Translating biosecurity world-making: Thinking with *Mycoplasma bovis* in Aotearoa.

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Figure 1
Mycoplasma bovis under the microscope (courtesy of Dr Jonathan Foxwell, the Animal Health Laboratory, Aotearoa).

This more-than-human research is dedicated to the four-legged actors who have been a big part of my life, including this research journey. Poppy left early on in the piece, but Louis and Cooper came very close to seeing the thesis finished and the realisation of more time for walking and playing.

Poppy (2004-2019). A totally sweet and maddeningly independent girl, and my first ever dog. As a Jack Russell-Chihuahua crossbreed, she weighed just 3.4kgs. Poppy remained dominant in our actor-network until the very end.

Louis (2007-2023). A lion-hearted terrier, not much bigger than Poppy, who would bravely confront larger and infinitely more ferocious dogs. While discerning in his ability to make friends, Louis was a gentle and loving soul who enjoyed adventures with his people. We were blessed to be those people for nearly sixteen years.

Cooper (2010-2023). A gentle and stoic Labrador who was born with arthritis in each of his joints - so severe that the veterinarian recommended euthanasia before his first birthday. Cooper lived a remarkably full life, and he particularly loved food, sticks and swimming.

Two-Headed Calf[1]

Tomorrow when the farm boys find this
freak of nature, they will wrap his body
in newspaper and carry him to the museum.
But tonight he is alive and in the north
field with his mother. It is a perfect
summer evening: the moon rising over
the orchard, the wind in the grass. And
as he stares into the sky, there are
twice as many stars as usual.

[1] Gilpin, L. (1976). This award-winning poem is placed up front because it speaks of the richness of multiple farming worlds.

Abstract

Aotearoa has one of the strictest biosecurity networks in the world and, at the same time, enacts one of the world's most export-driven agricultural economies. It was into these dual assemblages that *Mycoplasma bovis* (M. bovis) first emerged, in July 2017, causing the (then) Biosecurity Minister to declare that M. bovis was Aotearoa's 'single biggest biosecurity event'. Consistent with this problematisation, and in a world-first manoeuvre, the government and farming industry bodies decided to try to eradicate the bacteria. This thesis tells the story of that eradication attempt and of M. bovis' own attempt to fight back.

This more-than-human research follows the network translation attempts of five key actors involved with M. bovis' world-making. These are the eradicators themselves, the scientists enrolled in the programme, the farmers who were impacted by M. bovis (and by the eradicators), the cows who hosted the bacteria and M. bovis, the smallest living organism known to self-replicate. Together these network actors have enacted realities that are significant for the future of farming and biosecurity in Aotearoa.

At the time of writing, the eradicators have almost succeeded in protecting and stabilising farming by Othering M. bovis from the network. In doing so, however, the eradicators have reterritorialised a pasture-based farming assemblage that is inherently fragile. Farming's continual need for complex biological mobilities *itself* creates the need for ongoing biosecurity practices. Yet, as this thesis will show, these on-farm biosecurity practices are fundamentally incompatible with farming ontologies. There is a precarious misalignment between these two assemblages, each of which are vital for Aotearoa's economic security.

As to M. bovis' bacterial world-making, this seems to be irrelevant to the human actors, despite their collective interest in non-human health. As a spokesperson for this M. bovis assemblage, I have tried to expose a series of ontological worlds. In doing so, my aim is to create a conceptual space for reimagining farming and biosecurity in Aotearoa.

Acknowledgements

Where to begin with a process that has spanned more than four years of my life. There are many actors who have woven themselves into this work, whether it be advising or encouraging me, or whether their stories have directly shaped the narrative of this inscription device. All have *made* this thesis together. In keeping with the requirement of ontological flatness, the order that these acknowledgements are written in do not necessarily denote the order of importance.

First are the two actors who initiated this research in a very actor-network kind of way. I am indebted to former Ministry for Primary Industries' Director-General, Martyn Dunne (CNZM, QSO), who saw the need to connect public office and the academy in matters of national security. He and Professor Rouben Azizian, the (then) Director of the Centre for Defence and Security Studies at Massey University, generously agreed to have me undertake a year-long secondment to teach and research biosecurity in Aotearoa. Seven years later I am still teaching biosecurity, but now I also have a PhD. This achievement would never have happened if not for the foresight and generosity of these two key actors, and a thank you does not seem sufficient. *Tēnā kōrua, e aku rangatira.*

Then there were my supervisors, and I was fortunate enough to have not one but three. 'Trust us,' they said early on. And I did - completely and from the start, even when I was wading blindfolded through one actor-network swamp after another, and often in the rain. That trust paid untold dividends throughout the research and writing process. I am incredibly grateful to Associate Professor Matthew Henry and Drs Carolyn Morris and Germana Nicklin for their expert guidance and care. It is because of their own academic rigour that this work has something important to say. A particular thank you, too, to Carolyn for advice that I will use forever when tackling a large piece of writing: start in the middle and tell the story (or, colloquially expressed as, 'Just lash into it').

I am very grateful for the work of a vital and influential academic actor called Professor Michel Callon. He (with other eminent scholars) developed actor-network theory, and Callon's (1986) work on the scallops of St Brieuc Bay has been my shibboleth throughout this thesis. While Callon will never read my work, this research would not exist in its current form without his. *Merci beaucoup, monsieur.*

I also wish to acknowledge someone who was incredibly influential in my decision to take an academic path. That person is one of my former law school lecturers (and honours supervisor), Gay Morgan. She introduced me to a range of thinkers and writers outside of the standard jurisprudence course materials, and it was from her that I first learnt about more-than-human worlds.

Another valuable actor has been Massey University's Doctoral Research Committee, and Professor Tracy Riley in particular, for the award of a Massey University Doctoral Scholarship. When I began this PhD process, the award had just become available for part-time students. Thank you for all that this award has enabled, including the extra layer of accountability.

As to institutional support, I have greatly benefited from the Graduate Research School's doctoral seminars and online resources, and the School of People, Environment and Planning's post-graduate writing seminars and retreats. There seemed to always be one of these that was right for the time. And that prompts me to thank serendipity, which has always played a pivotal role in my research, and this thesis process has been no exception.

Towards the end of the writing process, there was one last push to completion. It was during these summer months that a friend recognised this 'stage' and reached out with a generous offer of weekly support. Thank you to Professor Averil Coxhead for giving of your time so that we could 'talk shop'. Not only did talking through ideas help with pulling the conceptual threads, but these informal catchups kept me sane and accountable to a friend, which is a different thing entirely.

As to friends, I owe a thank you to the friends who, over the years, persisted on asking how my PhD was going. It matters to have people ask that question. I am especially grateful for the villagers of Rangataua (you know who you are) who provided food and company when I needed a break from writing, and who left me alone when the blinds were drawn. Thank you for the comradery and the muffins in the letterbox.

I am hugely grateful to my partner Gina, who has unfailingly, and with fierce loyalty, supported my academic endeavours in all of their trials and tribulations. You have 'held space' for me to

work, which became particularly important towards the end of the writing process when unwavering focus was essential. Thank you for staying with this peculiar form of trouble.[2]

There are thirty more key actors to acknowledge. These are the human participants who gave of their time for interviews and who shared their experiences and expertise. Each and every person who spoke with me about M. bovis and who educated me about farming in Aotearoa has shaped this work. I regularly reflect on the honesty that was apparent in many of the interviews, and on the depth of knowledge that exists 'out there' in the regions. In addition, the interviews were a pleasure. Thank you to each of you.

Two groups of actors remain. There are the approximately ten million cows in Aotearoa who quietly give their freedom and lives to satiate and enrich the lives of others. As a human, I am very mindful of their sacrifices and my privilege. Last, but certainly not least, M. bovis – a bacterial actor that punches above its weight in intrigue and influence. Until we meet again.

[2] This is a reference to Haraway, D. J. (2016). *Staying with the trouble: Making kin in the Chthulucene*. Duke University Press Books.

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Glossary of Te Reo Māori terms

Māori placename	**Pākehā placename**
Aotearoa	New Zealand
Te Ika a Māui	The North Island
Te Waipounamu	The South Island
Te Matau-a-Māui	Hawke's Bay
Waitaha	Canterbury
Ōtākou	Otago
Te Taurapa o Te Waka	Southland

An Actor-Network Theory Primer

Before moving into the body of the thesis, it is first necessary to explain the particular language used here, and to embed it into the reader's consciousness. The language is that of actor-network theory (ANT), which is an empirically driven theory - to the point that it has been described as more of a methodology than a theory (Michael, 2017). The goal of ANT is to make sociological sense of the ontological complexities that hold together (and pull apart) more-than-human worlds (Law, 2019).[3] ANT's language is used purposefully throughout this thesis to describe M. bovis' world-making, along with the world-making of other actors in the network. Following Haraway (2016), it matters which words are used to describe worlds.

Below are the main terms that I rely on to 'translate' (see below) M. bovis' biosecurity world-making.

Actor

An actor[4] is a non-substitutable thing that "makes a difference" (Latour, 2005, p. 154). Actors are network elements that have an impactful presence or absence: their existence makes a transformation (Venturini, 2010a). Actors can be living organisms, technologies, documents or systems (Latour, 2005). Actors can also be several people or entities, such as a system or a group (Michael, 2017). Actors are only actors where their ability to create transformation is acknowledged by other network actors, otherwise they are intermediaries (Callon & Latour, 1981; Venturini 2010a). Actors use the tools of reasoning, persuasion, manipulation and coercion – sometimes force – to enrol other actors (Callon & Latour, 1981). Importantly, not all actors are equally influential (Venturini, 2010a), and the initiating or disrupting actor does not necessarily end up being the controller of the emerging network (Michael, 2017). ANT can measure and describe the winners and losers by using methodological symmetry and its own infra-language, which applies across all the social and technical spaces (Callon & Latour, 1981).

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[3] See the literature chapter for a thorough discussion of actor-network theory.

[4] Latour uses the term 'actant', which comes from A.J. Greimas (1983), to highlight non-human network actors (Michael, 2017). However, I am not using the term 'actant' in this thesis because I prefer to use the term 'actor' inclusively, without differentiation.

Actor-network

An actor-network is "an emergent and dynamic complex that forms when numerous social and material elements become linked together in particular ways" (Ali & Keil, 2008, p. 237). Actor-networks emerge when key actors successfully persuade other network actors to follow them, acknowledging them as leaders (Michael, 2017). The process of network building is itself heterogenous, which is why ANT applies the principle of generalised symmetry to understanding the associations without privileging some types of actors over others, and why free association is important, which tells against *a priori* assumptions about the types of actors that fit within categories (Latour, 2005, Michael, 2017). An important point about networks is that they are not made up of hard substances; rather, networks are traces that are left behind by moving and transforming elements (Latour, 2005). Networks are enacted by associations or attachments, not by actors. According to Latour (2005), building a new network results in new traces being left by the "social fluid" (p. 77) created by the shifting actors.

Assemblage

While assemblage theory is post-ANT (Anderson & McFarlane, 2011), it still focusses on the recursive process of making and remaking network relations, in which heterogenous elements are enacted by and enact each other (Law, 2004). Assemblages create territories, and those territories make meanings in the world (Wise, 2014). Like actor-networks, new elements may enter an assemblage, and old alliances may break down because assemblages are continually allowing for "new lines of flight, new becomings" (Anderson & McFarlane, 2011, p. 126). Deleuze and Guattari (2004) explain that maintaining assemblage stability means using a dual process of deterritorialisation (weakening existing relations) and reterritorialisation (reinforcing new relations) (see also Rosin et al., 2013, for a thorough discussion of assemblage concepts). This two-fold movement encompasses Deleuze and Guattari's 'lines of flight' (in the process of deterritorialisation) and 'lines of articulation' (in the process of reterritorialisation) (Rosin et al., 2013).

Black box

A black box is a metaphor for when network actors invisibilise the moments of translation that created the network (Callon & Latour, 1981). The intention of black-boxing elements of network building is to try and stabilise the emergent network, locking down those aspects that have become redundant or irrelevant (Callon & Latour, 1981). The more actors can black box

the hard work of network building, the more they can grow in authority (Callon & Latour, 1981; Michael, 2017). Latour (1987) says building a black box requires two steps: enrolment, so that others buy into the ideas or practices, and control, so that others use and disseminate those ideas and practices.

Controversy

Controversies, disputes, or disruptions exist because there are minority views and divergent interests that challenge the dominant actor's narrative (Callon, 1986). Conflicts are present in all kinds of heterogenous relations, and they endure until actors either compromise or one actor becomes dominant over the others (Venturini, 2010a). The role of a controversy is at the core of ANT because a controversy is a metaphorical crack in a network's foundational stability, thereby providing a point of entry for researchers to open the otherwise black-boxed processes of assembling, disassembling, and reassembling (Michael, 2017; Venturini, 2010b). Callon (1986) explains that a controversy is a situation where an actor's ability to speak on behalf of or represent other actors is challenged. For Latour (2005), controversies are not something to be quickly resolved because it is through controversies that social relations can be mapped and understood (see also Venturini, 2010a).

Immutable mobiles

Immutable mobiles are highly mobile but stable meanings capable of being black-boxed (Michael, 2017). Immutable mobiles are often written texts, and Michael (2017) says that they are frequently created within 'centres of calculation', such as laboratories (see also Latour, 1987). Other examples of immutable mobiles include government reports, legislation (where the policy process has already been black-boxed) and PhD theses (where the background research has become manifestly absent, and the document's findings are fixed at a point in time).

Inscription devices

Inscription devices are network elements that are capable of mediating realities, as well as performing their primary task of providing information (Nimmo, 2011; Law, 2004). These instruments, including technologies and written texts, are both actors and enactments, which means that certain ontologies or realities are made while others are made invisible (Latour & Woolgar, 1986; Nimmo, 2011).

Material semiotics

Material semiotics is a social science movement that is concerned with the ontological complexities of how more-than-human networks are formed and hold together (Law, 2019). ANT is a branch of material semiotics (Law 2019, Michael 2017). (See also Law 2007, who considers that material semiotics has an epistemological aspect, in providing knowledge of how society is made.)

Materiality

Materiality is the concept that all things, living and non-living, are material and each have unique capabilities, obtained because of their own network connections and entanglements (Ali & Keil, 2008). Focussing on materiality allows researchers to reimagine networks of heterogenous associations (Latour, 2005; Donaldson & Wood, 2004).

Mediators and intermediaries

The terms mediator and intermediary are vital to understanding the process of translation. Latour (2005) says that these two terms should be a researcher's 'shibboleth'. Mediators are actors that transform elements and distort meaning (Latour, 2005). Latour (2005) says of these actors, "[t]heir input is never a good predictor of their output" (p. 39), no matter how simple they may appear. In contrast, intermediaries transport meaning without changing it at all – they do not transform the message. Latour (2005) says of an intermediary, "defining its inputs is enough to define its outputs" (p. 39). As such, intermediaries are useful as tools to make networks stable because they are easily black-boxed and forgotten (Callon & Latour, 1981). Examples are not very useful to distinguish mediators from intermediaries because the distinction has to be made through observation.

Method assemblage

Law (2004) uses the term 'method assemblage' to describe a process by which new realities are made, unmade and remade. Michael (2017) describes method assemblage as means of grouping together fluid, emergent and multiple worlds. Method assemblage involves the realities of both the researcher and the researched (see also Law, 2004). Method assemblage, then, is a set of practices that are enacted in what Law (2004) metaphorically calls the 'hinterlands', which is the ontological space between what exists and what is new. It is within these hinterlands of method assemblage that realities are made in three key aspects: presence;

manifest absence; and Otherness (Law, 2004). These aspects, crafted by and through method assemblage, enact the shifting boundaries of multiple realities, and so are each necessary and mutually reliant.

Presence

What is present in an actor-network is that which is made visible and relevant within it. Law (2004) calls what is present an "in-here enactment" (p. 45). Some well-known examples of network presences include Mol's (2002) atherosclerotic blood vessels and de Laet and Mol's (2000) Zimbabwe bush-pump. Presence is what is made visibly manifest within a network through the process of assembling.

Manifest absence

What is manifestly absent from a network is also made through the process of assembling. Manifest absences are just as important as presences because presences (by definition) need absences. As Law (2004) says "[t]o make present is also to make absent" (p. 84). Taking the above example from de Laet and Mol, the bush-pump is used in different settings from the one in which it was made (in a factory setting). Those new situations necessitate the bush-pump (which is a network presence) being used and repaired in local and make-shift ways. The original setting of the bush-pump (the factory) is manifestly absent from the reality of its use. Manifest absence is still present within the network, even though what is present is only one part of the original element.

Other/Othered

Otherness is true absence; to be Other is to be made invisible and irrelevant. However, elements that are Othered still exist, but they sit outside or in the background of the network (Law, 2004). The role of Other is as important as presence and manifest absence, because sometimes networks can only be maintained if some elements are Othered, or because the mundane routine aspects of the network are best relegated to the unseen background. Law (2004) provides examples of Otherness in the provision of power-supply and the payment of wages to staff.

Methodological principles

Callon (1986) favours the use of three methodological principles when carrying out ANT investigations. These principles are termed: agnosticism; free association; and generalised symmetry.

Agnosticism

This term refers to the researcher's need for impartiality when observing the roles and influence of human and non-human network actors (Callon, 1986). Agnosticism is closely aligned with the principle of free association.

Free association

Free association is concerned with treating the natural and social worlds equally, and particularly describing elements within those worlds with a neutral language (Singleton & Michael, 1993). Practically, free association means tracing the fluid connecting network actors with an open mind, without applying any *a priori* assumptions or categorisations about which elements are social, scientific or technical (Callon, 1986; Michael, 2017).

Generalised symmetry

Related to both agnosticism and free association, generalised symmetry says that all network elements are potential actors, including the technical/non-living ones (Callon, 1986). Ontologies can never be pre-determined because, in ANT terms, knowledge emerges from the enacting of a network (Singleton & Michael, 1993; Law, 2004). (This is the epistemology component of networks.)

Methodological symmetry

Callon's (1986) methodological principles are closely aligned with Venturini's (2010a) methodological symmetry, but Venturini goes further in explaining the importance of differing actor roles and influences. Methodological symmetry can be described simply as the practice of listening to all of the actors without relying on any pre-determined ideas about importance (Venturini, 2010a). However, at the heart of methodological symmetry is the permission to treat those actors' voices differently, depending on their roles and influence in the network being researched (Venturini, 2010a). Law considers that method should be creative so that it can allow space for the emergence of alternative realities – resulting in different narratives and ways of thinking (Law, 2004), or more properly 'thinking with' those network elements (Haraway, 2008; Tsing, 2015).

More-than-human

The term more-than-human signals the desire to 'think with' (as opposed to 'about') organisms and all other lifeforms (Haraway, 2008; Tsing, 2015) The purpose of thinking with the more-than-human elements of networks is to trace the ontological fluids of multispecies worlds (Law, 2019). Tsing (2015) calls the term "multi-species" (p. 162) an artificial aid to help researchers get over the tendency to think that humans are exceptional.

Multiple/multiplicity

Mol (2002) famously argues that, not only are there different actor situations and epistemologies, but that these materialities actually enact different and multiple realities. Further, not only are realities constructed, but realities are made *together with* their production (de Laet & Mol, 2000). Importantly, while realities are multiple, they are not indefinite or disconnected. As Law (2004) observes about Mol's *Body Multiple*, here "[w]e discover multiplicity, but not pluralism" (p. 61). Multiplicity means that, inevitably, the different realities interfere with one another and overlap (Law, 2004). However, it is possible for there to be one, single reality at the point where actors have resolved their controversies, but otherwise and until then realities are multiple (Latour & Woolgar, 1986; Law, 2004).

Obligatory Points of Passage/Obligatory Passage Points

Michael (2017) explains that there are often main actors who try and persuade others to rely on their help to resolve network instability and conflict. These persuasive actors are termed obligatory points of passage (OPP), and they can be individuals or groups, such as researchers, scientists or government officials. Obligatory points of passage are funnels through which key actors can articulate the identity and purpose of the network (Singleton & Michael, 1993). OPPs can also be expressed in the form of a question that must be answered so that the actors can reach their goals (Callon, 1986). The OPPs use the tools of *interessement* and problematisation (see Translation below) to coerce or negotiate with the other actors so they align with or bend to the main actor's will for control of the network (Michael, 2017; Callon 1986). Actors are persuaded to follow this path through inscription devices and other immutable mobiles.

Performativity

The term 'performativity' means that actors enact things, and that those things create realities. Elements that have the force to 'perform' or create heterogenous worlds include written texts, speeches and technologies (Michael, 2017). Indeed, ANT values textual documents and technologies as performative actors in their own right, with "a social and ontological efficacy of their own" (Nimmo, 2011, p. 114). Michael (2017) observes that speaking a thing into the world has a performative effect. Researchers are also performed when they enact method assemblage (Law, 2004).

Social cartography

Social cartography is Venturini's (2010a) term for the process of mapping the controversies of social, scientific and technical worlds using methodological symmetry. Mapping a controversy requires aggregating information and condensing it, which necessitates the emergence of representative elements (Venturini, 2010a). Using repetition, themes appear and thus the research narrative gets tested against all the elements of the network. Latour (2005) considers that a quality account of social mapping is one where the actors' voices are louder than that of the researcher.

Topology

Topology focuses on movements and flows of actors within and among networks, and it frames the social world using fluid boundaries (Hinchliffe et al., 2013; Mol & Law, 1994). In this way, topology is similar to ANT, from whence it came. One of the main tenets of topology is that spaces are 'foldable' (Ali & Keil, 2008), which results in elements that are originally near becoming distant once space is folded, and *vice versa*. Latour (2005) considers that a topological approach is useful for allowing social cartographers to get 'inside' networks.

Translation

Translation is a semiotic tool used to describe the process by which actor-networks are formed (Callon & Latour, 1981; Michael, 2017). Translation is the process used by actors to redefine the interests of others and to put themselves in the position of speaking for those others (Callon, 1986; Michael, 2017). Translation creates "traceable associations" (Latour, 2005, p. 108) through encouraging mediators to coexist. When a researcher follows the formation of networks using ANT, she is following these associations.

The process of translating and recruiting actors from one network into another means that the other networks invariably shrink (Michael, 2017). To translate is not only to displace, but it is also to use one's own position as spokesperson to frame others' desires in one's own language; it is to speak for the actor-network (Callon, 1986). The process of translation is comprised of four "moments, which can in reality overlap" (p. 203): problematisation; *interessement*; enrolment; and mobilisation. Success is not guaranteed, and network building can fail at any of these four points in the process (Callon, 1986).

Problematisation

Problematisation occurs where certain actors who want or need to enrol other actors into their programme or narrative try to reframe the problem or issue and in doing so make themselves 'indispensable' to its resolution (see the definition of OPP). As Latour (1987) explains, "[a] group with a solution is looking for a problem but no one has a problem…Well, why not make them have a problem?" (p. 114). In other words, an issue becomes problematised through the narrative of those actors who want to enrol the others in their mandate.

Interessement

Interessement is where actors who want to enrol others, try and disconnect those actors from all other actor-networks so that they commit solely to the new actor-network being created (Michael 2017; Latour, 1987; Callon 1986). As Latour (1987) explains, the word '*inter-esse*' suggests that it is the 'interests' of others that lie between key actors and their translation goals. The influential actors *interesse* others by creating roles for them in the new actor-network and aligning their interests with those actors' programme or goals (Callon 1986; Latour, 1987; Singleton & Michael, 1993). Techniques such as persuasion and manipulation are used by the influential actors to 'interest' other actors and place barriers between them and competing networks (Law, 2004).

Enrolment

Successful *interessement* does not necessarily lead to enrolment (Callon, 1986). Only when actors align with the key actor's interests, are they are said to become enrolled in the new network. Callon (1986) describes the enrolment process as requiring "trials of strength and tricks" (p. 211). Enrolment involves 'capturing' the will of the other actors, which means that the other actors must also yield their wills to the key actor's interests: enrolment is an

arrangement requiring cooperation (Callon, 1986). Enrolment is a fickle thing, however, and loyalties are subject to challenge; disassociation and unenrolment can occur at any stage in the process (Callon, 1986; Michael, 2017). Successful enrolment is a process that requires constant maintenance (Callon, 1986).

Mobilisation

The final moment is called mobilisation, which describes the influential actors' methods for ensuring loyalty and commitment to the programme and preventing betrayal by actors leaving the newly formed actor-network or expressing views that are contrary to the influential actors' own (Callon, 1986). Mobilisation is a precarious moment in the process of translation, because here the enrolled actors may still abandon the programme or seek to undermine it and form their own, break-away actor-network. This is where Callon (1986) asks, "[w]ho speaks in the name of whom?" (p. 214). Callon views the answer to this question as being central to the influential actors' success and the success of their new actor-network. The moment of mobilisation is where betrayal and controversy are most likely to occur, however, which makes mobilisation a rich site of observation for social cartographers (Callon 1986; Venturini, 2010a).

Chapter 1 Introduction

To make sure that our travel through technoscience is not stifled by complicated definitions of reality, we need a simple and sturdy one able to withstand the journey: realities as the Latin word res indicates, is what resists. What does it resist? Trials of strength (Latour, 1987, p. 93).

In July 2017, a group of human actors discovered a group of bacterial actors called *Mycoplasma bovis* (M. bovis) on a large dairy farm in Waitaha, Aotearoa.[5] This event is notable because prior to that detection, Aotearoa was one of only two countries in the world to consider themselves free from the bacteria (currently, Norway is the only one) (MPI, n.d.a.; Laven, 2019). When M. bovis arrived in Aotearoa, it came to a country with a world-renowned biosecurity system (Trampusch, 2014). Unsurprisingly, the government's response to M. bovis was both swift and comprehensive. The biosecurity response, and subsequent eradication programme, were the largest in this country's biosecurity history, and attempting to eradicate M. bovis was a World-first translation manoeuvre.[6] At the peak of the incursion, there were thought to be 40 infected farms (at the one time), and overall, the total number of known infected farms was 279 (MPI, January 2023). At the time of writing a final draft of this thesis in early May 2023, there were no remaining farms known to be harbouring M. bovis in the country (Otago Daily Times [ODT], 2023). The eradicators had thought they had won the battle.[7] By the time my thesis was submitted a month later, however, another farm with M. bovis had emerged in Te Waipounamu (*Mycoplasma bovis* Programme [MBP], May 2023). As

[5] The decision about which country name to use (Aotearoa or New Zealand) took some time to work through, because naming is an intentional and arguably political act. It was too unwieldy to use both terms, as in 'Aotearoa New Zealand', though that would have been my preference. Then, there was the decision about what to call each island and referring to the South Island/Te Waipounamu and the North Island/Te Ika a Māui frequently was equally cumbersome for the narrative. For me, the name New Zealand speaks to the process of colonisation, and one of the means of colonising the country was by farming the land (see Campbell, 2021). Therefore, I have settled on the indigenous names, rather than the English ones, in a deliberate attempt to decouple farming from its origins in New Zealand and move it into a contemporary Aotearoa, which is now where biosecurity is practiced.

[6] All other countries have opted to manage the bacteria by changing their biosecurity practices (for example, Australia, which has had M. bovis since 2006 [Dairy Australia Corporation, 2017]).

[7] In brief, the eradicators are comprised of the Ministry for Primary Industries (MPI), and the farming industry bodies of Dairy NZ Limited (Dairy NZ), Beef + Lamb NZ Limited (B+LNZ) and Federated Farmers New Zealand (Fed Farmers). The eradicators will be described more fully in the preamble, which unusually does not appear until chapter four. The reason is because the preamble sets out the biosecurity response and eradication programme assemblages that are essential to know before moving into the eradicators' story in chapter five.

will be shown, this enactment of a 'tug of war' between the eradicators and the bacteria is typical of their network relations.

When I began this research five years ago, my intention was simply to tell the story of M. bovis' world-making prowess and of the struggles that the bacteria had endured trying to translate Aotearoa's biosecurity and farming actor-networks.[8] However, this research has revealed that while M. bovis has been a controversy that has challenged the black boxes of biosecurity and farming, the bacteria did not need to deterritorialise either assemblage to make its world here. Furthermore, and irrespective of any bacterial strategising (Law & Mol, 2008b), the opposite has occurred because of M. bovis' presence: biosecurity and farming have been *reterritorialised*. Hold on, wait - I am getting ahead of the actors' stories.

Returning to the narrative, what I had expected to find was that on-farm biosecurity would be a pivotal actor in the eradicators' success or failure against the bacteria. Surprisingly, this was not to be the case. The eradicators have almost succeeded in Othering M. bovis from farming without needing to enrol farmers in day-to-day biosecurity practices.[9] This apparent biosecurity success without biosecurity commitment highlights whose responsibility biosecurity remains, and it does not lie with the farmers. MPI carries out biosecurity for Aotearoa, and farmers farm cows for the economy; biosecurity and farming are separate assemblages.[10] Through the actors' stories, this thesis will describe the ongoing vulnerabilities for farming arising from this uneasy and seemingly opposing set of network relations. What M. bovis has done ontologically is to foreground an existing divide between biosecurity and farming imperatives.

