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Hooded Plover population of Yalgorup National Park: steep declines and other insights from a 30-year dataset

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Abstract. The Western Hooded Plover *Thinornis cucullatus tregellasi* is a threatened shorebird inhabiting southwestern Australia and has received limited research attention compared with the eastern subspecies. We analysed a 30-year dataset (1996-2024) from Yalgorup National Park, a stronghold of the western subspecies, to assess local population trends, flocking behaviour, breeding activity and movements. The findings show a 75% decline in the adult abundance, from 76 individuals (95% CI: 56-101) in 1996 to 18 (13-24) in 2024. Declines were observed at ten of 12 sites, with Lake Preston North experiencing the steepest reduction (99%). Seasonal patterns showed peak adult abundance and flock sizes in summer (December-February), with flocks progressively decreasing in size through autumn to winter. Across 219 breeding events, hatching and fledging success averaged 0.29 chicks/egg and 0.15 fledglings/egg, although uncertainty remained due to unknown nest fates and unassigned juveniles. Banding data revealed high mobility of juveniles and adults between lakes, limited local recruitment of fledglings and two long-distance movements (>160 km) between Yalgorup and inland lakes. While the drivers of the local decline are unclear, interacting factors likely include habitat degradation at inland lakes linked to increased salinity, reduced rainfall and predation, compounded by pressures on Yalgorup's feeding and nesting habitats. These findings highlight a substantial, ongoing decline in a key population of Western Hooded Plover, suggesting that local breeding success is not the primary driver, but rather regional habitat and predation pressures. Our study provides crucial baseline data, supporting the reassessment of the subspecies' national conservation status and informing targeted research, monitoring and management strategies.

Key words: *Thinornis cucullatus tregellasi*, long-term monitoring, flocking, colour banding, shorebird

INTRODUCTION

Australia has 188 nationally threatened bird species or subspecies (Garnett and Baker 2021), yet available data to assess their status are geographically biased. Most monitoring sites used to develop the threatened species index of Australian birds were in the eastern states, with only 13% located in Northern Territory, South Australia and Western Australia (Bayraktarov *et al.* 2021). Expanding monitoring in western regions is therefore critical to improve assessments of poorly studied species and subspecies.

The Hooded Plover *Thinornis cucullatus* is a shorebird native to Australia, with two recognised subspecies, eastern *T. c. cucullatus* and western *T. c. tregellasi*, based on morphological and molecular differences (Weston *et al.* 2020). The subspecies occupy separate, non-overlapping regions divided by the Great Australian Bight. The eastern subspecies occurs along south-east Australia and nearby islands, including Tasmania and Kangaroo Island (Barrett *et al.* 2003; Ekanayake 2025), whereas the western subspecies inhabits the south-west Western Australian coast and inland lakes north-east to Lakes Cowan and Moore and north-west to Leeman Lagoon (Marchant and Higgins 1993; Johnstone and Storr 1998). Western birds are larger, darker and genetically distinct from eastern birds (Weston *et al.* 2020) and differ ecologically: eastern birds are coastal residents, dependent on ocean beaches, with generalised diets and seasonal breeding, whereas western birds are nomadic, breed when suitable conditions prevail and may breed semi-colonially (Weston *et al.* 2020).

Internationally, the Hooded Plover is listed as a Vulnerable species (BirdLife International 2016). In Australia, only the eastern subspecies is listed as a threatened species under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), following documented declines since the 1980s (e.g., Baird and Dann 2003; Birds Australia 2008). However, the western subspecies likely comprises fewer than 2,500 mature individual birds, and declines are thought to be occurring in the coastal breeding birds (Garnett and Baker 2021). Yet, data, research and ecological knowledge of the Western Hooded Plover are much more limited compared to the eastern subspecies (Weston 2004).

Yalgorup National Park, 105 km south of Perth on the western edge of the Swan Coastal Plain, forms part of the Peel-Yalgorup wetland system, a wetland of international importance under the Ramsar Convention as it supports a large number and variety of waterbird species (Hale and Butcher 2007). The saline lakes that make up the Yalgorup National Park support an important population of Hooded Plovers, both breeding and non-breeding individuals, with counts often representing 1% of the total population (Hale and Butcher 2007; Rule and Singor 2009). Hooded Plovers in Yalgorup National Park will breed at any time of the year, although breeding peaks over summer, which coincides with maximum width of the lake shorelines (Russell 2000). The Hooded Plover population in Yalgorup National Park has been monitored since the mid-1990s onwards, and annual counts during national shorebird count in February suggest a steady decline in numbers (144 adults in 2005, 64 in 2015 and 22 in 2025). However, robust statistical analysis to quantify the decline and its uncertainty has never been conducted to this date.

This study analyses a long-term dataset (mid 1990s-2024) of Western Hooded Plover monitoring in Yalgorup National Park to assess (1) population trends, (2) seasonal abundance and flocking, (3) breeding activity and threats and (4) seasonal movements in this region during the study period. Previous studies addressed different aspects of the ecology of the species with shorter time series of this dataset (France 2003; Newbey 2002; Rule and Singor 2009; Russell 2004; Singor 2005, 2009), but this is the first analysis of the full dataset. Our study expands the limited knowledge of the Western Hooded Plover, focusing on local population trends, movements and flocking behaviour.

METHODS

Study site and surveys

The Yalgorup National Park (32°51′26 S 115°40′19 E) comprises ten saline lakes known as the Yalgorup Lakes, located between a series of linear coastal dunes (Hale and Butcher 2007). The lakes are shallow (< 3 m deep) and form three distinct lines running parallel to the coastline. Lake Preston is the largest of the lakes and closest to the sea (30 km long and 0.5-1.5 km wide), with an artificial causeway that separates the northern section from the remainder of the waterbody. Lake Clifton is the second largest (20 km long and 0.2-1.5 km wide) and furthest inland. The remaining eight lakes are smaller and form a disconnected chain between Lake Preston and Lake Clifton (Fig. 1). The lakes' water sources comprise direct precipitation, localised run off and groundwater (Hale and Butcher 2007). The smallest lakes — Swan Pond, Duck Pond, Boundary Lake and Lindas Lagoon — dry out completely over most summers, as does Lake Newnham south, Lake Preston north and the southern basins of both Lake Clifton and Lake Preston.

To coordinate the logistics of monitoring Hooded Plovers across the dispersed lakes, the study area was divided into three sections: northern lakes, middle lakes and Lake Preston, which was further split into North (north of causeway), Mid and South sections (Fig. 1). We aimed to survey the transects (hereafter sites) shown in Figure 1 at least once a month. Yet, difficult access, public access restrictions and water levels meant that monthly surveys were not always possible or that the entire site could not be surveyed, particularly for Lake Preston South and Mid, resulting in differences in survey frequency and effort among lakes (Table 1; Supplement 1). The smaller lakes (Swan Pond, Duck Pond, Boundary Lake, Lindas Lagoon, Lake Pollard, Martins Tank, Lake Yalgorup, Lake Hayward and

