Report on killing wildlife to control bovine tuberculosis (*Mycobacterium bovis*) in New Zealand

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Summary and Recommendations

Since the 1970's, New Zealand (NZ) taxpayers and farmers have been paying for the lethal control of introduced Australian brushtail possums (*Trichosurus vulpecula*), claimed to be the main wildlife reservoir of bovine tuberculosis (*Mycobacterium bovis* (Tb)) and vector of the disease to cattle and deer on farms.

Possum control includes wide scale aerial poisoning campaigns with negative effects including animal suffering, deaths of native wildlife, an enduring risk to dogs in carcasses, and increasing rodent populations.

In 2025, NZ's livestock have been internationally (World Organisation for Animal Health) qualified as Tb free for over 10 years. Nevertheless the country is facing years of poisoning in pursuit of complete Tb eradication, which may not be feasible through targeting possums due to its widespread presence in a range of mammalian wildlife.

The Tb control strategy's focus on killing possums has been criticised on both veterinary and economic grounds, and predictions from its underlying mathematical modelling, based on assumptions and sparse data, may be incorrect.

Review, transparency, measurement and an evidential, science-based strategy are needed. Consideration of Tb management techniques used in other countries such as France, which has a similar situation to NZ, is advised.

Recommendations

1) Independent Reviews
- Costs, benefits and risks of attempting bovine Tb eradication in NZ wildlife.
- Epidemiological examination of OSPRI-funded Landcare Research studies on bovine Tb in wildlife in Westland.
- All government and government-funded reports and data on bovine Tb in farmed cattle and deer, and wildlife, to be made available for public review.

2) Methodology
- PCR testing and/or other improved techniques to be used in Tb surveillance.
- Bovine Tb lesions reported in slaughtered livestock to be differentiated, quantified and reported as either infectious or inert and the source herds followed up and managed accordingly.
- The prevalence of bovine Tb to be surveyed in all mammalian wildlife.

3) Policy
- Strong support for farm-based management of bovine Tb, including recognition of the importance of animal welfare such as nutrition and shelter, and environmental contamination.
- Change the Biosecurity Act to require direct epidemiological evidence that bovine Tb exists in targeted wildlife in an area before control is applied.

- Legislation to address bovine Tb biosecurity in killed wild and feral animals, including pigs and deer.
- Humane, science-based wild animal surveillance and control, managed and assisted by all stakeholders.

1. Introduction

In the year ending June 2024, 30.6 million dollars of New Zealand (NZ) taxpayers' and farmers' money was spent killing the introduced brushtail possum (*Trichosurus vulpecula*), for its claimed roles as a wildlife reservoir and transmission source perpetuating bovine tuberculosis (*Mycobacterium bovis*, Tb) infections in farmed livestock (1). Possum control included aerial treatment of 300,000 ha of farmland and wilderness, over which cereal food baits laced with sodium monofluoroacetate ("Compound 1080" poison) were spread from spinner buckets beneath helicopters (1) (p.57).

Possum control using aerial poisoning has been carried out in NZ for over 70 years (2). The Tb control programme is conducted through a public-private partnership, OSPRI (formerly the Animal Health Board (AHB)). The National Pest Management Strategy for bovine tuberculosis aims to hold possum numbers below one possum per 10 ha for five years, at which time - according to mathematical models - Tb will die out in free-ranging possum populations, and subsequently disappear from all NZ wildlife (other wildlife hosts include red deer (*Cervus elaphus*), pigs (*Sus scrofa*), cats (*Felis catus*) and mustelids (*Mustela spp*.)), enabling its eradication from NZ (3). The current goals are to eradicate Tb from farmed livestock by 2026, achieve 'statistical freedom' from Tb in possums by 2040, and nation-wide biological eradication of Tb by 2055 (4).

For many years there has been no demonstrated economic benefit of the massive financial outlay on possum control - the AHB's argument that the economy was at significant risk from agricultural trade sanctions due to the presence of bovine Tb was identified as weak by economists in 2000 (5 and 2007 (6; 7), with the proposed AHB strategy in 2000 having "*the appearance of expediency and treating the Crown as a residual funder, a deep pocket to be picked*" (5, p. 17).

