only one pair is known to have bred in 2020. Many eggs, most chicks and pre-adult birds appear to have been predated. Foxes are considered to be the main predator. The surviving birds are in sub-optimal habitat with no recovery or protection programs. There is no evidence of successful dispersal of locally fledged birds to form new breeding pairs or recruitment of birds from external populations to the region. This small population is unsustainable and faces extinction in the foreseeable future.

INTRODUCTION

The Bush Stone-curlew *Burhinus grallarius* is a large, slim, mainly nocturnal, ground-dwelling bird endemic to Australia. In the early 1900s it was widely distributed over most areas of the continent, except for central inland areas (Matthews 1913-1914). Since then, the abundance and range of the species has declined by over 50% (Garnett & Crowley 2000). In southern and eastern Australia this appears to correlate with the distribution of the European Red Fox *Vulpes vulpes* (Robinson 1998) and the conversion of large areas of native vegetation to intensive agricultural practices and urban landscapes (Marchant & Higgins 1993).

Historically, in New South Wales (NSW) the Bush Stone-curlew was widespread and reasonably common in areas of suitable habitat, from Queensland to the Victorian border (Marchant & Higgins 1993). It remains widely distributed in the state but in very low densities. It is locally extinct from many areas of its former range (Blakers *et al*. 1984; Marchant & Higgins 1993; Barrett *et al*. 2003; Davey 2005).

There are widespread records from the Hunter Region for the first half of the last century. Early records of the species in the Upper Hunter are provided by the egg collection of Eric McPhee from the periods 1918-1921 and 1927-1928 (Stuart & Newling 2009). McPhee collected principally around Belltrees, Moonan Flat, Stewarts Brook and Broke. Hordern & Hordern (1931) reported the species in scrub around the Myall Lakes. Birds were seen and heard on the south side of the Comboyne Plateau (Chisholm 1934). Chisholm stated they had a poor chance of survival due to predation by foxes and dingo. A pair was often seen at Barrington (Hyem 1936). Hyem reported that foxes have practically exterminated the species in the area, taking both eggs and chicks. At West Maitland birds were seen in a local garden and heard from nearby lucerne paddocks (Enright 1939). The species was recorded on a list of birds of the Paterson District in 1952.

The species is listed as endangered in NSW under the *Biodiversity Conservation Act 2016.* It has been listed since 1995. This listing reflects the decrease in abundance and reduction in range across the state. The main threat is predation by introduced species (foxes and cats). Other threats include clearing of habitat for agriculture and urban development, modification of its preferred woodland habitat through removal of litter and fallen timber, disturbance in the vicinity of nest sites, high-intensity grazing, introduction of exotic grasses, inappropriate fire regimes and insecticide use (NSW Office of Environment and Heritage 2018). This report noted that numbers have declined greatly over the last century and there are concerns that in 10 or 20 years it will be too late to prevent the species from becoming extinct in NSW. The Red Fox is also identified as the principal current threat to the species in Victoria (Victorian Depart-

ment of Environment and Sustainability 2004) and on mainland South Australia (Gates & Paton 2005).

Birdata records in NSW since 1980 reveal the majority of the remaining population is clustered around three coastal areas: the Tweed, Byron and Ballina Shires; around Port Stephens; and the Central Coast. The Birdata average annual Reporting Rate (RR) for NSW and the ACT from 1998-2020 is 0.12%. In contrast to the rest of the state, a larger population is present in the Tweed, Byron and Ballina Shires. Here, monitoring since 2009-2010 has shown a considerable increase in population and the number of breeding pairs (Tweed Shire Council 2019; Charley 2020). This population is the southern extension of a relatively secure Queensland population and is not considered to be under threat. The average Birdata RR for this region for 2009-2020 is 2.19%.

A Recovery Plan for the species in NSW was approved in 2006 (Department of Environment and Conservation 2006). At that time the state population was estimated at around 1,000 breeding pairs and declining. The plan recorded a number of small coastal populations sporadically present from Sydney to the Queensland border. This included a population at Pindimar, Port Stephens. Following the release of the plan, there was a concerted effort by NSW National Parks and Wildlife Service (NPWS) and volunteer groups to implement recommendations and monitor the species. Activities conducted by NPWS to implement the plan locally included extensive community consultation and engagement, installation of temporary fencing to protect breeding sites, deploying remote cameras to monitor activity and maintaining vegetation to provide optimal habitat (S. Callaghan pers. comm.).

