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

Moyle River Floodplains to Arnhem Land Floodplains
May 2022

NORTHERN TERRITORY GOVERNMENT

Document title	Aerial Survey of Magpie Goose in the Top End of the Northern Territory
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Approved by	
Date approved	
Document review	
TRM number	BD2021/0010

Version	Date	Author	Changes made
1.0	June 20, 2022	Tim Clancy	Format Version 1

Acronyms	Full form
DEPWS	Department of Environment, Parks and Water Security
NT	Northern Territory
WMP MG	Wildlife management program for Magpie Goose (*Anseranas semipalmata*) in the Northern Territory of Australia 2020-2030

Contents

Acknowledgments

This survey was funded by the Northern Territory Government and supported by the Department of Environment, Parks and Water Security and the Australian Government Department of Agriculture, Water and the Environment.

Thanks to Paul Sharp from Sharp Aviation for providing airframes for the surveys, logistical assistance and professional piloting services for the duration of the fixed-wing surveys under exacting conditions.

Skilled observing, data recording and support with survey logistics was provided by Tony Griffiths, Brydie Hill and Keith Saalfeld from Flora and Fauna Division, and Ian Hunt from Parks and Wildlife Division, Department of Environment, Parks and Water Security. The data acquisition program was built by Qingyuan Zeng with support from Noe Nugraeni and Damian Milne.

The Department thanks the Traditional Owners, pastoralists and park management agencies who allowed the surveys to be undertaken across their land.

Glenn Edwards, Tony Griffiths and Keith Saalfeld provided critical review that greatly improved this report.

Summary

A fixed-wing aerial survey of Top End wetlands of the Northern Territory was undertaken from 3 May, 2022 to 25 May, 2022 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 a combined perception and visibility bias using the correction factors derived from Bayliss and Yeomans (1990a & b).

The population estimate for Magpie Goose was 1,856,935 ± 250,620 (± standard error) with a coefficient of variation 13.5%; which is an average density of 80.9 geese per km^2 within the survey region. This is a substantial increase of 89.1 % on the 2021 estimate. This estimate is slightly inflated due to the later timing of some of the Moyle/Daly Blocks where large number of fledglings were counted. Increases were recorded in most survey blocks following on from declines in the Kakadu, Mary River and Arnhem Land regions in 2021.

This result signifies a population that has increased in response to the good 2020/21 wet seasons and consequent good breeding, recruitment and survivorship. The population level is below the most recent peak 2,900,000 recorded in 2012 (Clancy 2020a) but very much above the historical low population estimate recorded in 2017.

The number of Magpie Goose nests was estimated to be 62,674 ± 17,895 for the surveyed area with a coefficient of variation of 28.55 %. This was above 2021 nesting levels and would be considered a moderate nesting season. However, similar to 2021 there was substantial variation in the timing of nesting and it is difficult to predict the level of recruitment going into 2023. The rainfall preceding the survey period was close to the long-term average for the wet season. 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.

1. 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. This includes the implementation of an annual aerial survey monitoring program across the key floodplain habitat post the wet season, timed to coincide with the period when birds are nesting. This also corresponds with the period 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 monitoring effort are set out in the WMP MG . The management program 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 2022 aerial survey. There was average rainfall across the Top End flood plains in the wet season of 2021/22 following on from widespread rains in 2020/21 and the very poor wet seasons of 2018/19 and 2019/20.

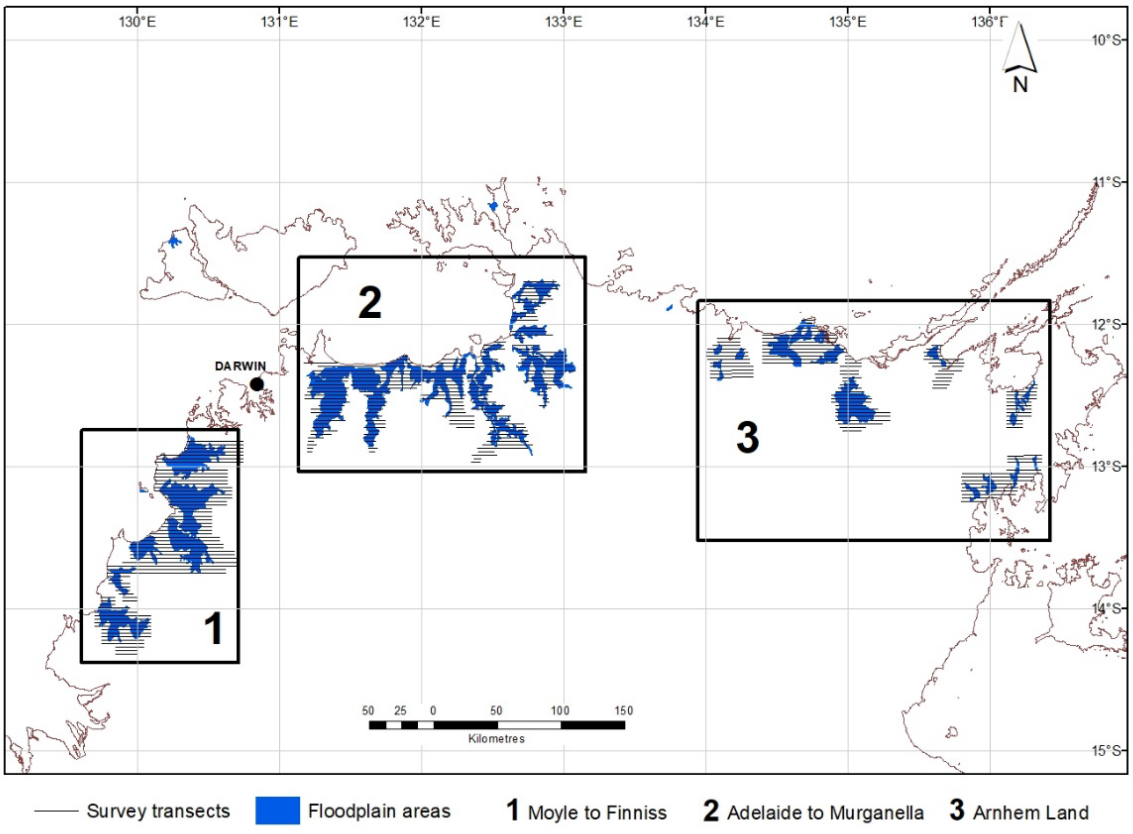


Figure 1: Map of the Top End of the Northern Territory showing the regions surveyed for Magpie Goose. All regions have been surveyed annually since 2017. From 2011 to 2016, Area 2 was surveyed annually and Area 1 on a biannual basis or more frequent basis. Area 3 was surveyed less regularly. See Clancy 2020a for details.

