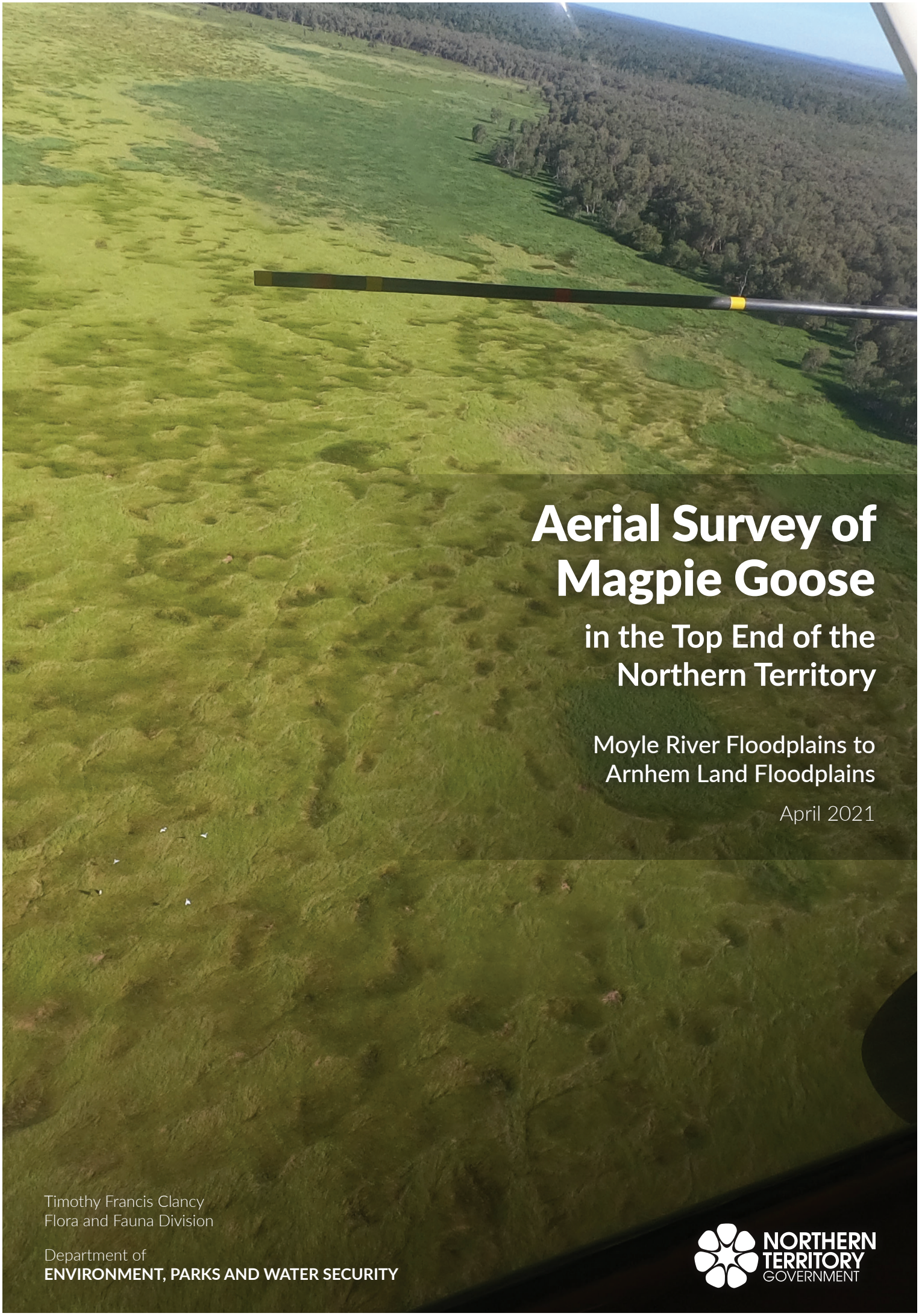

Aerial Survey of Magpie Goose

in the Top End of the Northern Territory

Moyle River Floodplains to Arnhem Land Floodplains

April 2021

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Department of
ENVIRONMENT, PARKS AND WATER SECURITY

NORTHERN TERRITORY GOVERNMENT

Aerial Survey of Magpie Goose in the Top End of the Northern Territory Moyle River floodplains to Arnhem Land floodplains, May 2021

Acknowledgments

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Summary

A fixed-wing aerial survey of Top End wetlands of the Northern Territory was undertaken from 11 April, 2021 to 30 April, 2021 to estimate population size and nesting activity of Magpie Goose. A total of 7,786 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 21,628 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 982,156 ± 283,717 (± standard error) with a coefficient of variation 28.89%; which is an average density of 45.4 geese per km^2 within the survey region. This is a decrease of -31.5 % on the 2020 estimate. This result signifies a population that has declined in response to two consecutive poor wet seasons and consequent poor breeding seasons. It is above the 2018 population of 918,200 which followed on from the historical low population estimate recorded in 2017.

The number of Magpie Goose nests was estimated to be 44,010 ± 9,086 for the surveyed area with a coefficient of variation of 20.65 %. This was above 2020 nesting levels, but despite the apparent favourable rainfall conditions for this wet season was below what would be considered a good nesting season. Similar to 2020 there was variation in the timing of nesting and it is difficult to predict the level of recruitment going into 2022. Rainfall preceding the survey period was above 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.

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 at the early part of the dry. The survey program is scheduled to coincide with the period when birds are nesting (so information about likely future population size can be gathered) and when the population is at its most geographically concentrated (to improve sampling efficacy, see Clancy 2020a).

