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

Moyle River Floodplains to Arnhem Land Floodplains

May 2019

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Acknowledgments

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Summary

A fixed-wing aerial survey of Top End wetlands of the Northern Territory was undertaken from to 13th to 30th May 2019 to estimate population size and nesting activity of Magpie Goose. A total of 8043 km of fixed-width survey transects was flown using the standard methodology applied since 2011. The survey incorporated key flood plain habitats from Moyle River in the west to the Blue Mud Bay region of Arnhem Land in the east and covered 22,263 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 **1,484,090** ± 231,849 (± standard error) with a coefficient of variation 15.6%; which is an average density of 66.66 geese per km^2 within the survey region. This is an increase of 62% on the 2018 estimate. This increase is at the upper limit of what is biologically feasible (Brook and Whitehead (2005) and equates to an annual rate of increase (r) of 0.48 for the species.

The number of Magpie Goose nests was estimated to be **10,485** ± 1,228 for the surveyed area with a coefficient of variation of 11.7%. This was substantially below 2018 nesting levels, with reasonable nesting being observed in only one wetland region. This is likely to cause a pause in the recently observed strong population growth, or potentially a decline, however the overall size of the population is close to the long-term average.

Rainfall preceding the survey period was well below the long-term average for the wet season and this probably accounts for the low nesting rate observed. If poor wet season rainfall results in poor nesting in future years, it may be necessary to lower the harvest pressure on the population (including from recreational shooting activities) to ensure the long-term conservation of Magpie Geese.

Introduction

In the Northern Territory (NT), the Magpie Goose *Anseranas semipalmata* is used as a food source by traditional owners and to provide recreational hunting opportunities for hundreds of Northern Territory residents, as well as being subject to a small but growing commercial harvest. Recreational hunting and commercial use of the species are managed under a Management Program approved under the *Territory Parks and Wildlife Conservation Act*. Annual assessment of the population size and nesting activity of Magpie Goose are essential ingredients of the Management Program and are key to ensuring that this iconic waterbird species is managed in a sustainable manner (see Delaney *et al*. 2009).

Since 2011, a standardised monitoring regime has been implemented for the Magpie Goose (Saalfeld 2011) that builds on previous survey work, especially that of Bayliss & Yeomans (1990a). Under the standard monitoring regime, the most significant Magpie Goose habitat area - extending from the Adelaide River floodplain to Murgenella Creek floodplain (Area 1 in Figure 1) - has been surveyed on an annual basis at the end of the wet season (with the exception of 2014). Another key habitat area extending from the Moyle River to the Finniss River (Area 3 in Figure 1) has been surveyed bi-annually since 2011 (Clancy 2018). A third but less important habitat area in eastern Arnhem Land (Area 2 in Figure 1) has not been surveyed on a regular basis. Area 2 typically contains a low proportion of the total NT population but still provides substantial potential habitat for the species. Following the large population decline recorded in 2017 (Groom and Saalfeld 2017), a decision was taken in 2018 to survey all three areas annually, including wetland areas of Arnhem Land.

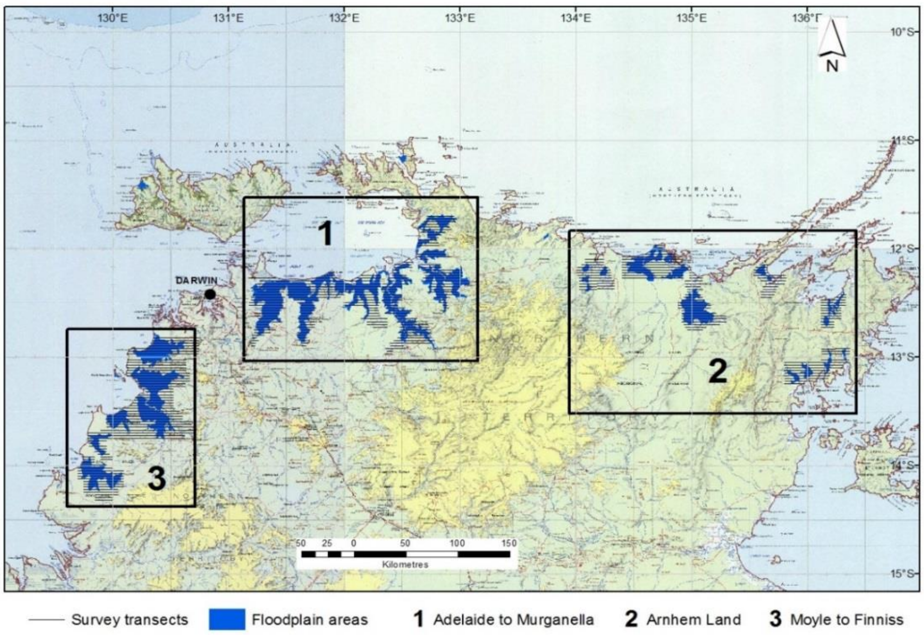

Figure 1: **Survey areas for Magpie Goose aerial surveys.** Since 2011**,** Area 1 has been surveyed annually and Area 3 on a biannual basis or more frequent basis. Area 2 has been surveyed less regularly. All areas were surveyed in 2018 and 2019.

Overall population estimates from aerial surveys from 2011 to 2018 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 consistently makes up 10% of total population in years when it is surveyed).

This report deals with the 2019 aerial survey of the Top End wetlands, including the Arnhem Land floodplains. It is believed that this survey area encompasses 90-95% of the current magpie goose population due to the use of the flood plains 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 2011 to 2018 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 2018).