In 2025, NZ's livestock has been officially Tb free by international (World Organisation for Animal Health) standards for over 10 years (1; 8). There has been no human health risk to give purpose to the strategy (9, pp. 539-557), nor clear biological justification (possum to cattle transmission of Tb has not been demonstrated) (10).

The costs of aerial poisoning include animal suffering and environmental harm and upheaval (11; 12; 13). The aerially distributed 1080 poison kills indiscriminately, including native birds (14), introduced wild mammals (e.g., deer (15, p. 26) and hedgehogs (16)), livestock (17) and dogs, which are particularly sensitive and suffer horrifically (17; 18). The carcasses of poisoned animals remain an enduring hazard as they age (2; 19) and can lie in streams or be washed out of the treatment area; for instance dogs died after scavenging dead possums on a beach after a flood (17). Vastly increased numbers of rodents often follow aerial 1080 poisoning, with potentially devastating effects on their prey species (20-25).

In 2024/5, a group of researchers united in having longstanding concerns from their observations of bovine Tb management in NZ, investigated the possum-focussed policy. The group comprised an ecologist, a dairy farmer, a veterinary pathologist, a zoologist, a former NZ Forest Service employee, a former regional councillor, a professional trapper and two hunters. This report from the group addresses current issues in Tb control and makes recommendations. Further, Appendix 1 on pages 18 to 20 describes part of the history of Tb management, from the time of the index discovery in possums, up to 2000/2001, when the AHB set out to more than double its expenditure on vector control.

2. The focus on possums

Very early after the first discovery of clinical bovine tuberculosis infection in free-living possums, in 1967 (26), they became considered responsible for giving the disease to cattle, and gained high priority status in the decision-making of the NZ Tb control program. By the early 1970s the government body responsible for national animal health (the Ministry of Agriculture and Forestry, MAF) had reported more than 23 locations across New Zealand's two main islands where obvious tuberculosis had been found in possum populations (27).

At the discovery site and some others, Tb infection from possums was blamed for the disease lingering in cattle herds - whereas compulsory tuberculin testing of cattle and slaughter of reactors had reduced Tb prevalence elsewhere (27).

A detailed history of how possums became considered the major wildlife reservoir and vector of Tb to livestock is provided in Appendix 1, and includes major assumptions, overlooked evidence and misinterpretation of data. Further history, on the focus of funding for possum control instead of veterinary-advised livestock disease management, is detailed in Appendix 2.

3. Current issues

3.1 Poor quantification

3.1.1 Tb in possums

No proof of the existence of Tb in possums in an area has been required before enforcing control such as broad scale aerial poisoning (Biosecurity Act (1993), Section 114[1]). This shortcoming has been a source of frustration to those affected, such as landowners, or hunters who hadn't observed it in decades of processing possums (28).

OSPRI works within "Vector Control Zones" with the aim of progressively declaring each zone free of Tb (29). Freedom of Tb in wildlife is estimated using measured or inferred possum

[1] Biosecurity Act Section 114 General powers: An inspector or authorised person who has lawfully entered a place under section 109 or 111 may do anything in, on, or in relation to the place that the inspector or authorised person considers necessary or expedient to—
(a) eradicate or manage a pest or unwanted organism on the place:
(b) prevent the spread of a pest or unwanted organism from or to the place:
(c) avoid, remedy, or mitigate any effect on the place of non-compliance with a pathway management plan.

numbers; modelling; empirical Tb surveillance data (which may be "sentinel" species substituted for possums) and livestock records (29).

Monitoring is made difficult by the presence of infected animals (identified by bacterial culture) that had no visible lesions (noted, in a survey of Tb in European wildlife, as occurring in early stages of the disease (30)). For example in Landcare Research in Westland, pooled samples from possums showing no visible Tb lesions in the field returned positive culture results for Tb (31) (pooling of samples was regrettable because this lost important information.)

3.1.2 Weaknesses in mathematical models

The mathematical modelling driving the Tb control strategy has suffered from a lack of empirical data to create and validate the models, and made major assumptions (32); (also see Appendix 1). Lack of certainty with the model predictions has led operators to "overdo" control (33).

3.1.3 Tb in livestock

"Infection" in slaughter records has not differentiated between likely infectious animals and those with an inert, historic infection (often a single, inert granuloma, developed at some stage during an animal's lifetime (e.g., 34)).