The WMP MG sets out survey methods to be used to allow continuity with previous monitoring effort. It 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 2021 aerial survey. There was widespread rains across the Top End preceding this year's survey following on from the poor wet seasons in 2018/19 and 2019/20.

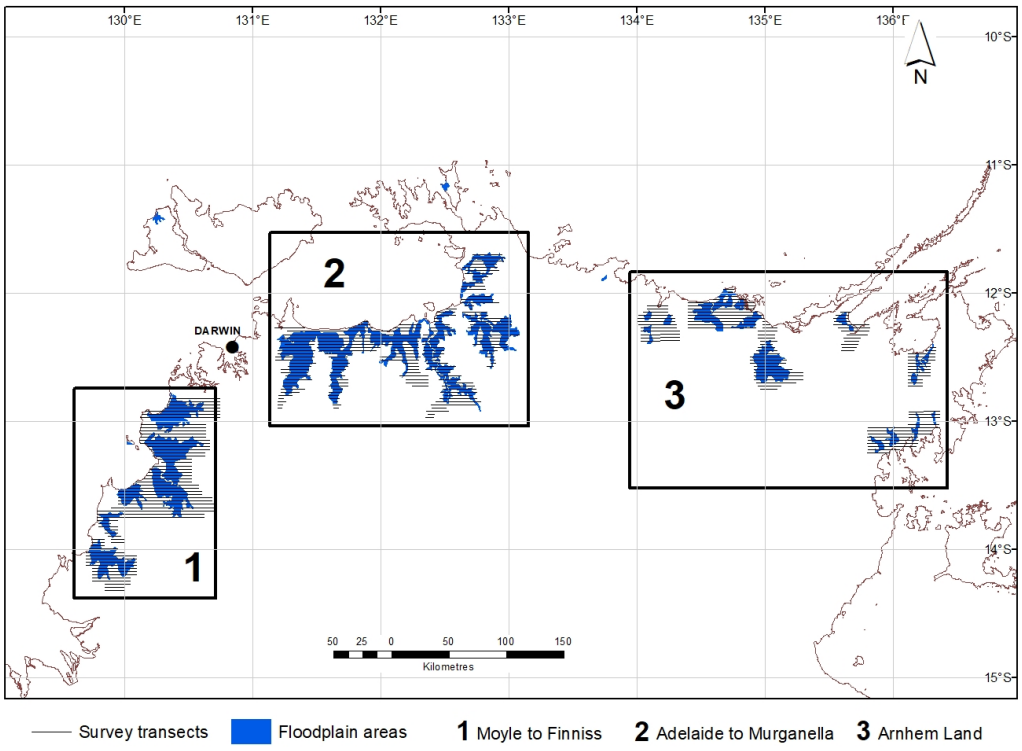


Figure 1: Survey regions for Magpie Goose aerial surveys. Since 2011, Area 2 has been surveyed annually and Area 1 on a biannual basis or more frequent basis. Area 3 has been surveyed less regularly. All areas have been surveyed annually since 2017.

Overall population estimates from aerial surveys from 2014 to 2020 are given in Table 1. In years when only one or two areas were 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 2021 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 current 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 2014 to 2020 derived from wet season aerial surveys. Estimates are adjusted to be comparable among years, independent of areas surveyed (Saalfeld 2011-2016, Groom and Saalfeld 2017, Clancy 2020b).

Population Estimate
2014 to 2020

Year	Number of animals	Standard error	Number of nests	Standard error
2014	1,300,000	100,000	134,000	4,000
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

Source: See *Clancy, T.F (2020b). 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

An opportunistic reconnaissance flight was undertaken over the Murgenella Flood plains on the 24 February, 2021 by Keith Saalfeld as part of a flight to Oenpelli. As nesting activity was observed it was decided to schedule the surveys for the mid April period to overlap likely peak nesting. Feedback from crocodile egg harvesters operating on relevant floodplains reported nesting on the western Daly River floodplains on 9 March and the Moyle on 10 March, 2021 confirming an early survey timing was required.

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 11 April, 2021 to 16 April, 2021. This area comprises six major survey blocks (Figure 2a).

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 2b) and was surveyed between 18 April, 2021 to 23 April, 2021. 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 27 April, 2021 to 30 April, 2021. This area was divided into six major survey blocks. Survey blocks were completed from east (based from Nhulunbuy) to west (based from Maningrida).The BMB survey block was incompletely surveyed due to poor weather conditions at the time making it too dangerous to continue.

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 Raoul Ribot, 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 Raoul Ribot who had previous extensive aerial and ground based surveying experience for waterbirds.

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 HP iPaq rx5900 Travel Companion linked to an external antenna mounted internal to the plane to improve GPS signal reception. Data were entered by observers using a purpose-built Basic program written by K. Saalfeld which allowed for Species [Magpie Goose, Magpie Goose Nest, Jabiru (*Ephippiorhynchus asiaticus*), Brolga (*Grus rubicunda*), Feral Pig (*Sus scrofa*), Horse (*Equus caballus*, generally only feral counted) and Buffalo (*Bubalus bubalis*)] and number to be recorded. This survey was also used to gather geo-located sightings of Saltwater Crocodile (*Crocodylus porosus*) for habitat occupancy modelling. 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.

Post Survey Data Handling and Editing

Data were downloaded daily from each observer's iPaq 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 etc.

Analysis and Reporting

Because transects were variable in length/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 using R version 4.1.0 and attached packages (see Appendix). Code was embedded in R Notebook document (Html) to produce this report as a knitted Distill markdown report (Allaire *et al.* 2018). Full code used in the analysis and reporting is available from the author.