There are two main reasons why biosecurity is not embedded within farming. The first is because the 'quotidian' (Barker et al., 2013, p. 16) biosecurity practices of veterinary checks, quarantine, surveillance, routine testing, animal tracing and boundary controls are difficult to

[8] The phrase 'multi-species world-making' can be attributed predominantly to Anna Tsing (2015) and Donna Haraway, though other theorists use this terminology. For Tsing, using this term represents a deliberate attempt to move "beyond human exceptionalism" (Tsing, 2015, p 162). This thesis employs the 'world-making' part of the phrase to signal an impartiality between human and non-human actors and an openness to the transformative power of bacteria.

[9] The term 'Other' was coined by Edward Said to illustrate how actors can create divisions through images of difference and distrust (see Said, 1991). In this thesis, Other is used in actor-network terms to describe the process and the event of making an actor completely absent or irrelevant to the network. (See the explanation of actor-network theory terms at the beginning of this thesis.)

[10] 'Cow' is the term that I am using for all cattle, including bulls, because it is more personal or intimate than cattle and because dairy cows were the first to that raise the alarm about M. bovis. So, using 'cows' is an acknowledgement of them. In addition, all cows have been given the personal pronoun, 'she'.

enact within a mobile farming assemblage like Aotearoa's. Farming here requires extensive cow movements. The second reason is because, while the eradicators have succeeded in keeping the number of endemic cow diseases low, there is no real incentive for farmers to practice biosecurity on their own farms. It is important to understand that while the eradicators wanted farmers to do biosecurity, their goal of eradication ran counter to their other goal of on-going biosecurity practices. As will be seen, the eradicators' own goals were inherently conflicting. Thus, while reterritorialising farming mobilities was convenient for all human actors in the short term, there is a serious downside: it leaves farming no more biologically or economically secure than it was before M. bovis and the eradication programme began.

By strengthening pasture-based farming, the eradicators have not only become aligned with the farmers (even though many farmers would likely disagree), but also with the bacteria themselves. This may seem an unusual set of allegiances, but extensive cow movements without biosecurity intervention suits farmers *and* it suits M. bovis. On the other hand, the eradicators' competing goal of biosecurity aligned with the scientists' and the cows' similar interests, each of whom benefit from farmers enacting biosecurity.[11] Thus, the eradicators were pushing for *both* the reterritorialisation and the deterritorialisation of farming in Aotearoa.

Another way to describe these assemblage tensions is to refer to each actor's line of flight or line of articulation (Anderson & McFarlane, 2011; Deleuze & Guattari, 2004), depending on their goals. To be clear, this thesis focusses primarily on the *actors* who were engaging in the "gathering and dispersing" (Anderson & McFarlane, 2011, p. 125) of assemblage elements, as opposed to describing the dual nature of the recursive process itself. While acknowledging that reterritorialisation and deterritorialisation occur concurrently (Rosin et al., 2013), the focus here is on separating out those lines of flight and articulation to describe each of the actors' practices of assemblage building and rebuilding (Deleuze & Guattari, 2004).

Therefore, for our purposes, the eradicators (wearing their eradication hat), the farmers and M. bovis all shared the same line of articulation because ultimately, they wanted to retain and strengthen the existing farming territory. What was particularly important for these actors was retention of unfettered cow mobilities. However, the eradicators (wearing their biosecurity hat),

[11] The scientists are comprised of a group of veterinarians, researchers and epidemiologists. They will be properly introduced later in the thesis.

the scientists and cows themselves all shared the same line of flight, because it suited their interests to deterritorialise farming, and in particular the unconstrained fluidity of biological connections at its source. These three actors saw the value in ongoing biosecurity.

While these actors' alignments might seem clear cut, the multiple realities of M. bovis for each of them makes the form of their allegiances considerably murkier. For example, the eradicators required the total absence of disease and the Othering of M. bovis to ensure the health of cows (because the bacteria could not be trusted to support the production goals of farmers). The scientists, cows and farmers also enacted the presence of health as the absence of clinical (visible) disease, but their method assemblage did not need the bacteria to sit outside of farming. M. bovis enacted its method assemblage uniquely as the presence of itself, sometimes with the absence of disease and at other times with the manifest presence of it. However, I am again getting ahead of the stories, and we have a long way to go.

In order to materially locate M. bovis' world-making, it is essential to understand that which has already been assembled. Therefore, the following sections contain a potted history of farming in Aotearoa and the country's biosecurity system. Farming has to be described first because this is the existing assemblage within (and with) which these actors make their worlds. Aotearoa's biosecurity assemblage comes next because biosecurity practices and policies developed primarily from the country's need to keep agricultural animals healthy for export revenue and cost-effective farming. I then turn to discuss the role of M. bovis in farming and the reasons why the bacteria have been problematised.

1.1 Farming in Aotearoa

Farming claims a fundamental position in Aotearoa's past and present as a colonising power, a site of innovation, and a powerful financial actor (Campbell, 2021). European settlement and the subsequent colonisation of the land and its people made Aotearoa a perfect farming outpost for feeding the British Empire (Mein Smith, 2003). Historical narratives about clean pastures and healthy animals developed from nationalistic and imperialistic sentiments about Aotearoa's role as "Britain's farm" (Mein Smith, 2003, p. 81; see also Trampusch, 2014). Dairy farming, in particular, played a key role in shaping the early identities of colonial settlers, and milk itself became an iconic image, representing Aotearoa to the world as a wholesome country (Mein Smith, 2003).

In the 1800s, successful farming simply required developing more land and farming greater numbers of stock. As Haggerty et al. (2009) explain, "the animal body needed only to keep step with the creation of more pasture through extensive land development" (p. 775). This fundamental value of 'productivism', or the "ideal of making two blades of grass where one grew before" (Thompson, 1995, p. 51), was "a long-held value in the largely Pākehā [non-Māori] farming community...that land that can be farmed should be farmed" (Park et al., 2002, p. 528). Productivism is entwined with the belief that agricultural production is an intrinsically honourable practice and is therefore linked to the concept of "good farming" (Haggerty et al., 2009, p 768; see also Campbell, 2021).[12] Farmers obtained social standing for enacting productivist farms, and they became known collectively as being the financial "backbone of the nation" (Park et al., 2002, p. 527–528, RNZ, 2018f), which continues to afford farmers significant political and cultural influence (Haggerty et al., 2009).

The pasture imported from Britain returned especially valuable dividends in the form of dairy products. Aotearoa built its own dairy factories as early as the 1890s, and in 1894, the government's Chief Dairy Expert declared, "[w]e have only to make the prime article in butter and cheese, then no power on earth can stay the flow of white gold in this direction" (Baldwin, 2016, p. 12). Indeed, from the 1900s until the 1960s, Aotearoa was known as the "Empire's Dairy Farm" (Mein Smith, 2003, p. 82).[13] By the 1920s, Aotearoa's dairy cows were supplying a quarter of Britain's butter and half of its cheese (Mein Smith, 2003).

[12] Le Heron et al. (2016) argue that one of the downsides of productivism is that it stifles new initiatives or alternatives for future farming, such as biological agriculture where the importance of lively and vital soils is at the centre. The actor enabling grass to thrive is soil, which has its own network agency, but which has been made to be "largely invisible in popular thought" (Le Heron et al., 2016, p. 170) even though it is the lifeblood of agriculture globally and has been ever since farming began. There is not enough space in this thesis to describe the role of soil in the farming assemblage, though it is acknowledged as a strong but silent actor. In the 1920s, the soil was eroding on Aotearoa's hills due to farming and deforestation. Agricultural science came to the rescue in the period known as the Grasslands Revolution (Brooking & Wood, 2013). This technical contribution to farming involved a network of scientists who figured out the best grass species to stabilise the soil on the hills and that would respond well to fertilisers. These grasses were *Lolium perenne L.* (perennial ryegrass) and *Trifolium repens L.* (white clover) (Campbell, 2021). Now grass for cows is grown almost entirely from these two species (Goldson, 2020). While these two types of grasses are highly productive, they are also vulnerable to invasive pests such as weevils. Because these grasses are exotic species in Aotearoa, they have no ecosystem diversity to help with resistance to predation by pests (Goldson, 2020).

[13] This reference in Mein Smith is about a marketing movie made by the Dairy Export Control Board in 1923 titled "New Zealand: The Empire's Dairy Farm". See also Jay (2007) for a thorough exploration of Aotearoa's dairy farming infrastructure.

Perhaps as a result of colonisation and productivism, Aotearoa now enjoys a reputation for being one of the most export-oriented food producing countries in the world, exporting more than 90 percent of all food produced (Campbell, 2021). Indeed, the country relies heavily on primary exports for its economic strength (Bewsell et al., 2012). Primary sector exports earned Aotearoa over NZ$53 billion in the twelve months prior to June 2022, and this figure is forecast to reach NZ$55 billion by June 2023 (Ministry for Primary Industries [MPI], December 2022). Dairy export revenue alone was approximately NZ$22 billion for the year ending June 2022, and meat and wool exports were more than NZ$12 billion for the same period (MPI, December 2022).

Aotearoa's farming history, including its political and market influences, is the reason why most farmers are still focused on volume over quality, although there is a growing consumer market for provenance, traceability and quality along with concern for environmental standards, sustainability and animal welfare (Pawson & Team, 2018). All of these elements have co-produced farming in Aotearoa over time and feed into the rural concept of a 'good farmer' with reference to productivity and animal health (Haggerty et al., 2009).

Over time, and with political assistance, farming has become an entity that has claimed and changed terrestrial space (Campbell, 2021). Modern-day farming in Aotearoa has been described as an assemblage with its own ontological boundaries (Campbell, 2021), and it is one within which cows themselves have become a sizable colonising force. There are about two times more cows than humans in Aotearoa, with approximately 6.3 million dairy cows and 3.9 million beef cows residing on approximately 49,500 farms at any one time (Statistics New Zealand, 2019).[14] To put into perspective the approximately 180,000 cows culled by the eradicators as at December 2022, a total of approximately 4.5 million cows were slaughtered for food during that same year (Statistics New Zealand, 2022).

Today, it is still the "naturalness of our production systems" (Arwen, Government) that drives international demand, and which adds considerable value to the economic bottom line (Campbell, 2021).[15] A pasture-based farming assemblage is the most profitable because grass

[14] Since M. bovis was discovered in 2017, the numbers of beef cows have increased and the numbers of dairy cows have dropped, changing the makeup of farming types (Statistics New Zealand, 2019).
[15] Arwen is one of the human actors who has helped make this research. See the methodology chapter for more information about the participants and how they got their pseudonyms. As will be explained in the methodology

is the cheapest feed. Seasonal grass growth means that the vast majority of farmers will ensure their cows all calve in the same six-week period in spring. Seasonal calving sees more than four million cows being born in the same period every year (Livestock Improvement Corporation [LIC], n.d.), and this approach to calving is celebrated as working "with nature rather than against it" (LIC, n.d.).

There are four main dairy farming regions in Aotearoa, and these are Waikato and Taranaki in Te Ika a Māui, and Waitaha and Te Taurapa o Te Waka in Te Waipounamu (LIC & Dairy NZ Limited [DairyNZ], 2021). There are more than 11,000 dairy herds in the country, and the average herd size is 444 cows (LIC & DairyNZ, 2021). Dairy farming has expanded in Te Waipounamu over recent decades with much larger dairy farms than in Te Ika a Māui, and this expansion has increased the overall average for the country. More than 70 percent of dairy *herds* are located in Te Ika a Māui, although more than 40 percent of dairy *cows* are located in Te Waipounamu (LIC & DairyNZ, 2021).

More than 70 percent of the country's beef cows are farmed in Te Ika a Māui, and they are mostly farmed with sheep for complementary pasture management (Beef+LambNZ [B+LNZ], September 2017). As will be discussed later, in the eradicators chapter, dairy farming contributes to beef farming significantly through the provision of dairy-beef calves and older (less productive) dairy cows for building up beef herds. Indeed, 38 percent of all cows slaughtered for beef begin their lives on dairy farms (B+LNZ, September 2017). This pasture-based farming assemblage is what the eradicators and farmers were acting to protect through the biosecurity response and eradication programme.[16]

1.2 Biosecurity in Aotearoa

Those purist sentiments about clean pastures and healthy animals not only enabled the export of quality animal products, but they also justified early national biosecurity measures (Ford, 2018). Biosecurity practices to protect farming from animal diseases were mandated by

chapter, the human participants have been given non-gendered personal pronouns ('they', 'their' and 'them') to help protect their anonymity. The M. bovis-affected farmers, scientists and biosecurity professionals are a relatively small group and some of these actors are easily identifiable by gender.

[16] There were two temporal periods within which MPI, and industry bodies acted and enacted their M. bovis realities. The first was the biosecurity response phase, which was before the eradication decision was made, but while MPI and industry bodies were acting to control the bacteria's spread. Once the eradication decision was taken, these actors became known as the 'eradicators'. These phases are described in detail in the preamble.

legislation as early as the 1890s, although the term 'biosecurity' has only been formally used since the Biosecurity Act 1993 came into force (Goldson, 2011; Trampusch, 2014). Some examples were the 1849 Sheep Ordinance, the Diseased Cattle Act 1861 and the Animals Importation Prohibition Act 1876. This legislation conferred a range of biosecurity powers on the government, such as the ability to place restrictions on importing agricultural animals, to inspect and quarantine them on arrival, and to cull those that were infected.

Along with biosecurity powers, scientific knowledge and farmer education became crucial to the development of agriculture. A Department of Agriculture (DoA) was established in 1892, and one of its functions was the dissemination of scientific knowledge to farmers. The DoA regularly distributed information to farmers about bacteriology, for example, though Ford (2018) recounts that farmers were sceptical about relying on the government's scientific advice. The DoA was very clear that the country's economic prosperity was reliant on the health of its cows and sheep (Ford, 2018).

A more recent political influence on biosecurity's development was the removal of farming subsidies in the 1980s (Trampusch, 2014). This change to the financial structure of farming was caused by the government of the day aggressively pursuing trade liberalisation, which in turn reified Aotearoa's market driven biosecurity assemblage (Trampusch, 2014; Jay & Morad, 2006). Trampusch (2014) describes Aotearoa as "an *extreme case* of [an] agricultural export economy and of agricultural trade liberalisation, as well as of market and trade-oriented national biosecurity policies" (p. 208, emphasis original). Yet, as this thesis will show, economics ultimately behaves as a forceful network element that runs *counter* to biosecurity in the farming assemblage. While biosecurity was made with and for farming, the two actor-networks have become increasingly incompatible over time.

Aotearoa's biosecurity assemblage is now known as one of the most integrated, comprehensive and stringent in the world (Trampusch, 2014; Higgins & Dibden, 2011; Bewsell et al., 2012). The Biosecurity Act 1993, and its associated regulations, plans and standards, provide an extensive range of biosecurity powers and management tools, including financial incentives and penalties. The biosecurity assemblage is also comprised of policy documents, such as the Biosecurity 2025 Direction Statement, which sets out the strategic direction for a 10-year period (MPI, 2016). The scope of biosecurity has grown over time to include protecting

indigenous biodiversity and ecosystems from pests and diseases, as well as protecting human health and cultural and social values from biological harm (MPI, 2016).

The biosecurity network envisages biosecurity practices being enacted at three main physical sites. The first is the pre-border or offshore site, which is where biosecurity work is carried out to prevent pests and diseases arriving in Aotearoa. This work involves the use of quarantine, testing and treatment, and relies on importers complying with Import Health Standards to minimise risk.[17] The border site is the country's geographical border, and this is where transitional and quarantine facilities hold imported goods, and where goods and people are inspected on arrival. The remaining site of biosecurity is the post-border space, which is within Aotearoa's territory (land and sea). Here biosecurity practices include hygiene, tracing, surveillance, quarantine and culling and/or managing infected animals as part of a biosecurity 'response', as well as implementing regional and national pest management programmes (Jay et al., 2003; MPI, 2016). The post-border site is where M. bovis' world-making has been occurring and is the part of the biosecurity assemblage that is relevant to this thesis.

1.3 M. bovis in farming

The presence of M. bovis in Aotearoa has been problematised, but surprisingly not by farmers; rather, the bacteria's presence has been problematised by the eradicators. Their main concern was that if the bacteria remained, its presence would undermine 200 years of seasonally driven, pasture-based, 'natural' farming. In particular, the eradicators predicted that the regular supply of beef cows that come from dairy farming might have to cease if M. bovis became endemic, along with calf-rearing practices such as the use of waste-milk, and the ability to move cows onto grazing platforms during the winter months (Elrond, Government).[18] Without the ability to winter-off dairy cows, the use of pasture as a cheap source of feed would be under threat, and because there would be fewer calves available, the beef farms would have fewer cows to feed into the export market. (This is despite there being other cow diseases that are endemic that also travel throughout the actor-network, such as bovine viral diarrhoea [BVD], which

[17] Import Health Standards are legal documents setting out import requirements for different types of 'risk goods', which are those that may harbour pests and diseases (sections 2 & 24A of the Biosecurity Act 1993).
[18] Waste-milk is the milk that dairy farmers discard because it cannot go into the milk vat – either because the cow has mastitis, or she is being treated with anti-biotics. This waste-milk, also known as 'discard-milk' is commonly fed to calves by calf-rearers, primarily because it is the cheapest form of milk. However, Dairy NZ do not recommend the practice due to potential impacts on calf health.

results in cow deaths and productivity loss [Gamling, Veterinarian].) This thesis shows that M. bovis has managed to frame its impacts differently to other microbes, however, by being a mostly benign presence on most farms. It will also become clear that the bacteria have proven the eradicators wrong by having very little impact on productivity.

There are multiple power struggles and attempts at translation afoot in this tale about a battle between bacteria, cows and the eradicators. Other actors such as farmers and scientists have been caught in the crossfire, but they have staked their claims as network mediators, nonetheless. There have been very few intermediaries in this high stakes endeavour.

The next section explains the overall structure and shape of the thesis, including the findings chapters, which are structured along similar lines to a narrative so eloquently told by Michel Callon (1986) about the scallops of St Brieuc Bay.

1.4 Structure of this thesis

After this introduction, the first substantive chapter is the literature review. The literature review makes clear the sets of theoretical framings drawn upon by this thesis by offering a focussed study of relevant biosecurity literatures. I have organised the literature by conceptual alignments, using for example a Foucauldian strand and a Callon, Latour and Law strand of thinking.

Next, chapter three, is the methodology chapter, which explains the conceptual foundations that underpin this empirical research, and which describes how the thesis uses Callon's (1986) 'four moments of translation' to structure M. bovis' world-making narrative. The chapter further describes the methods I used to choose the human actors, and how their goals and obstacles evolved from the interviews. It also highlights the limitations of and other influences on this research.

After the methodology chapter, there is a short preamble. The purpose of this preamble is to properly introduce the key actors and their interests, story the bacteria's journey to and discovery within Aotearoa and 'thickly describe' (Michael, 2017) the eradicators' moments of translation and controversy. This short chapter provides essential knowledge for the reader before moving into the more highly structured findings chapters, by which time the background knowledge will have formed a basis for the descriptions of the actors' world-making.

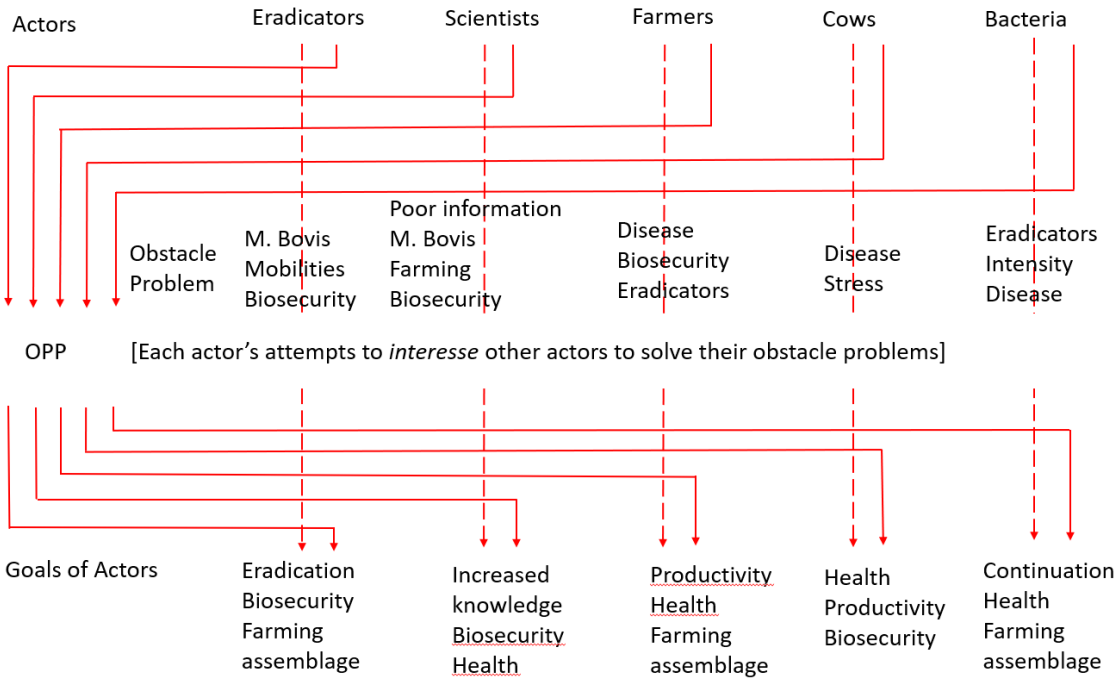
What follows the preamble is a series of localised stories told by each of the key actors about biosecurity and farming in Aotearoa, each chapter being centred around their experiences of M. bovis' world-making. While the eradicators, scientists, farmers, cows and bacteria represented by this thesis were not the only influential biosecurity and/or farming actors, they have revealed themselves to be the most powerful ones (see Venturini, 2010a). I decided to artificially separate out the actors' stories so that they could be clearly told (see Evans et al., 2021 on provisional distinctions), and the discussion chapter brings them back together at a later stage. Each of these substantive chapters focuses on the 'labour' of making worlds - those ongoing practices that are required to not only create but also to maintain realities. As the findings chapters will show, each of these actors had its own goals to achieve, its own obstacles to overcome and its own obligatory passage point (OPP) to pass through to achieve those goals (see the methodology chapter for an explanation on why this structure was chosen).

The findings chapters begin with the eradicators and end with the bacteria, but that order was originally the other way around. I initially began with M. bovis' story, followed by the cows' story, and then moved into the farmers, scientists and eradicators chapters last. However, what I found was that the eradicators spoke more loudly about M. bovis than the other actors and beginning with them allowed each subsequent chapter's descriptions and understandings to build on prior knowledge of the biosecurity and eradication situation. The following chapters could then begin to make comparisons between the worlds and have discussions about the success or otherwise of previous actors' attempts to translate farming and/or biosecurity in Aotearoa. It may appear as if the same stories are being told repeatedly, using the same sociological framework of translation, but the more actors who tell their M. bovis stories, the more the recurring themes created by those stories can be trusted (Venturini, 2010a). Ultimately, this is a collective story; one of emergence, provisionality, and multiple realities existing within several, simultaneous lines of flight and of articulation (Anderson & McFarlane, 2011).

I have manipulated Callon's (1986) diagram (which illustrates the first two translation moments of 'problematisation' and '*interessement*') to clarify the actors' own translation processes. The diagram has been amended specifically for each actor, so that it declares in advance every actor's OPP – or the question that must be answered so that a solution can be attained in accordance with that actor's goals. Unlike Callon's (1986) work, however, each

actor in M. bovis' assemblage had a different OPP. For clarity, each actor's translation process is illustrated with this diagram at the beginning of their own chapter, and in a lot more detail than here. Each chapter begins with an explanation of the actor's chart because the chart outlines the structure of their M. bovis narrative. For now, though, and for easy reference, *Figure 2* below provides an overarching description of each of the five actors' obstacles and goals together in one place.

Figure 2
Main network actors' obstacle problems and translation goals



This diagram shows, for example, that for the eradicators (top left), M. bovis, cow mobilities and (a lack of) biosecurity were obstacle problems that they thought they had to overcome to reach their goals. The eradicators' goals (bottom left) were eradication of the bacteria, on-farm biosecurity and the continuation of farming in Aotearoa. As their own chapter will show, the eradicators' OPP was, 'Can we eradicate M. bovis?' (The answer appears to be in the affirmative, or so the eradicators think).

Another example is M. bovis itself, which described its obstacle problems as the eradicators (unsurprisingly), dairy farming intensity and the manifestation of diseases (like mastitis) in cows. The reasons for these obstacles to the bacteria's world-making will become clear in its own chapter. M. bovis' goals were to continue living in Aotearoa, healthy cows (so they do not

betray the bacteria's presence) and the farming assemblage (because cow mobilities suit the bacteria's need to survive). M. bovis' OPP was, 'Does Aotearoa's farming assemblage suit us?', and the answer is that it does (in its current shape).

The final substantive chapter, before moving to the conclusion, is the discussion chapter. This chapter's purpose is twofold: first, to make sense of the actors' realities through the lens of existing biosecurity literature; and secondly to develop that literature by applying it to M. bovis within Aotearoa's farming actor-network. As the discussion chapter will reveal, the actors who have participated in this research have together performed three key biosecurity and farming realities. The first is the fundamental incompatibility between farming and biosecurity in Aotearoa (at least, as these two assemblages are currently formed). The second reality creates the conditions for the first, and is perhaps the most important, which is that while farming exists in conflict with biosecurity, its particular configuration also creates the need for biosecurity. Thus, there is a circularity about the relations between the two assemblages that can only be resolved by one becoming unmade and remade (Law, 2004), or perhaps both together. The third and final research current is that there is no room within biosecurity for the recognition of more-than-human worlds. This situation is a paradox that has consequences for farming because those lively forms of microbial life are the focus of agricultural biosecurity in Aotearoa.

The concluding chapter restates my contributions and identifies some important biosecurity implications that arise for farming. In addition, the conclusion offers some ideas and opportunities for future biosecurity research, which I argue is urgently required if farming is to become more biologically secure.

Chapter 2 Literature

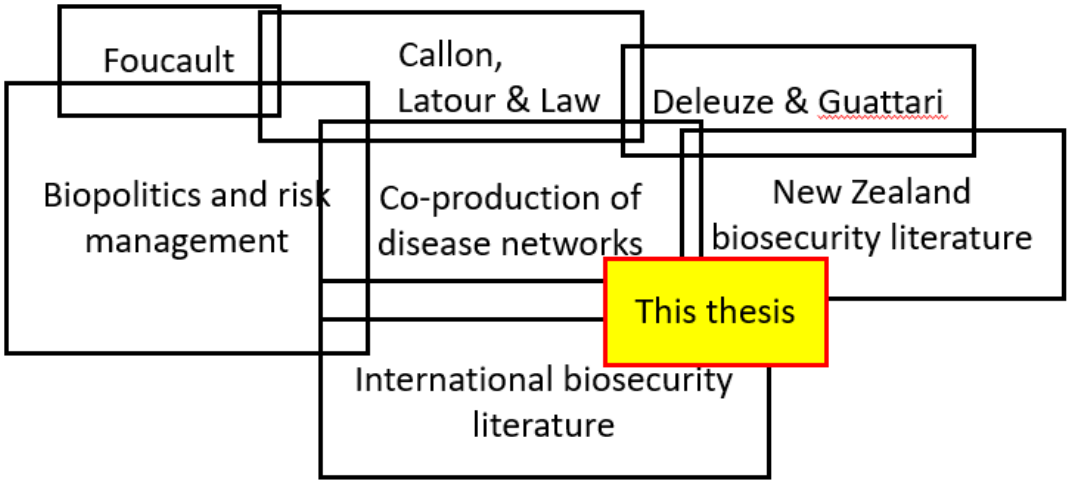
It matters what thoughts think thoughts. It matters what knowledges know knowledges. It matters what relations relate relations. It matters what worlds world worlds. It matters what stories tell stories (Haraway, 2016, p. 35).

2.1 Introduction

This literature review lays out the theoretical set of framings drawn upon and ultimately extended by this thesis. The aim of this chapter is to discipline the reader's eye to a particular way of acknowledging and representing the ontological problem of M. bovis' existence. The theoretical strands and connections set out here will be relied on over the course of this thesis, and in particular, as they weave throughout the multiple stories being told about M. bovis and its bacterial world-making. This literature review deliberately focusses on certain biosecurity literatures to the exclusion of some others, but that focus does not imply that the academic strands sitting outside of this chapter have not been considered.

In pictorial form, *Figure 3* below situates this thesis within the wider family of relevant literature beginning with Michel Foucault, the trio of Michel Callon, Bruno Latour and John Law, and the duo of Gilles Deleuze and Félix Guattari. It is from these thinkers that the modern strands of biosecurity thought have emerged. There are many ways to illustrate these different lines of thought, but this chapter visualises two prominent strands of biosecurity literature. The first is described as the Foucauldian strand, where biosecurity is a biopolitical concern. This strand is titled 'biopolitics and risk management'. The second is the Callon, Latour and Law strand, which deals with the material semiotic nature of the social world and includes the assemblage thinking of Deleuze and Guattari. This strand is termed 'co-production of disease networks', and it is this line of thought that I work with in the subsequent chapters. The overlapping rectangles in *Figure 3* are deliberate, because each of the biopolitics and co-production strands have interfered with each other and have influenced national and international biosecurity literature.

Figure 3
Situating this thesis within the literature



This thesis sits at the intersections between the actor-network theory of Callon, Latour and Law, the assemblage theory of Deleuze and Guattari, and the contemporary biosecurity literature that has built on the work of its predecessors. What the diagram does not show, but will be discussed below, is that the vast majority of biosecurity research and writing comes from the United Kingdom (UK), as opposed to Aotearoa. Even the social science research on biosecurity in Aotearoa mostly comes from UK-based researchers, and the lack of priority given to biosecurity by researchers from Aotearoa illustrates the importance of this thesis.