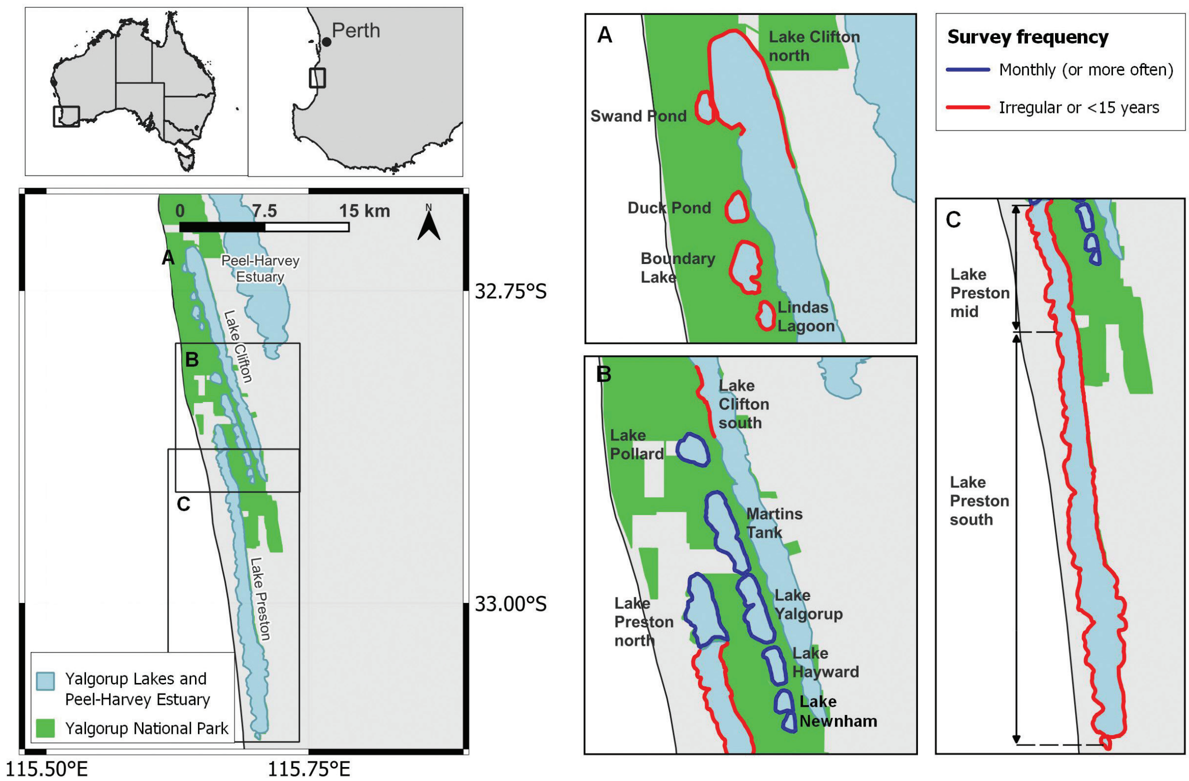


Figure 1. *The study area of Yalgorup National Park divided into three sections, Northern Lakes (A), Middle Lakes (B) and Lake Preston (C) and the survey transects that were surveyed to monitor Hooded Plovers between mid 1990s and 2024. Blue transects were surveyed at least monthly during the study period, and red transects were surveyed on a more irregular basis or during less than 15 years due to access difficulties and capacity.*

Lake Newnham) and Lake Preston North had easier access, and their entire site could be surveyed at each visit, water levels permitting. The survey periods also varied among sites (11 to 30 years of surveys) due to changes in the number of surveyors and accessibility during the study period (Table 1).

Surveys were conducted on foot by experienced volunteers, using binoculars and usually in the morning, between 0700 am and 1100 am, but note that not all lakes could be surveyed on the same day. For each survey, observers recorded the date, location and the number of adults and juveniles, evidence of breeding and threats.

Breeding events were recorded based on confirmed sightings of eggs or unfledged chicks, and covered the period since the event was first recorded until the event finished (i.e., chick(s) fledged, breeding failed or unknown outcome). Replacement clutches were included as separate breeding events. In some instances, we conducted targeted visits to nesting locations to check the progress of a breeding event, without surveying the entire site. We recorded the number of occupied breeding territories. Due to the high mobility of adults between lakes, we could not determine whether a breeding territory was used only by a unique breeding pair throughout the year, hence we refer to occupied breeding territories instead of breeding pairs. Where possible, we recorded the number of eggs, chicks and fledglings of a breeding event and determined its fate (i.e., failed, hatched, fledged, unknown). Note that our main objective was to monitor abundance rather than breeding success, and due to the monthly frequency visits and a focus on minimising disturbance of breeding birds, in some occasions we could not determine the fate of a breeding event.

Population trend analysis

We excluded targeted visits to nesting locations and sites with heterogeneous or unknown survey coverage due to access or length from the population trend analysis. These included all surveys at Lake Preston South and Lake Clifton South, for which we visually inspected patterns in the relationship between year and adult numbers using a smooth function with the R package ggplot2 (Wikham 2016). Surveys prior to September 1995 were also excluded, as effort was too sparse and inconsistent to support trend modelling. Where multiple counts occurred on the same day, we retained a single record with the maximum adult and juvenile counts. Juvenile absences were inconsistently recorded, so only adult abundance was modelled.

We modelled temporal trends in adult Hooded Plover abundance using a Generalised Additive Mixed Model (GAMM) fitted with the R package mgcv (Wood 2017). Generalised additive models allow nonlinear relationships to be modelled (Wood 2017), and mixed-effects models are well suited to ecological datasets with unbalanced sampling across groups, as is common in long-term monitoring programmes (Bolker *et al.* 2009; Zuur *et al.* 2009). We included site as a random effect to account for among-site heterogeneity and the non-independence of repeated surveys within sites (Gelman and Hill 2007). The response variable was the number of adults per survey, modelled with a negative binomial distribution to address overdispersion. The remaining predictors included year and month.

Year and month were fitted as additive smooth terms: a thin plate spline for year and a cyclic cubic spline for month to capture recurring seasonal effects. Because main breeding spans two calendar years (usually September-April), we defined years from September to August and coded them by the January breeding season (e.g., September 1995 to August 1996 = 1996). Years were centred by subtracting 1996 (first year of the dataset) so that the intercept represented the start of the series. Months were coded 1-12 (September = 1, August = 12).

Site was included as a random intercept using a random effect spline basis (Pedersen *et al.* 2019).We also included a random slope of year within site to allow temporal trends to vary by site. The log of transect length (km) was included as an offset to standardise survey effort. To prevent overfitting, the basis dimension of all smooth terms were set to k = 5.

Model fit was assessed using R package DHARMa (Hartig 2024) and mgcv diagnostic tools. Residuals showed no major patterns, and random effects approximated a normal distribution, indicating adequate fit.

Temporal trends and uncertainty were estimated using a bootstrap procedure with 2,000 replicates (Davison and Hinkley 1997; Harrison *et al.* 2014). The bootstrap procedure was implemented in R using a custom function that combined tools from the parallel, dplyr, purrr and mgcv packages (R Core Team 2025; Wickham *et al*. 2023; Wickham and Henry 2025; Wood 2017). Each replicate sampled the original dataset with replacement, refitted the GAMM to the sampled data, and generated predictions for each year and site (site-level predictions). Site-level predictions were aggregated annually across sites to calculate population-level estimates (i.e., predicted total abundance across sites). From the bootstrap distributions, we derived means as predicted abundance and the 2.5th and 97.5th percentiles as 95% confidence intervals (CI) (Puth *et al.* 2015). We then generated the bootstrap distribution of percentage change in adult abundance between the earliest and latest survey years at each site (to avoid extrapolating the predictions beyond the survey period of each site), and from 1996 to 2024 at the population level, from which we calculated the average percentage change, 2.5th and 97.5th percentiles for each site and the total population. If confidence interval included 0, the percentage change was considered non-statistically significant. Year predictor was back-transformed when plotting results.

All data processing and statistical analysis were performed in R version 4.5.1 (R Core Team 2025) in the RStudio environment v2025.5.1.513 (Posit team 2025).

Seasonal patterns and flocking

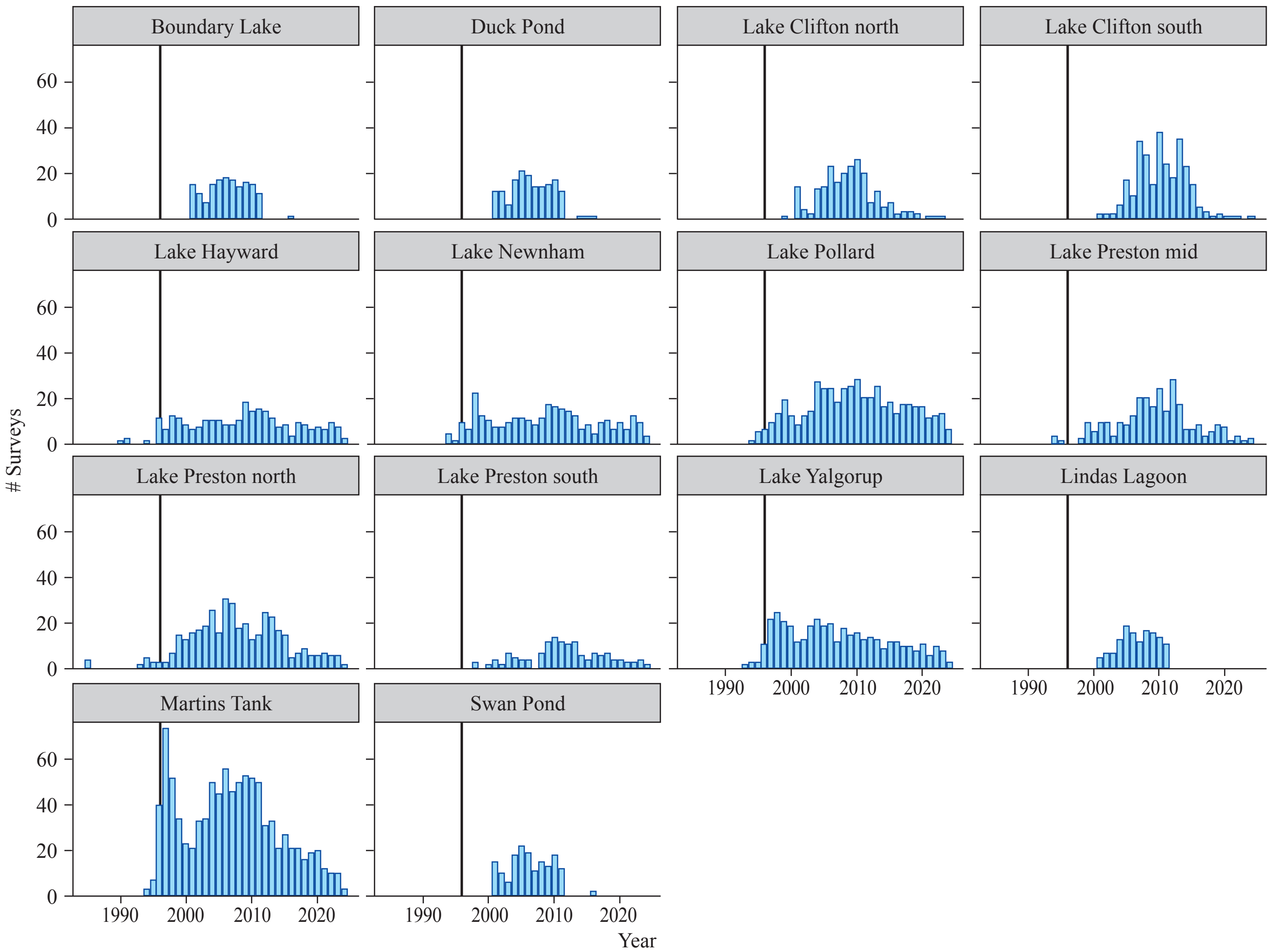
To assess seasonal patterns in the abundance of adult Hooded Plovers across the Yalgorup Lakes, we plotted the estimates and confidence intervals of the GAMM model over the months of a calendar year. We used the same bootstrap procedure described in the previous section to generate the estimates and confidence intervals for each month and site, which we then aggregated to obtain the total population estimates.