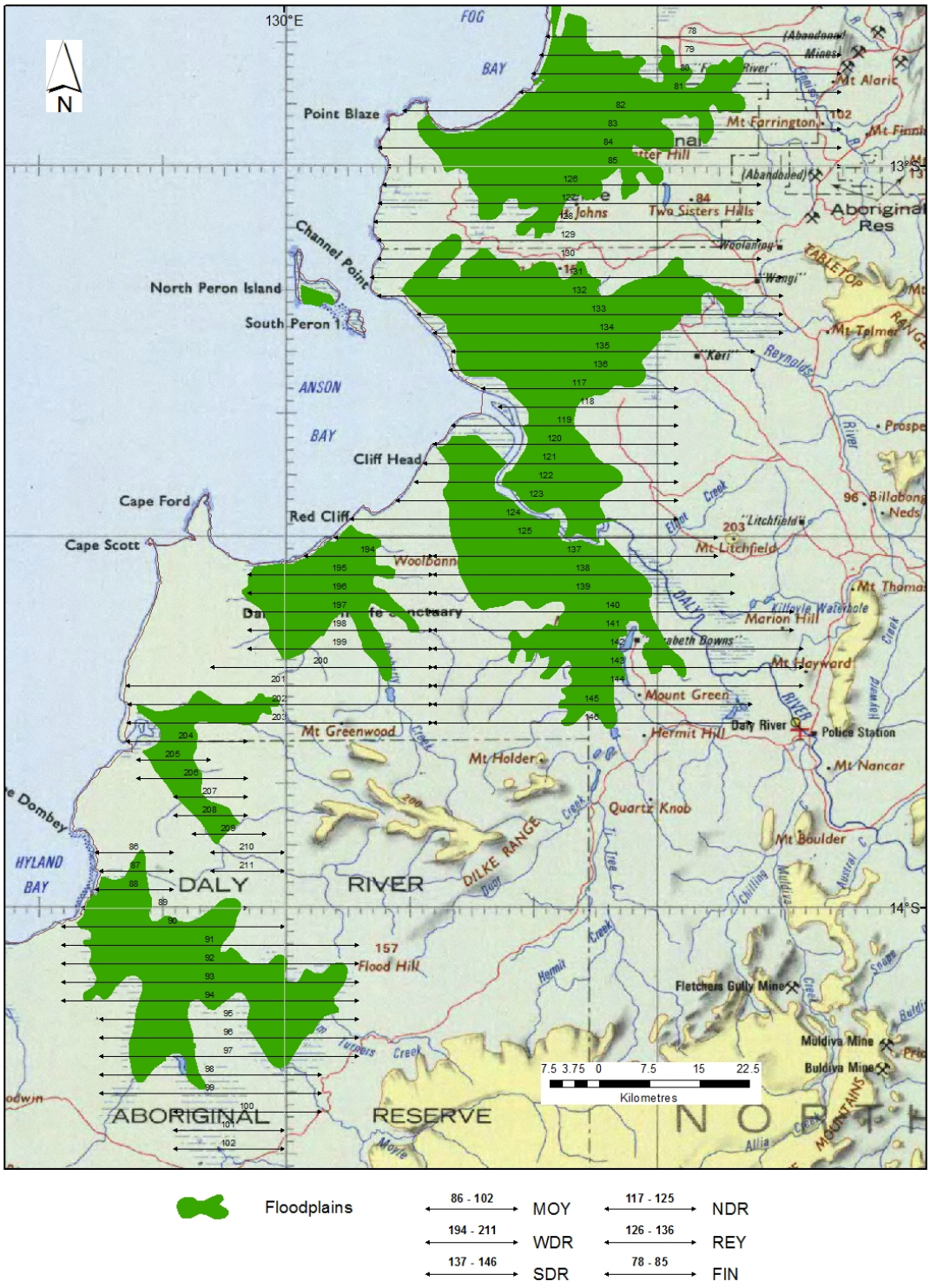


Figure 2a: Survey blocks and survey transects flown in the Moyle River floodplain to Finniss River floodplain survey region

