

Notice of and reasons for the Final Determination

The NSW Threatened Species Scientific Committee, established by the *Biodiversity Conservation Act 2016* (the Act), has made a Final Determination to REJECT a proposal to list The cascading effects of the loss or removal of dingoes from New South Wales landscapes as a Key Threatening Process in Schedule 4 of the Act. Listing of Key Threatening Processes is provided for by Part 4 of the Act.

The Scientific Committee has found that:

1. The dingo (also known in Australia as wild dog) has been present on the Australian continent for at least 3000–5000 years (Savolainen *et al.* 2004). Genetic evidence suggests that dingoes originated from domestic dogs in East Asia (Oskarsson *et al.* 2012). A recent phylogenetic analysis based upon mitochondrial and nuclear DNA suggests there are at least two distinct populations of dingo in Australia, one in the northwest and the other in the southeast, with the potential for two separate arrivals (Cairns & Wilton 2016; Cairns *et al.* 2017).
2. The dingo is an example of a controversial taxon with a much debated scientific name. Its taxonomic status is clouded by hybridization with feral dogs and confusion about how to distinguish ‘pure’ dingoes from dingo-dog hybrids. Crowther *et al.* (2014) undertook morphological analyses of early specimens collected soon after European settlement and showed that there is considerable overlap between dingoes and domestic dogs for most morphological characters. However, dingoes have a relatively larger palatal width, a relatively longer rostrum, a relatively shorter skull height and a relatively wider top ridge of the skull than domestic dogs. They proposed *Canis dingo* as the correct scientific name. Conversely, Jackson *et al.* (2017) reviewed existing evidence and found dingoes clustered with other dogs supporting their derivation from a domestic dog lineage. Given their evolutionary history, Jackson *et al.* (2017) suggested the name *Canis familiaris* for all free-ranging dogs, regardless of breed and location throughout the world, including the Australian dingo. More recently, Smith *et al.* (2019) argued that the dingo is a geographically isolated species from all other *Canis*, and is genetically, phenotypically, ecologically, and behaviourally distinct. They suggested the biological species concept should not be applied strictly in the case of this taxon. Accordingly, they recommended the name *Canis dingo*. Jackson *et al.* (2019) dispute this basis for a taxonomic revision and suggest a sufficient case has not been made for dingoes to have a deeply divergent evolutionary history that distinguishes them from other named forms of *Canis*. They argue that the correct binomial name for the taxon derived from Gray Wolves (*C. lupus*), by passive and active domestication, including dingoes and other Domestic Dogs, is *Canis familiaris*. Whatever the accepted taxonomic name and despite originating from domestic dogs, dingoes have a special status as one of the indigenous ‘ancient’ breeds (Jackson *et al.* 2017).
3. The dingo remains genetically and reproductively compatible with modern domestic dogs in Australia and is currently in the process of losing its distinctiveness through interbreeding with feral domestic dogs and hybrids. Hybridisation between dingoes and feral domestic dogs varies substantially by region with the southeast of Australia being highly admixed (99% of animals being hybrids or feral domestic dogs), whereas only 13% of the animals from remote central Australia are hybrids (Stephens *et al.* 2015). Almost all free-ranging dogs have some dingo ancestry, however, even in regions with large human populations, where hybridisation is higher (e.g. New South Wales and Victoria), more than 90% of wild dogs sampled retained at least 60% dingo characteristics (Stephens *et al.* 2015). This suggests that hybrids revert to wild type appearance and behaviour and that the dingo phenotype is dominant, even in areas where there is extensive hybridization (C. Dickman *in litt.* 7 January 2019). Cairns *et al.* (2017) highlight that the southeastern population of

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dingoes is under strong extinction pressure from both lethal control and hybridization and recommend that steps should be taken to preserve this population. More recent work has identified that most wild canids in north eastern NSW had predominantly dingo ancestry and only 0.6 % had no dingo ancestry (Cairns *et al.* 2020).