Year	Magpie Goose population (million)	Magpie Goose nests
2011	2.4 ± 0.4	283,000 ± 82,000
2012	2.9 ± 0.5	184,000 ± 36,000
2013	2.5 ± 0.4	13,000 ± 4,000
2014	1.3 ± 0.1	134,000 ± 4,000
2015	1.1 ± 0.2	105,000 ± 13,000
2016	1.3 ± 0.1	40,000 ± 6,000
2017	0.72 ± 0.1	95,000 ± 15,000
2018	0.92 ± 0.1	78,000 ± 14,000
Average	*1.7*	*115,000*
Median	*1.3*	*95,000*

Methods

Survey Area and Design

A reconnaissance flight over wetland areas was undertaken in a Robinson R44 (observers Keith Saalfeld and Tim Clancy) on May 1st and 2nd 2019 to examine nesting levels in key nesting areas in the Swim Creek region of the Mary River floodplain. The flight was used to determine the final timing of the main fixed-wing survey to maximise, as far as practicable, concurrence with the peak nesting activity (post egg laying but prior to most eggs hatching). The poor 2018/19 wet season resulted in nesting (as predicted) being delayed or forgone, leading to a later survey time than 2018.

The Moyle River floodplains to Finniss River floodplains survey area (latitude 11^{0}50'S to 14^{0}20'S, longitude 129^{0}40’E to 130^{0}45’E) includes all major floodplains and wetland habitat within that region (Figure 2a) and was surveyed between 13 May and 17 May, 2019. This area was divided into six major survey blocks.

The Adelaide River floodplains to Murgenella Creek floodplains survey area (latitude 11^{0}40'S to 13^{0}00'S, longitude 131^{0}10’E to 133^{0}00’E) includes all major floodplains and wetland habitat within that region (Figure 2b) and was surveyed between 17 May and 24 May, 2019. This area was divided into nine major survey blocks.

The Arnhem Land floodplains survey area (latitude 12^{0}00'S to 13^{0}18'S, longitude 134^{0}10’E to 136^{0}21’E) includes all major floodplains and wetland habitat within that region (Figure 2c) and was surveyed between 27 May and 30 May, 2019. 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 are shown in Figs 2a, 2b and 2c. All lines were aligned east-west to perpendicularly cross the general north-south orientation of the major river systems, ridges and escarpments of the area. 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.

During the survey, an opportunity was taken to train a small number of additional observers to increase the pool of experienced observers that could be used in future. The nature of the methodology and conditions means that observers generally require 4 – 5 sessions of experience to provide data consistent with experienced observers, and not all people are suitable due to the issue of motion sickness. For all surveys two experienced observers (Dani Best, Tim Clancy, Brydie Hill, Carol Palmer or Keith Saalfeld) were present, along with a trainee or external (non-government) observer.

Counting Procedure

The survey crew comprised a pilot/navigator, a starboard front seat observer, a port mid-seat observer and a starboard 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*), and Buffalo (*Bubalus bubalis*)] and number to be recorded. 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 geocoded 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 to .xls format. Simple totals were produced to examine any potential major discrepancies which could be queried with the relevant observer. When network access was available all files were backed up to network drives. Simple cross tab, filtering and macros were used to aggregate data into transect counts in each survey block for the whole of survey region (each of 3 survey areas) tables for analysis.

Analysis

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 mid-seat or starboard front-seat observers. Only data from experienced observers were used in the analysis. 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.