Overall population estimates from aerial surveys from 2015 to 2021 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 2022 aerial survey of the Top End wetlands as per the WTM MG (Clancy 2020a). It is believed that this surveyed area encompasses 90-95% of the total Northern Territory Magpie Goose population 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 (± standard error) for Magpie Geese from 2015 to 2021 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 2021

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

Source: See *Clancy, T.F (2021). Aerial Survey of Magpie Goose numbers in the Top End of the Northern Territory: Moyle River Floodplains to Arnhem Land Floodplains*

2. Methods

2.1. Survey Area and Design

A reconnaissance flight was undertaken over Djukbinj and Mary River National Park (traversing Koolpinyah, Woolner and Marraki) area and Wagait/Finniss (traversing Labelle Downs) area by fixed-wing plane (Cessna 185F high-wing aircraft) on 4 April 2022 (Figure 2). Only limited nesting and some pre-nesting activity was observed so it was decided to schedule the surveys for the start of May to overlap the likely peak in nesting. Feedback from crocodile egg harvesters operating on relevant floodplains obtained on 28 March 2022 indicated that there was limited nesting in the Adelaide River and West Daly River area, suggesting a later survey timing was required.

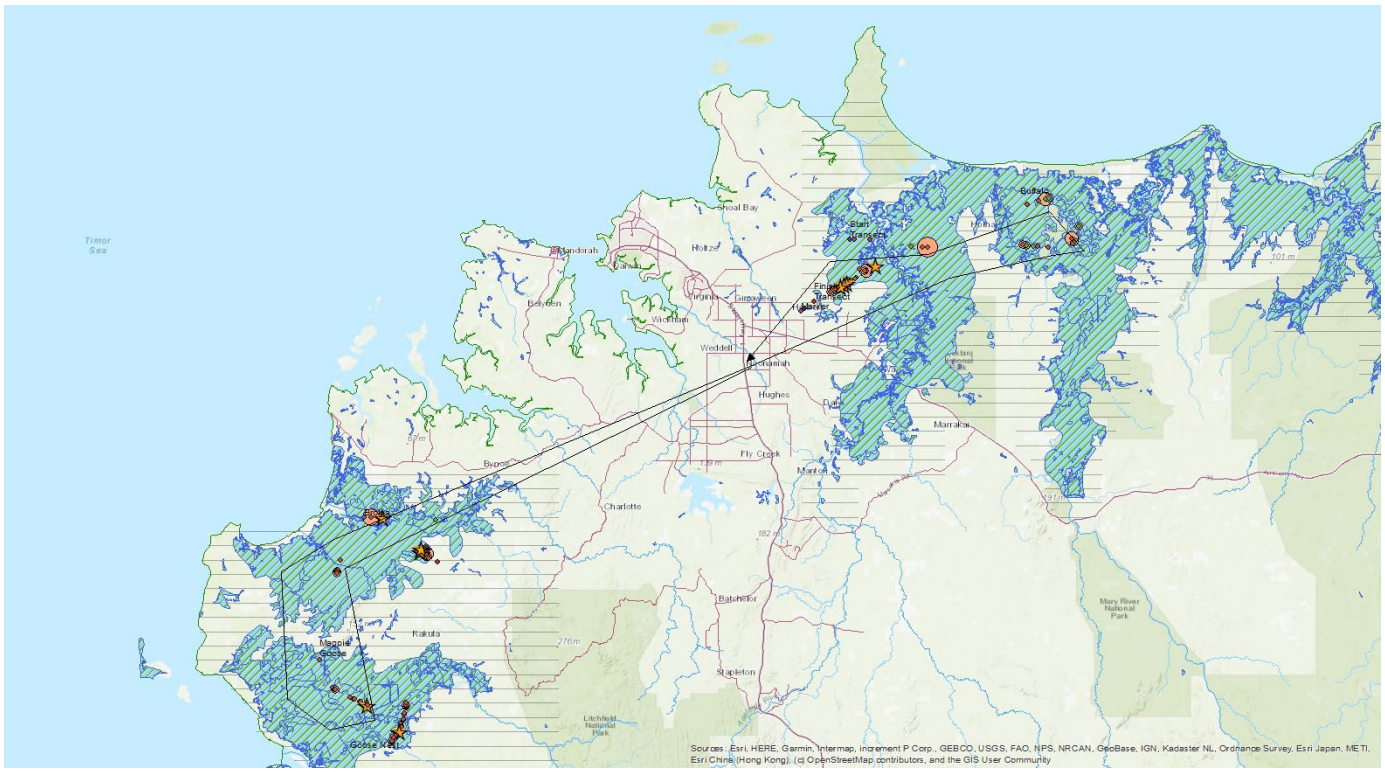


Figure 2: Flight path of reconnaissance flight to assess Magpie Goose nesting activity. Orange circles indicate observed Magpie Geese and stars represent observed nesting.

The Moyle River floodplains to Finniss 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 3 May, 2022 to 25 May, 2022. This area comprises six major survey blocks (Figure 3a).

The Adelaide River floodplains to Murgenella 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 3b) and was surveyed between 8 May, 2022 to 23 May, 2022. 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 3c) and was surveyed between 17 May, 2022 to 19 May, 2022. 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 3). 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 Ian Hunt, Keith Saalfeld, Brydie Hill or Tony Griffiths) were used. Observers all have over 200 hours experience in aerial surveying for Magpie Goose with the exception of Ian Hunt who had previous extensive aerial and ground based surveying experience for waterbirds including participation in previous Magpie Goose surveys.

