

Aerial Survey of Magpie Goose in the Top End of the Northern Territory

Moyle River Floodplains to Arnhem Land Floodplains May 2023



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Summary

A fixed-wing aerial survey of Top End coastal wetlands of the Northern Territory was undertaken from 16 April to 25 May, 2023 to estimate population size and nesting activity of Magpie Goose. A total of 8,268 km of fixed-width survey transects were flown using the standard methodology applied since 2011. The survey incorporated key floodplain habitats from Moyle River in the west to the Blue Mud Bay region of Arnhem Land in the east and covered 22,966 square kilometres (over 2 million ha) of potential habitat at a sampling intensity of 14.4%. All Magpie Goose and Magpie Goose nests sighted were recorded and corrected for bias using the correction factors derived from Bayliss and Yeomans (1990a & b).

The population estimate for Magpie Goose was $1,260,454 \pm 148,626$ (\pm standard error) with a coefficient of variation 11.8%; which is an average density of 54.9 geese per km² within the survey region. This is a decrease of 32.1 % on the 2022 estimate which at the time was believed to be slightly inflated estimate due to the later timing of some of the Moyle/Daly Blocks where large numbers of fledglings were counted. Decreases were recorded in both the Moyle River floodplains to Finnis River and the Adelaide River to Murguella survey regions.

This result signifies a population that has decreased in response to the average 2021/22 wet seasons noting that the declines are potentially exaggerated as the estimate for 2022 was considered high due to the late survey timing resulting in fledgling bird being counted in some survey blocks. The population level is below the most recent peak 2,900,000 recorded in 2012 (Clancy 2020a) but above the historical low population estimate recorded in 2017 of 724,500.

The number of Magpie Goose nests was estimated to be $45,900 \pm 5,932$ for the surveyed area with a coefficient of variation of 12.9 %. This was below 2022 nesting levels and would be considered a moderate nesting season. However, similar to 2021 and 2022 there was substantial variation in the timing of nesting and it is difficult to predict the level of recruitment going into 2024. The rainfall preceding the survey period was above the long-term average for the wet season across much of the survey region. Known factors impacting nesting habitat and key food resources, especially weeds and introduced buffalo and feral pig damage, continue to operate and are likely to influence population size.

Introduction

The wildlife management program for Magpie Goose (*Anseranas semipalmata*) in the Northern Territory of Australia 2020-2030 (WMP MG)(Clancy 2020a) sets out the management protocols to ensure the long-term conservation of wild populations of the Magpie Goose and its habitats in the Northern Territory, in the context of continuing sustainable harvest. A required management activity is the undertaking of an annual aerial survey monitoring program across the key floodplain habitat in the Top End (Northern Territory north of 15°S latitude) post the wet season. Surveys are timed to coincide with the period when birds are nesting and when the population is at its most geographically concentrated (to improve sampling efficacy, see Clancy 2020a).

The survey methods to be implemented to ensure continuity with previous surveys are set out in the WMP MG. The WMP MG also establishes population size thresholds that are used to determine safe offtake levels for recreational hunting, pest mitigation and any commercial harvest. This report presents the results of the 2023 aerial survey of the Top End floodplains (Figure 1). There was above average rainfall across much of the survey area of interest in the wet season of 2022/23, following on from average rainfall in 2021/22, widespread rains in 2020/21 and two consecutive poor wet seasons in 2018/19 and 2019/20.

All regions have been surveyed annually since 2017. From 2011 to 2016, Area 2 was surveyed annually and Area 1 on a biannual basis or more frequent basis. Area 3 was surveyed less regularly. See Clancy 2020a for details.

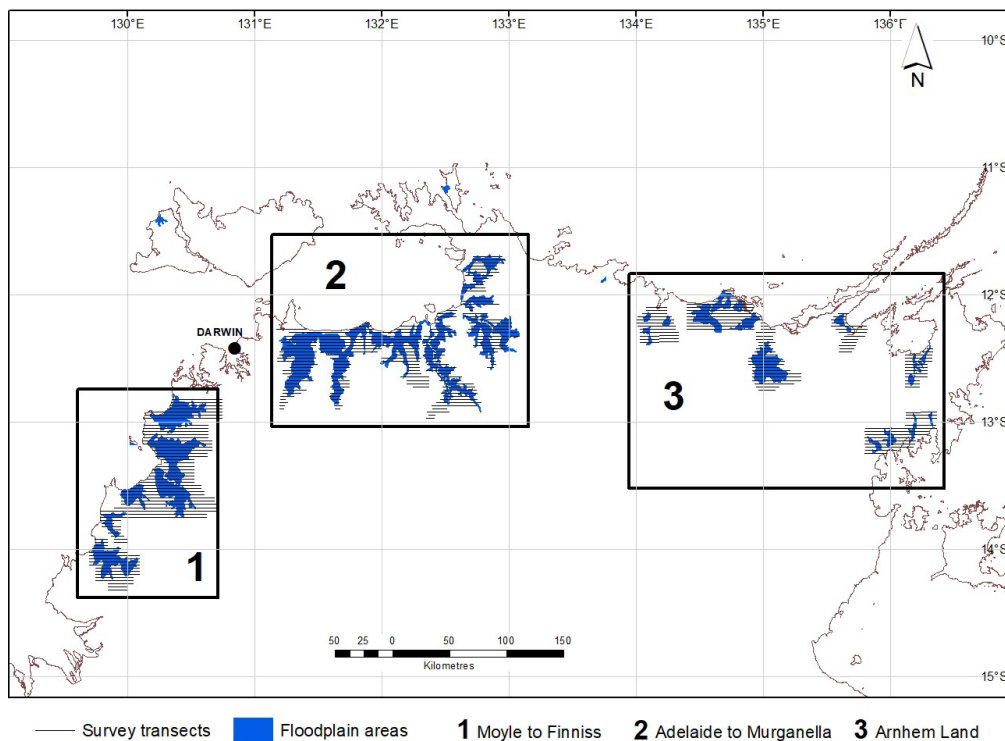


Figure 1: Map of the Top End of the Northern Territory showing the regions surveyed for Magpie Goose.

Overall population estimates from aerial surveys from 2015 to 2022 are given in Table 1. In 2015 and 2016 when some survey regions were not surveyed, the figures have been adjusted to give an estimated total in a *pro rata* manner relative to their contribution to the total counts (e.g. Arnhem Land is estimated to comprise 10% of total population in years when it was not surveyed).

