A historical review of Australian aerial vertebrate pest control, targeting dingoes and wild dogs 1946 - 2019

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ABSTRACT

This paper examines the history of aerial baiting in Australia since the first operations commenced in 1946, initially targeting the dingo *(Canis dingo)*. It was believed that dingo populations had proliferated during the Second World War, and posed a threat the re-emerging wool and meat industry. New technologies took advantage of skilled air force pilots, and the surplus of aircraft available post World War 2, to commence an inexpensive, sustained and landscape wide approach to pest management. Aerial baiting has continued to develop as a technology since this time. However, it was 21 years before Australia started the first comprehensive research trial into its efficacy in controlling the target species. The results of these tests that commenced in 1968 were an overwhelming failure. More tests in the 1970s had similar results, yet the broad-scale poisoning of pest species from the air continued. The application of aerial baiting in dingo/wild dog control is believed to have a temporal effect, anecdotally achieving short-term goals towards reducing livestock losses from predation. There is no conclusive data, however, to support this claim. The true impact of aerial baiting on target and non-target native species, and ecosystem function, is potentially great. It is not possible to gain accurate data on the impact of these programs due to the inaccessible nature of the terrain and/or lack of funding for before-after-control-impact (BACI) research and analysis. However, it is possible to conclude from reviewing historical and contemporary land baiting trials, that there is reason to be greatly concerned. Aerial campaigns originally designed to protect agricultural interests have been re-deployed in recent conservation programs, designed to protect biodiversity and to eradicate an increasing number of introduced "pest" species. A review of the scientific and historical data raises concerns about the ethics, inefficiencies, indefinable impacts, and high uptake of baits by non-target species, throughout aerial baiting operations in agricultural and conservation zones. The report concludes that the impact of aerial baiting is essentially incalculable, and potentially environmentally hazardous. The risks of these programs have been greatly understated in published reports and reviews over the past 70 years.

Key words: Dingo, wild dogs, 1080, strychnine, aerial baiting, environmental history, Australia, conservation, pest control, ecosystem management.

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The War Against the Dingo

> *I do not like indefinite poisoning and [aerial baiting] is the most indefinite ever undertaken. No one has a clue about what percentage of the baits are eaten or what is eating them, yet secretaries and presidents and treasurers are delighted to be photographed in the act of loading the meat into aeroplanes (Rolls, 1969, p. 455).*

In 1946, Australian landholders were recovering from the aftermath of the Second World War and struggling to maintain production and profitability. Between 1937 and 1945, the Australia sheep flock had dropped from 130 million to 98 million. Cattle numbers reduced by 60% in what was to be known later as the Ten-Year Drought, running from 1937 (ABARES, 2019). Much of the blame was directed away from the climate (effects evident in Figure 1), and towards the thriving dingo and rabbit populations that had moved into agricultural regions *(Poison baits for dingoes*, 1946). The cost of dingo destruction to stock during the war years of 1938-1945 was anecdotally

Figure 1: Drought starved sheep gather on dusty ground in the Wimmera, 1945. Source: Argus Newspaper Collection of Photographs, State Library of Victoria. Accession no: H2002.199/1367

tallied up and broadcast to the sum of £1,000,000 (*One fence: 600 miles*, 1947). A multi-faceted approach towards rejuvenating the agricultural industry was instigated – optimistically preceding the end of the drought.

Plans were drafted to repair the deteriorating dingo barrier fences (DBF), joining them up to make a continuous barrier fence running from the Queensland coast, around the NSW borders, and across South Australia to the Great Australian Bight (Philip, 2017; Woodford, 2003). In 1960 the DBF was over 10,000km long, sweeping up around the Queensland interior. The fence fell into disrepair and was shortened to the current 5,516km environmental barrier (Figure 2) in the 1980s.

Government funding increased towards ground baiting, traps and bounty schemes (*One fence: 600 miles*, 1947 p. 1). However, the main innovation heralded in 1946 was aerial eradication control.

Aerial Agriculture

The concept of aerial farming had been born in New Zealand in 1906. Inventor/farmer John Chaytor took to the sky in a hot air balloon, and threw seed out over the marshlands on his farm in South Island's Wairau Valley, Marlborough Region (Bridges & Downs, 2014). However, it was technically illegal to throw anything out of aircraft (bombs excepted) in Australia and New Zealand, until after 1945.

The United States Agriculture Department developed aerial crop dusting in 1921, in a joint venture with the US Army Corps. This involved the application of dry chemicals - initially lead arsenate - from fixed wing aircraft to protect crops from invertebrate pests and disease (*The History of the Agriculture Plane,* 2011). Expanding on this technology, the Australians pioneered the application of aerial vertebrate pest control in 1946. De-mobilized Royal Australian Air Force (R.A.A.F.) pilots found work broadcasting poison baits from the air to address the perceived super-abundance of dingoes that had taken over landholdings during the war years (*Aerial war against Queensland dingoes*, 1946).

