Pre-reading for Councillor Workshop

Summary of current research regarding dingo genetics, ecology, management and legislation

Wild dog and/or dingo management and control is a highly complex issue. Councillors are strongly encouraged to read this information summary prior to the Councillor Workshop on 1 June, to enable full participation in the workshop.

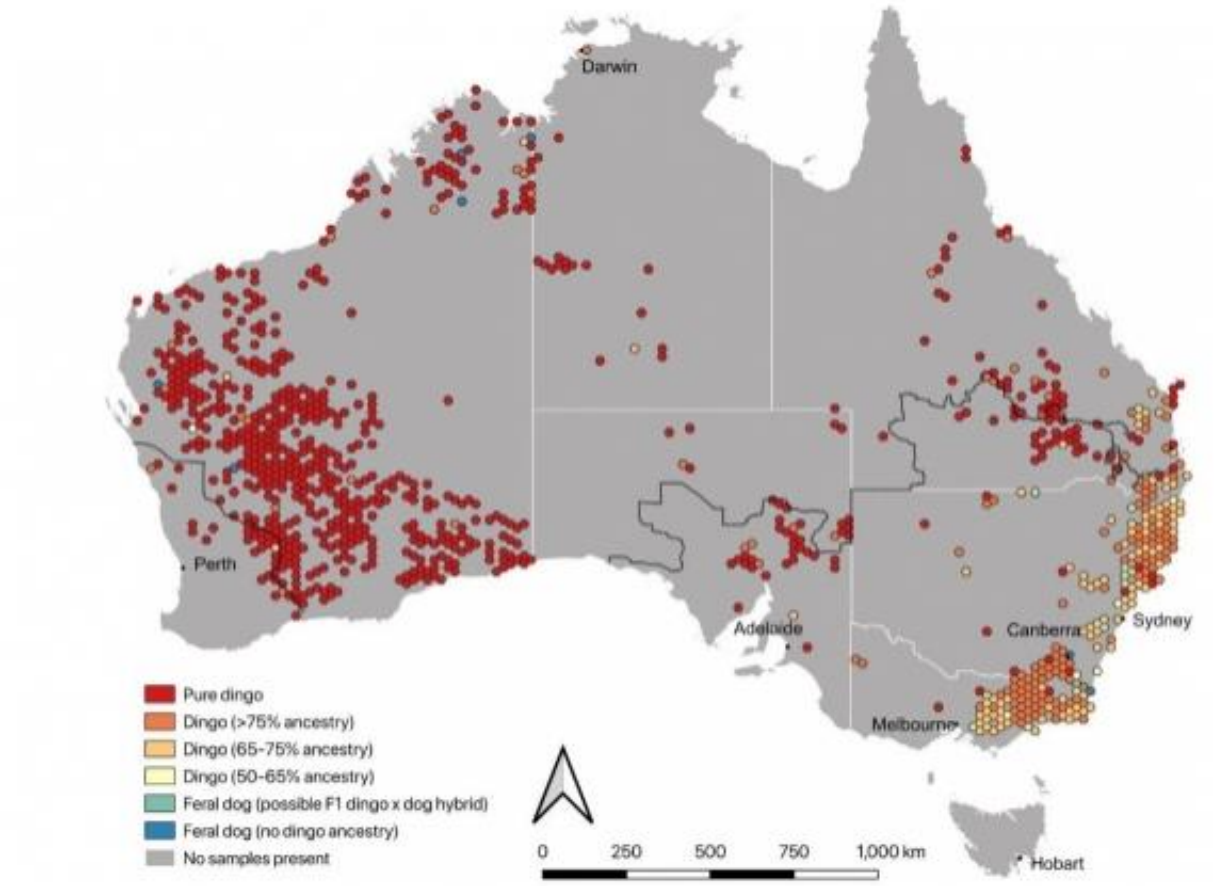
Genetic Studies

Early genetic studies indicated that all domestic dogs can interbreed with dingoes, resulting in widespread hybridisation between the two taxa (around 78% of wild canids reported as hybrids), particularly in southeast and southwest Australia (Newsome and Corbett 1985; Corbett 1995; Wilton *et al*. 1999), threatening the pure dingo taxon (Dickman and Lunney 2001).