The first task this chapter undertakes is to introduce the reader to the concept and practice of biosecurity; that is, what biosecurity is said to be about and what it is said to enact by its practices. The next section provides an overview of Aotearoa's and international biosecurity literatures, before moving deeper into the two lines of thought mentioned above. The biopolitical strand is unpacked in two brief subsections, while the co-production strand is unpacked into three categories of thought. Each line of thought begins with an explanation of its conceptual origins.[19]

[19] If reading this thesis online, the headings and subheadings used throughout will appear in the 'navigation pane' to the left of the document (View – Navigation Pane). These are useful in navigating the chapters.

2.1.1 What is biosecurity?

Before delving into the literature, it is important to understand how biosecurity is defined and described by researchers in the field.[20] Broadly, biosecurity is a generic term that is given to a group of heterogenous practices enacted for the purpose of securing valued forms of life from harm (for variations on that theme, see Higgins et al., 2016; Buller, 2008; Barker, 2008; Donaldson & Wood, 2004; Hinchliffe, 2001; Law, 2006; Donaldson, 2013; and Barker et al., 2013). My preferred definition comes from Clark (2013) primarily because it is more sociological in nature than many, but also because it acknowledges that biosecurity is practised, as opposed to being an outcome that is assured. He describes biosecurity as an "attempt to protect established and valued life from emergent, transgressive and undesirable life" (p. 18). At a high level, biosecurity poses the existential question of "how we live in the world and manage our relationships with other species" (Donaldson, 2013, p. 72).

Biosecurity practices and their narratives are more than a reaction to incursions of pests and diseases; they also 'problematise' such incursions and imbue them with social and political significance (Barker et al., 2013; Law & Mol, 2008a). Bingham et al. (2008) agree, describing biosecurity practices as providing "relief to certain problematics while managing to shield others from view" (p. 1528). Typical biosecurity practices target those transgressive lifeforms that are termed 'pests and diseases'. The practices include surveillance and monitoring, testing and trapping, isolation and quarantine, and eradication and long-term management. These 'mundane' (Donaldson, 2008) biosecurity practices foreground the never-ending work of securing biological life (Hinchliffe & Bingham, 2008) and they are enacted within localised "spatial, temporal and discursive contexts" (Barker et al., 2013, p. 5). The last point is important because M. bovis has multiple ontologies, whereas biosecurity practices are based on a singular epistemology, and as we will see this conceptual divide has caused conflict between the eradicators and the farmers.

As seen from the above definitions, biosecurity acts are political and social, as well as scientific and technical (see also Braun, 2013). Hinchliffe (2013) argues that biosecurity itself co-produces disease incursions, and that unwanted organisms emerge as entangled relations between human and non-human actors. Acknowledging the impermanence of security,

[20] Biosecurity practitioners tend to follow the public policy definition of biosecurity set out later in this section.

Hinchliffe and Bingham (2008) prefer to use the verb 'biosecuring' to foreground what they call the "unfinished business of making life safe" (p. 1542). Therefore, biosecurity can be more properly viewed as a process comprised of situated practices, as opposed to a stable state of being (Barker, 2008; Farbotko, 2015; Barker, 2015).

In Aotearoa, the term biosecurity is defined by public policy as "the exclusion, eradication or management of pests and diseases that pose a risk to the economy, environment, cultural and social values, including human health" (MPI, 2016, p. 4). In contrast to the academic definitions provided by biosecurity scholars, this definition of biosecurity is framed normatively, describing a *state* of biological safety, as opposed to acknowledging the unpredictability of working with "lively materialities" (Henry & Roche, 2013, p. 204). Following Bingham et al. (2008), this thesis argues that Aotearoa's definition of biosecurity not only invisibilises life's creative abilities but that it also black-boxes the social, economic, and political imperatives underpinning biosecurity practices, making them difficult to know (see also Barker, 2008).

There are multiple "modes of ordering" (Law, 1994, p. 20) driving the biosecuring process, including policy makers, biosecurity officials, scientists, and farmers - each invested in 'the how' of disease control as well as the goals. Enticott (2016b) considers that these modes of ordering speak volumes about the neo-liberal way disease is controlled, and that the imperative to manage disease "by any means possible" (p. 38) reflects farming's own vulnerability. Indeed, the biological insecurity inherent in Aotearoa's farming assemblage is a constant theme running though this thesis.

Now that biosecurity has been broadly defined, this chapter moves to consider Aotearoa's academic contributions to biosecurity literature.

2.2 Aotearoa's biosecurity literature

For a country as economically reliant on agriculture as Aotearoa, it is surprising that academic researchers have produced very little social science biosecurity literature. In fact, compared to the UK, there is scant non-scientific biosecurity literature written by Aotearoa's or Australia's

researchers (for Australia, see Higgins & Dibden, 2011; Higgins et al., 2016; Enticott & Higgins, 2017; Bryant & Higgins, 2019; Lien, 2005; Maye et al., 2012).[21]

The biosecurity literature that is located in Aotearoa can be classified into three topic areas. The first topic explores the economic and political tensions inherent in attempting to secure trade and protect the environment (see, for example, Jay et al., 2003; Jay & Morad, 2006; Higgins & Dibden, 2011). The second topic focuses on securing indigenous flora and fauna and protecting the biodiversity of valued nature from exotic species, including pests (see, for example, Norton et al., 2016; McDonald, 2019; Lambert & Mark-Shadbolt, 2021). The last and smallest topic area involves traversing Aotearoa's biosecurity history in the context of European settlement and land development (see, for example, Ford, 2018).

In addition to this biosecurity research, there is a strong portfolio of academic work on biological economies and agricultural assemblages - although these authors do not specifically focus on the role of biosecurity practices in making or upholding those assemblages (see, for example, Carolan, 2013; Henry & Roche, 2013; Le Heron et al., 2016; Forney et al., 2018; Pawson & Team, 2018; Campbell, 2021).

More relevantly, there are several biosecurity researchers investigating a cow disease called *Mycobacterium bovis* (as opposed to *Myco*plasma *bovis*), and much of this important body of work is located on Aotearoa's farms.[22] This group of academics directly consider biosecurity knowledge and practices on farms, focusing particularly on the following: regulating disease flows and the role of trust (Enticott, 2008b); the production of knowledges about animal diseases and the role of interdisciplinarity (Enticott, 2016b; Enticott & Vanclay, 2011); farming identity with respect to risk based approaches to trading cows (Enticott, 2016a; Hidano et al., 2019); and farmers' belief systems with respect to the circulation of animal diseases such as bovine tuberculosis (bTB) (Enticott et al., 2021).

Most recently, several researchers have been associated with an Otago University study on the impacts of the M. bovis eradication programme on the health and wellbeing of rural communities. Three journal articles have resulted from this research: Jaye et al. (2021) were

[21] I do not know why there is so little sociological biosecurity research in Aotearoa or Australia. Perhaps biosecurity is experienced more as a set of practices than an academic discipline in these countries.
[22] *Mycobacterium bovis* is the pathogen responsible for causing the disease of bovine tuberculosis (**bTB**).

primarily concerned with the impacts of government bureaucracy on farmers; Jaye et al. (2022) explored the concepts of moral capital and moral economy with reference to the investments of time and care that farmers make in their cows; and Noller et al. (2022) found that the biosecurity response and subsequent eradication programme had adversely impacted on farmers' wellbeing. These are existing research themes that resonate with some, but not all, of the findings in this thesis. These examples represent the only social science work being done regarding M. bovis in Aotearoa, even though it has been more than five years since M. bovis was discovered. Until these recent articles, all of the academic research that had been done on M. bovis in Aotearoa had been of a scientific nature, mostly written by veterinarians (see, for example, Jordan et al., 2021).

As seen from this brief introduction to Aotearoa's biosecurity literature, and as will be shown below in the section that discusses the international biosecurity literature, the sociological research that best frames this thesis' focus on M. bovis' bacterial world-making comes from the UK. Yet, a portion of this overseas research has developed from and even been based in Aotearoa (see Barker, 2008 & 2010; Clark, 2002 & 2013; Enticott, 2016a & 2016b; Enticott et al., 2021; Hidano et al., 2019). This thesis aims to extend the existing body of work by using ANT as the predominant frame for telling Aotearoa's M. bovis story, but this time with a more-than-human lens.

2.3 International biosecurity literature

Since the beginning of this century, there has been growing interest in social science biosecurity research, and this interest is exemplified by a core group of UK researchers. Prior to this creation of modern biosecurity literature, overseas academic discourses about the impacts and management of pests and diseases have also tended to be scientific in nature (Dobson et al., 2013). Unsurprisingly, many modern biosecurity researchers argue that the topic is better served by an interdisciplinarity of practices, rather than viewing the natural sciences as being the only answer to pathogenic problems (Dobson et al., 2013; Hinchliffe & Bingham, 2008; Enticott & Wilkinson, 2013; Price et al., 2017). Enticott and Wilkinson (2013) go further to suggest that it is "unrealistic" (p. 101) to think that minimising consequences from disease outbreaks will happen without social science input into biosecurity research and by employing interdisciplinary approaches, in particular.

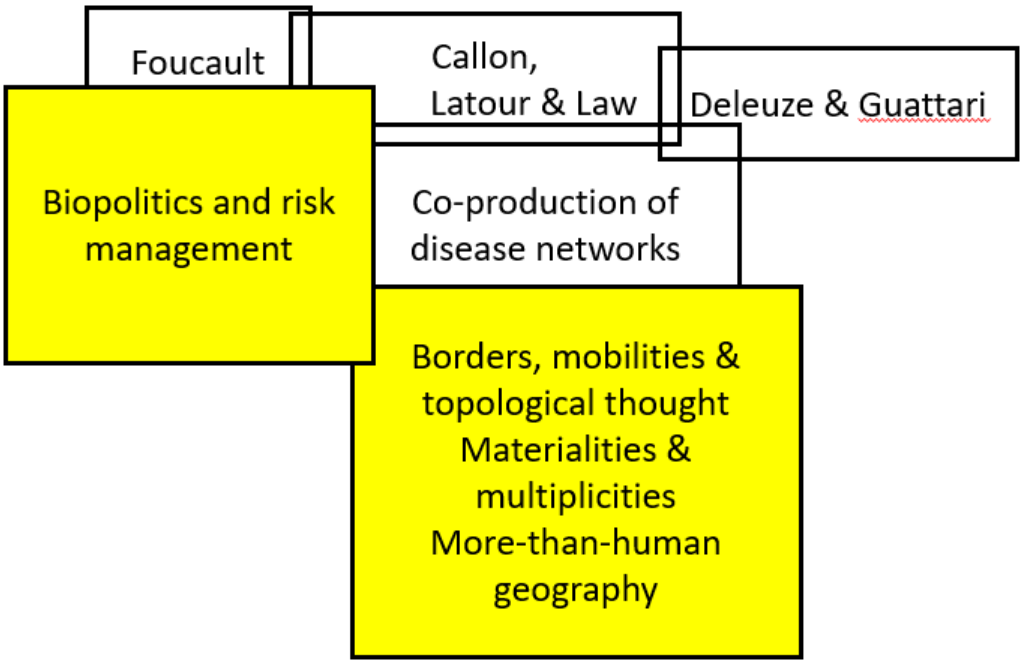
Indeed, it has been through social science researchers' dissatisfaction with extant, siloed approaches that modern interdisciplinary approaches to biosecurity have developed (Keil & Ali, 2008). Barker et al.'s (2013) view is that the number of theoretical approaches that are interwoven, and the breadth of issues, makes biosecurity "one of the most exciting and innovative areas of contemporary social research" (p. 4; see also Clark, 2013).

Within this emergent field, there are what Barker et al. (2013) call several "theoretical currents" (p. 3). The first of these currents centres around biopolitical concerns and population governance, as opposed to the second, which is more concerned with issues of risk and indeterminacy. The third of these attends to the role of non-human actors in co-producing networks, including issues of materiality and mobility. The fourth explores the spatial realms of biosecurity, including interrogating topologies and boundary-making. The final segment of work is coalesced around larger biopolitical issues of nationhood and globalisation.

Within this "burgeoning field" (Barker et al., 2013, p. 3) of social science inquiry a substantial volume of work has been created about agricultural and zoonotic disease assemblages, such as: foot and mouth disease (FMD) (Donaldson, 2004; Law, 2006; Law & Mol, 2008a, 2011; Law & Singleton, 2015), bovine spongiform encephalopathy (BSE) (Hinchliffe, 2001), bTB (Enticott, 2008b & 2016a; Enticott et al., 2021; Enticott & Wilkinson, 2013; Enticott & Vanclay, 2011; Hidano et al., 2019); avian influenza (HPAI H5N1), severe acute respiratory syndrome (SARS-CoV-1 and SARS-CoV-2) and swine flu (H1N1) (Ingram, 2013; Barker, 2012; Hinchliffe, 2013; Hinchliffe & Bingham, 2008; McDonald, 2020b; Connolly et al., 2020). Notably, there is an absence of empirical biosecurity research focussing on M. bovis coming from the UK, despite the long history of farming in the northern hemisphere and the long history of its presence.

This chapter builds on Barker et al.'s (2013) theoretical currents of biosecurity literature, but it organises them differently. As already mentioned, and as *Figure 4* below illustrates, this chapter considers two main groupings: the first is the literature on biopolitical biosecurity management, incorporating the notion of risk; and the second is the body of work involving the role of animals and technologies in co-producing biosecurity assemblages, including how these assemblages hold together and pull apart. The diagram below shows the arrangement in pictorial form.

Figure 4
Biosecurity currents within the literature



The Foucauldian thread is divided into two headings for ease of reading (biopolitics and risk management). The Callon, Latour and Law thread categorises three distinct bodies of thought: borders, mobilities and topological thought; materialities and multiplicities; and more-than-human geography. This 'pull apart' structure is for ease of understanding, though it is acknowledged that there is overlap by biosecurity theorists who will rely on both strands of thinking, often in the same work (see for example Li, 2007; Singleton & Law, 2013; Collier & Lakoff, 2008; Barker et al., 2013). The final section of the chapter explains how this thesis applies and extends current biosecurity thinking.

2.4 Mapping modern biosecurity literatures

2.4.1 Biopolitics and risk management

In this category, much of the social science literature tends to frame biosecurity as being a set of measures used to prevent a future emergency or catastrophe (see for example Clark, 2013; Collier et al., 2004). The conceptual origins of the 'emergency' and 'emergence of risk' biosecurity discourses stem primarily from Foucauldian thought about health and disease, which were developed in his seminal works on biopolitics, governance and surveillance (see Foucault, 1977, 2003, 2007). Clark's (2013) view is that this 'emergency' type of approach to

securing health uses the emergent properties of biological life as covert justification for increased government surveillance and social control. Similarly, Donaldson (2008) argues that biosecurity uses a "discourse of power" (p. 1555) to reinforce societal rules and behaviours.

For Barker (2008), these biopolitical and risk-based biosecurity discourses have missed out on the opportunity to work with emergence, still categorising spaces and creating boundaries for the purpose of surveillance or similar biosecurity pre-emption practices. Barker (2008) considers that the traditional biosecurity narrative paints a "conflicting picture" (p. 1600) of unpredictable life, and the exemplars chosen (often of zoonotic diseases) tend to be focussed on biosecurity failures which "tell particular stories to the detriment of others" (p. 1600; see also Donaldson, 2008; Donaldson & Wood, 2004; Hinchliffe, 2001; Hinchliffe & Bingham, 2008; Nerlich et al., 2009). Storytelling, and which stories are chosen for the purpose of speaking for M. bovis is at the heart of this thesis' structure, though the multiple stories of M. bovis' world-making are told through a material semiotic lens, as opposed to a lens of risk and politics.

2.4.1.1 Conceptual origins

Clark (2013) considers that biosecurity studies have essentially extended Foucault's "rhetoric of discipline, control and surveillance - beyond its original context of human bodies under duress to encompass the biosphere in its entirety" (p. 26.) However, Braun (2013) argues that Foucault's work on biopolitics was not merely about control of unruly and undesirable forms of life through population control, it was also fundamentally about the prioritising of life forms, so that some life can thrive while other life must die. For this reason, he considers that there may be benefit in extending Foucault's biopolitics even further into contemporary biosecurity discourses about those practices which "intervene…in life (and *against* life) in order to secure life" (Braun, 2013, p. 54). For Braun (2013), biosecurity is fundamentally a governance issue that lends itself naturally to Foucauldian thought.

There is no denying that Foucault's work, which contains an underlying theme of infection (see Sarasin, 2008), has made a considerable contribution to modern biosecurity discourses (see, for example, Li, 2007; Braun, 2013; Collier et al., 2004). Yet, some argue that many of his categories of control fail to acknowledge the indeterminacy, instability and mobility of life required to manage it (Barker, 2008; see also Hinchliffe & Bingham, 2008). For example,

Sarasin (2008) argues that because Foucault's categories of control are founded on an "epidemiological logic" (p. 279) as opposed to an ontological one, they lack the flexibility to deal with the mutability of disease. Enticott (2016b) argues that epidemiology itself "attempts to quantify objective risk, picturing agricultural space as a placeless flat surface" (p. 38). As will become apparent, the findings in this thesis clearly align with Sarasin's and Enticott's research. However, there remain several authors who still consider that there is enough in Foucault's writing to keep biopolitics and the concept of biopower relevant for contemporary biosecurity literature (for example: Braun, 2013; Hinchliffe & Bingham, 2008; Rabinow & Rose, 2006). Some of these authors bring with them their own material semiotic framings, which have significantly developed Foucault's original biosecurity thinking.

2.4.1.2 Categories of thought

2.4.1.2.1 Biopolitics

A persistent theme in the modern biopolitical current of work is that the biological security of human and non-human life is interconnected due to globalisation, making time and space almost irrelevant in a world that is "overfull" (Braun, 2013, p. 50; Massumi, 2009). As Barker et al. (2013) state, "some indeterminate future, becomes the local present" (p. 16). For Clark (2013), the threat of unruly life gets used as a justification for more intrusive state surveillance, of humans and non-humans alike (see also Hinchliffe & Ward, 2014).

Surprisingly, this type of thinking has developed to resonate with Mol and Law's (1994) topology work (see below), where those authors tell us that global networks behave as folds and flows, as opposed to territories with geographical borders, making linear time less relevant with the lack of space-time making biological life more proximate (Ali, 2008; Braun, 2007; Massumi, 2009). Similarly, Ali (2008) refers to Giddens (1990) who sees globalisation as being defined by a set of processes called "disembedding and re-embedding" (p. 239), which appears to be akin to assemblage theory (again, discussed below). In this type of biosecurity thinking, there is always the potential for life to interact in unexpected and unwanted ways (Massumi, 2009).

Foucault (2007) used the term 'biopolitics' to encompass the "political techniques that emerged in early modernity with the aim of monitoring, managing and enhancing what had come to be seen as the unruly energies of the living human body" (Clark, 2013, p. 23; see also Braun,

2007). For Braun (2013), biosecurity is best viewed as an issue of biopolitics because "an unavoidable consequence of the project of biosecurity is to 'cut' life up into desirable and undesirable forms" (Barker et al., 2013, p 16). Biopolitics is often discussed within "a constant state of emergency" posed by biological and political threats (Clark, 2013, p. 36). 'Biosecuritisation' is a related term used by some scholars to describe the securitisation of life and control of "life-like properties" (Dillon, 2007, cited in Clark, 2013, p. 23).

Hinchliffe and Ward (2014) define biopolitics as the actions of governing bodies for the purpose of valuing some forms of life and eradicating or controlling others. Hinchliffe and Bingham (2008) see biopolitics as being an inherently empirical endeavour, requiring observers to "investigate the practices as they make and remake the real" (p. 1541). While this ontological approach sounds more like ANT than Foucault, these two authors insist that Foucault's work is not intractably wedded to external and imposing governance structures (Hinchliffe & Bingham, 2008).

2.4.1.2.2 Risk management

Biosecurity has been described as a "site of problematisation" (Collier et al., 2004, p. 3) within which biology is framed as an emerging threat and constant risk (see also Barker, 2008, 2010; Clark, 2013; Donaldson & Wood, 2004; Hinchliffe & Bingham, 2008; Hinchliffe et al., 2017). Clark (2013) calls biological threats "a hazardous liveliness that is always emerging" (p. 26) and considers that the critical social science literature discusses biosecurity as that of pre-empting future emergency and catastrophe. Dillon and Reid (2009) also acknowledge an "emergency of emergence" (cited in Barker et al., 2013, p. 9) in biosecurity.

"Risk thinking", as Rothstein et al. (cited in Donaldson, 2008, p. 1556) call it, appears particularly in discourses around animal productivism, primary products and economics (Donaldson, 2008; Law, 2006). The premise here is that animal diseases are a risk to agricultural productivity, and that they therefore become a risk to socioeconomic stability and human health (e.g., zoonotic diseases) (Donaldson 2008; Bingham et al., 2008).

Potter (2013) considers risk assessments to be political decision-making, even though they are designed to appear scientifically justifiable. He argues that even the way biosecurity risks, or issues are framed is a political act, determining the purpose and recipients of the action. Potter therefore calls for the "black box of technocratic risk assessment" (Barker et al., 2013, p. 20)

to be prised open to make way for political debate. Again, the present need to unpack the black boxes of biosecurity and farming in Aotearoa are conceptual threads running through this thesis.

Some social scientists argue against the risk society thesis on the basis that it presents a narrow lens through which to view complex issues, which is like pre-empting the trajectory of description before the issues have been explored (see, for example, Barry et al., 2002). The contrary view is espoused by others, however, who consider that future preparedness *requires* "imaginative techniques of enactment" (Collier & Lakoff, 2008, p. 14) and that a risk approach "foreground[s] contingency" (Donaldson, 2008, p. 1557) without tying it down ontologically.

It is the material world that this thesis is primarily focused on, but the way in which the M. bovis story is being told requires more of the richness and complexity that comes from material semiotic literatures, such as ANT and assemblage theory. The next section reviews those two conceptual origins for the other main strand of biosecurity research, the co-production of disease networks.

2.4.2 Co-production of disease networks

The importance of engaging with living organisms during times of biosecurity emergency is acknowledged. There are some authors, however, who consider that humans should engage with the symbiosis of "living with" (Barker, 2010, p. 351) organisms generally (see also Haraway, 2008, 2016). Barker (2010) argues, for example, that biosecurity needs to be re-constructed in the context of a flexible spatio-temporal nature-culture to secure biological life, which *prima facie* may seem counterintuitive (Hinchliffe & Bingham, 2008).

An illustration of this counterintuitive nature of accepting life (versus shunning it) is provided by Allen and Lavau (2015), who argue that by "walling in" (Hinchliffe, 2013, p. 204) agricultural animals to protect them from disease they get reduced to "mere life" (Honig, 2009 cited in Allen & Lavau, 2015, p. 343), which perversely can create conditions for life to turn against itself (see also Esposito, 2008). Allen and Lavau (2015) review work from science and technology studies on biosecurity practices that conceive of disease "as a relational effect" (p. 343; see, in particular, Law & Mol, 2011; Law & Singleton, 2015).

The site for animal disease has been called a situation of 'intra-actions' (Barad, 2007) that contain pathogens and the capacity for illness (Hinchliffe et al., 2013). Allen and Lavau (2015) contend that this assemblage of intra-actions is actually "a landscape of intensities and pressure points rather than a series of breach points, in which disease can erupt as quickly as it can dissipate" (p. 343). As will be seen with M. bovis' world-making, network intra-actions can lead to bacterial eruptions, where life pushes itself beyond tipping points to create new life and destroy other forms of life (Allen & Lavau, 2015).

Hinchliffe (2001) instructs that acknowledging the mutability and contestability of life has a valuable role to play in disease prevention because what emerges as a pest or disease within a given network is relational. Enticott and Wilkinson (2013) go further and argue that biosecurity itself co-produces disease incursions, so that even the eradicators end up playing an impactful role in bacterial world-making (Donaldson, 2008; Enticott, 2008b; Hinchliffe & Bingham, 2008; Allen & Lavau, 2015).

Along the lines of Buller (2013) and other theorists concerned with the intra-actions of humans, animals and disease, Allen and Lavau (2015) urge other researchers to follow the human, animal and disease relationships, and trace the patterns of relations through sites of biosecurity practice such as farms, government departments and scientific laboratories (see also Buller, 2003; Donaldson & Wood, 2004). Finding connections among the flows of biological life has become particularly important now that globalisation has altered space and time such that life can co-create in unpredictable (and often unwanted) ways (Allen & Lavau, 2015; see also Thacker, 2005).

There are multiple theoretical strands that underpin this approach to the co-production of disease networks, and three of these are explored below. However, each of these categories of thought share the same theoretical origins, and it is to these conceptual beginnings that we first turn.

2.4.2.1 Conceptual origins

2.4.2.1.1 Actor-network theory

ANT emerged from the work of Bruno Latour, Michel Callon and John Law in the 1980s as a way of making sociological sense of scientific developments and technologies (Law &

Singleton, 2015; Law, 2007). The theory emerged in the context of the 'sociology of scientific knowledge', and strongly favours empirical research over epistemological understanding (Michael, 2017; Law, 2007).[23] ANT is more than one thing – Law (2007) calls it a "diaspora that overlaps with other intellectual traditions" (p. 2). Mol (2010) sagely cautions those researching with ANT that "as you walk nobody will hold your hand" (p. 261). Indeed, the present research has borne out Mol's advice in multiple ways, not only with respect to the challenge of identifying actors and their interests, but also the nature of their allegiances and conflicts.

More broadly, ANT is a branch of material semiotics, which is a social science movement that is concerned with the ontological complexities of how more-than-human societies are formed and hold together (Law, 2019). Material-semiotics explores the performance of realities – the ontological, as well as describing how knowledge is made – the epistemological (Law, 2007). Material semiotics explores how network actors "pattern themselves in weaves" (Law, 2019, p. 3) and then describes the social consequences of those patterns. In a human-centred world, those relations almost always occur unnoticed – even in the field of biosecurity, which is concerned with pests and diseases impacting humans, animals and plants (again see Law, 2019).

ANT's main premise is that society is a relational construct that is produced and reproduced through heterogeneous relations between humans and non-humans, including documents, texts and technologies (Callon, 1991; Latour, 2005; Michael, 2017). Realities are not politically or socially constructed; rather, they are "practised into being in heterogeneous networks of relations" (Law & Singleton, 2015, p. 10; see also Law, 2004; Mol, 2002). ANT is concerned with how those connections perform realities through speech, texts or actions (Michael 2017).

Adopting an actor-network approach to understanding multi-species relations and world creation allows for the possibility of exploring "strange and heterogenous links" (Law, 2007, p. 7), such as fishermen and scallops (Callon, 1986), or farmers and M. bovis. Referencing Callon's (1986) seminal work, Law (2007) explains that the differences between the fishermen and the scallops developed in a network of relations, but they did not precede those relations. Importantly, fishermen and scallops may perform differently in different networks, so an

[23] For an historical summary of the sociology of scientific knowledge's four principles, see Bloor (1976).

epistemological position cannot be used to assign types of behaviour to groups of actors (Law, 2007). This knowledge-making approach is radical because the division between the human and non-human has disappeared entirely – everything becomes relational (Law, 2015).

Latour (2005) famously wrote that one is never alone in acting because actors are 'made to act' (p. 46) by other actors in a network (see also Law, 2007; Latour & Woolgar, 1986). This point about relationships applies equally to how pests and diseases behave in their own actor-networks, and how emerging networks like M. bovis intra-act with other, existing actor-networks. As will be seen, M. bovis' success in forming its own network depends on farming and biosecurity practices, cows, geographies, human relationships, science and technologies, and the function of and relationships with existing actor-networks. A further example is Latour's (1988) description of the enactment of pasteurisation, where he rejects the idea that Pasteur was a national hero, because in a material-semiotic world all actions are relational effects. Put another way, Pasteur did not create the cure for anthrax; rather it resulted from the actor-network of farms, scientists, and bacteria themselves (not to mention the cows) (Latour, 1988a; see also Law, 2007).

Science and technology studies and its many theoretical relations take the approach that scientific 'discoveries' are actually scientific 'constructions' at certain points in history (Latour & Woolgar, 1986). Latour (1988a) sums up the position by declaring that "[n]othing is known - only realised" (p. 159). Law (2004) goes further in his claim that, "realities are produced along with the statements that report them" (p. 38), despite the insistence of scientists that they only deal in "hard facts" that exist independently of the laboratories' literary inscriptions (Latour & Woolgar, 1986, p. 70). As will be seen in the scientists' chapter, M. bovis realities have been produced with the technologies that named them, such as different types of scientific testing.

The related assemblage theory, known as a post-ANT (Anderson & McFarlane, 2011), is another founding school of thought for modern biosecurity academics. This theory is discussed in the next section, along with its relevance to M. bovis' attempt at world-making in Aotearoa.