It was the R.A.A.F.'s involvement from the first test flight on 18 July 1946 that made aerial baiting a reality (*Successful test with dingo baits from air,* 1946, p. 1):

> *Civil Aviation refused to waive the regulation forbidding the throwing of any object from a civil plane. Qantas officials were able to get last minute help from the R.A.A.F. at Amberley. A service Liberator and a flying crew were made available for the experiment.*

The trial involved the dispersal of non-poisoned brisket (fat) baits from the air at various altitudes. It was announced a success by Arthur Jones, the Minister for Lands (without coordinated assessment or investigation), paving the way for further trials. *The Canberra Times* reported in June (*Aerial war against Queensland dingoes*, 1946):

> *Arrangements are being made for millions of tablets, each containing a grain of strychnine, to be flown from England to Queensland within the next month. The tablets will be inserted in the baits as they arrive and aerial dropping will then begin.*

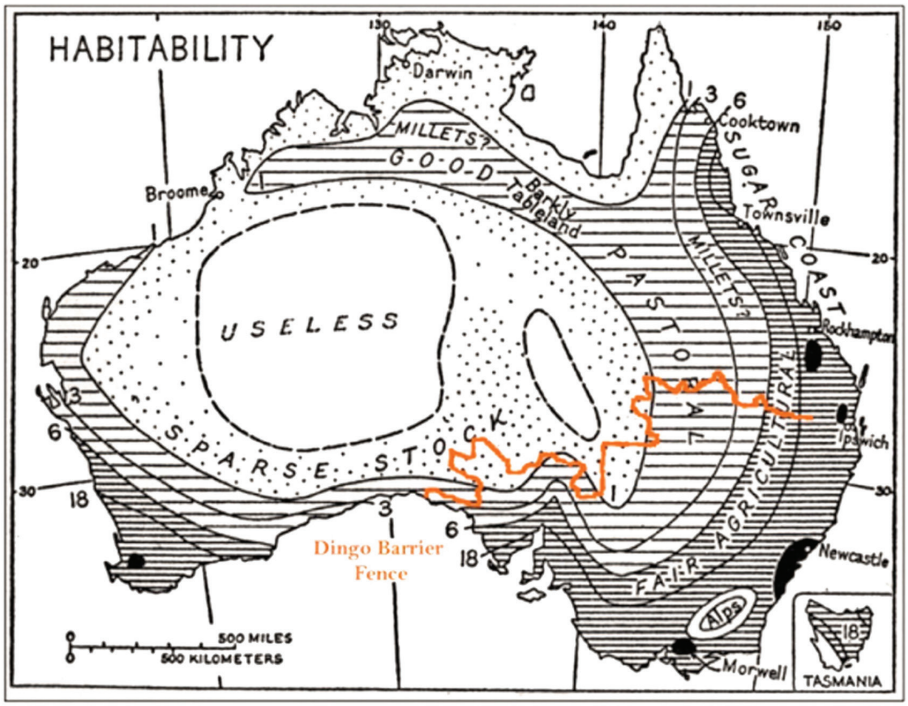

Figure 2: The dingo barrier fence 2019 (DBF) positioned over a map of Australian agricultural zones by geographer Griffith Taylor, 1923.

War Rhetoric

It was the Queensland and Western-Australian Governments that implemented the first programs. The first '*test aerial bombardment to combat the dingo menace*' using strychnine baits, commenced significantly on Remembrance Day, November 11, 1946 (*D-day for the dingoes,* 1946, p. 2). The project was considered a victory and supported by an enthusiastic press and government funding. The press employed all the rhetoric previously dedicated to the war effort:

> *'NOVEMBER 11 TO BE D-DAY FOR DINGOES' (31 October 1946); 'D-DAY FOR DINGOES War Begins On Armistice Day' (4 November 1946); 'AERIAL DINGO POISONING' (18 November 1946); 'AIR BLITZ ON THE DINGO' (17 January 1947);'RECORD AIR RAID ON DINGOES' (30 April 1948); 'AERIAL WAR AGAINST THE DINGO' (2 August 1948);*

Graziers Concerns

Before the first major operation began, there was outspoken condemnation of the campaign from the Graziers, publishing their concerns (*Dingo baiting criticism*, 1946):

> *As anyone knows who has laid out many of these baits, the dingoes soon get shy of them, and won't pick them up, much less eat them. Though this method may get a few inexperienced dingoes, it will also surely get innumerable pest-eating bird, such as magpies, small hawks, butcher birds, crows, and probably curlews and ibis.*

Farmers wrote in to the media, claiming that they had *never* known a dingo to be poisoned by the Government brisket baits with strychnine *tablet*s inside – one Grazier reported distributing over 200 baits, yet could not attribute to them the destruction of a single dog on his property (*Dingo Poisoning Campaign,* 1947).

The use of vertebrate pesticides had been mandatory on Australian landholdings for the past 100 years, with penalties imposed on anyone who failed to comply (Philip, 2019). This legal enforcing of lethal pesticides commenced with the first Dog Act in 1852 (6 Victoria, No. 44) promoting the destruction of the dingo with strychnine; costs were to be shared by neighbors. A society for the Destruction of the Native Dog had been established as early as 1811.

E. D. Wells, Rockhampton (*Dingo baiting criticism*, 1946) wrote:

> *Why waste time and money on them? The baits were first introduced to make it easy for the grazier to fulfill conditions. We were subject to a fine not exceeding £100, for not taking steps to destroy dingoes, etc.*

Despite this long history of employing agrochemical farming systems in Australia, the Lands Department received dozens of letters claiming that the aerial baiting scheme was a waste of money – particularly as the continuing drought provided ample feed to the dingo population, as an interview with W. H. Edwards records (*Graziers critical of dingo baiting plan*, 1946):

> *Dropping baits over thousands of square miles "willy nilly" must result in great waste of poison and wholesale slaughter of bird life, with an ultimate increase in insect pests ... It seems folly, Mr. Edwards states, to embark upon any scheme of dingo destruction in any part of Australia while animals are sprawling in death in thousands, as is the case at the moment.*

First Operations 1946-50

The criticism was rejected and baiting trials continued by the Queensland Government. In the first operation, 367,000 strychnine baits were dropped from planes. The campaign lasted 21 days, covering 156,000 square kilometers of dingo breeding territory in the northwestern corner of Queensland. The Land Minister stated that "*Costs of dropping baits from the air would be little in excess of the wages of one dogger for 12 months*", equating to around 2 shillings per mile (*Aerial war against Queensland dingoes*, 1946).