Cairns et al (2020) tested the genetic makeup of 783 wild canids across north-eastern NSW, from public and private land, captured between 1996 and 2012. They found that 75% of the animals tested were dingo-dominant hybrids – i.e. animals whose genetic make-up is dominated by dingo genes. Hybrids with mostly domestic dog genes only made up 2%, feral dogs with no dingo ancestry accounted for less than 1% and the remaining nearly 25% were likely pure dingoes. The study indicates that the majority of wild dogs in NE NSW are dingoes or dingo-dominant hybrids, and also identified pure dingo hotspots in Port Macquarie, Myall Lakes and the Washpool National Park area of NSW.

Subsequently the same authors looked more broadly at dingo genetics across the whole of Australia (Cairns *et al.* 2021). This study looked at over 5,000 wild canid DNA samples. They found that, across Australia, 99% of wild canines were pure dingo or dingo-dominant hybrids (>50% dingo genes). Only 1% were dog-dominant hybrids or feral dogs. 64% of canines tested were pure dingoes.
The data indicated higher dingo-dog hybridisation in more populated areas: from Victoria, up the east coast to SE Queensland, while in western and northern Australia 98% of the animals tested were pure dingoes.

Current research: dingo genetics, ecology, management and legislation



The median ancestry of wild canine DNA samples across Australia. Image: Cairns et al 2021.

While earlier genetic studies suggested that widespread hybridisation was threatening the purity of dingo populations, the new research shows that there are still a lot of pure dingoes in the wild, and very few pure domestic dogs. According to researchers from the University of NSW, it is these remaining populations with high genetic integrity that should be a priority for conservation (It's not 'wild dog' management – we are just killing dingoes | UNSW Newsroom). In NE NSW pure dingo hotspots were identified in Port Macquarie, Myall Lakes and the Washpool National Park area, and the researchers recommend a more balanced approach towards conservation and management in these hotspot areas. However, this can be difficult, Claridge *et al* (2009) used satellite tracking to find that dingoes and dog-dingo hybrids have much larger home ranges that previously thought, averaging 10,000 ha and up to 59,000 ha.

Cairns and her team are now carrying out further genetic studies to see if they can identify other hotspots of high dingo purity in the Great Dividing Range. Their recent studies use genetic methods that look at over 100,000 genetic markers, rather than the 23 markers used in earlier genetic studies. Dr. Cairns has advised us that, globally, this methodology is considered best-practice for the study of hybridisation in a wide range of animal species.

These newer genetic studies are starting to suggest that there may be much less hybridisation between dingoes and domestic dogs than previously thought. The data indicate that, rather than being one homogenous genotype, there is a lot of regional genetic variation between dingoes living in different parts of Australia. It is possible that this regional genetic variation has previously led to some pure dingoes being misclassified as hybrids.

Current research: dingo genetics, ecology, management and legislation

A note on species definition

There are two most commonly applied species concepts to the dingo: the biological (*sensu* Mayr 1942, 1963) and the phylogenetic species concepts (*sensu* Eldredge & Cracraft 1980; Cracraft 1983; Groves et al. 2017).

1. Biological species concept: with its emphasis on reproductive isolation, where capacity for hybridisation indicates a single species, i.e. all Canids would be 1 species.
2. Phylogenetic species concept: Biologists working across taxonomic groups have developed other species concepts to define and delimit biological variability beyond focus on reproductive limitations and towards the distribution of heritable characters on the species-concept continuum. May be defined using morphological or genetic characteristics or a combination of the two.

A note on terminology relating to hybrids

The term hybrid generally refers to only F1 crosses, i.e. the offspring of a dingo and domestic dog. But F2 animals (the offspring of two F1 hybrids) may also be referred to as hybrids (Hansson *et al*. 2012). Cairns *et al*. 2021 suggest that dingoes that carry domestic dog ancestry but are not F1/F2 hybrids should be referred to as dingo backcrosses or admixed dingoes. In NSW: Both domestic dogs and dingoes are considered subspecies of the wolf *C. lupus*.

