Wildlife Management Program for the Magpie Goose (Anseranas semipalmata) in the Northern Territory of Australia 2020-2030

Consultation Draft

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Acronyms / Terms	Full form / Definitions
Aboriginal traditional harvest	Harvest carried out by Aboriginal people in accordance with Section 122 of the Territory Parks and Wildlife Conservation Act 1976.
B	Billion
CDU	Charles Darwin University
CITES	Convention on International Trade in Endangered Species
DENR	Department of Environment and Natural Resources
DPIR	Department of Primary Industry and Resources
DTSC	Department of Tourism, Sport and Culture
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
IUCN	The International Union for Conservation of Nature
K	Carrying capacity or maximum population the habitat can sustain when conditions close to optimal
NAIWB	National Avian Influenza Wild Bird Steering Group
NLC	Northern Land Council
Non-Aboriginal harvest	Harvest carried out by either Aboriginal or non-Aboriginal people in accordance with a declared Waterfowl Hunting Season
NT	Northern Territory
M	Million
P	Minimum population estimate defined as the estimated population size from the standard aerial survey for the survey area of the 21,400 Km^2 wetland areas of the Top End
r	Exponential rate of increase or natural logarithm of population change for a given time period (annual unless otherwise stated)
Top End	Northern Territory north of 15^0S latitude
TPWC Act	Territory Parks and Wildlife Conservation Act 1976
Water Act	Water Act 1992
Western Top End	Area of the Top End to the west of 133^0E longitude

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A management program prepared under the Territory Parks and Wildlife Conservation Act 1976. An Act to make provision for and in relation to the establishment of Territory Parks and other Parks and Reserves and the study, protection, conservation and sustainable utilisation of wildlife

Keith Saalfeld, Peter Whitehead, Glenn Edwards, Tony Griffiths, Peter Ross, Warren Hunt, Mila Bristow, Alaric Fisher, Jonathan Vea, Lauren Young and Cindy McIntyre provided invaluable comments on drafts of this program.

Front cover: Magpie Goose

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Executive summary

This wildlife management program for Magpie Goose (*Anseranas semipalmata*) in the Northern Territory (NT) is a legal instrument under the Territory Parks and Wildlife Conservation Act 1976 (TPWC Act). It aims to protect and conserve the species whilst allowing for its sustainable use and appropriate control in situations where it is causing economic damage.

The Magpie Goose is found in continental Australia, surrounding islands and the southern lowlands of New Guinea. Its range contracted from the south-eastern part of Australia following European settlement. Magpie Geese are most abundant in the Top End of the NT with population estimates over the past 36 years ranging from just under a million to more than 3 million birds. High rates of recruitment are possible with nesting success closely tied to above average wet season rainfall.

Numbers are highest in the floodplains of the central Top End. Approximately 30% or about 1,400 km^2 of key Magpie Goose floodplain habitat lies within existing parks and reserves, most notably the Mary River National Park and Kakadu National Park.

Magpie Geese are protected wildlife under the TPWC Act and their conservation status is assessed as "least concern" in the NT. They are considered threatened in some other jurisdictions due to historical declines in distribution and abundance in those states. It is listed as a marine protected species under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

Magpie Geese have very high socio-economic values in the Top End with an iconic value for residents and visitors alike. They are a totemic animal for Aboriginal people as well as an important seasonal source of food. Other sections of the community see hunting as important with a tradition of such harvest since the early 1900's. In some situations Magpie Geese cause economic damage to horticultural production, and there is potential for significant commercial use of geese.

The species is taxonomically distinct and has a distinctive morphology with its unusual, partially-webbed feet with strongly clawed toes being adapted to both aquatic and terrestrial use. Magpie Geese aggregate in large breeding colonies in swamps at the end of the annual wet season and the species exhibits mixed monogamous and polygynous breeding behaviour, with groups of one male and two females where all participate in nest building, egg incubation and caring for young. Their distinct ecology means that the species is an important indicator of ecological health and likely plays an important role in the provision of ecosystem services in the extensive wetlands of the Top End.

A maximum of 70,000 birds per annum is estimated to be harvested by Aboriginal people as a traditional food source and a further 20,000 – 70,000 are estimated to be taken by non-Aboriginal hunters. There is a small but growing commercial use of Magpie Geese as well as a take for pest mitigation purposes to alleviate damage to horticultural operations, predominately around Darwin.

Existing land use patterns in the NT are generally consistent with retaining large wetland areas and their dependent waterfowl populations. The current potential major threats are habitat modification or loss (such as that caused by weeds and feral animals) and the impact of climate change through changes in sea levels, hydrology and saltwater intrusion. The latter is an increasingly important threat to Magpie Geese habitat. Unregulated take or overharvest is a potential threat especially in the context of extreme environmental variability impacting on the species' population dynamics.

The primary aim of this wildlife management program is 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. The program incorporates both Aboriginal traditional and non-Aboriginal use of Magpie Goose populations and encourages management practices that favour all waterfowl, particularly the Magpie Goose, and that protect wetland habitats beyond the boundaries of parks and reserves.

The five principal objectives of the management program are to:

1. conserve and protect Magpie Goose in the NT in its natural habitat
2. promote sound management of identified areas of habitat to ensure the survival of populations
3. ensure the sustainable use of Magpie Goose populations
4. minimise the economic loss of commercial fruit growers without adversely impacting on conservation of the species
5. enable ongoing refinement of Magpie Goose management through timely evaluation of management prescriptions and performance

Outcomes, key actions and responsible bodies, performance criteria and timelines for each objective are given. Priority actions include implementing an annual population monitoring and reporting program; the permitting of commercial, recreational hunting and damage mitigation takes anchored in sound wildlife management principles; maintaining a monitoring and compliance framework for the permitted take; and facilitating improved habitat management.

This management program recognises and authorises the non-Aboriginal harvest of magpie geese via the annual waterfowl hunting season. It also recognises that Aboriginal traditional use is an inalienable right under Section 22 of the TPWC Act. The following harvest limits are proposed for future sustainable use:

- The combined annual harvest from all anthropogenic sources, including both non-commercial and commercial harvest, is to be set at 8.4% of the annual minimum estimated Magpie Goose population for the Top End of the NT. The minimum population estimate (*P*) is defined as the calculated estimate for the survey area (recognising that a small proportion of birds occur outside the survey area) using the standard aerial survey methodology.
- Agricultural protection allows for the taking of up to 15,000 Magpie Geese. However, management will be aimed at minimising damage rather than maximising numbers taken and, as far as practicable, meeting the demand for pest reduction removals through other permitted harvest such as commercial take.
- A fixed hunting season of mid-August start for private land and the fourth Wednesday in September for hunting reserves with a closure on the Monday after the first Friday in January, noting some hunting reserves may be closed earlier for operational reasons. The later start for hunting on hunting reserves is to ensure that early arriving birds are not displaced onto nearby horticultural properties.

Bag limits for recreational hunting are to be set on the basis of the population monitoring results with the following thresholds:

Population Size (*P*)	Bag Limit (per day)	Comments
<500,000	0	Closed season
500,000 to <750,000	3	Requires reduced pest mitigation and potentially commercial takes
750,000 to <1,000,000	3	
1,000,000 to <1,250,000	5	
>1,250,000	7	

These limits have been set to maximise short-term hunting opportunities without impinging on long-term yields (and future hunting opportunities). Best estimates suggest that bag limits of 5 or 7 would apply in most years.

A minimum commercial harvest is set at 5,000 (where $P < 750,000$) to protect infrastructure investment and market access. The expectation is that a commercial harvest of 20,000 – 30,000 may be allowable in most years in the longer-term. No commercial take will be permitted during March to July to avoid impacts on breeding, unless specifically tied to a genuine pest mitigation need.

Management of anthropogenic take and comprehensive population monitoring as outlined in the program will ensure that the Magpie Goose remains a NT icon into the future. In keeping with the significant public interest in the species and the Government's Open Data policies, the results of annual monitoring programs will continue to be made publicly available, and relevant data and metadata will be available as a resource for education and research communities.

Integral to the management program will be an ongoing communication and consultation strategy. The communication activities include web-based publication of key information pertaining to waterfowl hunting, a series of videos on Magpie Goose management and an annual article in an appropriate hunting magazine promoting the upcoming season. Consultation will include regular meetings with key hunting stakeholders.

The program identifies some key areas for future Magpie Goose research including the cost effectiveness of using netting and other measures to reduce economic impacts to the horticulture industry, opportunities for new technology to improve population surveys, assessment of habitat use and movements, quantify impacts of feral pig and buffalo on breeding habitat and food resources of geese and update and improve estimates of Aboriginal harvest.

The nominal period of this program is 2020 to 2030. The program will be reviewed after 5 years to determine whether any significant revision is required.

Whilst not explicitly covered in this management program, it is noted that the establishment of an open season for other waterfowl is closely tied to the management of the Magpie Goose recreational hunting season. It is proposed the same season lengths apply to such permitted hunting to facilitate the management of hunting reserves, the necessary compliance and monitoring requirements and to maintain the low impact such hunting has on permitted species. Any decoupling of the duck hunting season from that for Magpie Geese would require the development of a detailed management plan for those duck species.

1 Introduction

1.1 Aim and Objectives

The aim of this wildlife management program is to ensure the *"protection, conservation, sustainable use, control and management"* of Magpie Goose and associated Waterfowl species in accordance with Part IV, Subdivision 3 of the Territory Parks and Wildlife Conservation (TPWC) Act.

The program acknowledges the socio-economic value of the annual harvest of Magpie Geese and other waterfowl to the Northern Territory (NT) by continuing to support Aboriginal traditional and non-Aboriginal use of Magpie Goose populations. The program aims to encourage management practices that favour all waterfowl, particularly the Magpie Goose, and protect wetland habitats beyond the boundaries of parks and reserves.

The program has 5 principal objectives:

1. To conserve and protect Magpie Goose in its natural habitat in the NT.
2. To promote sound management of identified areas of habitat to ensure the survival of populations.
3. To ensure the sustainable use of Magpie Goose populations.
4. To minimise the economic loss by commercial fruit growers from goose impacts without adversely impacting the conservation of the species.
5. To provide ongoing refinement of Magpie Goose management through timely evaluation of management prescriptions and performance.

Consultation Point: Are these overarching objectives appropriate and are we missing anything?

1.2 Species Background

The Magpie Goose (*Anseranas semipalmata*) is the sole living member of the family Anseranatidae with a fossil record dating back to the Pliocene (Sibley *et al*. 1988, Worthy 2008). This family is one of four making up the order Anseriformes (commonly termed waterfowl). The species is genetically more closely linked to the South American screamers (Family Anhimidae) than to other Australian waterfowl (ducks, pygmy geese, cape barren goose and black swan from the family Anatidae (Sibley *et al*. 1998). Subspecies or races have not been described.

The species has a distinctive morphology with its unusual, partially-webbed feet with strongly clawed toes being adapted to both aquatic and terrestrial use. Magpie Geese aggregate in large breeding colonies in swamps at the end of the annual wet season and the species exhibits mixed monogamous and polygynous breeding behaviour, with groups of one male and two females where all participate in nest building, egg incubation and caring for young (Bayliss 1989, Whitehead 1988). Details on the status, ecology of and management drivers for the Magpie Goose are provided in Clancy *et al.* (2019).

1.3 Distribution and Abundance

Prior to European settlement in Australia, Magpie Geese were likely extremely abundant across northern Australia and also locally common on swamps and on coastal and inland river floodplains in south-eastern Australia (Nye *et al*. 2007). By the early 1840's, populations in the Hawkesbury region near Sydney had

been extirpated (Gould 1848) and by the early 1900s there was a major contraction of range with no records in southeast Australia from the 1920's to the late 1950's (Nye *et al.* 2007).

A number of factors led to this decline (Nye *et al.* 2007), commencing with hunting pressure followed by habitat destruction (drainage of wetlands) and later poisoning efforts. Predation by introduced foxes, drought and river regulation were also seen as later factors. Whilst the temporal order of the action of each threat can be identified, there is no definitive data exist on the relative impacts of each, but habitat destruction is believed to be the primary driver in southern Australia.

Since the early 1970's there has been some level of recovery recorded in the south eastern and southern parts of the species' range. This is attributed to protection measures implemented for recreational hunting as well as the species adapting to exploit agriculturally-based food sources over time (Whitehead 1991, Nye *et al.* 2007). There have also been some deliberate attempts to reintroduce the species in areas such as the Hunter River are in NSW (https://wetlands.org.au/project/magpie-goose/).

The current range of the Magpie Goose is shown in Figure 1. The species occurs broadly across northern and eastern Australia and within the trans-Fly lowland ecoregion of southern Papua New Guinea and West Papua. Extensive breeding is restricted to the wetlands of northern Australia as well as the trans-Fly lowlands in New Guinea. Magpie Geese occur seasonally across a much broader range outside of the main breeding areas (Figure 1).

The Magpie Goose is abundant in the coastal and sub-coastal floodplains of the Top End of NT, with the wetlands of Kakadu National Park and the Mary River region supporting a significant percentage of the total goose population of the NT (Frith and Davies 1961, Bayliss and Yeomans 1990a). There is no evidence to suggest either a range reduction or long-term decline in mean abundance of Magpie Geese in the NT since European settlement (Frith 1967, Nye *et al.* 2007), although a significant population reduction (and subsequent partial recovery) was recorded in 2016 (Groom and Saalfeld 2017, Clancy 2019).

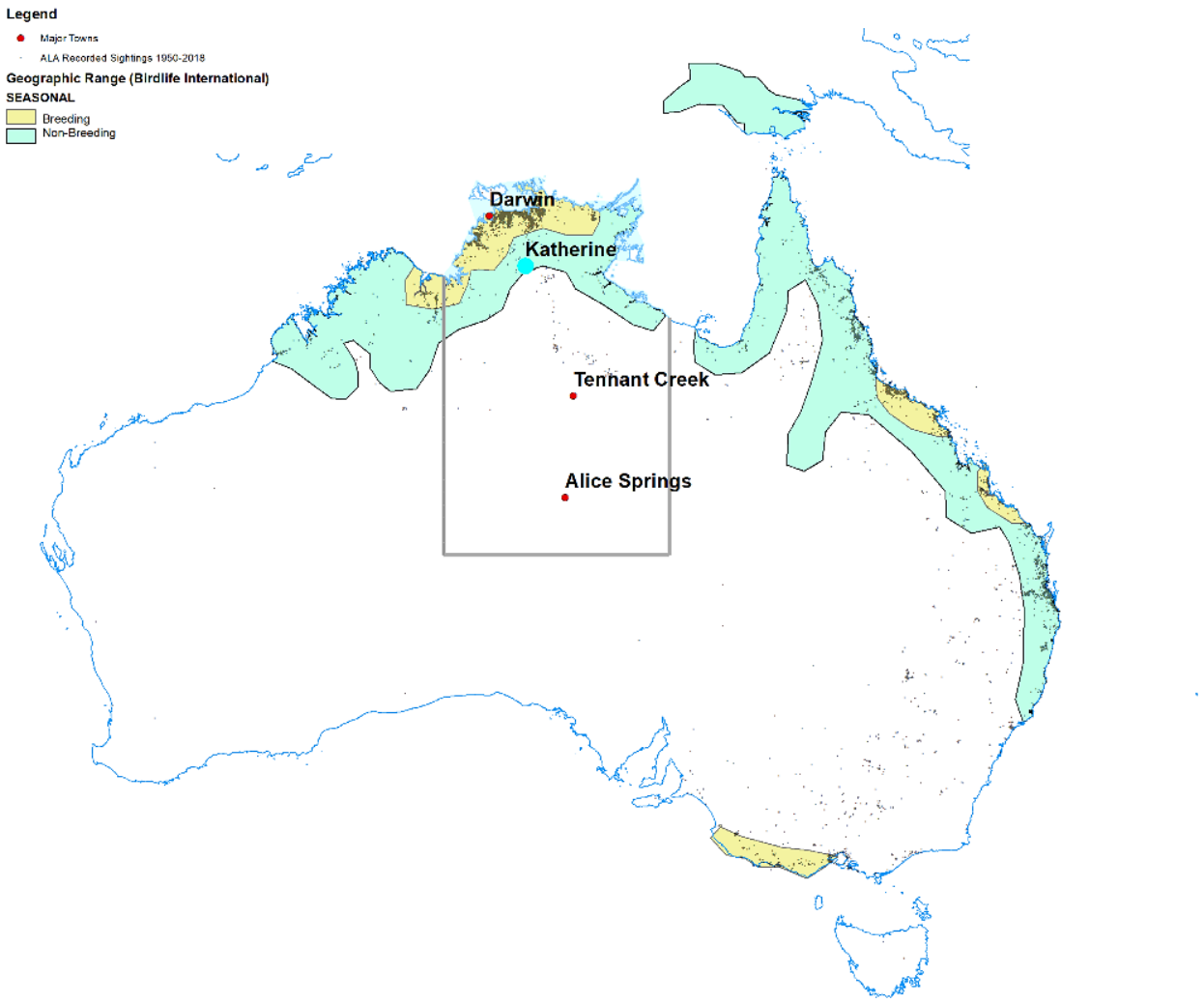


Figure 1: Distribution of Magpie Geese in Australia and southern Papua New Guinea and West Papua modified from IUCN Red List (Birdlife International 2016) and Atlas of Living Australia occurrence data (downloaded ww.ala.org.au accessed on Mon Jul 30 10:06:28 AEST 2018).

