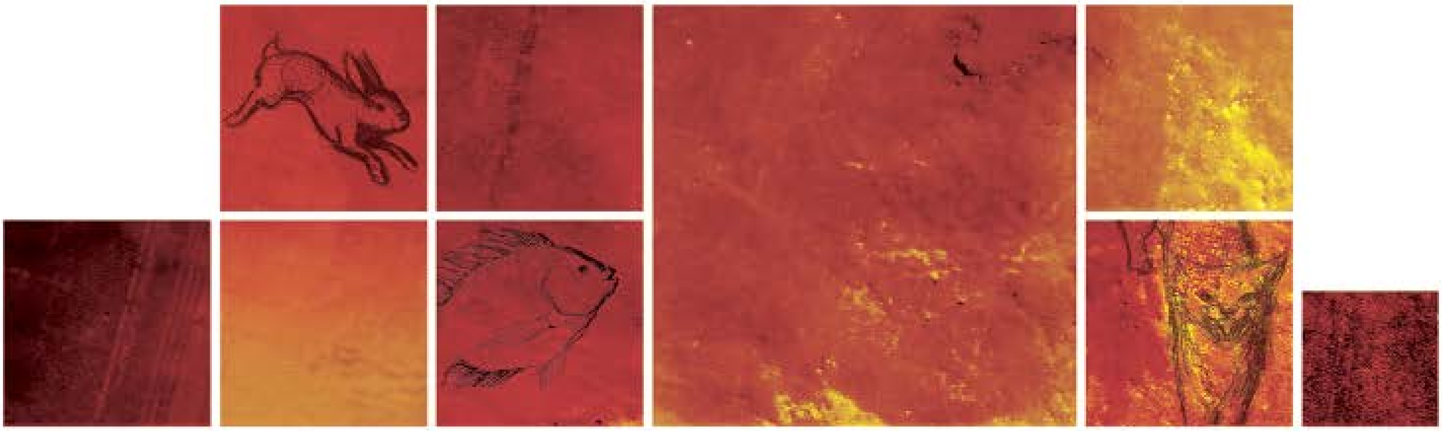

PESTSMART

CENTRE FOR INVASIVE SPECIES SOLUTIONS

Peri-urban wild dogs in north-eastern Australia

Ecology, Impacts and Management

Matthew Gentle, Benjamin L. Allen, James Speed

Queensland Government

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Front cover photo: James Speed

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Introduction

Wild dog impacts are increasingly being felt by agricultural producers and residents of towns and suburbs throughout the more populated areas of eastern Australia. Wild dogs in these areas can have substantial impacts on residential communities, fragmented conservation estates and a number of primary industries including grazing, dairy and intensive livestock industries. In various forums, local governments throughout Australia have consistently identified the need to improve our understanding of wild dog ecology and develop control tools and strategies for managing peri-urban wild dogs. State and local governments need this information to assist in planning and coordinating control activities and develop extension materials. Peri-urban wild dog management is often contentious and difficult to implement given the presence of a variety of stakeholders with wide-ranging and often conflicting ideologies. This conflict is compounded by a general lack of understanding about wild dog ecology and the effectiveness of management techniques in these environments.

There has been a critical need to assess the nature, impacts and origins of wild dog problems and provide a knowledge base from which to manage wild dogs in peri-urban environments. This project was initiated to improve management through understanding the ecology and impacts of peri-urban wild dogs, with a view to developing best practice management strategies and guidelines for implementing control in peri-urban areas. This report summarises the research findings and outputs from this project, and provides recommendations for future work.

Summary of research findings

Diet

Feeding and food selection are key ecological processes. Knowledge of the resource requirements of peri-urban wild dogs assist pest managers in developing suitable management approaches. Dietary study can also identify instances where livestock and native prey are likely to be under predation pressure from peri-urban wild dogs, and to determine the importance of anthropogenic food that may attract and support wild dogs in peri-urban areas.