Differentiating pure dingoes from hybrids

Recent genetic studies (Cairns *et al*. 2021, Cairns *et al*. 2023 in prep) use a cut off of greater or equal to 93% dingo DNA to define a ‘pure’ dingo. The last domestic dog ancestor for an animal with 93% dingo DNA and 7% dog DNA, would have been 4-5 generations past. While dog breeders would use a tighter definition of a ‘pure bred’ dog, Dr Cairns advised that the cut-off of 93% is a well-accepted standard for livestock breeders.

There isn’t much literature regarding reliable field methods for distinguishing pure dingoes from hybrids (Elledge *et al*. 2006). There are some behavioural characteristics (dingoes don’t bark), and reproductive characteristics (dingoes produce one litter each winter, but domestic dogs have 2 oestrus periods per year). Advice from Dr. Cairns is that an expert can generally tell the difference between a dingo, dog and dingo-dog hybrid by looking at a combination of morphological characteristics (e.g. dogs have floppy or pointy ears, a less bushy tail, broader skull and muzzle and forward facing eyes, whereas dingo ears are more arched, and their eyes located more towards the side of the skull). There is an opportunity for Council to partner with researchers to look in greater depth at both the DNA and morphology of canids sighted and trapped in this region, to get better understanding of the variation.

Scientists point out that we need more information on how observable morphological and behavioural characteristics relate to the genetic composition and ecological roles of dingo hybrids. This would help us to understand the degree to which hybridisation may compromise the ecological role of dingoes, and therefore help guide management of hybrids (Claridge and Hunt 2008). Cairns *et al* (2021) point out that morphological research about the phenotype (i.e. visible morphological characteristics) of dingoes with low levels of dog ancestry may assist on-ground management and conservation efforts, particularly if distinguishing features could be identified.

Current research: dingo genetics, ecology, management and legislation

The ecological role of dingoes

DINGOES AS A CONSERVATION TOOL

Some research indicates that dingoes can play an important role as 'trophic regulators' in natural ecosystems, and proponents suggest they may have a role as a biodiversity conservation tool, protecting native species by controlling the density of feral species, e.g. red foxes, cats and goats (Glen *et al*. 2007; Johnson *et al*. 2007; Wallach and O'Neill 2008, Cairns 2020, 2021, Dickman *et al*. 2009, Letnic *et al.* 2011).

Caughley *et al.* (1980) and Newsome *et al*. (2001) and more recent Lentnic (1990) indicated that dingo predation was responsible for the increased activity of native herbivores along the dingo barrier fence, which extends from the Strzelecki desert in south Australia, through western NSW to south east Queensland. In these drier environments, the loss of dingoes has also been linked to shrub encroachment (Gordon *et al*. 2017), changes to seed fate and vegetation dynamics (Gordon and Letnic 2016), altered sand dune profiles (Lyons *et al*. 2018), changes to soil nutrient profiles (Morris and Letnic 2017) and insect communities (Contos and Letnic 2019). In northern NSW forests Colman *et al*. (2014) found dingo control corresponded with increased fox activity. They didn't find any impact on cat activity, but suggested that the capacity of dingoes to suppress cats may be higher in open habitats.

However, there are also multiple studies arguing that there is little evidence that dog control leads to increases in foxes or cats in arid, semiarid, temperate or tropical parts of Australia (Fleming *et al*., 2019). For example, Allen (2005) and Eldridge *et al*. (2002) found fox and cat populations to fluctuate independently of dog control. Allen *et al.* (2013a, 2013b), Castle *et al.* (2021), Claridge *et al*. (2010) and Fancourt *et al.* (2019) found that reduced control of dingoes had little impact on the abundance of feral cats and/or red foxes.

Fleming *et al*. (2021) argue that, if we are to use dingoes as a biodiversity conservation tool, we need to consider whether they are able to fulfil their pre-European ecological role and restore ecosystem processes towards a pre-European state. Dingoes were likely a stable part of predator–prey interactions in Australian systems before European arrival, with populations controlled by factors like food and water availability. But today's landscape is highly modified, particularly in Eastern Australia: changes like clearing, overgrazing, water bores, human settlement, introduction of rabbits and livestock have increased resource availability for generalist predators like the dingo. Remote camera monitoring done by Local Land Services in Grafton, Dorrigo and Kempsey shows high survival rates of dingo pups in areas where resources are high, as well as changes in behaviour, with wild dogs occurring in packs of up to 14 and approaching houses, which is not normal dingo behaviour.