Livestock health and welfare affect the expression of Tb: a compromised immune system prevents animals from mounting a successful immune response to eliminate the bacteria or contain them successfully inside a granuloma; while stressors applied later in an animal's life can allow a formerly inert infection to become virulent (35). (In the case of a deer farm, widespread infection occurred rapidly and precipitating factors were suggested to include the physical demands of breeding (rutting and pregnancy) combined with poor weather conditions (36)).

Identifying "reactors" to the standard skin test used to detect Tb is not reliable. Estimates of the sensitivity of the tests range from 68-95% while specificity is estimated to be 96-99% (37). Due to these imperfections in testing, false-positive reactors are slaughtered needlessly, whilst false-negative reactors stay in the herd, with the potential to spread infection.

3.1.4 Tb in wildlife other than possums

"Overdoing" control (33) may also be a response to the fact that Tb is found in most of the mammalian wildlife species in NZ (38) and the unstated aim of aerial "possum control" may be to kill as many of them as possible. In his (AHB-funded) PhD, Graeme Nugent stated that 1080 poisoning was "*not a 'pure' reduction in possum density alone, but, rather, the effect of the poisoning on all host species combined* (15, page 60)."

The roles of the various NZ wild mammalian species in Tb cycling should be considered in dynamic equilibrium rather than static (39).

Monitoring for Tb in wild deer by OSPRI has been lagging - in areas of sustained possum control, Tb was found in approximately 17% of the few deer sampled in 2020/21 and again in 2021/22. In 2022/23, only 5 deer were tested (none were found to have Tb), and in 2023/24 no deer were tested (40) (Table 1).

Table 1. Prevalence of Tb in wildlife in areas of sustained possum control

OSPRI wild animals sampled in areas of sustained possum control (from Annual reports (40))												
	Possums			**Deer**			**Pigs**			**Ferrets**		
year	no.	no. Tb	% Tb	no.	no. Tb	%	no.	no. Tb	%	no.	no. Tb	%
2020-21	1494	3	0.2	18	3	16.7	785	3	0.4	258	15	0.06
2021-22	1215	0	0.0	23	4	17.4	274	10	3.6	212	3	0.01
2022-23	618	0	0.0	5	0	0.0	833	3	0.4	695	9	0.01
2023-24	653	0	0.0	0	0	0.0	1403	6	0.4	1950	8	0

Wild deer populations might be an expected target for Tb control in NZ, since their potential as a reservoir and transmitter of Tb is thought to be low *if* their numbers are controlled by hunters; indeed they have been aerially poisoned intentionally for Tb control (15, page 2; 41, page 353). The density of some deer species, such as red and fallow deer, are considered to have been increasing in many areas (42) and overall numbers of all the major ungulate species are much higher than in the 1980s (43; 44).

In July 2025, Member of Parliament Hon Damien O'Connor, whose experience encompasses working as a fourth generation dairy farmer on the west coast of NZ's South Island and being Minister for Agriculture (45, 46), queried whether a recent outbreak of bovine Tb in cattle in the North Island was due to transmission by deer (47).

Veterinary scientists long ago pointed to deer as important wildlife species for bovine Tb in NZ, being a likely source of on-going infection to other wildlife and livestock (48) and having possibly initiated the disease in possums (through hunters leaving deer waste to scavenge) (49). Standard wire cattle fences are no barrier to deer attracted to grazing pasture and crops. Deer of various species are implicated in the maintenance and spread of bovine Tb within parts of Europe (30), the United Kingdom (50) and North America (51). An experimental study in the USA showed that infected deer can transmit Tb to cattle through sharing of feed (52) and in Ireland, whole-genome sequencing of *M. bovis* sourced from infected cattle, badgers and deer suggested that *M. bovis* was transmitted between cattle and deer populations, and that deer may be an important source of infection (53).