We identified dietary items in scats of wild dogs in peri-urban areas of north and south-eastern Queensland, and compared diet between regions. We identified over 40 different food items in wild dog scats, from invertebrates to cattle, but most were native mammals. Agile wallabies (*Macropus agilis*), swamp wallabies (*Wallabia bicolour*), northern brown bandicoots (*Isodon macrourus*) and rats (*Rattus* spp.) were the primary prey in peri-urban areas. The occurrence of birds and invertebrates in scats varied widely with location. Dietary overlap was typically very high between regions, indicating that peri-urban wild dogs generally consumed the same types or sizes of prey in different areas. Importantly, human-sourced foods occurred infrequently in scats. This suggests that peri-urban wild dogs do not appear to be reliant upon human-sourced foods, and limiting access to these foods is unlikely to influence wild dog populations.

Sampling may have inadvertently excluded some wild dog scats that appeared to be from domestic dogs, given their proximity to areas of high human use (e.g. near mailbox, sporting field). Additionally, the typical high digestibility of human-sourced foods would reduce the ability to detect these items in scats. As a result, we conducted additional dietary analysis using stomachs (n=170) from wild dogs (Harriott et al. unpublished data). These results, reassuringly, support the scat analysis, and confirm that wild dogs in peri-urban areas consume a wide variety of prey items, again largely dependent on small to medium-sized mammals (e.g. macropods, bandicoots, possums and rats). Importantly, the results also support the finding that peri-urban wild dogs are not reliant on human-sourced foods, and management strategies focussing on limiting access to food are unlikely to substantially influence wild dog populations. Lastly, the presence of iconic and threatened wildlife species (e.g. koalas, *Phascolartos cinereus*) recorded in both scat and stomach dietary studies is concerning, and indicates potential for deleterious impacts in the peri-urban areas where local populations are threatened and restricted to bushland fragments. These dietary data support necropsy and forensic genetic analysis (see Genetics section) that wild dog predation is a significant cause of koala mortality in this region.

The stomach contents analysis also facilitated investigation of the influence of diet on disease and pathogen presence (Harriott et al. unpublished data).

Movement ecology

Predators around the world are becoming increasingly intertwined with humans, sometimes causing conflict and increasing health and safety risks in urban areas. Wild dogs are common in many urban areas across Australia, and cause a variety of impacts (see below). Knowledge of the ranging behaviour wild dogs is essiential for managing those impacts, although little research effort has been directed towards understanding this important part of their ecology.

We captured, GPS-collared and released 37 wild dogs, which were each monitored at 30 min intervals for 11–394 days. Individual activity patterns varied, but most dingoes were nocturnal, with an overall mean home range size of 17.47 km^2. However, some home ranges were less than 1 km^2 in size. Home ranges appeared to be constrained to patches of suitable vegetation fragments within and around human habitation. Mean daily travel distance was 6.86 km/day, and at all times wild dogs were within 1,000 m of houses and other buildings. We detected den sites on several occasions, all of which were characterised by large hollow logs in fragments of relatively open woodland habitat rarely disturbed or visited by humans. Despite this, wild dogs occupied a wide variety of habitat types – grassland, rainforest, open woodland, agricultural lands (crops), tropical savannah, highly disturbed areas (i.e. road verges), and built-up areas.

These results suggest that ‘open space’ within the national distribution of wild dogs should not be considered free of wild dogs without first undertaking a proper assessment of their presence or absence. That wild dogs exhibit such flexible and adaptable movement behaviours and habitat requirements over a broad range of land tenures also highlights the great difficulty of using management strategies intended to target whole populations of wild dogs. In contrast, these data suggest that urban wild dog management strategies should focus on mitigation of impacts at the individual or group level, and not population-level reductions in numbers.