2.4.2.1.2 Assemblage theory

Law (2007) argues that there is actually not much difference between the term actor-network and Deleuze's term 'agencement' (or 'assemblage' in English). An assemblage, like an actor-

network, focuses on the process of bundling, or assembling, and then unbundling and reassembling elements and entanglements into a semi-stable but ultimately impermanent entanglement (Law, 2004; Tsing, 2015). Like actor-networks, new elements may enter an assemblage, and old alliances may break down because assemblages are continually allowing for 'new lines of flight, new becomings' (Anderson & McFarlane, 2011, p. 126). Deleuze and Guattari (2004) explain that maintaining assemblage stability means using a dual process of deterritorialisation (weakening existing relations) and reterritorialisation (reinforcing new relations) (see also Rosin et al., 2013, and Thornton, 2018 for a thorough discussion of assemblage concepts). This process of making and unmaking assemblages has been at the heart of M. bovis' world-making struggles, along with the challenges of other key actors, each of whom have had their own goals to achieve.

There have been many uses of the term assemblage (see Campbell et al., 2018, for a thorough discussion) though they all emphasise the building of worlds (Anderson & McFarlane, 2011). Assemblages are essentially "more-than-human" (Bull, 2013, p. 167) entanglements, and like actor-networks, in order to understand an assemblage, "one unravels its knots" (Tsing, 2015, p. 83). For Li (2007), an assemblage implies emergence and not the end formation (see also Anderson & McFarlane, 2011). Importantly, assemblages create territories, and those territories make meanings in the world (Wise, 2014).

Aotearoa authors Campbell et al. (2018) enjoy the "reframing and ontologically disruptive power of assemblage thinking" (p. 6). These authors employ an "assemblage perspective" (p. 7) because they say it brings to light the complexity of connections by acknowledging multiplicity and emergence, while exposing political influences (Campbell et al., 2018). Similarly, Henry and Roche (2013) consider that assemblage theory is useful for unpacking the economic, cultural, and social relationships that give rise to problematic situations. Biosecurity deals with the wildness and unruliness of biological life (a problematic biological situation), so considering the alignment of elements that allow biosecurity assemblages to hold together and pull apart is a useful application of assemblage theory.

Henry and Roche (2013) talk of "the materialities of animals, meat products and food" (p. 198), and in doing so they raise the notion of "bio-economic assembling" (p. 198), or the relations between economic imperatives and goals and the performativity of the cow and sheep bodies themselves. This type of thinking is relevant to the ability of scientists and government officials

to find and trace M. bovis, because (as this thesis illustrates) the bacteria are made manifest through cow bodies and the economics that drive farming practices. More than that, the spatial and temporal impacts of M. bovis on cow bodies are the result of network assemblages co-creating disease in this space and time (Braun, 2007).

Forney (2016) acknowledges the role of non-human actors, allowing for connections to be made and multiple realities to be recognised, where "different sets of relations result in coexisting ontological variants of what something is" (p 70). In this way, researchers can be open to the unplanned and unforeseen outcomes of network actions, which are difficult to predict precisely because networks are creative assemblages (Forney, 2016; Law & Mol, 2008a). This approach has the benefit of being open to finding new ways of being, and new biosecurity possibilities.

Both actor-network and assemblage theories are integral to the stories that unfold within this thesis, and that describe how each actor makes its own M. bovis world. I treat the terms actor-network and assemblage as interchangeable throughout, as they both describe the continual process of heterogenous elements or actors coming together, pulling apart and reassembling by taking a different shape or form.

This next part of the chapter categorises and discusses the three strands of post-ANT biosecurity literature that frame the M. bovis narratives. The first of these strands is concerned with the role of borders within actor-networks, the mobility of biological life and how space-time impacts how societies live with these unruly organisms.

2.4.2.2 Categories of thought

2.4.2.2.1 Borders, mobilities and topological thought

Some social scientists consider biosecurity to be a set of practices dealing with the flows and connections created by unpredictable life, as opposed to the mere prevention of movement or ousting disease from a more-than-human population (Hinchliffe & Bingham, 2008; Dillon & Lobo-Guerrero, 2008; Law & Singleton, 2015). Hinchliffe and Bingham (2008), for example, expressly question whether biological security can be assured using the Foucauldian model of trying to eradicate infection from within society (see also Sarasin, 2008). Hinchliffe et al. (2013) contend that disease "emerges" (p. 540) within networks and is co-created by other

network actors as well as being a biological actor in its own right. In this reading of biosecurity, a binary Foucauldian narrative that disease is an invasion or infection from outside a societal 'wall' becomes problematic for the ability to adopt a nuanced approach to securing life (Hinchliffe et al., 2013).

Managing "mobile life" (Clark, 2013, p. 16) is an issue that Hinchliffe et al. (2013) say should be approached as an *engagement* with unruly life in a mutable context, as opposed to a "will to closure" (p. 533). Along similar lines, Allen and Lavau (2015) observe that "the disease risk is not so much at our door, as already inside, embedded within modern factory farming" (p. 349). Confined homogenous life in intensified biological environments is seen as a threat to animal and human health, because this type of assemblage is ripe for zoonotic diseases to flourish (Allen & Lavau, 2015). As Hinchliffe (2013) observes, "[t]he very act of securing by enclosing can create the conditions of possibility for different kinds of events, some of which may be far more serious than would have otherwise been the case" (p. 210).

In Aotearoa, biosecurity is generally concerned with keeping out or walling out problematic life – viruses, bacteria and fungal diseases, insects and other pests. This often involves drawing boundaries around populations, but as Donaldson (2008) notes these sites of biosecurity extend spatially beyond the farming property, including buying animals, moving them, and buying feed and equipment. The main challenge then is how to manage the "material geography" of bacteria and viruses, when these organisms use animal bodies to travel with (Donaldson & Wood, 2004, p. 385). The material geography and borderlands conceptual framings are apposite in this thesis because not only have M. bovis bacteria used bovine bodies to travel and make their worlds, but cows themselves are highly mobile in Aotearoa's farming assemblage. In this type of actor-network, there is an inherent tension between employing a Foucauldian model of exclusion and the fundamental nature of pasture-based farming itself.

Traditional methods of controlling unwanted life focus on geographical matters of space and boundary making to control the movements and flows of diseases (see discussion in Enticott, 2008b; see also Mol & Law, 1994). Hinchliffe and Bingham (2008) challenge this approach, saying that the establishment of control over a network or its actors is paradoxical, because in their view "the need for control is also the need for an absence of control" (p. 1547). For example, Hinchliffe (2001) argues that the bovine spongiform encephalopathy (BSE) disease crisis was partially the consequence of "a failure to acknowledge the mutable and contested

nature of the disease" (p. 183) and a failure to "translate a knowing of indeterminacy into the political process" (p. 200). As Hinchliffe (2013) explains "[t]he very act of securing by enclosing can create the conditions of possibility for different kinds of events, some of which may be far more serious than would have otherwise been the case" (p. 210) (see also Enticott [2008b] for farmers' experiences of disease management versus government-imposed models of control). As Law (2006) also observes in relation to increased regulation of slaughterhouses during the United Kingdom's FMD epidemic, increasing safety can perversely lead to less safety. This thesis will revisit these authors' ideas with reference to the M. bovis eradication programme, particularly in the Discussion chapter.

Hinchliffe et al. (2013) call for biosecurity narratives and practices to shift focus from 'breach points' that are aligned with a binary borderline mentality to "tipping points" (p. 538) that acknowledge the inherency of pathological life within intense and confined networks (Hinchliffe et al., 2013; see also Mol & Law, 1994). Taking a binary approach to animal diseases, bacteria and viruses can only be 'found' or 'observed', because that is how we know they have become present inside the farm boundary. It follows then, using this model, that health itself can only be declared to be present once it is known that disease is absent, or at least is presumed to be (Hinchliffe et al., 2013). Yet, as Enticott (2016b) observes, "[d]isease is always indefinite" (p. 43) and it is difficult to prove a negative (a total absence of disease). Indeed, Hinchliffe et al. (2013) argue that disease is continuously absent/present, as opposed to being part of a binary system of alternatively absent or present. As this thesis shows, M. bovis itself has been neither absent nor present, but has existed as an absent presence, making detection difficult for the eradicators. As ever, Law (2004) turns to the ontological questions of how disease-free networks are made and held together. He asks what tools are used to enact the absence of disease in place. This is also a question that is deeply embedded in the present research.

As with M. bovis, the eradication of agricultural diseases is most often achieved by culling the host animals, as if they are one and the same. Donaldson and Wood (2004) argue that the biosecurity practice of culling infected animals allows those human actors to tell themselves that the virus or bacteria no longer exists. The effect of culling is "to stamp out disease presence in order to standardise agricultural space" (Enticott, 2008b, p. 1572). However, taking bTB as an example, instead of creating more order, culling has been shown to create disorder because

it invariably alters badgers' territorial boundaries, and so the behaviours of these non-human actors can change in unforeseen ways (Enticott, 2008b; see also Law [2006] on the regulation of slaughterhouses). Yet, biosecurity sits within a "spatial duality of disease flows" (Bingham et al., 2008, p. 1530), so that focusing on protecting cows to the exclusion of attending to network actors such as M. bovis may have unintended and unforeseen consequences (Enticott, 2008b).

Enticott (2008b) refers to Law's (2006) argument that it is not possible to engineer a culture of safety across the agricultural system and he picks up on Law's (2006) term 'fluid engineering' to explain mobility and management of disease in spaces using barriers to direct and orient disease flows (see also Barad [2007] who uses the phrase 'spacetimemattering'). There is much potential for reimagining biosecurity practices in this way, especially when fluid engineering is applied to a farming assemblage built on a network of cow mobilities. As Enticott (2008a) states, the "[o]rganisation of space is central to an understanding of the emergence and rejection of biosecurity" (p. 1570). This idea is central to my research findings, and it is a theme that will be revisited many times.

Any discussion of spatio-temporalities must also include the related concept of topologies. Hinchliffe et al.'s (2013) research exemplifies how topologically "the powers *of* life often fold over into the power *over* life and undermine its very possibility" (p. 532, emphasis original). Yet, the authors insightfully observe that agricultural biosecurity mostly ignores this existential battle and predominantly concerns itself with the "statistical mapping" (p. 535) or spatio-temporal tracing of populations (Hinchliffe et al., 2013). In this sense, most often the management of disease is based largely on past events and movements, which then become the basis for future predictions (Hinchliffe et al., 2013; and see the above category of biopolitics and risk management). Hinchliffe et al. (2013) argue instead for a topological mapping of disease, a relational lens through which the entanglement of humans, animals, pathogens, and environments is central to their management (Hinchliffe et al., 2013. See also Hinchliffe & Ward 2014).

The "borders, mobilities and topological thought" strand of biosecurity literature is closely linked to the next one, which acknowledges the unknowability and mutability of "lively materialities" (Henry & Roche, 2013, p. 204; see also Forney, 2016) that enact realities complex enough to be multiple.

2.4.2.2.2 Materialities and multiplicities

Law and Mol (2011) tell us that different disciplines and their practices enact their own "ontological variants" (p. 2) of disease, making disease multiple through these practices (see also Enticott, 2016b). In the M. bovis actor-network, various disciplines have been enacted by those who wanted to eradicate M. bovis, the scientists who supported the eradicators, and the farmers themselves. Each of these groups have created their own realities of M. bovis, and in doing so have 'made' M. bovis in different ontological ways (Jackson et al., 2019).

Using the FMD outbreak in the United Kingdom in 2001 as an illustration, Law and Singleton (2015) contend that it is essential to consider all of the virus's materialities and see how these were practised into being at different sites, because these realities are "done in practices" (p. 5; see also Mol, 2002; Evans et al., 2021). Law and Singleton (2015) explain that ANT interprets everything material, every situation, as multiple. FMD was made differently by different actors because veterinarians, epidemiologists, biosecurity officers and farmers are actually dealing with different epistemological manifestations of FMD: the disease is "made or done to be different in these different practices" (p. 6). In addition, FMD was enacted in a particular way on the farm where it was found because of the network relations that were present (and materially absent) on that farm. As will be seen in the farmers chapter, the ways in which M. bovis has made itself manifest are also the ways in which it has been *made to be* manifest (or made to be absently present) by other network actors (see Jackson et al., 2019).

Acknowledging and thinking with multiplicity implies that different realities compete and 'interfere' with each other, not that realities are fragmented and disconnected (Law, 2004). Law (2004) puts the matter clearly, when he says that "'this' (whatever 'this' may be) is included in 'that', but 'this' cannot be reduced to 'that'" (p. 64; see also Mol, 2002). Law and Mol's work in science and technology studies are primarily concerned with the multiplicity of realities and practices, or "the multiple ways in which matters are made" (Hinchliffe & Bingham, 2008, p. 1541), and the social consequences of these mutable renderings. The realities can be made together or separately, but they are made within a network of other relations and actors (Law, 2004). As Mol makes clear, and as the actors' stories in this thesis show, "the single and the multiple are made together" (Hinchliffe & Bingham, 2008, p. 1542; see also de Laet & Mol, 2000). Or as Law (2004) puts the matter, realities are "made and remade. This is a version of ontological politics" (p. 69). Mol's ontological politics allows for an interference with 'reality'

to expose more than one truth and allowing for the emergence of some realities over others (Law, 2004). Law (2004) considers that realities are enacted in 'degrees' so that there are "more reals and less reals" (p. 139). The ability to have a dialogue about different realities and their enactment is a way of "giving voice to marginalised ontologies" (Evans et al., 2021, p. 13). Law (2004) addresses the issue of how those realities coexist and how people chose which reality to prefer when 'truth' is no longer held out as an objective reality. This 'problem-making' (Donaldson, 2008) exercise, of which realities get to speak more loudly than others is a fundamental 'matter of concern' (Latour, 2005) for the present research into M. bovis' world-making (see also the Methodology chapter).

Law and Singleton (2015) question what the significance is of knowing that FMD is practised "in different ways in different practices, and thus that it is made to be different?" (p. 7). This thesis seeks to answer the same question about M. bovis by describing the realities of the farmers, eradicators, cows and scientists who shared their assemblages with the bacteria. Acknowledging multiple realities, including among non-human actors, allows us to interrogate those realities without any *a priori* assumptions about their importance or value (Law & Singleton, 2015). Uncovering M. bovis' multiple realities and unpacking these through 'thick description' (Michael, 2017) has allowed me to hold them up against each other to make meanings as well as to expose a range of world-making practices (Evans et al., 2021). Evans et al. (2021) also acknowledge, as do I here, that holding these realities still for the purposes of deep description is a temporary construct, a "rhetorical device" (p. 7) that is employed to explore questions about assemblage relations and maintain the ability to be understood clearly.

On the other hand, presupposing a singular reality for agricultural diseases essentially black-boxes the world-building of a dominant actor and thereby conceals the hinterlands of method assemblage, making it impossible to identify and re-enact different biosecurity realities (see Law, 2004; Evans et al., 2021). Law and Mol (2011) explain that driving biosecurity practices are political practices that are concerned with enacting and then stabilising disease absence for certain goals (see also Barker, 2010). An example of this epistemology will be seen within the eradicators chapter, where those actors have a collective goal of Othering the bacteria.

2.4.2.2.3 More-than-human geography

The final school of thought included in this literature review draws on more-than-human geography, which does not start from a presumption of human dominance within networks (Whatmore, 2006; Haraway 2008, 2016; Bull & Holmberg, 2018). Hinchliffe et al. (2005) frame the human-animal relationship in a methodologically flat manner as 'enfoldings' of living organisms. In more-than-human geography, agricultural animals are actors in the farming assemblage and not merely passive economic units (Haggerty et al., 2009). Van Dooren and Rose (2012) acknowledge that animals build worlds too, and that they 'story place' but that they do so differently from human actors.

An important principle when working with non-human network actors is that they are imbued with creativity even without any intentionality. As Law and Mol (2008b) observe, "[i]n order to make a difference, a sheep does not need to be a strategist" (p. 58) (see also Latour, 1988a). This theoretical approach acknowledges that animals (and bacteria) play crucial roles in science and medicine, including by acting as sources of biological material for testing and experimentation (Cassidy et al., 2017). Cassidy et al. (2017) argue that these "more-than-human foundations of medical knowledge" (p. 12) have been key actors in gaining scientific knowledge, even though they are nearly always rendered passive by the human narratives around medical advances (see also Latour, 1988a).

Hinchliffe and Ward (2014) use a more-than-human framing to explore how young animals and animals introduced onto farms from other places obtain immunity. The authors consider immunity to be an emergent materiality that is practiced into being by many heterogenous organisms and their relations. This type of biosecurity thinking, based on "geographies of immunity or folded life" (Hinchliffe & Ward, 2014, p. 142), has important lessons for farmers who have to re-stock completely after having microbes like M. bovis or FMD present on their farms. Hinchliffe and Ward (2014) rely on the work of Napier (2012), suggesting that immunity is earned through interacting with difference, not sameness, which elevates microbial life to the status of an important and transformative actor for the health of other actors. Lorimer (2018) builds on Haraway's writing and claims that acknowledging microbial life in more-than-human assemblages will make humans more responsible in living with all forms of life.

Bull (2018) contends that animals are essential for human worlds, which are built on and with animals, and that the politics of living together and 'becoming with' each other (Haraway, 2008) is becoming increasingly evident. Bull (2018) proposes in his work on ticks that by attending to the work of non-human actors that dwell within liminal spaces, it may be possible to strengthen biosecurity policies for building worlds *with* unwanted biological life instead of against it (see also Enticott, 2016b). The theme of 'becoming with' cows and bacteria will be revisited with respect to Aotearoa's traditional farming practices in the discussion chapter.

2.5 How this thesis moves biosecurity forward

In 2015, Barker reflected that current biosecurity theories "have perhaps reached a moment of saturation" (p. 362) and proposed that it may be time for researchers to reimagine biosecurity practices. Eight years later, exploring M. bovis and the biosecurity response in Aotearoa using a material semiotic lens creates an opportunity for opening up the black box of biosecurity epistemologies and practices (Barker, 2015; Potter, 2013; Donaldson, 2008; see Wilkinson [2011] on sustaining that change). The broad goal of this thesis, then, is to make space for re-imagining not only Aotearoa's agricultural biosecurity practices but also this country's enactment of farming itself.

This thesis challenges current binary and human-centric biosecurity epistemologies by re-framing them using M. bovis' multiple realities (see Hinchliffe & Ward, 2014). Working with multiplicity and mutability is a process that creates the opportunity for doing biosecurity differently, and perhaps for doing it better than before (Donaldson, 2008). The way that this research makes space for rethinking biosecurity and farming is to weave the work of current scholars into a series of ontological stories, providing the reader with an experience of total immersion into the worlds of the eradicators, scientists, farmers, cows, and the bacteria themselves. These narrative framings describe the shifting relations and power struggles associated with M. bovis' more-than-human world-making. Through foregrounding network controversies, this research has been able to uncover fundamental incompatibilities between biosecurity and farming in Aotearoa.

2.6 Conclusion

This chapter has considered the relevant theoretical strands within biosecurity literature and illustrated that there are different ways to conceptually frame the ontological problem of M. bovis' existence in Aotearoa. Out of the two prominent currents of biosecurity literature discussed, this thesis is primarily concerned with the 'co-production of disease networks' strand that has built on the works of Callon, Latour and Law, among others. However, the Foucauldian strand also emerges in this thesis in two important ways. First, the Foucauldian strand will be identified as the guiding epistemology of those who sought to eradicate or Other M. bovis from the country. Second, but more subtly, this strand has formed a foundation for the more modern formulations found in the work of Braun (2007), Ali (2008) and Hinchliffe and Bingham (2008), which are also relied on here.

My research contributes to a very small body of work by Aotearoa's biosecurity theorists. Moreover, by focusing on M. bovis as opposed to *Mycobacterium bovis* (bTB) or on the biosecurity system more broadly, this nascent research stood alone in the social science literature until the first article written about M. bovis by Jaye et al. (2021). This thesis is novel because it takes a material semiotic approach to the presence of M. bovis and the biosecurity conundrums that these bacteria represent for the government and the farming assemblage, including for farmers themselves.

The next chapter discusses my methodological approach to M. bovis' ontological realm.

Chapter 3 Methodology

3.1 Introduction

Sociology is only lively and productive when it examines all associations with at least the same daring as the actors who make them (Callon & Latour, 1981, p. 292).

This chapter introduces the methodology underpinning my research and explains the main reasons why I chose it to tell this M. bovis story. The chapter is set out in two parts: the first discusses how this thesis uses ANT as a methodology; and the second describes the methods used to unpack the actors' M. bovis worlds. There is a lot of detail in the methods section below, which is an approach that is consistent with ANT. The methods are framed here in the categories of expected and unexpected actors. The expected actors are the cows, bacteria, humans, and inscription devices (such as reports and guidance documents). The unexpected actors were the multiple research programmes being undertaken by other human actors on M. bovis during the making of this thesis. These research programmes have impacted on the methods undertaken here in unexpected ways. There was also an actor that I initially thought would be influential, but eventually I came to see that it was something that the other actors have made. That excluded actor is 'biosecurity', and this chapter makes clear why biosecurity is not treated as an actor. Both the methodology and methods sections of this chapter also make clear the limitations or constraints on my findings.

3.2 Actor-network theory as a theoretical framework

As the Literature Review has made clear, ANT strongly favours empirical research over epistemological understanding (Michael, 2017). Empirical research is where ANT operates best, and as Law (2015) says this is "where we do our theory" (p. 2). ANT has been described as a "tool-kit for thinking about and studying the social", and more specifically for "charting practices of association" (Law & Singleton, 2015, p. 3; see also Ali & Keil, 2008), including within more-than-human worlds (Braun, 2007, p. 256). Latour (2005) illustrates ANT beautifully when he says that "there is no group without some kind of recruiting officer. No flock of sheep without a shepherd—and his dog, his walking stick, his piles of vaccination certificates, his mountain of paperwork to get EU subsidies" (p. 32). While no-one can seriously claim to speak for cows or bacteria, ANT provides a framework (Michael, 2017) for revealing and describing the roles of non-human actors within the emergent M. bovis network.

As will be seen, M. bovis' world-making success depends on farming and biosecurity practices, geographies, science and technologies, and the relationships between existing networks.

ANT engages the researcher at an empirical level to reveal the ways in which and the means by which networks and their black boxes are assembled and reassembled (Michael, 2017; Latour, 2005). ANT does not seek explanations, however; rather ANT theorists look to describe their observations in 'thick' detail (Michael, 2017). The purpose of describing observations is to reveal or uncover the ways in which and the means by which networks are built and assemblages are created (Venturini, 2010b; Michael, 2017; Latour, 1988b). Latour (2005) entreats researchers to 'just observe' because knowledge about network building is discovered only by immersing oneself in the network of actors and tracing how they tie and untie their relational knots (this is Tsing's [2015] terminology).

The controversies involved with assembling and disassembling networks are not something to be quickly resolved, because it is with controversies that those relations can best be understood (Latour, 2005). Following Callon (2001), ANT is "an open building site, not a finished and closed construction" (p. 65). Controversies are dynamic and mutable, so adopting a minimalist approach to theoretical and epistemological overlays is essential to faithfully describing the transformations taking place (Venturini, 2010a). The emergence of M. bovis lends itself to the application of actor-network and assemblage theories because when this research began the network was still forming and there was both an existential crisis (for M. bovis) and potential for network disruption (for human actors) (Venturini, 2010b; Michael, 2017).

Assemblage conflicts are complex (Latour, 2005), which is why it is important to dig deep into the layers of dispute by acknowledging all the actors and importantly the meanings that actors create (Venturini, 2010b). For Venturini (2010a), the more narratives there are the more there will be commonalities and points of overlap, so the more objective the research will become. Venturini (2010b) uses the metaphor of magma, the hot fluid under the earth's crust that can solidify into lava, to describe the processes involved with observing and describing controversies. When we observe controversies, we are watching the mutability and the liquid form of magma. When we describe controversies, we are solidifying them through literature (or a PhD thesis), rendering them immobile.

For ANT, there is no temporal division between ontology (what exists) and epistemology (knowledge of what exists): "realities are done along with representations" (Law & Singleton, 2015, p. 9). As will be seen here, biosecurity practices are as transformative of disease as they are transformed by it (Law, 2004). Taking the approach that diseases and biosecurity practices are enacted means that they must also be multiple, so that M. bovis itself becomes multiple (Mol, 2002). For example, a veterinarian will bring a different ontology than a farmer to the questions being asked about M. bovis' world-making (again, see Mol, 2002). Acknowledging "ontological multiplicity" (Law & Singleton, 2015, p. 9) allows social cartographers to interrogate realities and unravel the many ways of knowing disease (Venturini, 2010b).

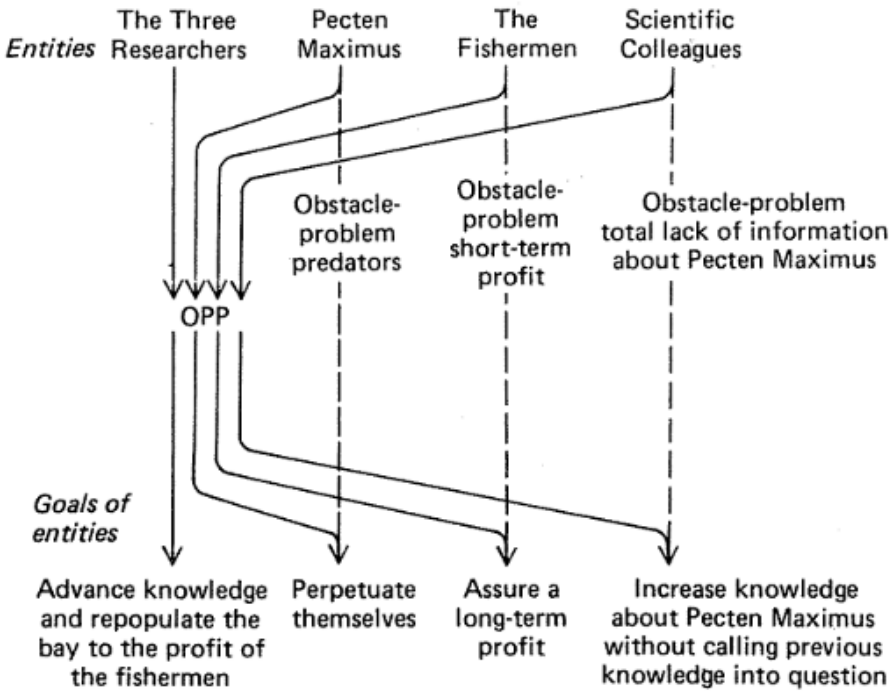
ANT uses the term 'method assemblage' to describe a process by which new realities are made, unmade and remade (Law, 2004). Method assemblage, as a set of practices, is enacted in what Law (2004) metaphorically calls the 'hinterlands', which is the ontological space between what exists and what is new. The present research is being made to enact the shifting boundaries of multiple realities within the hinterlands between the existing farming assemblage and M. bovis' world-making. Importantly, method assemblage acknowledges the fluidity and emergence of a world-making that involves not only the actors being researched but also the researcher herself (Michael, 2017; see also Law, 2004). My research is very much a method assemblage, being made by the actors present in this thesis but also by myself and my supervisors. In return, I have been 'performed' through enacting this method assemblage (Law, 2004; Michael, 2017).

Another key tenet of ANT is methodological symmetry or listening to all of the actors' experiences (Venturini, 2010a). However, applying methodological symmetry is not the same as treating all actors' voices equally or being impartial to their roles within the network (Venturini, 2010a). Proportionality in method allows for giving different weight to different actors, and Venturini (2010a) instructs social cartographers to bring that disparateness to the fore in describing the layers and relations of social and technical worlds. The opposite approach is methodological asymmetry, which is limiting because it narrows down the knowable realities and invisibilises the ways these are practiced into being (Law, 2004; Callon, 1986). Following methodological symmetry, this thesis tries to represent each actor or group of actors in a way that is commensurate with their status and influence within the network (Venturini, 2010a). This status or influence has emerged through the process of describing each actor's M. bovis reality. For example, the eradicators' chapter is much denser than the cows' chapter because

the former group of actors have had a significant influence over the M. bovis network. That is not to say, however, that cows have had no agency – they have, as their own chapter illustrates.

A final note here on the use of Callon's (1986) 'devices of *interessement*' diagram as a structure for unpacking each actor's story. *Figure 5* (below) presents the original chart taken from his work, titled *Some elements of a sociology of translation: Domestication of the scallops and the fishermen of St Brieuc Bay*:

Figure 5
Callon's (1986) devices of 'interessement' diagram (p. 207).



As the diagram shows, the researchers, their scientific colleagues, the scallops, and the fishermen each have a different obstacle problem and goal. However, the OPP is the collective point through which the actors must all pass if they are to achieve their disparate goals. The OPP was created by the researchers as a tool of problematisation to make themselves indispensable, and it was framed as a question: "does pecten maximus attach itself?" (Callon, 1986, p. 206). Without the scallops anchoring themselves, none of the actors thought they could achieve their individual goals.

I had also thought that a single OPP would emerge for all the actors in the M. bovis network. However, in applying methodological symmetry to these questions, it became clear that the goals of the cows, bacteria, farmers, scientists, and eradicators were not clearly aligned - even though some actors shared some aspects of each other's goals. Thus, each actor had its own OPP that emerged and spoke directly to its obstacle problems and goals. However, I acknowledge that the actors' translation processes could have been framed in many different ways. Developing the narrative of each actor's struggles to deterritorialise and reterritorialise their network has allowed their potential areas of cooperation and conflict to crystalise for the purposes of this particular inscription device.