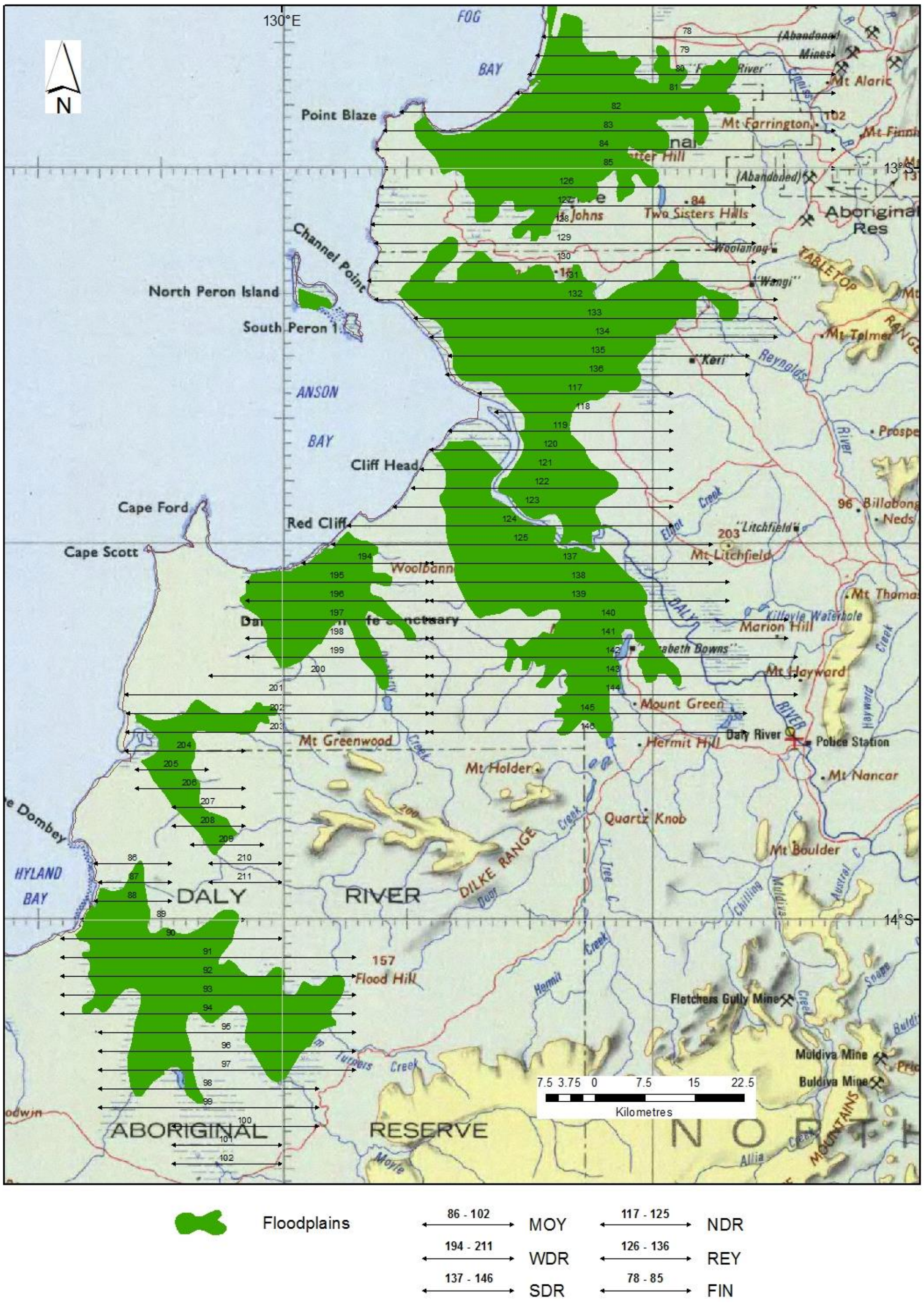

Figure 2a: Survey blocks and survey transects flown in the Moyle River floodplain to Finniss River floodplain survey area

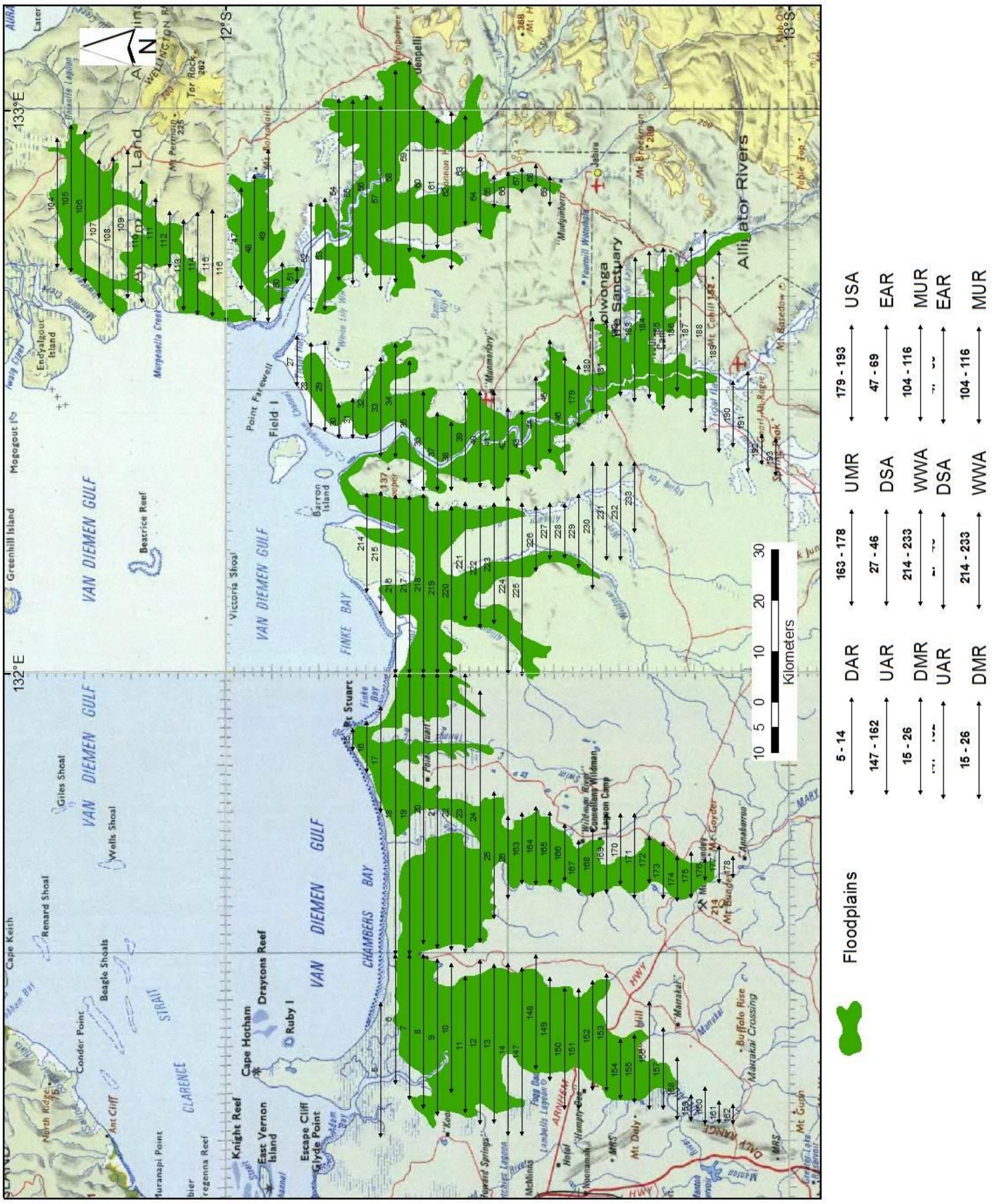

Figure 2b: Survey blocks and survey transects flown in the Adelaide River floodplain to Murgenella Creek floodplain survey area.