4. The IUCN elevated the global (Asia–Australia) status of dingoes to Vulnerable in 2004 (Corbett 2008). In 2008 the dingo was listed as threatened in Victoria under the Flora and Fauna Guarantee Act 1988. The dingo is not listed as threatened in other states or territories. Every state and territory in Australia controls 'dingoes, wild dogs and their hybrids'. Pastoralists and conservation agencies lethally control dingoes across Australia to reduce, limit or remove the threat they pose to livestock production. In NSW, pure dingoes are not protected as designated wildlife; they are excluded from protection under Schedule 5 of the *Biodiversity Conservation Act 2016*. Moreover, wild dogs are no longer a legally declared pest under the *Local Land Services Act 2013*, as the Wild Dog Pest Control Order was repealed on 1 July 2018 (B. Russell, *in litt.* 14 January 2019). In NSW, wild dog management is defined by the NSW Wild Dog Management Strategy 2017-2021, which promotes a balance between managing wild dogs in areas where they have negative impacts and preserving the ecological role of dingoes. This Strategy also informs the *Biosecurity Act 2015*, which requires measures to be taken to eliminate, prevent or minimise risks from biosecurity threats (including wild dogs). Control measures in NSW include barrier fencing along the edge of National Parks in the Northern Tablelands and the rangelands bordering South Australia, Northern Territory and Queensland. Other control measures include trapping and opportunistic shooting and poisoning using sodium fluoroacetate (1080) either via ground or aerial baiting, the latter being focused on inaccessible terrain adjacent to areas of stock losses (Harden 2001). Such control measures are also likely to influence the ecological role of dingoes. In a study of the Fraser Island dingo population, O'Neill *et al.* (2017) suggested stable pack structures were important for the maintenance of ecological function and territorial stability. The authors argued that dingo populations are self-regulating according to seasonality, prey abundance and other ecological variables. However, they proposed that such population regulation is socially mediated and breaks down with the advent of lethal control.
5. The dingo occurs across the entire mainland of Australia, including tropical rainforests, deserts and alpine areas (Corbett 2008). It is also found on many islands, but not Tasmania. In NSW the dingo is widespread in the eastern forested ranges and in some of the larger vegetated areas along the coast. Wild dog control programs keep them at low levels in the rangelands of western NSW, aided by the dog fence, which provides a barrier along the state's borders with South Australia, Northern Territory and Queensland (Corbett 2008).
6. Female dingoes generally have a single annual breeding season, though males are continuously fertile in most regions (Newsome *et al.* 1972; Catling 1979). Most matings take place between March and June with the majority of births occurring between May and August (Catling *et al.* 1992; Thomson 1992). In contrast, most modern domestic breeds do not have a seasonal pattern of breeding and can breed twice per year with females coming into oestrus every seven months on average (Lord *et al.* 2013). Captive-bred hybrids between a dingo and a typical domestic dog show a breeding pattern similar to that of domestic dogs with two breeding seasons that can occur throughout the year (Newsome *et al.* 1972; Catling 1979). By contrast, observations from free-ranging populations of admixed dingoes and feral domestic dogs have revealed a single annual breeding season but with a broader timing of matings and births (Jones & Stevens 1988). Cursino *et al.* (2017) found that dingo-dog hybrids in peri-urban areas (where hybridisation is high) have a single annual breeding season in winter, exhibiting the same breeding seasonality as dingoes. Existing hybrids appear to share a similar ecological role as pure dingoes (Daniels & Corbett 2003; Claridge & Hunt 2008; Glen 2010; Purcell 2010; Jones 2009; Parr *et al.* 2016). The proportion of

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sexually mature females in the population reflects those recorded in pure dingo populations (Catling *et al.* 1992). The limited data available on the social and movement behaviour of dingoes in areas with high levels of hybridisation also suggests similarity to pure dingoes, with home ranges mostly stable over time and equivalent in size to those of pure dingoes, and evidence of social pack formation (Robley *et al.* 2010; Claridge *et al.* 2009; Purcell 2010).