The number of individuals in distinct sightings recorded during the surveys at Yalgorup Lakes was used to assess flock sizes and seasonality. Here, we defined a flock as any group of at least three non-breeding Hooded Plover individuals, excluding chicks.

Table 1

Sites surveyed to monitor Hooded Plovers at Yalgorup Lakes, indicating a brief description of the site, survey period at each site, number of surveys (in brackets is the number of surveys included in the trend analysis if different for the total number of surveys), mean number of adults (± standard deviation, SD) and mean number of juveniles (± SD). *indicates that all surveys within that site were excluded from the trend analysis.

Site	Site description	Period	Surveys	Mean Adult ± SD	"Mean Juv ± SD"
Boundary Lake	Maintains water, fresh water seepage, salt sheets	2001–2016	157	3.28 ± 6.50	1.12 ± 1.48
Duck Pond	Dries out, seepage pools	2001–2016	162	2.85 ± 2.53	1.59 ± 1.35
Lake Clifton north	Never dries out, isolated location	1999–2023	220	2.70 ± 2.99	0.25 ± 0.87
*Lake Clifton south	Includes isolated transects on west and east shoreline. Southern basin dries out	2001–2024	286	12.50 ± 16.44	1.30 ± 1.90
Lake Hayward	Small, highly saline lake	1990–2024	265 (261)	0.80 ± 2.18	0.10 ± 0.47
Lake Newnham	Separated in northern and southern lake	1994–2024	294 (289)	1.78 ± 1.46	0.10 ± 0.43
Lake Pollard	Never dries out, has viewing hide	1994–2024	489 (485)	6.31 ± 8.23	0.38 ± 1.06
Lake Preston North	Dries out, fresh water seepage	1985–2024	375 (364)	7.25 ± 15.66	0.50 ± 1.49
Lake Preston Mid	Wide summer beaches fringed by grasses and sedges, backed by Melaleuca spp.	1994–2024	259 (255)	1.61 ± 3.30	0.11 ± 0.54
*Lake Preston South	In summer separates into three water bodies	1998–2024	125	1.97 ± 2.95	0.32 ± 0.80
Lake Yalgorup	Never dries out, highly saline	1993–2024	379 (375)	5.02 ± 7.31	0.60 ± 1.26
Lindas Lagoon	Dries out over summer, retains seepage pools	2001–2011	126	0.69 ± 1.24	0.75 ± 0.96
Martins Tank	Never dries out, camping site nearby	1994–2024	936 (929)	8.10 ± 8.42	0.98 ± 1.80
Swan Pond	Dries out, salt sheets, connected to Lake Clifton	2001–2016	149	1.87 ± 2.29	0.50 ± 0.86



Supplement 1. *Number of standardised surveys conducted per year at each site of Yalgorup Lakes between 1986 and 2024. The vertical line shows year 1996, which was the first year considered in the trend analysis.*

Table 2

Hooded Plover abundance (95% Confidence Interval, CI) predicted by the Generalised Additive Mixed Model (GAMM) at each site and across all sites (Site = Total all Lakes) in the first and last year of the survey period, and the percentage of change in adult abundance (95% CI) predicted between the first and last year. Bold percentages of change indicate that the CI does not include zero. Sites are sorted by percentage of change.

Site	Period	Predicted First Year (95% CI)	Predicted Last Year (95% CI)	% Change (95% CI)
Total all Lakes	1996 - 2024	76.38 (56.48–101.29)	18.20 (13.32–23.98)	**-75.62%** (-84.52– -65.13)
Lake Preston north	1998 - 2024	23.70 (15.88–33.72)	0.15 (0.07–0.29)	**-99.30%** (-99.78– -98.38)
Boundary Lake	2001 - 2016	7.29 (4.62–10.67)	0.64 (0.29–1.15)	**-90.39%** (-96.89– -77.95)
Lake Preston mid	1998 - 2024	3.73 (1.93–6.16)	0.40 (0.17–0.74)	**-87.44%** (-96.79– -66.74)
Lake Hayward	1996 - 2024	1.62 (0.79–2.69)	0.20 (0.07–0.38)	**-85.90%** (-96.65– -60.84)
Swan Pond	2001 - 2016	3.74 (2.83–4.87)	0.73 (0.40–1.19)	**-79.97%** (-90.68– -63.32)
Lake Clifton north	2000 - 2023	4.72 (3.38–6.36)	1.14 (0.63–1.84)	**-74.62%** (-88.63– -50.48)
Lindas Lagoon	2001 - 2012	1.62 (1.07–2.36)	0.45 (0.25–0.73)	**-71.10%** (-85.69– -49.83)
Duck Pond	2001 - 2016	4.53 (3.18–6.27)	1.54 (0.94–2.29)	**-64.10%** (-83.60– -33.77)
Lake Newnham	1997 - 2024	2.32 (1.88–2.85)	0.96 (0.67–1.31)	**-58.20%** (-73.10– -39.30)
Lake Yalgorup	1996 - 2024	5.47 (3.95–7.39)	2.62 (1.46–4.01)	**-50.18%** (-76.97– -10.84)
Lake Pollard	1996 - 2024	5.55 (3.85–7.61)	4.66 (3.19–6.39)	-12.94% (-52.49– 39.54)
Martins Tank	1996 - 2024	6.62 (5.53–7.83)	6.93 (4.84–9.47)	5.40% (-29.90– 45.88)

Banding program and dispersal

A leg banding program was implemented from 2002 to gather information on the distribution and movement patterns of Hooded Plovers between the Yalgorup Lakes. Fifty Hooded Plover individuals, 20 adults and 30 chicks, were colour banded by accredited A class banders. Initially coloured leg bands were used and later coloured leg flags. The banding efforts ended in April 2013 although monitoring of band resightings continued until 2022. Adults were captured using pull nets (22) and loop mats (3), whereas chicks were hand captured (25) (Baird and Dann 2003; Weston 2000). Annual banding reports were produced outlining the findings and movements of Hooded Plover within the Yalgorup National Park (Russell 2007).

RESULTS

A total of 5,149 surveys were conducted at the Yalgorup Lakes between 1986 and 2024. Of these, 4,222 corresponded to surveys of standardised transects that were considered for trend analysis (Table 1, Supplement 1). The average number of adults recorded at each site during the study period ranged between 0.69 (Lindas Lagoon) and 12.50 (Lake Clifton South), while the average number of juveniles ranged between 0.10 (Lake Hayward and Lake Newnham) and 1.59 (Duck Pond) (Table 1).

Population trend

After excluding targeted nest visits and surveys of unknown spatial coverage, 3,772 surveys between 1996 and 2024 at 12 sites remained for our trend analysis (Table 1). The GAMM model explained 33.6% of the deviance in the data. All smooth terms were statistically significant at the 0.05 level (i.e., p-value < 0.05), including year and month.