1.4 History of Use

The importance of Magpie Goose as a food source to Aboriginal people was noted by early European explorers (e.g. Leichardt after Gould 1948) and the central place the species plays in cultural traditions of the Traditional Owners of the floodplains speaks to a long history of use. X-ray style rock art depicting Magpie Goose is known from the freshwater period dating back to around 3,000 years ago (Tacon 1989). Whilst harvest rates are unknown, the number of language groups across the Top End that incorporate Magpie Goose into their art and other cultural lore along with the species abundance at the time of European arrival indicates a sustainable long term harvest existed for millennia.

From the early days of European settlement, Magpie Goose were seen as a potential food source and also especially by European migrants as a target species for recreational hunting (Clancy *et al.* 2019). A study of waterfowl hunting in the NT in 1984 and 1985 reported Magpie Goose as clearly the most important game species (around 80% of total waterfowl taken) attracting local, interstate and international interest for the then 4-month open season (Whitehead *et al.* 1988). Recent hunting permit data reflects a steady annual

increase in hunting demand (Table 1), with a total of approximately 3,400 licenced waterfowl hunters in the Northern Territory (NT) in 2019, the majority targeting Magpie Goose exclusively.

Table 1: Estimated harvest of Magpie Goose from the permits returns received (2001-18). Best quality estimates, based on percentage of returns received indicated by shading.

Year	Number of Permits Issued	Number of Permit Returns	Percent Licenced Hunters providing Permit Returns	Average Number of Geese per shooter	Number of Magpie Geese declared	Estimated Recreational Harvest (number of birds)
2001	985	91	9.2	34.1	3,101	33,566
2002	967	702	72.6	15.2	10,660	34,100
2003	854	347	40.6	25.9	8,999	22,100
2004	948	479	50.5	23	11,017	28,901
2005	1,033	142	13.7	18.7	2,655	19,300
2006	1,087	341	31.4	16.1	5,484	18,500
2007	1,387	561	40.4	24.6	13,782	34,100
2008	1,561	202	12.9	24.7	5,000	38,600
2009	1,864	108	5.8	24.5	4,410	45,700
2010	1,643	92	5.6	18.3	1,688	30,145
2011	1,855	92	5.0	31.5	2,896	58,392
2012	2,083	375	18.0	27.8	10,441	58,000
2013	2,070	285	13.8	19.9	5,683	41,276
2014	2,166	340	15.7	22.3	7,567	48,206
2015	2,429	226	9.3	18.2	4,115	44,227
2016	2,625	25	1.0	18	449	47,119
2017	2,570	355	13.8	5.8	2,051	14,848
2018	3,384	91	2.7	11.21	1,020	27,473

Once established as a food source by European settlers, it is likely a commercial trade existed although the size and scale are impossible to ascertain. In recent times there was a prohibition in most jurisdictions of taking for sale. The potential for a commercial take was identified in the previous management program (Delaney *et al.* 2009), however at that stage it was envisaged as based around a ranching type approach underpinned by a wild egg harvest (akin to the current crocodile industry) rather than a live harvest. In 2015, the first commercial harvest permit was granted to take adult birds and interest in this area has grown markedly in recent years (Clancy *et al.* 2019).

1.5 Responsible authority

The management and regulation of all aspects of use of protected wildlife in the NT, including harvest from the wild, is administered under the TWPC Act. The Department of Environment and Natural Resource Management (DENR) and the Department of Tourism, Sport and Culture (DTSC) administer the TWPC Act. DENR is responsible for Part IV Divisions 1 to 5 of the Act, which includes the determination of the

conservation status of plants and animals (the listing of wildlife species) and development of management programs. DTSC is responsible for Part IV Division 6 covering the issuance of permits to take and interfere with protected wildlife including for research and commercial use. In the situation of a formal management program, DENR is responsible for overseeing the harvest allocation process and works with DTSC to ensure appropriate permits are issued. DTSC, NT Police and DENR all work together to ensure compliance with permit conditions and undertake any necessary enforcement activities.

1.6 Legislation and international obligations

1.6.1 Northern Territory

The TPWC Act makes provision for the study, protection, conservation and sustainable utilisation of wildlife (native plants and animals). The Magpie Goose, as a native vertebrate species, is classified as protected wildlife under Section 43 of the TPWC Act, but it is not listed as a threatened species.

The TWPC Act specifies that management of species is to be carried out in a manner that accords with its classification, promotes the survival of wildlife in its natural habitat, and the sustainable use of wildlife and its habitat. Management should aim to control or prohibit any other act, omission or thing that adversely affects, or is likely to adversely affect, the capacity of wildlife to sustain its natural processes. These principles of management need to be adhered to in the development of any management program under the TPWC Act.

Section 66(1) of the TPWC Act prohibits the taking or destruction of protected wildlife without due authorisation. The Minister may declare that it is lawful to kill specified numbers of a protected animal during specified times, at specified places, and using specified means (Section 45). These provisions are used to declare an annual waterfowl hunting season and the conditions to which waterfowl hunting is subject. All persons hunting waterfowl in accordance with the declared waterfowl hunting season must obtain a permit to take protected wildlife from DTSC. Further, it is an offence to possess live Magpie Geese or their eggs except in accordance with a permit issued under Section 43 of the TPWC Act.

The rights of Aboriginal people to take wildlife for traditional purposes, including for hunting and food gathering, are explicitly protected under Section 122 of the TPWC Act. Aboriginal people are not bound by hunting regulations or seasons when taking wildlife, including Magpie Geese, for food or other traditional purposes.

1.6.2 Other States and Territories

The Magpie Goose is protected in all Australian States and Territories under each jurisdictions' relevant legislation. As of September 2019, the species was listed as vulnerable in New South Wales (Threatened Species Conservation Act 1995), threatened in Victoria (Flora and Fauna Guarantee Act 1988) and endangered in South Australia (National Parks and Wildlife Act 1972). It is not considered threatened in other range states (Western Australia and Queensland). The Australian Government and all states and territories in Australia recently have agreed to establish a common method for the assessment and listing of threatened species. Under the common assessment method, species are assessed at the national scale, using consistent threat criteria, categories, thresholds and definitions, and can only be listed in one nationally threatened category. A likely outcome of this is that the species would be recognised as not threatened across its range irrespective of more local abundance or historical changes in range.

1.6.3 Commonwealth

The Magpie Goose is a listed marine species under the Environment Protection and Biodiversity Conservation (EPBC) Act 1999. Whilst the species is recorded as occurring in Commonwealth marine areas (3 to 200 nautical miles from the coast), these areas would not be considered part of the species' usual habitat and this listing probably reflects sightings of birds moving between areas of preferred coastal habitat. The listing means that the species has additional levels of protection on Commonwealth lands and limits the circumstances under which birds may be taken.

Export from Australia of any Australian native animal, or its parts, requires a permit issued under the EPBC Act. Permits may only be issued where the specimens are derived from captive-bred animals or taken in accordance with a management program declared in a notice published in a Commonwealth Gazette to be an approved management program. Officers of the Australian Customs Service and the Australian Federal Police enforce the EPBC Act in the NT.

With respect to Kakadu National Park, in accordance with s.359A of the EPBC Act, management does not prevent Bininj/Mungguy and traditional owners from continuing, the non-commercial hunting or food-gathering, and for ceremonial and religious purposes, including the use of Magpie Goose. Section 8 of the EPBC Act also provides that the Act does not affect the operation of the Native Title Act 1993, which also includes provisions that preserve customary rights to use of land and waters.

1.6.4 International

The Magpie Goose is listed as Least Concern with a stable population under the IUCN Red List (Birdlife International 2016). It is not currently listed under the Convention on International Trade in Endangered Species (CITES) or the Convention on Migratory Species (Bonn Convention). Australia is a signatory to the Convention on Wetlands of International Importance (Ramsar Convention) and there are plans of management for both the Ramsar-listed areas of the NT (Cobourg Peninsula and Kakadu National Park) which protect wetlands and their dependent fauna, including Magpie Goose. DTSC is currently developing a revised plan of management for Cobourg Peninsula (Garig Gunak Barlu National Park).

2 Management Context

The Magpie Goose is a distinctive species that is widespread across the Top End. It is highly valued as a resource and has cultural and ecological significance. The NT has a policy of sustainable wildlife use that aims at reconciling the diverse drivers to ensure long-term conservation outcomes are achieved. In 1997, the use of wildlife species by Territorians was formally recognised and supported in the "*Strategy for Conservation through the Sustainable Use of Wildlife*". The development of a "Trial Management Program for the conservation of Magpie Geese" was one of the initial actions of that strategy and this revised program is a refinement of previously developed plans (PWC NT 2003, Delaney *et al.* 2009).

2.1 Socio-economic

2.1.1 Social Aspects of Recreational and Traditional Hunting

Hunting has been an integral part of hominid societies since the earliest known fossil records (Arnett and Southwick 2015). Whilst a somewhat divisive issue in modern society, hunting in many areas is seen as a fundamental foundation of a social (and economic) support system. Motivations for hunting are very diverse (Clancy *et al.* 2019) and, when appropriately managed to be sustainable, can be an important part of social capital.

Waterfowl hunting is a popular pastime in the Top End, valued from a recreational and social perspective and as a source of food, with Magpie Goose being the predominant target species. Earlies studies suggested that Magpie Goose, whilst clearly the most important species of game waterfowl in the NT, were not selectively targeted, with bag composition roughly equivalent to the relative abundance of target species (Whitehead *et al.* 1988). That is, their popularity was related to their abundance and relative availability rather than other issues or preferences.

Whilst not extensively studied, hunting trips on Aboriginal lands usually involve large family groups and last for several days or weeks. The social interactions on country are an important aspect of the annual harvest (Griffiths 2009). The role traditional hunting plays in building social capital in Aboriginal communities, whilst not well documented, builds on other positive aspects such as maintenance of cultural traditions, health and economic benefits (see below).

2.1.2 Cultural Values

For Aboriginal people in the Top End, the Magpie Goose is a key species in their culture. It is often represented in paintings and ceremonies because it is a totemic species. Hunting Magpie Geese also assists the transfer of skills and knowledge from one generation to the next amongst Aboriginal people (Altman 1987). Sharing the returns from hunting is also a way of fulfilling kinship obligations (Altman 1987).

For Traditional Owners, hunting trips are an important aspect of 'looking after country' enabling them to increase their monitoring of environmental threats and maintain traditional burning practices around floodplains. Hunting Magpie Geese takes people to places that they may not otherwise travel to, where they may come across threats to the environment such as new outbreaks of weeds. This is particularly important in remote areas where there are limited resources to monitor environmental conditions and to mitigate such threats. There are strong flow-on benefits of maintaining and strengthening culture through this connection to country. These include better health outcomes and continuation of cultural practices.

Many non-Aboriginal hunters have a personal or generational culture of harvesting from the land. Hunting waterfowl fosters this tradition. For visitors and Territorians, the vast flocks of Magpie Geese on the floodplains are part of their iconic image of the Top End.

2.1.3 Health

Research on traditional diets, both here and internationally, has highlighted the potential health benefits to indigenous peoples of wild foods, especially when linked to holistic caring-for-country lifestyles (Condon *et al.* 1995, Johnston *et al.* 2007, Burgess *et al.* 2005).

The pursuit of Magpie Geese contributes to a healthy lifestyle in the NT for both Aboriginal and recreational hunters. Also, Magpie Geese are a nutritious source of food which can be an important alternative to more readily available processed foods (Miller *et al*. 1993, Johnston *et al.* 2007).

Any health benefits may be negated, however, in the situation where lead shot is used to harvest birds due to the potential adverse impacts of ingestion (see section 3.6).

2.1.4 Economic

The economic value and benefits of using the waterfowl resource have not been accurately measured in the NT, but are thought to be considerable.

For hunters there is significant outlay on guns, ammunition and other equipment such as clothing and refrigeration, as well as fuel and vehicle costs. Extrapolating from national studies (Finch *et al.* 2014) and from regional studies from other areas of Australia (RMCG 2019), it is estimated that expenditure from waterfowl hunting in the NT is around $10 M and perhaps as high as $25 M pa, and indirectly creates around 100 jobs.

The harvest of Magpie Geese contributes to the local economy in other ways, particularly in many remote Aboriginal communities in the Top End. One Magpie Goose is large enough to be a meal for one or more people, and up to 60,000 Magpie Geese are harvested annually by Aboriginal people (A. Griffiths, unpublished data, Clancy *et al.* 2019). On the basis of a market replacement value of $20 per bird, the aboriginal harvest of Magpie Geese may contribute as much as $1.2 M a year to the NT economy. This represents a significant amount of food that does not have to be transported to remote communities or purchased by people that generally have little disposable income.

An economic benefit provided by Magpie Geese - that is very difficult to quantify – is their contribution to the tourism industry. Tourism is an important sector of the NT economy (a $1.6 B industry contributing 16,000 jobs) with the majority of domestic and international tourists coming here to experience the unique blend of natural and cultural experience (NT Tourism: Tourism Vision 2020). The vast Top End wetlands contain an abundance of wildlife. Most visitors want to experience these dramatic landscapes and animals, including the enormous flocks of water birds. The industry is especially important to regional communities, for example tourism in Litchfield, Kakadu and Arnhem Land regions was on average worth $128 M pa (6.3% of the gross value add for the region) in 2014-17 and supported 1,700 jobs (http://www.tourismnt.com.au/en/research/economics-and-the-tourism-industry).

2.1.5 Ecosystem Processes

The social, cultural and economic values derived from Magpie Geese are all part of the suite of ecosystem services (*sensu* Braat and de Groot 2012) underpinned by a well-functioning population of the species. Another, currently unquantified, potential service relates to the likely important role the species plays in the nutrient cycling of the coastal wetlands and surrounding areas (Clancy *et al.* 2019). Gravity, rainfall and landform work together to ensure the nutrients flow from the productive coastal plains to the ocean; however, the seasonal movements and breeding ecology of Magpie Goose are one factor in ensuring this flow is not completely unidirectional. At the simplest level, each fledgling goose that moves from the flood plain to higher areas is contributing to the nutrient cycling of the overall coastal ecosystem and the

implications of significantly diminishing or losing this component of the system may be profound (Clancy *et al.* 2019).

2.1.6 Sustainable use and conservation

Whilst not free of controversy, the consumptive use of wildlife is considered by conservation professionals as being not necessarily in conflict with conservation objectives, and in many situations can contribute to them (Webb 2002). A resolution of the International Union for the Conservation of Nature (IUCN) adopted at the General Assembly in 1990 recognised that "... ethical, wise and sustainable use of some wildlife can provide an alternative or supplementary means of productive land use, and can be consistent with and encourage conservation, where such use is in accordance with adequate safeguards" (Hale 1994).

Webb (2014) defines sustainable use as "use of wildlife associated with a process aimed at ensuring the use can continue indefinitely and any adverse impacts can be contained within defined limits". As Webb points out, the use of wildlife will always entail some impact and the crucial issue is in determining whether such an impact is significant in the specific context. This should be interpreted not just from the viewpoint of the particular target species, but also from the broader perspective of what implications such use has on ecosystem processes. Issues of scale (temporal, spatial and degree of change) and the precautionary principle (the requirement to protect from harm when science determines a plausible risk in cases were their certainty is lacking) become paramount.

Australia, and especially the NT, have had a leading role in the development of successful sustainable wildlife use programs, notably for Saltwater Crocodile (Webb 2014). The same underlying principles have been applied in this management program which aims to ensure that the use of Magpie Geese can be continued, that such use does not perturb population processes beyond acceptable limits, and that there is social and economic benefits from the use accruing to local communities.

Two crucial issues need to be considered in the context of best-practice sustainable use programs (see Webb 2014 p 38-43 for a more detailed discussion). Firstly, it needs to be recognised that most opposition to sustainable use is related to either philosophical opposition to the use of species and/or the ability to point to numerous unsustainable use practices (illegal harvests, overexploitation and lack of local input). Secondly, ensuring local communities, especially indigenous communities, have their traditional access maintained and can share in the benefits of such programs is central to ensuring a net conservation return. In the context of this plan it is therefore important to ensure that any harvest is clearly sustainable in the long run and there is potential for land owners, especially Traditional Owners, to benefit from economic opportunities that may arise.

> *Consultation Point: The management plan allows for the sustainable use of Magpie Geese whilst supporting the long-term conservation of species and the habitats they depend on.*
>
> *Do you think we have hit the correct balance?*

2.2 Population Estimates

The population size of Magpie Goose in the Top End has been monitored by aerial survey since 1983. The first systematic survey designed to estimate absolute abundance as well as nesting activity was undertaken in the 1984 wet season. At that time the goose population in the Top End of the NT was estimated at approximately 2.7 M (Bayliss and Yeomans 1990a).