Genetics

Improved knowledge of the genetics of wild dogs can assist in determining management priorities, such as determining and targeting source populations, in peri-urban areas. We studied the genetics of wild dogs from peri-urban and more regional areas in north-eastern Australia to determine the degree of hybridisation of dog populations and ultimately aimed to determine the genetic similarities between populations in defined geographic areas. Tissue or hair samples from free-ranging dogs captured through control and research programs were collected, and DNA extracted. Seventeen microsatellite loci were examined. Each sample was classified as domestic dog, pure dingo, probable dingo, or hybrid through comparison of allelic data to known dingo/domestic dog reference samples. Total (pooled) results from all regions show that hybrid wild dogs dominate and less than 36% were of dingo/probable dingo ancestry. Very few (~1%) were domestic dogs, and dingo genetics dominate in hybrid wild dog samples. This suggests that efforts to confine domestic dogs as a strategy to ‘reduce the source’ of wild dog populations would be ineffective. Spatial and regional differences in dingo hybridisation also suggest a trend of increased hybridisation with increased urbanisation. We identified nine genetically-distinct geographic groups of wild dogs that offer potential for delimiting management units. The geographic extent of such groups may be discreet, but the scale remains sufficiently large to limit effective management in peri-urban areas. Our study has also demonstrated novel applications of genetics, providing evidence that free-ranging wild dogs, and not domestic dogs, were responsible for attacking multiple koalas in a region of north Brisbane. Genetic sampling could be used by pest managers to identify and target the individual animals responsible for impacts (and not the wider population), and verify the successful removal of the individual animals responsible. Collectively, our approach demonstrates that genetic methods can yield valuable information to help to refine wild dog management, and should be considered as a monitoring tool.

Breeding biology and seasonality

A common perception is that 'wild dogs breed like domestic dogs' given the introgression of domestic dog genes into the predominantly hybrid, peri-urban wild dog population (Gentle et al. 2016a). Hybridisation between animals that breed once annually (e.g. dingoes) with those that breed twice annually (e.g. domestic dogs) may produce offspring that breed either once or twice annually. There is some conjecture about the breeding ecology of peri-urban wild dogs, with particular concern for increased breeding capacity and its implications on population growth and ultimately, impacts and management. The effects of hybridisation on breeding remains poorly studied, and there are little data from peri-urban wild dogs. We investigated the breeding seasonality of female dingo-dog hybrids in south-east Queensland by evaluating macroscopic and histological features of 71 female reproductive tracts (uteri and ovaries).

Most animals trapped in summer were pups less than 6 months of age, supporting a dingo-like breeding seasonality in hybrids. Maximum uterus diameter and weight coincided with the presence of a *corpus luteum* (CL) in winter, and most recent placental sites were also observed during this period. The follicular phase was characterised by growing follicles, around 1–3 mm wide, in late summer and autumn. Only two of the animals (~1.4%) showed out-of-season reproductive cycles: one was found with a CL in summer and another in autumn. We describe, for the first time, the presence of multi-oocyte follicles in dingo-dog hybrids. The presence of placental sites and CL in some younger dingo-hybrids demonstrates that a proportion may breed before 12 months of age. Early oestrus may be inherited from domestic dogs, although a small proportion of dingoes may also breed in their first year, and in both cases are likely aided by favourable resource conditions.

Pre-natal assessment provided estimates of mean litter size (7.2 ± 2.04) that is greater than that reported previously for dingoes (4–6 pups), using similar methods. While this suggests increased fecundity and rates of population growth, mortality and environmental factors may still constrain actual population growth to levels similar to those experienced by dingoes.

Photo taken by T Lacava

Hybridisation may provide some reproductive advantages to dingoes through the presence of multi-oocyte follicles (i.e. improved quality and fertilizable oocytes) and increased litter sizes, but it is probably unlikely to produce any meaningful changes to population growth. To investigate this issue further, we recommend that future studies seek to understand the mechanisms and causes driving population growth rates of dingoes and dingo-dog hybrids. Our findings clearly indicate that hybrid wild dogs have a single annual breeding season and exhibit the same seasonality of the breeding period as dingoes. Breeding patterns in female dingo-dog hybrids are more similar to dingoes than domestic dogs, and are also similar to those found in the closely-related New Guinea Singing Dogs. Similarities in breeding probably reflect the dominance of dingo, rather than domestic dog genetics in hybrid wild dogs coupled with environmental constraints. Proposed consequences of increasing hybridisation have yet to be realised, but should be considered in future studies.

The breeding biology and seasonality component of the peri-urban wild dog project formed part of a postgraduate study undertaken by Marina Cursino at the University of Queensland.