Adult abundance remained stable between 1996 and 2005, then declined steadily to 2024 (Fig. 2A). Estimated abundance dropped from 76.4 (95% CI: 56.5-101.3) adults in 1996 to 18.2 (13.3-24.0) in 2024 – a 75.6% decline (65.1-84.5%) (Table 2).

Temporal patterns varied among sites (Fig. 2B). Boundary Lake, Lake Preston North and Lindas Lagoon showed continuous declines; Duck Pond, Lake Hayward, Lake Preston Mid and Swan Pond were stable until the early 2000s then declined; and Lake Clifton North, Lake Newnham, Lake Pollard, Lake Yalgorup and Martins Tank peaked around 2005 before declining. Visual inspection of counts against year suggested similar patterns at Lake Clifton South (peak ≈ 2010) and Lake Preston South (continuous decline) (Supplement 2).

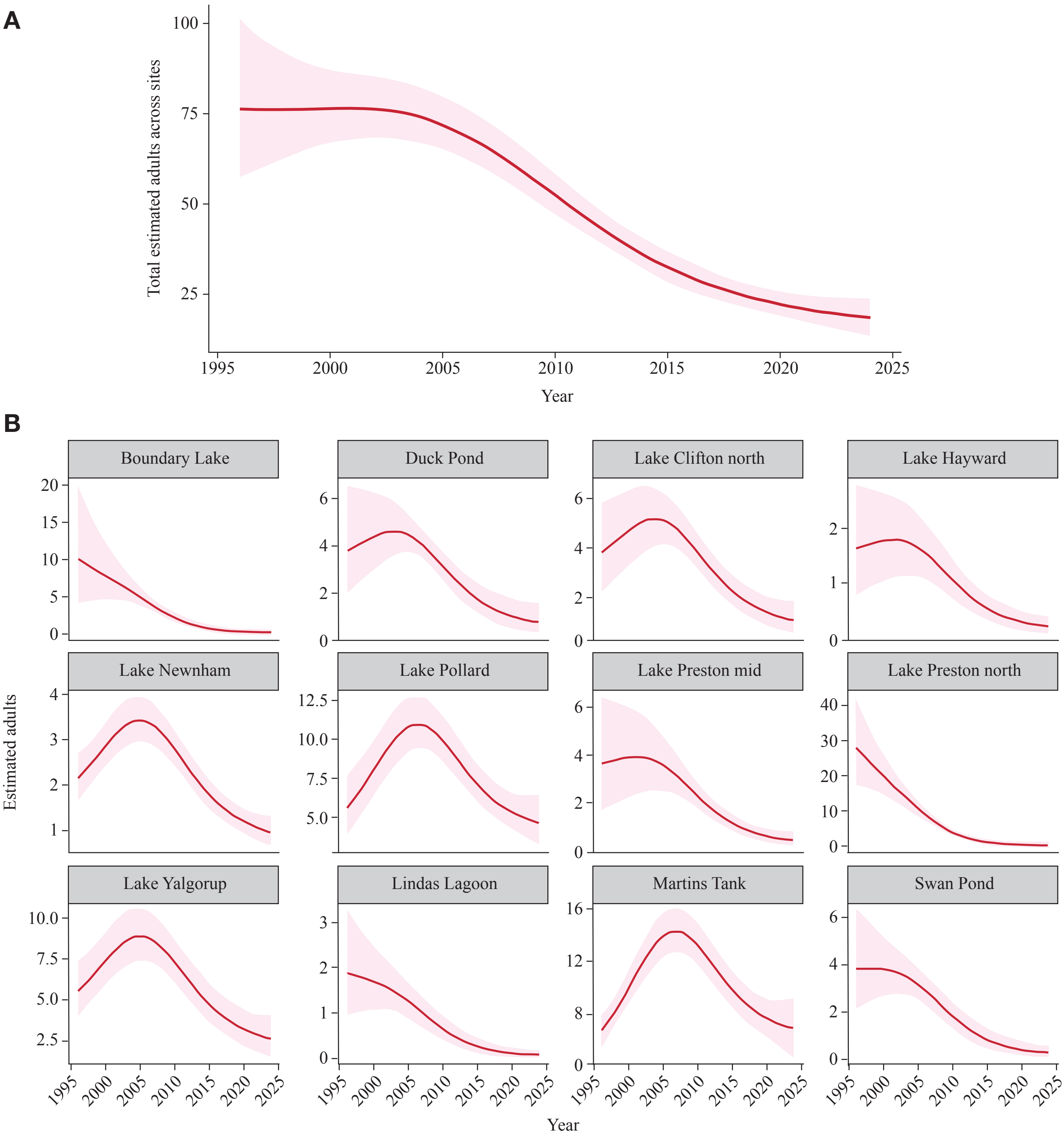
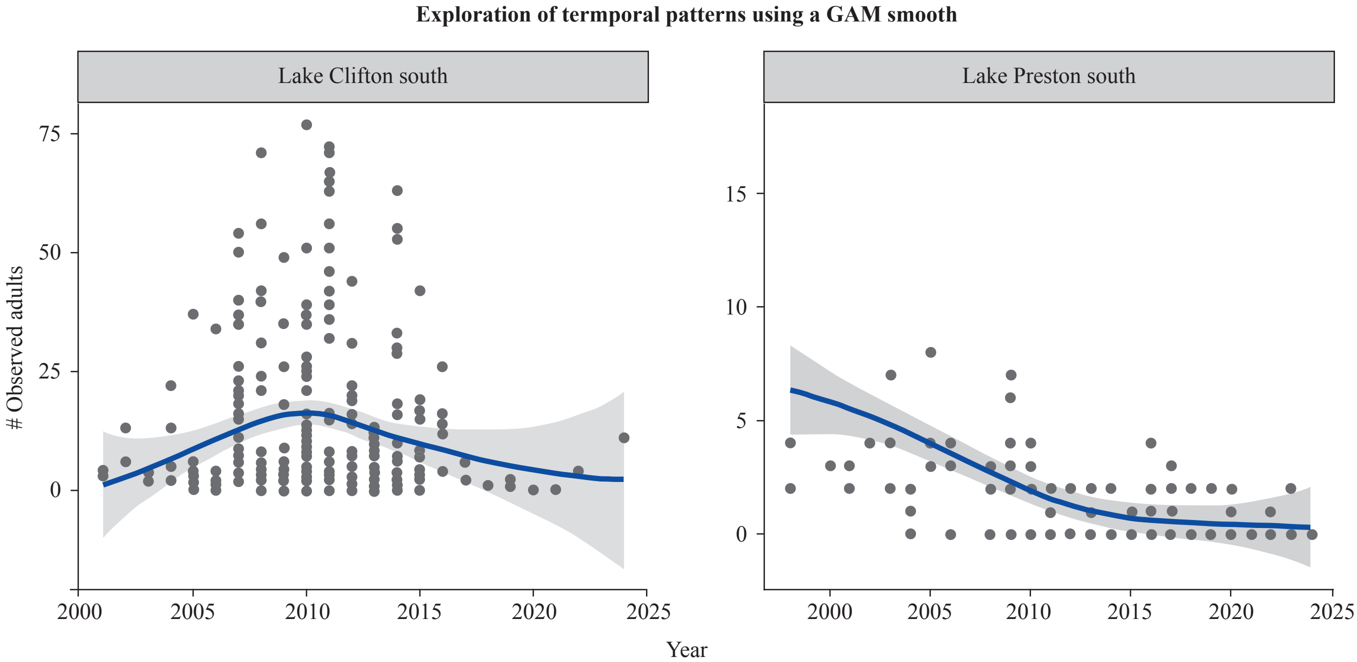


Figure 2. *Generalised Additive Mixed Model (GAMM) estimates (lines) and their 95% confidence intervals (shaded ribbon) of the average number of Hooded Plover adults over time, keeping month constant at February.* **A**. *Estimated total number adults across all modelled sites between 1996 and 2024.* **B**. *Estimated number of adults at each of the 12 modelled sites between 1996 and 2024.*

Ten of 12 sites showed a significant decline in the predicted adult abundance (50-99% reductions; Table 2), with no significant increases detected. Lake Preston North, which had the highest initial abundance, experienced the largest decline (99%). Only Lake Pollard and Martins Tank showed no statistically significant change.

Seasonal patterns and flocking

The estimated number of adult Hooded Plovers peaked in summer (December-February) and were the lowest in winter (June-July) (Fig. 3). Following a January peak, numbers declined steadily to June before increasing again.