This report deals with the 2023 aerial survey of the Top End wetlands as per the WMP MG (Clancy 2020a). It is believed that this surveyed area encompasses 90-95% of the total area of the Northern Territory Magpie Goose population at the time of the survey due to the use of the floodplains as breeding habitat and the reliance of birds on the lower floodplains for food during this period.

Table 1: Population and nest estimates (\pm standard error) for Magpie Geese from 2015 to 2022 derived from wet season aerial surveys. Estimates are adjusted to be comparable among years, independent of areas surveyed (Saalfeld 2015, Saalfeld 2016, Groom and Saalfeld 2017, Clancy 2020b).

Population Estimate
2015 to 2022

Year	Number of animals	Standard error	Number of nests	Standard error
2015	1,200,000	200,000	105,000	13,000
2016	1,350,000	136,000	40,000	6,000
2017	724,500	78,750	84,840	14,625
2018	918,200	117,000	77,840	14,250
2019	1,542,943	215,317	10,484	3,185
2020	1,432,793	211,784	39,723	7,743
2021	982,156	283,717	44,010	9,086
2022	1,856,935	250,620	62,674	17,895

Source: See Clancy, T.F (2022). *Aerial Survey of Magpie Goose numbers in the Top End of the Northern Territory: Moyle River Floodplains to Arnhem Land Floodplains*

Methods

Survey Area and Design

Contacts in the crocodile egg harvesting community and ranger groups were approached in early March 2023 regarding observations of magpie geese nesting activity on the floodplains. On 22 March 2023 there were reports by the Asyrikarrak Kirim Ranger Group of large aggregations of birds and some preliminary nest building occurring on Nyinji Nyinji floodplain region near Peppimenarti. Drone footage of geese activity in the region indicated that nesting should be well underway by mid April. It was decided to schedule the surveys from mid April in the Moyle Finnis area to overlap the likely peak in nesting. Feedback from crocodile egg harvesters operating on relevant floodplains obtained in March 2023 indicated that there was nesting in the Adelaide River and Mary River areas.

The Moyle River floodplains to Finnis River floodplains survey region (latitude 11° 50'S to 14° 20'S, longitude 129° 40'E to 130° 45'E) includes all major floodplains and wetland habitat within that region and was surveyed between 16 April, 2023 to 4 May, 2023. This area comprises six major survey blocks (Figure 2a).

The Adelaide River floodplains to Murgarella Creek floodplains survey region (latitude 11° 40'S to 13° 0'S, longitude 131° 10'E to 133° 0'E) includes all major floodplains and wetland habitat within that region (Figure 2b) and was surveyed between 18 April, 2023 to 13 May, 2023. This area was divided into nine major survey blocks.

The Arnhem Land floodplains survey region (latitude 12° 0'S to 13° 18'S, longitude 134° 10'E to 136° 21'E) includes all major floodplains and wetland habitat within that region (Figure 2c) and was surveyed between 22 May, 2023 to 25 May, 2023. This area was divided into six major survey blocks. Survey blocks were completed from east (based from Nhulunbuy) to west (based from Maningrida).

The survey was conducted using a Cessna 185F high-wing aircraft flown at a ground speed of 185 km/h (100 knots) and an altitude of 61 m (200 ft) above ground level. Altitude was maintained using a laser altimeter and the aircraft was fitted with Spidertracks Tracking, 406 GPS ELT. Where the transect had to traverse open water aircraft height was adjusted to maintain safe gliding range; in practice this did not impact on

survey areas as such occasions were very rare and did not occur in areas of significant Magpie Goose habitat. Transect width was demarcated by marker rods attached to the aircraft wing struts and calibrated (Marsh & Sinclair 1989) to give a transect width of 200 m on each side of the aircraft at survey altitude.

Transect lines flown on the survey were aligned east-west, i.e. perpendicular to the general north-south orientation of the major river systems, ridges and escarpments of the area (Figure 2). Transects were spaced at an interval of 1.5' of latitude (2.778 km) to give a survey intensity of 14.4% from the combined port and starboard transect width of 400 m. Navigation of transects was by Global Positioning System pre-programmed with all transect waypoints on Samsung Galaxy Tab 2 (7.0) using the OziExplorer Android GPS mapping software.

For all surveys two observers (Tim Clancy and either Cameron Winn, Keith Saalfeld, Brydie Hill or Tony Griffiths) were used unless indicated. Observers all have over 200 hours experience in aerial surveying for Magpie Goose with the exception of Cameron Winn who had previous extensive aerial and ground based surveying experience for waterbirds. On some survey flights an additional observer was present (generally a local Aboriginal Ranger group representative).

Counting Procedure

The survey crew comprised a pilot/navigator, a starboard front seat observer and a port mid-seat observer. The pilot and observers could communicate via aircraft intercom, and the pilot indicated the start and finish of each transect by calling either 'start transect' or 'finish transect'.

All data entry was via a iPhone 11 64 GB run in "flight" mode (to prevent mobile data connection during surveys and also to reduce power use and extend battery life) using the device's internal GPS receiver. Trials of GPS precision and accuracy found these devices had superior spatial location capabilities to the previously used HP iPaq rx5900 fitted with an external antenna.

Data were entered by observers using a purpose-built program written by Qingyuan Zeng (Zeng, Nugraeni and Clancy 2022) based on the previously used Basic program written by K. Saalfeld. Species recorded in 2023 were the same as for 2022 [Magpie Goose, Magpie Goose Nest, Jabiru (*Ephippiorhynchus asiaticus*), Brolga (*Grus rubicunda*), Feral Pig (*Sus scrofa*), Horse (*Equus caballus*, generally only feral counted), Buffalo (*Bubalus bubalis*) and Saltwater Crocodile (*Crocodylus porosus*)]. Number sighted and species code were entered by the observer upon sighting, or in the case of high densities as soon as practicable afterwards, with each record auto geo-coded on entry. This report deals only with the Magpie Goose and Magpie Goose nests observations.

Post Survey Data Handling and Editing

Data were downloaded daily from each observer's iPhone to a laptop computer and opened in Excel. Data were immediately checked for logged errors (signified by code 999 entered by the observer) as well as any apparent major errors in recording (e.g. transects wrongly coded by the observers). Files for each observer were merged on a survey block basis and converted from .csv format and uploaded to the RStudio desktop application (RStudio Team 2020) for analyses in R (R Core team 2020). Data files were run through a simple validation process via package "pointblank" (Iannone and Vargas 2020) to check for duplicated observations, missing values, non-conforming variable types and other anomalies (Appendix 1). For part of one survey block only one observer was available (TC) and the data from these lines was in-filled assuming the observer would have counted the same numbers (with the observer position recorded as null). As this was only a small fraction of the overall surveyed areas was assumed that this procedure did not introduce any bias into the overall estimate.