Fleming *et al* 2019 and Allen *et al* 2013 also caution against positive management of dingoes, without a thorough understanding of the other factors that may be contributing to threatened species decline. Populations of prey and predators are not just affected by predation, but also by weather and food and disease and the interactions of all these factors. Although there is considerable evidence suggesting a functional role for dingoes in suppressing foxes, uncertainties have led to calls for rigorous manipulative experiments to better resolve the value of the dingo in ecological restoration (Newsome *et al*. 2015). 'Top-down' conservation management approaches, such as re-introducing an apex predator, can be more risky than 'bottom-up' approaches (e.g. restoring habitat and forage availability), and may have a short-term rather than a longer term impact (Fleming *et al*. 2019).

Current research: dingo genetics, ecology, management and legislation

IMPACTS OF THE ENVIRONMENT ON THE ECOLOGICAL ROLE OF DINGOES

Adding to this complexity is the fact that Australia has many ecosystems, each with different processes and drivers, structural complexity and ecological carrying capacity. So, it is reasonable to expect a generalist predator like the dingo to have different roles and fill different ecological niches in different places (Visser *et al*. 2009). This means research in a dry environment may not be applicable in a wet environment – and dingo management that benefits native fauna in some ecosystems may be detrimental in others (Fleming *et al* 2019, Allen *et al* 2013a, b).

IMPACT OF HYBRIDISATION ON THE ECOLOGICAL ROLE OF DINGOES

Another factor to consider is that hybridisation with feral domestic may alter dog behaviour and ecosystem impacts. While Australian native animals clearly have some level of adaptation to canid predators (because dingoes have been here at least 5,000 years), feral dogs and hybrids are considered less likely to perform the same natural ecological function as dingoes, due to differences hunting behaviour, social structure and body size (Daniels and Corbett 2003; Glen and Dickman 2005; Mitchell and Banks 2005).

IMPACTS ON THREATENED SPECIES

It is also important to consider the costs and benefits to threatened species in any region – and there is some evidence that dingo hybrids do kill threatened species in this region. Gentle *et al*. (2019) investigated the genetic profiles of canids that had attacked koalas in SE Queensland, and found that free-ranging wild dogs (dingoes and dingo-domestic dog hybrids >75% dingo), and not domestic dogs, were responsible for killing the koalas sampled. Predation was by single dogs and packs, with several individual wild dogs involved in multiple koala killings. Beyer et al (2017) also found that dingoes and dingo hybrids accounted for a significant amount of koala mortality in the Moreton Bay region of SE Queensland. In SE Coastal NSW, Claridge *et al.* (2010) found that foxes were a greater threat than dingoes and dingo hybrids on threatened species. Threatened mammals were found in the dingo and dingo-hybrid scats, but a larger part of their prey was larger animals such as swamp wallabies and wombats. Gentle *et al*. (2019) suggest that prey-killing behaviours in dogs may be learned and removal of animals responsible (e.g. by targeted monitoring and trapping) can manage this predation.

Impacts of dingo control

REASONS FOR CONTROL

Wild dog/dingo control is carried out to protect livestock, but it is also done (e.g. by National Parks) with the objective of protecting dingoes (from hybridisation with feral dogs) and to protect other native wildlife (from predation). *Predation and hybridisation by feral dogs (Canis lupus familiaris*) has been listed as a key threatening process in New South Wales by the NSW Scientific Committee. Threatened species include the Spotted-tailed Quoll, Koala and Pied Oystercatcher (Predation and Hybridisation by Feral Dogs (Canis lupus familiaris) - key threatening process listing | NSW Environment and Heritage). Because dogs are well known to prefer small–medium prey species (Corbett 2001), the direct risks of dogs should not be overlooked or assumed to be less than their perceived indirect effects on other feral predators such as red foxes and cats (Fleming, Allen and Ballard (2012).