Supplement 2. *Visual inspection of the relationship between year and number of Hooded Plover adults observed at Lake Clifton South and Lake Preston South. Data points are the raw counts for each survey and year. Blue lines and shaded ribbons are trends and 95% confidence intervals estimated for the raw adult counts using the function geom_smooth of the R package ggplot2 with a gam smooth.*

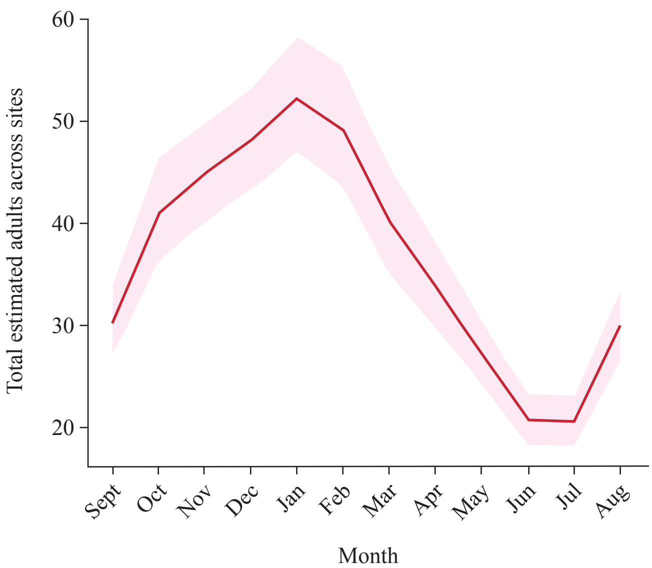


Figure 3. *Estimated total number adults (line) across all modelled sites and 95% confidence intervals of the estimates (shaded ribbon) over months (September to August), keeping year constant at 2010.*

The largest flock (81 individuals) occurred at Lake Clifton South in March 2010. Flocks typically formed between December and March, occasionally extending from November to April (Fig. 4). Flock sizes declined across all lakes during the study period, and after 2015, all flocks were below 40 individuals (Fig. 4).

When flocks were located at some of the smaller lakes, they did not remain there for long. The flocking sites often had wide beaches and were close to seepage points (Figs. 5-6). Large flocks (20-70 individuals) were frequent at Lake Preston North from 1997-2009 but fell sharply thereafter, with only seven flocks of 4-12 individuals observed there after 2009.

Breeding

Between 1996 and 2024, 219 breeding events were recorded (118 nests with eggs, and 101 during chick phase), with 2-16 occupied territories per year (i.e., September to August). Lake Preston South supported the highest number of breeding territories (up to nine in 2002/03). We observed active breeding in all months except July, peaking in December-February (Fig. 7).

Breeding was widespread across lakes, occurring annually at Lake Preston South and Martins Tank, and every few years at the other lakes. Territories were repeatedly reused across years, although not all territories were occupied within the same year, with nests in three main habitat types: **(1)** limestone headlands near the waterline, **(2)** sandy beaches between the waterline and vegetation and **(3)** dry lakebeds near seepage zones.

Of the 118 nests with eggs (249 eggs total), 55 failed (46%), 36 had unknown fates (31%), 12 hatched (10%) and 15 produced fledglings (13%). Of the 12 hatched nests, chicks from four nests likely failed and the remaining eight nests had unknown fates. We could determine the fate of 171 eggs (from 82 nests), which produced 49 chicks and 25 fledglings, equating to a hatching success rate of 0.29 chicks/egg and 0.15 fledglings/egg. The remaining 101 breeding events were found during the chick stage, with a total of 193 chicks, 78 of which were confirmed to have fledged from 43 nesting attempts. We also recorded at least 95 juveniles during breeding events that we could not allocate to any known nesting attempt.

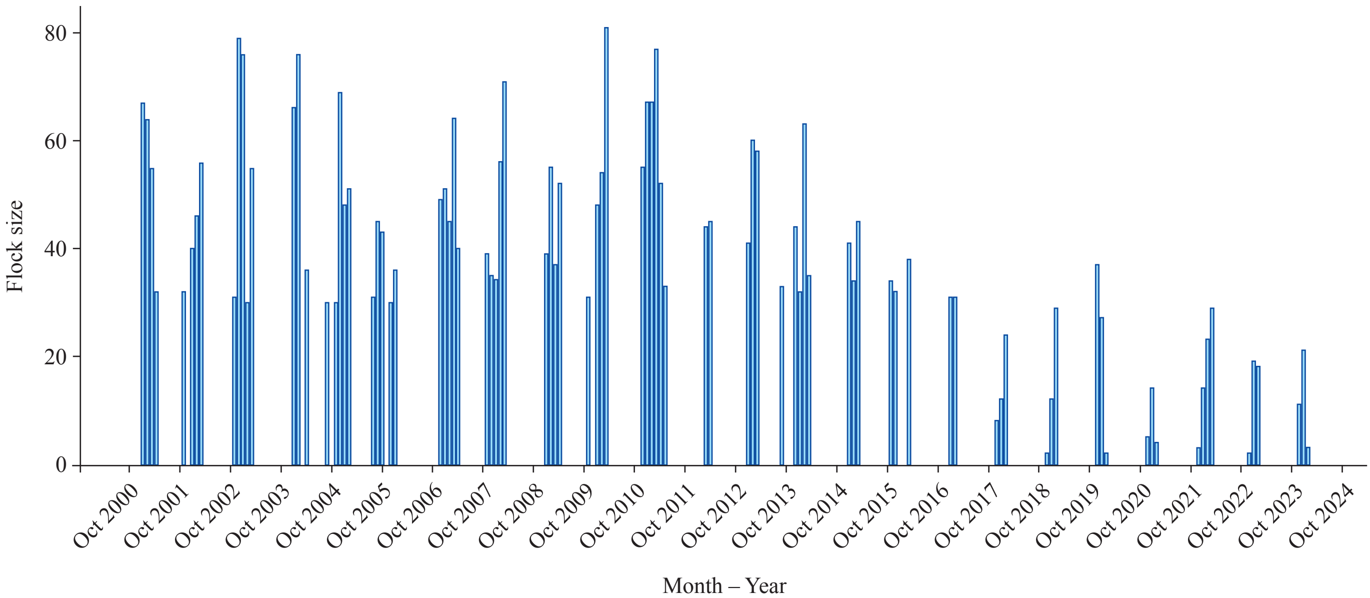


Figure 4. *Maximum flock size in each month between 2001 and 2024 across all Yalgorup Lakes. Months without a bar indicate that no flocks were recorded.*

Figure 5. *Western Hooded Plover flock comprising eight adult and two immature birds at Lake Pollard in Yalgorup National Park, January 8, 2020.*

Photo: Bill Russell.

Figure 6. *Western Hooded Plovers gathered on Martins Tank's wide beach at Yalgorup National Park, December 12, 2019.*

Photo: Bill Russell.

A diversity of threats and causes of nest failure were identified. Causes of nest failure included flooding (four nests at Lake Preston South), predation by Silver Gulls *Chroicocephalus novaehollandiae* (1 nest at Lake Clifton South and 2 at Lake Preston South), Fox *Vulpes vulpes* predation (1 at each Lake Preston, Lake Pollard and Martins Tank), and quad bike disturbance (2 at Lake Preston South). The causes of failure were unknown for 50 nests (91%).

Banding and dispersal

Of 50 banded individuals, 45 (90%) were resighted – 18 adults and 27 chicks. Twenty-four chicks (80% of banded chicks) were resighted as juveniles (3), sub-adults (3) and adults (18) within the Yalgorup Lakes (at four different sites on average). Six of the 20 banded adults were observed breeding within the lakes, and on average, each adult was observed at three different sites within the Yalgorup Lakes. Banded chicks were observed for three days to 11.2 years post-banding (mean ± SD = 855 ± 1,061 days), and adults were seen for a month to eight years (1,777 ± 741 days).

Resightings of individuals banded as chicks showed that after fledging, most juveniles joined mixed flocks of adults and other juveniles and moved between lakes within Yalgorup National Park. Nineteen of the 24 resighted chicks were observed away from the banding site within 22-155 days since banding and at one to four different sites during their immature stage. Three of the chicks bred at least once within the Yalgorup Lakes, including an individual that bred at Lake Newnham six times between 2011 and 2022, and once at Lake Hayward in January 2020 (Table 3).

All resightings but two were made at the Yalgorup Lakes, within 34 km of the banding site, and two long-distance movements were recorded. An adult travelled 171 km between Yalgorup Lakes and Lake Norring (33°27′00 S 117°17′36 E) in January 2007, returning 21 months later (Table 3). Another

Table 3

Selected resightings of banded Hooded Plover, and the associated movements, recorded in Yalgorup National Park between 2002 and 2022. No. = number of individual banded out of the total 50; Distance (km) = estimated distance in straight line between consecutive sightings; Reference = report or study with more details about the sighting.