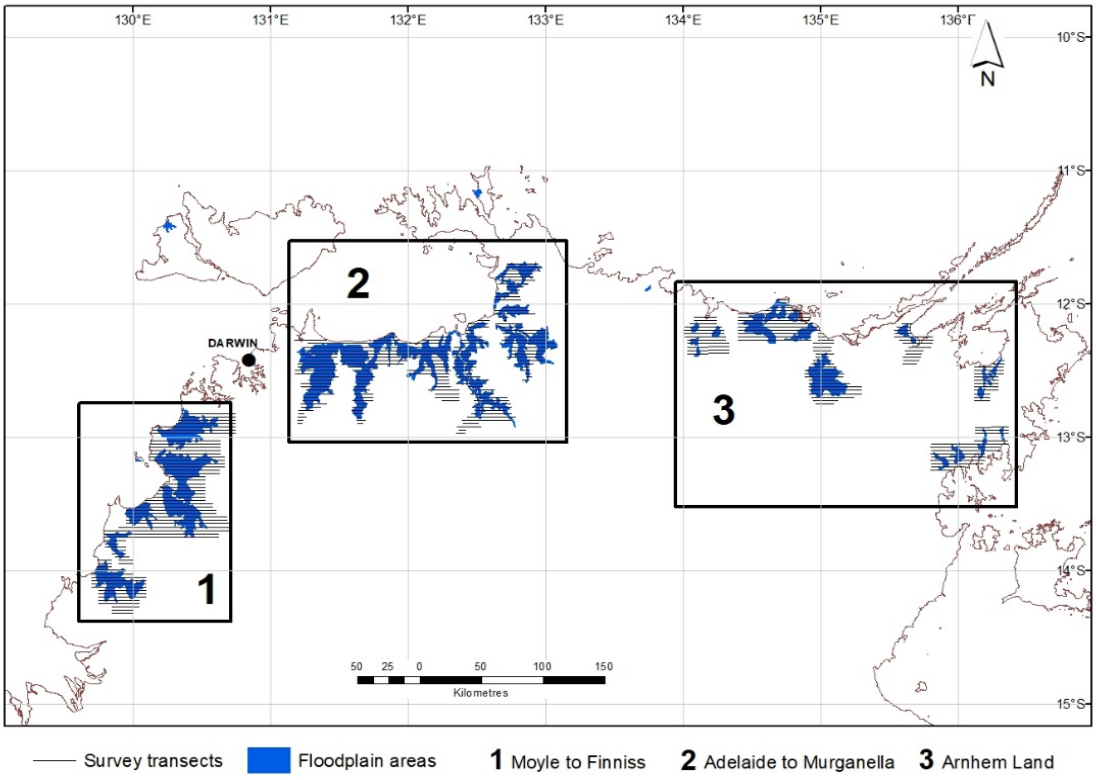


Figure 2: Survey zones for Magpie Goose aerial surveys. Each survey zone comprises of between 6 and 15 survey blocks (see Clancy 2019). Since 2011, Zone 1 has been surveyed bi-annually and Zone 2 on an annual basis or more frequent basis. Zone 3 has been surveyed less regularly. All areas were surveyed in 2018 and 2019.

From 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 season, so that additional data on nesting activity could be collected. Between 1994 and 1997 surveys were undertaken during the dry season (see Bayliss and Yeomans 1990a for characterisation of a late dry season survey) before reverting to an end of wet season count. After 2000 and prior to 2010, only two major aerial surveys of Magpie Geese populations in the Top End were undertaken, in 2006 and 2007. The rationale for undertaking counts at the end of the wet rather than later into the dry season is discussed below (see Section 4.1.1) and relates to the benefits of a significantly smaller survey area (and resultant costs and precision advantages) and of simultaneously collecting data on nesting levels, a key driver of population change (Clancy *et al.* 2019).

Since 2011, a standardised monitoring regime has been implemented that builds on previous survey work (Saalfeld 2011), especially that of Bayliss and Yeomans (1990a, b). Under this regime, the most significant Magpie Goose habitat area - extending from the Adelaide River floodplain to Murgenella Creek floodplain (Zone 2 in Figure 2) - has been surveyed annually with the exception of 2014. The second most important habitat area, which extends from the Moyle River to the Finniss River on the western Top End (Zone 1 in Figure 2) has been surveyed bi-annually since 2011 (Clancy 2018). A third Block covering eastern Arnhem Land (Zone 3 in Figure 2), which generally represents 10% of the population when it has been surveyed, was not flown on a regular basis during this period, although since 2018 all areas have been surveyed annually.

Wet season surveys (1984-1993, 1999-2000, 2006-2007) gave estimates of between 1 million and 2.6 million birds (Figure 3) for the central and western Top End of the NT. There is no evidence of any long-term decline over that period, however the volatility of the population and the decline from 2011 to 2017 was cause for concern in the context of potential for a high level of exploitation to hinder the population's capacity to recover.

The estimated numbers of nests showed similar large scale fluctuations with a low of under 15,000 in 2013 and 2019 and to a high of 283,000 nests recorded in 2011 (Figure 4). Large, rainfall-driven fluctuations of recruitment rate are common and these appear to drive the overall variability (Clancy *et al.* 2019). Populations respond rapidly to variation in rainfall (Bayliss 1989; Whitehead and Saalfeld 2000). Deteriorating environmental conditions associated with periods of below average rainfall can cause rapid and large declines in the population. While populations can increase relatively quickly given favourable rainfall conditions, the maximum rate of increase will usually be lower than the observed rates of decline as the former is constrained by reproductive factors.

Population estimates derived from aerial surveys underestimate absolute abundance (Caughley 1977, Bayliss and Yeomans 1990a, b). The size of this negative bias in aerial surveys of Magpie Goose populations is substantial and varies with seasonal conditions (Bayliss and Yeomans 1990b, Saalfeld 1990). Population estimates are corrected for bias (Bayliss and Yeomans 1990b, Saalfeld 1990) using the best available correction factors. Also, a small but varying proportion of the NT population will be outside the survey area and it is likely the population estimates returned are conservative in most survey years. The current correction factors applied are 3.28 for Magpie Goose sightings and 2.23 for nests, meaning it is assumed that on average only 30% of geese and 44% of nests are sighted within the survey strip in the standardised late wet season count.

2.3 Magpie Goose Habitat

2.3.1 Protected areas

Aerial surveys of the floodplains have determined that approximately 31% or 1,376 km^2 of key Magpie Goose floodplain habitat in the western Top End lies within existing parks and reserves, most notably the Mary River and Kakadu National Parks (Figure 5, Figure 6). Key habitat can be best characterised by the areas used by the species when it is most aggregated (see Section 4.1.1): firstly, when nesting and rearing young and secondly, when food resources are at their most limiting at the end of the dry season.

During both these phases the wetland areas of Kakadu and lower flood plains to the west of Kakadu are especially important. End of dry season aerial survey data from the early 80's and mid 90's emphasise the importance of some floodplain areas within Kakadu National Park. Boggy Plain and Nourlangie Creek floodplain areas on the South Alligator River, and Magella Plain on the East Alligator River may support as much of two-thirds of the total goose population during the late dry season (Table 2 and Figure 6).

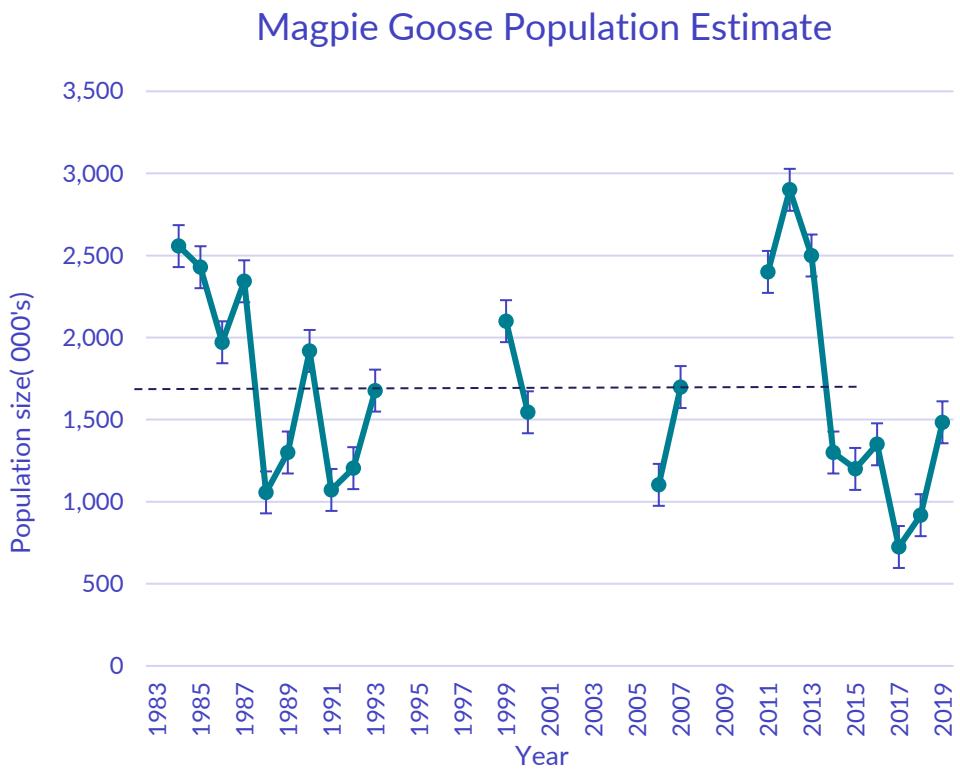


Figure 3 Annual Estimate of Magpie Goose population (mean ± standard error) from Aerial Surveys from 1984 to 2019. Dotted line shows long-term average of 1.7 M.

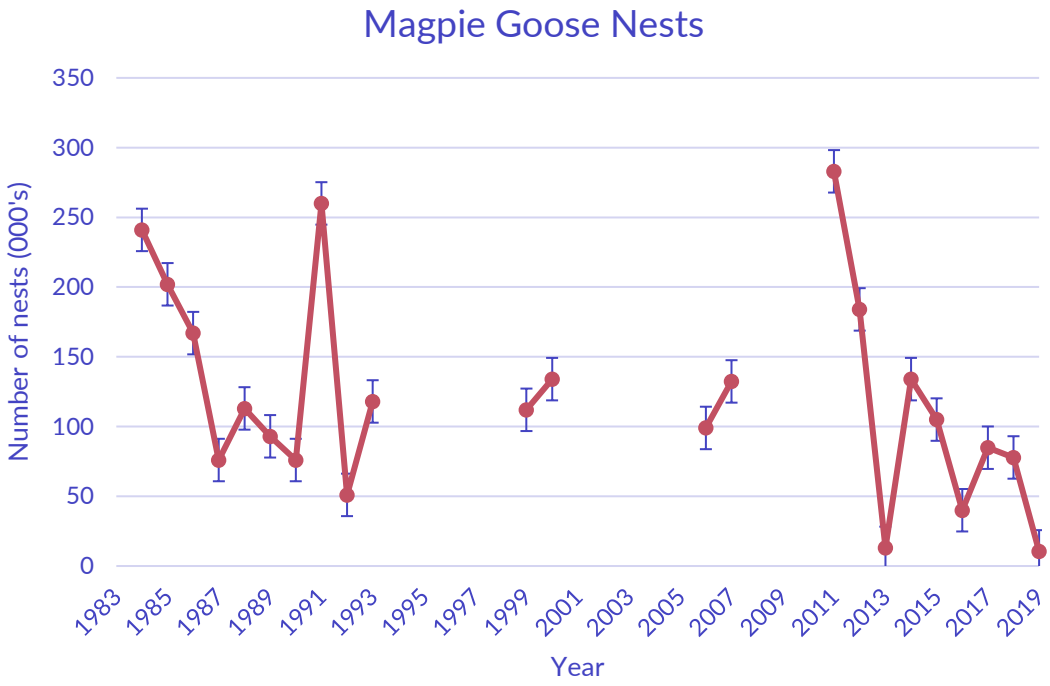


Figure 4: Mean estimates (± standard error) for the Top End of Magpie Goose nests based on aerial surveys from 1984 to 2019.

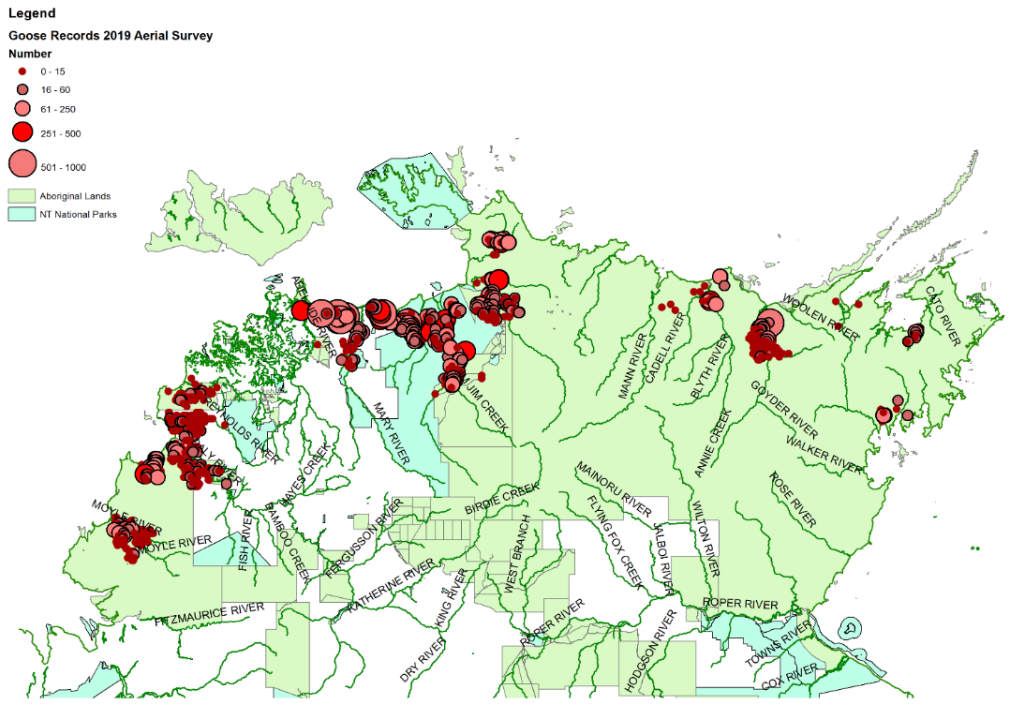


Figure 5: Distribution and density of Magpie Goose populations in relation to Parks and Reserves and non-reserved Aboriginal Lands in the Top end of the Northern Territory based on post wet season surveys in 2019.

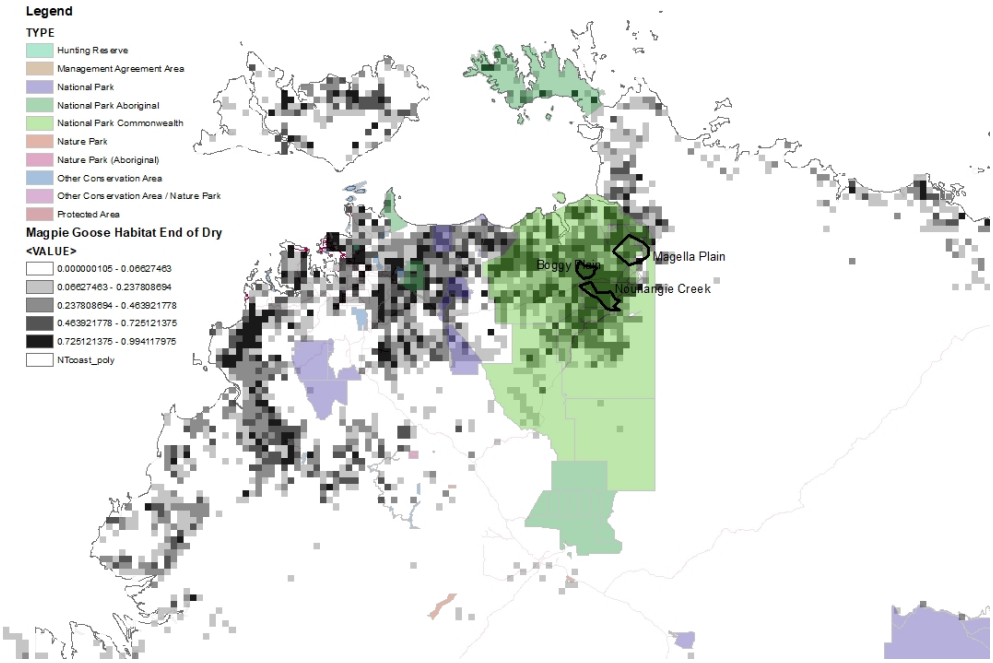


Figure 6: End of Dry Season modelled habitat of Magpie Goose from western and central Top End and location of protected areas. Key concentration points for Magpie Goose during this period based on previous aerial surveys are indicated (see Table 2 and Clancy *et al.* 2019).

Table 2: Estimated late dry season goose population (000's) in three key areas (all within Kakadu National Park) and estimated overall abundance of the Top End (After Delaney et al. 2009).

Area	1983	1984	1995
Boggy Plain	110	660	680
Nourlangie Creek	1,770	1,640	580
Magella Plain	160	240	70
Total	2,040	2,540	1,330
Overall abundance	2,970	3,870	1,950
Proportion of total Top End population	69%	66%	68%

2.3.2 Significant wetlands outside reserves

Habitat areas protected within National Parks and Reserves are complemented by extensive areas of potential habitat on non-reserved Aboriginal lands (Figure 5). Access by non-Aboriginal people is strictly limited and Traditional Owners control activities likely to affect habitats, or which may be detrimental to the long-term conservation of waterfowl. Recent programs to enhance regional capacity to manage natural areas (including Aboriginal Ranger programs) have the potential to mitigate threatening processes such as pests and weeds.

Additional significant habitat occurs on Pastoral leases, especially between the Adelaide River and Kakadu. Pastoral activities rarely conflict with Magpie Goose habitat values and, in some cases, management is actively improving habitat quality such as through concerted efforts to control floodplain weeds.

