

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

Moyle River Floodplains to Arnhem Land Floodplains
April-May 2018



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Acknowledgments

This survey was funded by the Northern Territory Government and supported by the Department of Environment and Natural Resources, Department of Tourism and Culture and the Australian Government Department of Environment.

Troy Thomas from Heli-muster NT Pty Ltd (survey) and Cameron Pennycuik from Remote Helicopters (reconnaissance flights) provided professional piloting service.

Skilled observing and data recoding was delivered by Brydie Hill, Carol Palmer, Kate Buckley, Rachel Groom and Claire Millen from Flora and Fauna Division, Department of Environment and Natural Resources; Alice Donne, McKay Smith, Ian Hunt and David Jacobson from Wildlife Operations, Department of Tourism and Culture; Shiona McDonald and Louise Harrison from Kakadu National Park; and Brian Boyle from Field and Game (NT).

Advice on and support with survey logistics was provided by Keith Saalfeld, Rachel Groom and Jo Pridham from Flora and Fauna Division, Department of Environment and Natural Resources; and Sally Heaton and Tracey Duldig from Wildlife Operations, Department of Tourism and Culture.

The Department is grateful to Traditional Owners and pastoralists who allowed the surveys to be undertaken across their land as well as for direct and indirect support from Commonwealth (Kakadu) and Northern Territory (NT Parks) park management agencies.

Report layout and content drew heavily on previous years' reports prepared by Keith Saalfeld and Rachel Groom. Glenn Edwards and Keith Saalfeld provided critical review that greatly improved this report.

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Summary

An aerial survey to estimate the Magpie Goose population size and nesting activity was undertaken from 29th April 2018 to 9th May 2018 across the Top End of the Northern Territory, from the Moyle River flood plains in the west to the Blue Mud Bay region of Arnhem Land in the east. A total of 8043 km of survey transect was flown using the standard methodology applied since 2011, sampling 22,263 square kilometres (over 2 million ha) of potential habitat at a sampling intensity of 14.4%. Counts for Magpie Goose and Magpie Goose nests were corrected for a combined perception and visibility bias based on correction factors derived from Bayliss & Yeomans (1990a & b).

The population estimate for Magpie Goose was **918,200** \pm 116,961 (coefficient of variation 12.7%), which is an average density of 40.1 individuals per km² within the survey region. This is an increase of 26.7% on the 2017 estimate and equates to an annual rate of increase (r) of 0.237, suggesting the population was growing at a rate towards the top of the range of the theoretical plausible r_m for the species proposed by Brook and Whitehead (2005).

The number of Magpie Goose nests was estimated to be **77,839** \pm 14,250 (coefficient of variation 18.3%) for the surveyed area. This was on a par with nesting levels for 2017 if only the common surveyed area is considered. This is considered high to very high nesting rates compared with relative nesting in previous years and is suggestive of a continued rise in population in 2018/19, if other factors including harvest from hunting are considered to be moderate to low. Rainfall preceding the survey period was above average across the wet season consistent with the observed high nesting rate for this year.

Introduction

The Magpie Goose, *Anseranas semipalmata*, is an iconic waterbird species valued for cultural reasons, as a resource for food, recreational hunting opportunities and as a wildlife viewing experience supporting nature based tourism in the Top End of the Northern Territory. Details of the species' biology, management context and conservation are provided in Delaney *et al.* (2009), as well as the future management regime and population monitoring requirements.

Monitoring of Magpie Goose populations in the Northern Territory by aerial survey has been carried out since the early 1980s. During the period 1983 to 1993, the annual aerial survey of Magpie Geese on the Top End floodplains was conducted during or immediately after the end of the wet season¹, so that additional data on nesting activity could be collected. Between 1994 and 2001 surveys were undertaken during the dry season (see Bayliss & Yeomans 1990a for characterisation of dry season survey) and the values of each approach are discussed in Delaney *et al.* (2009). Between 2000 and 2010 only two major aerial surveys of Magpie Geese populations in the Top End were undertaken, in 2000 and 2006. Both of these surveys covered the floodplain areas from the Moyle River in the west to Murganella in the east, including Kakadu National Park (Delaney *et al.* 2009).

Following a review of all the monitoring approaches a revised monitoring program was implemented in 2011 (Saalfeld 2011). Since then, the most important habitat area based on relative numbers of geese - the Adelaide River floodplain to Murganella Creek floodplain – has been surveyed on an annual basis (with the exception of 2014). The second most important area - Moyle River floodplain to Finnis River floodplain - has been surveyed on a less frequent basis but has generally been surveyed in totality in most years since 2011 (Groom and Saalfeld 2017). The third most important area - Arnhem Land, which typically contains only 10-15 % of the total NT population - has been surveyed less frequently due to financial and logistical constraints.

Overall population estimates from aerial surveys since 2011, adjusted to be comparable among years independent of areas surveyed, are shown in Table 1.

This report provides details of the 2018 aerial survey. Due to the declining population estimates after 2013 and historically low estimate in 2017, a decision was made to survey the full extent of Top End Magpie Goose habitat in 2018, including Arnhem Land floodplains.