Current research: dingo genetics, ecology, management and legislation

In National Parks, management of wild dogs is informed by the NSW Wild Dog Strategy. This is intended to balance the need for managing wild dogs where they are having negative impacts and preserving the ecological role of dingoes. So wild dog control is focused on areas where risk of negative impacts is highest, and not undertaken in other areas to allow dingoes to fulfil their natural ecological role.

BAITING

Baiting with 1080 poison, including aerial baiting, is one of the ways wild dogs/dingoes are controlled There are several concerns around baiting, the main one being that it is non-selective, so can impact on non-target species, including native wildlife - although there are a number of studies that suggest the benefit to native wildlife outweighs the cost (e.g. Claridge and Mills 2007, Claridge *et al*. 2021).

Another concern is that baiting may impact the social structure and territoriality of dingoes. NSW Environment and Heritage note that the impact of baiting on dingo social structure is not well known (Predation and Hybridisation by Feral Dogs (Canis lupus familiaris) - key threatening process listing | NSW Environment and Heritage). However, in other wild canids (coyotes, red wolves), lethal control has been identified as a factor increasing the likelihood of interspecific hybridisation by breaking up social structures and altering demographic patterns (Bohling and Waits 2015).

Cairns *et al*. (2021) found dingo populations to be more stable and intact in areas that don't use widespread aerial baiting (northern and western Australia); and suggest that baiting may fracture dingo pack structure and allow domestic dogs to integrate into the breeding packs. However, they also note that the parts of Australia with more dingo-dog hybrids are those with a longer history of European Settlement, and higher domestic dog populations. As per the discussion in the previous section, hybridisation may alter the behaviour, social structure and ecological role of dingoes in the wild. Further to this, Letnic and Crowther (2020) found a link between baiting and increased body size of dingoes, which may increase their impact on livestock. Cairns *et* al. (2020) support the need to reduce human-driven dingo-dog hybridisation, by finding evidence-based strategies to limit interbreeding opportunities and maintain natural barriers to reproduction.

Note: Byron Shire Council does not use 1080 baiting. Recent conversations with local landholders indicate that many landholders in this area prefer targeted trapping to baiting.

RECOMMENDATIONS FOR CONTROL

Letnik and Cairns (2019) believe that there needs to be a balance between how we control and try to conserve dingoes: 'like kangaroos, they can be a pest but they shouldn't be wiped out' (It's not 'wild dog' management – we are just killing dingoes | UNSW Newsroom). They suggest that targeted methods of lethal control (shooting, trapping) might be appropriate to remove animals that are posing a particular threat to livestock. They also suggest avoiding shooting during the dingo breeding season (winter), to help reduce the risk of dingo x dog hybridisation.

They also recommend that management of feral, stray or roaming domestic dogs should focus on responsible pet ownership including spaying and neutering of pet animals, keeping pet and working dogs under control and confined during the night (Cairns *et al*. 2021). Responsible pet ownership and continued exclusion of domestic dogs from National Parks and conservation areas can reduce the occurrence of future dingo x dog hybridisation events.

Current research: dingo genetics, ecology, management and legislation

The pestsmart website lists alternative more humane baiting options for dogs Baiting of wild dogs with para-aminopropiophenone (PAPP) - PestSmart

Wild dog problems and impacts

In 2014, 71 per cent of surveyed landholders in wild dog affected areas knew of wild dog attacks occurring in their area and 67 per cent reported having a wild dog problem on their own property. Twenty-six per cent of landholders in the areas surveyed rated the wild dog problem on their property as severe or extremely severe (ABARES 2015) – refer map overleaf.

Recent conversations with Byron Shire landholders report sightings of both dingoes and feral domestic dogs – the latter being distinguished as being as being much larger, stockier, barrel-chested, barking, with features resembling pit bull, German shepherd, collie etc. Farmers throughout the shire report livestock losses, including chickens, cattle, sheep, goats and horses, as well as frightening encounters with dogs approaching people on rural roads and coming near to houses.