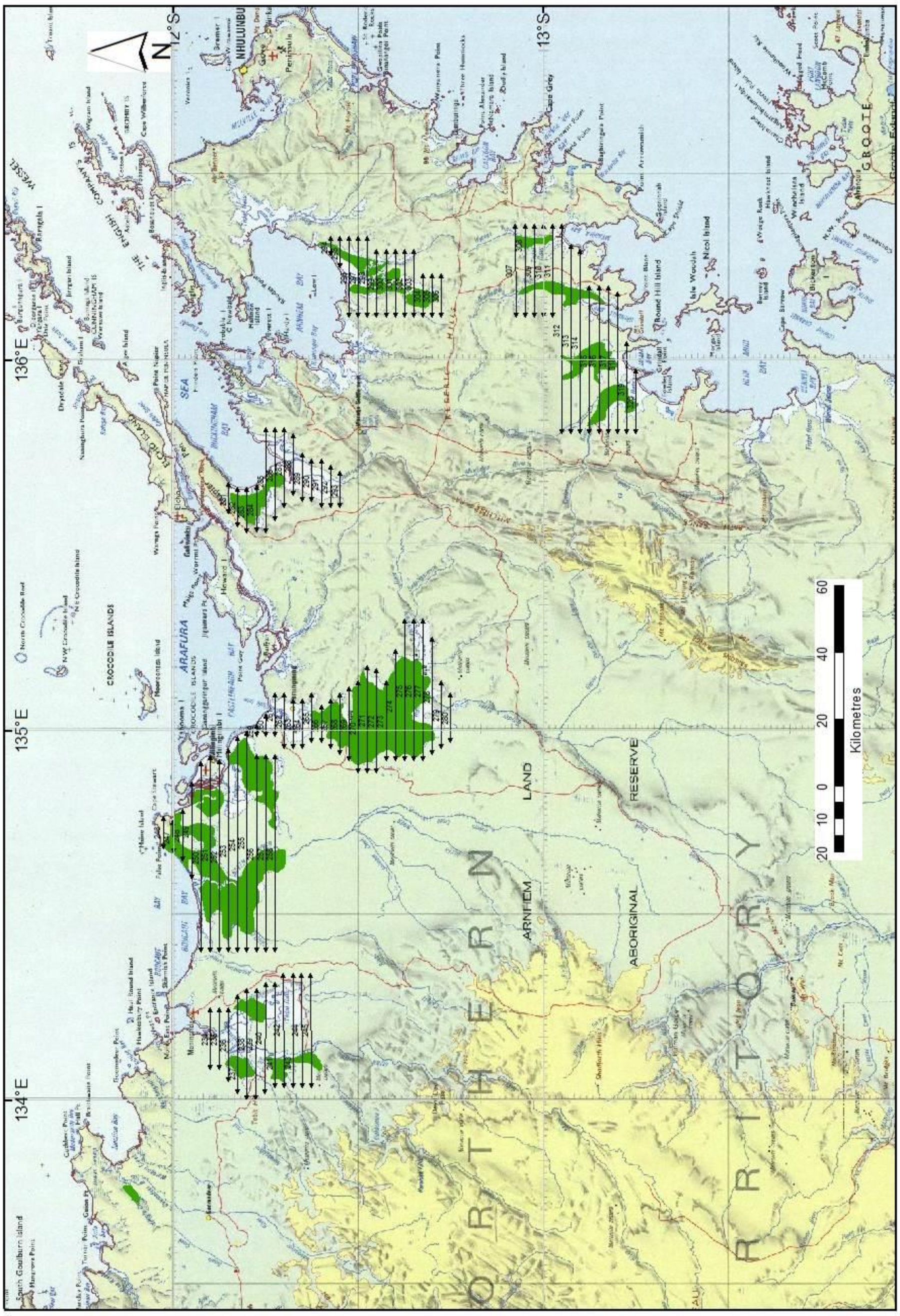

Figure 2c: **Survey blocks and survey transects flown in the Arnhem Land floodplains survey area.**

Results

Survey Block Population and Density Estimates

The population estimates for each survey block within the three survey areas are presented in Table 2 a-c, along with density and error for all estimates. Consistent with previous survey results, 64% of the total population occurred in the survey area from west of Adelaide River to Murgenella Creek and around 10% was found in the Arnhem Land region.

In contrast to previous years, the largest numbers of geese were recorded in the downstream Mary River block. Previously, the largest counts were recorded in the East Alligator River block in all years that this area has been surveyed since 2011. For this survey, the downstream Mary River block represented 39% of the survey area population estimate (and almost one quarter of the total population) whereas in 2018, this block represented only 14% of the survey area population total (and 10% of total estimate). By comparison, in 2018, the East Alligator Block was one third of the block population total and just under one quarter of the total estimate (Clancy 2018). Over 50% of all nests that were recorded were from the downstream Mary River block which represented the only area of reasonable nesting in 2019.