No.	Site banding	Date banded	Age banded	Resighting	Distance (km)	References
5	Boundary Lake	3 Feb 2002	Adult	2002–2006: Most lakes inside Yalgorup NP	35	Singor (2005)
				27 Jan 2007: Lake Norring	171	
				28 Mar 2007: Yalgorup NP	171	
16	Lake Pollard	28 Feb 2004	Chick	2004–2005: Fledged, with flock within Middle Lakes (Yalgorup NP)	6	Singor (2005)
21	Martins Tank	20 Mar 2004	Adult	2004–Jan 2012: Martins Tank each year	Within Yalgorup NP	
29	Martins Tank	17 Feb 2008	Chick	Sep 2008: Yalgorup NP	Within Yalgorup NP	
				3 Jan 2009: Flagstaff Lake (with a flock)	167	
30	Martins Tank	17 Feb 2008	Chick	2008–March 2016: Middle Lakes (Yalgorup NP)	Within Yalgorup NP	
34	Lake Pollard	3 Aug 2009	Chick	2009–Jan 2017: Yalgorup NP (with flocks)	Within Yalgorup NP	
42	Martins Tank	7 Dec 2010	Chick	20 Nov 2011: Lake Newnham (breeding)	1	
				17 Mar 2012: Lake Clifton South	7	
				1 Jan 2020: Lake Hayward (breeding)	1	
				12 Mar 2022: Lake Yalgorup	4	

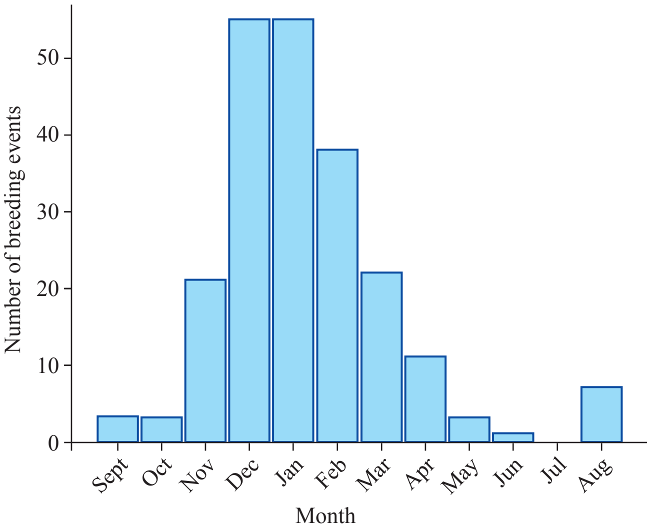


Figure 7. *Number of breeding events recorded in each month across all Yalgorup Lakes during the study period.*

1-year old bird travelled 167 km between Yalgorup Lakes and Flagstaff Lake (33°30′39 S 117°15′26 E), where it was seen with a flock in January (Table 3). The individual was then observed at Yalgorup each summer between 2010 and 2016 (Table 3).

DISCUSSION

The Hooded Plover population in Yalgorup National Park has been monitored for 30 years since the mid-1990s. Despite variable survey coverage, our analysis revealed a steep 75% decline in adult numbers between 1996 and 2024, from 76 (95% CI: 56.48-101.29) to 18 (13.32–23.98). Although data from Lake Clifton South and Lake Preston South were unsuitable for modelling, visual inspection indicated similar trends, supporting a significant overall decline across Yalgorup (Supplement 2). This is a steeper decline than in some regions in the eastern range: 33% in Victoria from 1980-2008 (Birds Australia 2008), 58% on Phillip Island from 1981-1997 (Baird and Dann 2003), 25% on Kangaroo Island from 1985-2004 (Dennis and Masters 2006). Our findings show steep declines of western Hooded Plover in a stronghold of Western Australia, supporting concerns that the subspecies is declining (Garnett and Baker 2021) and warranting a reassessment of its national conservation status.

The Yalgorup lake system provides scarce and highly suitable habitat on the Swan Coastal Plain region (Hale 2008), suggesting the decline showed here is unlikely to be due to dispersal to other areas. Given the small, estimated size of the western population (*c.* 2,250 mature individuals) and suspected ongoing decrease (Garnett and Baker 2021), the decline in Yalgorup likely represents part of a broader state-wide trend. Declines in other resident inland shorebirds have been linked to wetland degradation and altered water regimes (Clemens *et al.* 2016), threats expected to intensify under climate change (Finlayson *et al.* 2013), which will increase the pressure on inland Hooded Plover populations. While monitoring of Hooded Plover populations along beaches in south-western Western Australia is increasing (e.g., Ekanayake 2025), standardised and sustained surveys of inland and coastal lake populations remain a critical gap. Collating existing datasets and applying appropriate statistical approaches should be a priority.

Population declines in the Eastern Hooded Plover have been attributed to low breeding success (Weston 2003). Reported hatching rates ranged from 18-40% of nests in the 1980s and 1990s across different regions of Victoria, South Australia and Tasmania (Buick and Paton 1989; Hanisch 1998; Dowling and Weston 1999; Weston 2000; Weston and Morrow 2000; Baird and Dann 2003), with fledging success as low as 0.067 fledglings per egg on Phillip Island between 1992 and 1996 (Baird and Dann 2003). In Yalgorup, at least 21% of nests hatched and fledging success averaged 0.15 fledglings per egg (0.10 under worst-case assumptions, where all eggs with unknown fate failed), exceeding breeding success metrics reported for some eastern populations. However, high uncertainty around breeding success and how it has varied across years remain due to variable survey effort, particularly in Lake Preston South, a high proportion of nests of unknown fate and high number of juveniles of unknown origin. Hence, the extent to which local breeding contributes to the Yalgorup population is unclear, and further confounded by visiting birds whose productivity elsewhere likely influences local abundance as well. Continued standardised surveys to monitor breeding and systematic nest searches are needed to better quantify breeding effort, success and recruitment.

The main causes of the reduced breeding success in Eastern Hooded Plover are human disturbance, predation and habitat loss. Human disturbance is greatest on popular beaches, and intensive management to mitigate human threats, such as egg crushing and off-leash dogs, have proven effective (Maguire *et al.* 2014). We suspect, however, that human disturbance is lower at the Yalgorup Lakes nesting sites compared to the beaches in eastern Australia, as most of the lakes' shoreline have difficult access and do not receive many visitors (M. Singor, *pers. obs.*). Nonetheless, we found quad bike tracks near two failed nests, and vehicles are known to disturb shorebirds and kill shorebirds globally (Schlacher *et al.* 2025). Systematic recording of human activity indicators (e.g. footprints, dog prints, vehicle tracks) is needed to assess disturbance levels, particularly given proposed developments near the park that may increase visitation and cumulative pressures (Raines 2002). Even remote areas with low human disturbance can experience high nest failure due to predation and flooding (Maguire *et al.* 2014; Sanchez and Maguire 2025). We documented predation by Silver Gulls and foxes, and flooding events, although causes of failure were unknown for 50 of 55 failed nests. Deploying nest cameras would help identify causes of failure and inform targeted management actions, such as ongoing fox control and proposed cat baiting by the Department of Biodiversity, Conservation and Attractions (DBCA).

Hooded Plovers from inland lake systems depart the dried-out lakes in search of new feeding sites and join non-breeding flocks at Yalgorup and other coastal lakes (Singor 2019). Banding resightings revealed that at least two locally banded individuals travelled over 150 km to inland lakes and later returned to Yalgorup, movements first documented by Singor (2009) and confirmed by subsequent records showing one individual present in Yalgorup flocks each summer from 2010 to 2016. Recruitment of banded chicks into the local breeding population was low (three of 15 banded chicks observed as adults within Yalgorup), and only six of the 20 banded adults were observed breeding at Yalgorup, while 12 were seen only in flocks. These observations suggest that many of the flocking birds observed in Yalgorup breed inland – several inland breeding locations were identified by Elson and Singor (2008) – and the decline in flock size likely reflects reduced health or productivity of inland breeding populations. Regular monitoring in inland lakes and further banding efforts would help increasing the likelihood of observing more banded birds and identify breeding location of flocking birds outside of Yalgorup.