The campaign was considered a victory, despite only recovering one dingo carcass during the trial. This assessment was established through the observation that there were far fewer dingo tracks after the baiting than before. This was taken as an indication that the dingo had been effectively eradicated, though they may have just relocated (Tomlinson, 1954).

In October 1947, the Dalrymple Shire in north-east Queensland commenced an aerial baiting campaign to deliver over three times the previous year's poison tally – the Superintendent for Stock Routes arranged for the distribution of 1.5 million baits in the remote dingo breeding areas, west of the sheep country (*Dingo Poisoning Campaign*, 1947). He announced that planes would cover an area "to the borders of the State, north to the 19th parallel of latitude, and across to the Great Dividing Range for an average depth of 160 to 180 miles."

A Dragon Rapid aircraft on charter from Qantas was fitted out with a purpose built poison dispenser (Figure 4): an electrically driven machine designed to distribute the baits at 60-70 baits per mile (*Dingo Poisoning Campaign*, 1947).

The campaign was conducted over 81 days, involved 94 flights, covered an aggregate distance of 45,500 kilometers, and 64 million hectares. Landholders were notified and 488 cases of meat baits were consigned to the Charters Towers Shire Council for the project.

Figure 3: Dingoes feeding on cattle carcass, Queensland *n.d.* Source: CSIRO

Figure 4: Interior of the Dingo bait-laying plane, Eagle Farm, 1949. Source: Queensland State Archives Item Item ID: 1252426, Photographic material.

The following year, *The Argus* announced (*Record Air Raid on Dingoes,* 1948, p. 1):

> *Two-and-a-quarter million baits will be dropped by plane over more than 200 million acres of Queensland and Northern Territory between July and August in a record aerial campaign against dingoes.*

Trials were also started in 1948 in the Barkly *Table*lands, Northern Territory, with 194,950 baits dropped at a cost of £1,800 – it was again a cheap and widespread campaign. However, a later Commonwealth Scientific and Industrial Research Organisation (CSIRO) assessment noted: "*It was localized and not followed up by a ground drive or survey, so no clear picture of its effect was obtained*" (Stephens, 1969).

By 1950, both the United Gaziers Association and the Queensland Local Government Association in Australia had spoken out publicly condemning aerial baiting, claiming the project a waste of money – mainly because they believed the birds and ants beat the dingoes to the baits (*It will be of breathtaking size–Australia's new Dingo Cage*, 1955). Results from a nationwide survey conducted at this time by N.M.G. Macintosh at the University of Sydney (Challis Professor of Anatomy, 1955), also concluded that Graziers were overwhelmingly unsupportive of the new aerial baiting technology (van Eeden *et al.,* 2018b).

Trappers did not support the project, claiming that the dingo was extraordinarily intelligent and would not take the bait. They claimed that given the difficulty that they often had in catching them with traps, guns or ground baiting, aerial control would be ineffective. One trapper wrote the following account (Dingoes, *The Bulletin*, 1959):

> *I have been after dingoes' scalps for over 50 years, and I agree that aerial baiting is not generally successful It's impossible to estimate how many dingoes would be killed by this method … I have laid baits and set traps, using all the wiles I know. The dingo comes along, sniffs the bait or trap, lifts his leg and fouls it, then turns and kicks some dirt over it – just to let you know that he has passed that way.*

Tomlinson's Report 1954

The Western Australian Government commenced a research project to gather data from aerial baiting programs, to set the Grazier's fears to rest. The Tomlinson report, published in 1954, detailed the distribution techniques and quantities of baits deployed from 1948 to 1953, and the results included the number of dingo carcasses recovered. The target zones were described as mainly areas surrounding water-sources (Tomlinson, 1954, p. 42):

> *In the dry season campaigns, the baits are dropped on water-holes, soaks, junctions of dried water courses, gorges in hills and all places where dogs must travel or gather in their search for water and game and in their movements with pups from the breeding areas.*

Analysis of the data in the Tomlinson report showed that on average 14,941 baits were dispensed for every dingo carcass recovered (*Table* One). Early rains had compromised the results, but on the first test drop 300 dog carcasses were found. However, this was later attributed to the lack of experience of the planners. They had dropped baits near station properties and settlements, much to the distress of the communities who lost their domestic and working dogs as a result.

In the conclusion to the project, the use of poison baits was considered successful. Distribution from the air reduced costs, making dispersal of the baits between 3 to

Table One: Research data results from the aerial baiting program 1948 to 1953, collated from the Tomlinson 1954 report (J. Philip).

Year	Number of Baits	Total number of dingo carcasses recovered	Ratio of baits per carcass
1948	285,000	300	*950 to 1 Data unusable*
1949	455,000	25	18,200 to 1
1950	590,000	27	21,852 to 1
1951	130,000	38	3421 to 1
1952	507,000	20	25350 to 1
1953	350,000	26	13,461 to 1
Total	**2,032,000**	**136**	**14,941 to 1 (Average)**

8 times cheaper than distributing them on the ground. It was, however, considered less effective than ground control, and the final recommendations were for both aerial and ground baiting to be done simultaneously to obtain the best results (Tomlinson, 1954, p. 49).

NWG Macintosh, 1954

Tomlinson's findings were not without their critics. Dr, N.W.G. Macintosh was conducting behavioural trials on dingoes over this time, in addition to conducting a nation-wide survey (van Eeden *et al.*, 2018b), and raising a captive population of dingoes in the basement of the Anatomy and Histology Department on campus at the University of Sydney (Figure 5). Macintosh concluded that most of the money spent on eradication programs, including aerial baiting and barrier fencing, had been wasted. He wrote (Reading & Macintosh, 1954): "After the rabbit, the dingo is Australia's greatest pastoral pest … The conventional dog-proof fence is not high enough; poisoned baits dropped from the air do not tempt the dingo." From Macintosh's behavioural trials, the dingo fence would need to be extended to 3 meters in height to present an effective barrier to the dingo – it averages around 1.8 meters high, an issue that has never been resolved, despite millions dedicated to its annual upkeep.