Diseases and pathogens

Canines are known to harbour a variety of pathogens, some of which present as a public health concern, and some that cause disease within livestock or other domestic species. However, the significance of infection in domestic canines often is reduced by the use of broad-scale anthelmintic therapy and the requirement of owners to remove any faeces left by their dog in public use areas. As a result, contamination of the environment with pathogens by animals is most likely to be by untreated wild populations. Despite this, there are large gaps in our knowledge regarding the role that peri-urban wild dogs play in harbouring zoonotic pathogens.

To establish the current status of key zoonotic and economically-significant pathogens in peri-urban wild dogs, a cross-sectional investigation into a broad range of macroparasitic and bacterial pathogens was conducted. A total of 201 peri-urban wild dogs from south-east Queensland and northern New South Wales (see Figure 1) were trapped and tested using microbiological and molecular methods. Helminth parasites were the most common and detected within 79.6% of peri-urban wild dogs. *Echinococcus granulosus* was present within

50.7 ± 6.9 % of dogs. Worm burdens of *E. granulosus* ranged from 40 up to 85,950 worms with the total adult worm burden from all species carried by infected wild dogs being 998,856 worms. *Spirometra erinacei* was the second most commonly detected pathogen (36.6 ± 6.4 %) followed by: hookworms (28.8 ± 7.1 %); *Toxocara canis* (5.4 ± 3.1%); and *Taenia* spp (4.5 ± 2.8 %). Bacterial pathogens were much less common. Those detected included: methicillin resistant *Escherichia coli* (20 ± 10.1 %); *Salmonella* spp (3.7% ± 3.7 %); and methicillin sensitive *Staphylococcus aureus* (3.3 ± 2.7 %). However, there are limitations to the bacterial results due to the difficulty of collecting samples in the field and possible sample degradation. The results of this survey clearly show that peri-urban wild dogs harbour a range of parasitic and bacterial pathogens of significance to public and livestock health.

This study provides essential baseline data into the presence of pathogens in peri-urban wild dog populations in north-eastern Australia. This information can be used to identify and refine further research into significant pathogens. It also enables comparison with future recording of the status of pathogens in peri-urban wild dogs. Prevalence of pathogens is essential to inform the management of wild dog impacts in peri-urban areas. To help minmise the risks of pathogen transmission, we recommend the development of a best-practice guide to highlight the practices and personal protective equipment required by people who have any indirect or direct contact with wild dogs.

The diseases and pathogens component of the peri-urban wild dog project formed part of a postgraduate study undertaken by Lana Harriott at the University of Queensland.

Photo taken by Lee Allen

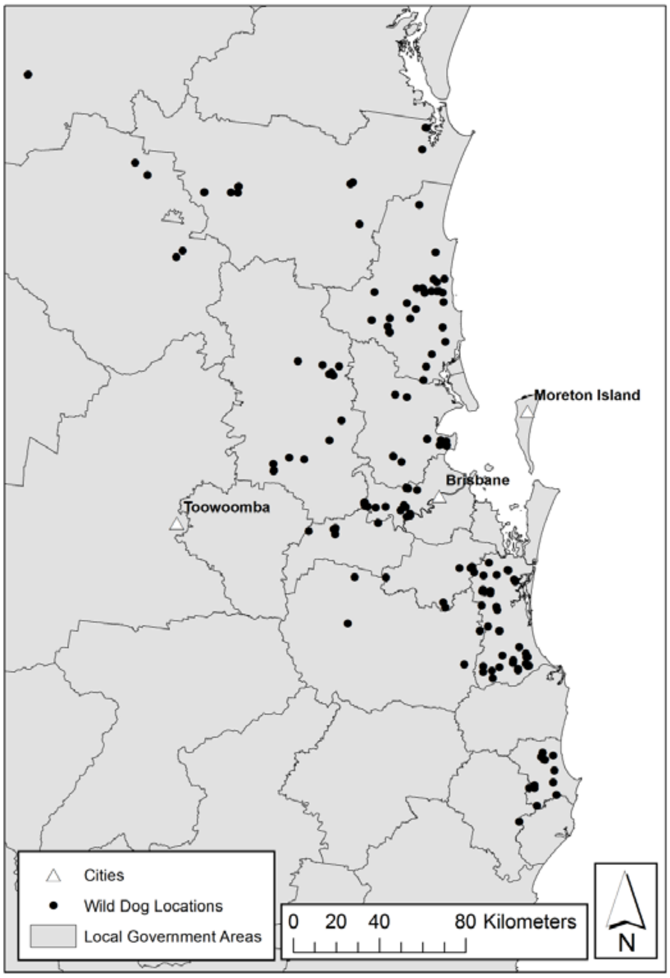

Figure 1. Locations of 201 peri-urban wild dogs captured during routine management programs and used for disease study. (Source: L. Harriott)