Salt lakes in south-west Western Australia are threatened by reduced rainfall, increased salinity, mining, groundwater extraction and pollution (Timms 2005). Increased salinity and reduced water surface have been linked to reduced food availability and waterbird abundance at saline lakes in many parts of the globe (e.g., Senner *et al*. 2018), and there are also examples of adult mortality caused by pollutants (Schroeder *et al*. 1988). Secondary salinisation is particularly widespread in the region and degrades lake ecosystems, but its effects on invertebrate communities – the primary food source of shorebirds – remain poorly understood (Lawrie *et al.* 2021). Non-breeding Hooded Plovers at Lake Gore mainly feed on *Coxiella* sp. (Weston 2007), an endemic gastropod tolerant of extreme salinities (Lawrie *et al.* 2024), though Hooded Plover diet at salt lakes likely includes diverse invertebrates given the region's richness (Lawrie *et al.* 2021). Local extinctions of *Coxiella* seem to have occurred in south-west Western Australia (Lawrie *et al.* 2024), and local extirpations of other invertebrate species in the region have been linked to increasing salinity and aridity (Atkinson *et al.* 2021; Timms *et al.* 2009). Salinity and dry periods have also intensified at Yalgorup Lakes (Hale and Butcher 2007), and Whitehead (2012) identified increasing salinity as the greatest threat to the survival of invertebrates in hypersaline sections of Lake Preston (e.g., northern section). Hence, it is likely that salinisation and aridity are reducing food availability for Hooded Plovers and other shorebirds in the Yalgorup Lakes.Limited prey at Lake Preston North may partly explain the sharp decline there, though targeted invertebrate surveys over time are needed to confirm this (but see Whitehead 2012). Extended dry periods may also reduce the cooling benefits of wet substrates (Ryeland *et al.* 2021), while hypersaline conditions may impose physiological stress and may impair bird condition (Gutiérrez 2014). Conversely, persistently high water levels from heavy rainfall or water mismanagement can inundate feeding and breeding habitats, flooding eggs and limiting reproductive success (Elson and Singor 2008). However, moderate rainfall following events such as cyclones can also create new breeding habitat (Elson and Singor 2008), highlighting that the balance of water levels is critical for suitable foraging and nesting conditions. With salinisation, drought and extreme rainfall expected to intensify (State of the Climate 2024), targeted research on their effects on food availability and breeding outcomes is essential – not only for Hooded Plovers, but also for the many migratory shorebirds that share these inland salt lakes and rely on similar habitats and prey. Where possible, investigating management options to increase habitat availability in productive areas may be beneficial (Jackson *et al.* 2024).

Predation pressure may also play a role in the health of inland populations. Elson and Singor (2008) documented high fox activity during November and December 2006-2008 in inland and coastal lakes, including fox tracks leading from Hooded Plover nests. The frequency of fox tracks also appears to have increased at sites near Esperance (WA South Coast Shorebird Network 2012). However, nest failure and bird mortality due to fox (or cat) predation have not been quantified. Another threat is the use of nesting inland sites for grazing cattle, which degrades feeding and breeding habitat and pose a risk of crushing nests (Elson and Singor 2008; Garnett and Baker 2021). In 2018, cattle-proof fences around some lakes in the North Stirling region were installed to protect Hooded Plover nesting sites (Green Skills 2018). Continued monitoring will be needed to assess the effectiveness of fencing and to understand the potential impact of predation on these inland breeding populations.

CONCLUSIONS

We found strong evidence of a 75% decline in adult Hooded Plovers in Yalgorup National Park between 1996 and 2024. The causes of this decline remain uncertain, but likely involve multiple, subspecies-specific factors linked to the health of inland populations. We propose that predation and habitat degradation linked to rising salinity and reduced rainfall at birds' inland breeding sites are likely to have a negative impact in inland breeding populations, which resulted in the decrease of flock sizes in Yalgorup. Continued degradation of Yalgorup's feeding and nesting habitats may also contribute to the decline. Targeted monitoring of inland breeding sites and enhanced breeding monitoring within Yalgorup, systematic recording of threats and research on impacts of habitat degradation and predation are priorities. The steep decline documented here warrants reassessment of the subspecies' national conservation status, likely meeting criteria for listing under the EPBC Act.

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REFERENCES

Atkinson, S.T., Cale, D., Pinder, A., Chambers, J.M., Halse, S.A. and Robson, B.J. (2021). Substantial long-term loss of alpha and gamma diversity of lake invertebrates in a landscape exposed to a drying climate. *Global Change Biology* **27**(23): 6263-6279. https://doi.org/10.1111/gcb.15890

Baird, B. and Dann, P. (2003). The breeding biology of Hooded Plovers *Thinornis rubricollis* on Phillip Island, Victoria. *Emu* **103**(4): 323-328. https://doi.org/10.1071/MU02031

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). *The New Atlas of Australian Birds*. Royal Australasian Ornithologists Union, Hawthorn East.

Bayraktarov, E., Ehmke, G., Tulloch, A.I.T., Chauvenet, A.L., Avery-Gomm, S., McRae, L., Wintle, B.A., O'Connor, J., Driessen, J., Watmuff, J., Nguyen, H.A., Garnett, S.T., Woinarski, J., Barnes, M., Morgain, R., Guru, S. and Possingham, H.P. (2021). A threatened species index for Australian birds. *Conservation Science and Practice* **3**(2): e322. https://doi.org/10.1111/csp2.322

BirdLife International (2016). *Thinornis cucullatus*. *The IUCN Red List of Threatened Species* 2016: e.T22693883A93429190. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22693883A93429190.en [Accessed 12 September 2025]

Birds Australia (2008). *November 2008 Biennial Hooded Plover Count*. Unpublished report. Birds Australia, Melbourne. https://beachvol.birdlife.org.au/mod/folder/view.php?id=190 [Accessed 26 September 2025]

Bolker, B.M., Brooks, M.E., Clark, C.J., Geange, S.W., Poulsen, J.R., Stevens, M.H.H. and White, J.-S.S. (2009). Generalized linear mixed models: a practical guide for ecology and evolution. *Trends in Ecology & Evolution* **24**(3): 127-135.

Buick, A.M. and Paton, D.C. (1989). Impact of off-road vehicles on the nesting success of Hooded Plovers *Charadrius rubricollis* in the Coorong region of South Australia. *Emu* **89**: 159-172.

Clemens, R., Rogers, D., Hansen, B., Gosbell, K., Minton, C., Straw, P., Bamford, M., Woehler, E., Milton, D., Weston, M., Venables, B., Weller, D., Hassell, C., Rutherford, B., Onton, K., Herrod, A., Studds, C., Choi, C.-Y., Dhanjal-Adams, K. and Fuller, R. (2016). Continental-scale decreases in shorebird populations in Australia. *Emu* **116**: 119-135. https://doi.org/10.1071/MU15056

Davison, A.C. and Hinkley, D.V. (1997). *Bootstrap Methods and Their Application*. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511802843

Dennis, T.E. and Masters, P. (2006). Long-term trends in the Hooded Plover *Thinornis rubricollis* population on Kangaroo Island, South Australia. *South Australian Ornithologist* **34**(7-8): 258-266.

Dowling, B. and Weston, M.A. (1999). Managing a breeding population of the Hooded Plover *Thinornis rubricollis* in a high-use recreational environment. *Bird Conservation International* **9**: 255-270.

Ekanayake, K. (2025). *Report on the 2024 Biennial Hooded Plover Population Count*. BirdLife Australia, Melbourne. https://beachvol.birdlife.org.au/public_files/42/Report%20on%20the%202022%20Biennial%20Hooded%20Plover%20Population%20Count.pdf [Accessed 20 September 2025]

Elson, S.J. and Singor, M.J.C. (2008). Hooded Plover *Thinornis rubricollis tregellasi* breeding data from Western Australia. *Stilt* **53**: 6-12.

Finlayson, C.M., Davis, J.A., Gell, P.A., Kingsford, R.T. and Parton, K.A. (2013). The status of wetlands and the predicted effects of global climate change: the situation in Australia. *Aquatic Sciences* **75**(1): 73-93. https://doi.org/10.1007/s00027-011-0232-5

France, T. (2003). Anthology of Hooded Plover behaviour (Part 1). *Western Australian Bird Notes* **108**: 1-4.

Garnett, S.T. and Baker, G.B. (2021). *The Action Plan for Australian Birds 2020*. CSIRO Publishing, Melbourne.

Gelman, A. and Hill, J. (2007). *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge University Press, New York.

Green Skills (2018). *Hooded Plover and Salt-Lakes Foreshore Conservation, North Stirlings, WA: Project Report for Feb-March 2018*. Green Skills Inc., Perth, Western Australia. https://static1.squarespace.com/static/5f573d9a9d70eb09a8e9ec77/t/623aa3e8c82c4203ad259bde/1648010233736/15+Cranbrook+Lakes+and+Hooded+Plover+Report+v18+May+2018s.pdf [Accessed 25 September 2025]

Gutiérrez, J.S. (2014). Living in Environments with Contrasting Salinities: A Review of Physiological and Behavioural Responses in Waterbirds. *Ardeola* **61**(2): 233-256. https://doi.org/10.13157/arla.61.2.2014.233

Hale, J. (2008). *Monitoring and Evaluation Guide for the Peel-Yalgorup Ramsar Site*. Report to the Peel-Harvey Catchment Council and Department of Environment and Conservation, Perth.

Hale, J. and Butcher, R. (2007). *Ecological Character Description of the Peel-Yalgorup Ramsar Site*. Report to the Department of Environment and Conservation and the Peel-Harvey Catchment Council, Perth.