Years later, Macintosh revised his attitude towards dingo control. Anthropologist A.P. Elkin recorded (1978, p. 129):

> *Macintosh made a study of the dingo one of his major interests ... he did conclude that what had been regarded as a pest was actually a potent factor in the balance of nature, and that people on the land had deprived themselves of an asset, and at much cost. Indeed, he formed the idea after years of inquiry that the dingo served "a useful role as a predator on such pests as rabbits, marsupial mice, feral cats and as a remover of carrion" although it did make sporadically attacks on lambs and perhaps calves.*

Research trials, 1968-1972.

Twenty-one years after the aerial campaigns first began in 1947, the Australian Federal Government's CSIRO commenced the first comprehensive four-year long study to test the effectiveness of aerial baiting. The consensus was that the Tomlinson 1954 report was far from conclusive. The CSIRO report, published in 1972, stated (Newsome *et al.* 1972, p. 3):

> *No previous evidence has been obtained on the baiting campaigns anywhere in Australia … The effectiveness of aerial baiting is usually assessed on circumstantial evidence of declines both in scalp bonuses paid afterwards, and in killing of stock.*

The project commenced in 1968, and the first test involved dropping 175,000 brisket baits containing *table*ts of strychnine in a central Australian region. The conclusion was that the baits were found unpala*table* to dingoes, and were mainly eaten by ants – in fact the number of dingoes increased over the course of the study (Newsome *et al.*, 1972).

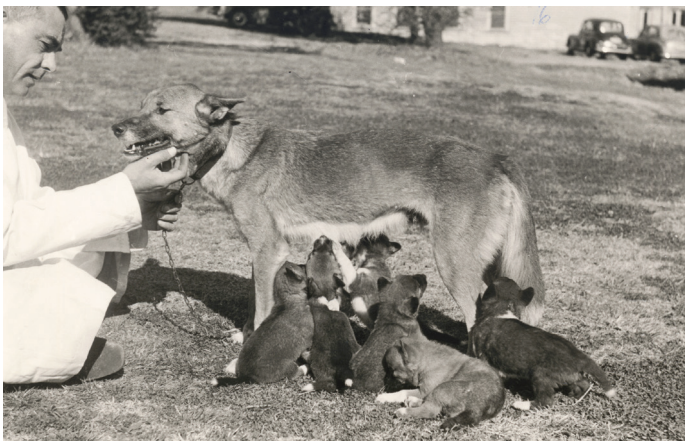

Figure 5: NWG Macintosh and dingoes at the University of Sydney, c.1950s. Glass Plate Negative, by permission of the NWG Macintosh collection, J. L. Shellshear museum, University of Sydney.

The researchers also trialed feeding the baits to a captive population of dingoes and recorded the following results, confirming Macintosh's statement that "*poisoned baits dropped from the air do not tempt the dingo*" (Reading & Macintosh, 1954), along with the Graziers and trappers concerns published in the 1940s (Newsome *et al.,* 1972, p. 9):

> *Six dingoes from the CSIRO kennels and two mongrels from Alice Springs pound, weighing from 17 to 44lb were deprived of food for a day and then presented with baits. The animals did not treat the baits as food. They played with them, tossed them around, rolled on them, and even urinated on them … Two of them, a mongrel and a dingo, did eventually eat baits, but the others had to be given the strychnine tablets inside fresh meat … All died, but the time taken to do so varied enormously.*

It took from 0.75 hours to 12 hours for the canines to die from the poison. The baits were still toxic after 14 weeks. The scientists concluded (p. 10-11, *original author's* emphasis):

> *There is no doubt that this aerial baiting campaign against dingoes was a failure, just as earlier campaigns using similar baits in the Northern Territory appear to have been (Stephens, 1969). Excellent seasons and unpalatable baits are the most likely causes of the failure …* It is important to emphasize that, though this aerial baiting campaign was a failure, such a conclusion does not necessarily apply to any other campaign.

A review by CSIRO researcher, D. R. Stephens, titled *Dingoes, a relentless war,* was published in 1969. Stephens examined a large co-operative pest elimination scheme using both ground baiting and aerial baiting in the Kimberly of Western Australia. The results from the distribution of 300,000 baits turned up 9 dingo carcasses in the week following the baiting. The baits were dropped along each side of all major rivers and creeks, with concentrations in breeding areas of rough basalt country that was otherwise inaccessible. This terrain made evaluation of the results of the baiting "*particularly difficult*", Stephens noted (p. 139). The results, reviewed in *Nature Walkabout*, state (*Dingo Bait*, 1969):

> *Results showed clearly that baiting was not effective, Dingo numbers fell insignificantly on six properties, including two of the three unbaited properties used as controls, but rose on all others and almost trebled on the property with the most dingoes.*

Stephens included data from the inspection of dingo stomach contents in the evaluation, and found that their diet consisted mainly of lizards, rodents, rabbits, wallabies, dried hide and carrion – in addition to donkeys, pigs, brumbies and camels. The general consensus from scientific studies into the diet of the dingo, is that around 4% of their diet consists of livestock (sheep/cattle) – noting that some of this is no-doubt carrion (Stephens, 1969; Corbett, 1995).