2.4 Pattern of use

2.4.1 Aboriginal traditional harvest

Magpie Geese have been hunted by Aboriginal communities for food and customary purposes for millennia. Use was documented by the earliest European chroniclers, for example Leichardt (after Gould 1948) stated "So dense are the flocks that occur in the northern parts the country that the natives are enabled to procure numbers of them by spearing." It was noted that they only appeared to spear them when they were on the wing and that, by using spear throwing technology (e.g. wulumba type throwing aids) could hit a target bird over 150 m away. Thomson (1939) reports on hunters "spearing six to seven geese" in a day, and carrying those not eaten on the journey in a "half cooked state" back to the camp to provide for the women and children.

Information on current levels of Aboriginal traditional harvest of Magpie Geese in the Top End is limited. Research from 2001-2002 suggests that the Aboriginal harvest may be as much as 60,000 birds per annum (A. Griffiths, unpublished data, Table 3) and population growth since then potentially leads to harvests 15% larger (Clancy *et al.* 2019). The maximum Aboriginal traditional harvest of Magpie Geese was derived using an observed ratio of shot shells per bird for Aboriginal hunters, the amount of lead shot sold in a remote community, the proportion of shot shells used to hunt Magpie Geese over two years and extrapolated using ABS census data for the Top End (Griffiths, unpublished data). This was a significant reduction in estimates from an earlier study that estimated a potential annual harvest of around 300,000 birds (Vardon *et al.* 1997). Delany *et al.* 2009 quotes a minimum estimated harvest of 30,000 Magpie Geese based on an extrapolation of direct estimates of harvest from the Maningrida area to the other two major areas of Aboriginal traditional harvest, the Kakadu and Finniss/Daly floodplains.

Table 3: Estimated size of annual Top End Magpie Goose harvest by Aboriginal communities in 2001-2002 period from Griffiths (2009, unpublished data). Regions are based on Australian Bureau of Statistics ATSIC boundaries and definitions.

Region	Jabiru	Katherine	Nhulunbuy	Darwin	Total
Remote	21,618	368	15,427	956	38,369
Rural	7,649	444	6,260	2,199	16,552
Urban	-	112	234	6,502	6,848
	29,267	924	21,921	9,657	61,769

An unknown number of eggs are also harvested by Aboriginal people, chiefly for immediate consumption. Early reports suggested that an egg harvest was an important part of traditional harvests, notably in the Arafura Swamp region (Thomson 1939). Current egg harvest levels are not known but suspected to be small. There is an observed high natural loss rate of eggs due to environmental conditions and native predators (e.g. Water Python *Liasis fuscus*, Whitehead 1999). A proportion of Magpie Geese may lay again in the same season if the clutch is lost, especially if early in the incubation period (Whitehead and Saalfeld 2000). Egg harvests may therefore have a limited impact on wild populations.

There are anecdotal reports of an informal market for the sale or barter of birds taken as part of the Aboriginal traditional harvest. The extent of this is not known, nor whether such trade is larger than the likely historical barter levels among communities. Trade in eggs occurred during the late 1960s and early 1970s but this appears to have ceased. Aboriginal people may include parts of the Magpie Goose (particularly feathers) in artefacts manufactured for sale.

The estimated Aboriginal traditional harvest (30,000-70,000 birds and minimal eggs), is considered sustainable (notwithstanding that there is a substantial additional levels of anthropogenic take, see 2.4.2 and 2.4.3). In the context of this plan, given the inalienable right of Traditional Owners to take Magpie Geese, Aboriginal hunting is viewed as an unregulated harvest, varying between the best estimates of minimum and maximum take in a density-dependent manner (i.e. hunting success per unit of effort is higher when populations are higher, Clancy *et al.* 2019).

2.4.2 Non-Aboriginal (recreational) hunting

Magpie Geese have been harvested for food by non-Aboriginal people since early European settlement (Nye *et al.* 2007), generally by ground based hunting. In more recent times there has been a significant and growing number of licenced waterfowl hunters (also known as recreational hunters). The non-Aboriginal harvest is managed in the NT through the declaration of an annual Waterfowl Hunting Season and regulated by varying the duration of the hunting season, bag limits, and firearm and ammunition restrictions. Hunting permits allow permit holders to hunt on any land, with landholder permission, and dedicated hunting reserves have been established since 1984 to provide additional hunting opportunities.

The overall recreational off-take is assessed using the number of permits issued and data submitted on permit returns (Table 1). The number of permits issued has grown from just under 1000 in 2001 to over 3000 in 2019. Unfortunately the proportion of returns submitted by recreational hunters is quite variable ranging from a low of 1% in 2016 (season was very restricted in this year) to a high of 73% in 2002 (when returns were compulsory).

The hunting season parameters for 2002 to present are given in Table 4. Up until 2011, the bag limit for Magpie Geese was set at seven. The period 2011-13 coincided with high population estimates (Figure 2) and the bag limit was increased to 10 Magpie Geese. When the population was observed to decline

sharply in 2014, the bag limit remained at 10. The bag limits was reduced to seven in 2015 and 2016. Following the large decline in the population in 2017, the bag limit was further reduced to three and the overall season length was reduced to eight weeks (Table 4).

On the basis of data provided in the hunting returns and number of hunting permits issued, the total annual recreational harvest has been estimated as varying from a low of around 15,000 (when the bag limit was three) to a high of 58,000. Analysis of the hunting return data suggest no relationship with season length but there are clear positive correlations between offtake and both bag limit and the number of registered hunters (Clancy *et al.* 2019, Figure 6). Whilst there is a large amount of uncertainty with the hunting return data, these trends appear real and it is considered that bag limit is an important lever in influencing season offtake whereas the season length (in the NT context) makes little difference. The latter is likely related to the hunting opportunities, especially on the hunting reserves, being more strongly influenced by the timing of the arrival of Magpie Goose in the greater Darwin area and by issues such as the timing of monsoon arrival. The increase in harvest size with increasing numbers of hunters is also an expected result.

Table 4: Bag limit (maximum number of animals that can be taken by a hunter per day) for Magpie Goose and other Waterfowl species, and season timing and duration from 2002 to 2019.

Year	Bag Limit (No. Magpie Geese	Bag Limit (No. Ducks	Season Opening	Season Close	Season Duration (Weeks)
2002	7	7	17/08/2002	15/12/2002	17.1
2003	7	7	30/08/2003	30/11/2003	13.1
2004	7	7	18/08/2004	14/12/2004	16.9
2005	7	7	31/08/2005	23/12/2005	16.3
2006	7	7	30/08/2006	30/12/2006	17.4
2007	7	7	3/09/2007	30/12/2007	16.9
2008	7	7	3/09/2008	28/12/2008	16.6
2009	7	7	1/09/2009	30/12/2009	17.1
2010	7	7	1/09/2010	30/12/2010	17.1
2011	10	10	23/09/2011	2/01/2012	14.4
2012	10	10	19/09/2012	2/01/2013	15.0
2013	10	10	18/09/2013	5/01/2014	15.6
2014	10	10	12/09/2014	6/01/2015	16.6
2015	7	10	23/09/2015	3/01/2016	14.6
2016	7	10	1/10/2016	23/12/2016	11.9
2017	3	10	27/10/2017	23/12/2017	8.1
2018	5	10	1/10/2018	2/01/2019	13.0
2019	7	10	25/9/2019	6/01/2020	14.7

Whilst there is a relationship between bag limit and total harvest, the majority of hunters take on average only 3-4 birds per hunting trip, irrespective of the bag limit (Clancy *et al.* 2019, Figure 8). This is because only a small proportion of hunters take very large bags across the season. For example, in 2014 when both the bag limit and total harvest were high, 88% of hunters took 50 or fewer birds across the full season and 5% of hunters took over a quarter of the total birds harvested that year (Figure 9).

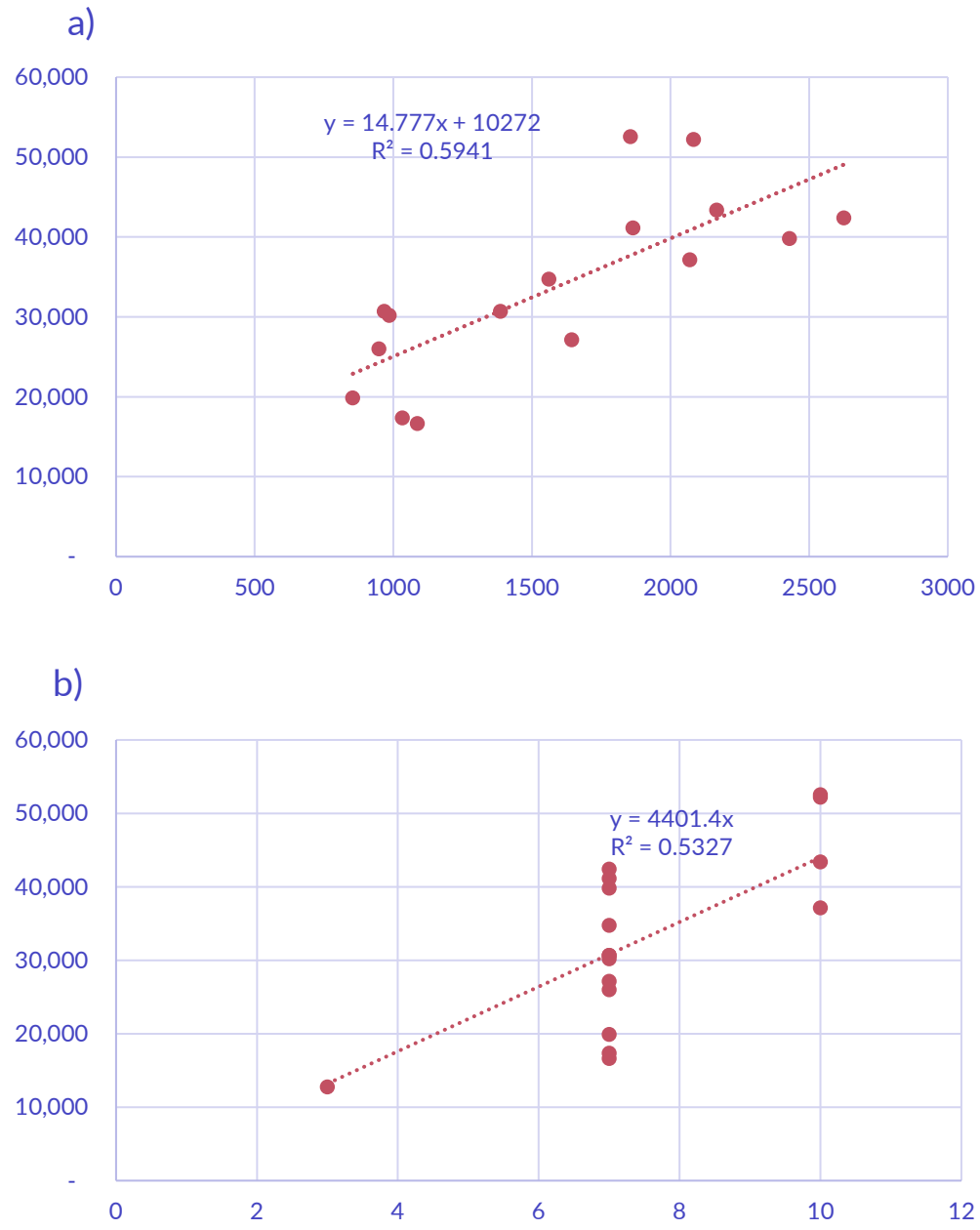


Figure 7 Relationship between a) Number of registered shooters and b) bag limit and the best estimate regression of recreational hunting offtake. Models assume that a higher proportion of non-responders did not shoot in a given season (see Clancy *et al. 2019* for details).

Figure 8: Average number of Geese taken per trip (± standard error) in each month of the open season for a) 2014 and b) 2018. Bag limits different for each year. Data for 2018 based on small number of returns.

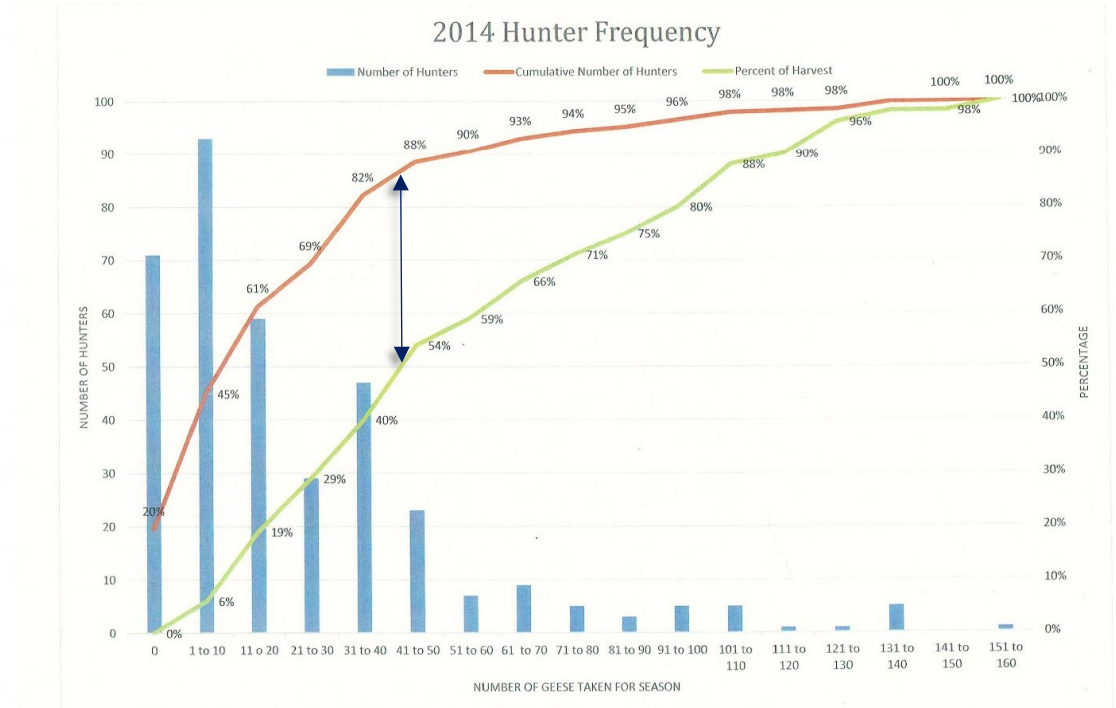


Figure 9: Total number of Magpie Geese taken over the 2014 season by individual hunters (Blue Bars, Left Axis), Cumulative percentage of hunters (Red Line, Right Axis) and cumulative proportion of the total harvest (Green Line, Right Axis). ↕ Line represents the 50% of the harvest point with approximately 85% of hunters taking half the total harvest (and 15% taking the other half).

2.4.3 Commercial use

Prior to 2002, three permits were issued for minor commercial use of Magpie Geese taken from the wild. No permits were issued during the life of the first formal management program (2002 to 2007). At the time of preparing the 2009 management program, although there appeared to be a strong market for Magpie Goose meat, it was considered that the high health standards for handling field–killed game made commercial harvesting uneconomical (Delaney *et al.* 2009). The cost of raising birds from eggs also appears to inhibit development of 'ranching' projects similar to those existing for crocodiles.

A commercial licence was granted to a company in 2015 to harvest 4,000 birds per annum for human consumption. Since that time, demand has grown and the licence allows 6,000 birds to be harvested in 2019. In recent times, other companies have made preliminary enquiries about access to a commercial quota, with the most advanced of these indicating the potential for a long-term harvest in the order of 25,000 birds per annum.

Interest in Magpie Goose as a food commodity has been largely driven by demand from the gourmet restaurant industry. It is becoming increasingly valued as an authentic Australia bush food ingredient. For example, Adelaide's Orana Restaurant which was named the 2018 Gourmet Traveller's Restaurant of the Year, specialises in incorporating native foods and often features Magpie Goose on the menu (Figure 10). Two marketing points have been the sourcing of animals from pest mitigation programs (ABC News 2016) and the link to Aboriginal cultural practices (ABC News 2018).

Figure 10: Magpie Goose has been increasingly added to the menu of many top Australian restaurants (Photo credit Restaurant Orana, all rights reserved)]

Consultation Point: This plan attempts to balance competing demands for the permitted harvest of Magpie Geese including recreational hunting and commercial harvesting.

What do you think is the most equitable way to balance these competing demands?

2.5 Adaptive Management

The management of any wild harvest has to deal with a significant number of uncertainties, perhaps the most crucial is the extent to which hunting offtake is compensated by enhanced survival (i.e. the extent any removals are mitigated by increased survivorship of unharvested birds) at a population level, Caughley and Sinclair 1994). Adaptive management (Walters and Holling 1990, Shea *et al.* 1998) is promoted by wildlife management professionals as one way of dealing with uncertainty. Adaptive Management formulates management as a process of learning-by-doing that aims to increase knowledge about the ecosystem processes in order to improve policies and management programs (Williams 2011). One of the best examples of a long running waterfowl management program that is managed in an adaptive way is the Northern American Waterfowl Adaptive Harvest Management (AHM) Program (Box 1).

In the context of this management program, the adaptive management approach is based on a scaled down version of the AHM (see Section 4.2.3). A limited number of bag limits have been established with their application linked to population thresholds based on current understanding of Magpie Goose population dynamics. Over time, critical uncertainties can be addressed (pending appropriate monitoring) which will allow for future refinement.