In 2016 NSW introduced the Saving our Species Program which included management of Bush Stone-curlew. Under this program, the birds are managed at a landscape scale and the Hunter Region is recognised as a priority landscape. However, no management sites have been established to date due to a lack of local interest (S. Callaghan pers comm.). The status of Bush Stone-curlew in the Hunter Region is uncertain (Williams 2019).

The objectives of the present study were to review records of Bush Stone-curlew in the Hunter Region, identify breeding events and evaluate the population trend of the species.

The Hunter Region is defined by Williams (2019) as the area managed by Local Governments of Newcastle, Lake Macquarie, Maitland, Cessnock, Port Stephens, Dungog, MidCoast, Muswellbrook, Scone, Singleton and the area formerly managed by Local Governments of Merriwa and Murrurundi. It also includes the ocean within 100km of the coastline.

METHODS

All available records were extracted from the BirdLife Australia Birdata portal (https://birdata.birdlife.org.au), the Cornell Lab of Ornithology eBird Australia portal (https://ebird.org/australia/home) and the NSW Department of Environment and Heritage BioNet Atlas (http://www.bionet.nsw.gov.au/). Records were also extracted from Annual Bird Reports for the Hunter Region (https://www.hboc.org.au/publications/annual-bird-report/) for years 1993-2019 and from a spreadsheet of early records (1979-1993) for the region (A. Stuart pers. comm). Records were consolidated by year and the number of birds present each month was determined. Banding, breeding and predation data was also extracted from these sources. Annual RR for the Hunter Region for years 1998-2020 for all survey types was downloaded from the Birdata portal.

To confirm the current status, a limited amount of playback surveying was done in August 2021 in known locations around Port Stephens, and requests for reports of the species were posted on websites of the Port Stephens Econetwork, the Soldiers Point - Salamander Bay Landcare Group and the Myall Koala and Environment Group.

RESULTS

The following were downloaded from online databases: Birdata, 103 records, 1980-2021; eBird, 25 records, 2006-2021; BioNet, 43 records, 1952-2019. Records from HBOC Annual Bird Reports for 1993-2019. Six records were obtained from HBOC early bird records from 1979-1993. There was considerable duplication between the sources.

No responses were obtained from the August 2021 playback surveys and no reports were received from the online requests for information.

Most of the records were from one of three local districts – Port Stephens, Northern Hunter and Lake Macquarie – with a handful of others from other isolated locations within the region. The records are summarised in **Table 1**. The majority were from Port Stephens, from 11 locations, mainly Bobs Farm, Carrington/ Tahlee, Karuah, Little Swan Bay

and Lemon Tree Passage. There were records from 11 locations in the Northern Hunter and seven locations around Lake Macquarie.

Annual population numbers were determined for the period 1998-2021, together with an estimate of possible additional birds identified by calls only, and are charted in **Figure 1**. Breeding records for districts were summarised and are shown in **Table 2**. The annual Birdata RRs for the Hunter Region for the years 1998 to 2020 are shown in **Figure 2.**

Population trend

The annual population numbers for 1998-2021 are shown in **Figure 1**. The maximum numbers, of 20-23 birds, were recorded in 2010-2011 and numbers have declined rapidly since then. There are only six birds present within the Hunter Region in 2021; a pair at Little Swan Bay and single birds at Tahlee/Carrington, Karuah, Salamander Bay and Dora Creek. The pair that have bred at Bobs Farm since 2005 did not return in 2021. A single bird at Salamander Bay in January 2021 is the first known record from that area.

The annual Birdata RR for the Hunter Region from 1998-2020 had a maximum of 0.29% in 2004 and declined to 0.07% in 2020 (see **Figure 2**)**.** The average RR over the period was 0.11%. A similar trend was evident for NSW and the ACT for the period 1986-2006 (Cooper *et al*. 2014).

Information from banding studies

Chicks were banded at four nesting sites as part of the NPWS Recovery Plan from 2004 to 2009:

- Bobs Farm: Chicks were banded in November 2008, November 2009, January 2010, with subsequent observations in January 2009, February 2009, January 2010.
- Fenninghams Island: Chicks were banded in January 2009.
- Lemon Tree Passage: Chicks were banded in December 2005, December 2006, November 2008, with subsequent observations in September 2010, December 2010.
- Little Swan Bay: Chicks were banded in March 2009.

Three adult birds were taken into care at public locations, banded and released elsewhere:

- February 2010: Single bird captured at Horseshoe Beach and released at Fenninghams Island.
- February 2011: Single bird captured at Newcastle Airport and released at Karuah.
- March 2011: Single bird captured at Kooragang Island and released at Karuah.