This analysis of the research data is indicative of what Van Eeden *et al.*, (2018a, p. 33) describe in the evaluation of large carnivore-livestock conflict worldwide: " *success was measured as either financial investment or management effort.*" - that is, success has been measured by the number of baits dropped and amount of funding raised. Measured impacts on target and non-target species on the ground is lacking. The absence of experimental design, standardization, and response variables to mitigation or carnivore conflict is an area of investigation that remains unresolved today (van Eeden *et al.*, 2018a). Establishing landscape-wide dingo and wild dog control programs based on anecdotal evidence has remained largely unchallenged within Australian agrochemical operations since the 1950s.

New South Wales 1973

An additional scientific research project was conducted in New England, New South Wales in the early 1970s, looking at dingo movements and diet. The results of this research also tested assumptions about the dingoes' behavior, and the severity of their threat to livestock. The results, published in 1973, found very little evidence that dingoes preyed on domestic stock, and they did not range widely as was assumed (hence the broad-scale of aerial baiting up until that time). Bob Harden, the principal researcher of the project, expressed alarm at his findings (*[The] Good Side Of Dingoes* 1973, p. 9):

> *How, he asks, could a civilized highly developed country like Australia have permitted the broad use of aerial baiting without a thorough test of its suitability?*

Harden raised concerns that the continued persecution of the dingo would reduce their numbers to the point where harmful ecological changes would occur. Evidence had indicated from his study, that the removal of dingoes led to a prevalence of wallabies and other herbivores (*[The] Good Side Of Dingoes* 1973, p. 9). Harden warned that the resulting overgrazing and habitat damage could have serious impacts on water catchments. This echoes concerns of naturalists and scientists as far back as the mid-1800s (Philip, 2019). Dublin born director of the National Museum of Australia and President of the Royal Society of Victoria, Frederick McCoy, had noted the superabundance of herbivores in the absence of the dingo, in 1866 (cited in Smyth, 1878, p. 18):

> *The native dog has been almost exterminated in the more open parts of Victoria; and other animals formerly his prey hare multiplied exceedingly. I have seen mobs of kangaroos in the Western district so large as to defy even an attempt to make an approximation to the numbers.*

Decline in the National Sheep Flock, 1970-2017

The national sheep flock numbered 180 million in 1970. This fluctuated, eventually reducing by 60% to 70 million, over the following 4 decades – see Figure 6 (ABARES).

The overall decline was due to multiple factors including long-term droughts and reduction in global demand. This decline followed similar trends in other sheep raising nations in the region without dingo populations. The New Zealand flock declined from 70 million in 1982 to 27.3 million in 2017 (NZERS, 2019).

Dingo control has, however, continued over this time, developing new techniques in ground and aerial dispersal of raw meat baits, laced with 1080 poison. The dingo's actual contribution to the decline in the national flock has been arguably so small as to be insignificant when compared to other factors, as reviewed by Forsyth *et al.* (2014; p. 461):

> *The five detailed reviews published on Australia's sheep industry since 1990 all attribute Australia's declining sheep flock to a long-term decline in the real price paid for wool compared with other textiles, and to the high cost of growing and processing wool, reducing the profitability of wool growing relative to other agricultural products. A similar conclusion was reached for the cause of declining sheep flocks in New Zealand and the USA.*

Thomson Report 1986

More testing was conducted on aerial baiting in the 1980s, with research scientist P. C. Thomson publishing results of trials in northwestern Australia. In these trials, 750 baits were distributed for each dingo carcass recovered, a far lower bait-to-kill ratio than 1970s figures. This was considered a cost effective and successful outcome (Thomson, 1986). The use of 1080 (sodium fluoroacetate) replaced strychnine largely from 1970 onwards in dingo/wild dog baiting. It is considered less damaging – though not without risk – to non-target wildlife (Fleming *et al.*, 2001). Other campaigns, such as aerial baiting against mouse plagues, continued to use strychnine until it was banned in 1997, "*...not because of its dangers but because of Australia's need to meet international residue standards for exported products.*" (Caughley, 1998 p.15).

AVPMA regulations vs. pest control boards

In 2008, the Australian Pesticides & Veterinary Medicines Authority (APVMA) regulations specified that to reduce risk to non-target species using 1080 baits, a maximum of 10 baits per km transect (a linear measure) should be implemented for dingo/wild dog aerial baiting programs. This distribution rate was found to be inadequate to impact significantly on canine populations in trails run by the Department of Primary Industries and published by Fleming and Bollard, 2014. They found that laying 40 baits per km^{-1} was necessary to achieve around a 90% kill rate of collared/radio tagged