3.3 Materialising methodological principles (or Methods)

This part of the chapter explains the methods I have used to uncover M. bovis' world-making in Aotearoa and render it immobile in this thesis. The first two sections conceptually frame this thesis' treatment of M. bovis and cows as lively, network building actors and illustrate how I treated their meaning-making, even though they could not be interviewed. The next section introduces the human actors themselves and explains why and how they were chosen, including a discussion of the ethical considerations and limitations involved. Next, this chapter moves to consider the inscription devices involved with M. bovis, including technical and government works, followed by an explanation of the role of media articles about M. bovis and the eradication programme within this research.

After considering the written influences, I then describe a group of unexpected actors that were made manifest within and have influenced the shape of this research. This group includes the viral actor SARS-CoV-2 (Covid-19) and human researchers entering the M. bovis network during the period this thesis was being written. Finally, this section explains why I have not treated biosecurity itself as an actor in this research.

3.3.1 The actors

3.3.1.1 Bacteria

Callon (1986) famously asked, "Who speaks in the name of whom?" (p. 214). My research asks the same question, and it finds that not only did each of the human actors speak for M. bovis and for cows, but they each spoke of those non-human actors differently. Yet, bacteria also speak in their own names, and they do so ontologically (see Tsing, 2015). For example,

M. bovis bacteria have spoken using their ability to multiply within and transmit among hosts, their power to make scientific testing difficult and unreliable, and their resistance to vaccination or antimicrobial treatments (see scientists' chapter). M. bovis' 'speech' (which could also be framed as 'survival') has made worlds by enrolling cows and their farmers in their survival. In this thesis, M. bovis is acknowledged as making its own world, and the bacteria have their own chapter storying their process of translation, with goals, obstacle problems and OPPs just like the other (human) actors have been afforded.

3.3.1.2 Cows

Like human actors, cows are capable of enacting meaning in their lives and within farming itself (Armstrong, 2018; McTavish, 2015; Law & Mol, 2008b). Cows 'story' their own realties, too (van Dooren & Rose, 2012). Yet, despite giving of their lives and freedoms for humans (see Latour [1988a] on this point), cows' and other agricultural animals' lives are usually storied out of the milk, cheese, and meat that they produce (Bull & Holmberg, 2018). Like the farms they inhabit (Campbell, 2021), cows' bodies themselves are 'embodied' spaces with physical and social boundaries that are assembled and disassembled (Bull & Holmberg, 2018).

Cows are actors in the M. bovis network, not mere intermediaries. Cows have hosted the bacteria, they have moved the bacteria between farms, they have 'hidden' the bacteria within their bodies, passed it on to their calves and been made symptomatic by M. bovis (or put alternatively, cow bodies have enacted M. bovis as a manifest disease) (see the scientists' chapter). Cows were key actors in M. bovis' world-making, and being the only bodily host for M. bovis, cows were key to the bacteria's survival.

The cows' chapter was the most difficult to write because the temptation to anthropomorphise was strong - yet cows require someone to speak for them. Cows had goals and obstacles like the other actors in this narrative, and they had their own OPP to navigate the process of translation; their world-making story had to be methodologically the same as the other actors' narratives. For simplicity, I chose to tell their story through one cow, an imaginary dairy cow called Araw. She tells a straightforward tale of a dairy cow life, of the places she knows and makes meaning with, and of how she navigates her relationships with human and bacterial actors (see also McTavish, 2015).

3.3.1.3 Humans

As already mentioned, Latour (2005) considers that all groups need to have a spokesperson, and that these spokespeople are continually looking for ways to reify their groupings and protect their boundaries. In this research, I am the spokesperson for the actors and their relationship struggles. However, this research has been enacted with 30 other spokespeople involved with M. bovis and/or biosecurity in Aotearoa.

There are three main groups of human actors present in this thesis: the eradicators, scientists, and farmers. While there is an artificiality about this type of grouping of actors, the reason is to allow each set of actors' M. bovis realities and their attempts at translating the farming network to be clearly described (see Evans et al., 2021). (The actors' stories do converge as one conversation again in the discussion chapter, which considers the key themes arising from their M. bovis realities.)

All but one human actor has participated in a one-to-one interview with me.[24] The Information Sheet asked them to allow an hour, but the vast majority of interviews took less than an hour (though a few took longer). Twenty-seven of the interviews were held by Zoom, and three were held in person. My intention was to hold most interviews in person, but they were all held between October 2020 and July 2021 (post the Covid-19 incursion, and by then Zoom had become a communication medium of choice). Participating in the interviews has afforded me a deep level of engagement within farming and biosecurity networks; this interaction, combined with the breadth of human actors interviewed and consistency of the findings has provided a high level of comfort in their relevance. The diversity of actors was shaped by the ethics approval process, which has proven to be advantageous, because some of these actors have told of M. bovis and/or biosecurity realities that I did not expect to hear.

3.3.2 Human ethics approval process

Massey University's Human Ethics Southern B Committee (Ethics Committee) required me to submit a full ethics application for this research (SOB19/60). The reason for needing to make a full application was because my research involved an eradication programme managed by the Ministry for Primary Industries (MPI) (amongst others), and I was employed by MPI during

[24] Denethor provided me with a copy of their diary entries (from when they were involved with the eradicators) instead of being interviewed.

the whole period of my thesis research.[25] My employment status had to be disclosed to potential participants in the Information Sheet, even though I had been teaching fulltime at Massey University since July 2016 (prior to M. bovis' discovery). Another complicating factor was my desire to interview MPI staff who were involved with the eradication programme; so, I had to carefully consider how I would manage potential conflict of interest and privacy issues. The ethics application process took two months, though it ended up being invaluable for framing the human engagements.

There is a particular condition that has significantly shaped the M. bovis stories. The Ethics Committee granted approval on the condition that I would not interview any farmers who were engaged with the M. bovis programme at the time of interviewing, whether they be at the testing or depopulation stages, or whether they were still engaged with the compensation process because of a perceived conflict of interest (for me as an MPI employee and a researcher). This condition, while there to protect all human actors involved in the research, effectively meant that I only got to hear from affected farmers after they had come out of the eradication programme and not while they were in the middle of the turmoil. It is impossible to know just how this condition has altered the research observations and influenced the discussions contained in this thesis, but it did mean that I had to cast my net more widely and include farmers who had not been involved with the eradicators at all, as well as transporters and stock agents. It turned out that those actors could tell wider stories about cow farming and biosecurity in Aotearoa, and those stories have significantly shaped this research.

3.3.3 Choosing human actors

I started by contacting a few key actors who I knew were involved with the eradication programme, as well as others identified from official inscription devices and media reports. Then, I used the snowballing technique (see O'Leary, 2017) to follow the network. Some actors whom I contacted chose not to participate in this research, so their stories are consequently absent, even though they would likely have made valuable contributions to this thesis.

A complicating aspect of grouping the actors to tell their stories clearly was that many of these actors' network roles overlap. For example, some actors were veterinarians *and* farmers, or

[25] However, I was teaching at Massey University from July 2016, and I did not have any involvement with the M. bovis biosecurity response or eradication programme.

government officials *and* farmers. Due to the layers of overlapping roles, and for the sake of clarity, the human actors are referred to in the M. bovis stories below in terms of the primary role they had in the M. bovis controversy. This means that where someone was interviewed as a farmer, they will be called 'farmer' even if they are also a veterinarian in another capacity, and *vice versa*. This approach ensures that there is no 'double-dipping' of actors between chapters – they generally only get to speak once, in their main network role.

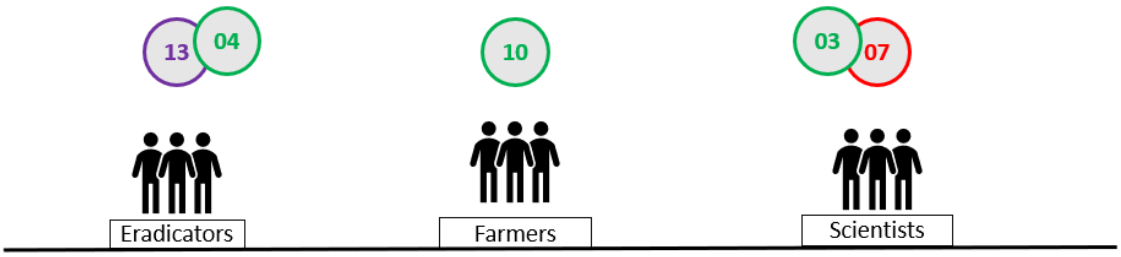
In the group called the 'eradicators', I interviewed eight MPI employees and/or contractors, one researcher and three industry body representatives. The industry representatives are from Federated Farmers (Fed Farmers), DairyNZ Limited (DairyNZ) and Beef + Lamb New Zealand Limited (B+LNZ). OSPRI New Zealand Limited (OSPRI) is included as an eradicator, too, even though OSPRI was not officially a part of the eradication programme. The reason is because OSPRI is responsible for administering the National Animal Identification and Tracing (NAIT) system.[26] There were three government biosecurity actors who were also farmers, and one industry actor, making the overlap with the 'farmers' category four out of the 12 eradicators.

The 'scientists' collective was comprised of two epidemiologists, four veterinarians and a researcher. Out of the total number of seven scientists, there were also three who were farmers. The 'farmers' collective itself included seven farmers, five of whom had M. bovis on their farms, one stock and station agent (also a farmer but not counted as one of the seven) and two transporters. This makes the total number of actors in the farmers' collective 10.

There is an additional researcher who was aligned with the eradicators and purported to speak on their behalf. This is Galadriel (Researcher) and they appear in the eradicators' chapter, taking the eradicators' number to 13. *Figure 6* illustrates the 30 human actors and their overlapping roles.

[26] The NAIT system will be described in depth in the eradicators' chapter, but briefly NAIT is a database that holds cow and deer movements. The original purpose of the NAIT system was to hold information that would assist with bTB management, but the system has now become a general biosecurity database for traceability purposes.

Figure 6
Overlapping categories of human actors



As seen above, the green number in each of the eradicators' and scientists' groups represents how many of those actors were also (or were formerly) farmers, even though they were not interviewed as farmers. This situation is perhaps reflective of farming, where many aspects require multi-disciplinary skills and knowledge, as well as the M. bovis programme, which engaged a limited number of actors involved with biosecurity and/or farming, making the relationships between actors more intertwined than might otherwise have been the case. The multiple realities within each actor category make for a richness in their storytelling.

3.3.4 Omission of two influential human actors

At the time I made the decision to hear from a wide range of actors involved in the M. bovis network, I decided to exclude two key actors from the interviewing process. Those actors are well-known in Aotearoa's media for having had M. bovis on their farms: they are the van Leeuwens and Alfonse Zeestraten. The van Leeuwens owned the first farm where M. bovis was identified in July 2017 (known by the eradicators as Infected Place 1 [IP1]) (RNZ, 2017). Alfonse Zeestraten, on the other hand, owned a pasture-based dairy farm in Te Taurapa o Te Waka. His farm was identified in December 2017 as being the *original* source farm for M. bovis (RNZ, 2018e) (six months after IP1 and is known by the eradicators as IP8) (Farmers Weekly, 2019a).[27]

There are several reasons for not contacting these two sets of farmers, even though they were key actors in the early days of M. bovis' emergence. The first is that there is a lot of publicly available information about these two farms and their farming practices through mainstream

[27] The first infected place found does not necessarily equate to the original source farm for the country – the first IP is just where the disease manifested itself and was reported for the first time.

media outlets. Given the number of times those farmers have been interviewed by government officials and journalists, I had doubts about whether any different M. bovis stories would arise. The second reason relates to the first, which is that it was clear through the media stories that these farming families and their cows had been severely impacted by M. bovis and by MPI's biosecurity response, so any potential insights from interviewing them did not seem to outweigh the potential harm for them in reliving those experiences. A further, methodological consideration fed into the decision too, which was that this research makes space for hearing from the quieter, less obvious voices involved in the M. bovis network, such as cows and the bacteria themselves. However, because the van Leeuwens, their sharemilkers (the Potgieters) and Alfonse Zeestraten have spoken for M. bovis multiple times, some of their stories as told by the media do appear at points within the thesis.

3.3.5 Finding the themes

My semi-structured interview questions focused on M. bovis, the eradication programme, on-farm biosecurity measures and cow farming in Aotearoa. Appendix A is the generic interview schedule approved for use by the Ethics Committee. As the interviews progressed, however, the interview schedules became more refined, as the one created for an industry body representative illustrates (see Appendix B). During the course of the interviews, a particular focus developed on tracing the relations made by cow mobilities and the connections between dairy and beef farming. Asking these types of network questions allowed me to obtain a broad understanding of the cow farming assemblage within which the eradicators expected biosecurity to occur.

Once I had transcribed each of the actors' stories, and they had each had an opportunity to edit and approve their transcripts, I then randomly assigned each actor a pseudonym based on characters from J. R. R. Tolkien's *The Lord of the Rings* (1954).[28] A reason for choosing mythical names is because of their more-than-human character, lending themselves not only to anonymity but to a flatness and lack of hierarchy between humans and other actors, such as cows and M. bovis itself. In addition, I have given the human actors non-gendered personal

[28] My primary supervisor (Associate Professor Matthew Henry) suggested using *The Lord of the Rings* characters.

pronouns to try and ensure their anonymity; there are not very many actors in the M. bovis network, and gender is an attribute that could point to their identity in some cases.[29]

I then entered all the transcripts into Nvivo 12 Pro software and, using an inductive approach (O'Leary, 2017), I explored the emerging themes and connections within the actor-network, capturing these as 'codes' within the programme. Key codes related to farming practices, biosecurity practices, M. bovis, the NAIT system and the eradication programme. As will be seen, each collective actor's translation goals and struggles have been informed by these themes, as well as from the inscription devices used to inform and to test the actors' M. bovis realities.

3.3.6 Inscription devices

This research follows three sets of inscription devices about M. bovis: those made by the eradicators, those made by scientists, and those made by media actors. Below is a brief explanation of each type of device and how they appear in the actors' stories.

3.3.6.1 Technical work speaking for M. bovis

The emergence of M. bovis in Aotearoa has encouraged the creation of many inscription devices and other technical documentation. These include government reports and advisories, policy documents and plans, and eradicators' written tools of enrolment. Most of this written work has been commissioned by the M. bovis Science Programme (Science Programme) and the M. bovis Governance Group (Governance Group), the latter of which is comprised of Chief Executive Officers from MPI, DairyNZ and B+LNZ. In addition, much of the scientific documentation comes from the Technical Advisory Group (TAG), which is comprised of veterinarians and scientific researchers, and which was established to advise the Governance Group about the feasibility of eradicating M. bovis.

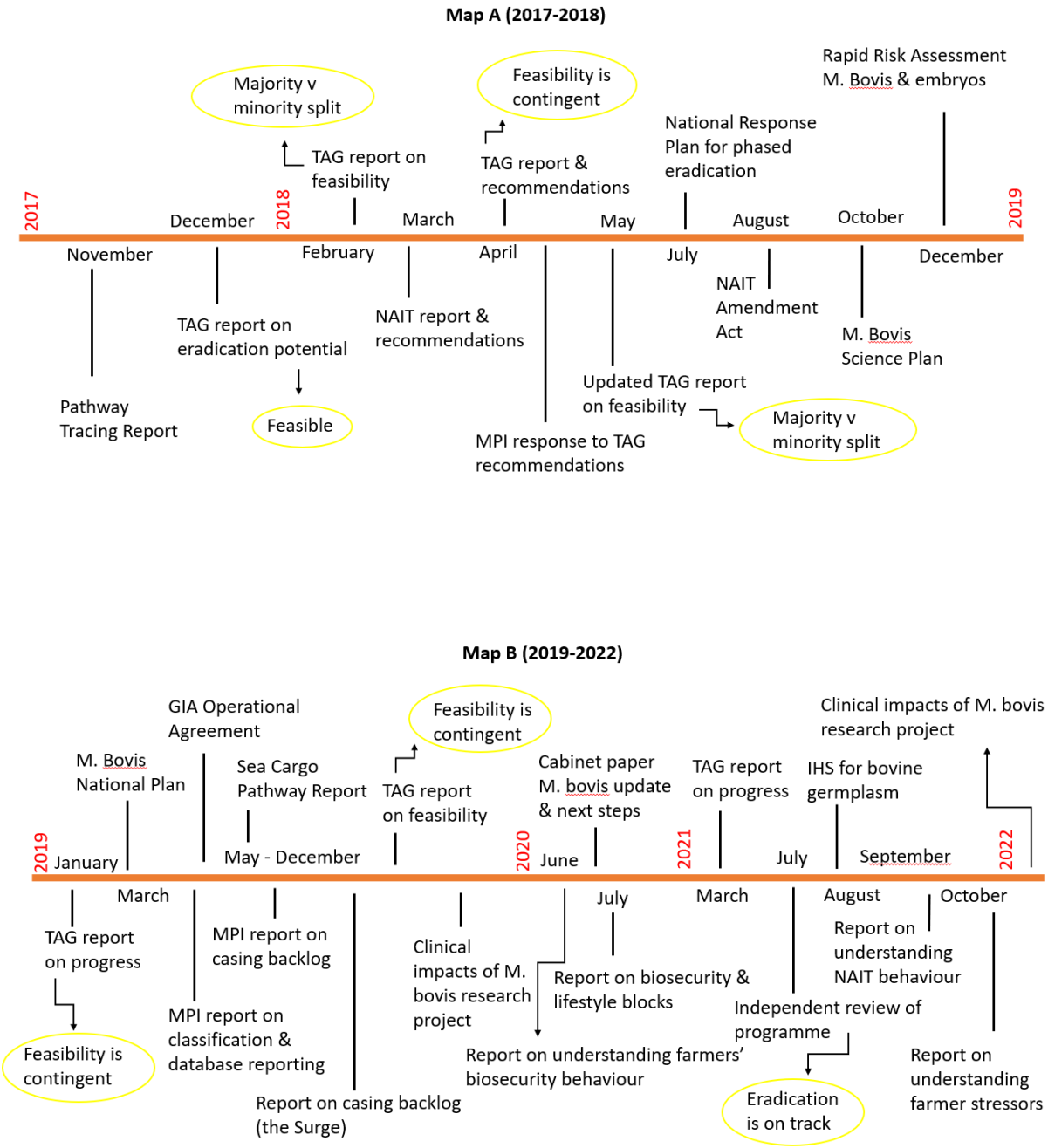
Figure 7 below provides a timeline of the key official documents created between July 2017 and July 2022, though there are many more in existence. A point to note is that the yellow circles are there to foreground some of the controversies occurring temporally about whether

[29] Where there are human actors speaking in public, for example in media releases, then their gender is identified.

or not attempting to eradicate M. bovis would be likely to succeed. These controversies are explored in detail in the eradicators chapter.

Figure 7

Temporal map of key official documents speaking for M. bovis (2017 to 2022)



As can be seen, there are many inscription devices speaking for M. bovis and, in actor-network terms, each of these has enacted M. bovis in the world, co-creating a network of multiple

bacterial realities. My research aims to unpack these worlds, in part by describing how the inscription devices have performed realities and network relations, but also by 'storying' (Cassidy et al., 2017) M. bovis differently. Hence, there is a focus here on incorporating the fleshy realities of non-human actors.

3.3.6.2 Scientific work speaking for M. bovis

There is a large amount of scientific literature about M. bovis and its impacts on cow bodies. Some of this literature is situated in Aotearoa, but most of it is international. In contrast, there has been an absence of social science research on M. bovis until very recently (see the literature review). Yet, following Law (2004), "[t]he practices of science make relations, but as they make relations, *they also make realities*" (p. 29, emphasis original). The scientists involved with M. bovis have made their own realities and immobilised them within key inscription devices making their influence within the M. bovis network visible and rendering it important. The eradicators have relied heavily on the scientists and their knowledge, so a discussion of these types of immutable mobiles, such as the TAG reports illustrated at *Figure 7*, appears in the eradicators' chapter.

3.3.6.3 Media articles on M. bovis

My PhD confirmation event was held on 20 March 2020, and I had planned to begin interviewing the human actors in April 2020.[30] However, a State of National Emergency was declared on 25 March and lasted until 13 May 2020, and the country went into an Alert Level 4 lockdown due to Covid-19 from 25 March 2020 until 27 April 2020 (New Zealand Government, June 2022). Given the uncertainty and distress associated with the pandemic, I decided to postpone my interviews until later in the year. To keep moving forward, I undertook a review of M. bovis media reporting in Aotearoa to learn more about the biosecurity response and subsequent eradication programme and the range of actors involved with the bacteria.

I began reviewing online articles dating from July 2017, which is when Oamaru veterinarian Merlyn Hay (in conjunction with Massey University) first identified the presence of M. bovis

[30] In Aotearoa, the PhD confirmation event is a seminar that a provisional PhD candidate prepares for and holds before a panel. The purpose is to test the research and the candidate's abilities, and the desired outcome for the candidate is to move from provisional to permanent registration as a PhD researcher.

in Aotearoa.[31] I continued reading media publications even after the interviews began and concluded this aspect of the research in July 2021. The media sources were all online, and included *Stuff, Radio New Zealand, Rural News Group, Farmers Weekly, Newshub, NZ Herald, Otago Daily Times*, and *Scoop*. My original search was a Google search for 'Mycoplasma bovis in New Zealand'. The research method was simply to 'follow' the links from one story to the next and record the details of each one. I kept a chart of the stories, each with a number, the article's title and date, the date accessed and the uniform resource locator (URL).

The media search uncovered a range of actors in the M. bovis network who were speaking loudly for M. bovis, including farmers, MPI, the eradicators, scientists and other 'experts', and the media themselves. This media search also raised questions that I could then ask of the human actors when it came time to interview them. In this way, reviewing media articles was valuable as background preparation for the interviews as well as for reinforcing the actors' stories.

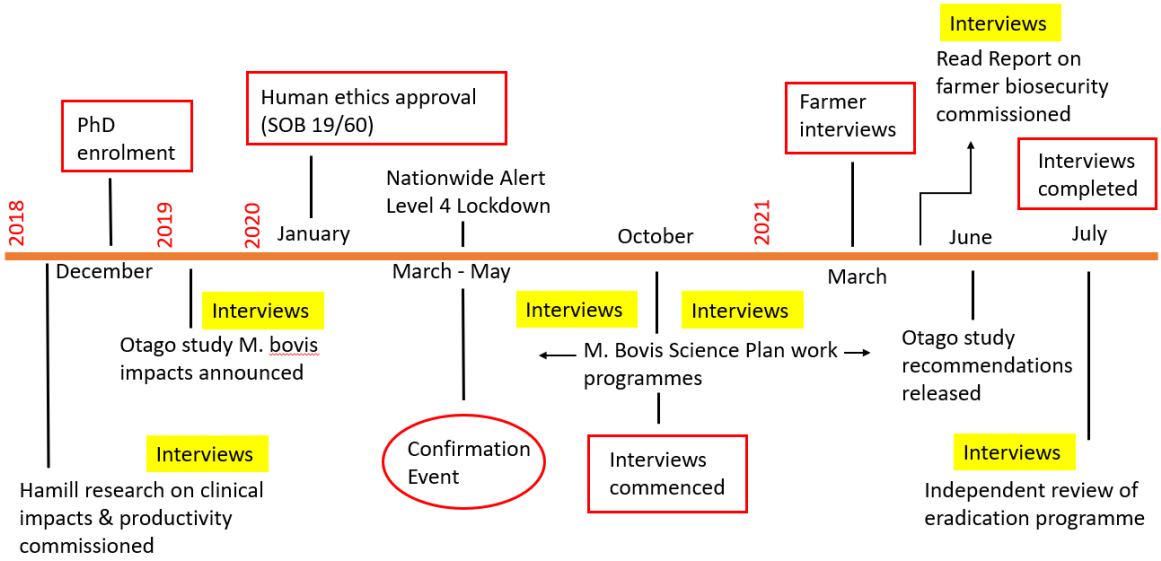
3.3.7 Unexpected and excluded actors

3.3.7.1 Multiple research programmes

The timing of this thesis and the initial postponement of interviews because of the Alert Level 4 lockdown also meant that my interviews were carried out during the period when several large research projects were being undertaken by the eradicators and other researchers, all involving talking with farmers impacted by M. bovis. *Figure 8* illustrates the types of research being undertaken between 2018 and 2021 relative to the timing of my farmer interviews (PhD key events and my interviews are illustrated by the red boxes and circle). The yellow highlighted 'interviews' represent the interviews with farmers and others carried out by other researchers during the period of my own PhD research. The purpose of showing these interviews and their timing is to highlight the amount of M. bovis research that was happening during this period and the number of times farmers have been interviewed about M. bovis and the eradication programme.

[31] While the sharemilkers on the Tainui farm identified the diseases caused by M. bovis, they did not 'name' the bacteria (RNZ, 2018b).

Figure 8
Assemblage of human interviews



As can be seen from the diagram, the first piece of research was commissioned in 2018. MPI commissioned a practicing veterinarian to complete her master's thesis on the clinical impacts of M. bovis and farming practices that are risk factors for the manifestation of disease (see Hamill, 2019b). These interviews with farmers appear to have been carried out in 2018 and 2019; so, while this veterinarian's research did not impact on the timing of interviews for my thesis, the existence of these interviews themselves may have impacted on the content and/or the willingness of M. bovis impacted farmers to participate. It is not possible to know for sure whether the five farmers who declined my invitation were part of Hamill's study.[32]

The next major piece of work was undertaken by social science researchers (and a veterinarian) associated with the University of Otago. The research involved a study of farmers' experiences of the M. bovis biosecurity response and eradication programme. The University of Otago research involved 18 farmer interviews and has resulted in several academic journal articles (see the literature review). These farmer interviews appear to have been carried out during 2019 and early 2020, more than a year prior to the farmer interviews that I carried out for this

[32] In addition, Hamill's thesis is not available online. The researchers did not obtain the appropriate human ethics committee approval for the farmer interviews, so Massey University has banned publication of the thesis indefinitely. The abstract is, however, available (Hamill, 2019b).

research. While there was no timing impact on this research, the fact that some farmers had already been approached for an academic study may have affected the participation rates and/or content of my farmer interviews.

In 2020, the Governance Group commissioned a further work programme that influenced the present research. The broad purpose of this work programme was to "develop a road map for an on-farm biosecurity programme" (MPI et al., June 2020, p. 4) for the purpose of enrolling farmers in biosecurity practices. The research involved interviews with eradicators, farmers and others about farmers' biosecurity attitudes and on-farm biosecurity practices. The interview findings culminated in an inscription device about farmer biosecurity known as the 'Read Report', being named after its primary author.[33] Those researchers' interviews appear to have taken place during March and April 2020 (the time that I had intended to begin my interviews). The eradicators' chapter and the discussion chapter both situate the Read Report's findings within the present research.

In late 2020 and early 2021, farmers were being contacted again – this time by MPI as part of work carried out under the M. bovis Science Plan (Science Plan).[34] In addition to the Science Plan's workstreams that formed part of the biosecurity response, such as national surveillance and epidemiological analysis, there were workstreams focusing on the clinical impacts of M. bovis on milk production (another scientific study associated with Massey University, but different to the Hamill thesis) and the drivers of biosecurity decision-making among farmers. In addition, there was a related piece of work known as the 'Litmus study' (Litmus, October 2021), which evaluated the stressors that farmers experienced because of the M. bovis eradication programme.[35] Each of these work programmes required interviewing farmers whose worlds had been impacted by M. bovis. Those interviews were undertaken in late 2020 and early 2021.

[33] Liz Read, founder and Managing Director of Reputation Matters, the agency tasked with providing the research for MPI.
[34] The M. bovis Science Plan was prepared by the Strategic Science Advisory Group (SSAG, October 2018). The main purpose was to identify the scientific knowledge that was key to Aotearoa's successful eradication of M. bovis.
[35] Prepared by Litmus, which is a company that carries out research for a wide range of social and community purposes.

Given the 'busy' state of research occurring in 2020 and in the first quarter of 2021, and in order to avoid any confusion about the relationship between this research and the MPI research, I decided to begin interviewing the eradicators and scientists first and to leave talking with farmers until the second quarter of 2021. Due to that decision, it was not until March 2021 that I began to hear farmers' M. bovis stories, which was after many of them had already been contacted and/or interviewed by other researchers and government officials for other studies. The timing of this delay and the previous interview processes will have impacted on my research in unknown ways. One likely impact could have been that the stories I was told were actually retellings, because they have already been told before.

A final, unexpected research actor emerged in the second half of 2021. The eradicators sought an independent review into the M. bovis eradication programme and a panel was tasked with uncovering lessons that could be learnt and making recommendations for future biosecurity responses (the resulting report is known as the 'Lessons Learnt Report' [MPI et al., July 2021]. Farmer interviews were an integral part of the eradicators' learning to become more effective and efficient, though this time they were likely to have been held after I had carried out my own farmer interviews.

In total, five farmers, three eradicators, and two scientists declined to participate in my research. I cannot know how many of the human actors that I interviewed have also told their stories previously, or how many who declined to be interviewed did so because they had already been spoken to by other researchers prior to or during that same period. A corollary is that the interviews carried out by the independent review panel in the second half of 2021 will be similarly impacted by all the approaches and interviews preceding it, including the stories written about here.