Analyses and Reporting

Because transects were variable in length and therefore area, the Ratio Method (Jolly 1969, Caughley and Grigg 1981, Marsh and Sinclair 1989) was used to estimate density, population size and their associated standard errors for the survey area. Input data were the observed numbers of each species for the port mid-seat and starboard front-seat observers. All species raw data were used in pre-analysis data checks including data validation described above; however, this report only deals with population estimates for Magpie Goose and their nests. Estimates were corrected for perception and visibility bias using the wet season correction

factors of Bayliss & Yeomans (1990a, b); 3.28 for Magpie Geese and 2.23 for Magpie Goose nests. All analyses were performed in RStudio (RStudio 2022.07.1+554 “Spotted Wakerobin” Release for Windows; RStudio Team 2020) using R version 4.2.2 (R Core team 2020) and attached packages (see Appendix 2). Code was embedded in R Notebook document (Html) to produce this report as a knitted Distill markdown report (Allaire *et al.* 2018) which was converted to pdf for final publication. Full code used in the analysis and reporting is available as part of this report (Appendix 2).

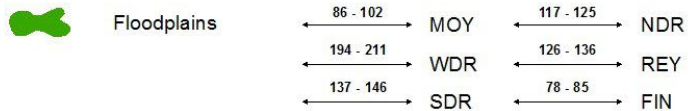
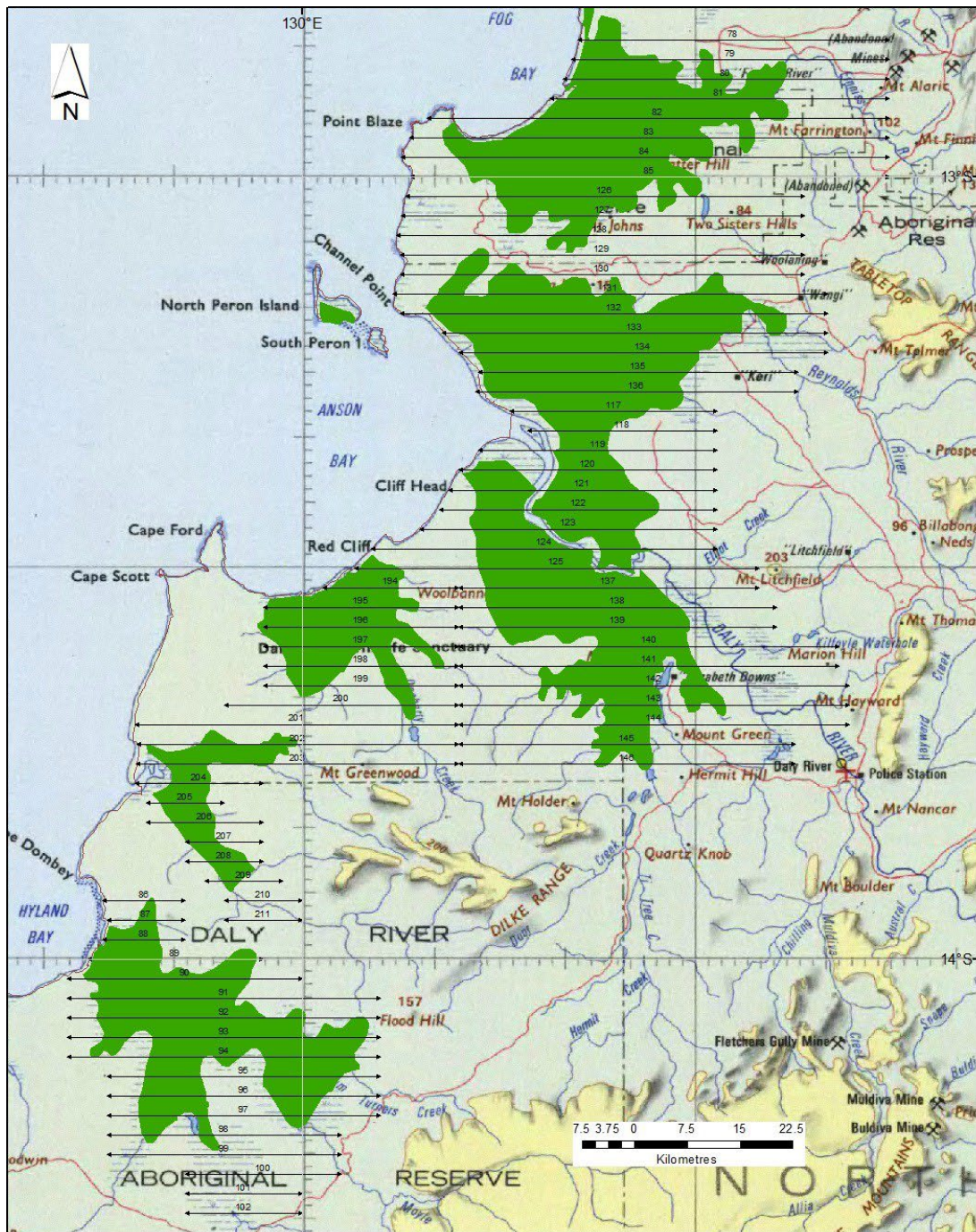


Figure 2a: Survey blocks and survey transects flown in the Moyle River floodplain to Finniss River floodplain survey region