¹ Wet and dry season definition as per BoM <http://www.bom.gov.au/climate/glossary/percentages.shtml>.

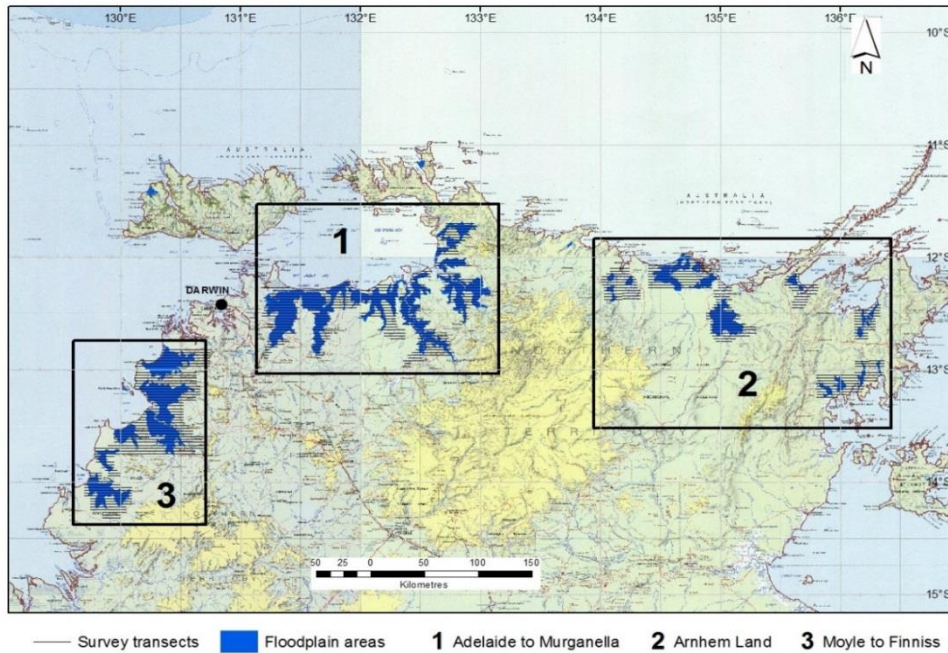


Figure 1: Survey areas for Magpie Goose aerial surveys. Since 2011, Area 1 has been surveyed annually and 3 on a biannual basis or more frequent basis. Area 2 has been surveyed less regularly. All areas were surveyed in 2018.

Table 1: Population and nest estimates from 2011 to 2017 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).

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

Methods

Survey Area and Design

A reconnaissance flight over wetland areas was undertaken in a Robinson R44 (observers Rachel Groom, Brydie Hall and Tim Clancy) on April 10, to ascertain progress of the nesting season. A further flight was undertaken on April 16. Observations guided the final timing of the main survey and survey block order to maximise, as far as practicable, concurrence with the peak nesting period.

The Moyle River floodplains to Finniss River floodplains survey area (latitude 11°50'S to 14°20'S, longitude 129°40'E to 130°45'E) includes all major floodplains and wetland habitat within the region (Figure 2a) and was surveyed between 23 April and 27 April, 2018. This area was divided into six major survey blocks.

The Adelaide River floodplains to Murganella Creek floodplains survey area (latitude 11°40'S to 13°00'S, longitude 131°10'E to 133°00'E) includes all major floodplains and wetland habitat within that region (Figure 2b) and was surveyed between 29 April and 4 May, 2018. This area was divided into nine major survey blocks with the eastern blocks (based from Jabiru) undertaken first.

The Arnhem Land floodplains survey area (latitude 12°00'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 6 May and 9 May, 2018. 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 206 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 radar altimeter. 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 1989a) 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 traverse 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 generally observers 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 were present, along with a trainee or external (non-NTG 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*), Feral Horse (*Equus caballus*), 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 accumulate 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 & 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); correction factors were 3.28 for Magpie Geese and 2.23 for Magpie Goose nests.