2.2. 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 2022 where as for 2021 [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.

2.3. 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 RStudio (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).

2.4. 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. 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 word and then to a pdf for final publication. Full code used in the analysis and reporting is available as part of this report (Appendix 2).

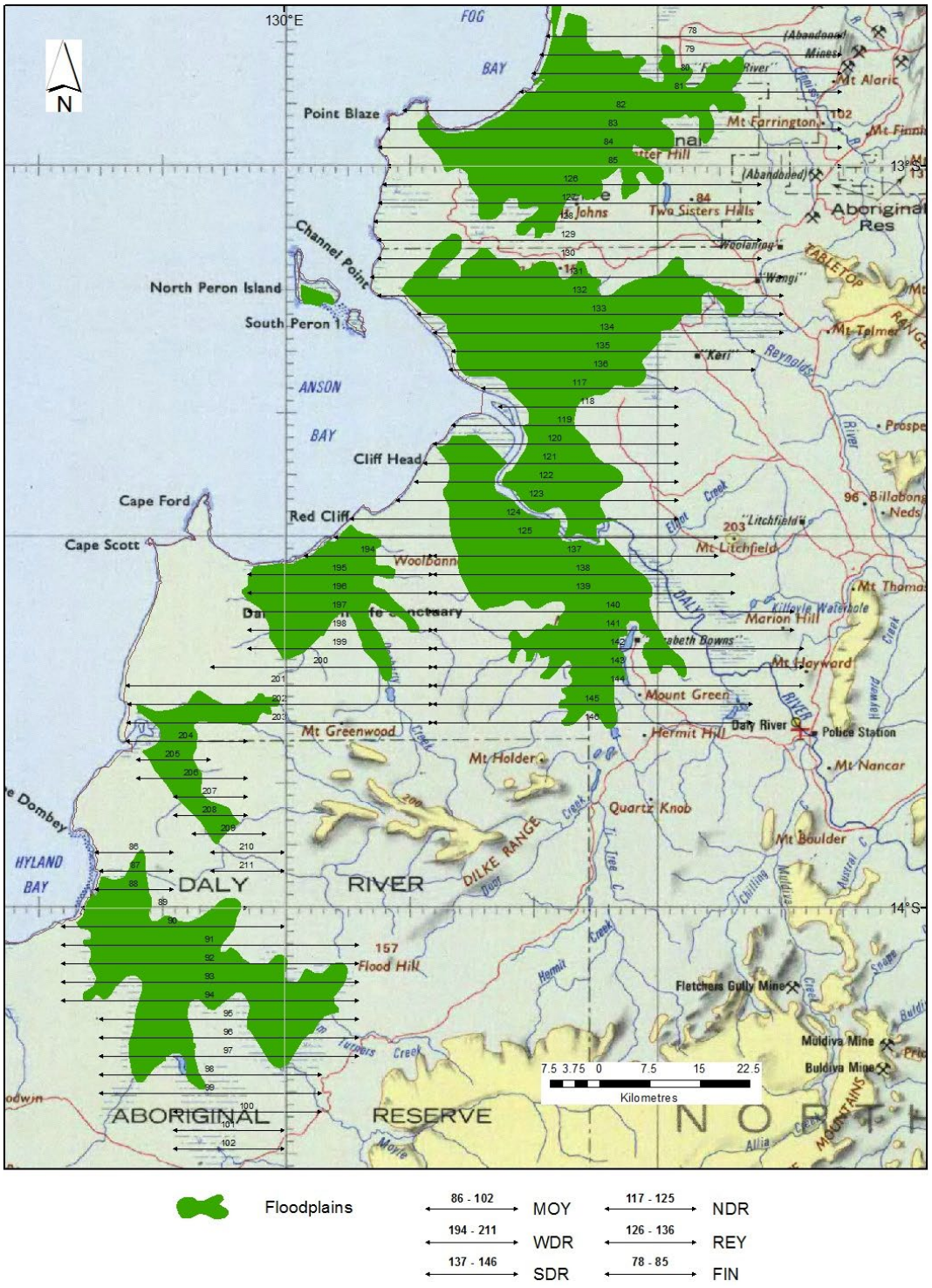


Figure 3a: Survey blocks and survey transects flown in the Moyle River floodplain to Finniss River floodplain survey region