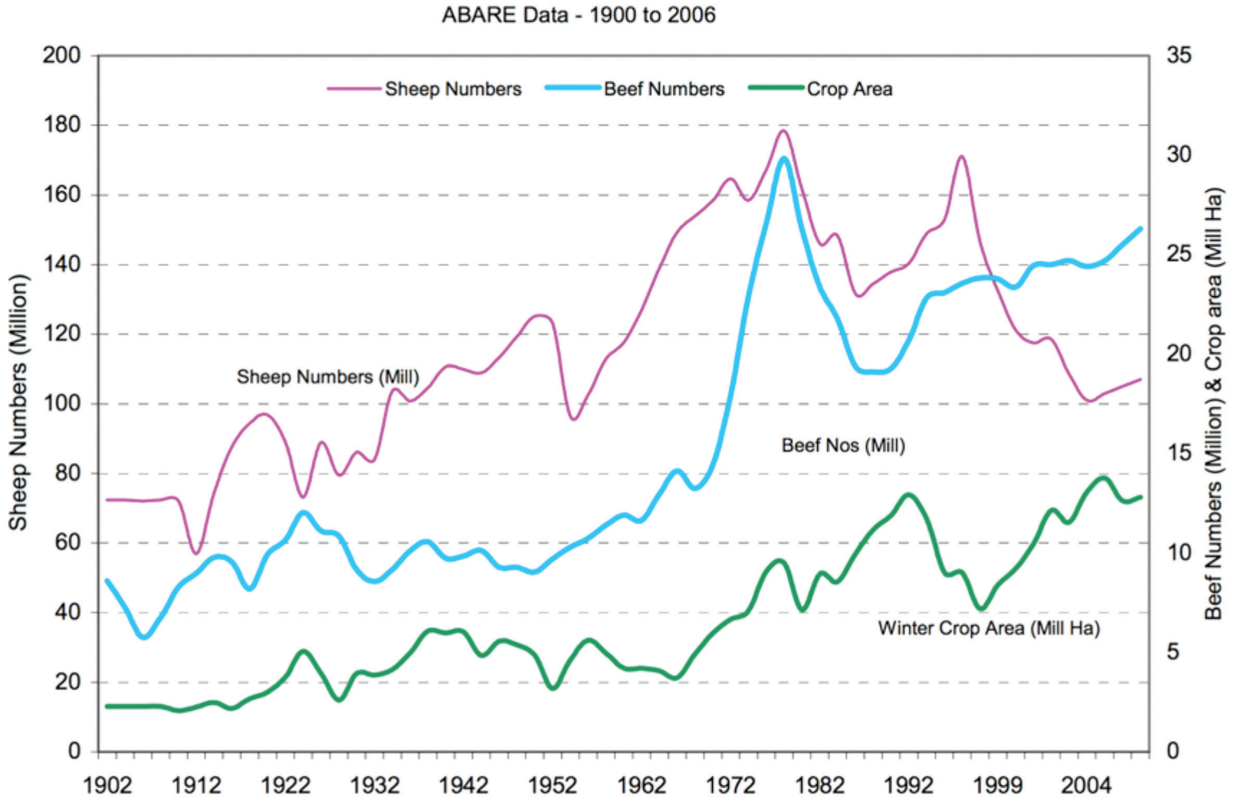

Figure 6: Sheep numbers, beef numbers and crop areas (ABARES 2006).

wild dogs and dingoes in their study. They did not record the total number of baits used in the trials.

Ten years later, the wild dog baiting teams still did not observe this DPI research - it seems that finding a compromise between the safety of wildlife and the efficacy of canine eradication is not possible. A campaign in 2018 distributed almost 50,000 baits following the AVPMAs ineffective regulations of 10 baits per km^{-1}. *The Western Magazine*, Dubbo, announced on September 25 2018: (*Aerial baiting starts, ready for a dog fight.* p. 10):

> *A massive aerial baiting program of almost half of NSW is about to get under way as the wild dog problem moves inexorably south. More than 49,000 baits will be dropped from an aircraft at more than 500 feet along ridge lines and in inaccessible country from the Queensland border all the way down to Balranald ...*
>
> *The aerial baiting is done at a rate of 10 baits per kilometre. That equates to 12,250km of baited land. The aerial baiting follows an on-the-ground baiting program over the last few weeks with 87,000 baits put out over about 19 million hectares in the Western Division ... "The thing with 1080 is that the results are not often seen as the dogs may not die for a week. "*

These numbers are greater than the previous autumn dingo/wild dog baiting program in 2018, that included distribution of 18,300 aerial baits "*broadcast in hilly and inaccessible country managed by National Parks, State Forests and Crown Lands land, as well as privately owned farms.*" in the Central *Table*lands of NSW ("*Central Tablelands autumn wild dog baiting completed.*" 2018).

Plans for autumn baiting in 2019 were announced in the media in December of 2018, indicating that aerial baiting control has gained popular support among farming communities in an increasingly industrialized and agro-chemical reliant environment. Bait rates are increasing with a 'cross-tenure' or 'nil-tenure' approach to dingo management, that enforces a landscape wide, coordinated approach to dingo control across both public and private land (Fleming *et al.*, 2001; van Eeden *et al.*, 2018b). This is outlined in the "*Central Tablelands autumn wild dog baiting program.*" 2018 report:

> *Central Tablelands Local Land Services is gearing up for the autumn wild dog baiting program [2019] ... Senior Land Services Officer Paul Gibb, says the campaign planned for next autumn will be conducted along up to 900 kilometers of aerial bait trails on the eastern boundary of the Central Tablelands region, a significant increase on the 477 kilometers of bait lines in 2018.*

The campaign indicates no sign of slowing down, despite the region being in severe drought at the time of the planning. The yearly increase in bait rates is concerning given that the protocols for dispersal have been proven to be ineffective. There is also no consensus across Australian States for regulations controlling aerial baiting – the quantity of baits applied, the level of poison per-bait, protocols for bait recovery etc. In Tasmania, 1080 baits are used to target native grazing marsupials to protect commercial forestry, with the dose rate per-bait many times higher than considered accep*table* (or legal) on the mainland (AVPMA 2008).

Ground Baiting Results, 2018

An on-ground baiting project by Tracey Kreplins *et al.* (2018) in Western Australia, 2018, titled "Fate of dried meat baits aimed at wild dog (*Canis familiaris*) control", gives valuable insight into the potential impact indefinite baiting has on non-target species. These data would be impossible to gather in an aerial baiting campaign due to the difficulties in tracing objects dispensed from planes, in addition to the often inaccessible terrain covered. However, the results are clearly correlative. Researchers installed camera traps and sand pads to record the uptake of 936 ground-laid meat baits, laced with broad-spectrum sodium fluoroacetate (1080) poison, targeting dingo/wild dog populations in the southern rangelands of Western Australia. The research was conducted over a period of 18 months, 2016-2017. Of these, 337 baits had a known fate (36%), with a total of 4 baits consumed by (juvenile) dingoes. This makes a ratio of 84:1 known bait fates per-dingo (234:1 if the results include all baits of known and unknown fate). This ratio is significantly lower than earlier trials – note the researchers were also testing the effectiveness of applying a fish oil lure. What is concerning is the uptake by non-target species of 71%, with only 1.25% attributed to dingoes (see Figure 7).