Box 1: Northern American Waterfowl Adaptive Harvest Management (AHM) Program

AHM was developed as a systematic process for dealing objectively with the inherent uncertainties in managing multiple species of waterfowl as a shared resource across multiple jurisdictions. The key components of AHM include (Johnson *et al*. 1993, Williams and Johnson 1995):

(1) a limited number of regulatory alternatives, which describe Flyway-specific season lengths, bag limits, and framework dates;

(2) a set of population models describing various hypotheses about the effects of harvest and environmental factors on waterfowl abundance;

(3) a measure of reliability (probability or "weight") for each population model; and

(4) a mathematical description of the objective(s) of harvest management (i.e., an "objective function"), by which alternative regulatory strategies can be compared.

Multiple species are involved with multiple objectives which are distilled down to one objective function. For example in the case of Mallards, the objective is maximise the annual harvest (H_t):

$$\sum_{t=0}^{\infty} Ht\left(\frac{\hat{N_{t+1}}}{8.5}, 1\right)$$

Where Nt+1 is the breeding population size the next year and 8.5 is the population goal for the region in millions (see Runge *et al.* 2013).

Alternatives are chosen from a small set of regulatory packages: Closed (no season), restrictive, moderate and liberal; which differ in daily bag limit and season length. The decision on which regulatory package to apply in any one year is based on "passive adaptive dynamic" modelling with the prediction and the outcome looked at post the annual harvest based on extensive population and harvest monitoring (Runge *et al.* 2013).

3 Threats and Impacts

Existing patterns of land use (on pastoral, conservation reserves and Aboriginal lands) in areas where Magpie Goose live are generally non-intensive and allow for the retention of large wetland areas and their dependent waterfowl populations. Major potential threats to the species include habitat loss or modification (including by weeds and feral animals) and excessive human harvest. The impact of climate change through changes in sea levels, hydrology and saltwater intrusion is an increasingly significant threat to Magpie Geese habitat. Other lesser threats include adverse interactions with agriculture and horticulture and disease.

3.1 Weeds and introduced plants

3.1.1 Mimosa and Olive Hymenachne

Mimosa, *Mimosa pigra*, is a weed of national significance and a statutory Weed Management Plan under the Weed Management Act 2001 is in place. Mimosa is considered an ongoing threat to Magpie Goose habitats in the Top End (Braithwaite et al 1989, Bayliss *et al.* 2012). When unchecked, Mimosa produces an impenetrable thicket and displaces the grasses and sedges needed by Magpie Geese for food and nesting. Mimosa was first detected in Kakadu National Park in 1981 with over 160 individual infestations detected by the early 1990's (Walden and Bayliss 2003). It is estimated to have invaded over 800 km^2 of seasonally inundated floodplains in the Top End (Londsale 1992), however ongoing invasion has been halted by containment efforts in recent years (Barratt *et al.* 2004).

Mimosa is controlled through integrated management including bio-control agents, herbicides and grazing management. Continuing the effort to contain and reduce the spread of Mimosa is a critical element of waterfowl conservation. Extensive control projects have been implemented involving Indigenous land managers, the pastoral sector and the Territory Government. A range of biological control agents have been released as part of an integrated management program in the NT, some of which have proven very successful. Control of noxious plants is the responsibility of the landholder and the NT Government expects owners and occupiers of land in the Top End coastal flood plains to strategically control and contain all infestations of mimosa.

Olive Hymenachne, *Hymenachne amplexicaulis*, is another weed of national significance that can impact detrimentally on Magpie Goose habitat, especially as it is known to replace areas of wild rice, which is a favoured food plant. Olive Hymenachne is a prolific seeder with seeds spread by water, including flooding events, when transported in mud by animals and birds. It can also spread vegetatively from small plant parts making it highly invasive.

The DENR Weed Management Branch provides extension services to landholders to support the control of Mimosa and Olive Hymenachne, as well as other invasive plants.

3.1.2 Introduced pasture species

Replacement of native floodplain grasses by exotic species (especially Para Grass *Urochloa mutica* and Aleman Grass *Echinochloa polystachya*) presents a significant long-term threat to Magpie Goose populations. Mature birds and goslings are heavily dependent on seeds of native annual plants, especially during the breeding season, and these may be displaced by exotics (Ferdinands *et al*. 2005).

The increasing use of invasive exotic grasses on pastoral properties and their frequent escape into neighbouring sites (including the public conservation estate) is likely to substantially degrade wetland habitat values for Magpie Geese over the mid to long-term (Clarkson 1995, Whitehead and Dawson 2000). In Kakadu, para grass is impacting on hunting areas and fire regimes on the floodplains, and have the potential to invade

and alter vast areas if left unchecked. A National Environmental Research Programme project shows that the success of previous best practice management of weeds such as mimosa is likely to be negated if resources are not invested in the control of para grass (Director of National Parks 2016).

3.2 Feral animals and domestic stock

The negative impacts of Feral Pigs, *Sus scrofa*, and unmanaged Swamp Buffalo, *Bubalus bubalis*, are not definitively known but are likely be significant. Feral pigs are common on the western floodplains and may compete with geese for some foods like bulbs of the sedge *Eleocharis dulcis* during the dry season. Feral buffalo have caused substantial environmental change in the seasonal wetlands of the NT through reducing vegetation cover, accelerating erosion, increasing rates of drainage and subsequent premature drying of swamps, and causing saltwater intrusion into previously freshwater areas (Mulrennan and Woodroffe 1998). Infilling of billabongs due to processes of sedimentation triggered by feral buffalo has also occurred.

When the NT management program for Magpie Geese was last reviewed in 2009, there was no direct evidence to indicate that pigs and other feral animals were adversely impacting Magpie Goose populations or wetland habitat. However, recent studies (e.g. Bayliss *et al.* 2018) taking a more risk based approach, have suggested that the negative impacts of feral animals on Magpie Geese and their habitats may have been underestimated. Recent analyses have shown that Magpie Geese do not nest in some areas that appear to be suitable and that there is a negative correlation between the density of Magpie Geese nests and the level of habitat use by feral pigs and buffalo (Figures 11 and 12, see also Clancy *et al.* 2019**)**. This suggests that pigs and buffalo are degrading habitat quality for Magpie Geese.

Other feral animals do not occur at densities that are likely to threaten wetland habitats. The issue of introduced pasture species notwithstanding, managed cattle grazing is not believed to have a major detrimental impact on Magpie Goose habitat. Many of the management activities undertaken by pastoralists (e.g., weed and fire management) may in fact be beneficial in this regard.

There are currently no major studies aimed at evaluating the threat posed by feral animals to Magpie Goose habitat, and this is a knowledge gap that needs to be addressed.

3.3 Climate change and saltwater intrusion

One of the major projected effects of climate change is a rise in sea level (Hennessy *et al*. 2004). Magpie Geese are vulnerable to such rises with some 70% of the goose population in the NT using dry season habitat that is less than one metre above current sea level. These calculations do not take into account other anticipated and compounding changes such as further saltwater intrusion, or changes in hydrology and the distribution and impacts of weed and feral animals. Under these conditions, the long-term sustainable harvest of Magpie Geese may be compromised.

Experience in Kakadu National Park has shown that it is possible to reverse or check the effects of saltwater intrusion by constructing relatively minor earthworks. However, current climate change predictions for sea-level rises over the long-term are probably greater than can be controlled though such minor earthworks.

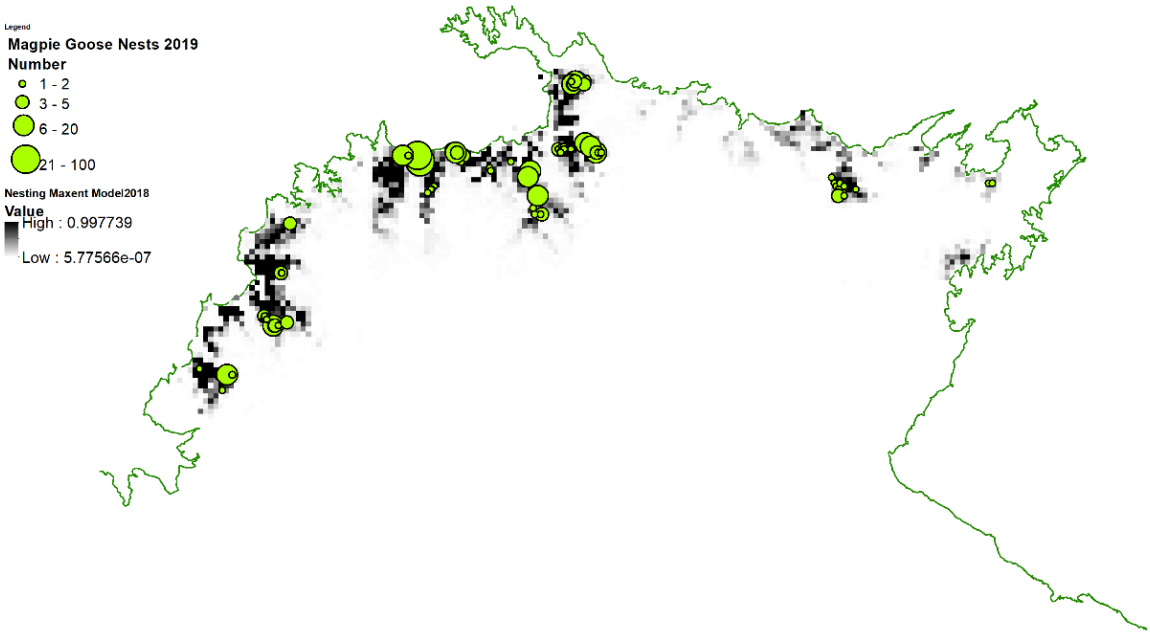


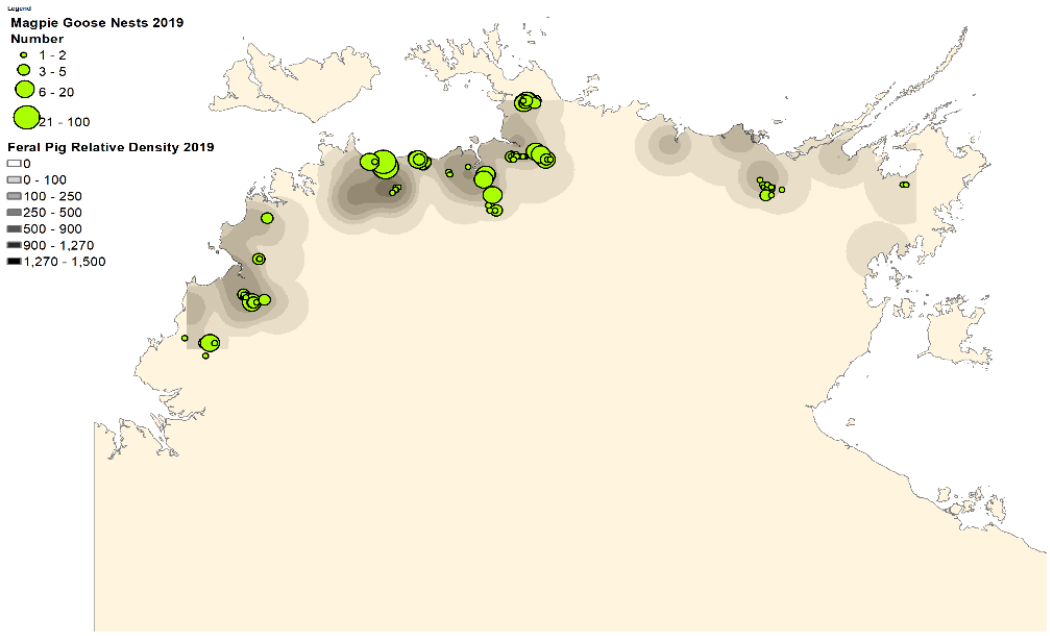
Figure 11: Comparison of Nesting in 2019 with potential nesting areas based on Maxent occupancy model. See Clancy *et al.* 2019.

3.4 Hydrology and water quality

Wetland vegetation is sensitive to changes in hydrological regimes including the rate, timing and depth of flooding (Bowman and Wilson 1986; Whitehead *et al.* 1990) and floodplain environments also act as "sinks" that may accumulate pollutants such as heavy metals (Hart *et al.* 1987) and herbicides and pesticides. Thus, Magpie Goose habitat may be affected by activities that influence water flows on either the floodplain itself, or elsewhere in the catchment.

The potential impact of changed hydrology and effluents or pollutants on water bird habitat is considered in assessments of proposals to extract water or to manage water quality under the Water Act 1992 and in Water Allocation Plans which have processes for maintaining environmental flows. Heavy metal pollutants to floodplains originate principally from mining operations. Their discharge is regulated through a license under the Water Act that includes water quality monitoring, and in some cases monitoring the load (mass) of metal contaminants to rivers and streams.

a)



b)

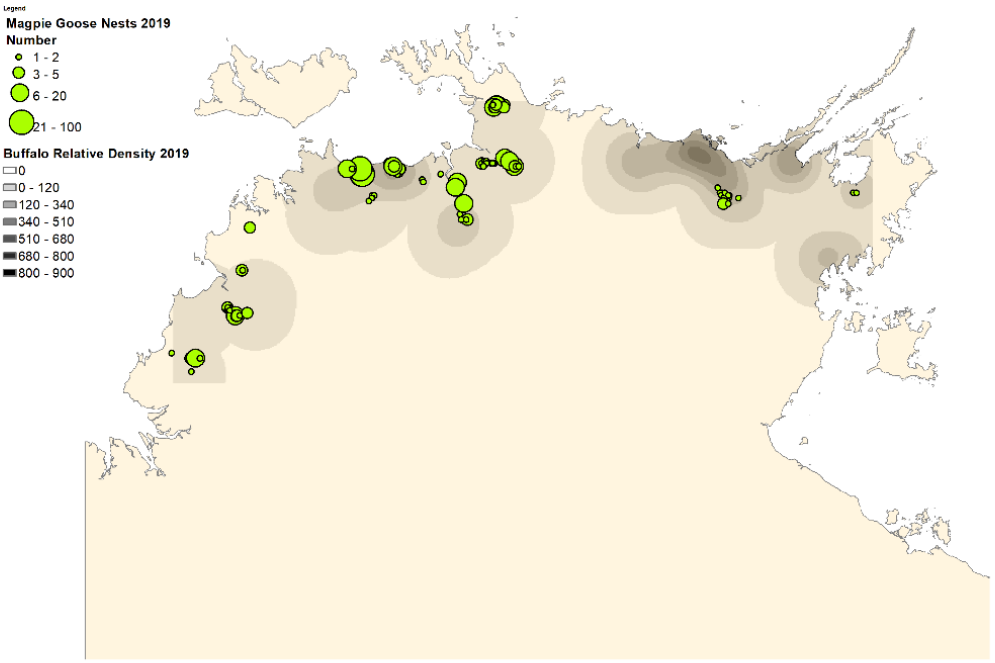


Figure 12: Distribution of Magpie Goose nests in 2018 compared to a) Feral pig relative density and b) Buffalo relative density.

3.5 Harvest

The goal of any consumptive wildlife use program is to ensure the allowable harvest results in a sustainable offtake (Caughley and Sinclair 1994). A starting point is usually to determine the maximum sustainable yield (MSY), the point where population offtake can be maximised. This generally equates to reducing the population to half of its carrying capacity. However, in a practical sense, "Harvesting a population at maximum sustainable yield should never be contemplated" (Caughley and Sinclair 1994 p. 282) as it will result in population instability and potentially trigger population crashes. This is because of the interactive impact of the harvest and environmental variability, and the more variable the inherent populations dynamics the greater the effect (Beddington and May 1977). The main conclusions that can be made about harvesting in a fluctuating environment include: the predictability of harvest decreases as effort increases, the destabilising effects increase if effort is kept constant, and some feedback mechanisms are desirable to deal with environmental variability (Beddington and May 1977). In a practical sense and in the context of a wild harvest of Magpie Geese, this means that the harvest should be set below any calculated MSY and that it is preferable to vary effort (or the offtake allowed) in response to changes in population size driven by environmental change.

As discussed, Magpie Geese have been sustainably harvested over millennia. The species is abundant and rapid response of populations to perturbations are possible because of high potential breeding output. This does not mean that harvests at all levels will be sustainable. There are examples of abundant species being overharvested; in the case of birds two well documented examples are of the Passenger Pigeon, (*Ectopistes migratorius*) (Halliday 1980) and Carolina Parakeet (*Conuropsis carolinensis*) (Saikku 1991). Both species went from being hyper-abundant to extinction with hunting being considered a significant contributing factor. According to the IUCN global database, some 50 bird species that have become extinct since 1500 (*c*. 40% of the total) had been subject to over-harvesting. A further 507 threatened bird species (39%) are affected by overexploitation for human use including thorough hunting for food. Often these are large and conspicuous species, such as pheasants or large waterbirds (Birdlife International 2012).

Harvest impacts on Magpie Goose are reviewed in Clancy *et al.* (2019) including all sources of anthropomorphic take. Key conclusions are that the demand for both recreational and commercial take is growing whereas the trends in Aboriginal hunting cannot be ascertained without further studies. With further growth of the human population in the NT, harvest by both Aboriginal and non-Aboriginal hunters has the potential to influence the dynamics of local Magpie Goose populations. The extent to which harvest mortality reduces overall survival rates is unknown. A long-term sustainable harvest is achievable, however the various demands of the stakeholder groups will need to be balanced.