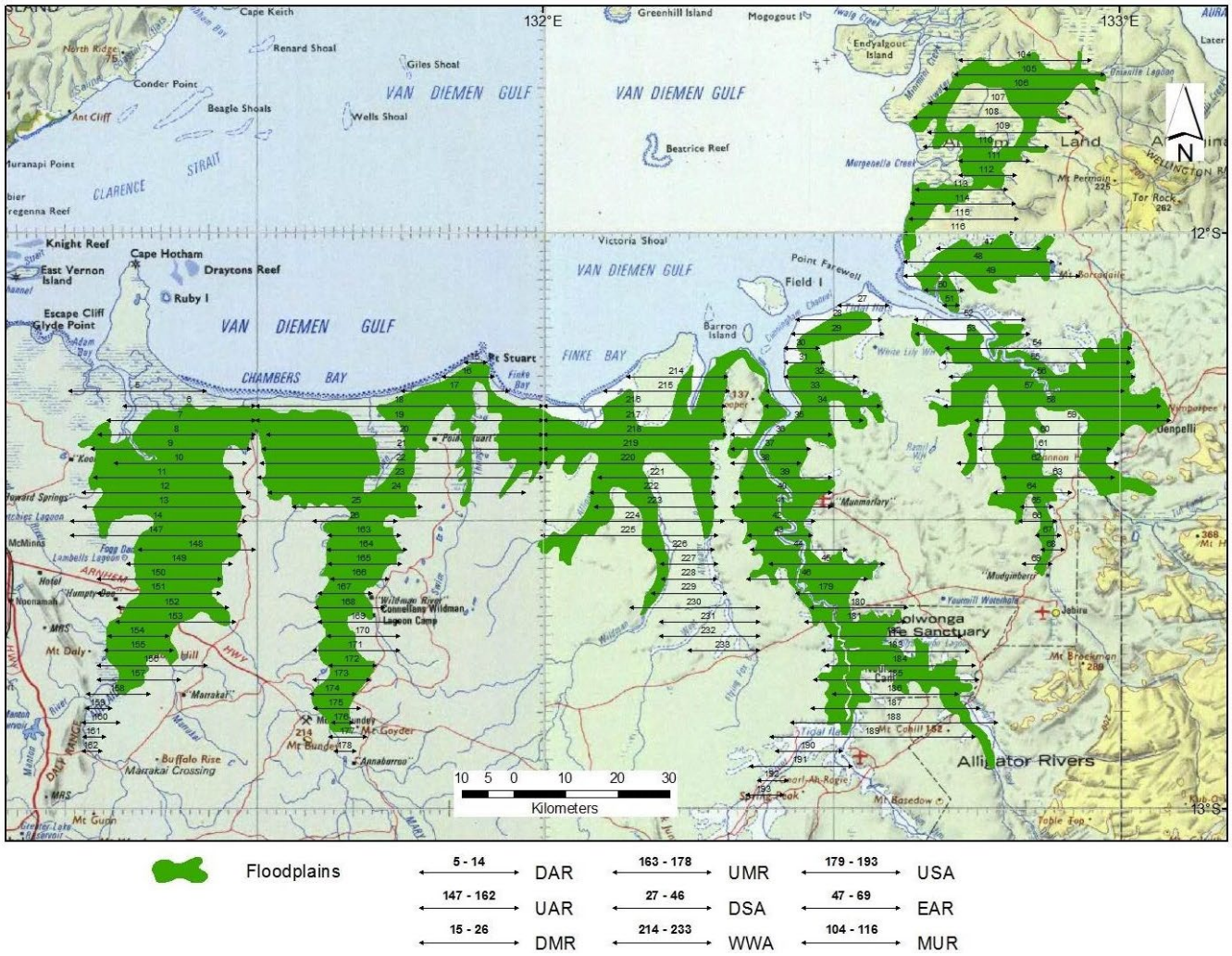


Figure 3b: Survey blocks and survey transects flown in the Adelaide River floodplain to Murgenella Creek floodplain survey region.

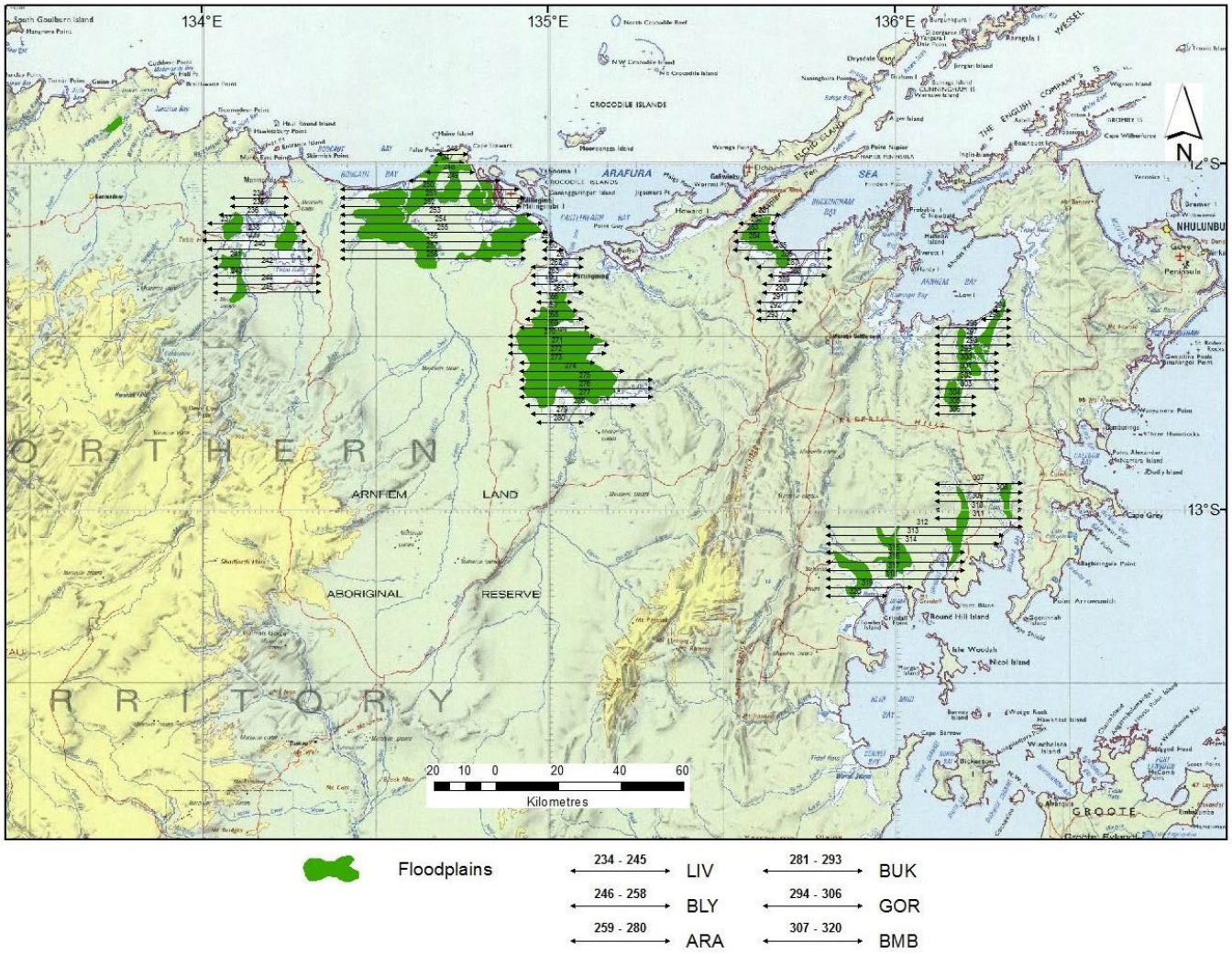


Figure 3c: Survey blocks and survey transects flown in the Arnhem Land floodplains survey region.