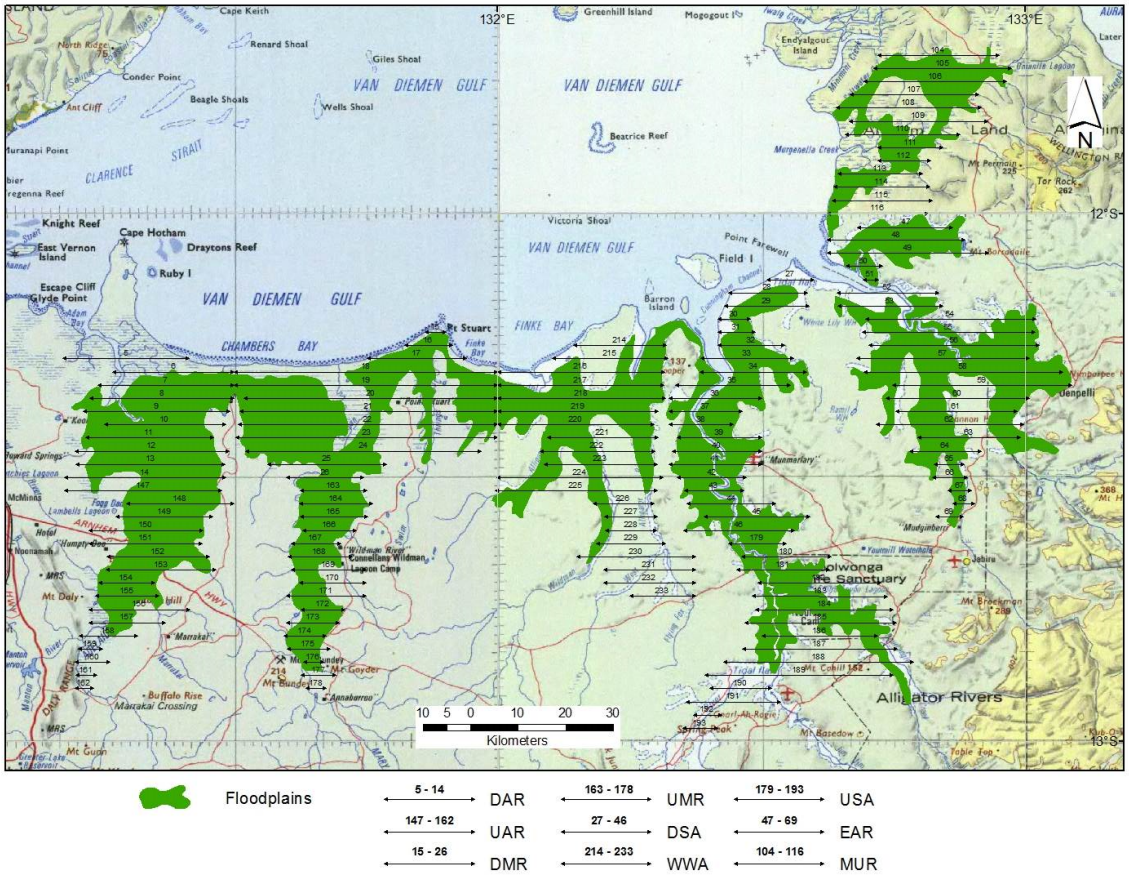


Figure 2b: Survey blocks and survey transects flown in the Adelaide River floodplain to Murgenella Creek floodplain survey region.

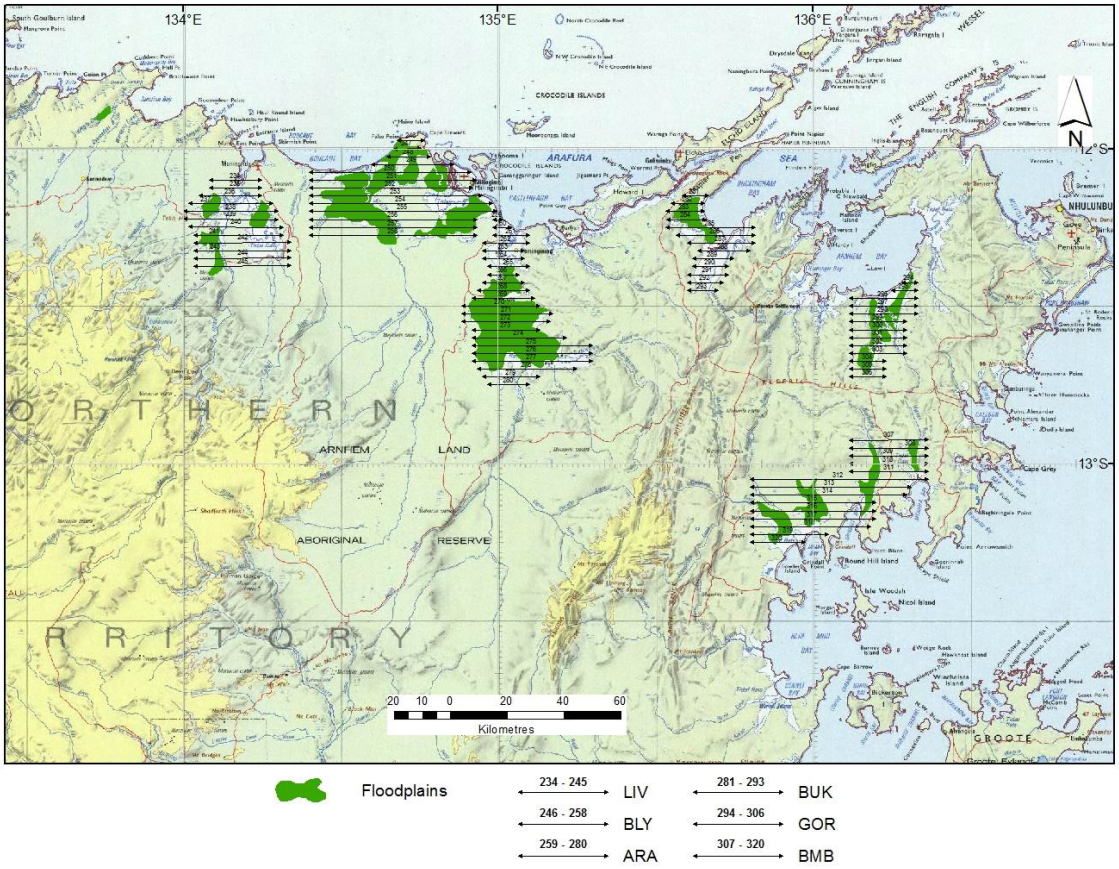


Figure 2c: Survey blocks and survey transects flown in the Arnhem Land floodplains survey region.

Results

Overall Population Estimate and Nesting level

The total population of Magpie Goose in the Top End in 2021 was estimated to be 982,156 ± 283,717 (± standard error) geese with a density of 45.41 ± 13.1 per km^2 (mean ± standard error), and a precision of 28.89 %. For Magpie Goose nests the estimate and standard error was 44,010 ± 9,086, an overall density of 2.03 ± 0.42 nests per km^2, at a precision of 20.65%.