Management practices – PAPP baits

The recent registration of commercially-manufactured wild dog baits (Dogabait®) containing para-aminopropiophenone (PAPP) offers an exciting development for the humane, effective and safe control of wild dogs, particularly in peri-urban areas. However, little is known about the longevity of PAPP baits in the environment. Usage strategies must consider the longevity of baits to determine effective periods of toxicity to the target animal, and also recommend withholding periods for non-target animals (e.g. domestic dogs). We conducted a bait degradation trial at Nambour, Queensland between autumn and spring 2015, which is the time-of-year when wild dog control is typically undertaken. This is the first study of PAPP degradation in Dogabait® wild dog baits. Baits were placed in cages (50 mm netting) within a fenced (1200 mm high) area to prevent access and removal by mammals and birds. At eight sampling periods over 25 weeks, baits were removed from each treatment (buried, surface or storage) and frozen before being sent for chemistry analysis. Analysis of stored baits showed that Dogabait® are shelf-stable, containing ~90% of the original PAPP dose at 25 weeks. Buried Dogabait® baits degrade faster than surface-laid baits, although both treatments can remain toxic to dogs for several months, even after considerable rainfall. Our results suggest that domestic or working dogs should be suitably restrained or excluded from baited areas for extended periods to minimise the risk of accidental poisoning. The period of persistence of PAPP baits may provide opportunities to improve the duration or longer-term efficacy of wild dog baiting campaigns, but care is needed to protect domestic and working dogs and ensure responsible and safe use.

Management practices – Ejectors

Wild dogs and foxes are routinely targeted for lethal control by local government agencies in attempts to mitigate human-wildlife conflicts. Canid pest ejectors (CPEs) have been shown to be effective for wild canids, and offer great advantages over other lethal control techniques in peri-urban areas. Advantages include target specificity and their inability to moved or cached by animals. However, CPEs are also likely to be activated by domestic dogs, creating negative social impacts that may undermine wild dog control programs. This project component deployed non-toxic CPEs in peri-urban areas to 1) investigate whether interference by domestic dogs and people in peri-urban areas is likely to be problematic at an operational scale; and 2) collect ancillary information to help define appropriate usage guidelines (e.g. lure type, placement, timing).

CPEs were tested at two sites, one in south-east Queensland and one in northern New South Wales. Sites contained a mixture of privately- and publicly-managed lands, and were representative of lands where wild dog management is undertaken (and required). Between the two sites, we deployed non-toxic ejectors for over 65,000 ejector nights, with 24 monitoring cameras used across the two sites. Results indicate that CPEs are target specific to dogs and foxes, with wildlife species usually showing interest, but little activity at ejector sites. The trigger rate for ejectors at the Tweed coast was 15% and 39% at the Sunshine Coast; the higher trigger rate at the latter is likely due to the higher activity of foxes at this site. Salami and kangaroo meat lures appeared to be more attractive (38% and 35% trigger rates respectively) than ground liver and other dried meat-based attractants (18% trigger rate average for the remainder tested).

The visitation by canids per week following deployment was examined to investigate the relative attractiveness of ejectors over time. Although visits by foxes and wild dogs were recorded up to eight and nine weeks following deployment (respectively), most visits occurred within the first week. Approximately 60% of visits by foxes and wild dogs occurred within two weeks following deployment, and 77% within 3 weeks, suggesting this may be an optimal period for ejector servicing. Observations suggest two-three weeks may be the optimal period for lure longevity, particularly under coastal (e.g. wet, warm, humid) field conditions.