3. Results

3.1. Total Population Estimate and Nesting level

The total population of Magpie Goose in the Top End in 2022 was estimated to be 1,856,935 ± 250,620 (± standard error) geese with a density of 80.86 ± 10.9 per km^2 (mean ± standard error), and a precision of 13.5 %. For Magpie Goose nests the estimate and standard error was 62,674 ± 17,895, an overall density of 2.73 ± 0.78 nests per km^2, at a precision of 28.55%.

3.2. 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 236.3 km^{-2} from the Murganella flood plain survey block (MUR). The majority of the total population (56.1%) occurred in the survey region from west of Adelaide River to Murgenella 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). The unusually large aggregation of geese in the Reynolds block observed in 2021 had dissipated with the largest number of birds in absolute sense being in Moyle flood plain (MOY) block. 6.9% of the total population was recorded in the Arnhem Land region, which was higher than in 2020 and 2021 but below the 10% typically found there in previous years. Recent trends in population size for the three survey regions are given in Figure 4.

3.3. Population dispersion

The average size of observed groups of magpie goose is given in Figure 5 along with those recorded in previous years. The sightings were more clumped than in 2021 but much less aggregated than they were in 2016 and 2019.

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 17.1, 26.4 and 25.1 % respectively). The overall estimate has a coefficient of variation of 13.5%. 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.

3.4. 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 2022, the value was 3.4% which signifies a poor nesting season. However, it is likely this underestimated the overall level of nesting due to issues with delays in survey timing and the general lack of nesting synchrony, meaning in some areas birds had already hatched (inflating the number of total birds and reducing the number of nests that would have been counted if survey was earlier). This follows on from moderate (but also potentially underestimate level) of nesting in 2021 after a good wet season after two poor nesting seasons in 2019 and 2020. Rainfall recorded across the Top End was average for most of flood plain areas and their catchments in the 2021/22 wet season (Figure 6).

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

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 variaiton (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	26,468	21.5	71.5	1,069	0.9	84.4
MOY	1,375	319,937	232.7	48.1	40,636	29.6	42.6
NDR	958	103,024	107.6	54.1	4,321	4.5	73.3
REY	1,648	126,257	76.6	35.8	5,575	3.4	41.5
SDR	1,362	20,728	15.2	62.0	108	0.1	68.1
WDR	1,805	90,610	50.2	23.6	1,611	0.9	26.8

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

Values and Coefficient of variaiton (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	66,283	83.1	24.2	1,796	2.3	52.6
DMR	1,240	129,104	104.1	49.5	2,292	1.8	39.2
DSA	915	140,835	154.0	29.4	93	0.1	64.5
EAR	1,404	222,266	158.3	38.0	248	0.2	41.6
MUR	822	194,340	236.3	51.5	542	0.7	60.8
UAR	719	82,911	115.4	48.1	1,874	2.6	77.2
UMR	490	6,537	13.3	52.0	449	0.9	80.7
USA	950	56,147	59.1	45.7	31	0.0	64.4
WWA	1,205	143,249	118.9	55.6	217	0.2	51.8

Table 2 *cont.*

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 variaiton (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	102,614	75.4	31.9	1,688	1.2	37.0
BMB	1,468	10,637	7.2	58.2	31	0.0	92.7
BUK	595	0	0.0	NaN	0	0.0	0.0
GOR	623	6,423	10.3	53.6	93	0.1	63.7
MAN	975	2,278	2.3	92.7	0	0.0	0.0
MIL	1,662	6,287	3.8	69.9	0	0.0	0.0

4. Discussion

4.1. Population Size and Dispersion

The population estimate for Magpie Goose in the Top End of 1,856,935 ± 250,620 (mean ± standard error) reflected a large increase from that estimated in 2021 (982,156 ± 283,717). 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 migration from other data sources (e.g. comparing frequency of Magpie Goose sightings reported in eBird (www.ebird.org) outside the survey area). Also the results are consistent with the prevailing environmental conditions and there is no need to assume any emigration to explain the year to year trend. However, issues with the survey timing leading to a much larger number of birds already having hatched in some areas (notably the Moyle region) may have contributed to a slight over estimate relative to previous years with a commensurate underestimate in the number of nests.

The precision of the overall population estimate was reasonable (13.5%). The recorded coefficient of variation was less than half the previous years' surveys (28.9%, Clancy 2021) 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).