There has been assurance that aerial poisoning will come to an end by 2030, because Tb will have been eradicated in wildlife (54) (p. 20). But there has also been a warning that many more years of poisoning lie ahead due to the presence of Tb in deer: "*Latently infected deer*[2] *therefore act as the key temporal vector carrying bTB through time. Even though the number of such deer that might live to 10 or 15 years of age is small, and the risk of spillback from deer to possums is also small, the possibility appears to be too significant to ignore, making it appear unwise to cease possum control after just 5–10 years … This constraint may in some instances double the duration of possum control required, and therefore have a major impact on the total cost of achieving bTB elimination*" (33).

In recent years, Tb has turned up in hunted wild deer from deep in the rugged back country of Westland, along with a high prevalence of Tb in possums (31).

In OSPRI's Operations Plan for 2026, a diagram shows both ferrets and deer as dead-end hosts, stating "*Pigs, ferrets and sometimes deer get TB from possums but not from each other* (55, page 5). This contrasts with information on ferrets (35) and the uncertainty regarding deer.

3.2 Poor control over risk factors

3.2.1 Unknown infection route

Mycobacterium bovis has an exceptionally wide range of mammalian hosts and can also survive outside hosts, potentially for months in cold, damp conditions (35), and is found in excretions (urine, faeces, saliva) from infected animals (30). Tb lesions in cattle and deer are consistent with infection via the oral and respiratory routes (35), however the means of transmission from wildlife has not been identified (10).

3.2.2 Poor uptake of veterinary advice to investigate and manage risks

Veterinarian Dr Bert Cook's early warning (in 1975) against indiscriminate poisoning of wildlife, because it would make Tb hard to find and strategically eliminate (56) went unheeded (57). Other early veterinary advice was to avoid grazing stock on undeveloped land, where there might be infected possums (27).

Further veterinary advice over the years failed to shift the focus away from broad scale possum control as follows.

In 1991, Massey University's Professor of Epidemiology Roger Morris and veterinary epidemiologist Dr Dirk Pfeifer gave a keynote address to the Symposium on Tuberculosis (58). Criticising the Tb management policy of focusing on the possum as a vector, they said it was first necessary to know what transmission pathways were realistic, and that "*The epidemiological investigation starts from the hypothesis that there will be multiple*

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[2] "*it is believed that approximately one third of all infected animals [possums, red deer, ferrets] are without gross lesions at necropsy. This ... implies the development of an equilibrium between various states of infection and suggests that in some cases the bacilli either die, decrease in abundance or become dormant, following a period of infection … Bacterial persistence in the dormant state, and endogenous reactivation are believed to be one of the crucial epidemiological features of human tuberculosis, without which, the disease probably would not exist … This is also likely to be true of M. bovis infections in animal reservoir hosts*" (38, page 432).

transmission mechanisms, and then uses the field data to test which of these are supported and which negated by the evidence."

Morris and Pfeifer (58) advised the investigation of farm management factors that were risk factors for, and protective against, establishment of Tb in livestock. They also recommended intensively analysing herd testing histories to gain insight into managing the disease at the lowest cost (since the data was being collected already).

During the 1990s the Massey University veterinary team devised a series of field study sites, to examine the interaction of livestock systems and wildlife, to learn about bovine[3] Tb, and make recommendations to the animal health regulator about how to manage it. Farm support systems were created, for instance Joanna McKenzie and others presented a decision support system that integrated spatial and farm management information with the farm's Tb history (59); Carola Sauter-Louis surveyed farmers then designed a successful on-farm intervention study to reduce Tb in livestock, using grazing management and farm-based vector control (60).

3.2.3 Poor movement control of livestock

Farmer compliance with movement controls intended to contain infected stock appears to have been a long time coming. In its 2024/5 operating plan OSPRI stated *"Since the start of a joint compliance focus on animal registration between MPI and OSPRI in 2019, the registration of animals before first off-farm movement has increased from 60% (2018) to above 95%"* (61) (page 13).

3.2.4 Infected material left by hunters

The remains of Tb infected hunted animals left available to scavengers are a likely source of ongoing infection in wildlife (48; 49). Rather than formally addressing this risk, OSPRI has produced instructions for deer and pig hunters on how to identify infection and advised that if Tb is evident, hunters should leave the remains, and contact OSPRI to collect them (62).