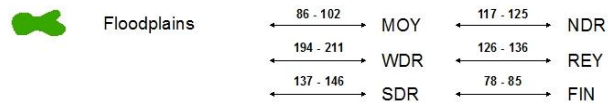
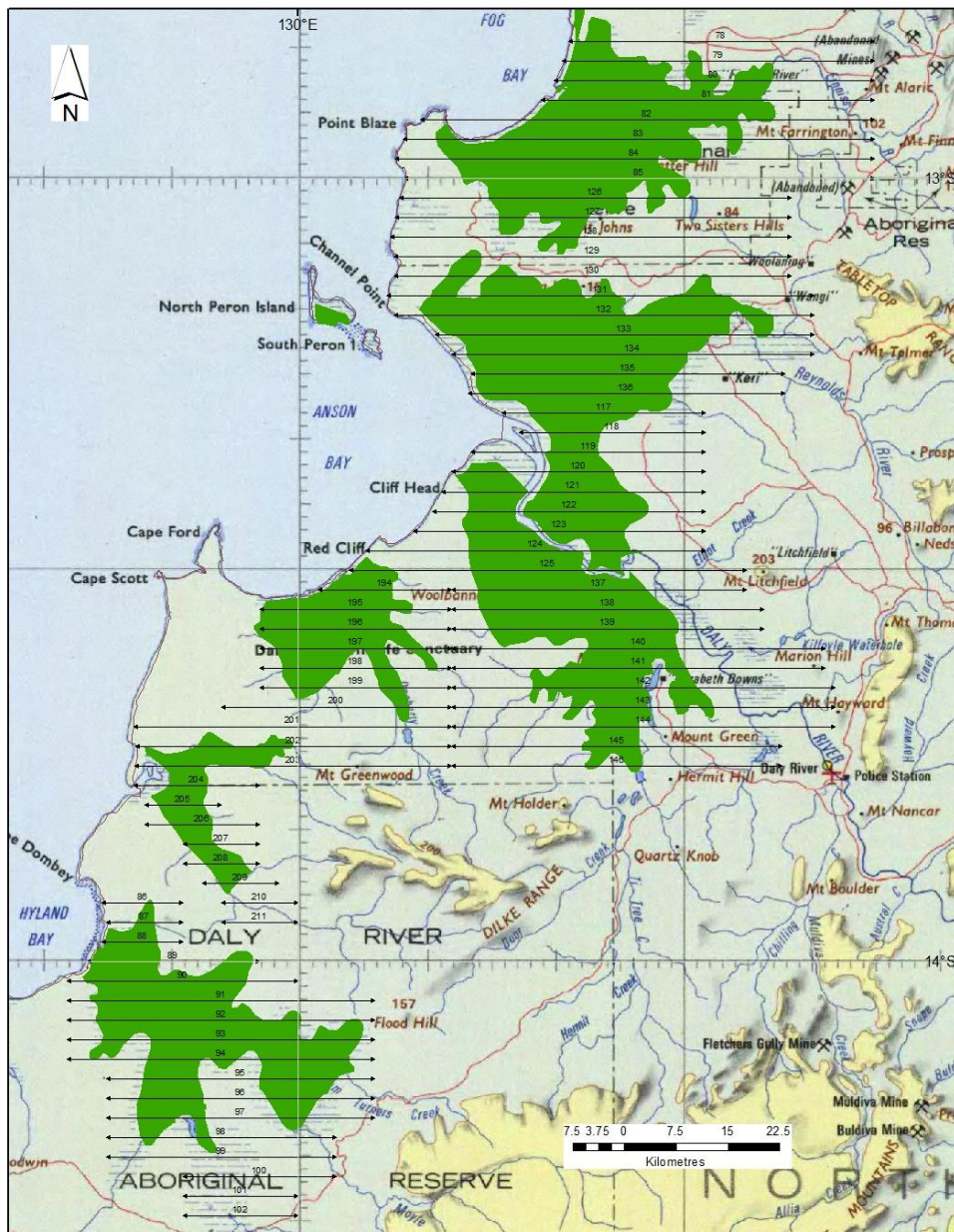


Figure 2a: Survey blocks and survey transects flown in the Moyle River floodplain to Finnis River floodplain survey area