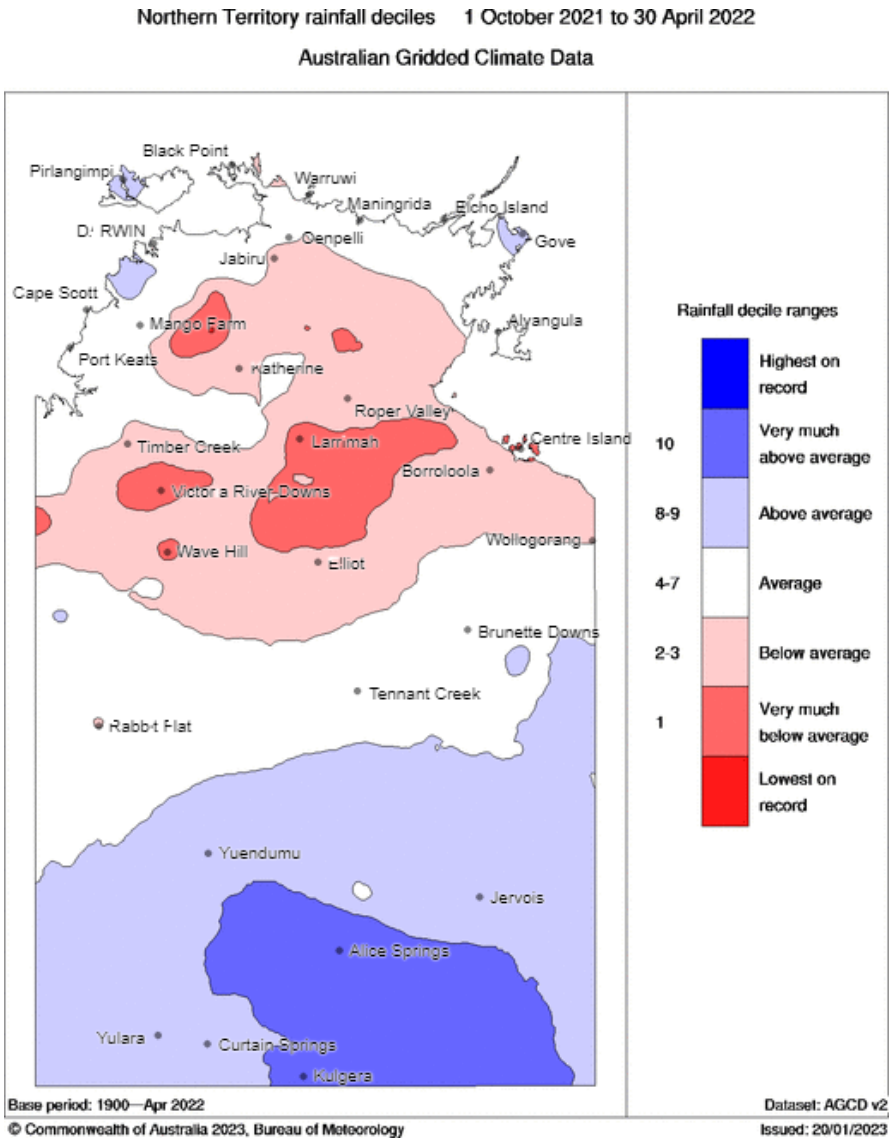


Figure 6 Map of the NT showing rainfall deciles for the 2021/21 wet season period. Figure from bom.gov.au.

4.2. Population trends and outlook

A comparison of the changes in Magpie Goose population and in nesting activity from 1983 to 2022 is provided in Figure 7. The 2022 result is consistent with a population below carrying capacity exhibiting very high growth following two poor breeding seasons in 2019 and 2020. The population level is below the most recent peak 2,900,000 recorded in 2012 (Clancy 2020a) but very much above the historical low population estimate recorded in 2017. Rainfall-driven variability in both population size and nesting index

Figure 7a. Population of Magpie Goose in Top End of NT

1983 to 2022 (End of Wet Season Surveys)

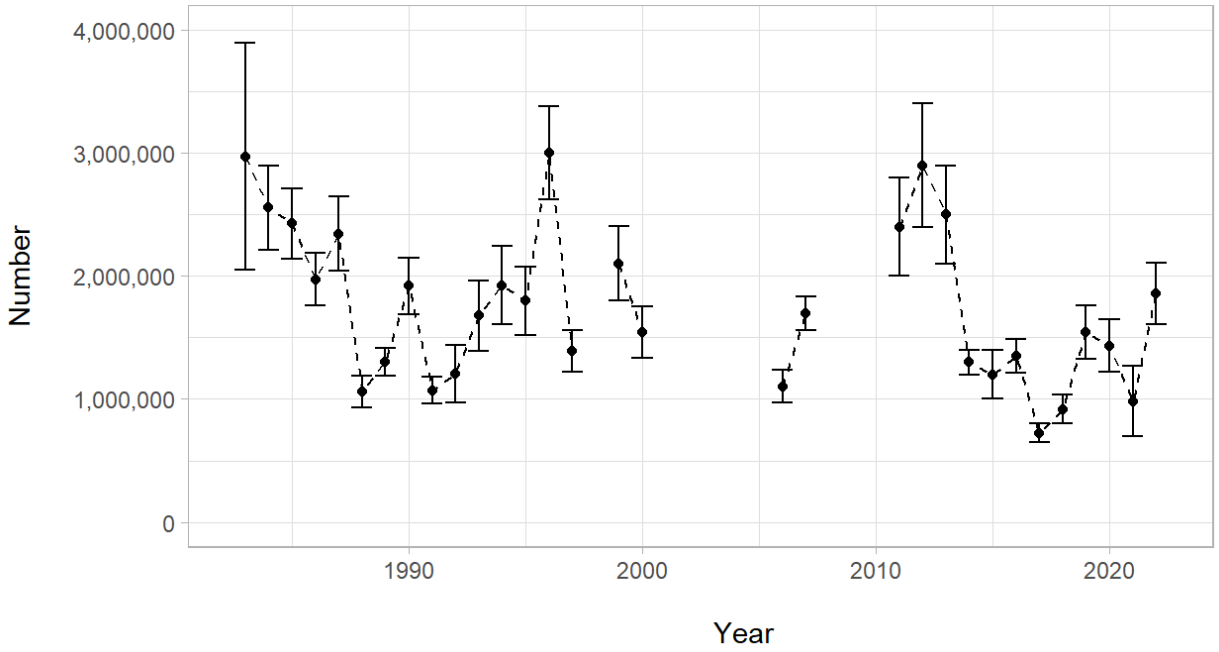
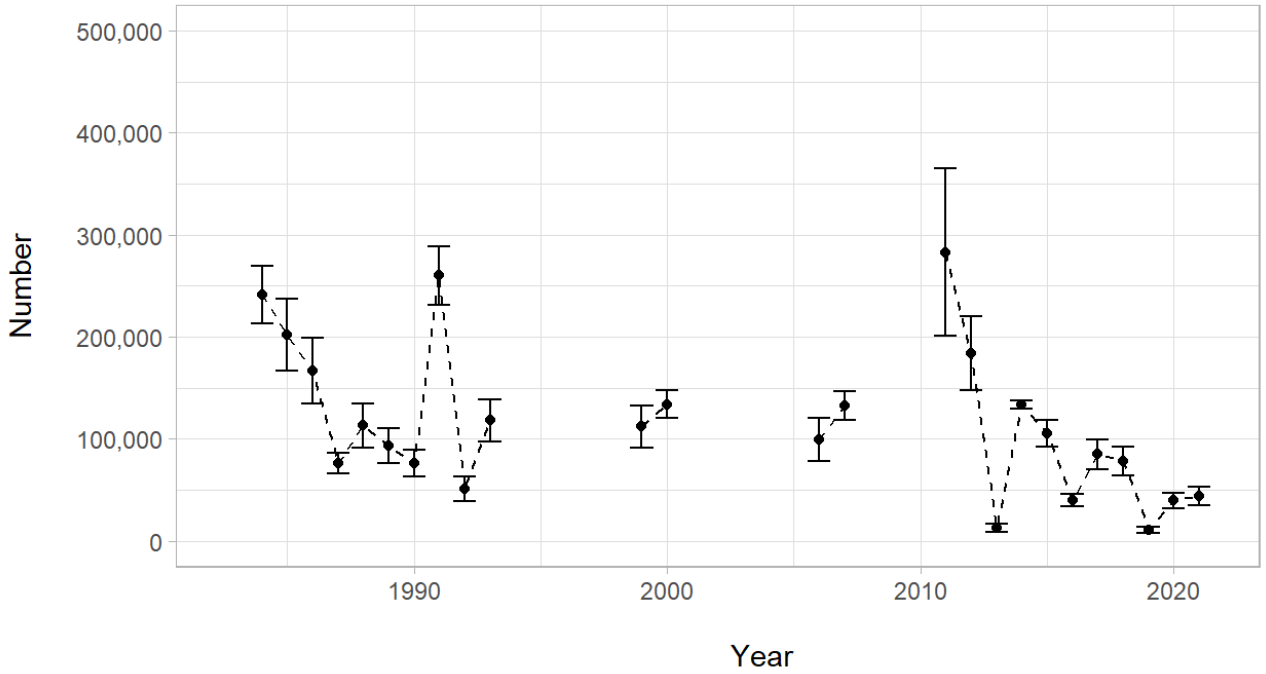