Photo supplied by James Speed

Domestic dogs (and people) did locate and trigger CPEs, although the level of interference by people was extremely low. People seemed not to “find” or “notice” CPEs (only 1.6 % of photos of people near ejectors were showing interest in the ejector) but the attention of domestic dogs, on cameras, appeared to assist in detecting ejectors. Paradoxically, some ejectors were removed by people on public lands, but CPEs deployed on private lands had no interference from domestic pets and people.

It is recommended that longer-term deployment should be on private lands, or public lands closed to the public with very low public traffic, to avoid deleterious interactions with domestic pets and people. Data from the other project components could also be further analysed to help predict periods of high human activity on public lands, to avoid periods of ejector use.

Impacts

Public reports

We assessed the impacts of peri-urban dogs through collation and categorisation of media and local government reports. Media reports helped demonstrate the scale and type of impacts from wild dogs, including perceived benefits. Media reports can provide a biased assessment, and thus local government records were used as an alternative quantification of impacts. Sightings and impacts reported to local governments between 2000 and 2015 were collated and categorized from seven local governments in eastern Queensland (n= 2,115). Impacts were initially categorised into the lowest possible damage category, before being grouped to higher-order categories. Across all areas, economic impacts were the dominant category (41%), with social/psychological (26%), other (26%), and environmental impacts (7%) also reported, although there was geographic and temporal variation.

Economic impacts were dominated by reports or threats of (perceived) attacks to livestock, including sheep and lambs, cattle and calves, goats and poultry. Stock (including poultry, cattle and calves, sheep and lambs) were the most common animal group attacked (77.4%).

After removing unidentified stock (unknown), poultry accounted for almost half (49%) of the stock animals attacked. Calves and adult cattle (22.1%) were attacked in similar numbers to sheep and lambs (19.5%). Native species represented 6.3% of animals attacked, and included scrub turkeys and other birds, possums, and reptiles, but macropods (kangaroos and wallabies) were the most common. Pet animals comprised ~15% of the animals attacked, with domestic dogs (~85%) and cats (~15%) dominating.

Across six local government areas in south-east Queensland (pooled), the reports of stock attacks steadily increased between 2011 and 2014 (peaking at 116 reports in 2014), and declined (to 77) in 2015. Trends in the number of stock attacked over time were similar, but declined to pre-2011 levels by 2015. Pet attacks were less common, and fewer animals were attacked per report compared to stock attacks. Pet attacks peaked in 2013 (41 reports), but generally fluctuated little between 2011 and 2015. Trends towards increased attacks were apparent during autumn and spring, but generally pet attacks fluctuated little during the year. Peaks in stock attacks during May (autumn) and October (spring) are apparent.

Wild dog attacks and injury to humans were recorded, but appear to be rare. Such attacks were also reported to four local governments (Brisbane, Somerset, Gold Coast and Townsville). There were five reports of people being attacked by wild dogs, but only scant details from each incident were recorded. One report records an encounter between a male person and four adult dingoes reportedly defending a den site; another mentions a male person being bitten on his back. Although lacking in detail, the reports indicate that direct interactions between wild dogs and humans do occur, and threatening behaviour and physical injuries to people can result.

Despite the widespread reporting of impacts, there is some support for the continued presence of wild dogs/dingoes within communities. Collectively, these results support the ongoing need to manage the pervasive and varied impacts of wild dogs whilst ensuring that any control strategies remain sympathetic to community concerns.

Wildlife predation case study

The recent construction of railway infrastructure in northern Brisbane suburbs (Petrie to Redcliffe), south-eastern Queensland, intersects the threatened Pine Rivers koala (*Phascolarctos cinereus*) population. Wild dogs are also known residents of the area (McNeill et al. 2016), and the proximity to urban areas suggest that roaming domestic dogs may also be present. Intensive koala monitoring in the area suggested heavy predation by canids. Canid predations are usually categorised from physical evidence at necropsy, characteristics of the kill or kill locations, but it can be difficult to correctly identify the predators.

We used a range of genetic techniques to show that free-ranging wild dogs
(or what lay people would call ‘dingoes’), and not domestic dogs, were responsible for attacking and killing the koalas we sampled. These results verify the assessment of the veterinary examinations on the sampled koalas, and support the identification of wild dogs as a major cause of koala deaths in this area (41.2% of overall mortality to 30 June 2016). Predation by wild dogs can be considered a key threat to koala populations in this region and elsewhere. Our approach demonstrates that genetic methods can yield additional valuable information on the impacts of wild dogs that can help refine wild dog management. Through genetic sampling of both predator and prey, pest managers could target the actual animals responsible for impacts, rather than simply attempting broader-scale reductions of population size.