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 less than 1 km^{-2} for a couple of blocks in Arnhem Land to 196.6 km^{-2} from the REY survey block. 47.4% of the total population occurred in the survey region from west of Adelaide River to Murgenella Creek which was lower than in previous years when around two thirds of the total population generally are counted there. This was a result of quite a high proportion of the population concentrating in the Reynolds region with over one quarter of the total (33 %) from this one block (REY). Only 4.4% of the total population was recorded in the Arnhem Land region, similar to 2020 but less than half what is typically found 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 sightings were less clumped than in 2020 and substantially less than in 2019. The dispersion index (ratio of mean to variance where ~ 0 = uniform, ~ 1 = random and » 1 = clumped; Caughley and Sinclair 1994) of the component blocks all reflected significant clumping (Range 0.2 to 898).

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 15.1, 24.8 and 58.0 % respectively). The overall estimate has a coefficient of variation of 28.9%. For both the goose population estimate and the nest estimate, the precision values are at acceptable levels for tracking the underlying trends in population size.

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 2021, the value was 4.5% signifying a poor nesting season, which was unexpected given the good wet season and follows on from two poor nesting seasons in 2019 and 2020. Rainfall recorded across the Top End was above average for most of flood plain areas and their catchments (Figure 5).

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 %)

Block	Region (Km2)	Number of Geese	Density (km-2)	CV% Geese	Number of Nests	CV% Nests
FIN	1,234	7,403	6.0	49.8	93.0	58.8
MOY	1,375	75,281	54.8	28.9	13,938.0	39.8
NDR	958	34,941	36.5	22.4	1,208.0	25.5
REY	1,648	323,832	196.5	84.5	1,502.0	32.3
SDR	1,362	7,699	5.7	35.7	387.0	45.1
WDR	1,389	24,509	17.6	31.8	1,285.0	35.0

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 %).

Block	Region (Km2)	Number of Geese	Density (km-2)	CV% Geese	Number of Nests	CV% Nests
DAR	798	37,173	46.6	54.1	10,716.0	62.1
DMR	1,240	57,878	46.7	39.1	5,962.0	34.2
DSA	915	101,475	110.9	31.9	1,115.0	39.6
EAR	1,404	72,092	51.3	38.3	2,648.0	47.1
MUR	972	86,943	89.5	38.0	1,022.0	41.2
UAR	719	17,448	24.3	54.7	1,022.0	42.3
UMR	490	5,535	11.3	54.1	325.0	93.8
USA	950	60,999	64.2	50.4	573.0	37.3
WWA	1,205	26,012	21.6	40.4	403.0	47.0

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 %).

Block	Region (Km2)	Number of Geese	Density (km-2)	CV% Geese	Number of Nests	CV% Nests
ARA	1,361	24,008	17.6	27.8	1,765.0	36.3
BMB	129	0	0.0	NaN	0.0	0.0
BUK	595	0	0.0	NaN	0.0	0.0
GOR	623	1,116	1.8	60.9	46.0	94.2
MAN	975	14,737	15.1	54.2	0.0	0.0
MIL	1,662	3,075	1.9	69.8	0.0	0.0

Figure 3. Population size (± standard error) of Magpie Goose 2016 to 2020 (End of Dry Season Surveys)