Two banded birds dispersing from elsewhere were recorded:

- August 2006: A single banded adult bird was at Balickera.
- August 2006: A single banded adult bird was at Swansea. This bird had been banded at St Huberts Island, Brisbane Water in February 2006.

The data indicate that the majority of banded chicks and pre-adult birds were probably predated. Only one banded bird dispersed and survived in the region for longer than one year – a bird which had been banded at Bobs Farm in November 2009 was recorded several times at Carrington/Tahlee between April 2014 and August 2016. Only one confirmed bird from outside the Hunter Region was recorded. It did not remain in the region.

Breeding records

A summary of breeding records is presented in **Table 2**. Breeding was not recorded in every year over the intervals shown. There were seven locations with breeding records between 1980 and 2020, all around the shores of Port Stephens. The longest set of records were from Bobs Farm (2005-2020) and Lemon Tree Passage (1980-2014). However, since 2000, the number of breeding pairs has declined. After 2002 there were only four active breeding pairs and after 2010, only one. The pair at Bobs Farm did not return to breed in 2021 (V. Diemar pers. comm.) and the pair at Little Swan Bay were last reported nesting in 2018. One instance of possible successful dispersal was recorded at Bobs Farm in 2017 when the resident breeding female was joined by a new male bird (V. Diemar pers. comm.). It is not known where the new bird had dispersed from but the only other active breeding pair in the region at that time was at Little Swan Bay. The distance between the two sites is 9.4 km. Records from BioNet indicate that breeding pairs in the region usually laid two clutches of two eggs each breeding season, but that chicks rarely survived more than 1-2 months.

Table 1. Bush Stone-curlew records for the Hunter Region 1952-2021.

District	Location	Date of record and number of birds
Port Stephens	Bobs Farm	2005-2020 (p), Nov 2008 (4), Aug 2009 (2), Oct-Dec 2009 (4), Jan 2010 (3), Aug 2010 (2), Dec 2010 (3), Jan 2011 (3), Apr 2011 (3), Sep 2011 (2), Nov 2011 (2), Sep-Oct 2012 (3), Nov 2012 (3), Oct-Nov 2013 (2), Oct 2016 (2), Oct 2019 (2), Oct 2020 (3)
	Bull Island	Jun 1980 (p), Nov 1980 (2)
	Fenningham's Island/ Taylor's Beach	Dec 1979 (p), Jun 1980 (2), Nov 2000 (p), Sep 2005 (1), Sep 2008 (2), Jan-Feb 2009 (2), Sep 2009 (2), Nov 2009 (2), Feb-Mar 2010 (1) (relocated from Horseshoe Beach)
	Carrington/Tahlee	Apr 2014 (2), Jan 2015 (1), Jul 2015 (2), Oct 2015 (p), Nov 2015 (2), Feb-Apr 2016 (2), Jul 2016 (2), Mar 2017 (2), May-Jul 2017 (2), Sep 2017 (3), Jan 2018 (1), Apr 2018 (1), Jul-Aug 2018 (1), Oct 2018 (1), Jun-Jul 2020 (1), Sep-Dec 2020 (1), Jan-Feb 2021 (1), Jun 2021 (1)
	Karuah	Jun 1989 (1), Nov 1998 (2), Jul 1999 (2), Nov 1999 (2), Aug 2005 (p), Nov 2005 (2), Sep 2008 (2), Aug-Sep 2010, Nov 2010 (2), Feb 2011 (1) (relocated from Newcastle Airport), Mar 2011 (1) (relocated from Kooragang Island), Jan 2012 (2), Feb 2015 (2), Apr 2015 (1), Jun 2021 91), Oct 2021 (1)
	Little Swan Bay	Oct 2000 (1), Dec 2004 (4), Sep 2007 (3), Sep 2008 (2), Dec 2008 (2), Mar 2009 (3), Sep-Nov 2009 (3), Feb 2014 (2), Feb 2017 (3), Dec 2017 (2), Jan 2018 (2), Oct 2018(2), Jul 2018 (3), Aug 2019 (4), Feb 2021 (2)
	Lemon Tree Passage	1980-1992 (p), Jan-Mar 1993 (p), Oct 1996 (4), Oct 2000 (p), Nov 2002 (p), Nov 2003 (p), Sep 2004 (p), Dec 2004 (p), Dec 2006 (3), Nov 2007 (p), Jan 2008 (2), Sep-Dec 2010 (3), Oct 2014 (2)
	Medowie	Jan 2010 (1)
	Pindimar/ North Arm Cove	1998 (4), 1999 (4), 2000 (2), 2001 (2), 2003 (1), 2004 (2), 2005 (p), Sep 20011 (1), Feb 2017 (1)
	Tanilba	2001 (2), 2003 (2), Oct 2006 (p), Sep 2008 (2), Aug 2011 (1)
	Salamander Bay	Jan 2021 (1), Oct 2021 (1)
	Wallaroo NP	Aug 2006 (1)
Northern Hunter	Harrington	Apr 1991 (1), Apr 1998 (1), Jul-Aug 2006 (1), Mar 2011 (1), Jul 2007 (2), Aug 2011 (3)
	Old Bar	Mar 1993 (4), Jan 2007 (p), Jul 2011 (3), Nov 2018 (1)
	Crowdy Head	Jul 2002 (1)
	Crowdy Head NP	Mar 2003 (2)
	Diamond Head	Oct 2019 (1)
	Green Point	Dec 2005 (1)
	Bungwahl	2008-2009 (2), Jan-Feb 2010 (1)
	Knappinghat NP	Mar 2013 (2)
	Black Head Reserve	Oct 2019 (1)
	Coorabakh NP	Oct 2000 (2)
	Wang Wauk NP	Aug 2001 (1)
Lake Macquarie	Wyee	Feb 1998 (1)
	Warners Bay	Jan 2003, Nov 2004 (2)
	Swansea South	Aug 2006 (1)
	Jewell's Swamp	Mar 2007 (1)
	Dora Creek	Jan 2011 (1), Jul-Dec 2012 (1), Oct 2021 (1)
	Eraring	Jan-Mar 2013 (1)
	Fennal Bay	Feb 2015 (1)
Other Records	Paterson	1952 (p)
	Allyn River	May 1980 (1)
	Stockton Sandspit	Sep 1988 (1)
	Muswellbrook	Oct 1999 (2)