3.3.7.2 Biosecurity as an actor

When I began this thesis, I created a pictorial of all the actors that might be prominent in the M. bovis network. Biosecurity was one of those actors. However, as this research has progressed and taken its own path, it has become clear that biosecurity is not an actor. Rather, biosecurity is the practised world-building of other actors. Biosecurity is an effect, not a cause, and not a network disruptor. This short section explains why biosecurity does not speak as an actor in the M. bovis assemblage.

Actors are network elements that "make a difference" (Law & Mol, 2008b, p. 58), so on that basis it might be said that biosecurity practices are a collective actor. However, that framing does not neatly fit for a group of practices that are reliant on other actors accepting and enacting those practices. Biosecurity is made and performed, but it is not an "entity able to associate texts, humans, nonhumans and money" (Callon, 1991, p. 140). Biosecurity is comprised of a heterogenous and partial set of practices that are made differently with different actors. Biosecurity is not an 'author' that puts "intermediaries into circulation" (Callon, 1991, p. 141). Biosecurity interacts with and is reliant on other actors to make itself manifest within actor-networks; those *actors* make biosecurity enrol other actors, but biosecurity itself does not.

3.4 Conclusion

This chapter has described my methodological and method choices and illustrated how these have made and bounded the present research. Before moving into the preamble, it is important to signpost that the shape of the chapters in this thesis are asymmetrical. As previously mentioned, in accordance with ANT methodology and allowing the actors to speak, the actors each have had different amounts to say about their M. bovis worlds. Consequently, the eradicators' chapter is the largest chapter, and the bacteria chapter is the smallest. The other actors' chapters fit in between the two in length and complexity. This is just how each of the actor's translation goals have emerged.

Chapter 4 Preamble to the actors' chapters

[A]ny attempts at 'biosecurity' can only be viewed with modesty and humility (Barker, 2015, p. 362).

4.1 M. bovis' assemblage

This is a story about an existential battle that began on Aotearoa's farms when M. bovis emerged in July 2017. The battle has been waged between MPI, Dairy NZ, B+LNZ and Fed Farmers (known collectively as the eradicators), and the M. bovis bacteria themselves. Caught in the middle of the struggle, but no less actors of considerable influence in determining the outcome, were the group of scientific experts that advised the eradicators (also known collectively as the scientists), and two other collective groups: farmers and cows.

In fact, cows were crucial to the translation success of both the eradicators and M. bovis, because the first group's interests lay in disease-free cows and the second group relied on infected cows. While these two key actors needed to enrol cows into their respective actor-networks, it will be seen that enrolment has been a fraught and fickle process. We know that actors can become distracted (and *interessed* away), and their loyalties can easily waver (Callon, 1986; Michael, 2017). Like the scallops of St Brieuc Bay, cows needed to be enticed by both the eradicators and M. bovis through a series of negotiations.

As for the eradicators enrolling M. bovis, this could never happen. They had nothing that M. bovis desired - quite the opposite. Nonetheless, and unusually, it will be seen that the eradicators and M. bovis shared the same ultimate goal of reterritorialising farming. In the meantime, the eradicators have metaphorically 'displaced' (Callon, 1986) M. bovis from their bovine homes and transported the bacteria into the boardrooms of industry offices and government buildings, where policies and practices can be built around their demise. The eradicators have succeeded in (visibly) Othering the bacteria from farms all around the country, despite its active resistance.

The eradicators embedded key actors into their roles of problematic disease, sick cows, expert veterinarians, objective scientists, government officials, good farmers, and bad farmers. They created biosecurity policies and legislative reforms, along with a financial compensation regime to entice and coerce farmers into mobilising with them. At any stage, however, the eradicators could have been betrayed by M. bovis, the cows, the scientists and/or the farmers,

each of whom may have wanted an alternative outcome to eradication, or who might have wished to achieve that outcome by different means. Farmers could have impactfully betrayed the eradicators through persistently poor biosecurity practices, for example, and the assemblage itself may have operationalised that betrayal through its inherent hypermobility. If M. bovis is still hiding out on a farm in Southland, for example, that betrayal may yet come to pass.

Essentially, what follows is an introductory story of how Aotearoa's farming assemblage has been threatened by M. bovis and reterritorialised by the eradicators, with support from the scientists, but with varying degrees of enrolment from farmers and cows themselves. The purpose of this preliminary tale is simply to describe the moments of translation and controversy without embellishment (Venturini, 2010a), before moving to focus on each actor's M. bovis reality in depth.

4.2 Problematising M. bovis

Sometime in late 2015 or early 2016, M. bovis made its way to Aotearoa (see below), though the bacteria's country of origin and means of transport remain unknown. M. bovis lived incognito for 18 months more or less, initially keeping away from human interference. Finally, in the winter of 2017, MPI caught up with these bacteria with the assistance of two sharemilkers and a veterinarian.[36] It is on the Waitaha dairy farm, known as the 'Tainui' farm, that the eradicators' story began.

The eradicators thought that M. bovis' most likely pathway to Aotearoa was via germplasm (frozen bovine semen and embryos), even though they considered the likelihood to be very low (MPI, November 2017). There were other potential pathways, too, but each carried an even lesser likelihood of transmission. These alternative routes included live cows, feed, farm machinery, veterinary medicines, and biological products (MPI, November 2017).[37] The only

[36] That veterinarian was to later receive an Outstanding Contribution to the Primary Industries Award for her tenacity and commitment to identifying M. bovis (RNZ, 2019a).

[37] The seventh potential pathway is not immediately apparent from the publicly released version of the *Analysis of risk pathways for the introduction of Mycoplasma bovis into New Zealand* (MPI, November 2017) (Pathways Report) because the report was redacted under s 6(c) of the Official Information Act 1982 prior to release. Section 6(c) provides the ability to withhold information where disclosure would be likely to "prejudice the maintenance of the law, including the prevention, investigation, and detection of offences, and the right to a fair trial". However, another report titled *Rapid Risk Assessment: Mycoplasma bovis in bovine feed, used equipment and veterinary medicines & biological products* is listed in the reference section of the Pathways Report. This same phrase "bovine feeds, used equipment, [redacted under s 6(c)]" appears on p. 5 of the Pathways Report, indicating that the additional (but redacted) pathways are "veterinary medicines and biological products".

option that the eradicators could rule out was that "there was no live cow smuggled in through Auckland airport" (Gandalf, Government). It seems that the bacteria's journey to that initial farm in Te Taurapa o Te Waka will likely remain a mystery to all actors, except of course M. bovis itself.[38]

The bacteria first presented *as* M bovis in 2017, which is not to say that it was previously materially absent. For example, the eradicators considered that M. bovis had entered the country "in late 2015 to early 2016" (MPI, May 2018), though they could not be certain that the bacterial population had not arrived even earlier but become extinct due to Aotearoa's extensive, pasture-based farming assemblage (MPI, December 2017). One of the causes of this uncertainty is that M. bovis' bodily expression can be easily mistaken for common bovine diseases, especially when it is cooperating at a cell level with other bacteria or viruses (MPI, February 2019). This chameleon-like quality would have made it difficult for farmers and veterinarians to identify M. bovis even if it were previously present.

The multiple actors who collaborated to expose M. bovis on the Tainui farm are alluded to in the document titled, *Analysis of Risk Pathways for the Introduction of Mycoplasma bovis into New Zealand* (MPI, November 2017), as this excerpt illustrates:

> [T]he characteristics of the affected enterprise are unusual and may have contributed to the epidemiology of the outbreak. Clearly there are some factors that are different from many farms in New Zealand. The enterprise is large scale, on some of the farms utilises robot milking parlours (although not on those farms determined to be infected), cattle are housed indoors on some farms, and anecdotally the management style adopted in the enterprise is highly entrepreneurial in nature…We also have to consider that the epidemiology of the outbreak on the index farm (within the affected enterprise) was peculiar. The outbreak presented as an unusually high proportion of animals showing clinical signs (pp. 17 & 18).

These unusual characteristics on the Tainui farm enacted the bacteria in a unique presentation such that the human actors involved were determined to discover (and name) its nature. While

[38] However, the Pathways Report was published in November 2017, and it was not until December of that year that the Zeestraten farm in Te Taurapa o Te Waka was discovered to have had M. bovis *prior to* July 2017, making it (and not the van Leeuwen farm) the first infected farm. There was never a follow-up Pathways Report.

not expressed in this way, the above passage conveys a tacit understanding about the influence of actor-network relations on disease manifestation (Law & Singleton, 2015).

MPI initially identified Tainui farm as Aotearoa's first M. bovis infected place (IP1). In accordance with usual biosecurity practices, MPI placed restrictions on all movements of cows and other 'risk goods' on and off the farm.[39] On 31 July 2017, scientific testing confirmed the presence of M. bovis on a second farm, which was also owned by the Van Leeuwen Dairy Group (VLDG).[40] In August, MPI began a surveillance and tracing programme, including swabbing cows' mouths and testing their milk and blood for the presence of M. bovis (MPI, n.d.e.). In that same month, MPI began culling (systematically killing) cows on all infected places (IPs) within the VLDG of farms. At that time, MPI's biosecurity goal was to find and contain the bacteria, as opposed to eradicating it, and at that time culling cows was simply used as a means of containing M. bovis. By December 2017, epidemiologists had confirmed the prior existence of M. bovis in Te Taurapa o Te Waka, on a farm owned by Alfonse Zeestraten. As previously mentioned, the Zeestraten farm was subsequently found to be the very first IP in Aotearoa (making Tainui farm the second known IP). By early 2018, MPI had discovered that the bacteria had already travelled to Te Ika a Māui.

Below is an illustration of the IPs that MPI located within the first 12 months of the biosecurity response.[41] Each IP on the chart represents when M. bovis was found during that first 12-month period, and the points in red represent Te Ika a Māui locations. *Figure 9* also shows how long it took MPI (and its contractors) to trace M. bovis back to the Zeestraten farm by following cow movements.[42] That six-month gap between first finding M. bovis on the Tainui farm (IP1) and tracing it back to the Zeestraten farm (IP8) allowed the bacteria to take advantage of cow mobilities to travel the length of the country.

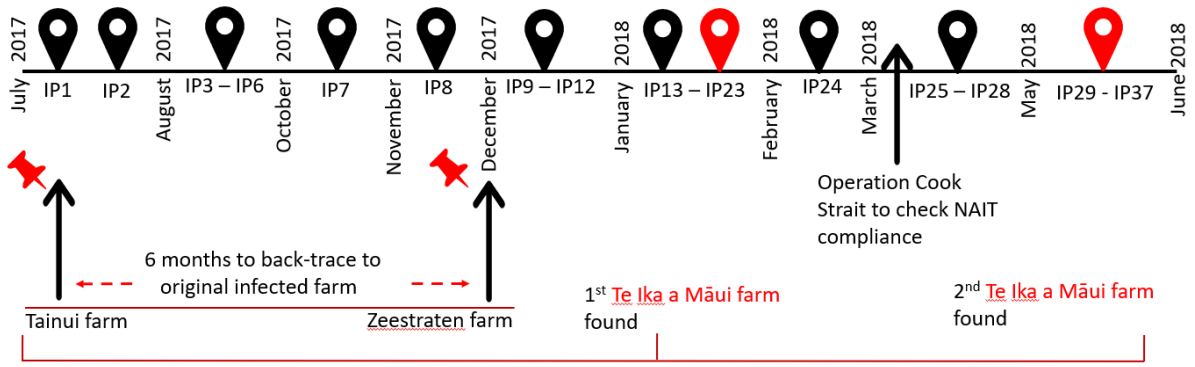
[39] Risk goods are defined by s 2 of the Biosecurity Act 1993 as organisms, organic material or other substances that might reasonably be expected to harbour harmful organisms (such as pests and diseases) because of the nature or origin of the goods. The movement restrictions are known as Restricted Place (RP) notices, and the purpose is to prevent any organisms or other goods from being removed from, or introduced into, that place (s 130 of the Biosecurity Act 1993).

[40] At the time M. bovis was discovered on Tainui farm, the Van Leeuwen Dairy Group had a total of 16 farms and 12,500 cows in Waitaha and North Ōtākou (RNZ, 2018e).

[41] The pictorial is informed by data taken from media articles and articles (see for example, RNZ, 2018a).

[42] MPI contracted AsureQuality Limited (a State-Owned Enterprise) to carry out monitoring and tracing in the Early Days of the biosecurity response (for more information see OMNI, May 2019).

Figure 9
Finding M. bovis



This chart only identifies when the bacteria were found, so it cannot tell us when they were first present. Equally, the absence of evidence of M. bovis on *other* farms during that first twelve-month period is inconclusive evidence of M. bovis' absence.[43] This is not to blame MPI. They had many controversies to deal with during the biosecurity response, including incomplete cow movement records and inadequate scientific testing capabilities (see the eradicators' and scientists' chapters). MPI was also dealing with several other significant biosecurity responses at the same time.[44]

By January 2018, MPI and DairyNZ had begun a nationwide milk surveillance programme, searching for M. bovis' presence. March of that year saw the government and industry partners of DairyNZ and B+LNZ increase biosecurity funding for the M. bovis response by an additional NZ$85m, and the introduction of Operation Cook Strait, which was a checkpoint to monitor farmers' compliance with the National Animal Identification and Tracing Act 2012 (NAIT Act). Te Ika a Māui farmers had previously called for MPI to close the 'border' between the two islands, to protect their farms from M. bovis (Stuff, 2018a). That same month, MPI directed that all cows on known IPs (28 by that time) would be culled, whether they were infected or not.

[43] The origins of the saying, 'Absence of evidence is not evidence of absence' are unclear, but it is commonly attributed to British astrophysicist and Astonomer Royal, Martin Rees.
[44] During the Early Days of the M. bovis biosecurity response MPI was also dealing with other time-consuming incursions, including pea weevil, *Bonamia ostreae* (an oyster parasite), myrtle rust (affecting iconic indigenous trees), *Phytophthora agathidicida* (kauri dieback disease) and Queensland fruit fly. Bilbo (Veterinarian) thought that these other biosecurity incursions were MPI's "excuse for a poor response" to M. bovis.

May 2018 was a significant month for MPI, because it marked the beginning of a new phase where the initial biosecurity response (of following and containing M. bovis) transitioned into a phased eradication programme (of Othering M. bovis from the assemblage). The eradicators' attempt to oust M. bovis was ambitious. Every other country has opted to manage the bacteria by increasing on-farm biosecurity and adapting cow buying practices.[45] Interestingly, and despite being the country's lead biosecurity agency, MPI did not champion eradication as being the preferred option (Gandalf, Government). Gandalf spoke about the politics of the eradication decision as an added layer of complexity:

> There was a new government in place that wasn't seen as traditionally friendly to farmers, and I think you could be cynical and say – which is what many farmers said to me, it's obviously not my opinion but what I was told many times, that the government found they had an option to swing NZ$800m out in front of farmers to show them that they loved them before they came after them for environmental issues.

Outside of political influences, there were several other factors said to weigh in support of an eradication attempt. The most crucial was that the scientists (whose M. bovis story is a critical part of this thesis) had confirmed that Aotearoa had just one strain of the bacteria, indicating a single point of entry and therefore increasing the odds of successful eradication (MPI, December 2017). In addition, MPI considered that M. bovis was "limited to one network of farms that are connected by animal movements" (MPI, June 2018, p.1), which was again thought to greatly increase the odds of phased eradication success.

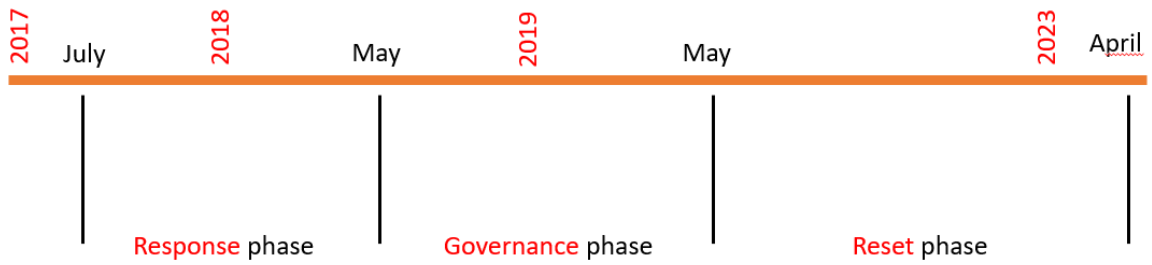
The key imperative, however, was the desire to protect and maintain the extensive cow movements that this country's pasture-based farming assemblage requires (Aragorn, Government). As already mentioned, the vast majority of cows in Aotearoa are pasture-fed (as opposed to grain-fed), which means that they live mostly outdoors. Pastural grazing requires cows to move regularly at certain times of the year, in accordance with the seasons. There is also a consequential and immovable calving season of six to eight weeks in spring.[46] This calving season is linked to grass growth, but it results in more calves being born at once than farmers need or want to retain. The excess calves are raised as dairy replacements or sold to

[45] For example, M. bovis is managed in Australia primarily through health checks of cows, the use of quarantine herds (for new cows), cleaning milking and other equipment between uses, and separating hospital herds from healthy ones (Dairy Australia Corporation [DAC], September 2017).
[46] Some farmers will calve their cows in the autumn, however, and there are some (in the minority) who calve different mobs up to four times a year, which is what occurred on the Tainui farm.

beef farmers (Stafford, 2017; Boulton et al., 2018).[47] There are other cow movements that are crucial elements of the farming network, too, such as share-milking herds (see Buchanan, 2002), and beef cows that are traded regularly among farmers based on their live weight. Then, there are other biological mobilities, such as bull semen, and the waste-milk that is routinely fed to calves by calf-rearers.[48] The decision to eradicate M. bovis was significantly influenced by the need to maintain these biological movements and flows.

Before leaving the problematisation of M. bovis, it is relevant to note here that there have been three distinct temporalities that have impacted on MPI's success pre-eradication and the eradicators' success once eradication had been decided. These are known as the response phase, the governance phase, and the reset phase, as illustrated in *Figure 10* below.

Figure 10
The eradicators' translation temporalities



The response phase began when M. bovis was discovered in July 2017 and ended when the government opted for eradication, which was in May 2018. This initial period was characterised by MPI adopting a standard biosecurity response approach to managing the bacteria without any formalised financial commitment from or shared decision-making with farming industry bodies (MPI et al., July 2021). The response phase is also known colloquially as the Early Days, which was a highly controversial period, and which is described in depth in the eradicators' chapter. The next key phase was the eradication phase, which ran from May 2018 to May 2019. This phase was also known as the governance phase, because during this

[47] If the excess calves are unwanted, they are culled between four and seven days of age. These unwanted calves are known as bobby calves (Stafford, 2017; Boulton et al., April 2018). Bobby calves are defined as unweaned calves that farmers intend to transport to slaughter within their first week of life (Boulton et al., April 2018).
[48] As already mentioned, discard or waste-milk is the milk that farmers cannot put into the milk vat for collection because the animals have mastitis or are being treated with antibiotics. This milk is commonly fed to calves because it is more cost effective than using commercial milk formulas.

period the eradicators (excluding Fed Farmers) formed a Governance Group. The eradication costs were to be borne by the government (68%) and B+LNZ and DairyNZ (32%) respectively (MPI, June 2018).[49] The industry bodies had the dual roles of representing their farmers' interests and supporting the eradicators, but as will become apparent in the next chapter, there were times when those tensions became too great to manage. There is an important final phase, too, known as the reset phase. This is where from May 2019 onwards the eradicators began to show their strengths and make some translation gains after an array of initial difficulties that dogged the Early Days and much of the governance phase (MPI et al., July 2021). For present purposes, I have taken the reset phase to end when the eradicators thought that they had depopulated the last known farm to host M. bovis, which was April 2023, and which was before M. bovis appeared again in the following month.

At the beginning of the governance phase, the eradicators had estimated that approximately 150,000 cows would be slaughtered, and of the 24,000 beef and dairy farms in Aotearoa, about 200 would be de-populated (or around one percent of all farms). The phased eradication process was expected to take several years, with most culling being carried out by the end of 2020. By the end of the reset phase, the eradicators had culled more than 180,000 cows (MPI, April 2023).

At the conclusion of the reset phase, the eradicators began to shift their focus from confirming a presence to confirming an absence, and so the surveillance for M. bovis' presence continues. This is a different and much more difficult task for them than confirming M. bovis' presence (Frodo, Government), though that was difficult enough (as will be seen in subsequent chapters). The eradicators acknowledge that it could take up to 10 years to prove the absence of M. bovis using the scientists' testing and their own surveillance measures. The financial cost of the eradication programme was initially predicted to be NZ$886 million (calculated over the 10-year period) (MPI, June 2018). The financial (including production) cost of living *with* M. bovis, which would have necessitated substantial changes to the farming assemblage, was estimated in excess of NZ$1 billion (calculated over that same period) (Office of the Minister for Biosecurity, 10 July 2020).

[49] In June 2019, MPI, DairyNZ and B+LNZ signed an Operational Agreement (OA) under their Government-Industry Agreement partnership arrangement. The OA formalised the eradication programme cost sharing and decision-making arrangements between these organisations.

Once the government had decided to try and eradicate M. bovis, and the eradicators had formed as a collective, they had an overarching goal to meet and various obstacle problems to overcome. The eradicators' catch cry was, "if we have the opportunity to eradicate, then we should take it" (Office of the Minister for Biosecurity, 10 July 2020, p. 3). The eradicators' OPP was in the form of a question: 'Can we eradicate M. bovis?'. For them, the answer to this question was indispensable and, for the most part, they leaned heavily on the scientists for answers. M. bovis was a known obstacle problem, but as the eradicators' chapter will show there were additional unknown factors they encountered on their journey.

The next chapter shows that the eradicators desired three outcomes from their collective efforts. One outcome was the removal of M. bovis from Aotearoa, and not in the least because they had invested so much in the result. Another outcome was the primary driver of their first goal, which was the continuation of the farming assemblage in its current shape, with all of its fluidity and freedoms. The third goal was that the eradicators wanted farmers to embrace biosecurity practices as an ordinary and expected part of farming. The next chapter tells the eradicators' own story, describing their M. bovis realities in rich detail.

Chapter 5 The eradicators

We were geared for foot and mouth, which is what we were trained for. Bovis came up, and I'll be quite honest, when I got the phone call on the Friday night to say that we might have bovis and that was before it was confirmed, I went 'what is it?' (Gandalf, Government).

5.1 Introduction

The eradicators' chapter is concerned with the push-pull of the existential power play that they have enacted against M. bovis (though, and spoiler alert, M. bovis did a good job of pushing back). This chapter describes how the eradicators went about performing their roles in their quest to reterritorialise farming in Aotearoa, and in doing so traces their key moments of translation. More broadly, this chapter explores some of the multiple dynamics and power struggles involved with doing agricultural biosecurity work in a land where farming is a powerful, albeit fragmented, actor and where human knowledge and experience is privileged over that of the cows and bacteria who sit at the heart of the human actors' concerns and interests.

The eradicators are the first actors to speak in this work, and that is partly because this human group have created the battle between themselves and M. bovis. The eradicators were a group multiple, being comprised of different sub-groups, each with their own and sometimes divided loyalties and interests. There were the public officials, whose network role was to work towards Othering M. bovis by navigating the obstacle problems that arise and funneling the other actors through their OPP to attain their goal of eradication. These were mostly employees and contractors of MPI, and their roles were ideologically quite straight-forward. Then, there were those who were both eradicators and farmers. These actors were employed or contracted by MPI and were either still farming or were farmers before joining MPI. This sub-group at times spoke with tongues multiple, as those actors navigated their dual roles, interests, and loyalties.

Another sub-group that has emerged were those who were eradicators but who also worked for the industry bodies of Dairy NZ, Fed Farmers, and B+LNZ. There has been a marked split in loyalties between the industry bodies and the public officials during times of controversy. Mostly these splits in the eradicators' 'one voice' have been over methodological differences, such as tracing and containment procedures, but some have been deeper, speaking to a continuing distrust of Wellington-based officials by those farming in the country's regions.

Adding to the eradicators' layers of complexity, Fed Farmers was an organisation multiple within itself, because there were regional 'fiefdoms' (Gandalf, Government), each with differing priorities and views on the role of farming and farmers in Aotearoa. Together, however, these various groupings of government and industry actors are referred to here as the eradicators.

Before moving on to this chapter's narrative, there is a short section below that conceptually frames the eradicators' efforts to reterritorialise farming and to encourage farmers to engage with biosecurity practices.

5.1.1 The eradicators' world-making efforts

As explained in the preamble, the eradicators began their journey after MPI had mounted a year-long biosecurity response to M. bovis. When they began their process of translation, the eradicators did not know whether it would succeed or fail, and either outcome depended on their dedication to imposing their will on others, keeping other actors *interessed* in their programme and mobilising those actors to act without betrayal. The eradicators also had problems keeping their own sub-groups enrolled at times, as divergent interests threatened to undermine the collective will. Yet, as this chapter shows, the eradicators eventually grew in strength through learning from their challenges and enduring their disappointments, and they successfully mobilised enough key actors, such as scientists, to further their goals. A big challenge for the eradicators was how to manage the "material geography" of the bacteria (Donaldson & Wood, 2004, p. 385), which is where epidemiologists have played a valuable role in finding and following M. bovis.

In taking a Foucauldian approach of excluding M. bovis from the farming assemblage (see Sarasin, 2008; Hinchliffe & Ward, 2014), the eradicators have deemed M. bovis to be "matter out of place" (Bull, 2018, p. 218), framing these bacteria as a disease to be Othered.[50] By employing extreme biosecurity practices, the eradicators have denied the complexity of M. bovis as a microscopic organism and its world-making abilities. Embedding other network actors into their roles of 'problematic disease', 'vulnerable but valuable cows', 'expert

[50] Foucault's work on biopolitics was not merely about control of unruly and undesirable forms of life through population control, it was also fundamentally about the prioritising of life forms, so that some life can thrive while other life must die (see Barker et al., 2013).

veterinarians', 'objective epidemiologists', and 'good and bad farmers', has been achieved using all means available, including at times force (in the case of M. bovis and cows), coercion and persuasion (in the case of the human actors). In so doing, the eradicators have shown their fear of M. bovis' disruptive potential to farming because the presence of microbial life highlights the vulnerability of this assemblage (Enticott, 2016b). Protecting the 'backbone' (Park et al., 2002) of Aotearoa's economy was a foundational motive and a strategic move to enrol farmers.

The eradicators were not interested in acknowledging or enacting a continuous bacterial absence/presence (Hinchliffe et al., 2013; Law, 2004), because for them the world of an unwanted organism is binary and devoid of liminality (Bull, 2018). By taking a binary approach to animal diseases, the bacteria could only be 'found' or 'discovered' by human actors; that is how the eradicators knew M. bovis had become present inside farm boundaries. It follows that cow health itself could only be declared where disease was not made manifest or was presumed absent (Hinchliffe et al., 2013). Put another way, the eradicators had a need to "standardise agricultural space" (Enticott, 2008b, p. 1572) in face of a bacterial ability to hold liminal space (see also Hinchliffe & Ward, 2014). Agricultural biosecurity mostly ignores this liminality, however, by predominantly concerning itself with the statistical 'mapping' or spatio-temporal tracing of identifiable populations (Hinchliffe et al., 2013). Presupposing a singularity for M. bovis, which is what the eradicators have done, essentially hides the practices that make biosecurity materialities. This human-centred epistemology would have increased their struggles during the eradication programme, and it may yet work against them in the long-term 'post-M. bovis' surveillance process.

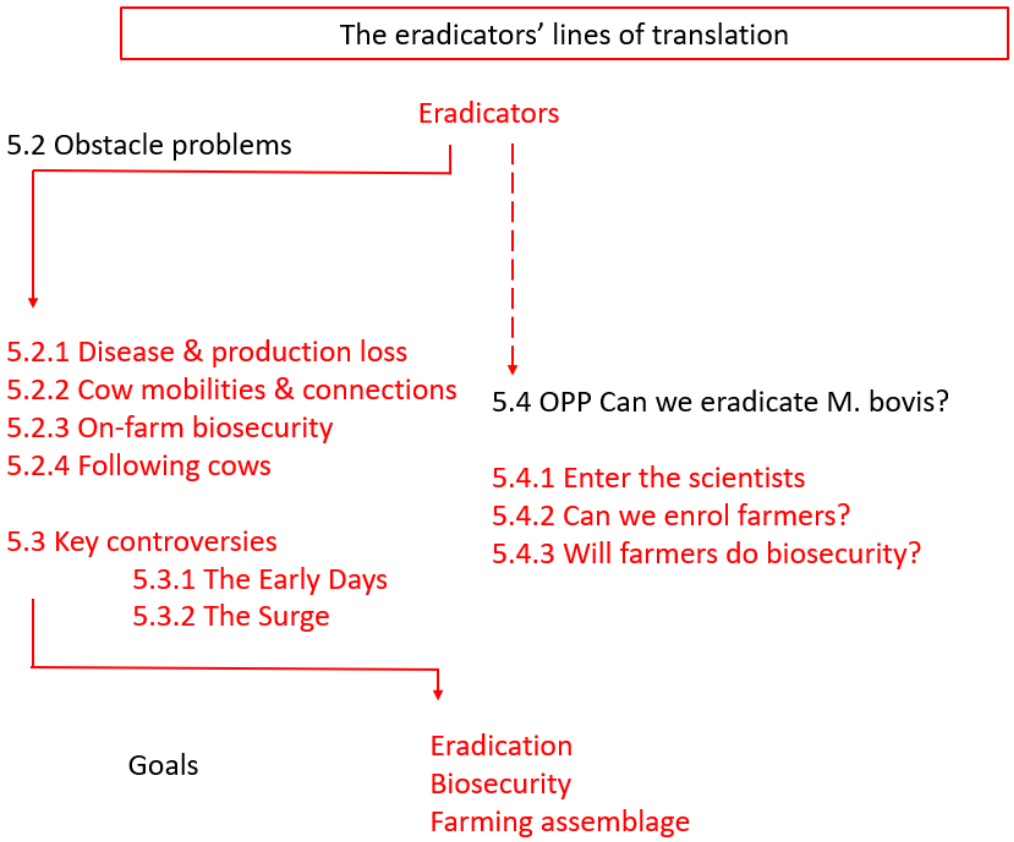
5.1.2 This chapter's narrative structure

As explained in the methodology chapter, every actor's narrative is organised following Callon's (1986) diagram of the lines of translation that he found were present in his study of the power relations between researchers, fishermen, scientists and *Pecten maximus* (a species of scallop). There, the researchers sought to problematise the anchorage of scallop larvae and enrol the other actors in their proposed solution. Callon explained each of the actor's obstacles, OPPs and goals using a diagram. To aid understanding of the actors in this thesis and their problems, solutions and goals, each findings chapter is set out using the same 'lines of

translation' format. (There is an overarching and inclusive diagram, showing all of the actors' ambitions and problems in one place, provided in the introduction.)