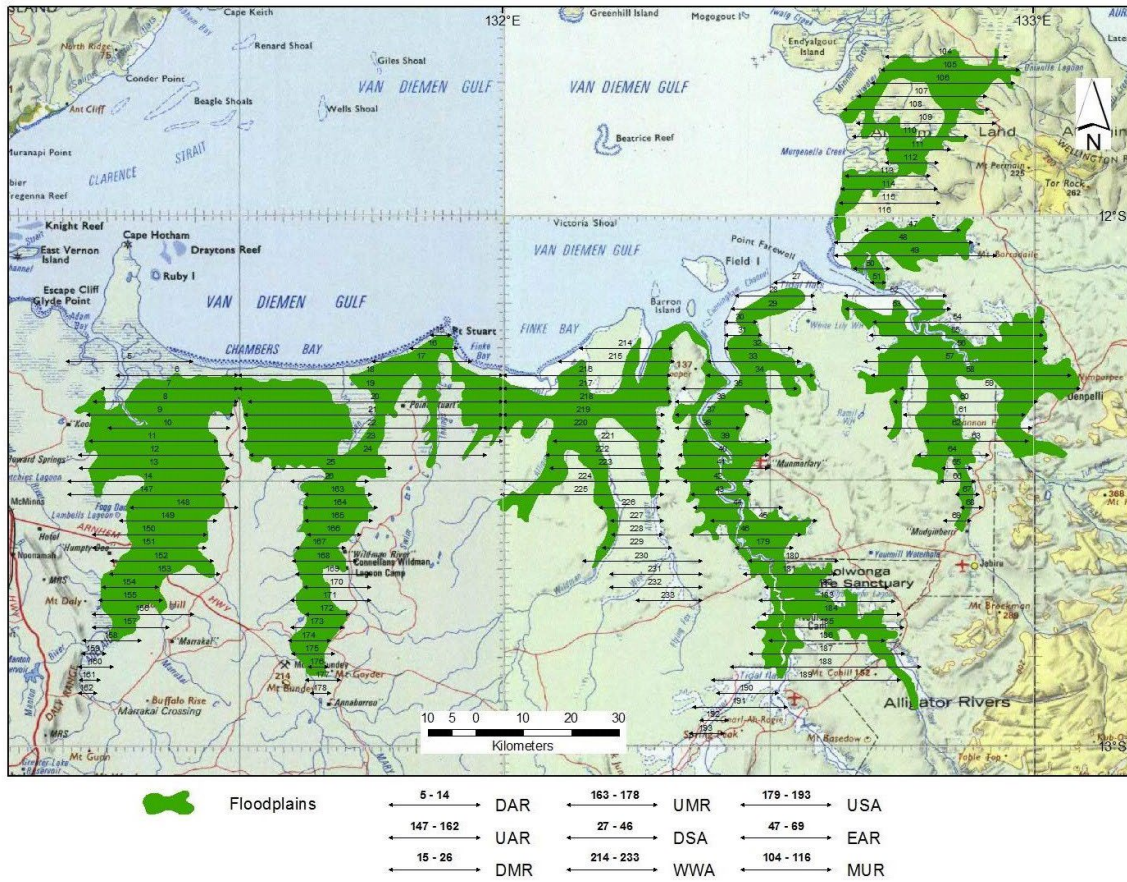


Figure 2b: Survey blocks and survey transects flown in the Adelaide River floodplain to Murgella Creek floodplain survey region.

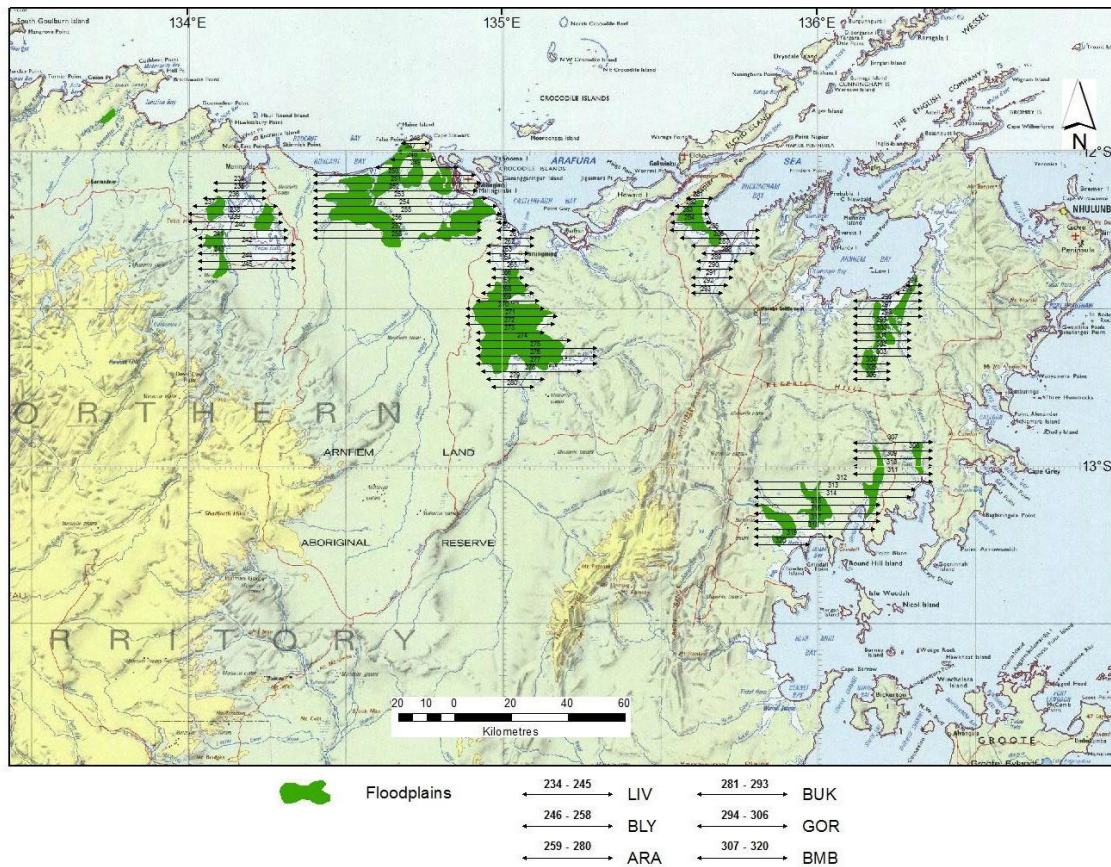


Figure 2c: Survey blocks and survey transects flown in the Arnhem Land floodplains survey region.

Results

Total Population Estimate and Nesting level

The total population of Magpie Goose in the Top End in 2023 was estimated to be $1,260,454 \pm 148,626$ (\pm standard error) geese with a density of 54.88 ± 6.47 per km^2 (mean \pm standard error), and a precision of 11.8%. For Magpie Goose nests the estimate and standard error was $45,900 \pm 5,932$, an overall density of 2 ± 0.26 nests per km^2 , at a precision of 12.9%.