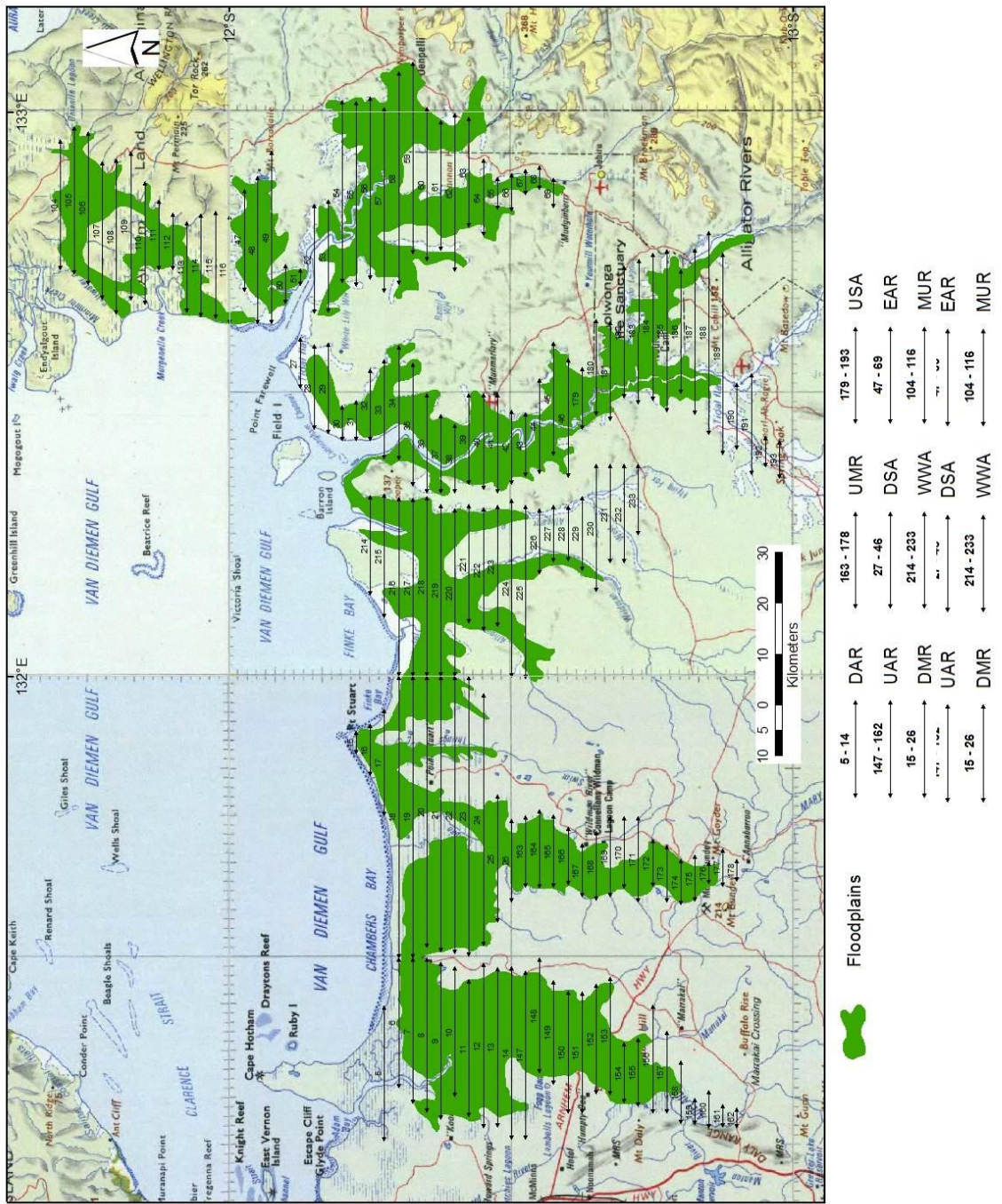


Figure 2b: Survey blocks and survey transects flow in the Adelaide River floodplain to Murganella Creek floodplain survey area.

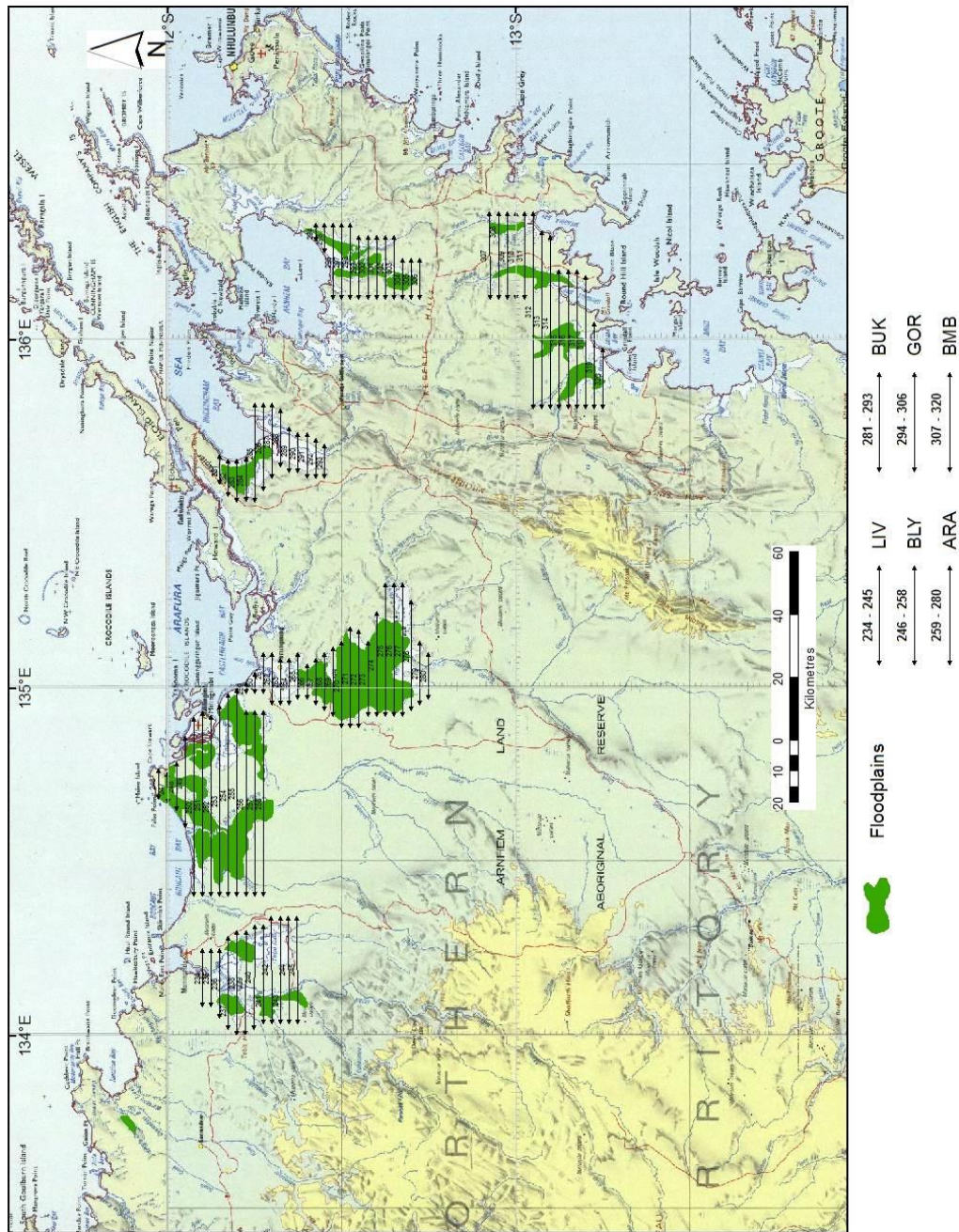


Figure 2c: Survey blocks and survey transects flown in the Arnhem Land floodplains survey area.