7. Across Australia, almost 75 % of prey eaten by dingoes is mammalian; the remaining diet consists of birds (c. 19 %), vegetation (3 %), reptiles (2 %) and an assortment of insects, fish, crabs and frogs (4 %) (Corbett 2001). In terms of prey size, medium-sized mammals (0.5-15 kg) predominate (Corbett 2001). The main prey species of dingoes in eastern and southeastern Australia are Eastern Grey Kangaroo (*Macropus giganteus*), Swamp Wallaby (*Wallabia bicolor*), Common Brushtail Possum (*Trichosurus vulpecula*) and Bare-nosed Wombat (*Vombatidae* spp.). Dingoes also prey upon a number of introduced pest species including European rabbits (*Oryctolagus cuniculus*), feral goats (*Capra hircus*), pigs (*Sus scrofa*) and deer (Cervidae spp.) (Marsack & Campbell 1990; Newsome 1990; Mitchell & Banks 2005; Glen *et al.* 2007; Purcell 2010). One dietary study from the Barrington Tops found extensive overlap between the diet of wild dogs, foxes, cats and quolls (Glen *et al.* 2011). However, cats mainly consumed smaller prey and wild dogs' larger prey. The main prey species change throughout the year depending on prey abundance and on the dingo's annual reproductive cycle (Newsome *et al.* 1983; Thomson 1992; Purcell 2010). When dingoes are in stable cooperative packs, they tend to hunt larger prey such as kangaroos, while solitary dingoes hunt small to medium prey that are easier to catch (Glen *et al.* 2007).
8. Top-order, predators play an important role in terrestrial, marine and freshwater ecosystems (Power *et al.* 1985; Estes *et al.* 1998; Crooks & Soule 1999; Ripple and Larson 2000; Berger *et al.* 2001; Carpenter *et al.* 2001; Myers *et al.* 2007; Baum & Worm 2009; Beschta & Ripple 2009; Letnic *et al.* 2009a, b; Ritchie & Johnson 2009; Letnic *et al.* 2012; Ritchie *et al.* 2012;). At a continental scale, there is a correlation between the persistence of native rodents and marsupials and the presence of the dingo (Johnson 2006). Inside the dingo fence in western NSW - an area that has had no, or very few, dingoes for close to 100 years - 24 native mammal species have become extinct (Purcell 2010). Although a number of other factors undoubtedly played a role in these extinctions, dingo removal may have been a contributing factor. Research either side of the dingo fence in western NSW provides evidence of a trophic cascade effect whereby the effects of dingoes and/or large herbivores (including livestock) extends to the soil nutrient pool (Letnic and Koch 2010; Morris and Letnic 2017). Dingoes prey upon native herbivores such as kangaroos and wallabies, species which, without predation, can deplete native vegetation and simplify its structure (Caughley *et al.* 1980; Short 1985; Thomson 1992; Johnson & VanDerWall 2009; Letnic *et al.* 2009b; Wallach *et al.* 2009; Letnic *et al.* 2013; Colman *et al.* 2014; Gordon *et al.* 2017). Dingoes may also provide benefits for small and medium sized native mammals by suppressing the abundance of introduced predators, the Red Fox and feral cat (Letnic *et al.* 2011; Brook *et al.* 2012). This phenomenon is referred to as mesopredator release (Ritchie & Johnson 2009). Populations of native animals that are preyed upon heavily by cats and foxes may be suppressed in areas where dingoes are controlled (Letnic *et al.* 2009a&b, Letnic & Dworjanyn 2011; Gordon *et al.* 2015). The suppression of dingoes likely allowed introduced mesopredators (cats and foxes) to increase predation on the smaller 'critical weight range' species (between 100-5000g; Johnson & Isaac 2009), but also left larger herbivores (kangaroos) unregulated, causing extensive overgrazing and adding further pressure through competition for resources on smaller mammal species (Newsome *et al.* 2001; Letnic *et al.* 2009a&b; Letnic & Crowther 2013; Purcell 2010; Gordon and Letnic 2016). A study in NSW forests found that in areas where dingoes were controlled, the activity of herbivorous macropods, arboreal mammals and the Red Fox were greater, but understorey vegetation was sparser and abundances of small mammals lower (Colman *et al.* 2014). Both predation by foxes and depletion of understorey vegetation by macropods were related to lower activity of small