Survey Block Population and Density Estimates

The population estimates for each survey block within the three survey regions are presented in Table 2 a-c, along with the density and calculated error (expressed as % coefficient of variation) for all estimates. The block densities ranged from 0 km^{-2} for the Buckingham River floodplain block (BUK) in Arnhem Land to 192.1 km^{-2} from the Downstream Mary River flood plain survey block (DMR). The majority of the total population (63.2%) occurred in the survey region from west of Adelaide River to Murgellen Creek which was higher than in the two previous surveys but still less than historical levels when around two thirds of the total population generally are counted there (Clancy 2018, Clancy 2019). In the Moyle River floodplain to Finnis River floodplain survey region the largest number of birds in absolute sense being in North Daly flood plain (NDR) block with 106,987. Ten percent of the total population was recorded in the Arnhem Land region, which was higher than in 2020 to 2022 period and in-line with what had been typically recorded there in previous years. Recent trends in population size for the three survey regions are given in Figure 3.

Population dispersion

The average size of observed groups of magpie goose is given in Figure 4 along with those recorded in previous years. The mean group size was similar to 2023 but birds were much less aggregated than they were in 2016

and 2019 (which were both very dry years with low nesting success when birds tended to be in very large flocks rather than spread out across the nesting areas).

The precision of individual block estimates (as measured by the coefficient of variation, CV) ranged from around 26% to as high as 83% (Table 2 a,b,c); However, as with previous years the high sampling intensity means that at a whole of survey block level the estimate is generally satisfactory (CVs of 16.7, 28.3 and 16.4 % respectively). The overall estimate has a coefficient of variation of 11.8%. For both the goose population estimate and the nest estimate, the precision values are at acceptable levels, indicating that the overall population estimates are robust.

Nesting rate and rainfall

The ratio of nests to total population of Magpie Goose gives an indication of the nesting rate for the season. For 2023, the value was 3.6% which signifies a moderate nesting season. However, similar to 2022, it is likely this underestimated the overall level of nesting due to the general lack of nesting synchrony, meaning in some areas nesting may have been delayed. This follows on from moderate levels of nesting in 2021 after a good wet season following two poor nesting seasons in 2019 and 2020. Rainfall recorded across the Top End in the north and the east was average to above average for most of the flood plain areas and their catchments in the 2022/23 wet season, with areas of very good rainfall in the west, especially in the Moyle River region (Figure 5).

Table 2 Population size for Magpie Goose and nests in the three floodplain survey regions in 2023.

2a Estimated population, density and precision (coefficient of variation expressed as a %) for Magpie Goose and nests in the Moyle River floodplain to Finniss River floodplain survey region.							
Values and Coefficient of variation (CV %).							
Survey Block	Survey Region Km2	Number of Geese	Density per sq km	CV % Geese	Number of Nests	Density per sq km	CV % Nests
FIN	1,234	23,871	19.3	60.9	712	0.6	49.3
MOY	1,375	83,025	60.4	33.6	15,471	11.3	26.3
NDR	958	106,987	111.7	28.6	1,053	1.1	36.5
REY	1,648	28,108	17.1	30.0	1,363	0.8	43.8
SDR	1,362	24,737	18.2	22.0	2,245	1.6	51.6
WDR	1,164	66,192	56.9	46.4	1,920	1.6	46.3

Table 2 cont.

2b Estimated population, density, and precision (coefficient of variation expressed as a %) for Magpie Goose and nests in the Adelaide River floodplain to Murgellenella Creek floodplain survey region.

Values and Coefficient of variation (CV %).

Survey Block	Survey Region Km2	Number of Geese	Density per sq km	CV % Geese	Number of Nests	Density per sq km	CV % Nests
DAR	798	94,163	118.1	30.2	2,927	3.7	44.9
DMR	1,240	238,210	192.1	44.8	6,535	5.3	31.8
DSA	915	100,814	110.2	29.4	1,595	1.7	47.2
EAR	1,459	134,981	92.5	32.7	2,385	1.6	46.1
MUR	822	69,905	85.0	37.4	3,190	3.9	74.7
UAR	719	76,283	106.2	50.0	1,053	1.5	57.2
UMR	490	18,587	37.9	62.5	403	0.8	57.5
USA	950	15,466	16.3	38.7	558	0.6	47.2
WWA	1,205	48,289	40.1	41.0	542	0.4	60.3

2c Estimated population, density, and precision (coefficient of variation expressed as a %) for Magpie Goose and nests in the Arnhem Land floodplain survey region.

Values and Coefficient of variation (CV %).

Survey Block	Survey Region Km2	Number of Geese	Density per sq km	CV % Geese	Number of Nests	Density per sq km	CV % Nests
ARA	1,361	99,972	73.4	35.2	3,004	2.2	40.8
BMB	1,468	12,368	8.4	65.0	852	0.6	67.5
BUK	595	0	0.0	NaN	0	0.0	0.0
GOR	623	10,842	17.4	56.0	15	0.0	96.3
MAN	975	1,367	1.4	92.6	0	0.0	0.0
MIL	1,662	6,287	3.8	77.3	77	0.0	93.4

Figure 3. Population size (+/- standard error) of Magpie Goose
2016 to 2023 (End of Dry Season Surveys)