As *Figure 11* below shows, the eradicators had four clear obstacle problems to achieving their ambitious goals of eradication, better biosecurity and strengthening farming. Their obstacles were identified as diseases and production loss caused by M. bovis itself, extensive cow movements across the country and a lack of on-farm biosecurity (including NAIT usage by farmers). The eradicators wanted to know whether they could eradicate M. bovis, and this question was expressed as their OPP. The eradicators' chapter is more structurally complex than any of the other actors' chapters. This complexity is partly because of the eradicators' own ambitious goals, but also their inability to enrol (and subsequently mobilise) farmers into their biosecurity network. The eradicators also introduced two key temporal controversies into the narrative, and these have influenced the world-making of all the actors. The controversies are designated in the chart below as the 'Early Days' and the 'Surge', and they will be described in detail later in this chapter because these periods have typified the "trials of strength" (Callon, 1986, p. 207) that the eradicators have endured in overcoming their obstacles and pursuing their goals.

Figure 11
The eradicators' lines of translation



This chapter's structure follows the chart's order, unpacking the eradicators' obstacle problems and OPP question in rich detail (each has its own section below). The eradicators' goals do not have their own section; rather they are discussed throughout the chapter with reference to their own world-making. Next, this chapter foregrounds the obstacle problems that the eradicators faced in their attempt to translate the newly disrupted farming network.

5.2 Obstacle problems

As signalled above, the eradicators had four main obstacles in the way of achieving their goals. The first obstacle problem for the eradicators was the bodily disease that M. bovis can cause, which can become a welfare problem for farmers, and which then becomes an expense (requiring veterinarians and their medications). A persuasive consideration for the eradicators has also been the overseas research link between bodily diseases, such as mastitis, and a drop in productivity, especially in dairy cows. They hypothesized that if left alone, M. bovis would spread and become endemic over time, and thereby lead to the animal welfare issues and lack

of productivity seen in other countries. The eradicators saw this potential for financial harm for farmers and therefore the national economy as a weighty factor in their drive to eradicate the bacteria.

The second obstacle problem for the eradicators is a recurring theme in this thesis, which was that cows move from farm to farm with alarming frequency and cover large geographical distances. The extent of cow mobility was not known by MPI before M. bovis emerged, but it became an important risk factor for the eradicators. One of the problems identified early on, and a problem shared with the scientists assisting the eradicators, was that many questions still remained in the overseas data about M. bovis' behaviour and for obvious reasons there was no information about how the bacteria would behave in Aotearoa.

Linked to the heightened risk of spread, and lack of ability to contain the bacteria was the eradicators' discovery that farmers were not entering their cow movements in the NAIT system – either contemporaneously or at all. Farmers' poor biosecurity practices were the eradicators' third and fourth obstacle problems. This absence of information about where cows were at any given time, and where they had been prior to that time, increased the risk that M. bovis would quickly become endemic. In addition to the lack of NAIT data, farmers were not actively engaging with biosecurity on their farms. The eradicators found that most farmers had either poor or no biosecurity awareness, and this lack of understanding of biosecurity's importance for their biological assets flowed into an absence of biosecurity practices. For example, the eradicators observed that very few farmers had a biosecurity plan for their farms, very few asked questions about the health and origins of the calves and cows they purchased, and hardly any implemented farm-gate controls such as boot washes, sign in procedures or limiting visitors' access to sheds or paddocks (Saruman, Government; Gandalf, Government; Treebeard, Government). This is the existing assemblage in which the eradicators made their bold decision to try and Other M. bovis from Aotearoa.

The eradicators talked about M. bovis being a rehearsal for FMD, and they spoke with one voice on the topic of preparedness for FMD, which was their frame for responding to serious cow diseases in Aotearoa. The eradicators thought they were ready to meet FMD, and M. bovis helped them to realise that they were not. The eradicators acknowledged that if FMD had arrived in Aotearoa instead of M. bovis, the result would have been an abrupt deterritorialisation of farming (and the national economy) (Frodo, Government). For the

eradicators, M. bovis has highlighted major biosecurity weaknesses and provided an opportunity for learning and for making things much harder for other unwanted life to make their worlds here in the future.

I now move into a detailed description of the eradicators' journey through each of their obstacle problems, beginning with the existence of M. bovis itself. For the eradicators, M. bovis was a threat to agricultural productivity, resulting in diseased cow bodies and lowered milk production. As will be seen, however, M. bovis surprised the eradicators by not behaving as they might have expected.

5.2.1 Diseased cows and production loss

When they began their biosecurity response, MPI knew that the World Organisation for Animal Health (WOAH) was not troubled by which countries had M. bovis present in their herds.[51] Countries with M. bovis are not subjected to trade restrictions, and the meat and milk from infected cows are safe for human consumption (MPI, n.d.a.).[52] However, Aotearoa's export value relies in large part on its relative disease freedom, which means fewer veterinary medicines in use and the ability to move cows to pasture in a natural environment. In addition, the WOAH has been encouraging countries to move away from antibiotic use in cows; so, to rely on antibiotics to cure M. bovis-caused mastitis would run counter to international expectations (Gamling, Veterinarian). There was a reputational narrative at stake for the eradicators, and it was incompatible with providing space for unpredictable bacterial lives.[53]

The eradicators have relied on international research showing that M. bovis causes significant production problems, particularly for dairy cows. The eradicators were advised by their Strategic Science Advisory Group (SSAG) that M. bovis is experienced by farmers in many countries as "an economically significant pathogen of cows" (SSAG, 2018, p. 2). In addition to chronic diseases like mastitis, the eradicators were advised by the SSAG (2018) that M. bovis tends to render cows more susceptible to other infections and diseases. The eradicators calculated this possibility of bacterial and viral interrelations as an extra production cost. One of the important actors in determining productivity was the role of antibiotics used to treat

[51] The WOAH was founded as the Office International des Epizooties, and still also known as the OIE.
[52] Eighty percent of all beef produced in Aotearoa is exported (B+LNZ, September 2017).
[53] See for example a promotional video selling Aotearoa's natural image that was launched by the 'New Zealand Story' (created by the Government, export industries and Māori): https://youtu.be/zoulQlzA7qs.

mastitis, and mastitis in cows tends to respond poorly to antibiotic treatment (SSAG, 2018), so veterinarians' options to mitigate cows' pain and disease were severely limited.

The eradicators initially looked to Australia for answers because all the main dairy farming regions have M. bovis present (Dairy Australia Corporation [DAC], September 2017). An important difference between Aotearoa and Australia is that Australian herd sizes are larger on average. The larger the herd, typically more than 500 cows, the more impactful M. bovis diseases can be (Gamling, Veterinarian). On impacted large dairy farms, diseases such as severe mastitis have caused substantial financial losses through a drop in milk production and the consequent culling of cows (DAC, September 2017). Even so, there remains much that is unknown about the dynamics of M. bovis in Australian dairy herds (DAC, September 2017). Of concern for the eradicators was that the average size of a dairy farm in Te Waipounamu is 750 cows, and some of the dairy farms in Waitaha are larger still (Gamling, Veterinarian).[54] In Te Ika a Māui, however, the average dairy herd size is still only 440-odd cows, and many farms have fewer cows than that (Gandalf, Government).

A further consideration was that Aotearoa is one of the few exporting countries in which farming does not attract government subsidies, making beef and dairy farmers highly exposed to the volatility of international markets (Stafford, 2017). In addition, transporting food products from Aotearoa to any of its international markets is more expensive than for competitors (Stafford, 2017). Given that Aotearoa's agricultural production needs to remain extremely cost effective to be internationally competitive (Stafford, 2017), it was determined that farmers could not absorb the "sub-clinical cost on production" associated with M. bovis (SSAG, 2018, p. 1). Essentially, the eradicators' assessed the financial cost of living with and adapting farming practices to accommodate M. bovis as too great a burden on farmers (MPI, n.d.b).

It was not until the governance phase that the eradicators sought to discover the actual costs of M. bovis on production in Aotearoa. MPI sponsored a veterinarian to undertake a Master of Veterinary Science degree researching the clinical (visible) and subclinical impacts of M. bovis on cows (Hamill, 2019a, 2019b). The research data was collected from 69 infected beef and

[54] At the time M. bovis was discovered on Tainui farm, the Van Leeuwen Dairy Group had a total of 16 farms and 12,500 cows in Waitaha and Ōtākou (RNZ, 2018e).

dairy cow herds across Aotearoa, and it showed that "[c]linical disease attributable to M. bovis was not widespread" (Hamill, 2019b). Hamill (2019a) also found that while disease in *calves* was widespread, this could have been caused by other factors. Where disease expression was evident in dairy cows, however, it was found to be severe. Nonetheless, the findings indicated that milk production did not decrease significantly on farms with M. bovis, and that somatic cell count levels (which, if heightened, indicate the presence of infection) did not significantly increase on those farms, and consequently nor did the purchasing of veterinary medicines (Hamill 2019a & 2019b). This research was conducted at a time when the M. bovis controversy was at its peak (2018/2019), adding weight to Hamill's productivity findings. Hamill (2019a) also made the surprising finding that movement restrictions associated with the eradication programme were likely contributors to *more*, not fewer, severe diseases in cows, due to the consequential changes in farming practices and stocking rates.

Earlier that same year (2019), MPI itself had hypothesised that a "very low level of prevalence with little impact to the industry as a whole could be expected" from an endemic M. bovis population (MPI, February 2019, p. 13). Nonetheless, the eradicators tried again in 2020 to research M. bovis' impacts on milk production and cow health in Aotearoa. The research was again conducted through Massey University, and one of the four researchers was Hamill. There was only one farm chosen for the research, which was Lincoln University's Ashley Dene Research Farm.[55] The researchers found "no association between M. bovis test status and either occurrence of clinical diseases associated with M. bovis infection, such as mastitis, or with daily milk yield" (Compton et al., 2022, p. 3). By the time this research was carried out, however, there were comparatively few farms with M. bovis to study, raising the question about its usefulness in confirming whether productivity was in fact an obstacle problem for the eradicators.

Perhaps unsurprisingly, given the lack of conclusive research, there was some dissention among the eradicators themselves, not all being in favour of the eradication approach. Gandalf (Government) did not support the eradication decision, even though they were employed by the eradicators. Gandalf, a farmer themselves, said that most farmers they spoke with took the approach that M. bovis only causes diseases in cows that are stressed, and for them this means,

[55] The researchers used data from 166 cows on the one farm because they had to exclude certain milking records due to the risk of bias, and they expressly acknowledge that sample size was a limitation on their findings.

primarily, intensively barn farmed animals (not pasture fed dairy cows). They looked to the situation in Australia, too, and concluded that M. bovis "doesn't damage your production figures and there's no animal welfare issue" (Gandalf, Government). Nonetheless, the eradicators collectively put forward the position that M. bovis has caused significant problems in other countries and that it could do so in Aotearoa, too.

Eradication is a process of translation based on a clear non-acceptance of M. bovis, even before the eradicators knew the answer to M. bovis' impacts on cow health and productivity in Aotearoa. Thus, even prior to the key actors passing through the OPP question of whether M. bovis could be eradicated, the process prematurely began. Apart from the two productivity studies (2019 & 2020) mentioned above, no data exists on the production impacts of M. bovis in Aotearoa's farming assemblage.[56] If translation succeeded for the eradicators, it must also have failed for the scientists who have supported them, because the scientists have lost their ability to increase knowledge about M. bovis (see the scientists' chapter) (and this knowledge could have led farmers to an acceptance of farming *with* the bacteria). One of the scientists' key research questions may have been whether farmers could accept the presence of M. bovis and still be able to move their cows as freely as they do now. This largely redundant question leads us into the next section, and the second (and significant) obstacle problem for the eradicators - that of cow mobilities as a biologically insecure foundation for farming.

5.2.2 Cow mobilities and connections

In Aotearoa, cows move in accordance with the seasons, and these cow and calf movements are a main source of bacterial connections (Saruman, Government; Arwen, Government). Movement is an actor in its fluid materiality. When asked how many cows move between the islands, Treebeard (Government) replied "shit loads", and in both directions. They described a northerly flow for beef cows and a southerly flow for dairy cows. Elrond (Government) confirmed Treebeard's account:

> I think we were all pretty gobsmacked about how far and wide cattle move through New Zealand. I mean, people who call[ed] for there to be a stop across the Strait soon

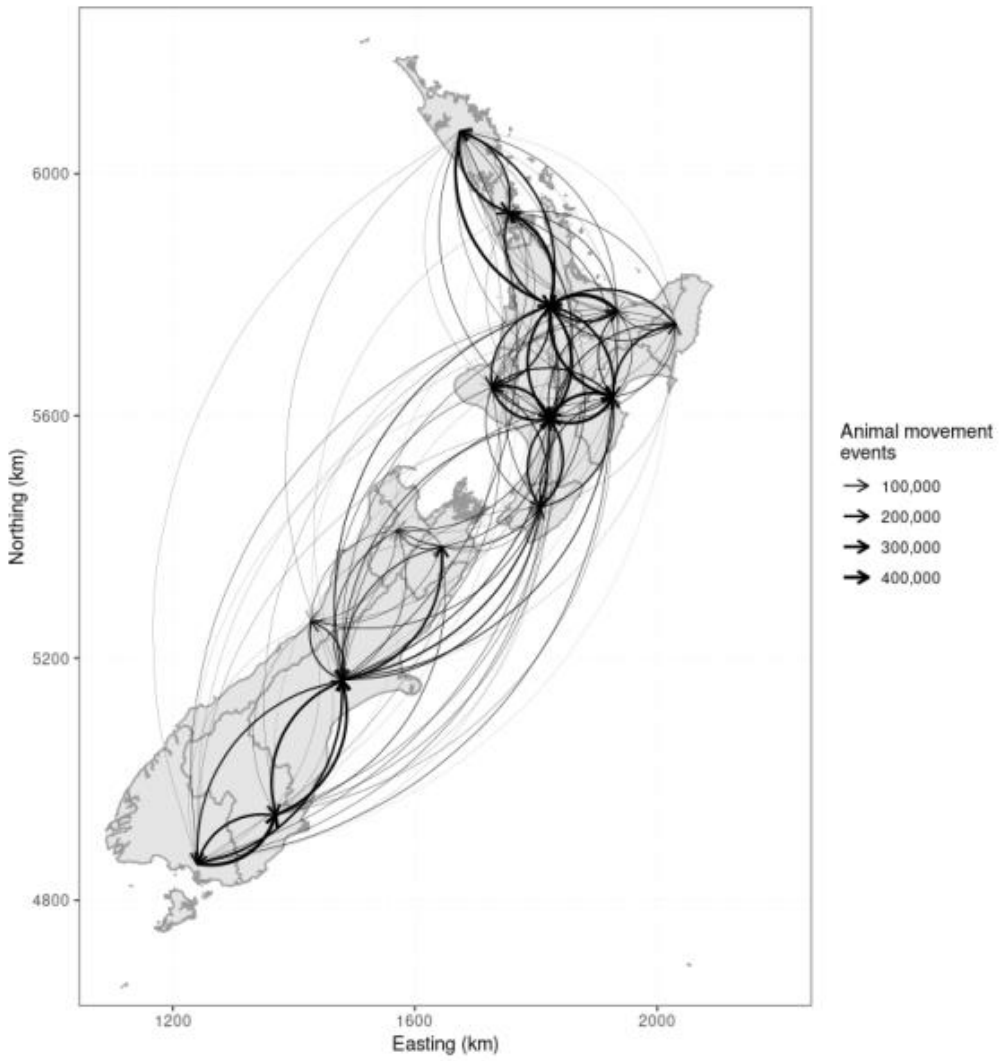
[56] In addition, there is a Master of Veterinary Science thesis where the student researched one of the earliest Te Waipounamu farms with M. bovis (Kearney, 2021). Kearney's research was focused on the presentation and diagnosis of clinical mastitis on that farm for the purpose of enabling veterinarians to more clearly diagnose M. bovis caused mastitis in the future.

> found out that the amount of movements since the time that bovis was supposedly in New Zealand was just enormous.

To illustrate Elrond's point, below is a snapshot (*Figure 12*) of the extensive cow movements that were recorded over a three-month period in 2019. The picture is partial because some cow movements are not required to be recorded, and not all farmers upload the movements that are required anyway (MPI et al., July 2021; University of Melbourne et al., July 2021).[57]

[57] The authors of the University of Melbourne report referred to above analysed NAIT movement data between 2017 and 2020 (inclusive) and found that more than half of the cows in the NAIT system did not have a recorded date of birth.

Figure 12
Cow movements from 1 October to 31 December 2019 (MPI et al., July 2021)



As this picture shows, cows move the length of the country on a regular basis and in great numbers (see also Hidano et al., 2016).[58] Approximately 9.5 million cow movements were recorded during 2020 (and many more cows moved that were not recorded) (University of Melbourne et al., July 2021). This vast cow actor-network can be contrasted with countries that barn their cows, where there are very few movements off the farm and their movement practices are more 'closed' (Saruman, Government). As already mentioned, a large part of the difference

[58] This map excludes movements of fewer than one thousand cows.

in farming practices is because of the role of pasture. There is a long history involved with how farming became so reliant on and driven by grass (see Brooking & Pawson, 2007; Brooking & Wood, 2013; Goldson, 2020), but pasture remains the cheapest feed available, so "we tend to move our animals to the feed, rather than feed to the animals" (Saruman, Government). Another driver for freely moving cows to the feed has already been mentioned, which is that there are very few endemic diseases in Aotearoa, so there is more incentive to move cows in this type of low-risk disease environment (Saruman, Government).

How many cows are mobile at any given time varies from month to month. For Te Waipounamu cow transporter Fredegar, their busiest month is May when the business typically moves up to 30,000 cows.[59] In other months, it could be as few as 5,000 or 10,000 cows. As a farmer in Te Waipounamu, Treebeard (Government) knows first-hand how many cows get bought and sold regularly:

> I was a cattle man, so to speak, so primarily beef and dairy. I was lucky enough that I covered both sides. Business wise I was selling 5,000 odd 100 kg calves up to the North Island every year. I sold a lot of calves into the Hawkes Bay and up into Northland as well. About 1,500 to 2,000 230 kg calves on contract per year as well, going up to the North Island, so I had a lot of beef animals being sold and those 230 kg animals were bulls going up in the autumn.

Treebeard thought that each year there would be between 20,000 to 25,000 calves sent up to Te Ika a Māui just from the Waitaha region alone. From Te Waipounamu, they suspected that

> just on Friesian bulls at 100kgs, out of the South Island 50,000 to 60,000 calves go up north every year. And then you get into that 230kg again, probably being an additional 15,000 to 20,000.

Despite the significant cross-over between beef and dairy cow movements, there was a prevailing view in the Early Days that the two industries remained separate parts of the farming assemblage (Aragorn, Government). Back then, the eradicators did not understand the extent of M. bovis' world-making potential.

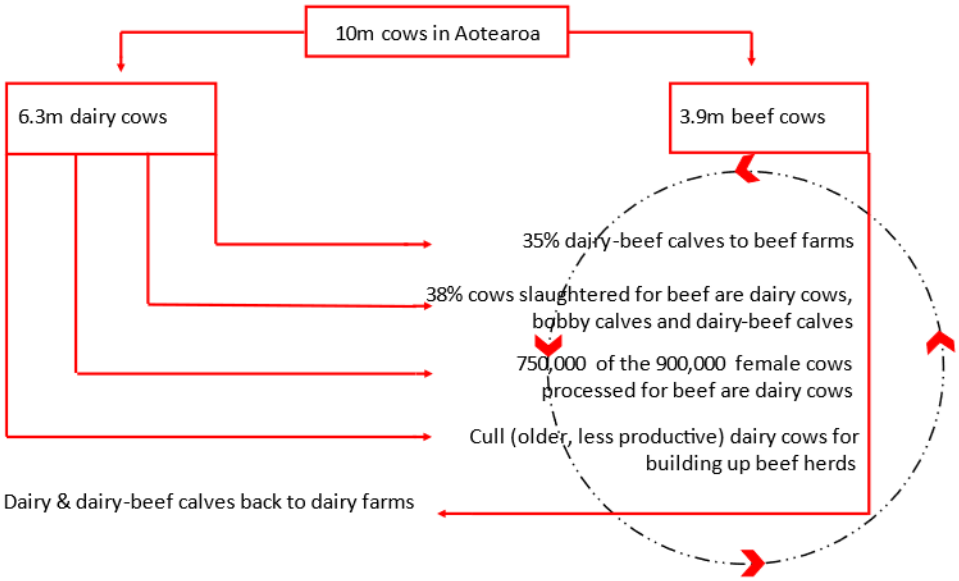
[59] This account is consistent with research showing that the greatest number of movements over all tend to occur between May and June, but for dairy cows the peak time for moving is between April and June and for beef cows the peak time is between October and December (University of Melbourne et al., July 2021).

Below is another diagram (*Figure 13*) that illustrates how central buying and selling cows is to farming and why the eradicators were so keen to protect it. Some of the key movements of dairy cows onto beef farms are illustrated, along with movements of beef calves back into dairy farming. The flows are vaster one way, from dairy to beef, but within beef farming itself the movements from farm to farm are greater than within dairy farming.[60] In trying to oust M. bovis, the eradicators were protecting both farming types: beef farmers because they cannot operate without dairy farmers, given their need for replacement calves; and dairy farmers because they need beef farmers to take the excess calves, so that reciprocity is essential.[61]

[60] This information has been drawn from interviews with human actors, industry documentation such as from B+LNZ and from Statistics New Zealand.

[61] It has been said that dairy farming essentially enables beef farming in Aotearoa. There are only about 800,000 or 900,000 'straight beef' cows, and they cannot produce the number of replacements required to keep the industry going. Therefore, the dairy herds produce the remainder of beef cows. This cooperation between the two farming networks makes sense when it is considered that beef farming requires around 8,250 new bulls annually to keep up with demand (B+LNZ, September 2017). Most farming decision-making is primarily driven by finances. For example, some beef farmers (especially those starting out) typically buy cull cows (those nearing the end of their productive lives) for their herds because they are cheaper than calves. Those cows that are pregnant (and 50% of all cull cows will be pregnant (B+LNZ, September 2017)) will put on weight with good pasture and care and will then calve in the spring. These cows will also generally 'foster' one or two other calves that need milk. This cooperative approach is a cost-effective way for beef farmers to build up their herds, and to use artificial insemination to have more dairy breed calves that those farmers can then sell back into the dairy industry, making the animal movements a two-way system (B+LNZ, September 2017; Technical Advisory Group [TAG], July 2021).

Figure 13
Illustration of cow movements typical to the farming actor network



Eradicators like Aragorn were surprised to learn that 35 percent of all beef calves each year begin their lives on dairy farms, and that dairy-beef calves comprise 19 percent of all adult cows slaughtered for meat (see B+LNZ, September 2017). Dairy cows are also cheaper for beef farmers to purchase than beef cows and readily available. When cull dairy cows and calves are included in the figures, the estimate of dairy cows being slaughtered for beef rises to 38 percent of the annual total (B+LNZ, September 2017).[62] Moreover, of the 900,000 cows slaughtered each year for processed beef (e.g., mince and meat-patties), a surprising 750,000 of these are dairy cows (B+LNZ, September 2017). If cows could not move as fluidly as they currently do, the farming assemblage would have to be deterritorialised and a different set of relations would need to be reassembled in its place. That new assemblage may not be as profitable, however, particularly given the cost of exporting primary products from Aotearoa into global markets.

[62] The number of cull cows being sent for slaughter each year depends on the availability of replacement cows for those dairy farmers, and especially for sharemilkers who are contractually required to have a certain number of cows in their milking herds (B+LNZ, September 2017).

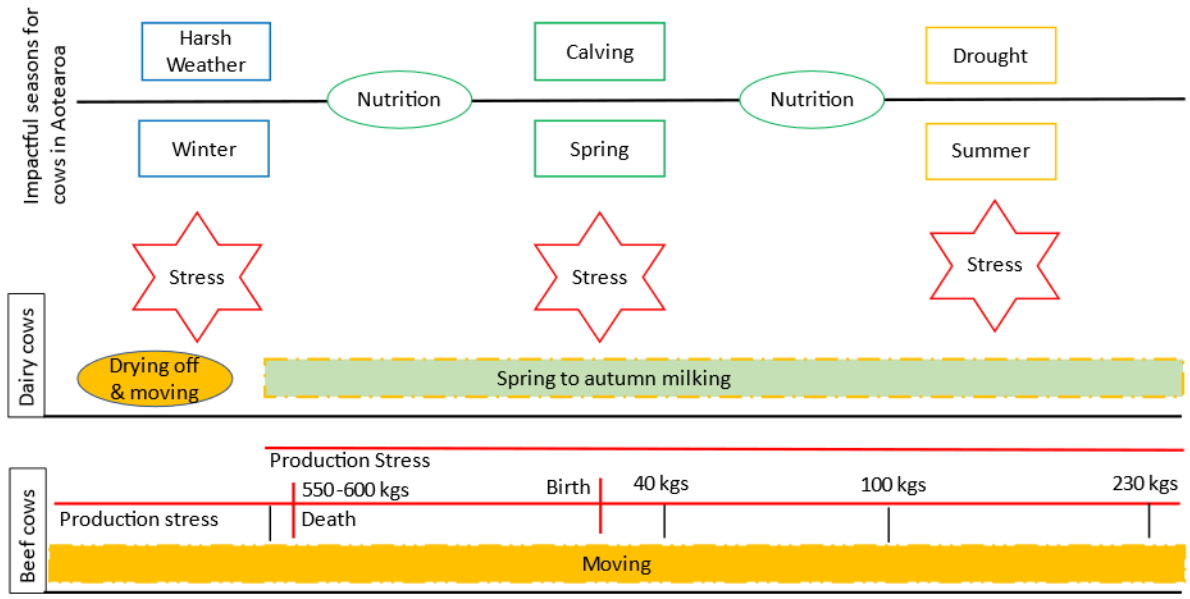
The risk for bacterial transfer does not only lie in the movements of live cows and their calves, but in the milk they make.[63] Each year, about 450,000 four-day old bull calves are reared by calf-rearers using waste-milk from dairy farms (or artificial formulas, but waste-milk is cheaper). These bull calves come almost exclusively from dairy farms (B+LNZ, September 2017). Moving waste-milk off milking platforms for calf-rearers provides a direct transmission pathway for M. bovis and other microbes. Boromir (Industry) rated the biosecurity risk of calf rearing as "significant" because calves are highly susceptible to infections, and because they are picked up from a variety of dairy farms, put together and then provided milk that humans will not drink, again from a variety of dairy farms. That makes for a rough start, irrespective of the direct microbial transfer risks. The remainder of the dairy calves that are made by pastural farming are unwanted, however, so they are slaughtered as 'bobby calves' in their first week of life (Boulton et al., 2018). Tragically, bobby calves are an "inevitable by-product of the New Zealand dairy industry as it currently operates" (Boulton et al., 2018, p. 57). These calves are rendered invisible within the dairy supply chain, and it appears that the eradicators (and farmers) have no appetite to disrupt the practice.

As mentioned above, there is a seasonality to cow and calf movements.[64] *Figure 14* below highlights the key movement periods for dairy and beef cows, respectively. Dairy cows move predominantly during the winter months, whereas beef cows and calves move throughout their lives, the trigger for their movements being primarily how much they weigh.

[63] Even the annual employment of 200,000 service bulls (to inseminate cows) presents an opportunity for M. bovis to move, yet as Arwen (Government) observed, "we give very little thought to [bringing in bulls] from a biosecurity perspective". The use of service bulls is a very risky practice for M. bovis transmission because even when the bulls are tested the tests lack the necessary level of sensitivity to M. bovis for a hundred percent certainty (TAG, April 2018).

[64] That said, recent research indicates that the number of cow movements does vary from year to year because of the "dynamic nature of cattle movement patterns in New Zealand" (University of Melbourne et al., July 2021, p. 7).