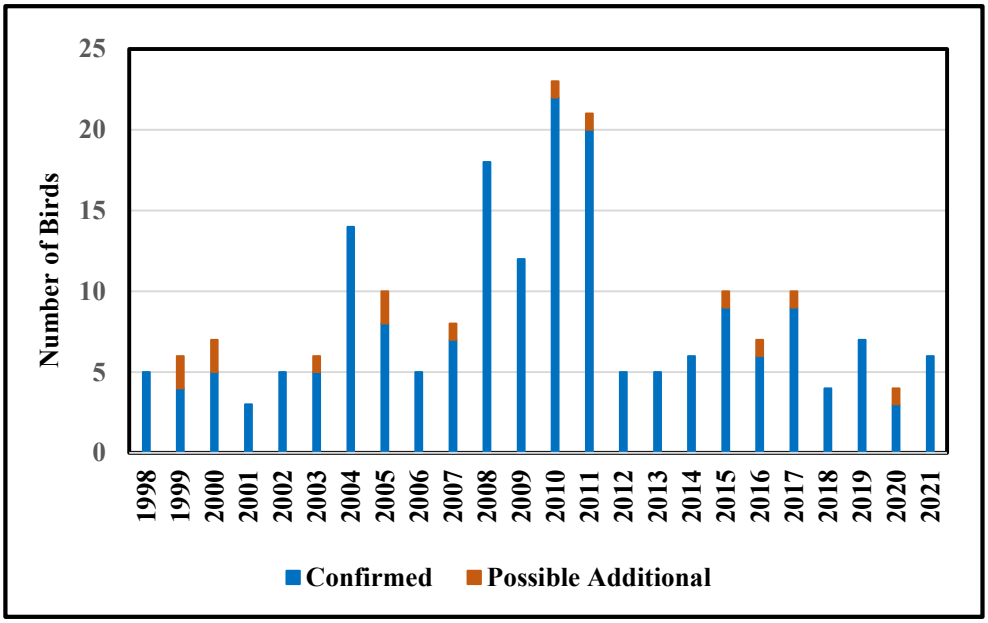

Figure 1. Total annual number of Bush Stone-curlew recorded in the Hunter Region, 1998-2020.