Hanisch, D. (1998). *Effects of Human Disturbance on the Reproductive Performance of the Hooded Plover*. Unpublished BSc (Hons) thesis, University of Tasmania.

Harrison, P.J., Buckland, S.T., Yuan, Y., Elston, D.A., Brewer, M.J., Johnston, A. and Pearce-Higgins, J.W. (2014). Assessing trends in biodiversity over space and time using the example of British breeding birds. *Journal of Applied Ecology* **51**(6): 1650-1660. https://doi.org/10.1111/1365-2664.12316

Hartig, F. (2024). *DHARMa: Residual Diagnostics for Hierarchical (Multi-Level / Mixed) Regression Models*. doi:10.32614/CRAN.package.DHARMa, R package version 0.4.7, https://CRAN.R-project.org/package=DHARMa.

Jackson, M.V., Mott, R., Delean, S., Hunt, B. J., Brookes, J.D., Cassey, P. and Prowse, T.A.A. (2024). Shorebird habitat selection and foraging behaviour have important implications for management at an internationally important non-breeding wetland. *Ecological Solutions and Evidence* **5**: e12316. https://doi.org/10.1002/2688-8319.12316

Johnstone, R. and Storr, G.M. (1998). *Handbook of Western Australian Birds. Volume 1*. Western Australian Museum, Perth.

Lawrie, A.D., Chaplin, J. and Pinder, A. (2021). Biology and conservation of the unique and diverse halophilic macroinvertebrates of Australian salt lakes. *Marine and Freshwater Research* **72**(11): 1553-1576. https://doi.org/10.1071/MF21088

Lawrie, A.D., Chaplin, J., Rahman, M., Islam, M.A. and Pinder, A. (2024). Experimental and field evidence suggests extreme salinity tolerances in *Coxiella* gastropods from Australian salt lakes. *Hydrobiologia* **851**(1): 205-221. https://doi.org/10.1007/s10750-023-05329-w

Maguire, G., Cullen, M. and Mead, R. (2014). *Managing the Hooded Plover in Victoria: A Site-by-Site Assessment of Threats and Prioritisation of Management Investment on Parks Victoria Managed Land*. Report to Parks Victoria, Melbourne.

Marchant, S. and Higgins, P.J. (eds) (1993). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings*. Oxford University Press, Melbourne.

Newbey, B. (2002). Hooded Plover breeding at Lake Preston over two seasons. *Western Australian Bird Notes* **103**: 23-25.

Pedersen, E.J., Miller, D.L., Simpson, G.L. and Ross, N. (2019). Hierarchical generalized additive models in ecology: an introduction with *mgcv*. *PeerJ* **7**: e6876. https://doi.org/10.7717/peerj.6876

Posit team (2025). *RStudio: Integrated Development Environment for R. Posit Software*. PBC, Boston, MA. URL http://www.posit.co/.

Puth, M. T., Neuhäuser, M. and Ruxton, G.D. (2015). On the variety of methods for calculating confidence intervals by bootstrapping. *Journal of Animal Ecology* **84**(4): 892-897. https://doi.org/10.1111/1365-2656.12382

R Core Team (2025). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Raines, J. (2002) Hooded Plover Management Plan (2002-2012) Western Australia. *Western Australian Bird Notes,* Supplement **No.7**: 12-14

Rule, D. and Singor, M. (2009). Waders in Yalgorup National Park, Western Australia. *Stilt* **56**: 23-28.

Russell, B. (2000). Waders in Yalgorup National Park. *Western Australian Bird Notes* **93**: 12-16.

Russell, B. (2004). Hooded Plover movements. *Western Australian Bird Notes* **110**: 9.

Russell, B. (2007). *Report on the Sightings of Colour-Banded Hooded Plovers in Yalgorup National Park*. Unpublished report.

Ryeland, J., Weston, M.A. and Symonds, M.R.E. (2021) The importance of wetland margin microhabitat mosaics; the case of shorebirds and thermoregulation. *Journal of Applied Ecology* **58**: 382-391 https://doi.org/10.1111/1365-2664.13769

Sanchez, S. and Maguire, G. (2025). Beach-nesting Birds within Corner Inlet: Monitoring of beach-nesting shorebird and seabird breeding success in Corner Inlet to assess the health of the RAMSAR site, 2024-2025. BirdLife Australia Report, Collingwood, Victoria, Australia.

Schlacher, T.A., Weston, M.A., Maslo, B., Dugan, J.E., Emery, K.A., Hubbard, D.M., Kelaher, B.P., Lastra, M. and Parsons, S. E. (2025). Vehicles kill birds on sandy beaches: the global evidence. *Science of the Total Environment* **975**: 179258. https://doi.org/10.1016/j.scitotenv.2025.179258

Schroeder, R.A., Setmire, J.G. and Wolfe, J.C. (1988) Trace elements and pesticides in the Salton Sea area, California. In: *Proceedings on Planning for Irrigation and Drainage*, 19-21 July 1988, (ed. D.R. Hay) pp. 700-707. Lincoln, Nebraska, USA, American Society of Civil Engineers, Irrigation and Drainage Division.

Senner, N.R., Moore, J.N., Seager, S.T., Dougill, S., Kreuz, K. and Senner, S.E. (2018). A Salt Lake under Stress: Relationships among Birds, Water Levels, and Invertebrates at a Great Basin Saline Lake. *Biological Conservation* **220**: 320-29.doi: 10.1016/j.biocon.2018.02.003.

Singor, M. (2005). Summary of Hooded Plover research in Yalgorup National Park. *Stilt* **47**: 40-44.

Singor, M. (2009). Inland movements of the Hooded Plover in Western Australia. *Stilt* **55**: 25-26.

Singor, M. (2019). Hooded Plover flocks. *Western Australian Bird Notes* **170**: 20-23.

State of the Climate (2024). CSIRO and Bureau of Meteorology, Government of Australia.

Timms, B. V. (2005). Salt lakes in Australia: present problems and prognosis for the future. *Hydrobiologia* **552**(1): 1-15. https://doi.org/10.1007/s10750-005-1501-x

Timms, B.V., Pinder, A.M. and Campagna, V.S. (2009). The biogeography and conservation status of the Australian endemic brine shrimp *Parartemia* (Crustacea: Anostraca: Parartemiidae). *Conservation Science Western Australia* **7**: 413-427.

WA South Coast Shorebird Network (2012). *WA South Coast Shorebird Network Newsletter*, Issue 4 - May 2012. Denmark, Western Australia. https://library.dbca.wa.gov.au/static/Journals/080129/080129-04.pdf [Accessed 25 September 2025]

Weston, M.A. (2000). *The Effect of Human Disturbance on the Breeding Biology of the Hooded Plover*. Unpublished PhD thesis, University of Melbourne.

Weston, M.A. (2003). *Managing the Hooded Plover in Victoria: A Review of Existing Information*. Parks Victoria Technical Series No. 4. Parks Victoria, Melbourne.

Weston, M.A. (2004). Managing the Hooded Plover – information gaps and research needs. In Straw, P. (ed.), *Status and Conservation of Shorebirds in the East Asian-Australasian Flyway: Proceedings of the Australasian Shorebirds Conference 13-15 December 2003, Canberra, Australia*. Wetlands International Global Series 18, International Wader Studies 17, Sydney, Australia.

Weston, M.A. (2007). The foraging and diet of non-breeding Hooded Plover *Thinornis rubricollis* in relation to habitat type. *Journal of the Royal Society of Western Australia* **90**: 89-95.

Weston, M.A., Clarke, K., Maguire, G.S. and Sumner, J. (2020). Morphological and molecular evidence of population divergence in a widespread shorebird across its southern mainland Australian distribution. *Conservation Genetics* **21**(4): 757-770.

Weston, M.A. and Morrow, F. (2000). *Managing the Hooded Plover in Western Victoria*. Threatened Bird Network Report to Parks Victoria, Melbourne.

Whitehead, M. (2012). Lake Preston: food chain dynamics and ecology. Personal publication.

Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag, New York.

Wickham, H., François, R., Henry, L., Müller, K. and Vaughan, D. (2023). *dplyr: A Grammar of Data Manipulation*. doi: 10.32614/CRAN.package.dplyr, R package version 1.1.4, https://CRAN.R-project.org/package=dplyr.

Wickham, H. and Henry, L. (2025). purrr: Functional Programming Tools. doi: 10.32614/CRAN.package.purrr, R package version 1.0.4, https://CRAN.R-project.org/package=purrr.

Wood, S.N. (2017). *Generalized Additive Models: An Introduction with R*, 2nd ed. Chapman and Hall/CRC.

Zuur, A.F., Ieno, E.N., Walker, N., Saveliev, A.A. and Smith, G.M. (2009). *Mixed Effects Models and Extensions in Ecology with R*. Springer, New York.