Results

Survey Block Population and Density Estimates

The population estimates, density and precision figures for the three survey areas are presented in Tables 2a, 2b and 2c. As has been the pattern of previous surveys, just over two thirds of the magpie geese were observed in the survey area from west of Adelaide River to Murganella Creek, with a third of these (and almost a quarter of the overall total population) being recorded in one block, East Alligator River. This highlights the extremely clumped population distribution of the species (dispersion index: ratio of mean to variance for Survey Area 1 = 8.8 where ratio ~ 0 = uniform, ~ 1 = random and $\gg 1$ = clumped; Caughley and Sinclair 1994). Similarly, survey area 2 (Arnhem Land, dispersion index = 6.8) and survey area 3 (Moyle to Finniss; dispersion index = 4.0) exhibited highly clumped dispersion patterns.

This clumped dispersion patterns lead to coefficient of variation (a measure of precision or the confidence of the individual estimator in question) for individual survey blocks of a moderate to high level; typically 20-40% but for some blocks as high as 90% (Table 2 a,b,c). However, the high sampling intensity means that at a whole of survey block level the estimate is generally acceptable (less than 20% for the higher density survey areas and 33% for Arnhem Land).

The overall (three survey areas combined) Magpie Goose population estimate was $918,200 \pm 116,961$, equivalent to an overall density of 40.1 ± 5.1 geese/km², at a precision of 12.7%. For Magpie Goose nests the estimate was $77,839 \pm 14,250$, an overall density of 3.4 ± 0.6 nests/km², at a precision of 18.3%. For both the goose population estimate and the nest estimate the precision value 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 a broad indication of the nesting rate for the season. For 2018 the value was 8.5%, although this is likely to be an underestimate for the overall season due to an apparently lower than normal synchrony in nesting, possibly influenced by the “stop start” nature of the 2017/18 wet season. Rainfall recorded in the western (Darwin Airport) and eastern (Groote Eylandt) Top End across the wet season is given in Figure 3 a & b. Overall, the main nesting areas for Magpie Goose received above average rainfall, but this did not extend across the whole of the wet season in the east of the Top End.

With respect to the rainfall received across the main nesting habitat areas, the season started very strongly, then there was a relative dry period across December, meaning that the cumulative rainfall fell back in line with long term averages. This was followed by a relatively high rainfall in January associated with a very strong monsoon trough, and average rainfall for February through April, which pushed the season back above the long term average in the central and west Top End (BoM 2018). It is likely this “stop start” pattern across the wet caused some geese to start nesting relatively early, but others to delay (especially in the most northern areas which were still largely inundated at the time the surveys occurred). During the reconnaissance flights, the full gamut of nesting was observed

from nests just beginning construction, to eggs in nests, through to a small number of areas where fledgling birds had already arrived. Consequently, the recorded nest numbers and derived nesting rates may be an underestimate.

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 Finnis River floodplain survey area. Values are \pm standard error (incorporating the errors resulting from sampling).