3.2.5 Aerial poisoning causing Tb spread

Effects of wide scale poisoning differ between wildlife hosts and it may spread Tb, for instance feral cats and ferrets extended their range after poisoning (63); scavengers such as harrier hawks (*Circus approximans*) can scatter infected carrion (15); wide ranging feral pigs are less susceptible to 1080 poisoning than other wildlife (64) and populations of pigs can increase when hunters avoid poisoned areas (65).

3.3 Impracticality/feasibility of eradication of Tb from wildlife

Impracticality and cost could bring an end to the wildlife Tb eradication goal. Economists Clough and Nixon pointed out in 2005 that the law of diminishing returns applies and Tb may become very expensive to eradicate if/when infection becomes hard to find (5). Vast areas will need to be scoured. On finding a high prevalence of Tb in possums and also Tb in deer, deep in the rugged back country of Westland, Landcare researchers commented that it "*appears to be*

[3] The name "bovine" is misleading – cattle are not better suited to host the disease than other mammals (35)

neither safely achievable nor affordable to achieve the high level of area-wide surveillance and/or monitoring coverage currently required by the "Proof of Freedom" framework" (31, p. 1).

The international (WOAH) regulations regarding a country's qualification for, and maintenance of, Tb freedom in livestock do not require its eradication from wildlife (8). The regulations state: "*The country or zone status of free from infection with M. tuberculosis complex in bovids is not affected by the occurrence of infection with M. tuberculosis complex in other animal categories or feral or wild animals provided that measures intended to prevent transmission of infection with M. tuberculosis complex to bovids have been implemented and are periodically reassessed*" (8).

In 1994 veterinary epidemiologist Dirk Pfeiffer wrote:

"*The success of disease control strategies depends to a significant extent on an adequate understanding of the epidemiology of the disease. The wider the host spectrum of an infectious organism the more difficult it is to gain sufficient insight into its epidemiology …*

"… evidence suggests that the control of bovine tuberculosis in cattle [in NZ] can be achieved using the standard test-and-slaughter policy based on the tuberculin skin test …

"… the situation is different for disease control in wild animals, especially the brushtail possum …

"… large scale possum control operations can only be seen as a short term measure because they are unlikely to achieve disease eradication" (66).

In 2007, veterinary epidemiologist Dr. Leigh Corner wrote:

"the New Zealand experience illustrates that a proven reservoir of infection in wildlife need not prevent control of tuberculosis in domestic animals" (67).

4. Alternative management and recommendations

4.1 Need for change

The Tb management policy affects a vast number of New Zealand's inhabitants, and for decades has been a heavy weight to bear.

Current evidence shows that humane, effective wildlife management can be carried out by hunters, such as the Wapiti Foundation, who also fill basic conservation roles in maintaining access tracks and huts and controlling a range of "pest" mammals (68) (and could also carry out Tb surveillance). In 2023, ex-Landcare Research ecologists Leathwick and Byrom wrote that scientific knowledge and methods must be instilled in wildlife management and that history shows shared governance achieves better results than state-run control (69).

The situation in France is similar to NZ - livestock are officially Tb free, and Tb is present in wildlife (70). The French have a comprehensive, on-going informed approach to Tb management in wildlife and on-farm, including: a national passive and active monitoring system for Tb in wildlife ("Sylvatub"); legislation on wildlife biosecurity issues; thorough diagnosis methods at herd level and at slaughter (including training courses for slaughterhouse monitoring and veterinary surgeons performing the skin test, and inclusion of the interferon gamma test and PCR to provide additional diagnostic sensitivity and rapid diagnostic responses); and obtaining the commitment of the different partners involved in the Tb program (local authorities, veterinarians, slaughterhouse staff, farmers) (70). One of the main Tb prevention measures in France addresses biosecurity on the farm. "A Guide to Good Biosecurity Practice for Protection Against Bovine Tuberculosis" provides clear explanations and comprehensive information to farmers on managing biosecurity, such as why and how to isolate grazing herds, feedstuffs and water supplies from possible infection from other livestock and wildlife (71).

4.2 Recommendations

4.2.1 Independent Reviews

- Costs, benefits and risks of attempting bovine Tb eradication in NZ wildlife.
- Epidemiological examination of OSPRI-funded Landcare Research studies on bovine Tb in wildlife in Westland.
- All government and government-funded reports and data on bovine Tb in farmed cattle and deer, and wildlife, to be made available for public review.