ADL_MUR = Adelaide R to Murgenella Ck, ARN_LND = Arnhem Land, FIN_MOY

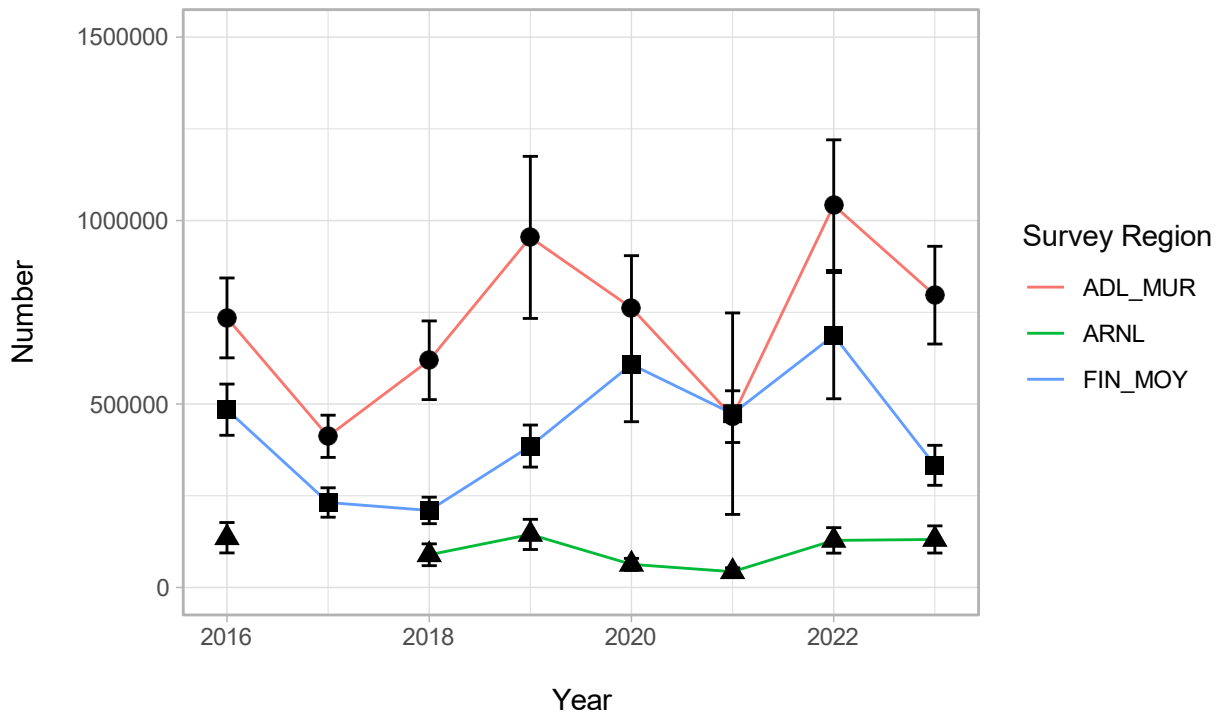
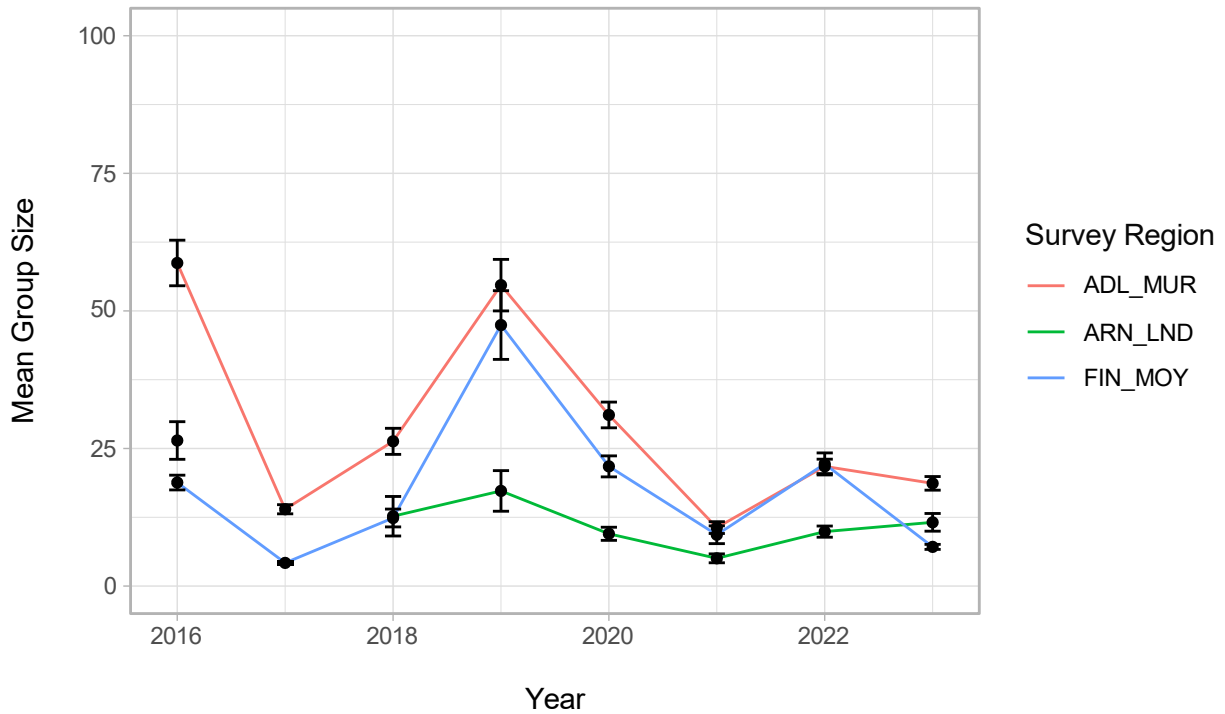


Figure 4. Mean (+/- standard error) recorded group size of Magpie Goos
2016 to 2022 (End of Dry Season Surveys)

ADL_MUR = Adelaide R to Murgenella Ck, ARN_LND = Arnhem Land, FIN_MOY = Fi



Northern wet season rainfall deciles for Northern Territory 01/10/2022 – 30/04/2023