The report records that the wild dogs/dingoes (Kreplins *et al.*, 2018, p. 531) "*... left baits on the ground despite locating them and interacting with them (e.g. sniffing the bait, rolling on the bait, urinating on the bait)*".

In the research conclusion Kreplins *et al.*, wrote (p. 537):

> *The overall aim of a wild dog control program is to reduce livestock and financial losses to producers. Interference by non-target species and wild dog aversive behaviour towards baits are hindrances to these programs ... alternative control strategies may need to be incorporated into current landscape-scale baiting programs. Varying bait types frequently could minimize bait aversion and capitalize on curiosity for novel objects shown by many canids.*

This conclusion does not clearly address the poor uptake by the target species, the potential harm inflicted on non-target species, and offers no insight into the mysterious disappearance of 599 baits that evaded ground and camera surveillance.

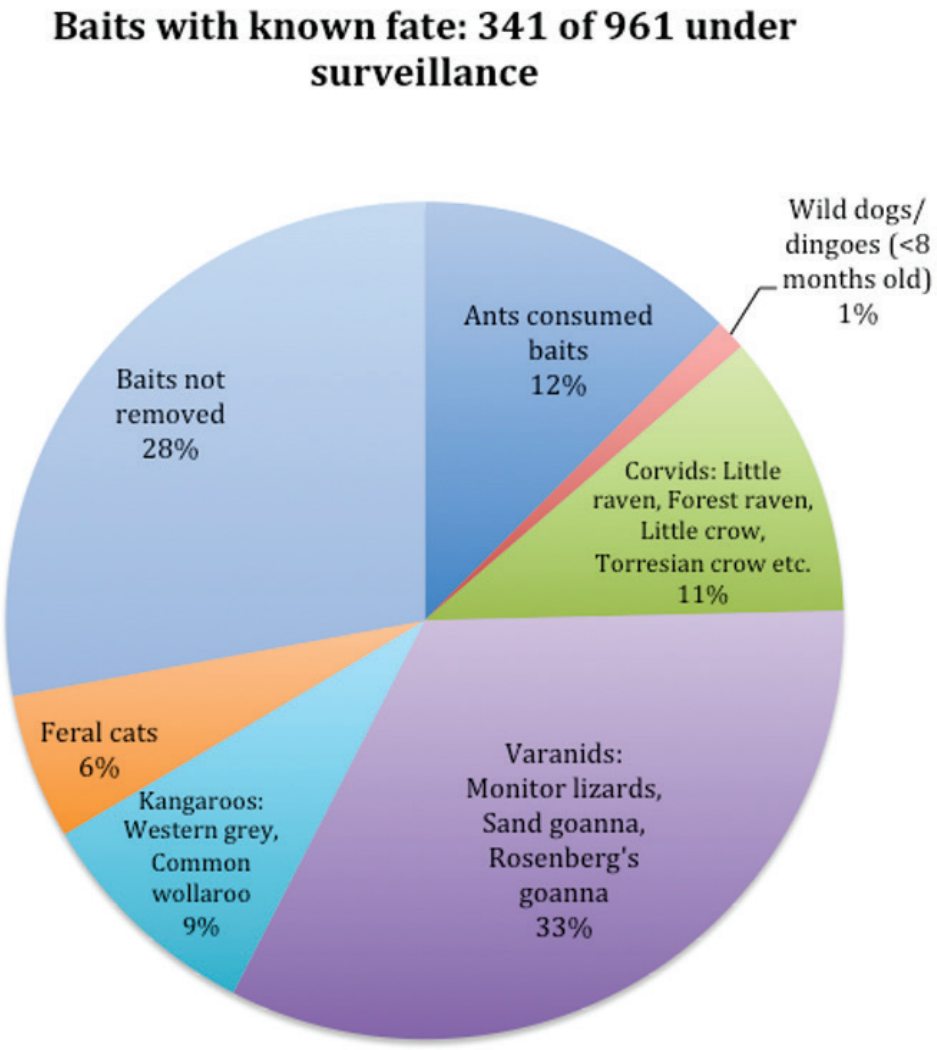

Figure 7: Published results of known bait uptake from Kreplins *et al.*, 2018 trial.

Native species have a greater natural tolerance to 1080 than canines. However, a CSIRO report by McIlroy (1981) established that repeat doses can be fatal. Juveniles are more susceptible to the poison than adults, and pouch young die from very low (supposedly non-lethal) dosages transferred through their mothers milk - this result was observed in trials with tammar wallabies, *Macropus eugenii*, brush-tailed possums *Trichosurus vulpecula*, and the endangered northern quoll, *Dasyurus hallucatus*. Sub-lethal doses may also affect reproduction, health and mobility. This data is not included in the Kreplins study.