4.2.2 Methodology

- PCR testing and/or other improved techniques to be used in Tb surveillance.
- Bovine Tb lesions reported in slaughtered livestock to be differentiated, quantified and reported as either infectious or inert and the source herds followed up and managed accordingly.
- The prevalence of bovine Tb to be surveyed in all mammalian wildlife.

4.2.3 Policy

- Strong support for adoption of farm-based management of bovine Tb, including recognition of the importance of animal welfare such as nutrition and shelter, and environmental contamination.
- Change the Biosecurity Act to require direct epidemiological evidence that bovine Tb exists in targeted wildlife in an area before control is applied.
- Legislation to address bovine Tb biosecurity in killed wild and feral animals, including pigs and deer.
- Humane, science-based wild animal surveillance and control, managed and assisted by all stakeholders.

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Appendix 1. History of possum-focussed control of bovine Tb in NZ

Following the discovery of bovine tuberculosis (Tb) infection in possums in 1967, possums soon became considered responsible for giving the disease to cattle. By the early 1970s Tb had been reported in possum populations in more than 23 locations across NZ (1). Infection from possums was blamed for the disease lingering in some cattle herds; whereas compulsory tuberculin testing of cattle and slaughter of reactors had reduced its prevalence elsewhere (1).

In 1972, the NZ Department of Agriculture contracted NZ's Pest Destruction Boards and the NZ Forest Service to conduct extensive possum control to eradicate Tb from possums: large-scale aerial 1080 operations were undertaken in areas where tuberculous possums were seen as an immediate threat to livestock. Aerial operations were already being carried out to protect indigenous and commercial forests from possum browsing (2).

Cattle farmers were advised to carry on with customary husbandry and grazing practices for their cattle (3), although a senior government veterinarian stated that while mass poisoning achieved "satisfactory" results in bringing down herd infection rates, farmers could also avoid grazing stock on undeveloped land where possums might remain (1).

According to government officials, mass poisoning of possums in the 1970s rapidly reduced the number of Tb-infected livestock herds (4) (although effects would have been confounded: for instance due to other wildlife species being killed by the poison; plus on-going culling of livestock reactors to Tb testing and movement control of reactor-containing herds (4)).

In 1975, a government veterinarian, Dr Bert Cook, condemned the broad scale poisoning that was being carried out without prior monitoring for the presence of tuberculosis in possums, stating it would make the pockets of disease hard to find (5). He had led a study in 1973-1974 investigating the prevalence and range of clinical tuberculosis in Tb-infected possums at Hohonou Mountain (central Westland) and recommended that targeted, effective depopulation should be carried out once the locations of groups of Tb-infected possums were mapped. In his study, the infected possums were all found less than 4km into the bush from the pasture's edge (5). However, Hohonou was aerially poisoned in 1974 (6).

Government funding for possum control was cut back in 1978. This has been attributed to "*complacency, government austerity, and a spike in fur prices*" (7); plus concern about the 1080 poisoning of deer, native animals, dogs and livestock; and uncertainty about whether possum browsing had in fact been damaging forests (2). The reduced funding was "*made worse by an ad hoc and fragmented approach to TB control in general*" (7). During the 1980s, national Tb control and decision making had been delegated to an industry-led advisory committee, and possum control was left up to locally- funded Pest Destruction Boards, which became integrated with Regional Councils in 1989 (7). Infection in livestock herds (as detected by the *in vivo* herd testing method – tuberculin hypersensitivity reaction) steadily rose from

1982 and possum control funding returned (2). The advisory committee was remodelled into the Animal Health Board (AHB) by 1993 (when it became an Incorporated Society) (7).

The AHB assumed control under the Biosecurity Act 1993, funded by farmer levies, the Crown, industry organisations and local government, with possum control largely managed through Regional Councils (7). The Biosecurity Act gave enormous powers to any "*authorised officer*" to carry out poisoning for Tb control wherever and how they felt was "*necessary or expedient*"[4], and no prior monitoring of possum numbers or any evidence of Tb (in wildlife or livestock) was required.