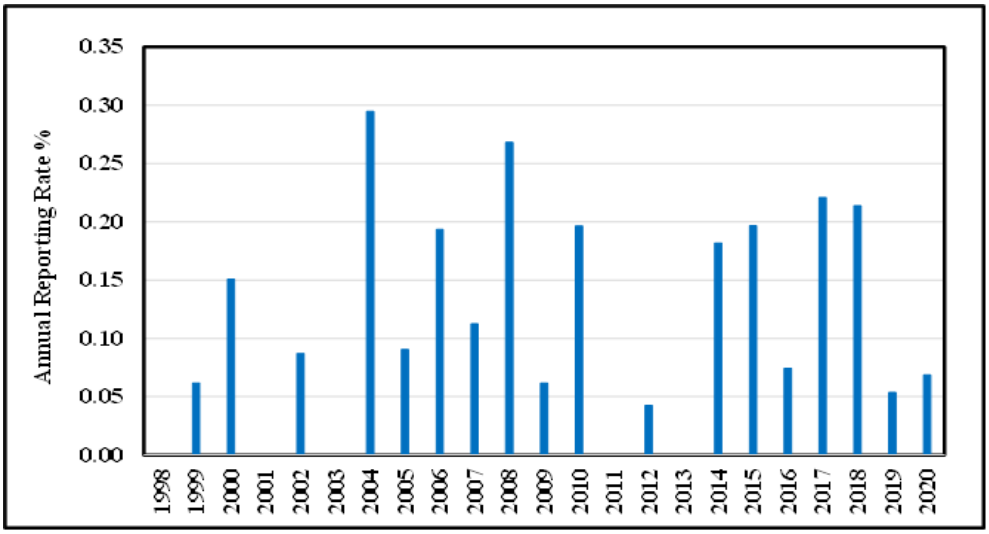

Figure 2. Annual Reporting Rate for Bush Stone-curlew in the Hunter Region, 1998-2020.

Table 2. Breeding locations, intervals and number of records for Bush Stone-curlew, Hunter Region, 1980-2020.

Location	Breeding Records	
Bobs Farm	2005 - 2020	15
Fenninghams Island	2001-2002	2
Karuah	2005	1
Lemon Tree Passage	1980 - 2014	10
Pindimar	1998 - 2002	4
Little Swan Bay	2007 - 2018	6
Tanilba Bay	2001 - 2002	2

Predation

Many eggs and most young chicks were lost to predation. At Bobs Farm, predation of chicks by Southern Boobook *Ninox boobook* and Laughing Kookaburra *Dacelo novaeguineae* was observed and a fox was recorded taking eggs (V. Diemar pers. comm.). At Lemon Tree Passage, two two-day-old chicks were predated by a Laughing Kookaburra in December 2007 (Stuart 2008).

DISCUSSION

The long-term security of an organism depends largely on the extent of its geographical range, the number and extent of habitats it can occupy and its average density within these habitats, which together determine its overall numbers (Newton 1998). Prior to European settlement, Bush Stone-curlew had a large range, occupied a number of different habitats and was relatively common. The species was well adapted to low level of predation from other endemic species. Today in the Hunter Region, the species has a small range around Port Stephens, occupies limited habitats and has very low density. This, according to Newton (1998), puts the species in the most-at-risk category for extinction.

The 2006 Recovery Plan for Bush Stone-curlew identified Red Fox as the major threat to the survival of the species, although other factors such as loss of habitat also had a role. The fox is now a successful apex predator. In NSW it favours fragmented landscapes and coastal forests where densities are around 1-2/km^2. Populations are well established in peri-urban and urban areas where food is abundant and where densities may be as high as 12/km^2 (Agriculture Victoria 2021; NSW Department of Primary Industries 2018). The 2016 Saving our Species program also recognised predation by Red Fox as a Key Threatening Process for Bush Stone-curlew.

Bush Stone-curlew live for up to 30 years and are believed to form long-term pair-bonds. Breeding begins at 2-3 years of age and a breeding pair will usually lay two clutches, usually of two eggs, within a breeding season. The birds exhibit nest-site fidelity (Marchant & Higgins 1993). This life strategy successfully maintained the species' population prior to European settlement. It has a vigorous anti-predator response to protect its nest and chicks, involving a mantling display and distraction behaviour. In other instances when confronted with a predator, the birds will run to escape rather than fly (Marchant & Higgins 1993). These behaviours evolved in response to threats from endemic predators but are not effective in deterring introduced foxes. The predictions of Chisholm (1934) and Hyem (1936) have been borne out by the absence of reports from the Western Hunter Region since the early 1950s.