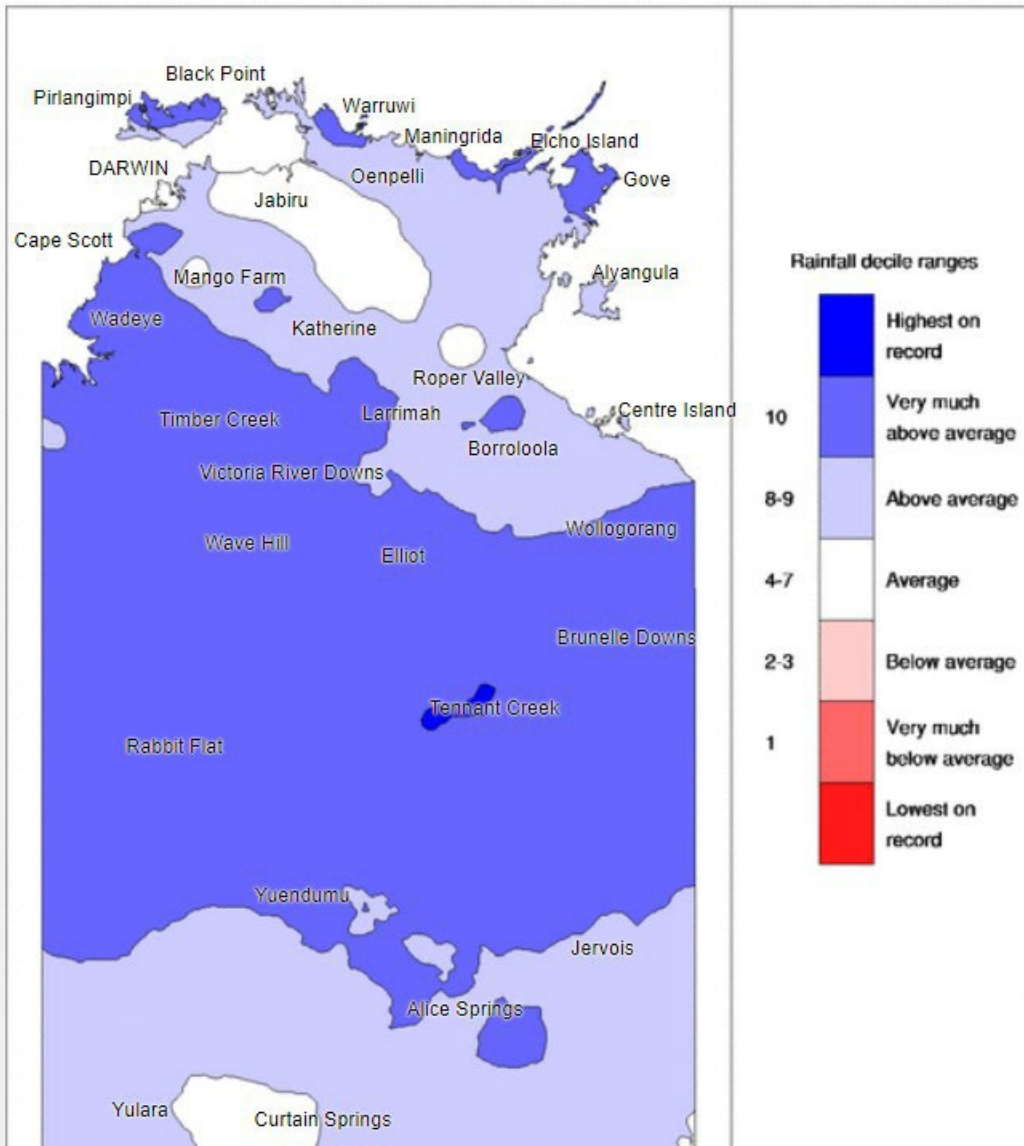


Figure 5 Map of the NT showing rainfall deciles for the 2022/23 wet season period. Figure from bom.gov.au.

Discussion

Population Size and Dispersion

The 2023 population estimate for Magpie Goose in the Top End of $1,260,454 \pm 148,626$ (mean \pm standard error) reflected a large decrease from that estimated in 2022 ($1,856,935 \pm 250,620$). However, the 2022 survey was believed to be an overestimate due to survey timing issue. Due to the later timing of some of the Moyle/Daly Blocks, a large number of fledglings were counted (see Clancy 2022). This follows a substantial decline recorded from 2020 to 2021 (Clancy 2021). As in previous years, the total population estimate may represent a conservative estimate of the species population in the NT, recognising that some birds may occur outside the surveyed area at the time of survey. However, it is not considered likely that there had been large scale migration outside the survey region during the survey period. There is no evidence of unusual movements of birds from within to outside the survey area from other data sources (e.g. comparing frequency of Magpie Goose sightings reported in eBird (www.ebird.org)). Also the results are consistent with the prevailing rainfall conditions and there is no need to assume any emigration to explain the year to year trend.

The precision of the overall population estimate was very good (11.8%). The recorded coefficient of variation was less than half the previous years' surveys (28.9%, Clancy 2022) and in line with typical coefficients of variation which have been in the range of 8-18 % (see Table 1). Wildlife management often centres on diagnosing trends in abundance over time which requires a reasonable level of precision and most wildlife surveys aim for a CV 20% (Harris *et al.* 2013).

Population trends and outlook

A comparison of the changes in Magpie Goose population and in nesting activity from 1983 to 2023 is provided in Figure 6. The 2023 result is consistent with a population below carrying capacity coming off a reasonable 2022 breeding season but with low survival across the 2022 dry season. The population level is in a "moderate" phase below the most recent peak 2,500,000 recorded in 2012 (Clancy 2020a) but very much above the historical low population estimate recorded in 2017 (Table 1). Rainfall-driven variability in both population size and nesting index are a feature of Magpie Goose population dynamics in the Top End (Bayliss & Yeomans 1990a, Whitehead & Saalfeld 2000, Delaney *et al.* 2009, Groom & Saalfeld 2017, Clancy 2020a).

The rainfall conditions experienced in 2021/22 were conducive to population growth following on from the poor 2018/19 and 2019/20 wet seasons (Table 5). The extent of the year to year decrease was potentially overestimated due to the noted issue of fledglings being recorded as part of the overall population estimate in 2022.

Magpie Goose nests were estimated to be only $45,900 \pm 5,932$ (coefficient of variation 12.9 %) for the Top End. This level is lower in absolute terms but approximately equivalent in relative terms to last year (Figure 6b, Table 5). However, it is likely this is an underestimate of breeding success due to a recent pattern of lower synchrony of nesting across the survey area.

Overall, the monitoring results show a healthy population, that whilst well below historical highs is above recent population troughs.

Figure 6a. Population of Magpie Goose in Top End of NT
1983 to 2023 (End of Wet Season Surveys)