Whitehead (1998) and Brook and Whitehead (2005a, b) indicate that a maximum sustainable harvest of 5-14% of the total population over the long-term may be viable, on the basis of analysis of the vital rates of the species. Clancy *et al.* (2019) extends on this analysis and incorporates an appropriate factoring-in of environmental variability to establish a range of harvesting thresholds that should be sustainable in the long-term, whilst maximising the hunting opportunities on a year-to-year basis. It was concluded that the best estimate of sustainable harvest is 8.4% *per annum* (well within the range of Brook and Whitehead 2005b) when an appropriate discount rate is used for environmental variation and best estimates of population carrying capacity (*K*) and rate of increase (*r*) are used.

3.6 Shot toxicity and bioaccumulation

Lead derived from spent lead shot is a toxic substance that can harm humans, wildlife and the environment, and can contribute significantly to the deaths of many waterbirds. The build-up of lead in the tissues of birds, and the leaching of lead into the soil can affect other fauna by accumulating in animals higher in the food chain (Thomas 1997, Fisher *et al*. 2006).

The most common lead poisoning in birds is a result of ingestion of spent toxic shot used during waterfowl hunting.

Poisoned animals experience considerable suffering prior to death, including anaemia, kidney and heart damage, increased susceptibility to infectious diseases and starvation. Predators (including humans) are also vulnerable to lead poisoning if they eat birds that have consumed lead shot (Beintema 2004), Burger *et al*. 1998). Other studies indicate that humans who consume birds that have been hunted with lead shot pellets also show increased concentrations of lead in their tissues (Thomas 1997). Even if toxic shot is banned, wetlands containing lead shot will continue to be polluted into the future because of leaching of accumulated lead into the surface water, soil and groundwater.

High levels of lead poisoning at Howard Springs Hunting Reserve (Whitehead and Tschirner 1991) resulted in a prohibition of the use of toxic shot at all NT hunting reserves. While the amount of lead that has accumulated in wetlands in the NT is not known, substantial accumulations have been shown at a number of regularly hunted sites (Whitehead and Tschirner 1991, Saalfeld 1991), and problems are also likely to develop or increase at other sites used repeatedly by recreational or Indigenous hunters.

The NT was the first Australian jurisdiction to prohibit the use of lead shot for waterfowl hunting. Initially this prohibition was limited to the four government-managed hunting reserves, but now the use of non-toxic shot is a requirement for all permitted waterfowl hunting activities. The reduction in use of lead shot on Aboriginal lands is actively pursued, although this use has not been totally eradicated.

Before restrictions were placed on the use of lead shot, it was estimated that hunters contributed approximately 350 tonnes of lead to wetlands in Australia each year (Whitehead and Tschirner 1991). While this has no doubt decreased markedly in in the NT context, the legacy impacts of previous depositions is likely to persist for many years.

3.7 Other threats and issues

3.7.1 Interaction with horticulture

During the late dry season, Magpie Geese may visit fruit farms in large numbers and damage horticultural crops by trampling, grazing, uprooting plants or consuming fruits (e.g. mangoes, Figure 13) (Whitehead 1991). Other horticultural crops (e.g. melons and papaya) can be impacted across the wet season and into the early dry (movements of birds to breeding areas usually abates such damage). The NT horticulture industry was worth over $200 M dollars in 2017 (DPIR 2017) with 9,210 ha of land under crops. In mangoes it is estimated that the overall loss from geese may be 10% of production annually and local losses as high as 40% have been claimed (Corriveau unpublished data). The threat of damage is also seen as a significant impediment to building a viable papaya industry (M. Pheeney, pers com.).

DTSC, with advice from DENR, issues permits to destroy birds upon request to mitigate crop damage. The strategies and tactics available to horticulturalist to mitigate damage (focusing on mango farms) has been the subject of a recent research project that ran from 2015 to 2018) funded by Hort Innovation (Corriveau and Campbell, unpublished data; Hort Innovation 2019). This research was most useful in gaining an improved understanding of both the behaviour of the species and the efficacy of certain mitigation strategies.

The magpie goose is now using farmland and orchards as preferred late dry season habitat and coordinated management efforts are required to reverse this behavioural shift. Research has shown Magpie geese that farmers are not dealing with the same static or homogenous flock over the course of a season with geese potentially moving in from large distances. This has implications for management where ongoing management maybe required rather than one off dispersion.

Satellite tracking has determined that Magpie geese have a daily local pattern of movement — roost site, feed site and watering site (Hort Innovation 2019). Drone interventions may work — when these are larger specially configured machines with mounted sound devices are effective in dispersing geese for greater than 24 hours. It is critical that drones when deployed are used on an area-wide basis — else neighbouring farms could be disadvantaged with dispersed geese seeking refuge.

Other aversion techniques e.g. static ground-based visual and noise systems, or shooting, appear to be less effective. Magpie geese are heavily imprinted behaviourally — despite shooting, geese come back to the same wetland areas year after year. Some general rules with dispersal of Magpie geese are to avoid routines that promote geese habituation, and aim to collaborate with neighbours on what techniques to use based on based on efficacy, resources, and sensitivities (Box 2).

Negative interactions between Magpie Geese and horticulture may increase as new areas are opened up to horticulture. There is also potentially a negative feedback loop: if the quality of preferred floodplain habitat declines, Magpie Geese may become more dependent on the alternative food sources provided by horticultural activities.

3.7.2 Disease outbreaks

Avian influenza has been detected in waterfowl species but not Magpie Geese (Tracey *et al.* 2004). Magpie Geese and other waterfowl populations are monitored for virulent strains of Avian Influenza as part of the wild bird surveillance program. In 2006, the National Avian Influenza Wild Bird (NAIWB) Steering Group was established to ensure national coordination and collaboration of wild bird avian influenza surveillance activities. Harvesting may be curtailed or stopped should such a disease outbreak reduce Magpie Goose populations. Hunters can potentially play an important role in detection of disease outbreaks. For more details on the surveillance program see https://www.wildlifehealthaustralia.com.au/ProgramsProjects/WildBirdSurveillance.aspx.

Figure 13: Magpie Geese often congregate in large numbers on mango orchards in the late dry causing significant conflict with growers.

Box 2: Key learnings from Corriveau and Campbell; Hort Innovation project *Understanding and mitigating the aggregative response to the magpie goose to mango orchards in the Northern Territory* (MG15005). (Hort Innovation 2019) were:

- Earlier mango harvest resulted in reduced damage from geese.
- A later mango season saw increased risk from geese.
- The better the wet season, the later the geese arrival.
- The poorer the wet season, the earlier the migration out of wetlands and arrival in orchards.
- Seasonal conditions and geese behaviour are a dynamic system — each year will be differ in terms of risk.
- Geese have a daily behavioural routine – moving between the daily roosting site, watering site and food site.
- Disrupting those patterns of daily movement assists dispersal.
- In the future, better understanding the interaction between end of wet season geese population surveys and the effect of wetlands water levels, may assist in anticipating the level of geese risk each harvest season.
- Research with using Doppler radar detection of geese movement is showing promise – research is ongoing.

What is not recommended in a Magpie Geese IPM program:

- Relying on shooting of geese in isolation to other approaches
- Relying on any single method in isolation
- Assuming we know everything about the species behaviour and interactions.
- Available off-the-shelf sprays – i.e. chilli spray, Flame Guard®, D-ter® and Bird Away® - they don't work against Magpie geese.
- Complacency following low infestation years.
- Delaying effective interventions in years when geese risk is higher.
- Leaving unpicked fruit on trees or waste fruit around orchards — they are a food source that will encourage geese to stay.
- Thinking that solutions are isolated to a single farm or crop situation
- Failing to collaborate and cooperate with neighbours.

4 Management Approaches

This management program is written in the context of adaptive management, which is defined as a systematic approach to improving the management of natural resources by learning from management outcomes based on appropriate monitoring. It also incorporates feedback to date from various stakeholder groups on existing management approaches (e.g. Box 3). Whilst not all stakeholder' aspirations could be explicitly met in the resolution of key issues raised, this plan attempts to balance all views without compromising on core objectives of the program.

4.1 Required Monitoring

4.1.1 Geese and Nesting

Substantive issues that have been raised regarding the monitoring of the Magpie Geese population and nesting can be distilled down to four key issues:

a) Suspicion regarding the accuracy of the counting technique

b) Concern that the mobile nature of the species means a large segment of the population is unavailable to be counted during the survey period (e.g. because they have migrated elsewhere)

c) Preference for counting to be undertaken later in the dry season to obtain a higher population count (as current year fledglings would be counted)

d) Use of other techniques, e.g. drones/UAV to survey.

With respect to the aerial survey counting technique, it is recognised that a large proportion of birds are missed within the scanned strip during the surveys. This is dealt with by the use of published correction factors (Bayliss and Yeomans 1990) which in practice adjust for 70% of birds and 55% of nests being missed, on average. Whilst further work on these correction factors would be useful, there is nothing to indicate that any refinements would substantially change the interpretation of overall trends in population size as the technique is fundamentally robust and compares very favourably with other broad scale monitoring programs (Clancy *et al.* 2019). Whilst accuracy (especially in the context of developing sustainable offtake estimates) is important, it is of secondary consideration to precision (the amount of variability of the estimate) (Caughley and Sinclair 1994). Precision underpins the degree of confidence that can be had in individual estimates and our ability to assess change through time. The current aerial survey technique is the only practical way to sample an adequate proportion of the potential habitat (in this case 14.4 %) for Magpie Geese in the Top End for management purposes (Clancy *et al.* 2019) given the species' large range and area of occupancy.

The monitoring program is designed to survey the vast majority of the population that is permanently resident in the NT. Nevertheless, there is always going to be a proportion of the population outside the survey area and the potential for some birds to migrate to other areas of habitat outside the NT. Radio-tracking and tagging studies (Traill *et al.* 2010, Corriveau *et al* in prep) do not support the concept of large scale emigration or immigration to areas in other States. Also, the observed fluctuations in density in the NT can largely be attributed to rainfall-driven fluctuations of nesting levels within the areas surveyed (Clancy *et al.* 2019).

Box 3: Summary of key points/issues raised by hunting group representatives in consultation meetings. (Taken from meeting July 2018).

- Aspiration for regular bag limit of around seven (some prefer higher).
- Understanding that "thresholds" will be required to demonstrate appropriate management etc. Perhaps a sliding scale for bag limit- 3/5/7/10.
- Management to be informed by science but recognition that there are knowledge gaps.
- Small number of people questioned the validity of the monitoring that is undertaken.
- Other levers needed regarding other harvest components.
- Consensus (but not unanimous) that preference for certainty and rule-based set of hunting parameters that would be adhered to rather than a discretionary approach.
- Ideally a 17 week season, with consideration of de-coupling of duck season to provide more hunting opportunities.
- Season could run from mid Sept. to early Jan.; however, differing opinions on the later end point. Rainfall patterns can alter the impact of season length especially in the context of reducing impact on hunting reserves (chopping up roads etc).
- Feeling that many of the issues regarding perception that an early start causes displacement onto mango crops have been ameliorated (earlier fruiting, not many actually impacted etc.).
- Season should ideally start mid-week; weekend opening especially problematic.
- Land access an important issue.
- Need to reduce lead shot, especially in indigenous take.
- Need for articulation of all the different offtakes.
- Habitat protection and management important – hunters play important role.
- Hunting deters poaching and promotes good practices, etc.
- Enhancing role of hunting organisations in driving hunting best practice (skills, safety, hunting ethics etc)
- Examples of hunting plans/initiatives from other jurisdictions that can have elements adopted.
- Expect continued growth in participation.
- Other reserve options needed.
- Desire for some additional hunting opportunities.

Magpie Goose area of occupancy (the area within the broader range that is occupied) at a given time varies seasonally. A fundamental principle of population estimation is that the precision of the estimate is directly related to the proportion of the population counted (Caughley and Sinclair 1994). In a practical sense, this means that that a much greater area needs to be sampled when a population is dispersed or else precision (confidence in the estimate) is compromised. Modelled habitat gives a visual index of potential area of occupancy for Magpie Geese among seasons (Clancy *et al.* 2019, Figure 14). There are two periods when the geese are most concentrated during the peak breeding period: just after the wet and at the very end of the dry.

For practical reasons, the end of the wet is the best time to monitor as surveys conducted at this time provide both a precise estimate of the total population and an index of nesting success (and therefore likely future population trends). An end of dry survey is problematic for a few reasons. Firstly, it would mean that information for the establishment of sustainable offtake would need to be based on the previous year's survey (the hunting season parameters would need to be announced well before any such survey). Secondly, in the case of early wet season onset, populations might have dispersed at the time of any scheduled survey.

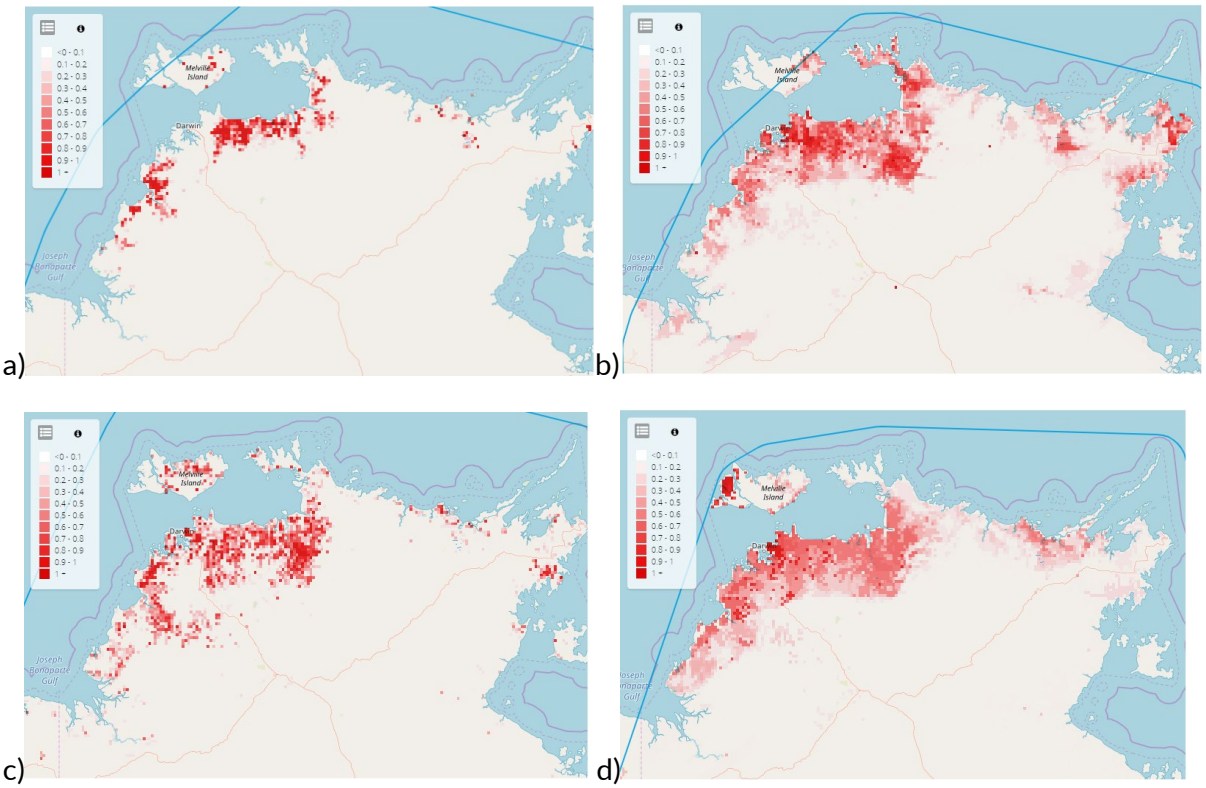


Figure 14: Modelled habitat showing the changes in dispersion of Magpie Goose potential occupancy for a) Post wet (breeding period, April -May) b) Mid Dry Season (June-August) c) End of Dry Season (October) d) Wet Season (Dec-February). See Clancy *et al*. (2019) for details. Note extent of clumping in (a).

Thirdly, whilst the total count will often be higher at the very end of the dry season than that obtained at the end of the wet, the population is also at its most volatile, being dependent on fledgling survivorship. This is because the critical "post *Eleocharis dulcis* late-dry resource bottle neck" (Brook and Whitehead, 2005b) is a period of potentially high mortality for this cohort (see Whitehead and Tschirner 1991, Brook and Whitehead 2005b). A survey delayed until the end of the wet will include only those fledglings that have survived through to their first year and be less sensitive to the specific timing of the survey. As such, these surveys will give a clearer picture of the overall population trends, especially where it is only feasible to undertake a single annual survey.

Survey methodology, especially in the context of rapidly evolving technology including use of radar (Lehrke in prep) and unmanned aerial vehicles (UAV) or drones, is open to improvement over the life of this plan. Existing protocols may be also refined, especially by application of high definition filming (either time-lapse or video) (Clancy *et al.* 2019). At the time of writing, there were no definitive data to recommend a change in the current standard approach to population monitoring but new techniques should continue to be

explored within reasonable cost constraints and with an eye to ensuring consistent population estimation to underpin robust long-term trend analysis.

Annual monitoring by intensive aerial survey of the major floodplains of the Top End should be undertaken for the life of this plan. The standard monitoring protocol (see Clancy 2019) should apply at least until there are clear improvements in accuracy, precision and cost arising from new technology (e.g. the use of survey UAVs or radar). To ensure public confidence in the survey results, survey reports should continue to be prepared and publicly released as soon as practicable after the relevant survey is completed.