Landholders also report declining wildlife, including koalas, pademelons, wallabies and lyrebirds in hinterland areas over the last 20 years, with increasing numbers of wild dogs being sighted.

Community engagement

Fleming, Allen and Ballard (2021) suggest that proponents of positive dingo management follow an inclusive, community co-management approach, where managers engage with the diverse range of stakeholders to create an environment where all involved parties consider both scientific and other evidence, and the sociopolitical issues, before determining and implementing appropriate action. This allows greater ownership by stakeholders, reduces disenfranchisement of key people affected by the management, and allows stakeholders to adapt procedures as knowledge improves and situations change.

We also need to be aware that community or society attitudes towards predators may shift over time. Those who accept the notion of positive dingo management today might not in the future. Although anecdotal evidence and popular media suggest that the average Australian is relatively positive towards dingoes, this could shift as people interact more closely with the animals, and negative experiences associated with dogs (e.g. predation of pets or livestock, predation of local wildlife, threat of dog-borne disease, and direct threats to human safety) literally come closer to home (Allen 2006a).

Legislation

The section below gives a summary of the treatment of dingoes and wild dogs in federal legislation and by legislation in the different states of Australia.

FEDERAL LEGISLATION

Canis familiaris — Domestic Dog, Dingo (environment.gov.au)

Current research: dingo genetics, ecology, management and legislation

The EPBC act defines a native species as, “a species (f) that was present in Australia or an external Territory before 1400” (Chapter 8 Part 23 division 2 session 528 p. 563-564). Under this definition the dingo would be considered a native species as it has been in Australia for over 4,000 years.

The Australian Government Species Profile and Threats Database (Canis familiaris — Domestic Dog, Dingo (environment.gov.au)) lists domestic dogs and dingoes as the same species, *Canis familiaris*. On this database there is no approve conservation advice for this species.

The dingo is also considered a significant pest animal under the Australian Pest Animal Strategy 2017 (Australian Pest Animal Strategy - DCCEEW).

NSW LEGISLATION

Wild dogs | NSW Environment and Heritage

The wild dog is considered a pest under the NSW Biosecurity Act 2015. The dingo is considered a native species under Biodiversity Conservation Act 2016 division 2 item 4.3.

Under the NSW Biosecurity Act 2015, a wild dog is any dog living in the wild, including feral dogs (*Canis lupus familiaris*), dingoes (*Canis lupus dingo*) and their hybrids. Because it’s considered that wild dogs can have significant impacts on livestock, especially sheep, they have been identified as a priority pest animal under the 11 Regional Strategic Pest Animal Management Plans developed by Local Land Services. It is therefore necessary to manage wild dogs under the **General Biosecurity Duty** of the Biosecurity Act 2015. This means that the occupier of lands (both private and public) is to ensure that, so far as is reasonably practicable, the biosecurity risk is prevented, eliminated or minimised. It is the responsibility of individuals to ensure they discharge their general biosecurity duty to manage the biosecurity risks posed by pest animals. The Biosecurity Regulation 2017 outlines mandatory measures for pest animal management in NSW.

The acceptance of the term invasive pest animal for wild dogs and dingoes also implies that they present a similar threat to native animals as do foxes and feral cats and need to be lethally controlled accordingly. However, there is controversy over this because native wildlife in Australia have had 4000+ thousand years to adapt to “dog” like predation while foxes and cats are relatively new to the environment.

Under the North Coast Regional Strategic Pest Animal Management Plan 2018-2023 (north-coast-regional-pest-plan.pdf), the goal of Wild Dog management at the regional scale is ‘asset based protection’, with assets being people, livestock, domestic pets, native fauna. The NSW Wild Dog Management Strategy 2017-2021 (DPI 2017) promotes a balance between managing wild dogs in areas where they have negative impacts (on aforementioned assets) and preserving the ecological role of dingoes. Hence the North Coast Regional Pest Plan promotes targeted control on areas where the risk of negative impacts are greatest, rather than undertaking control in parts of the landscape where the risk of negative impacts from wild dogs is low, which allows wild dogs to fulfil their natural ecological role.