Figure 7b. Number of Nests in Top End of NT

1983 to 2022 (End of Wet Season Surveys)



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 2020/21 were conducive to population recovery following on from the poor 2018/19 and 2019/20 wet seasons and this is reflected in this year's survey results (Table 5). The extent of the increase was potentially overestimated due to the noted issue of recent hatchlings being recorded as part of the overall population estimate. Whilst these birds could be distinguished during the survey, the data gathering process only allowed for birds or nests to be recorded.

Magpie Goose nests were estimated to be only 62,674 ± 17,895 (coefficient of variation 28.55 %) for the Top End which his higher in absolute terms than 2019 to 2021 (Table 1) but lower in relative terms to last year. However, it is likely this is and underestimate of breeding success due to survey timing issues discussed.

Table 5: Comparison of Top End Magpie Goose population trends and previous years nesting success from 2011 and 2021, and predicted trend in 2022.

[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

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Appendix 1

R package "*pointblank*" Preliminary data check (Iannone and Vargas 2020). Extract only. Contact Author for interactive Distill version.

Overview of AllSp2022AerialSurveyTidy

- Overview
- Reproducibility

Reproducibility Information

Scan Build Time	2023-01-30 12:00:29
pointblank Version	0.11.2
R Version	R version 4.2.2 (2022–10–31 ucrt) *Innocent and Trusting*
Operating System	x86_64-w64-mingw32