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

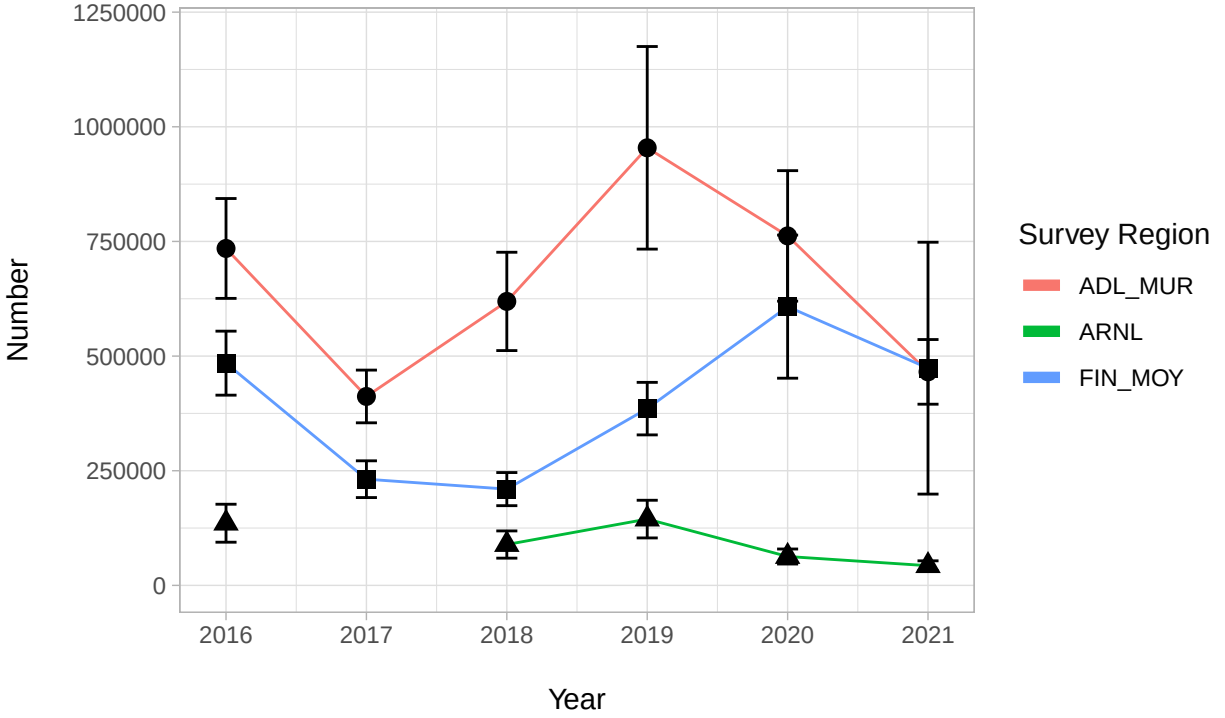
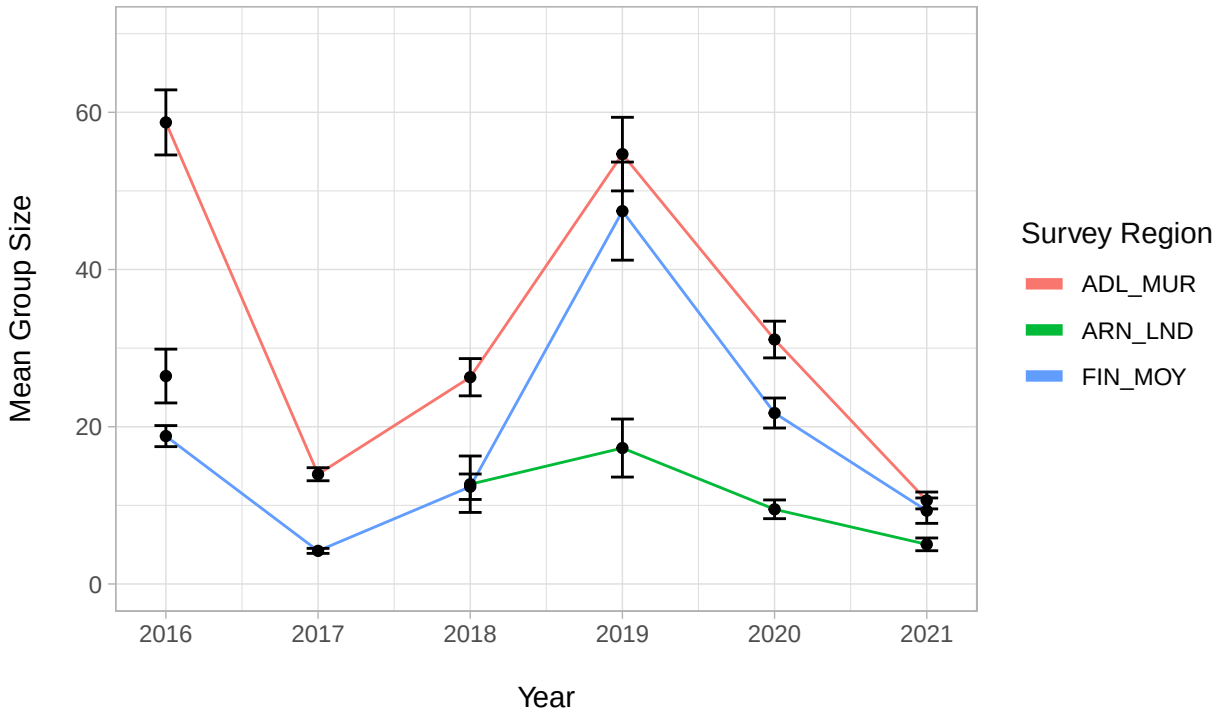


Figure 4. Mean (± standard error) recorded group size of Magpie Goose s 2016 to 2019 (End of Dry Season Surveys)