QUEENSLAND LEGISLATION

Wild dog control and the law | Business Queensland

Current research: dingo genetics, ecology, management and legislation

The wild dog is a restricted invasive animal under the Queensland Biosecurity Act 2014. The dingo is defined as both 'wildlife' and 'native wildlife' under the Queensland Nature Conservation Act 1992. This means:

- Under the Queensland Biosecurity Act 2014, dingo is considered a restricted invasive animal and landholders have a legal responsibility to control wild dogs (including dingoes) on their land. Wild dogs cannot be moved, kept, (if a dingo), fed, given away, sold, or released into the environment without a permit.

- Under the Queensland Nature Conservation Act 1992, the dingo is protected within protected areas (e.g. national parks). Protected areas have their own management principles, which help to conserve their natural resources and natural condition; however, the Department of Environment and Science's good neighbour policy allows for the management of wild dogs in protected areas in certain circumstances.

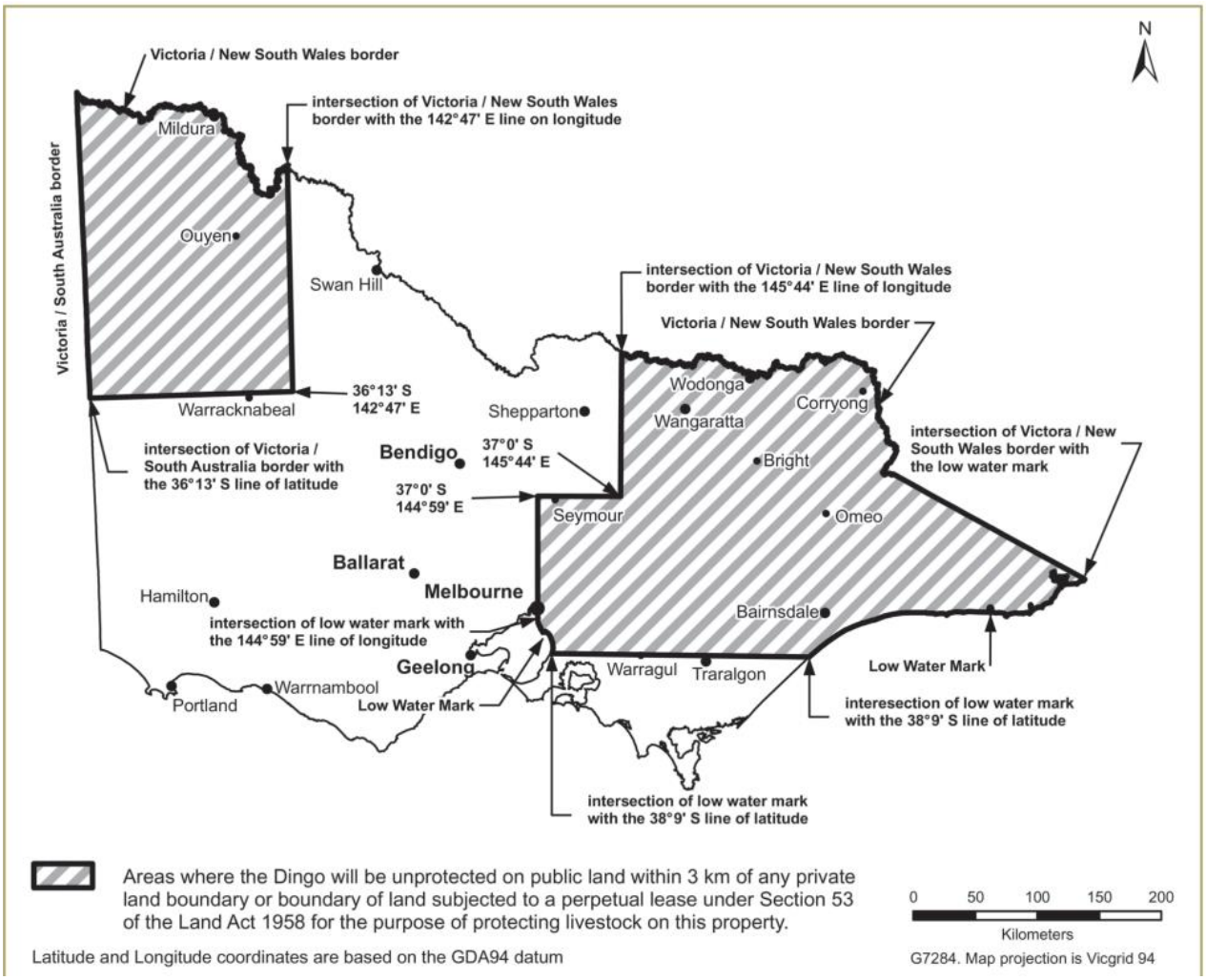
VICTORIAN LEGISLATION

Dingoes (wildlife.vic.gov.au)

In 2010, accepting a recommendation from the Victorian Scientific Advisory Committee (VSAC), the then Victorian Minister for the Environment listed the dingo as a threatened native taxon under the Flora and Fauna Guarantee Act 1998. Threatened species status meant that the dingo governance fell to the Victorian Wildlife Act 1975, rather than the pest animal provisions of the Catchment and Land Protection Act 1994, under which it previously had been governed as an ‘established pest animal’, along with feral pigs, goats and rabbits, to be ‘…eradicated or controlled or its spread in the wild … prevented’ (Catchment and Land Protection Act, 1994).

There are potential issues in implementing this legislation because dingoes cannot always be reliably visually distinguished from wild dogs. To allow the continued control of wild dogs where they threaten livestock, an Order in Council was made under the Wildlife Act 1975, declaring the Dingo as unprotected wildlife in certain parts of the state. As per the map below, dingoes were listed as unprotected in more heavily farmed eastern and western parts of the state, allowing ongoing control to protect livestock, while dingo control was excluded from the central area. Monitoring indicated reduction in sheep killed/maimed throughout the state, inferring that management practices can be designed to benefit industry and safeguard wildlife.

Current research: dingo genetics, ecology, management and legislation