The NPWS Fox Threat Abatement Plan (Fox TAP) ranks the Bush Stone-curlew highly as a species which suffers population level impacts from fox predation. However, because of the widespread and isolated distribution of Bush Stone-curlew, no Fox TAP programs specifically targeting Bush Stone-curlew populations have been implemented. The impact of foxes on Bush Stone-curlew mortality has not been measured experimentally, but anecdotal evidence demonstrated that foxes can kill adult Bush Stone-curlews as well as chicks (Department of Environment and Conservation NSW 2006). A search of the NSW Department of Environment and Heritage BioNet Atlas from 1980 to the present, reveals foxes have been reported in all the areas where Bush Stone-curlew were breeding around Port Stephens. Focussed Fox TAP programs conducted by NPWS in national parks in the region to reduce the threat to other high priority species (National Parks and Wildlife Service 2001) are likely to have only indirectly assisted Bush Stone-curlew.

While evidence of decline due to fox predation is largely anecdotal, populations on coastal islands such as Coochiemudlo Island and Magnetic Island in Queensland (Cannard & Milton 2012; Coleman *et al*. 2021) and Kangaroo Island in South Australia (Gates & Paton 2005), which are fox free, are flourishing. These authors have suggested Bush Stone-curlew have adapted successfully to the peri-urban and urban environment on these islands and their populations are supported by some elements of urban infrastructure.

A GIS study of habitat preferences of Bush Stone-curlew on the NSW Central Coast and Port Stephens (Murialdo *et al*. 2015) showed that the birds observed around Port Stephens were more likely observed in dry sclerophyll forests and saline wetlands. As these habitats are widespread throughout Port Stephens, it is unlikely that a lack of suitable habitat is a factor in the species' decline.

It is probable that the higher numbers of Bush Stone-curlew in the Hunter Region reported from 2004-2011 resulted from increased conservation activity by NPWS and volunteer groups to implement recovery strategies and monitor numbers following the development of the Recovery Plan. However, since 2011 these activities have declined and the effectiveness of

the program has diminished. This was due to a number of factors: NPWS decided to focus more on threatened species within National Parks; key personnel left the program; and some detrimental management efforts resulted in a loss of support from local landholders (S. Callaghan pers. comm.). At McCann Park, Lemon Tree Passage for example, the fenced breeding site was not maintained and the ensuing dense, rank vegetation rendered the site unsuitable. There were no further nesting attempts after 2010 and no records from the site after 2011. The fate of the birds that had nested there is unknown.

The majority of the records from the Hunter Region from 1979-2021 are from semi-rural, peri-urban and urban locations. There are relatively few records from areas of open forest in regional National Parks. The few remaining Hunter Region sites are all located on small semi-rural holdings, none of which are conducting activities that support Bush Stone-curlew recovery. Fox baiting is unlikely to be undertaken on these properties due to the risk to residents and domestic animals. The habitat on these small landholdings is at risk of being cleared for agriculture and residential purposes, and any remaining woodland habitat modified through removal of litter and fallen timber. Exposure to agricultural chemicals is also more likely on these properties.

It is apparent that the majority of eggs, chicks and pre-adult birds in the Hunter Region are being predated and that dispersal to form new breeding pairs is not occurring. There also is no evidence that the breeding population in the Hunter Region has been subject to recruitment from the Central Coast population, although a bird from that population was briefly present in the Lake Macquarie area in 2006. A 15-year study (2003-2018) of the Brisbane Water population on the NSW Central Coast concluded that the population is effectively isolated. No banded birds have been observed north of Brisbane Water in company with unbanded birds (Price *et al*. 2018). A single bird at Dora Creek in October 2021 was probably a Brisbane Water bird displaced by breeding parents (A. Morris pers comm.).

CONCLUSIONS

A small population of Bush Stone-curlew was previously widely dispersed across a broad area of near-coastal habitat in the Hunter Region. Peak numbers in the past 50 years were 20-23 birds around 10 years ago that corresponded with the implementation of a Recovery Plan and increased survey effort. In the past 10 years numbers have rapidly declined and in 2021 only six birds were known – five in the Port Stephens area and one at Dora Creek. Only one pair is known to have bred in 2020. Many eggs, most chicks and pre-adult birds appear to have been predated. Anecdotal evidence indicates foxes are the main predator.

The surviving birds are located on properties where active recovery or protection activities are not being undertaken, significant habitat modification has been undertaken and human disturbance is common. There is no evidence of successful dispersal of locally fledged birds to form new breeding pairs or recruitment of birds from external populations in the region. The inevitable outcome for the species is regional extinction in the foreseeable future.

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