The estimate of the total population and standard error for the survey period is 1,484,090 ± 231,849 geese with a density of 66.66 ± 10.41 per square km (mean ± standard error), and a precision of 15.6 %. For Magpie Goose nests the estimate and standard error was 10,485 ± 1,237, an overall density of 0.47 ± 0.06 nests/km^2, at a precision of 11.8%.

The average size of observed groups of magpie goose is given in Figure 3 along with those recorded in previous years. The sightings were much more clumped than in 2018. The dispersion index (ratio of mean to variance where ~ 0 = uniform, ~ 1 = random and >> 1 = clumped; Caughley and Sinclair 1994) of the component blocks for the Adelaide River to Murgenella Creek survey area was around 3 times higher than in 2018 (23.4 compared with 8.8).

The precision of individual block estimates (as measured by the coefficient of variation, CV) ranged from around 20% to as high as 93% (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 14.9, 23.1 and 28.4 % respectively). The overall estimate has a coefficient of variation of 15.6 %. 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 2019, the value was only around 1% signifying a very poor nesting season, which was expected given the poor wet season. Rainfall recorded across the Top End was below average to well below average (Fig. 4) with only the Mary River to Western Kakadu region of the potential breeding areas recording average rainfall.

During the reconnaissance flight, the only observed nesting area was in the Mary River – Swim Creek region (contained within the downstream Mary River survey block); however the nesting within this small area was well advanced with most nests having a full complement of eggs (6-8).

Table 2a: Estimated population, density (in brackets), and precision (coefficient of variation expressed as a %) for Magpie Goose and nests in the Moyle River floodplain to Finniss River floodplain survey area. Values are ± standard error (incorporating the errors resulting from sampling).

Block (area in km^2)	Magpie Goose	Magpie Goose nests
Moyle River (731)	185,153 ± 51,169 (253.4 ± 70.0) 27.6%	434 ± 262 (0.6 ± 0.4) 60.3%
Daly River west (1,164)	27,814 ± 12,067 (23.9 ± 10.4) 43.4%	352 ± 300 (0.3 ± 0.3) 92.3%
Daly River south (1,362)	20,775 ± 11,230 (15.3 ± 8.2) 54.1%	248 ± 77 (0.2 ± 0.1) 31.0%
Daly River north (958)	49,910 ± 37,240 (52.1 ± 38.9) 74.6%	0 ± 0 (0 ± 0) -
Reynolds River (1,648)	50,707 ± 12,544 (30.8 ± 7.6) 24.7%	139 ± 131 (0.1 ± 0.1) 94.1%
Finniss River (1,233)	51,049 ± 15,231 (41.4 ± 12.3) 29.8%	47 ± 44 (0.0 ± 0.0) 95.2%
Total survey area (8,186)	385,408 ± 57,266 (54.3 ± 8.1) 14.9%	1,193 ± 429 (0.2 ± 0.1) 35.9%

Table 2b: Estimated population, density (in brackets), and precision (coefficient of variation expressed as a %) for Magpie Goose and nests in the Adelaide River floodplain to Murgenella Creek floodplain survey area. Values are ± standard error (incorporating the errors resulting from sampling).

Block (area in km^2)	Magpie Goose	Magpie Goose nests
Downstream Adelaide River (798)	25,194 ± 23,367 (31.6 ± 2.3) 92.7%	170 ± 158 (0.2 ± 0.2) 92.7%
Upstream Adelaide River (719)	228 ± 181 (0.3 ± 0.3) 79.2%	0 ± 0 (0 ± 0) -
Downstream Mary River (1,240)	369,280 ± 187,684 (297.8 ± 151.3) 50.8%	5,297 ± 1,665 (4.3 ± 1.3) 31.4%
Upstream Mary River (490)	15,035 ± 7,160 (30.7 ± 14.6) 47.6%	93 ± 23 (0.2 ± 0.0) 25.2%
Wildman/West Alligator River (1,205)	132,030 ± 70,589 (109.6 ± 58.6) 53.5%	47 ± 10 (0.0 ± 0.0) 22.3%
Downstream South Alligator River (915)	86,403 ± 20,181 (94.5 ± 22.1) 23.4%	558 ± 24 (0.6 ± 0.0) 4.2%
Upstream South Alligator River (950)	73,760 ± 16,101 (77.6 ± 16.9) 21.8%	341 ± 84 (0.4 ± 0.1) 24.5%
East Alligator River (1,404)	155,904 ± 63,506 (111.0 ± 45.2) 40.7%	1,084 ± 245 (0.8 ± 0.2) 22.7%
Murgenella (822)	96,312 ± 57,295 (117.1 ± 69.7) 59.5%	1,270 ± 351 (1.5 ± 0.4) 27.6%
Total survey area (8,657)	954,145 ± 220,879 (111.69 ± 25.9) 23.1%	8,859 ± 1,728 (1.0 ± 0.2) 19.5%

Table 2c: Estimated population, density (in brackets), and precision (coefficient of variation expressed as a %) for Magpie Goose and nests in the Arnhem Land floodplain survey area. Values are + standard error (incorporating the errors resulting from sampling).