In 1995 the AHB developed a National Pest Management Strategy (NPMS) as required by the Biosecurity Act, and it came into effect in 1996 (8). The strategies are reviewed every 5 years and in 2000 the AHB released a discussion document with the proposed new NPMS which brought major changes: under the old strategy the number of infected livestock herds had decreased but Tb-infected wildlife had been found in new areas (7). The new goal would be official Tb freedom in livestock by international standards (<0.2 % of herds infected), and more than double the previous amount was to be spent on wild animal-vector control (up from $30.6 to 68.5 million per year, comparing 1999/2000 with 2005/6) (8).

The AHB's discussion document presented in 2000 made the unreferenced statement that "*It is estimated that more than 90% of new and persistent infections are attributable to a vector source and the return from investment in vector control is eight times greater than the same investment in disease control activities*" (8, p. 42). A harshly critical (commissioned) review of the AHB's proposal by economists from the New Zealand Institute of Economic Research noted that this important statement was unreferenced (9). In an amended strategy proposal from the AHB (2001), this oversight was corrected with the reference to "*Bicknell, 1999*" (10, p. 23).

Dr Katie Bicknell's 13-page, unreferenced, unpublished report to the AHB (11) was obtained by the investigating group (mentioned in the main text, above) under NZ's Official Information Act (1982). The report used a mathematical model (which was not referenced nor formally presented) to predict outcomes (numbers of Tb-infected herds of cattle) that could be modelled based on two disease control options: (1) investing in either additional wildlife <u>vector control,</u> or (2) additional <u>tuberculin testing</u> of livestock (to include cattle thought to be at less risk of Tb).

The forecast from Bicknell's mathematical modelling was that money invested in vector control would 'save' more than nine times as many herds from infection as an equivalent amount directed at additional livestock Tb testing (11).

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[4] Biosecurity Act Section 114 General powers: An inspector or authorised person who has lawfully entered a place under section 109 or 111 may do anything in, on, or in relation to the place that the inspector or authorised person considers necessary or expedient to—
(a) eradicate or manage a pest or unwanted organism on the place:
(b)prevent the spread of a pest or unwanted organism from or to the place:
(c) avoid, remedy, or mitigate any effect on the place of non-compliance with a pathway management plan.

Aside from the extremely limited options given to Bicknell to compare, information used to develop and test the model was not included in her report (11). Under the heading "Validating the results," she wrote "*Unfortunately, there is a shortage of empirical data with which to estimate either the initial parameters or how the parameters are likely to change under each policy scenario. Consequently, supplementary data were used to make a rough calculation of the number of herds saved by each of the proposed policies, which was then compared to the model output"* (11) [underlining added].

Bicknell estimated - based on data not included in the report - that additional possum vector control would 'save' nearly eight times as many herds as additional testing.

She noted "*it is important to remember that the results reported above were derived from a number of important assumptions. While it is unlikely that a different set of assumptions would support tuberculosis testing as the superior strategy, the precise benefits of each policy are not known with certainty."*

Bicknell wrote: "*The impact of increased vector control is very difficult to estimate from field data … there is a high degree of uncertainty surrounding the level of disease that would have been observed in the absence of* [wild animal vector] *control*."

Bicknell also presented a list of many other costs and benefits of the policies that had not been included in her quantitative analysis, such as the deaths of non-target wildlife in vector control poisoning operations and extra tuberculin testing potentially providing more epidemiological information (11).

Thus the output of a poorly refined, undisclosed model, based on undisclosed data, comparing two very narrow management options, was used to justify allocating a very large amount of bovine Tb funding to wild animal vector control.

Further observations

Behind the Tb policy is a large quantity of unpublished and inaccessible reports to government. Gaining access to these empirical reports and foundational data sets has been particularly difficult. Much of this background research and data is funded by government and yet it remains classified and not readily accessible.

An important document is officially missing: an unpublished 1986 report (12) by West Coast Regional Veterinary Officer Paul Livingstone (later the AHB's Tb eradication and research manager, then scientific leader of the TBfree NZ programme; knighted in 2011). The inaccessible (13; 14) report was cited as a foundational reference for several early attempts at tuberculosis transmission modelling, and contains early within-herd tuberculosis transmission data used in subsequent bio-economic modelling (including by John Kean (15, cited in Bicknell's PhD; Bicknell's PhD (16) and very likely, Bicknell's 1999 report to the AHB (11).

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