Photo supplied by Currumbin Wildlife Sanctuary

Research Findings – a quick guide

Research area	Methods	Key findings	References
Diet	Scat collection, stomach collection	Small to medium-sized native mammals dominate diet Some threatened species (e.g. koalas) consumed Human-sourced foods uncommon, and limiting access to these foods is unlikely to influence the size or distribution of wild dog populations	Allen, et al. 2016 https://doi.org/10.1038/srep23028 Harriott unpublished data
Movement ecology	GPS collaring	Wild dogs exploit a wide variety of habitat types Home range sizes are relatively small, and can occupy unusual fragments of land (e.g. road verges only) Wild dogs can be active at all times of day, but are most active at night Wild dogs live within 1000 m of residential areas at all times	Allen, et al. 2013 https://doi.org/10.1016/j.landurbplan.2013.07.008 McNeill, et al. 2016 https://doi.org/10.3390/ani6080048
Genetics	Tissue sampling, 3Q Score, cluster analysis	Hybrid wild dogs dominate peri-urban wild dog populations; very few (~1%) domestic dogs Dingo genetics dominate in hybrid wild dogs Confinement of domestic dogs to 'reduce the source' of wild dog populations would be ineffective Wild dog populations comprise genetically-distinct groups of wild dogs that offer potential for delimiting management units	Gentle, et al. 2016a Gentle, et al. 2017b http://www.pestsmart.org.au/wp-content/uploads/2017/05/AVPC-Handbook-on-line-version-FINAL-2017.pdf
Breeding biology and seasonality	Female reproductive tract	Hybrid wild dogs breed like dingoes - once per year, same seasonal breeding period	Cursino, et al. 2017 https://doi.org/10.1071/ZO17005

	examination	Pre-natal litter size appears greater than dingoes, but more study needed to determine implications for population growth rates Similarities to dingo breeding probably reflect predominance of dingo genes and environmental constraints	
Diseases and pathogens	Necropsy, faecal floats, PCR	Peri-urban wild dogs carry serious diseases, and likely pose a significant risk to public and livestock health Helminth parasites were most common (79.6% of wild dogs), especially *Echinococcus granulosus* (50.7%) and *Spirometra erinacei* (36.6%)	Harriott et al. 2016 Harriott submitted
Management practices – PAPP baits	Field degradation trial of PAPP wild dog baits	Slow rate of environmental degradation for PAPP (vs 1080) Buried baits degrade faster than surface-laid baits Lethal doses for domestic and wild dogs persist for several months Extended witholding periods recommended to avoid domestic dog poisoning	Gentle, et al. 2016b Gentle, et al. 2017a https://doi.org/10.1007/s11356-017-8668-3
Management practices - Ejectors	Camera monitoring of field-deployed ejectors	Non-toxic CPEs in coastal peri-urban sites were regularly visited and triggered by wild dogs, foxes and domestic dogs People did find and occasionally trigger CPEs on public lands CPEs placed on private land had no interference or interactions with people or domestic dogs	Speed et al. unpublished data
Impacts	Local government and media records Forensic examination of prey remains	Varied and widespread damage reported. Attacks to livestock, pets, wildlife common, but rarely people. Dingoes/hybrid wild dogs (not domestic dogs) were responsible for attacking koalas in peri-urban north Brisbane. Predation at sufficient levels to threaten localised koala populations.	Gentle et al. unpublished data

Recommendations

Overall, this project has highlighted that wild dogs are common residents in peri-urban areas in northern Australia and can be responsible for wide-ranging impacts. Management is constrained in peri-urban areas where it is difficult to apply control strategies at scales suitable for reducing wild dog populations. Additional new tools (e.g. PAPP bait, canid pest ejectors) have perceived benefits (humaneness, antidote, target specificity) that may improve adoption and acceptability of wild dog control in peri-urban areas. However, these have similar restrictions to existing techniques, limiting the application as per current guidelines. Control objectives may need to focus more on specific individuals, groups or impacts to ensure wild dogs responsible for impacts are targeted and impacts are reduced.