Block (area in km^2)	Magpie Goose	Magpie Goose nests
Liverpool - Tomkinson River, Maningrida (975)	113.9 ± 64.7 (0.1 ± 0.1) 56.8%	0 ± 0 (0 ± 0) -
Blyth - Cadel River (1,338)	29,727 ± 17,065 (22.2 ± 12.8) 57.4%	0 ± 0 (0 ± 0) -
Arafura Swamp (1,362)	88,157 ± 34,383 (45.5 ± 17.8) 39.0%	403 ± 154 (0.2 ± 0.1) 38.3%
Buckingham Bay (595)	159 ± 63 (0.3 ± 0.1) 39.2%	0 ± 0 (0 ± 0) -
Gorrumurru River	9,841 ± 6,466 (18.4 ± 12.1) 65.7%	31 ± 43 (0.1 ± 0.1) 138.8%
Blue Mud Bay	16,538 ± 13,113 (13.3 ± 10.5) 79.3%	0 ± 0 (0 ± 0) -
Total survey area (4,594)	144,537 ± 41,076 (21.8 ± 6.2) 28.4%	434 ± 160 (0.1 ± 0.0) 36.9%

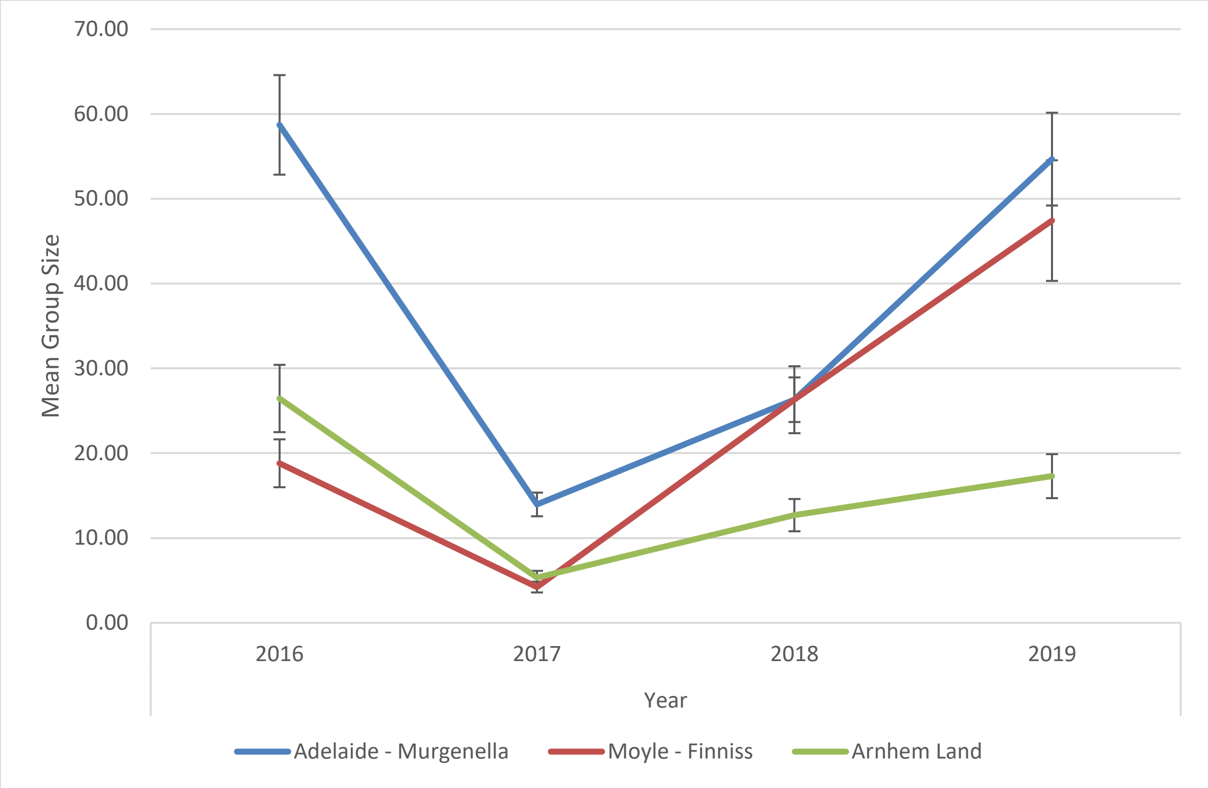

Figure 3 Mean (± standard error) recorded group size of Magpie Goose sightings for aerial surveys 2016 to 2019.