Variables

species
character

Distinct	12
NAs	0
Inf/-Inf	0

Toggle details

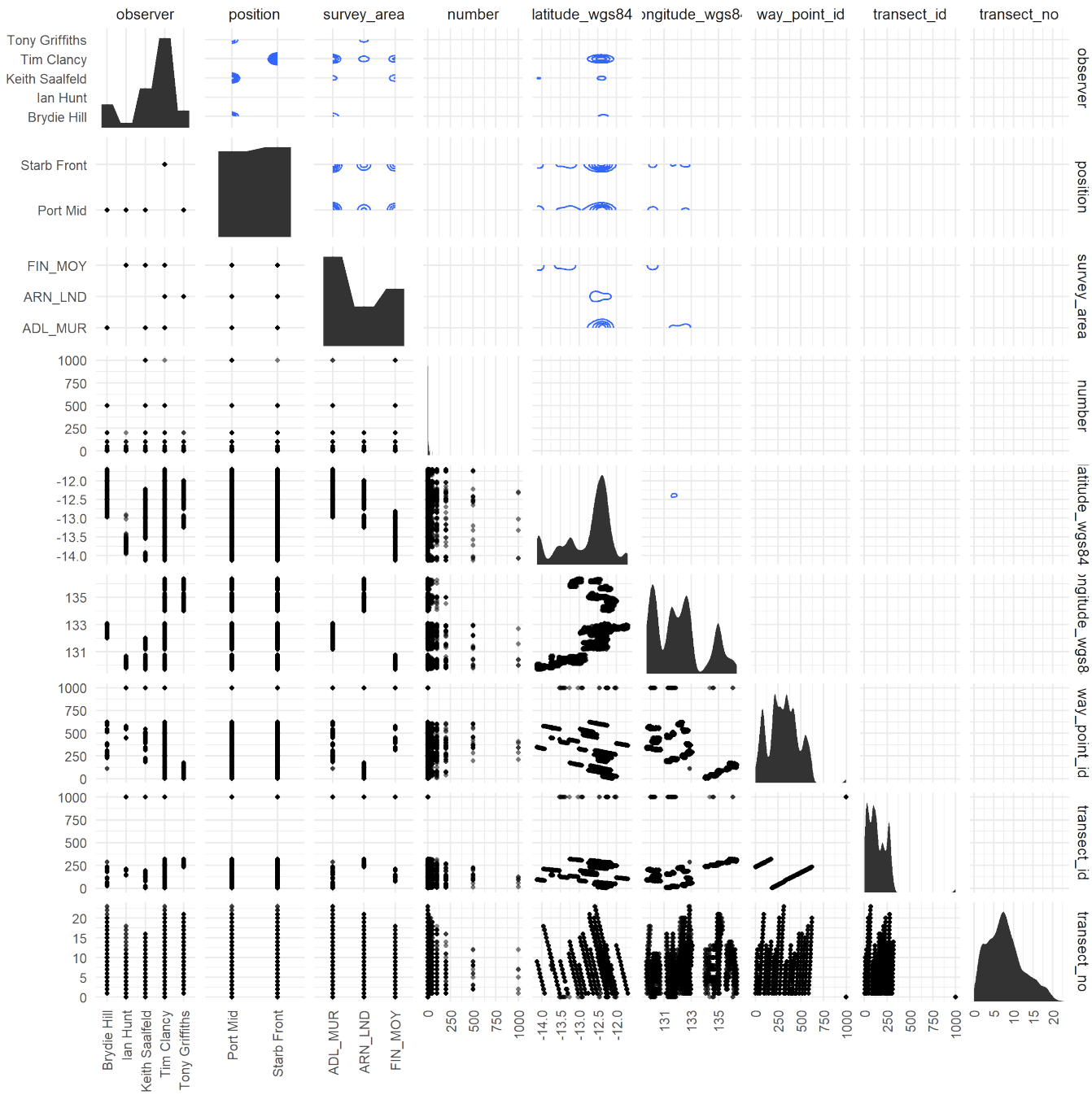
Inf/-Inf	0

Toggle details

survey_area
character

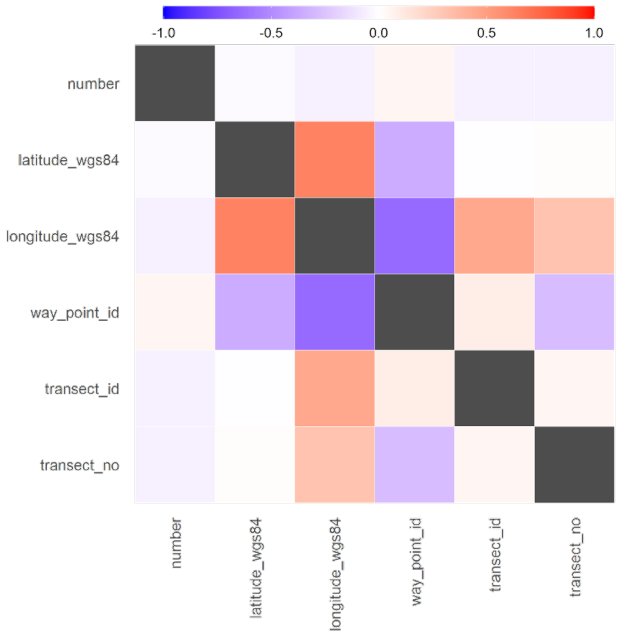
Distinct	3

Interactions


observer
position
survey_area
number
latitude_wgs84
ongitude_wgs8
way_point_id
transect_id
transect_no
Tony Griffiths
Tim Clancy
Keith Saalfeld
Ian Hunt
Brydie Hill
Starb Front
Port Mid
FIN_MOY
ARN_LND
ADL_MUR
1000
750
500
250
0
-12.0
-12.5
-13.0
-13.5
-14.0
135
133
131
20
15
10
5
0

Correlations

- Pearson
- Kendall
- Spearman



Missing Values

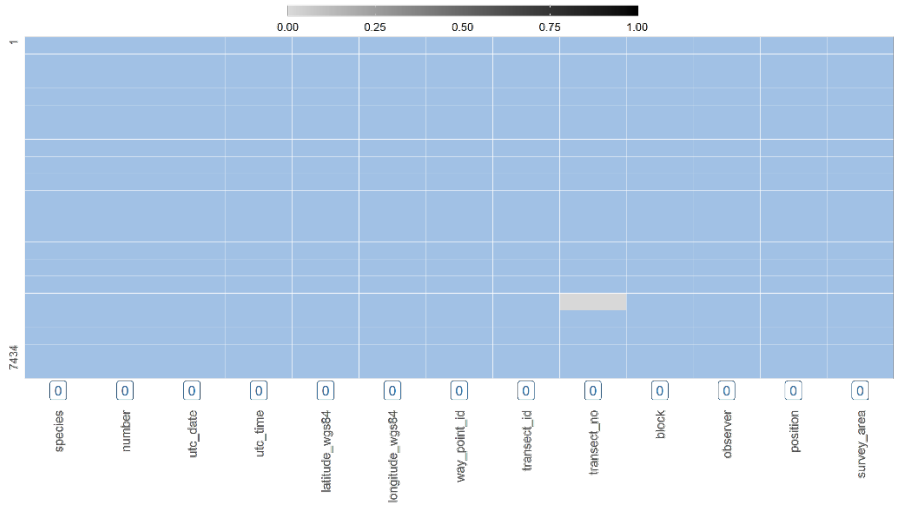


Table scan generated with pointblank.

Appendix 2

Full code available from author.

Packages used:

```
library(knitr)
knitr::opts_chunk$set(echo= TRUE)
options(tinytex.verbose = TRUE, gt.html_tag_check = FALSE)

## Load required packages
library(pointblank)
library(tidyverse)
library(magrittr)
library(janitor)
library(yaml)
library(gt)
library(ggthemes)
library(here)
library(tinytex)
library(lubridate)
library(scales)
library(knitr)
library(broom)
library(fs)
library(usethis)
library(distill)
## Attached Packages/Conflicts, nb. restart r session to detach all previous

Ap1 <- sessionInfo(package = NULL)
print(Ap1)
## Styleguide

# Workflow
#Prepare R studio
## Set Environment
getwd()

## Install Packages
## Package overwrite code <- "install.packages("package name",dependencies = TRUE,
#repos = "http://cran.us.r-project.org")"
## Check Conflicts
## Attached Packages after load
```