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



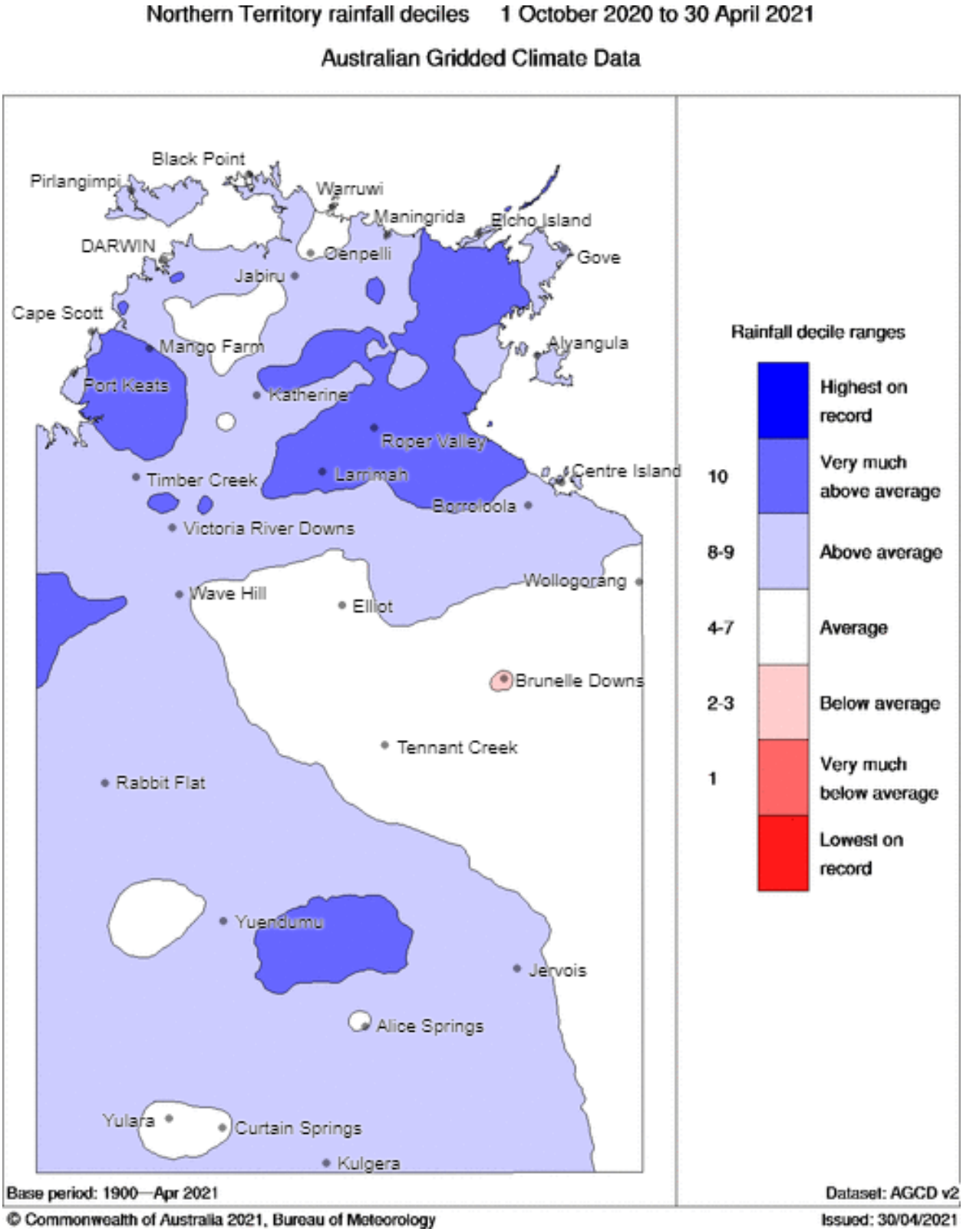


Figure 5 Map of the NT showing rainfall deciles for the 2020/21 wet season period. Figure from bom.gov.au.

Discussion

Population Size and Dispersion

The population estimate for Magpie Goose in the Top End of 982,156 ± 283,717 (mean ± standard error) reflected a large decrease from 1,432,793 ± 211,784 in 2020. This was on top of the slight decline recorded from 2019 to 2020 (Clancy 2020b). 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 Geese sighitngs 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.

The precision of the overall population estimate (28.89%) was lower than previous years' surveys where the coefficients of variation have been in the range of 8-18 % (see Table 1). This is wholly driven by the concentration of geese in one survey block, with numbers of virtually all others being below their historic average.

Population trends and outlook

A comparison of the changes in magpie goose population from 2011 to 2021 is provided in Table 3. The 2021 result is consistent with a population well below carrying capacity, following two poor breeding seasons in 2019 and 2020. The population remains well above the historical low in 2017 of 724,500. The decline in population followed on from a growth pause in 2020. Prior to 2020 there had been strong annual increase in numbers (25% and 62%) from 2017 to 2019 which followed on from a period of declines punctuated by period of relative stability from 2012 to 2017 (Clancy 2020b).

Significant 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 2018/2019 and 2019/2020 (as reflected in the low nesting; Table 3) were not conducive to continued population growth and this is reflected in this year's survey results. However, that the population declined significantly after consecutive poor rainfall years suggests that adult survivorship across the 2020 dry period was poor compared to the previous year (where the population only declined slightly despited poor breeding, Clancy 2020b).

Magpie Goose nests were estimated to be only 44,010 ± 9,086 (coefficient of variation 20.65 %) for the Top End, which is whilst low compared with the recent good nesting of 2017 and 2018, was higher than in 2019 and 2020 (Table 4).

Magpie Goose nests were estimated to be only 44,010 ± 9,086 (coefficient of variation 20.65 %) for the Top End which his higher than the most recent seasons poor seasons of 2019 and 2020 (Table 4). However, this is still poor nesting numbers compared with historical levels, despite a relatively good wet season. Nesting was more widespread than in 2020 where the only substantial nesting was observed on the Moyle River flood plain. There is potential that the higher rainfall this year will promote higher survivorship of fledglings. There were also indications that breeding this year was less synchronous than previous years so may underestimate overall production of young.

The monitoring results show that the population is well below historical highs and likely to be less than half the estimated long term carrying capacity (Clancy 2020a). A key feature of any harvest offtake is the level of compensatory mortality (whether offtake is additive or there is increased survivorship; Caughley and Sinclair 1994). With the current population estimates below half the long-term carrying capacity, there is likely to be relatively less pressure on the population in its current phase than if it were significantly higher. However, the low population size means that the absolute impacts may be greater and a low harvest offtake is required to ensure the population isn't destabilised.

Figure 6a. Population of Magpie Goose in Top End of NT

1983 to 2021 (End of Wet Season Surveys)