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- mammals at poisoned sites. A meta-analysis of 17 different studies that measured the effects of dingo control on 23 mammal species found that dingo removal, overall, had negligible effect on other species of mammal (Hunter *et al.* 2018). However, heavier species were more abundant with dingo removal, while lighter species (below critical weight range) tended to decline in abundance.
9. Interactions between dingoes and mesopredators could happen through direct killing, but also via influencing the behaviour of these species (Newsome *et al.* 1983; Marsack & Campbell 1990; Thomson 1992; Lundie-Jenkins *et al.* 1993; Mitchell & Banks 2005). Brook *et al.* (2012) showed a shift in abundance indices of feral cats inverse to that of dingoes within paired sites (dingoes controlled or uncontrolled) across 18 sites in northern Australia. They also noted a trend for cats to avoid areas frequented by dingoes. Elsewhere, dingoes have been found not to suppress cat activity (see Fancourt *et al.* 2019 and below).
 10. A body of literature has expressed caution about interpreting the functional role of dingoes. Criticisms have highlighted that studies are often inconclusive and have issues around replication, methods and sampling bias (Allen *et al.* 2013a; Allen *et al.* 2014a; Claridge 2013; Fleming *et al.* 2012; Hayward & Marlow 2014). Moreover, the evidence for dingo suppression of cat and sometimes fox activity is variable. For example, long-term studies of ground vertebrates in the forests of southeast NSW found no evidence for dingo suppression of cats or foxes (Claridge *et al.* 2010; Arthur *et al.* 2012). A study in the Blue Mountains confirmed a negative association between wild dogs and foxes at a fine-scale, but not at the landscape scale (Mitchell & Banks 2005). Although Colman *et al.* (2014) found dingo control corresponded with increased fox activity in forests of northern NSW, there was no evidence for an effect on cat activity. Suppressive effects of dingoes on cats are likely to be habitat dependent and greater in open habitats (C. Dickman in litt. 7 January 2019). For example, cats showed little spatial avoidance of dingoes at a coarse scale at the last remaining wild population of bridled nailtail wallabies *Onychogalea fraenata* (Wang & Fisher 2012). These authors proposed that control of dingoes should not be abandoned at the site, because the potential moderate benefits of reduced cat activity for this endangered wallaby may not outweigh the detrimental effects of dingo predation. A recent study at this site found that feral cats coexist with dingoes, without apparent suppression of activity, abundance or fitness of cats (Fancourt *et al.* 2019).
 11. Dingoes are predators of and considered a risk to some threatened species (Allen and Fleming 2012; Davis *et al.* 2015). For example, canid predation is a known threat to koalas (Beyer *et al.* 2018) and northern hairy-nosed wombats *Lasiorhinus krefftii* in Queensland (Banks *et al.* 2003). Dingo predation has been suggested to produce unexpected ecological effects on other threatened species (Fleming *et al.* 2012; Allen *et al.* 2013a; Allen *et al.* 2017). 'Predation and Hybridisation by Feral Dogs (*Canis lupus familiaris*)' is a listed Key Threatening Process for threatened species, populations, and communities in New South Wales.
 12. Relationships between dingoes and other species are often complex, especially in human altered ecosystems. For example, provisioning of food to wild dogs near human settlements has the potential to alter trophic cascades (Newsome *et al.* 2013b). Alternative explanations for the complex ecological interactions have been proposed, such as bottom-up forces (White 1978), which may affect interactions among Australian dingoes, red foxes and feral cats (Allen *et al.* 2015). Similarly, Forsyth *et al.* (2019) recently highlighted the complexity involved in the interactions between dingoes and introduced herbivores and that the level of suppression by dingoes will vary by species, location and time. Although there is considerable correlative evidence suggestive of a functional role for dingoes suppressing foxes and large herbivores, uncertainties have led to calls for rigorous manipulative experiments to better resolve the value of the dingo in ecological restoration (Newsome *et al.* 2015). Landscape-scale, manipulative experiments of canids in the Australian

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rangelands found no short-term mesopredator release and little measurable response from a range of prey species, probably because poison baits were taken by target and non-target predators, and these predators quickly recovered to pre-control levels (Allen *et al.* 2013b; Allen *et al.* 2014b).

Section 4.32 of the Biodiversity Conservation Act 2016 states that:

(1) A threatening process is eligible to be listed as a key threatening process if, in the opinion of the Scientific Committee—

- (a) it adversely affects threatened species or ecological communities, or
- (b) it could cause species or ecological communities that are not threatened to become threatened.

The cascading effects of the loss or removal of dingoes from NSW landscapes is not eligible to be listed as a Key Threatening Process as, in the opinion of the Threatened Species Scientific Committee:

- (a) Despite there being correlative evidence that the loss of dingoes could adversely affect some threatened species or ecological communities, there remains a considerable difference of scientific opinion about the complexity of interactions involved,
- (b) 'loss or removal of dingoes' is ambiguous and ill-defined in relation to the extent, time-frame and area such 'loss or removal' is required to influence the functional role of dingoes,
- (c) Dingo predation adversely affects some threatened species.

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