Consultation Point: The department's estimates of population size have come under recent criticism from sectors of the hunting community especially in response to the observed decline in 2017.

Do you agree with the approach suggested as the best way forward?

4.1.2 Harvests

Currently monitoring of harvest offtake from recreational hunting is based on voluntary returns supplied by licenced hunters. However, the data provided is only a sample of all hunters and the return rate fluctuates markedly among years (Table 1). Response bias, non-response bias and methodological issues can all be problematic in estimation of harvest offtake (Padding and Royle 2012) and it is likely that in years with very low response rates, the data are particularly unreliable as an indicator of the overall harvest. No ongoing monitoring of Aboriginal offtake occurs other than using ammunition sales for waterfowl-relevant shot sizes as a rough index (Griffith unpublished data, Clancy *et al.* 2019). With respect to the commercial harvest, it is a permit condition to report on all Magpie Geese harvest and mandatory reporting is also required for Magpie Geese taken under damage mitigation permits.

In some jurisdictions (e.g. Victoria, Moloney and Turnbull 2017) detailed surveys in the field and by phone are undertaken to collect hunting data, but these can be both time consuming and expensive. To deal with the data paucity and to ensure no adverse impacts of harvesting, a conservative approach to estimating offtakes has been used here. Given the increasing number of licenced hunters (see below), an increase in offtake was factored into projected harvests in future years. Whilst this may overestimate the actual offtake at a given bag limit, in the absence of definitive data this is preferable to underestimating the offtake and potentially triggering a decline in the population.

Current mandatory reporting and compliance checking is believed to be adequate to monitor commercial and damage mitigation take. There is likely to be a level of unreported and illegal take outside the regulated recreational and damage mitigation take, although this is considered to be small and is factored into the harvest modelling (Clancy *et al.* 2019). The issue of improving monitoring of the Aboriginal take is discussed in Section 6.4.

Consultation Point: How can we better gather information on annual offtakes by recreational hunters?

4.1.3 Habitat

Most significant habitat for long-term conservation of Magpie Geese occurs on Kakadu National Park and issues such as effective management of weeds and pest animals in this reserve will have a major impact on the management of the overall Top End population (Bayliss and Ligtermoet 2018). The importance of appropriate management of the most proximate threats as well as being able to deal with longer term issues including climate change is likely to be high on the agenda of relevant management agencies over the life of this plan. A key management issue going forward will be ensuring the lessons garnered from research and management of Kakadu floodplains are communicated effectively to park managers and traditional owners, as well as Aboriginal and pastoral land managers outside the park.

Significant advances are being made in the field of remote sensing of wetland extent and condition and it is proposed that a suitable index of Magpie Goose habitat is developed. As a starting point, models for nesting and feeding habitat have been developed (Clancy *et al.* 2019).

4.2 Recreational Hunting Management

4.2.1 Bag Limits and seasons

The establishment of parameters for the hunting season is an important component in ensuring any permitted hunting is sustainable. As discussed, the setting of bag limits on an annual basis is the most effective lever that can be used to influence offtake, especially in the context of an abundant species and relatively small hunting population, meaning more restrictive management strategies used elsewhere, such as ballots, highly restrictive seasons, high licence or tag costs, are not appropriate.

The approach taken to establishing suitable take levels was as follows (Clancy *et al.* 2019):

- An overall sustainable harvest was determined on the basis of carrying capacity using the standard formula (Sustainable Harvest = $Kr/4$ where K = population's carrying capacity and r = the intrinsic or maximum rate of increase; Caughley and Sinclair 1994) and allowing for environmental variability using an appropriate discount rate (Choquenot *et al.* 1998).
- The final model used published r values at the maximum end of the range given by Brook and Whitehead (2005b) and discount rates based on relevant variation in population size combined with rainfall variation (see Choquenot *et al.* 1998 Table 1 page 27).
- As no definitive carrying capacity number is known, the full range was examined with a focus on the most plausible range of 2-3 million birds (Clancy *et al*. 2019).
- An appropriate long-term offtake from recreational hunting, factoring in all sources of anthropogenic take, was established. This linked the recreational offtake to appropriate season parameters (fixed season length of as long as practicable, allowance for continued growth in permitted hunters) with bag limit being varied.
- To develop thresholds for annual take a variable harvest regime governed by population size was applied, with the starting point limiting the annual take to double the average long-term annual yield.

The overall conclusion from the modelling exercise that, even with reasonably low rates of all other categories of offtakes, bag limits of 10 were not sustainable. Long-term bag limits of 5-7 appeared to be more sustainable (from the perspective of not destabilising the population) than higher bag limits (Table 5).

Table 5: Extract from harvest impact model using a simple lagged logistic growth model. Output relates to the following parameters Carrying Capacity *K* = 3,000,000; rate of increase, *r* = 0.28, Aboriginal Take between 30,000 and 60,000; Commercial Take = 10,000; Pest Mitigation = 6,000; Unreported = 2,000. Numbers shown are the number of new birds added at the relevant population size and bag limit with positive increases shown in green and negative reductions in red. At low population sizes decreases are more related to offtakes whilst at high they are predominately demographically driven (After Clancy *et al.* 2019).

Population Size	Bag Limit 0	Bag Limit 3	Bag Limit 5	Bag Limit 7	Bag Limit 10
					-
0	-48,000	-66,000	-76,000	-88,000	113,000
100,000	-35,623	-53,623	-63,623	-75,623	-70,623
200,000	-23,885	-41,885	-51,885	-63,885	-88,885
300,000	-12,787	-30,787	-40,787	-52,787	-77,787
400,000	-3,329	-21,329	-31,329	-43,329	-68,329
500,000	5,489	-12,511	-22,511	-34,511	-59,511
600,000	13,667	-4,333	-14,333	-26,333	-51,333
700,000	21,206	3,206	-6,794	-18,794	-43,794
750,000	24,736	6,736	-3,264	-15,264	-40,264
800,000	28,105	10,105	105	-11,895	-36,895
900,000	34,364	16,364	6,364	-5,636	-30,636
1,000,000	39,984	21,984	11,984	-16	-25,016
1,100,000	44,964	26,964	16,964	4,964	-20,036
1,200,000	49,304	31,304	21,304	9,304	-15,696
1,250,000	51,234	33,234	23,234	11,234	-13,766
1,300,000	53,004	35,004	25,004	13,004	-11,996
1,400,000	56,064	38,064	28,064	16,064	-8,936
1,500,000	58,485	40,485	30,485	18,485	-6,515
1,600,000	60,266	42,266	32,266	20,266	-4,734
1,700,000	61,407	43,407	33,407	21,407	-3,593
1,800,000	61,909	43,909	33,909	21,909	-3,091
1,900,000	61,771	43,771	33,771	21,771	-3,229
2,000,000	60,993	42,993	32,993	20,993	-4,007
2,100,000	59,575	41,575	31,575	19,575	-5,425
2,200,000	57,517	39,517	29,517	17,517	-7,483
2,300,000	54,820	36,820	26,820	14,820	-10,180
2,400,000	51,483	33,483	23,483	11,483	-13,517
2,500,000	47,506	29,506	19,506	7,506	-17,494
2,600,000	42,889	24,889	14,889	2,889	-22,111
2,700,000	37,633	19,633	9,633	-2,367	-27,367
2,800,000	31,737	13,737	3,737	-8,263	-33,263
2,900,000	25,201	7,201	-2,799	-14,799	-39,799
3,000,000	18,026	26	-9,974	-21,974	-46,974
3,100,000	10,210	-7,790	-17,790	-29,790	-54,790
3,200,000	1,755	-16,245	-26,245	-38,245	-63,245

Harvest Driven →

←Demographically Driven

Using a variable bag limit, linked to population size, was the best way to optimise offtakes without the risk of causing population declines, or impeding the population's ability to recover after environmentally modulated declines (Table 6).Establishing clear thresholds linked to population size is the best way to ensure sustainability and deliver certainty to the hunting community without compromising management responsibility.

From the analyses, harvest limits were identified that ensure that future use is sustainable. The combined annual harvest from all anthropogenic sources, including both non-commercial and commercial harvest, is to be set at 8.4% of the annual minimum estimated Magpie Goose population for the Top End of the Northern Territory. This is close to the midpoint of the theoretical range of harvest rates suggested by Brook and Whitehead (2005b) of between 5-14% but derived using a different approach. The minimum population estimate (*P*) is defined as the calculated estimate for the survey area (recognising that a small proportion of birds occur outside the survey area) using the standard methodology.

Table 6: Impact of variable harvest on population growth. Output relates to the following parameters Carrying Capacity *K* = 3,000,000; rate of increase, *r* = 0.28, Commercial Take = 10,000; Pest Mitigation = 6,000; Unreported = 2,000. Numbers shown are the number of new birds added at the relevant population size at the bag limit as set. *NB* Higher bag limit left at inflexion point to highlight thresholds. At population size between 500,000 and 750,000 lower commercial and pest mitigation levels set in final model.

Population Size	Aboriginal Harvest	Offtake Allowed	Residual	Est Hunting Take	Total Take Impact	Bag Limit
300,000	30,000	25,200	-10,800	-	-10,800	0
400,000	31,000	33,600	-3,400	-	-3,400	0
500,000	32,000	42,000	-1,000	17,424	-18,424	3
600,000	33,000	50,400	6,400	17,424	-11,024	3
700,000	34,000	58,800	13,800	17,424	-3,624	3
750,000	34,500	63,000	17,500	17,424	76	3
800,000	35,000	67,200	21,200	17,424	3,776	3
900,000	36,000	75,600	28,600	17,424	11,176	3
1,000,000	37,000	84,000	29,000	29,040	-40	5
1,100,000	38,000	92,400	36,400	29,040	7,360	5
1,200,000	39,000	100,800	43,800	29,040	14,760	5
1,250,000	39,500	105,000	39,500	40,656	-1,156	7
1,300,000	40,000	109,200	43,200	40,656	2,544	7
1,400,000	41,000	117,600	50,600	40,656	9,944	7
1,500,000	42,000	126,000	58,000	40,656	17,344	7
1,600,000	43,000	134,400	65,400	58,080	7,320	7
1,700,000	44,000	142,800	72,800	40,656	32,144	7
1,800,000	45,000	151,200	80,200	40,656	39,544	7
1,900,000	46,000	159,600	87,600	40,656	46,944	7
2,000,000	47,000	168,000	95,000	40,656	54,344	7
2,500,000	52,000	210,000	132,000	40,656	91,344	7
3,000,000	57,000	252,000	169,000	40,656	128,344	7

A fixed hunting season is proposed, commencing in mid-August on private land and the fourth Wednesday in September for hunting reserves, and closing on the Monday after the first Friday in January. Some hunting reserves may be closed earlier for operational reasons. The later start for hunting on hunting reserves is to ensure that early arriving birds are not displaced onto nearby horticultural properties. The proposed duration of around 15 weeks is less than the 17 weeks requested by hunting groups with respect to hunting reserves. However, the proposed earlier opening on private land may provide some additional hunting opportunities.

Bag limits for recreational hunting will be determined on the basis of the population monitoring results (minimum population estimate) according to the following thresholds:

Population Size (*P*)	Bag Limit (per day)	Comments
<500,000	0	Closed season
500,000 to <750,000	3	Requires reduced pest mitigation and potentially commercial takes
750,000 to <1,000,000	3	
1,000,000 to <1,250,000	5	
>1,250,000	7	

These criteria have been set to maximise short-term hunting opportunities without impinging on long-term yields (and future hunting opportunities).The expected implications of applying these criteria would be bag limits of between 5 and 7 in the majority of years, except in the most pessimistic of scenarios which may arise due to regular future wet season failures (Table 7).

In an adaptive management context, a range of uncertainties can be identified which have implications for regulating the overall harvest offtake going forward (Table 8). These can be structured as a set of alternate hypothesis which can be tested by collection of management data (e.g. through population monitoring) and potential responses including changes to the established harvesting thresholds. Fixing the season length in the next few years will remove one variable from the equation, giving greater opportunity to flesh out impact of other variables (bag limit and hunter numbers) on harvest offtake. Over the life of the management program, the requisite data can be collected to narrow the range of these uncertainties and better inform management responses. The specified ten year lifespan of the Program, with a five year review, would seem a suitable duration in most cases to make such adjustment. Due to the inherent environmental variability of the system, relatively long periods of data collection are needed to provide adequate certainty.

4.2.2 Permitting and Compliance

Compliance checks on adherence to permit conditions, focused on the designated hunting reserves (in the case of recreational hunters), and occurs across the open season. Enforcement activities are undertaken by Wildlife Operations Rangers from DTSC in conjunction with NT Police. Random patrols are conducted of hunting grounds to ensure hunters have their permits with them and are not using lead shot. Overall compliance with permit conditions has been high, with breeches that are detected usually at the lower end of the scale. In recent years, only very few licenced hunters have been detected in possession of non-compliant shot or exceeding bag limits.

Table 7: Example population sizes and future bag limits based on four population growth scenarios; Optimistic – highly favourable run of seasons, Pessimistic – Run of exceptional bad years, recent history – Based on recent population changes including declines; Long run history – Based on long term average population sizes. Includes last 2 years for comparison. Figures are number of Geese.

	Population Growth							
Year	Optimistic	Bag Limit	Pessimitic	Bag Limit	Recent History	Bag Limit	Long run History	Bag Limit
2018	*908,200*	*5*	*908,200*	*5*	*908,200*	*5*	*908,200*	*5*
2019	*1,400,000*	*7*	*1,400,000*	*7*	*1,400,000*	*7*	*1,400,000*	*7*
2020	1,120,000	5	1,120,000	3	1,778,000	5	1,778,000	7
2021	1,344,000	7	1,422,400	5	2,258,060	7	2,258,060	7
2022	1,612,800	7	938,784	3	1,174,191	5	2,867,736	7
2023	1,935,360	7	1,192,256	5	1,083,869	5	1,433,868	7
2024	1,500,000	7	953,805	3	600,297	3	1,821,012	7
2025	1,800,000	7	1,211,332	5	762,377	5	2,312,686	7
2026	2,160,000	7	969,065	3	968,218	5	2,937,111	7
2027	2,592,000	7	1,230,713	5	1,229,637	5	3,730,131	7
2028	2,073,600	7	984,570	3	639,411	5	1,865,066	7
2029	2,488,320	7	1,250,404	5	812,052	5	2,368,633	7
	Average Bag Limit	6.8		4.0		5.0		7.0
	Years Under 5	0		3		1		0

No changes are suggested for the current permitting and compliance regime, although the option of mandatory permit returns is left open.

4.3 Commercial Harvesting

A viable commercial industry for the Magpie Goose is seen as a positive both from an economic perspective but also as a tool to reduce conflict between horticulturalists and geese. The potential for much greater involvement of Aboriginal communities in the value chain, including increasing direct supply of products to remote communities, is also worthy of investigation.

A minimum commercial harvest is set at 5,000 (where $P < 750{,}000$), which is required to protect infrastructure investment and market access for a viable industry. The expectation is that a commercial harvest of 20,000 – 30,000 may be allowable in most years over the longer term. No commercial take will be permitted during March to July to avoid impacts on Magpie Goose breeding, unless specifically tied to a genuine pest mitigation requirement.

4.4 Damage Mitigation

Agricultural protection allows for the annual take of up to 15,000 Magpie Geese. However, management will be aimed at minimising damage rather than maximising numbers taken and, as far as practicable, meeting the demand for pest reduction removals through other permitted harvest such as commercial take.

Table 8: Key uncertainties in determination of allowable offtakes and potential implications and adaptive management responses

Key Parameter	Estimate Used	Alternatives	Implications re estimate of allowable take	Key Monitoring Data	Potential Adaptive Management Response	Comments
Carrying Capacity (*K*)	3,000,000	Lower and/or declining due to ongoing habitat degradation	Over	Index of habitat quality	Improve habitat or reduce offtake	Trackable with current methods but could be improved
		Underestimated by 15% or more	Under	Total population size	Increase allowable offtake / Decrease thresholds	Existing techniques largely adequate
Rate of Increase (*r*)	0.28	0.232 (predicted by Brook and Whitehead)	Over	Relative population size	Decrease allowable offtake/ Increase thresholds	Higher precision plus longer run of data desirable
		0.35-0.4 (As indicated by tracked numeric response)	Under	Relative population size	Increase allowable offtake / Decrease thresholds	
Discount Rate	0.6	0.5 (Variability of nesting a better index of variability than rainfall)	Over	Long term estimate of wetland habitat or nesting success variation	Decrease allowable offtake/ Increase thresholds	Existing techniques largely adequate. Accounts for environmental variability
		0.7 (Over estimate of CV of N due to movements)	Under	Improved precision of population estimates	Increase allowable offtake / Decrease thresholds	Higher precision plus longer run of data desirable
Overall Offtake	Variable	Underestimate of Aboriginal Take or undetected upward trend	Over	Best estimate of Aboriginal Take. Ancillary data on shot sales and population trends	Decrease allowable offtake/ Increase thresholds	Requires more R&D
	Variable	Overestimate of Aboriginal Take or undetected downward trend	Under	Best estimate of Aboriginal Take. Ancillary data on shot sales and population trends	Increase allowable offtake / Decrease thresholds	

Key Parameter	Estimate Used	Alternatives	Implications re estimate of allowable take	Key Monitoring Data	Potential Adaptive Management Response	Comments
	Low	Underestimate of un reported take	Over	Detections of illegal take	Increased enforcement or reduction in allowable take	Legal harvesters (Aboriginal, Licenced hunters and commercial operators the best detectors of illegal operators
Hunting Offtake	Bag limit impact	Steeper relationship or higher constant	Over	Actual harvest take	Decrease allowable offtake/ Increase thresholds	Dependent on greatly improved harvest return rate, better estimation of non-response bias and accurate representations of harvest by responders
		Shallower relationship or lower constant	Under	Actual harvest take	Increase allowable offtake / Decrease thresholds	
	Number of Hunters	High level of "non-hunters" applying for permits	Under	Actual harvest take	Increase allowable offtake / Decrease thresholds	As above
		New hunters looking to shoot smaller total numbers than existing	Under	Actual harvest take	Increase allowable offtake / Decrease thresholds	

4.5 Habitat Management

Any protection and management of Magpie Goose habitat is best addressed through the broader lens of wetland and floodplain protection rather than an explicit species-specific approach. Nevertheless, it is important to ensure the habitat requirements of geese are addressed, where relevant, in management plans for protected areas and in other land management programs and strategies. On both Parks and unreserved Aboriginal land, this is being achieved by the identification of Magpie Geese as an important ecological asset within plans, and through undertaking important land management activities (burning, and pest animal and weed control) in a way that best protects this asset.