Extracted from: Action Statement No. 248

Current research: dingo genetics, ecology, management and legislation

SOUTH AUSTRALIAN LEGISLATION

In South Australia, the management actions that apply to dingoes and wild dogs are delineated by the Dog Fence. Inside the Dog Fence wild dogs are declared for destruction under the Landscape South Australia Act 2019 (hereafter LSA Act). Dingoes are considered native to Australia and they have important cultural roles inside and outside the Dog Fence. Outside the Dog Fence they are managed as unprotected native animals under the National Parks and Wildlife Act 1972 because they are considered to have an important ecological role. On Aboriginal Lands, public lands, mining lands and townships, dingoes are typically only controlled when they pose a threat to human safety.

Cattle producers outside the Dog Fence limit their control of dingoes to times and places where they are impacting cattle. The Wild Dog Management Plan of the SA Arid Lands Landscape Board limits the amount of poison bait that can be used.

WEST AUSTRALIAN LEGISLATION

Wild dogs in Western Australia | Agriculture and Food

The term wild dog is used to describe pure-bred dingoes, feral/escaped domestic dogs and their hybrids. Both dingoes and wild domestic dogs are the same species, *Canis familiaris*. They are declared pests for the whole of Western Australia under section 22 of the Biosecurity and Agriculture Management Act 2007. Dingoes are considered native wildlife under the Biodiversity Conservation Act 2016 (BC Act). An exemption order made under section 271 of the BC Act exempts people from the requirement for a licence for activities involving dingoes. Western Australia's policy for wild dog management is to control all wild dogs, including dingoes, in and near livestock grazing areas in Western Australia. In other areas dingoes are left undisturbed.

NORTHERN TERRITORY LEGISLATION

The term wild dog includes the dingo and the feral domestic dog, as well as hybrids of these. Dingoes are protected in the Northern Territory (NT). A permit is needed to take or interfere with wildlife. In the NT, wild dog control measures have been less intensive than in other states and territories, and there has been little or no change in the distribution of dingoes. This is largely because livestock in the NT is restricted mainly to cattle, which are only preyed on by dingoes if there is a lack of other prey. Dingoes are more likely to prey on smaller animals like sheep and chickens.

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