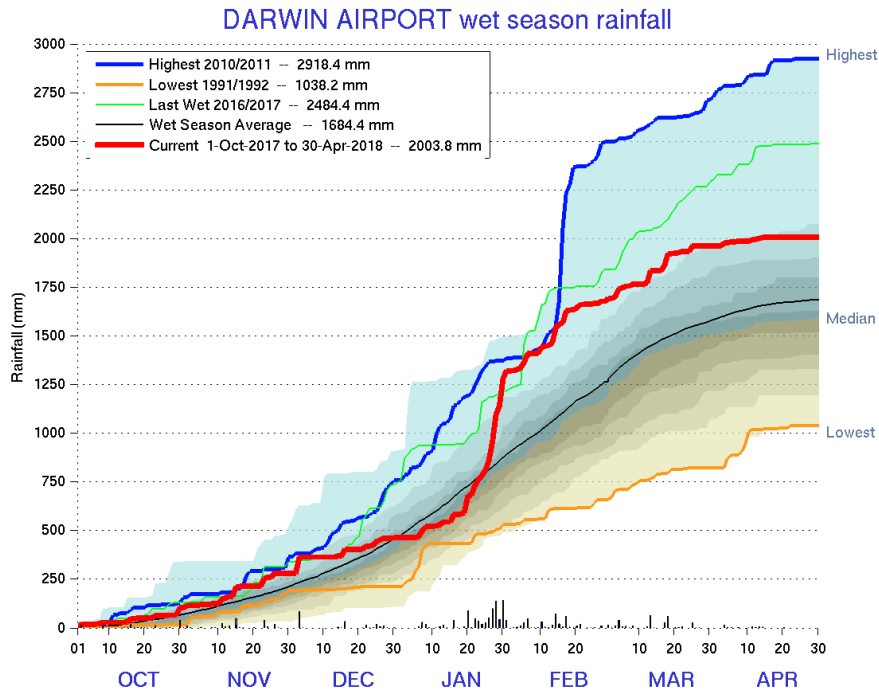
Block (area in km ²)	Magpie Goose	Magpie Goose nests
Moyle River (731)	48,976 \pm 19,521 (35.6 \pm 14.2) 39.9%	13,567 \pm 4,582 (9.9 \pm 3.3) 33.8%
Daly River west (1,164)	58,179 \pm 23,352 (50.0 \pm 20.1) 40.1%	2,152 \pm 1,154 (1.8 \pm 1.0) 53.6%
Daly River south (1,362)	23,121 \pm 8,403 (17.0 \pm 6.2) 36.3%	759 \pm 643 (0.6 \pm 0.5) 84.8%
Daly River north (958)	40,798 \pm 14,800 (42.6 \pm 15.5) 36.3%	2137 \pm 903 (2.2 \pm 0.9) 42.3%
Reynolds River (1,648)	29,317 \pm 7,943 (17.8 \pm 4.8) 27.1%	2,137 \pm 903 (2.2 \pm 0.9) 42.3%
Finniss River (1,233)	9,545 \pm 5,088 (7.7 \pm 4.1) 53.3%	526 \pm 320 (0.4 \pm 0.3) 60.7%
Total survey area (8,186)	209,937 \pm 36,125 (27.1 \pm 4.7) 17.2%	21,946 \pm 4,975 (2.8 \pm 0.6) 22.7%

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 Murganella Creek floodplain survey area. Values are \pm standard error (incorporating the errors resulting from sampling).

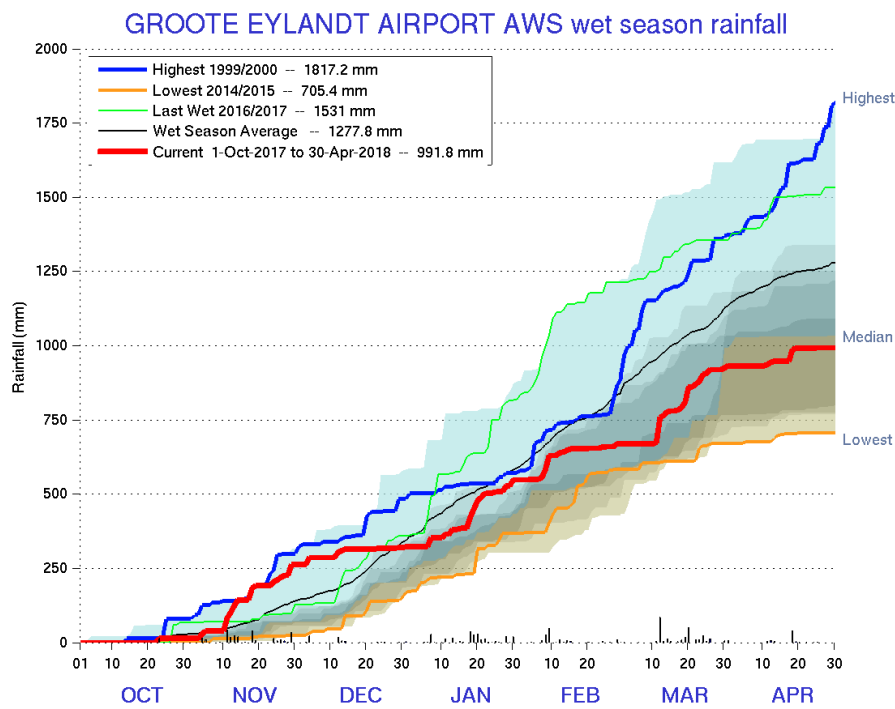
Block (area in km ²)	Magpie Goose	Magpie Goose nests
Downstream Adelaide River (798)	38,703 \pm 17,277 (48.5 \pm 21.7) 44.6%	13,102 \pm 6,774 (16.4 \pm 8.5) 51.7%
Upstream Adelaide River (719)	31,208 \pm 11,854 (43.4 \pm 16.5) 38.0%	1,425 \pm 526 (2.0 \pm 0.7) 36.9%
Downstream Mary River (1,240)	90,276 \pm 39,408 (72.8 \pm 31.8) 43.7%	8,735 \pm 3,687 (7.0 \pm 3.0) 42.2%
Upstream Mary River (490)	9,681 \pm 6,765 (19.8 \pm 13.8) 69.9%	10,346 \pm 8,881 (21.1 \pm 18.1) 85.8%
Wildman/West Alligator River (1,205)	68,908 \pm 34,020 (57.2 \pm 28.2) 49.4%	6,505 \pm 5,349 (5.4 \pm 4.4) 82.2%
Downstream South Alligator River (915)	82,029 \pm 37,547 (89.7 \pm 41.0) 45.8%	3,686 \pm 1,077 (4.0 \pm 1.2) 29.2%
Upstream South Alligator River (950)	14,032 \pm 3,636 (14.8 \pm 3.8) 25.9%	1,657 \pm 610 (1.7 \pm 0.6) 36.8%
East Alligator River (1,404)	222,375 \pm 77,997 (158.3 \pm 55.5) 35.1%	6,071 \pm 2,146 (4.3 \pm 1.5) 35.3%
Murganella (822)	61,983 \pm 28,131 (75.4 \pm 34.2) 45.4%	3,609 \pm 2,208 (4.4 \pm 2.7) 61.9%
Total survey area (8,657)	619,195 \pm 107,205 (72.5 \pm 12.5) 17.3%	55,135 \pm 13,351 (6.5 \pm 1.6) 24.2%