4.6 Extension and consultation

4.6.1 Public communication

This document provides an opportunity for all NT residents to have input into the management of this iconic species.

Up to date information on Magpie Goose, waterfowl hunting and wildlife permitting requirements are published on the NT Government Website. These pages will be continue to maintained and updated in the future. DENR also releases important information via its social media pages.

A range of information material will be prepared as part of the finalisation of this management program. This includes a series of short videos of issues related to the management of Magpie Geese (including hunting, damage mitigation and species ecology).

4.6.2 Hunting Stakeholders

DENR and DTSC have been undertaking regular consultation with hunting stakeholders through identified key representative groups (NT Field and Game, Sporting Shooters, NT Firearms Council, Darwin Women's Hunting and Fishing Group, and Shooting Supplies Retail Sector) and it is useful to maintain a regular schedule of formal meetings at around a quarterly basis.

The DTSC have developed an Android and IOS app available for download which gives easy access on mobile phones to waterfowl hunting rules and information. This app allows hunters to search for waterfowl species, bag limit information and hunting zone locations. The Hunting Mate app is updated for each annual waterfowl hunting season.

4.6.3 Traditional Owners

Consultation with Traditional Owners on issues related to Magpie Goose management will be coordinated through the Northern Land Council (NLC). The NLC is responsible for administering the permit system access to Aboriginal land in the Top End designed to help protect the privacy of Aboriginal communities, preserve Aboriginal culture, safeguard the natural environment and promote visitor safety. With respect to any commercial operations on Aboriginal Land these are covered by Aboriginal Land Rights (Northern Territory) Act 1976 section 19 Land Use Agreement process. NLC carries out consultations and negotiations on behalf of Traditional Owners with those interested in carrying out commercial activities on Aboriginal land and waters, and seeks to ensure that any use proposal is fair and equitable.

Another important consultation mechanism is via relevant Aboriginal Ranger Groups. These provide a formalised structure for the transfer of traditional knowledge from old to young, as well as being a vehicle for land and sea conservation and the training and employment of young Aboriginal people living in remote

areas. Ranger Groups are especially important in delivery of pest, weed and fire management programs on the ground which protect Magpie Goose habitat.

4.6.4 Other Wetland Managers

The increasing recognition of the ecosystem services provided by wetlands in Australia, and their conservation, aesthetic, recreational, and economic values, has encouraged more sensitive management of these systems. DENR seeks to further promote public awareness of the need for wetland protection in the NT in collaboration with key management agencies.

Specific management actions are set out in the Northern Territory Natural Resource Management Plan 2016-2020 for the Top End Region (Territory NRM 2016). The development of this Action Plan was facilitated by Territory Natural Resource Management (TNRM) in collaboration with the primary stakeholders, including landholders, Traditional Owners, pastoralists, government, industry groups, researchers, Aboriginal organisations and community groups. The plan provides an integrated and collaborative approach to ensure sustainable management of our water, land, soils and biodiversity in the Top End including key wetland areas.

DENR also seeks to increase options available for landholders to derive an income from natural wetlands, thereby encouraging retention of natural wetlands as a viable land use option. The sustainable commercial use of Magpie Geese is one of those options.

4.6.5 Horticulturalists

Consultation regarding management of the conflict between horticulturalists and Magpie Geese is jointly managed by DPIR (Integrated pest management), DTSC (Take Permits) and DENR (Wildlife Use and Pest Animals). This has been enhanced in recent times by involvement of CDU in research projects looking at mitigation responses. A risk with such an approach is fragmentation or lack of clarity on who best to approach to deal with issues. The implementation of the CDU research project provided an effective mechanism for coordination but this only focused on mango farmers and funding has now finished.

Pending the final write up of the research work to date an interdepartmental steering group should be maintained (chaired by DPIR).

4.6.6 Research and education community

Charles Darwin University (CDU) and CSIRO have a long history of involvement in Magpie Goose research. Institutions like CDU's Research Institute for the Environment and Livelihoods (RIEL) have significant research strengths in wetland systems and co-operative research with land management agencies and traditional ecological knowledge. DENR will continue to liaise regularly with scientists from RIEL and other relevant bodies to develop collaborative research and education programs.

A key element in developing strong collaborative research programs and leveraging from existing knowledge is sharing research findings and supporting an open data agenda. There is a strong case that Magpie Goose is an appropriate model system to explore a range of issues related to the conservation and management of wetlands and waterbirds, not just from a NT but also from a global perspective (Clancy *et al.* 2019). The ongoing release of survey data and related information in line with NT Government policies is an important resource for the research and education communities.

5 Scheduled Actions and performance measures

5.1 Performance Criteria and Actions

Performance criteria, key actions, actors and timelines for each of these actions are summarised in Table 9.

Table 9: Actions proposed across each of Management Program Objectives

Outcomes	Actions	Performance Measures	Action Officer	Partners	Timeline
Objective 1: To conserve and protect Magpie Goose in its natural habitat in the NT.					
Magpie Goose remains a protected species and its current (non-threatened) conservation status is maintained	Objective and transparent conservation assessment	Current and projected status as assessed against IUCN criteria is maintained	DENR	Birdlife Australia	Ongoing. Next due 2021
Species remains abundant across the Top End and population processes are maintained	Publically available distribution and abundance data regularly updated	Population maintained between historical upper and lower thresholds and range size maintained	DENR		Annual, July
Ensure anthropogenic impacts are appropriately managed: a) Aboriginal take	Aboriginal take assessed	a) Aboriginal take is consistent with long term use patterns	DENR	DTSC, NLC	TBD
b) Non-Aboriginal take	Maintain and implement recreational, commercial and damage mitigation offtake permits system	b) Non-Aboriginal offtake is regulated under permit with adequate compliance checking.	DTSC	DENR	Ongoing. Annual Compliance (April). Annual Inspections (TBD) and review of commercial offtake (July)

Outcomes	Actions	Performance Measures	Action Officer	Partners	Timeline
Objective 2: To promote sound management of identified areas of habitat to ensure the survival of populations.					
Spatial representation of high quality occupancy and nesting habitat available to management agencies and research community	Maintain maxent occupancy and nesting habitat models	Models with True Skill Statistic of >0.7; ROC > 0.8	DENR		Annual model updates and publication of spatial layers
Ramsar, Park Management Plans and Regional NRM strategies cognisant of Magpie Goose habitat, threats and management requirements	Desktop review of existing management plans/strategies	Explicit treatment of wetland habitat for maintenance and improvement of key breeding and feeding areas	DENR	DTSC, Parks Australia, Territory NRM	Ongoing
Landholders supportive of good management of wetland habitats including pest and weed management	Best practice water, weed and pest management information accessible to landholders	Area of habitat treated for pest and weeds relative to area impacted	DENR	Includes DTSC, TNRM	Ongoing
Hunting reserves managed to promote Magpie Goose habitat	Pest and Weed control	Area of habitat treated for pest and weeds relative to area impacted	TBD	Hunting Groups, DTSC, DENR	Ongoing
Objective 3: To ensure the sustainable use of Magpie Goose populations					
Offtakes from all sources kept within sustainable limits	Population survey	Population estimate of ≤ 20% precision for numbers and nests	DENR	DTSC, Parks Australia	Annual (April-May)
	Setting annual offtake	Total annual offtake 8.5% of population estimate	DENR	Hunting reference group	Annual (June)
	Monitor long term trends in numbers and offtake	Population maintained above 1 M	DENR	DTSC, Parks Australia	Annual

Outcomes	Actions	Performance Measures	Action Officer	Partners	Timeline
Equitable access to resource	Parameters established in this program	Sustainable harvests and community support	DENR	Hunting reference group	Established here, reviewed within 5 years
Hunting opportunities maintained or increased	Investigate opportunities for new hunting areas	Bag limits of 5-7 achieved in future years. New hunting areas	NTFC	Hunting reference group	Annual Hunting season set in Early July
Viable commercial industry	Assessment of future demand for resource	Industry growth to $1 M + within 5 years	DENR	DTSC, DBTI, Commercial stakeholders	Annual update of 5 year projections
Traditional hunting opportunities maintained or increased	Promote habitat management practices to protect significant feeding and breeding areas on Aboriginal land	TBD	DENR /NLC	TNRM, DTSC	
Social licence for sustainable use maintained	Demonstration of scientific basis of management. Promotion of ethical hunting. Assess livelihood and economic benefits of commercial industry to Territorians	TBD	DENR	DTSC	Ongoing
Objective 4: To minimise the economic loss by commercial fruit growers from goose impacts without adversely impacting the conservation of the species					
Reduction in conflict between Magpie Geese and Horticulturalists	Promulgation of best practice information to minimise adverse impacts of Magpie Geese	Reduction in destructive pest mitigation permits and in damage by Magpie Geese. Commercial and/or recreational take improving mitigation	DTSC /DPIR	CDU, Horticulture Australia, DENR	Ongoing

Outcomes	Actions	Performance Measures	Action Officer	Partners	Timeline
Improve efficiencies of mitigation efforts	Integrated pest management strategy for horticulturalists	Adoption of site specific management approaches	DPIR	DTSC, CDU, Horticulture Australia, DENR	TBD
New mitigation measures	Investigate cost benefit analysis of netting and other non-destructive mitigation measures	Cost effective and practical solutions	TBD	DTSC, CDU, Horticulture Australia. DENR	TBD
Objective 5: To provide ongoing refinement of Magpie Goose management through timely evaluation of management prescriptions and performance					
Continued or improved stakeholder support	Annual assessment of relevant performance measure	% of performance measures met	DENR		Annual
Continued or improved stakeholder support	Program Review against all outcomes and performance measures	Achievement of objectives and outcomes	DENR		In 5 years
Best practice management program	Program Revision based on 5.2	New program as required	DENR		In 5 years (if required)

5.2 Review and revision

The actions and performance criteria outlined in this program will be monitored annually to ensure compliance. As outlined in the Action plan (Table 9) there will be a formal review in the fifth year of operations informed by annual monitoring outcomes and ongoing stakeholder input.

6 Management Program Activity Implementation

6.1 Communication and Consultation

DENR will develop a specific communication strategy in 2020 reflecting all the activities outlined above and undated annually. Regular consultation with formal meetings of the hunting stakeholder reference group will be held on a 3 monthly basis.

6.2 Monitoring

Standard aerial surveys will be continued annually unless research provides improved and validated techniques (with a net improvement in precision and/or accuracy or significant cost savings).

The current approach of collection of hunting effort data based on voluntary returns from licenced hunters will be revisited in consultation with key hunting stakeholders to examine opportunities to improve ongoing data collection in a cost effective manner.

Compulsory return information from commercial and damage mitigation permits will continue with compliance a requirement for ongoing permitting.

Assessment of anthropogenic take and comprehensive population and habitat monitoring as outlined in this program will ensure that the Magpie Goose will remain an NT icon into the future. In keeping with the significant public interest in the species and the Government's Open Data policies, it is proposed to continue to make the results of annual monitoring programs publicly available, including the publication of underlying data and metadata as a resource for education and research communities.

6.3 Harvest Permitting

The existing permitting process as administered by DTSC will continue across the duration of the management program, subject to any future machinery of government changes.

6.4 Research and Development

The impact of recreational and other takes on population dynamics involves a level of uncertainty due to a combination of environmental variation, the inherent variability of the dynamics of the species and in the precision and accuracy of estimates of parameters used (e.g. level of Aboriginal take). To deal with this uncertainty, a balanced approach was used in line with best available data and best practice approaches. Notwithstanding this uncertainty, it is expected that the approach documented could be applied for at

least the next 10 years without adversely impacting the viability of Magpie Goose populations in the Top End.

Analyses of the relationship between nesting habitat of Magpie Geese and Feral Pig and Buffalo numbers highlight the need for further research to better understand the impacts of these species, likely requiring direct manipulation of Feral Pig and Buffalo densities.

New mitigation measures are required to reduce economic damage caused by Magpie Goose to horticultural industries. The outcomes of the CDU research program on the mitigation of damage to mango farms should be built on. The cost/benefit analysis and incentivisation of netting may have potential to reduce long-term impacts of a range of native animal species and have ancillary benefits in production (shade, water savings etc.) and should be pursued as funding opportunities arise.

7 Issues for further discussion

This consultation draft represents an amalgamation of both a long history of implementation of management programs for the Magpie Goose and ongoing consultation with major stakeholder groups. Nevertheless, a range of issues have been highlighted that require input from the broader community and potentially more data gathering to address some key knowledge gaps (Box 4). Feedback from hunting stakeholders in recent times, especially in the context of the decision to put in place a very restrictive season in 2016 in response to the lowest recorded population level ever recorded for Magpie Geese, has centred on two major issues. Firstly, related to the level of consultation with the community about the decision, and secondly, the desire for much greater certainty about the decision process for significant issues that impact on hunting, including bag limits.

Further consultation is required to ensure all stakeholder groups have the opportunity to contribute to this Management Program prior to its finalisation. The following questions will be considered, among others, as part of this process:

- Is the overall approach to determine harvest limits appropriate?
- Once a sustainable offtake is established, how should this be allocated across the different use categories including traditional, recreational, commercial and pest mitigation?
- Is there merit in increasing season length on private land from that of the hunting reserves to increase flexibility of landholders to use recreational hunters as part of their integrated pest management approach?
- Is a large commercial harvest appropriate for this species?
- How can better data be collected on recreational hunting without requiring either an undue burden on government resources or being too onerous for hunters?
- Are there opportunities to improve feeding and nesting habitat for the species that can enhance population viability?

A key issue for waterfowl hunters is pressure on the hunting reserves with Park system in Top End at capacity. Opportunities on private, pastoral or Aboriginal Land maybe arise and options to increase the number of accessible hunting areas needs to be explored. Ancillary issues of improving the opportunity for hunting to play a more direct role in the reduction of feral animal impacts is also worth further discussion.

Whilst not explicitly covered in this management program, it is noted that the establishment of an open season for other waterfowl is closely tied to the management of the Magpie Goose recreational hunting

season. It is proposed the same season lengths apply to such permitted hunting to facilitate the management of hunting reserves, the necessary compliance and monitoring requirements and to maintain the low impact such hunting has on permitted species. Any decoupling of the duck hunting season from that for Magpie Geese would require the development of a detailed management plan for those duck species.

Once public comment to this exposure draft has been considered, the management program will be revised and formulated as a final program that will then be submitted for approval by the Administrator in accordance with Section 34 of the TPWC Act.

Box 4 Key Management Issues:

1. What are appropriate sustainable harvest limits?

A key request from the hunting community was for more certainty in establishment of annual season parameters including bag limit. The information available suggests that, whilst the risk of overharvest is relatively small there are nonetheless situations where a high harvest may impinge on population processes. The species population and harvest models establish thresholds for harvest directly linked with the preceding population estimate as assessed by aerial survey, and agreed thresholds should deliver certainty.

2. How should the harvest be allocated amongst the use cases?

The take by Aboriginal traditional owners is an established right. Once this is allowed for, there is discretion on the allocation of any allowable offtake amongst other users (recreational, commercial, pest mitigation) as well as potential synergies (e.g. commercial take and pest mitigation approaches).

3. What data should be collected to inform review and revision of future management plans?

Annual population monitoring is central to this management program. Whilst the current approach reflects best practice, emerging technologies may provide for future improvements. Also, understanding of specific harvest impacts (notably Aboriginal and recreational) is limited by the quality of data available on annual offtakes.

4. A key issue for recreational hunters is access to hunting areas; how can more land be made available to meet growing demand?

Hunter numbers have been steadily growing in recent years putting more pressure on hunting reserves. What are the impediments to accessing private land and can these be reduced?

5. How can the key knowledge gaps identified in this plan be addressed and what that should be focussed on during the next 5 years?

A range of important research gaps are identified in this plan including the need for better ways to reduce impacts of Magpie Geese on horticulturalists. Further input is sought as to whether this list is comprehensive, how these gaps could be best addressed and potential funding opportunities, as well as which are the highest priorities to improve the long-term sustainability and economic benefits arising from use of the species.

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