In a report, published by the NSW Office of Environment and Heritage, Professor Lesley Hughes (2008) noted that though 1080 poison has been used since the 1950s, there has never been standard protocols for its application across Australia, and that evidence of the impact on non-target species was "*largely anecdotal*" (Hughes, 2008):

> *... Secondary poisoning is possible through consumption of undigested bait in the stomach of a poisoned animal. Target species sometimes vomit stomach contents containing high concentrations of 1080, which is then potentially eaten by non-target fauna. Maggots in meat baits can accumulate enough toxin to kill a vertebrate (e.g. insectivorous bird) that picks multiple maggots from the bait. Secondary poisoning has been demonstrated to kill individual non-target animals but no data are available demonstrating that such poisoning can cause significant reduction in the population sizes of native species in NSW.*

Hughes wrote that the negative impacts were "*potentially great and mortality of individuals has been recorded*". However, she supported continued baiting programs, because (2008):

> *... there is currently no substantive evidence that, in NSW: (a) it adversely affects threatened species, populations or ecological communities, or (b) could cause species, populations or ecological communities that are not threatened to become threatened.*

Discussion

In 2019, biannual aerial baiting continues to thrive in south-east Australia, and threatened species populations continue to decline. The industry itself is vast, as noted by ecologist Jamie Steer (2015, p. 52):

> *Pest management has become a multi-billion dollar worldwide industry ... the costs of this industry do not necessarily equate with benefits and, more importantly, that the industry itself is now a major impediment to notions of [ecological] reconciliation.*

NSW currently has nearly 1000 species of animals and plants listed as at risk of extinction by the NSW Department of Environment and Heritage. The Western Division of NSW – an area targeted with 87,000 baits, over 10 million hectares in 2018 (*Aerial baiting starts, ready for a dog fight*. 2018, p. 10) – is one of the most vulnerable regions in Australia (Dickman *et al*., 1993; Lunney, 2001). Historical and recent data elucidates on both the scale and the very real potential for catastrophic damage to occur through these actions (Philip, 2018). Both the removal of the influence of the top order predator (the dingo), and the uptake of baits by non-target species in this landscape wide environmental intervention, has potentially destabilized the entire ecosystem.

Pest management is greatly influenced by cultural, political and economic factors. The target species such as the dingo have impacted on agricultural production over time, though they exerted very small influence when compared to climate and economic forces (Forsyth *et al.,* 2014). However, dingo/wild dog control has been an essential component of the agrochemical farming system in Australia for close to 200 years (Philip, 2019). The impact of the removal of dingoes from the environment has rarely been considered in assessments of eradication projects, or considered alongside the toll on non-target species. Before-after-control-impact (BACI) data are difficult to obtain even in controlled experiments such as described by the Kreplins *et al*. (2018) study. However, the role of the dingo in ecosystem function and resilience has been explored by ecologists with significantly favorable results (Dickman & Lunny, 2001; Glen *et al.,* 2007; Letnic *et al*., 2012).

Methods of pest control move in and out of favor over time, including bounty schemes, trapping regulations, poison controls etc. The editor of *Nature Walkabout* wrote a review of the 1969 Stephens paper on dingo control, stating that "*the philosophy of the quick dollar should not be allowed to ruin the environment*", and addressing underlying economic and political powers at play in the field of pest management (*Dingo Bait*, 1969):

> *Years ago when I asked a politician friend why they kept on paying bonuses on "vermin" when it had been proved that such methods were useless, his reply was "useless for controlling pests, but marvelous for controlling votes".*

The CSIRO report on agricultural adaptation to climate change by Pavey & Bastin (2014), suggests that moving away from dingo/wild dog control to more inclusive land management practices is almost inevi*table* in coming decades. This would reduce the need for vertebrate pesticides, and establish farming systems more compatible with the Australian environment. This would come at a time when environmental conditions are increasingly demanding (p. 19):

> *The distribution and abundance of dingoes within the Rangelands Cluster is predicted to increase in response to both climate change and changes in rangeland management ... The management changes are twofold. Firstly, there is a growing appreciation of the positive impacts of dingoes on ecosystems and of the need to manage them appropriately as a keystone species (e.g. Ripple et al., 2014). Second, dingoes are persecuted most heavily in sheep-grazing regions. The extent of sheep grazing in the rangelands of Australia is declining steadily, as it is in other parts of the world (Forsyth et al., 2014) and as this happens the need to control dingoes will decline.*

The benefits to local ecology from this step back from lethal dingo control are potentially enormous.

In conclusion

Millions of strychnine baits were broadcast from the air each year across Australia's remote regions from the late 1940s. They were dispersed in and outside of designated agricultural lands, along watercourses, into and around waterholes. The campaigns were designed to eradicate wild canines, protecting unguarded livestock from predation. Over time the technology became more sophisticated. Strychnine brisket baits were replaced with raw meat baits containing 1080 poison in the 1970s, and these were distributed in the hundreds of thousands over the following decades to current day, into remote agricultural lands, National Parks and conservation zones.

The impacts of these campaigns cannot be accurately estimated. The clearest figures to date are presented in Kreplins' report (2018) into wild dog/dingo baiting, with records a 0.4% to 1.2% chance of uptake by the target species, and around 71% to 89% chance of uptake by non-target species. Bait to target (dingo-kill) rates vary from the 1950s: 0.007%; the 1960s: 0.003%; and the 1980s: 0.13% to target. These are disastrously low results that bring to question the ethical, ecological and economic viability of these programs.

Australia has been a trailblazer in the area of aerial baiting technology. After trials began in 1946, the broadcasting of poison baits became an integral part of Australia's agrochemical farming systems. The technology has recently been re-deployed increasingly against a growing number of

vertebrate introduced "pest" species held responsible for the country's current and escalating biodiversity crisis.

This historical review of aerial baiting presents compelling evidence that the dangers of this technology have been greatly underestimated. The long view of the history and science behind aerial baiting suggests it has left a catastrophic legacy. The continuation of aerial baiting campaigns represents unacceptable risk to the survival of Australia's most vulnerable native wildlife, presenting potentially a key threatening process to the survival of ecosystems within the most remote, fragile and inaccessible of environments.

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