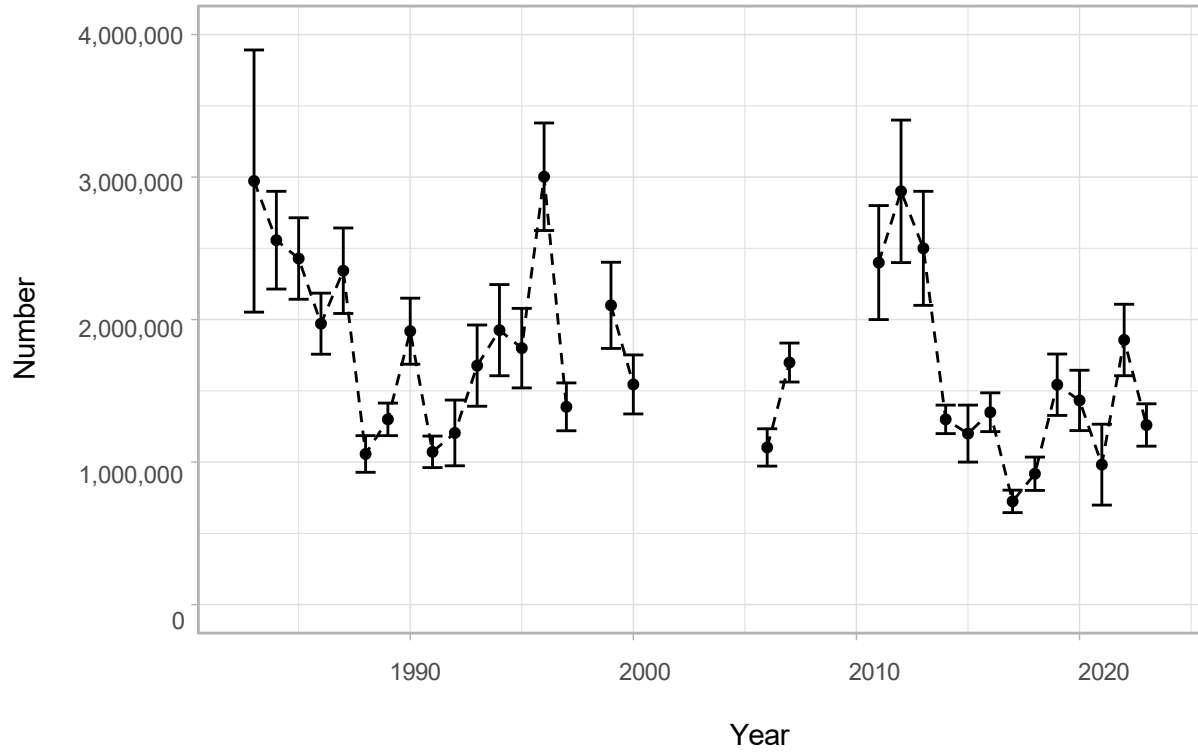


Figure 6b. Number of Nests in Top End of NT
1983 to 2023 (End of Wet Season Surveys)

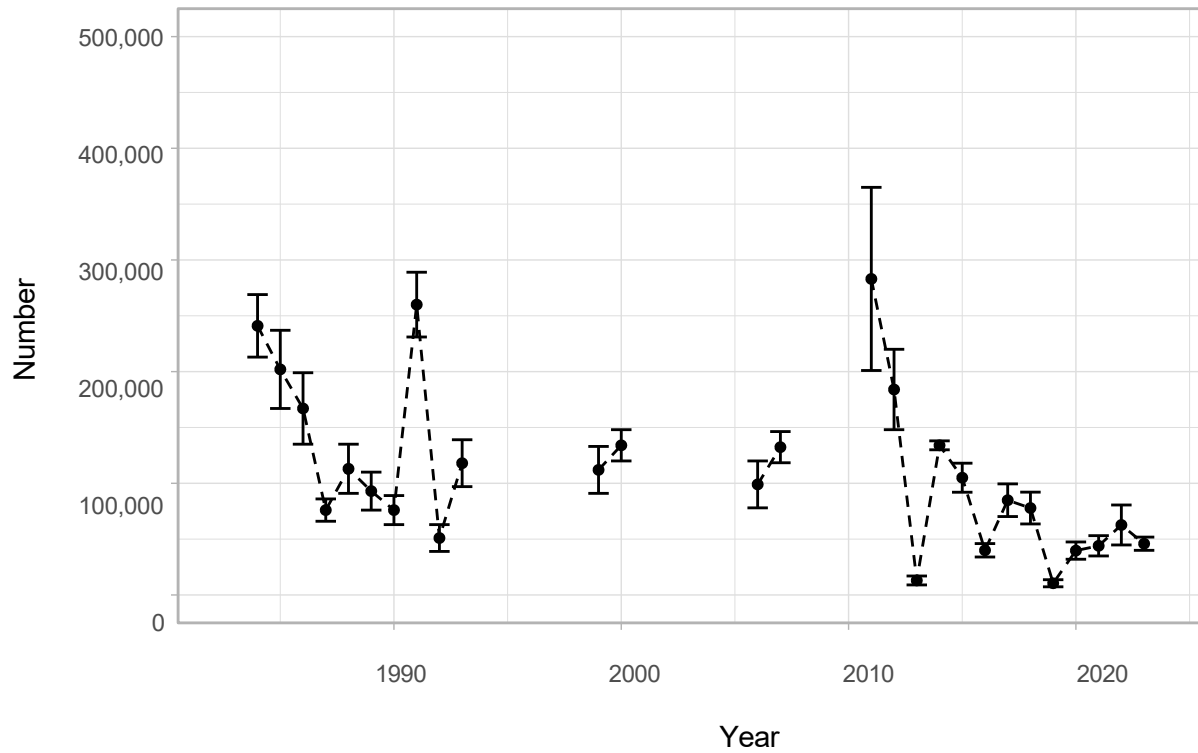


Table 5: Comparison of Top End Magpie Goose population trends and previous years nesting success from 2011 to 2023.

[A] Nest count relative to overall goose population; [B] Change in estimated population size from previous year; [C] Index of nesting rate: < 5 % = Low (L), 5-10% = Moderate (M), 10-20%= High (H), >20% = Very high (VH); [D] Index of nesting success projected forward 1 year; [E] Observed and predicted population trend relative to nesting success index, > 10 % population change = Increase (I), - 10%-+10% Stable (S); -10% - -30% = Decrease (D); > -30% change = Big Decrease (BD).

Year	[A] Nesting Proportion	[B] Population Change	[C] Nesting Success	[D] Nesting Success Previous Year	[E] Population Trend
2011	12%	NA	VH	NA	NA
2012	6%	21%	M	VH	I
2013	1%	-14%	L	M	D
2014	10%	-48%	H	L	BD
2015	9%	-8%	H	H	S
2016	3%	8%	L	H	S
2017	13%	-44%	VH	L	BD
2018	10%	25%	H	VH	I
2019	1%	62%	L	H	I
2020	3%	-7%	L	L	D
2021	5%	-31%	M	L	BD
2022	4%	89%	M	M	BI
2023	4%	-32%	M	M	BD

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Appendix 1

R package "pointblank" Preliminary data check (Iannone and Vargas 2020). Digital version available from author.

Appendix 2

Code Appendix. Digital version available from author.

```
code <- readLines(knitr::purl("../r_docs/Aerial_Survey_MG_2023_NotebooDistill.Rmd", documentation = 1))
code #iterative version
```