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 \pm standard error (incorporating the errors resulting from sampling).

Block (area in km ²)	Magpie Goose	Magpie Goose nests
Liverpool - Tomkinson River, Maningrida (975)	68.3 \pm 45.2 (0.1 \pm 0.0) 66.2%	0 \pm 0 (0 \pm 0) -
Blyth - Cadel River (1,338)	8,588 \pm 6,097 (6.4 \pm 4.6) 71.0%	46.5 \pm 42.3 (0.03 \pm 0.03) 91.0%
Arafura Swamp (1,362)	64,535 \pm 28,081 (33.3 \pm 14.5) 43.5%	480 \pm 216 (0.2 \pm 0.1) 45.0%
Buckingham Bay (595)	14,146 \pm 7,443 (11.4 \pm 6.0) 52.6%	186 \pm 140 (0.1 \pm 0.1) 75.4%
Gorrumurru River	1,093 \pm 780 (2.0 \pm 1.5) 71.4%	46.5 \pm 42.5 (0.1 \pm 0.1) 91.5%
Blue Mud Bay	14,146 \pm 7,442 (11.4 \pm 6.0) 52.6%	185 \pm 140 (0.1 \pm 0.1) 75.4%
Total survey area (4,594)	89,068 \pm 29,696 (13.4 \pm 4.5) 33.3%	759 \pm 264.5 (0.11 \pm 0.04) 34.9%



a)



b)

Figure 3 Rainfall recorded at a) Darwin and b) Groote Eylandt across the 2017/18 wet season, with comparison to historical records. Data and Figures from bom.gov.au.

Discussion

Population Size and Dispersion

As has previously been reported, the distribution of magpie geese within the survey area is highly clumped providing challenges in adequately surveying numbers. However, the high sampling intensity, coupled with the extensive areas surveyed, delivered population estimates for each of the three survey blocks with acceptable levels of precision.

The population estimate for Magpie Goose in the Top End was $918,200 \pm 116,961$ (mean \pm standard error), and represents a conservative estimate of the species population in the Northern Territory, recognising that some birds may occur outside the survey area at the time of survey.

The Adelaide River to Murganella Creek survey region contained the majority of geese (two thirds of the total population) with over a third of the survey region density (and nearly one quarter of the total birds) occurring in the East Alligator River Survey Block. This survey block represents some 140,000 ha (approximately 6 %) of the 2.3 M ha total survey area.

This is a similar pattern to most, but not all recent years, with 2011 and 2017 not exhibiting such a significant congregation in this area. The area is clearly of major importance to the overall population of the species, although the same pattern is not evident from the nesting data where five other survey blocks (four in Area 1 and one in Area 3) had higher nesting densities.

The precision of the estimate was reasonably good and we can be 95% certain that the population lies between 688,956 and 1,147,444. A coefficient of variation of under 15% for the overall survey area compares favourably with aerial counts of waterbirds in eastern Australia (e.g. Kingsford 2001; coefficients of variation of 18-60%) and is comparable with previous years surveys where the coefficient of variation have been in the range of 8-18 % (see Table 1).

A comparison of the changes in magpie goose population from 2017 to 2018 is provided in Table 3. The population estimate represents a 26.7 % increase on the 2017 count, which was the lowest that had been recorded since broad scale aerial surveys commenced in the early 80's.

The year to year increase equates to an annual rate of increase (r) of 0.237. This value is towards the top of the range of the theoretical plausible r_m for the species proposed by Brook and Whitehead (2005; between 0.11 and 0.28), suggesting the population was growing at close to its maximum rate. This is also consistent with the relatively high nesting rate that was observed in 2017 (Groom and Saalfeld 2017).

Magpie Goose nests were estimated to be $77,839 \pm 14,250$ (coefficient of variation 18.3%) for the surveyed area, which is similar with nesting levels for 2017. This can be considered high to very high nesting compared with relative nesting in previous years and is suggestive of a continued rise in population in 2018/19 if other factors including harvest from hunting are

considered to be moderate to low. Rainfall preceding the survey period was above average across the wet season consistent with achieving a high nesting rate for this season (Figure 3). It is notable that there was very little nesting recorded in the Arnhem Land survey area.

Table 3: Comparison of Top End Magpie Goose population and nest estimates from 2017 and 2018 by Survey Area.