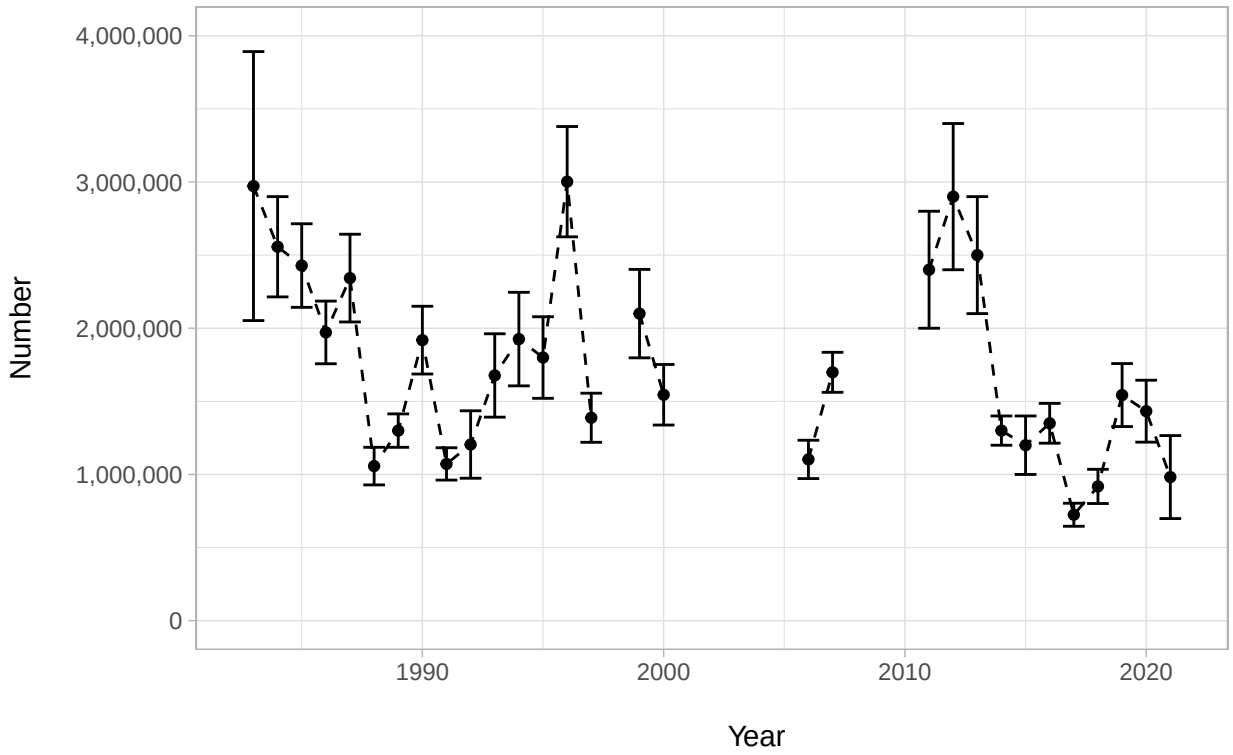


Figure 6b. Number of Nests in Top End of NT

1983 to 2021 (End of Wet Season Surveys)

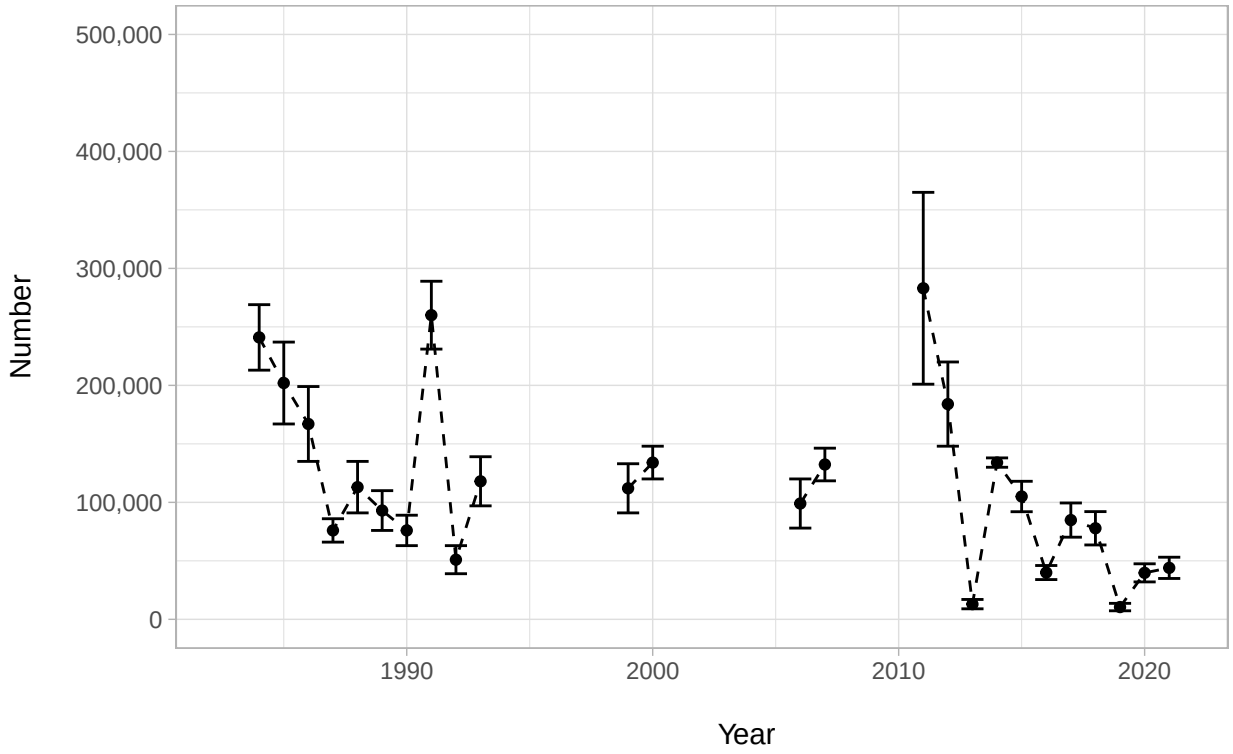


Table 3: Comparison of Top End Magpie Goose population trends and previous years nesting success from 2011 and 2019, and predicted trend in 2020.

[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% - -40% = Decrease (D); > -40% change = Big Decrease (BD).

Year	[A] Nesting %	[B] Popul Change	[C] Nesting Success	[D] Nest Success Previous Yr	[E] Popul 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%	L	L	D

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