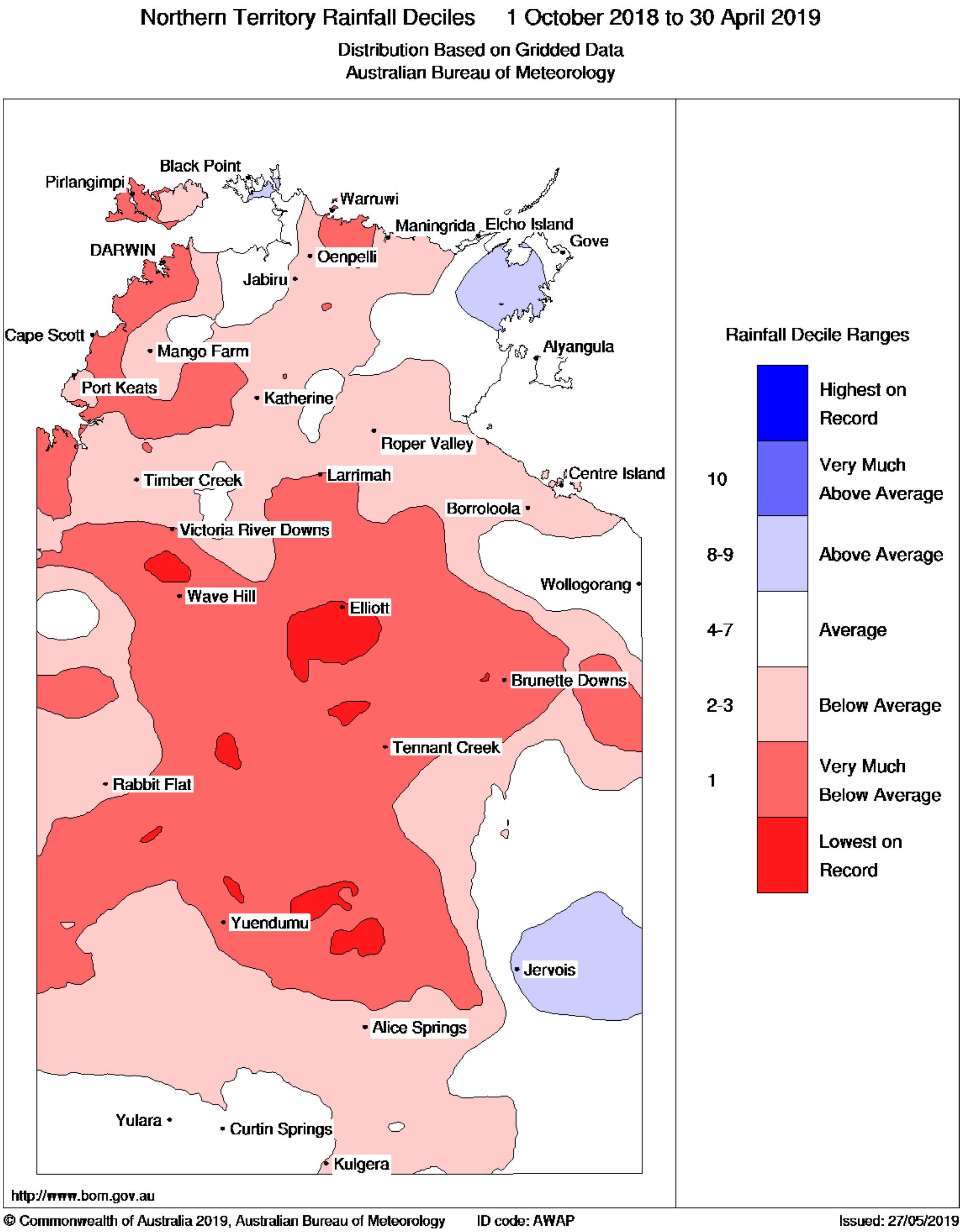

Figure 4 Map of the NT showing **rainfall deciles for the 2018/19 wet season period.** Figure from bom.gov.au.

Discussion

Population Size and Dispersion

The population estimate for Magpie Goose in the Top End was 1,484,000 ± 232,000 (mean ± standard error), a significant increase from 918,000 ± 117,000 in 2018. As in previous years, this may represent a conservative estimate of the species population in the NT, recognising that some birds may occur outside the survey area at the time of survey. However, this year birds were unusually concentrated in large aggregations, rather than spread out across the usually flooded lower wetland areas. This may have resulted in the population size being overestimated, as large aggregations are likely to be more visible than smaller aggregations and the standard correction factor may need to be adjusted downward to account for this.

A comparison of the changes in magpie goose population from 2017 to 2019 is provided in Table 3. The relative increase in numbers (62%) from 2018 to 2019 is at the upper limit of the biologically possible rate of increase postulated by Brook and Whitehead (2005), being dependent on almost complete survivorship of animals, all mature females reproducing and equivalent to 100% compensatory survivorship of birds removed from the population.

The specific environmental circumstances and demographic features of the population moving from 2018 to 2019 were probably optimal for a rapid increase. These circumstances included a population size equivalent to approximately half potential carrying capacity, a large amount of demographic vigour as the population was in a recovery phase from a significant decline (leading to a high proportion of breeding age females, low proportion of old birds and limited competition for breeding habitat) and well above average 2017/18 wet season rains leading to high food availability across the dry season of 2018. As noted above, the 2019 population figure may be an overestimate, as the standard correction factor is not appropriate when birds are highly aggregated, so the proportional increase may actually be less than calculated. Nevertheless, the current population is likely to be close to the longer-term average (Table 1), meaning that it has recovered strongly from the very low levels recorded in 2017.

In the 2018 survey period, nearly one quarter of the total birds were recorded in the East Alligator River survey block (Clancy 2018). Similarly, in 2019 there was substantial clumping of the population, but the epicentre of goose density has shifted slightly west to the downstream Mary River block, which also coincided with the only area where reasonable nesting occurred. This survey block is 112,000 ha in size and accounted for approximately 5.6 % of the 2.3 M ha total survey area, highlighting the challenges in the surveying of an abundant but relatively mobile and unevenly dispersed species.

The precision of the overall population estimate was reasonably good (15.6%) and is comparable with previous years' surveys where the coefficients of variation have been in the range of 8-18 % (see Table 1).

Table 3: Comparison of Top End Magpie Goose population and nest estimates for 2017, 2018 and 2019 by Survey Area. Estimates for Arnhem Land in 2017 are based on the longer-term data set.

Region	Year			
Geese	**2017**	**2018**	**2019**	***% Change 2018 to 2019***
Adelaide - Murgenella	411,988	619,195	954,145	*154%*
Moyle - Finniss	231,555	209,937	385,408	*184%*
Arnhem Land	*80,957*	89,068	144,537	*162%*
Total	724,500	918,200	1,484,090	*162%*
Nests	**2017**	**2018**	**2019**	
Adelaide - Murgenella	63,978	55,135	8,859	*16%*
Moyle - Finniss	20,845	21,946	1,193	*5%*
Arnhem Land	*14,616*	759	434	*57%*
Total	99,439	77,840	10,485	*13%*

Population trends and outlook

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 2018). The rainfall conditions experienced in 2016/2017 and 2017/2018 were conducive to strong population growth and this is reflected in this year's survey results. The low level of nesting observed in 2019 is also consistent with the very poor 2018/19 wet season across the Top End.