Specific recommendations for testing and incorporating management strategies into peri-urban areas include:

- Test efficacy of 'point of impact' strategy vs 'limiting the source' strategy. Includes focusing on new and existing control tools at the point of impact, such as private backyards, rather than perceived source areas, such as large forested tracts. Also includes desktop evaluation of costs-benefits and decision support tools for local governments. Use social science research to investigate potential for reduced complaints to council following 'point of impact' approaches.

- Testing the feasibility of localised eradications of wild dogs in key fragments. Includes demonstrating that small populations (i.e. packs) of wild dogs can be permanently eradicated from suitable fragments of peri-urban bushland (e.g. Townsville, Castle Hill or Hays Inlet, Brisbane etc). Some of these areas are known 'trouble spots' for impacts on people, pets and wildlife. Potentially requires experimental use of PAPP, ejectors, and/or fumigants in built-up areas.

- The broadscale application of ejectors in suitable peri-urban environments should be tested. Suitable environments could include areas of the Brisbane Valley, and Ipswich, Lockyer Valley or Somerset local government areas. Manipulative experiments could be tested on a 'valley scale' to compare impacts (or wild dog activity) in valleys with high ejector coverage, vs valleys with conventional control (e.g. local government co-ordinated control) vs no dog control. Information on the costs of each strategy should also be recorded.

- Assess the allocation of control effort on the basis of genetic population boundaries (identified from gene flow analysis). Where research has highlighted distinct populations, local dog control should not be compromised by reinvasion from surrounding management units. This needs to be tested. The application of management strategies/control tools within management units should determine the costs, benefits (short and longer-term) and feasibility of managing dogs within a management unit structure. Initial feasibility must consider the size (area) of the genetic population, and the ability to apply sufficient control to the entire population, which may be problematic in peri-urban areas.

- The collation of both media reports and local government records is a useful first step to quantify the range and type of impacts from wild dogs. We recommend further analyses of the current dataset, and continued collation of records from local governments to determine any spatial relationships, and trends over time, in wild dog incidents. We recommend continued monitoring of trends in wild dog impacts through the collation and analysis of local government records to help evaluate wild dog control programs. Reports from local governments/authorities are considered a more accurate and therefore, more appropriate source of data than media records to quantify and monitor trends in wild dog impacts.

- The genetic study showed great promise for developing target-specific strategies and also providing feedback on success of such strategies. Confirming the dominant role of wild dogs in predation events (rather than domestic dogs) suggests that management should focus on strategies to reduce wild dog impacts, rather than free-ranging domestic dogs. Genetic sampling of both predator and prey could be used to identify and verify the successful removal of the animals responsible for attacks. In some situations, targeting individual problem animals may be more fruitful than broad-scale population reductions.

- Continue to collaborate and support social science researchers to thoroughly investigate the drivers and barriers to managing the impacts of wild dogs in peri-urban areas. While strategies and techniques may be ecologically and technically sound, implementation and acceptability of control techniques by landholders and the public is crucial to the successful use of these techniques. The suggested techniques above need to be reviewed as part of a framework that identifies strategies from a biological, technical and social perspective. While we have a greater understanding of the biological and technical difficulties, and strategies to overcome these, the response of landholders to such strategies needs to be thoroughly investigated.

- A manipulative experiment should be undertaken to determine the benefits of the communication strategies identified from the above (and other, ongoing research in this field). This could be undertaken through applying different communication treatments (optimal identified strategy, current strategy, or *ad hoc*/no strategy) to different local government areas, and comparing the attitudinal/behavioural change prior to and following communication. This needs to be completed collaboratively with local governments, state agencies and tertiary research institutions.

- We recommend the development of a best-practice guide to highlight the strategies, practices and personal protective equipment required to minimise the risks of pathogen transmission to people, livestock and pets.

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Additional publications

Additional publications associated with the project:

Allen, B.L. (2013) The ecological roles of dingoes. Far North Queensland Pest Advisory Forum, Mareeba.

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