Survey Area	2017	2018
<i>Goose Numbers (\pm SE)</i>		
Adelaide River to Murganella Creek	411,989 \pm 57,477	619,195 \pm 107,205
Moyle River to Finniss River	231,555 \pm 40,0074	209,937 \pm 36,125
Arnhem Land	<i>Estimate 80,956</i>	89,068 \pm 29,696
Overall	724, 500 \pm 78,750	918,200 \pm 116,961
<i>Nests (\pm SE)</i>		
Adelaide River to Murganella Creek	63,978 \pm 12,826	55,135 \pm 13,351
Moyle River to Finniss River	20,846 \pm 3,653	21,946 \pm 4,975
Arnhem Land	<i>Estimate 9,676</i>	759 \pm 265
Overall	94,500 \pm 14,605	77,839 \pm 14,250

Population trends and outlook

Magpie Goose population estimates have been highly variable over the 35 years that the population has been formally monitored (Figure 4), and the population underwent a marked decline from a historically high estimate in 2012 to a historical low in 2017. Care must be taken in making any direct comparisons between years prior to the standardisation of survey methodology in 2011. The population has been trending downwards since 2012 with steep declines in abundance in 2014 and 2017, both following a year with very poor nesting. A broad comparison of population change and the previous year's nesting rate provides some evidence of a concordance of high and low nesting with rises and declines in subsequent population (Table 4). This is in agreement with previous studies which have concluded a relationship between Magpie Goose numbers and rainfall (e.g. Bayliss 1989, Bayliss and Yeomans 1990a, Whitehead and Saalfeld 2000). The high nesting rate observed this year suggests the population should continue to increase or, at worst, remain stable.

From a management perspective, the monitoring results indicate that, whilst there has been a significant increase in the population since 2017, the total population remains low relative to levels recorded over the past four decades. This suggest caution should be applied in

dealing with potential impacts of the various direct and indirect mortality agents, if the population is to meet its full productive capacity. The current *Management Program for the Magpie Goose (Anseranas semipalmata) in the Northern Territory of Australia, 2009-2014* specifies the objectives of maintaining permits for pest mitigation to < 1% of the population level in any given year, and for hunting pressure (both indigenous and non-indigenous) to be kept below 10% over 3 years and not exceeding a maximum of 14% in any given year. The results from this year's survey will inform management decisions to be made for the upcoming 2018/19 period.

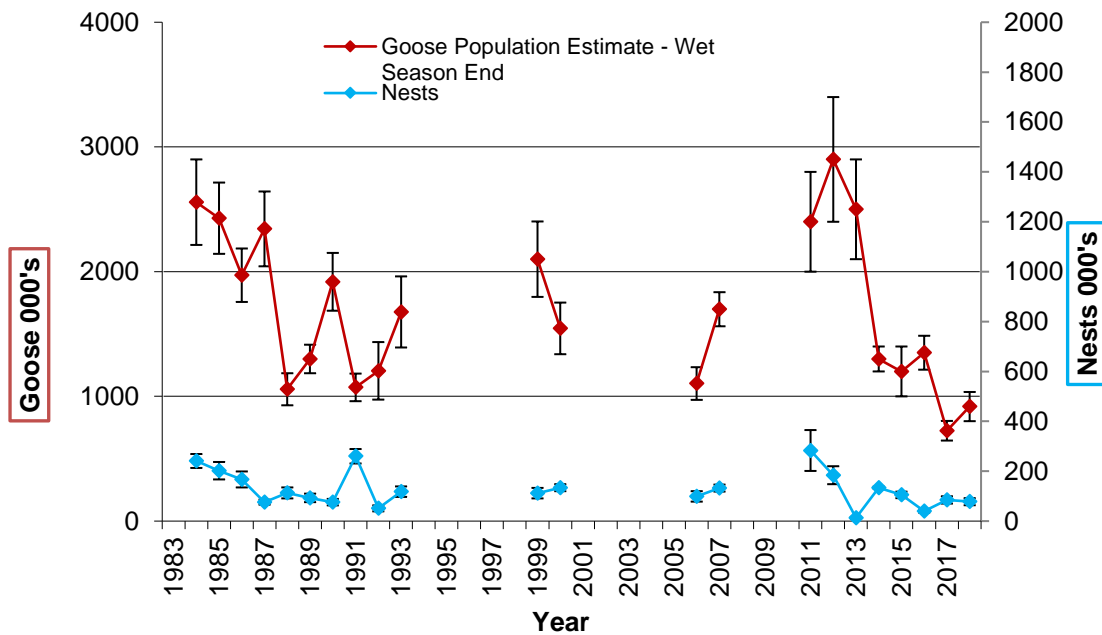


Figure 6: Magpie Goose population and nest estimates for the period 1983 to 2018, derived from aerial survey data at the end of the wet season. Note that goose numbers (left axis) and nest numbers (right axis) are on different scales.

Table 4: Comparison of Top End Magpie Goose population trends and previous years nesting success from 2011 and 2018, and predicted trend in 2019. [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	<u>L</u>	<u>BD</u>
2015	9%	-8%	H	H	S
2016	3%	8%	L	H	S
2017	13%	-44%	VH	<u>L</u>	<u>BD</u>
2018	10%	25%	H	VH	I
2019				H	<i>S-I (projected)</i>

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