Magpie Goose nests were estimated to be only 10,485 ± 1,237 (coefficient of variation 11.8%) for the Top End, which is very low, especially compared with the recent good nesting of 2017 and 2018 (Table 3). This is highly likely to result in a decline in population in 2020, or at the very least a pause in the recovery observed since 2017 (Table 4). Given this, it may be prudent to keep the cumulative offtake from all anthropogenic sources (recreational hunting, commercial take, pest mitigation and traditional take) within the estimated safe sustainable yield level which would equate to 8.5% (120,000) of the current or long-term average population estimate. As the best estimate of Aboriginal traditional take is around 60,000 (Delaney *et al.* 2009), this would mean that daily hunting bag limits should not exceed 7 birds (which equates to an offtake of approximately 40,000 birds).

The monitoring results indicate that there has been a significant increase in the population since 2017 (Table 1; Figure 6) and the population is approaching the longer-term average. 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). Whilst the exact level of compensation is not known, the relative level will be at its highest when the population is close to half the long term carrying capacity. The long-term carrying capacity is likely to be in the 2.5- 3 M range for the NT Magpie Goose population (Clancy, in prep), with the current population estimates at half the long-term carrying capacity. That is, there is likely to be relatively less pressure on the population in its current phase than if it were significantly lower. However, the low nesting, if followed up with subsequent poor rainfall, may require a future lowering of offtakes to prevent an anthropogenic-driven decline.

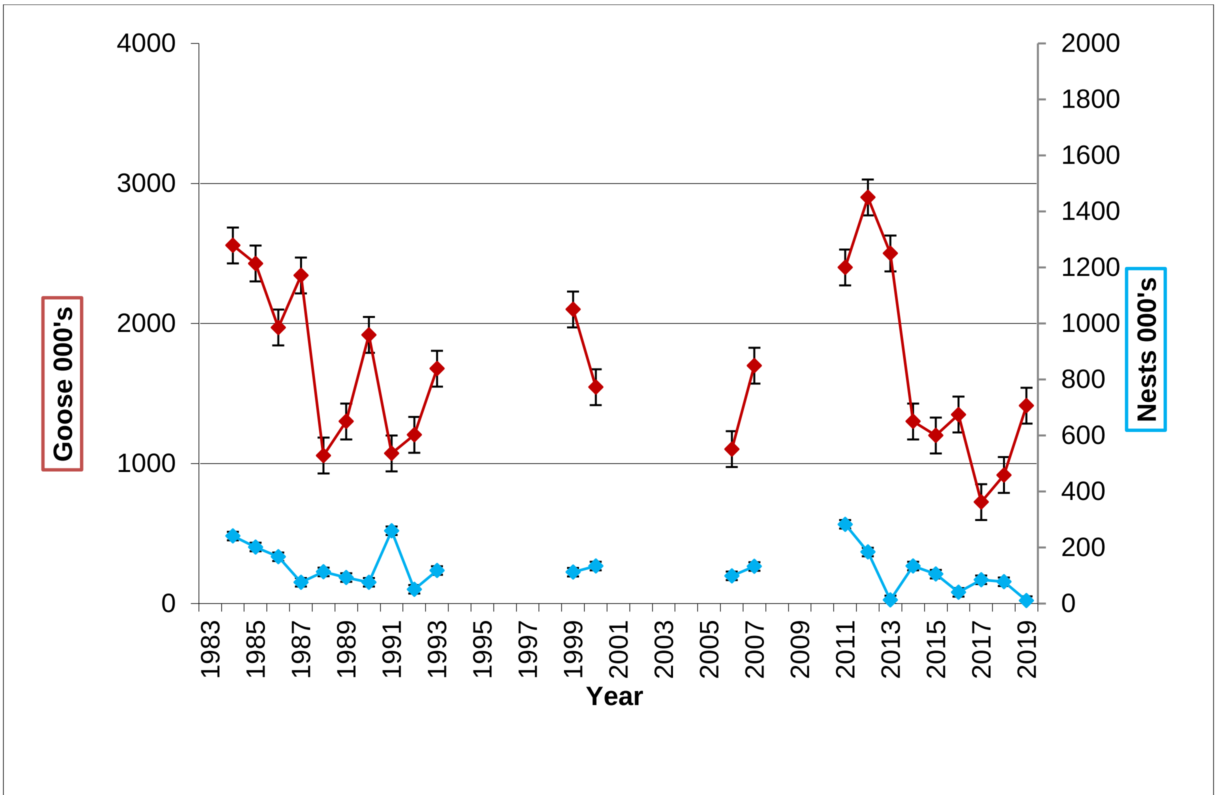

Figure 6: **Magpie Goose population and nest estimates (means ± standard error) for the period 1983 to 2019, derived from aerial survey data.** Note that goose numbers (left axis) and nest numbers (right axis) are on different scales.

Table 4: 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 Proportion	[B] Year to Year Population Change	[C] Nesting Success	[D] Nesting Success Previous Year	[E] Population Trend
2011	12%		VH		
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		*-25%*		L	*D*

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