Figure 14
Seasonal stressors for pasture-based cows



For dairy cows, winter is stressful because this is when they stop milking and leave their dairy farms for grazing, as well as the pressures of inclement weather. Spring is when most dairy cows will calve, which is another pressure on a body that is already stretched by production. Summer can bring droughts, lack of feed and scorching temperatures in which to walk to the milking sheds. For beef cows, the stressful times relate to calving and moving between farms, sometimes travelling very long distances in cramped conditions.[65]

There is another important seasonal practice, too, which is the existence of share-milking herds (see Buchanan, 2002). One of the arguments made in favour of eradication was that to allow M. bovis to become endemic would effectively undermine the viability of sharemilking, which is viewed as an integral and egalitarian part of Aotearoa's dairy farming assemblage (Buchanan, 2002).[66] Sharemilking is a practice that is 'unique' to this country (Buchanan,

[65] There is a Code of Welfare (Transport within New Zealand) (October 2018) that sets out the animal welfare requirements that must be met when transporting animals. This can be found at https://www.mpi.govt.nz/dmsdocument/46015-Code-of-Welfare-Transport-within-New-Zealand.
[66] The practice of shifting houses and taking cows and machinery to a new farm every few years (usually in winter, and 1 June is traditionally moving day for sharemilkers) is well-established in the dairy industry (Buchanan, 2002). The primary purpose of sharemilking is to allow new farmers to grow their herds and wealth slowly, so that they can one day purchase a farm of their own (MPI, n.d.c.). Dairy farming is said to benefit from sharemilking because new and often young farmers bring new ideas and innovations into the industry, thereby continually raising standards across the industry (Buchanan, 2002). Sharemilking grew out of necessity

2002) and it has even been described as the "foundation stone of the New Zealand dairy sector" (MPI, n.d.b, p. 5). Arguably, it is sharemilkers who carry the biggest biosecurity, animal welfare and economic risks in this arrangement because their stock-in-trade and only real asset is a biological product.[67] There is a high financial reward for sharemilkers, however, which entices farmers into these practices, despite the biosecurity risks involved (Buchanan, 2002).

Overlaid on all these movements and seasonal requirements are regional farming differences.[68] In Waitaha (where M. bovis was first discovered) most dairy farmers will winter stock off the farm and buy in heifers, making their system more of an open movement one. In addition, the eradicators found "a hell of a lot of inter-trading and a lot of stock movements going through that particular part of the world" (Treebeard, Government). Gandalf (Government) is "a born and bred dairy farmer" in Te Ika a Māui, but when they went to Te Waipounamu as part of the M. bovis biosecurity response, they found a completely foreign dairy farming network:

> [T]heir corporate model is 'cows to grass', that's all they cared about was cows to grass. Cows eat grass and they produce milk, [so] they just moved stock willy-nilly to where the grass was…It's all to do with money, and so people would say 'oh I've got too many stock, I can't milk them all', so you go and milk them in a neighbour's shed and he can take a cut. There were incredible movements of stock around on paddocks where herds mixed and got separated later on, which in a disease-free environment is actually okay. It's not a good practice, but in a disease-free environment nobody knows, nobody gets hurt.

Elrond (Government) provided an extreme and cautionary tale about cow movements involving a large Te Waipounamu dairy farm. One particular farmer wintered off their cows from different but connected properties. When the cows came back for spring calving and milking, the farmer put all the cows that were due to calve first together, regardless of which farm property they were originally from. Elrond explained that financially this is a sensible approach because then there is just one milking shed running instead of three or four at once. For biosecurity, however, splitting and mixing mobs is a high-risk activity. In that case, some of those cows tested positive for M. bovis, but because the cows from each property were not kept

because of the speed with which Aotearoa's dairy farming assemblage grew and it required that type of succession planning (Saruman, Government).

[67] Buchanan (2002) repeats the oft-quoted farming adage, 'Where you have livestock, you have dead stock'.

[68] And levels of interconnectedness. Some regions, such as Manawatū and Waikato, are central network nodes for cow movements (University of Melbourne et al., July 2021).

separate, all 8,000 cows were sent to slaughter in the depopulation process. For Peregrin (Researcher), who worked for the eradicators, M. bovis has served to highlight these vulnerabilities:

> I have been in New Zealand for 16 years and [the number of cow movements] has been mentioned many, many, many times…So, I think that we need to have a really good think about this when we are no longer in response mode, and more in planning mode.

Even though the eradicators have collectively acted to support the retention of this highly mobile biological assemblage, they were disturbed by the low level of biosecurity awareness that existed within farming. In addition, the absence of biosecurity practices added complexities to their task of tracing M. bovis in many important ways.

The next part describes the state of on-farm biosecurity that the eradicators encountered (particularly during the response and governance phases) and it highlights the influence that this material absence has had on their ability to eradicate M. bovis.

5.2.3 On-farm biosecurity

Biosecurity is one of those areas where there were strong differences of opinion between the human actors. The conversations were not so focussed on what biosecurity entails, but who was responsible for doing it. The eradicators' experience was that farmers thought biosecurity was something that MPI carried out at the border, and that if MPI did its job then farmers could get on with their job of farming (Gandalf, Government; Treebeard, Government). A research programme commissioned by the eradicators in 2020 revealed that biosecurity was not a priority for farmers, and they did not understand its relevance to their business (MPI et al., June 2020). The researchers consequently recommended that work be carried out to "improve biosecurity resilience" and "improve voluntary on-farm biosecurity practices" (MPI et al., June 2020, p. 5).

Saruman (Government) told me that farmers "just want to farm…[t]hey don't see [biosecurity] as furthering their business or protecting their enterprise, it's just money in, money out." Gandalf (Government) explained further:

> Before this happened, I could have gone and talked about biosecurity and they all would have said, that's what you do at the airport…They'd say disease management, yes that's

> me as a farmer because I don't want to get disease in my cows, but biosecurity is nothing to do with a farmer.

For Treebeard (Government), there has been a complete disconnect between the biological economy of farming and the practice of biosecurity:

> If you ask everybody, as far as the New Zealand economy is concerned, which sector has the most to lose as far as biosecurity's concerned, and they say farming. And then I ask, how many of you guys have got biosecurity plans in place for your farm, and it's just dead silence. Every single time a coconut.

Treebeard talked about the "sense of entitlement" they encountered among farmers during the response phase. They said that farmers "put themselves up on a pedestal" because farming roles are important to the economy, and while farmers may not "enjoy the cavalry turning up, the cavalry does turn up", but by then there is no incentive for behavioural change.

Elrond (Government) also told me that there was "no biosecurity plan on 99.9 percent of farms." "It's not because they're ignorant", they explained about farmers, "it's just because there's nothing necessary in New Zealand." This is a surprising framing of the value of biosecurity from a government official, though they are also a farmer, which is where the eradicators multiple can manifest in the programme. Loyalties can waiver with these dual citizens.

B+LNZ (September 2017) also take the position that there are very few diseases impacting on beef cows in Aotearoa, whether they be in feedlots or on pastures, providing the animals are well fed and cared for. Yet, for this industry body, the main disruptive or stressful events that can trigger diseases are routine activities such as castration, transportation, calving and dehorning of cows (B+LNZ, September 2017). Other industry representatives have enacted their own poor biosecurity examples, too, and in so doing have effectively betrayed the eradicator collective. For example, Elrohir (Industry) thought it was acceptable practice to sell calves to "mates" and "life stylers" without recording the transactions:

> At the end of the day, if you're selling to a mate, you probably know where they've gone. Are you likely to record them? Sometimes. I sell calves to my neighbouring lifestyle blocks…my sister's got 10 calves, another friend wants 12 calves, you know. We all do it.

Arwen (Government) has had experience with farming in the UK where they said biosecurity was a lot more "second nature" than in Aotearoa, and that this was brought about primarily because of the FMD outbreak in 2001. Aragorn had "assumed that there'd be a much higher level of awareness and better practices than there [are]." That said, "[n]o-one really wanted Mycoplasma bovis" (Galadriel, Researcher). Galadriel thought that farmers have "just gotten sloppy" with their animal health practices, and that M. bovis is "the first time they'd been hit with a disease that is blamed on themselves". Overall, the eradicators found there was a lot of room for biosecurity improvement and innovation - from farmers to traders to cow movers, and for Frodo (Government) these are the people who should be driving the change: "[i]t is not necessarily the place of the regulator to do that."

One of those biosecurity practices with which the eradicators thought farmers have been sloppy is the NAIT system, which exists to hold accurate movement data about all cows in Aotearoa. The eradicators' research showed that farmers found the NAIT system difficult and time consuming to engage with, and that "[e]ven a whiff of any hassle factors will turn farmers off complying" (Colmar Brunton, September 2021, p 2). In the Early Days of the biosecurity response, the level of compliance with the NAIT system sat at around 30 percent, so 70 percent of cow movements that were eligible to be recorded were made invisible within the network (Frodo, Government). According to Legolas (Government), the main reason that farmers do not comply with the NAIT system, apart from the interface being clunky and the data entry being time consuming, is that they do not see any benefit from it. Farmers need to know "what's in it for me" (Legolas).

Sometimes farmers did not bother with NAIT because the cows are "only going for a week for grazing" (Gandalf, Government). Even Fed Farmers National Vice-President Andrew Hoggard admitted that his NAIT transactions were not up to date. He said, "there's just so much crap comes through the mailbox you don't pay attention to it all as much as [you should]…I'm certainly re-registered now" (RNZ, 2020).

Shagrat (Industry) thought that farmers had been "living in this naïve state where we think we're ten-foot-tall and bullet proof, rather than ensuring that we are protecting our own backyard." They were surprised at the number of times that some farmers were acquiring M. bovis, "getting bovis a second, third, fourth time." Shagrat's opinion was that overall farmers did not value traceability, preferring to place their trust in stock agents or whomever they are

purchasing their cows from (see also Farmers Weekly, 2021). The next part of the eradicators' translation journey describes the struggles that they have had trying to follow M. bovis while working with inaccurate and missing movement data.

5.2.4 Following cows

The NAIT system was established in 2012, by the NAIT Act, to provide the technology to trace farmed cow and deer movements.[69] One of the main reasons for setting up this technological actor was to manage another type of M. bovis, that of *Myco*bacterium *bovis*. This other type of M. bovis causes bTB, which is managed by routine testing and slaughtering infected cows. *Mycobacterium bovis* is endemic in certain regions of Aotearoa, though these bacteria are the subject of their own long-term eradication programme.[70]

Underpinning the NAIT system was the idea that farmed cows and deer would achieve 'lifetime traceability' from the movement data attached to their radio-frequency identification (RFID) tags, and that this lifetime traceability would enable farming industry bodies and MPI to trace and control bTB.[71] The NAIT system has evolved to be an important part of Aotearoa's biosecurity network, because traceability is integral to managing or eradicating other bacteria and viruses, too (OSPRI, March 2018).[72]

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[69] The NAIT system is managed by NAIT Limited, a subsidiary company of OSPRI New Zealand Limited, which is a not-for-profit company. TBfree NZ Limited is another subsidiary company of OSPRI NZ Limited, which has four shareholding organisations from across industry and government (DairyNZ, B+LNZ, Deer Industry NZ and MPI). A significant focus of the drive to eradicate bTB from Aotearoa is the culling of possums (B+LNZ, September 2017).

[70] In 2017, B+LNZ identified bTB as being the biggest biological threat to Aotearoa's beef export market. In the same publication, B+LNZ claimed that the NAIT system "greatly enhance[d] our biosecurity integrity and therefore the confidence of our international customers" (B+LNZ, September 2017, p 3).

[71] TBfree NZ Limited is the statutorily appointed agency to implement the National Bovine Tuberculosis Pest Management Plan. The long-term goal of TBfree NZ limited is to eradicate bovine TB from New Zealand. Entering calves into the NAIT system is a two-part process. Farmers must first tag every calf with a NAIT tag within 180 days of birth or before the calf leaves the farm, whichever is sooner (bobby calves going straight to slaughter are exempt). Then, farmers must register those calves in the NAIT system within seven days of tagging or before they leave the farm, whichever is sooner. Registering the tag activates it, so that those cows can be traced when movements on and off a farm are recorded, which must be done within 48 hours of the event and this requirement remains for the life of each cow.

[72] OSPRI NZ Limited undertook a review of the NAIT system in 2018. One of the more aspirational findings was that NAIT could be better utilised as a promotional tool for primary product exports – a table to plate assurance with respect to animal health and food safety (namely for beef, lamb and venison) (OSPRI, March 2018). However, the NAIT system has a significant problem in that while the database *allows* farmers to capture the movements of sheep, for example, this is not a requirement. The current absence of real time information about cows and deer, irrespective of sheep movements, remains a significant risk for the farming assemblage.

The eradicators relied on the NAIT system because it should have provided a complete picture of cow movements. However, M. bovis has "highlighted flaws in the NAIT scheme" (New Zealand Government, July 2019), and former Prime Minister, Jacinda Ardern, has admitted that NAIT was "shamefully underfunded" (The Spinoff, 2018). There were other farming databases to choose from, but each of these holds incomplete data and these technologies do not "talk' to one another easily.[73] While there is some general alignment across these databases, there are important gaps in species type and network coverage, which raises questions about the accuracy of the information present in each database (Jewell et al., 2016). These technological actors impacted on the eradicators' ability to obtain an accurate picture of cow numbers and movements throughout Aotearoa, slowing them down in their quest.

For example, the NAIT system interacts with other farming databases such as MINDA and FarmIQ (see footnote below), but the information in those systems only goes one way, and that is into the NAIT system. There is no automatic feedback loop that pushes the NAIT information back into the other databases, and this is one way that significant data mismatches can occur. Each system in effect creates a different ontology of cow movements and geographical positions. Legolas (Government) explained the inaccuracies that can happen when movements are recorded by farmers using a system other than NAIT:

> The way it was sold to farmers was that you can do it all in one, you can do it all in FarmIQ, you can do it all in CRV Ambreed solutions, but M. bovis really showed up that that wasn't actually working. We discovered that we had a massive issue. For example, a MINDA user might need to record some test results or record some treatments against an animal, but the animal is sitting over with a grazier. Now in MINDA, to actually update those records they need to bring the animal back to their 'home location' [in the system] so they can do it. So, they bring the animal back to their home location, and they record the treatments and then they send it back out to the

[73] One of the systems is called AgriBase, which was developed in 1993 to hold farm locations and types (using unique identifiers) for the purpose of preparing for foot and mouth disease (FMD). AgriBase is maintained by AsureQuality Limited. Another system is called FarmsOnLine (FOL), which is maintained by MPI. FOL is a voluntary system, but it has the capacity to hold information about farms, meat processors and sale yards, including boundaries and contact details. For a discussion about how these systems interact, see Jewell et al., 2016. There is a further system, too, which is called FarmIQ, but that is a farm management system that is focussed on beef rather than dairy farming. FarmIQ allows farmers to map their paddocks, record movements between them, measure grass growth and monitor fertiliser application (Legolas, Government). Then there are two dairy farming systems. One is called MINDA, which is another farm management system, but it is linked to productivity. MINDA is administered by LIC. The other is called MyHerd, which is a similar type of system, but it is administered by CRV Ambreed (LIC's competitor) (Legolas, Government). Each of these systems holds information about cows, and potentially important biosecurity information, but they operate separately from each other.

> grazier. All on their MINDA system, because they need to bring that animal back from 'grazing' to the 'home location' and then back again. What they don't realise is that in the NAIT system, it's a movement…So then we've got a false movement within the system.

Those false movements become exponential, resulting in more and more 'false' movements in the NAIT system. This issue had a significant impact on the ability of the eradicators to trace cows from farms with M. bovis, and much time was wasted following false leads (Legolas). To complicate matters further, some large farms (especially corporate farms) have several different NAIT locations registered, so movements of cows within farms using FarmIQ or MINDA will show up as actual movements off farm in the NAIT system (Legolas).

Another example is provided by Gandalf (Government), who talked about what happens when "ghost cows" (a term used by Legolas) are not recorded, so that the NAIT system thinks the cows are still on their home farm:

> You go to some of the big farms in the South Island, and a year later we've still got discrepancies – some said we've got 60 cows missing. That's when I'd say to the farmers, that's impossible, and they'd say no it's not. Sixty cows and they have no idea where they went. These aren't calves, these are heifers. They'd say we know they were born and they never went to the works – where did they go? That's the problem (Gandalf).

Compounding the lack of traceability for cows on some Te Waipounamu farms was a local practice of moving cows at night during the eradication programme to avoid anyone seeing where they were going (Gandalf). The eradicators not only failed to enrol this group of farmers, but these farmers threatened to undermine the eradication programme through their actions. The key problem for the eradicators was simply "too many cows moving around that nobody knows [about]" (Stuff, 2018d).

The NAIT system has been an influential obstacle problem for the eradicators, both because of its lack of flexibility and poor interface with other systems and because of its passivity, relying on human actors to make meaning by entering the cow movements manually (The Spinoff, 2018). Prime Minister Ardern publicly denounced NAIT in May 2018, saying that it had "failed abysmally" (RNZ, 2018f); Elrohir (Industry) went further, describing the NAIT system as "a dog". They compared NAIT to the (superior in their view) Livestock Improvement Corporation's (LIC) database:

> So LIC has about 97 percent of the national herd of cows on their database for breeding worth, production worth and genetics. And that's the national standard. LIC offered that to MPI and they turned it down. Farmers buy and sell their cattle on their breeding worth, production worth or their genetics. And a lot of those cows have all been DNAed as well, so proof of mother and daughter and all those sort of things. So LIC offered that to MPI saying, hey this thing is way better than NAIT. And they said no. LIC even offered to send reports to them for free (Elrohir).[74]

Shifting loyalties among the eradicators showed in other ways too, particularly arising from the Early Days when few of the MPI officials meeting with farmers were experts in farming themselves. Again, Elrohir criticised MPI for using the NAIT system in the first place:

> Then they go out in public, the minister did, and slate farmers who aren't using NAIT. Well…why would you use the Lada when you can use the Rolls Royce…When I asked MPI staff why they didn't use the LIC offer they didn't know what it was. So, you had staff employed and they didn't know what the major recording system was for dairy cows. They were just out of their depth. If you're hired as an expert, at least be an expert in your subject.

As mentioned previously, one of the main weaknesses of the NAIT system is that the RFID tags are completely passive, without any automation built in for real-time uploading of information about cow movements (Legolas, Government). This reliance on human actors is problematic for obvious reasons. When farming is busy in the spring, for example, farmers' NAIT compliance is worse than usual (Legolas). Yet, spring is a time of physical stress for cows with calving, and it is a time when M. bovis can be active and the bacteria can be shedding (Arwen, Government). Spring is also a busy month for calf movements. Often farmers will tag cows out on the farm but will not record the tag in the NAIT system until a convenient time, such as back at the house in the evenings. In the meantime, those cows could have gone on the truck to the saleyards and been scanned there. The tag then activates, the farmer has technically committed an offence and the cow has lost its lifetime traceability; so "lifetime traceability is pretty crap to be honest" (Legolas). Gandalf (Government) thought that the biggest problem with NAIT was that farmers had to do something. If we take farmers out of the picture, they said, the NAIT system would work.

[74] However, there may have been some issues about commercial sensitivity in such an offer, making the use of the database problematic.

Yet, the eradicators continued to use the NAIT system as their means of 'truth' about cow movements, even though they discovered early on that its reliability was undermined by inaccurate and missing information (MPI et al., July 2021).[75] The eradicators' efforts to find M. bovis were severely thwarted by farmers' lack of engagement with NAIT, and they lost valuable time following up cow movements through having to rely on farmers' memories and/or their diary entries (MPI et al., July 2021). There were many farmers who did not have their grazing movements or sale and purchase details written down anywhere, making it almost impossible to trace cow movements quickly during the biosecurity response. While that information might have been in their heads, there was no real certainty about the details or exact timing (OMNI, May 2019). According to Saruman (Government), the younger farmers are more organised, but they said that the older farmers never saw the need to keep good written records.[76]

The "missing data" (Hasufel, Researcher) in the NAIT system has shaped the trajectory of the eradication programme, both spatially and temporally, just as much as the unreliable data present in the system. Even when NAIT compliance improved during the governance phase, the nature of the data collected when compliance was poor continued to pose "a critical risk" to the eradicators' success (MPI et al., July 2021). As Frodo (Government) said, if M. bovis had been FMD instead, which is a much faster moving virus, "we'd be buggered". Saruman (Government) predicted that "if NAIT was 90 percent compliant at the time we kicked off the M. bovis response, we could have traced everything within four months". Gandalf (Government) echoed Saruman's sentiment, but they predicted a six-month window for success.

During the governance phase, the eradicators commissioned researchers to analyse the data obtained from stock trucks' global positioning systems (GPS) to compare actual cow movements with those recorded in the NAIT system. What they found was an extraordinary *20 times* more movements of cows between farms than those being recorded by farmers in the NAIT system (Onside, July 2021). This research shows there are sizable mobilities increasing

[75] The NAIT system has been revised because of the eradicators' experiences during the M. bovis programme (see OSPRI, March 2018). The changes include making compliance easier for farmers but also increasing penalties for non-compliance.

[76] This lack of record-keeping has consequences for farmers, too, when it comes to claiming compensation for their cows. As Hasufel (Researcher) said, "if your business has got a decent balance sheet you will be right, but if it doesn't you will be screwed".

the risk of microbial transmission that are invisible to the NAIT system. What troubled Hasufel (Researcher) was that even the cow movements that appeared in the NAIT system were skewing the network, because "the most compliant properties tend to show up as being the most connected", which is not necessarily the case.[77] These misrepresentations were additional obstacle problems for the eradicators.

The eradicators eventually declared the NAIT system to be unsuitable for use in a large-scale biosecurity response (MPI, n.d.c.). Since then, however, there have been "quite significant" improvements arising from NAIT's engagement with M. bovis (Aragorn, Government). Lessons learnt from the eradication programme sparked a review of how NAIT had been working, and the review resulted in a series of recommendations relating to ease of system use, improving the relevance and meaningfulness of the information held for biosecurity purposes and improving farmer engagement with the programme generally (OSPRI, March 2018; Colmar Brunton, September 2021).

Unfortunately for the eradicators, the NAIT system, extensive cow movements and lack of farmers' willingness to practice biosecurity were not their only hurdles. There were other highly influential moments of controversy to overcome, too. Earlier in this chapter, I introduced two temporal periods called the Early Days and the Surge (these periods were named by the eradicators themselves). The next section describes these moments of controversy and the impacts that they had on the eradicators' success.

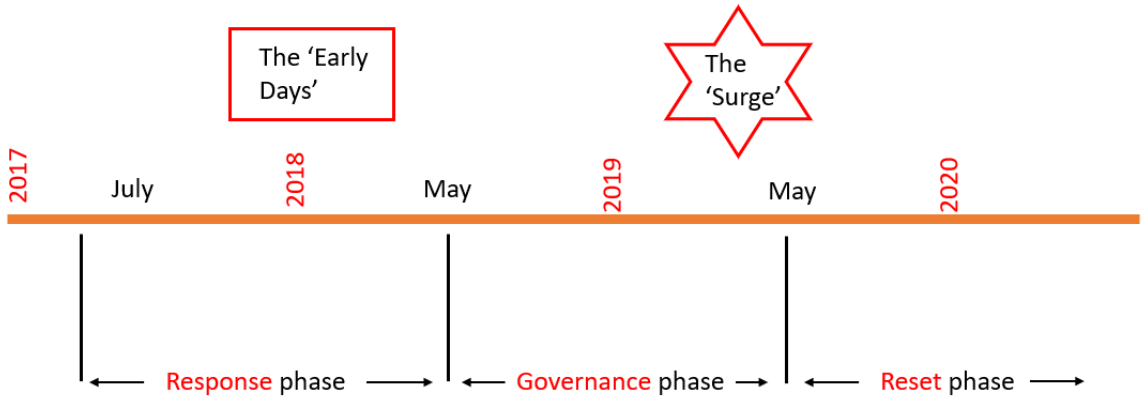
5.3 Key controversies in M. bovis

As seen from the forgoing description, the eradicators have endured many obstacles in pursuing their goals of eradicating M. bovis, stabilising farming and strengthening the biosecurity assemblage. However, there are two periods that have typified the "trials of strength" (Callon, 1986, p. 207) that the eradicators have endured in pursuance of their goals. The first is a period they called the Early Days, and the second is a period known as the Surge. Below is a simple

[77] Contrary to Hasufel's caution, the Melbourne University et al. (July 2021) report recommends that in future the eradicators should rely on those centralised nodes of movements and connections existing within NAIT, because these are the "high risk" locations (p. 7).

chart showing each of these phases and controversial periods, which, while similar to *Figure 10* in the preamble, also situates these two controversies.

Figure 15
The eradicators' temporalities of controversies



The Early Days occurred during the response phase, and they were precarious for the eradicators. MPI and industry bodies made many mistakes in following M. bovis during this period, and these missteps led to the real risk that they would fail to enrol key actors or fail to mobilise them once enrolled in the subsequent eradication programme. In contrast, the Surge represented a hidden world of M. bovis and cow movements that took the eradicators by surprise when they discovered the extent of its presence. This controversy happened once the government had decided to try and eradicate M. bovis, during the period known as the governance phase. The Surge was nearly the tipping point for programme failure, but instead the eradicators used this crisis to strengthen their goals, resulting in the reset phase of the programme.

5.3.1 The 'Early Days' of the biosecurity response

The Early Days were difficult for MPI, who were then managing the bacteria within a biosecurity response framework pending the government's decision on eradication. The increasing workload as the response became more complex was an unanticipated actor itself, severely impacting on MPI's ability to follow M. bovis (MPI, n.d.c.). MPI had "underestimated the scope and complexity of managing the M. bovis response" (MPI et al., July 2021, p. 18),

and the organisation's lack of preparedness for a large-scale agricultural biosecurity response was rivalled only by the farming industry's own:

> Too few staff were well trained or experienced and many processes and policies required to manage the response and its impacts on staff and farmers did not exist or were ineffective. Arrangements among industry partners to step up to the challenge presented by M. bovis were embryonic and under-resourced (MPI et al., July 2021, p. 9).

For farming industry bodies there was confusion about their role in the biosecurity response, as Boromir (Industry) explained:

> From an industry perspective, there were challenges along the way in terms of knowing where we fit into things as industry personnel. Because we weren't the lead agency, we were loaned in, it sometimes made it difficult to establish where we fit into the picture and have that full network connection across organisations, as well. Sometimes it was difficult to achieve things because you were essentially DairyNZ and not formally MPI. We had a few privacy, confidentiality and security issues at times. There were some challenges in the early days just working within the system that was.

One of the sayings that was prevalent amongst MPI staff during the Early Days was, "we are building the bridge as we walk across it" (Frodo, Government), or as Saruman (Government) put it, "we were building the plane as we were flying it". That lack of preparedness was catastrophic for farmer enrolment and mobilisation, and while the eradicators learnt and upskilled during the governance phase, "it's almost like it is branded in people's memories – the impact of those early days" (Saruman).

Treebeard (Government) has called MPI "the cavalry" that comes to the rescue with resources and funding when there is a biosecurity incursion. They said that this description is apt even though not entirely flattering. There is still "a general feeling out there that the cavalry is a bit of the Keystone Cops and to be honest…I'd have to agree with it" (Treebeard). Essentially, "MPI didn't know what they were doing" (Saruman, Government) and that damaged the perception of the eradicators and their subsequent programme, and that reputational harm proved very difficult to undo (Saruman; Rural News Group, 2021a).

Initially, MPI approached the biosecurity response as a science problem to be solved by tracing, containing and culling cows, and they underestimated the impacts on farmers of M. bovis and

of having the government deterritorialising their farming operations (Aragorn, Government). Shagrat (Industry) found that their role in those Early Days was that of a "sounding board" for farmers, who "were expressing frustration around the way they were being treated, the lack of empathy that was being displayed" by MPI. Elrond (Government) explained their experience of those Early Days in powerful terms:

> I've had four CE roles, worked with Boards of Governors, worked with farmers...I have never, ever worked in a situation that was that difficult, as in the last three years. So, because we were dealing at that life and death, financial survival versus bankruptcy point with many, many farmers… the programme as it stood was incredibly difficult on farmers. And I think it was exacerbated by many of the people who had a leadership role in the programme who did not understand that impact on farmers, and did not understand how we could perhaps modify some of our actions, or delay them slightly, so that the impact on the survival and long-term rehabilitation of that farm and that farmer was less impacted.

The gulf between what MPI considered important and what farmers thought was important resulted in a "lack of buy in" (Saruman, Government) from farmers. Boromir (Industry) reflected that "there wasn't much that had been done in terms of helping farmers understand what's in it for them". As Saruman explained, "[t]hey don't understand the why, so they don't necessarily want to participate or agree with the purpose. I think that was probably the biggest thing and to some extent probably still is".[78]

There were many incidences during the first 12 months that impacted on the ability of the eradicators to enrol farmers into, first the biosecurity response and, secondly the programme, yet farmer enrolment was crucial to their tracing success. Because of the limitations of scientific testing for M. bovis (see the scientists' chapter) and the time it initially took for MPI to confirm its presence in a herd (on average 20 days, during which time the farm would be under movement controls), combined with poor communication by MPI with affected farmers, there was "a huge amount of anger, there was a huge amount of uncertainty" amongst farmers (Elrond, Government). The decision to eradicate was not taken until May 2018, nearly a year after M. bovis was first discovered, and MPI had to continue culling cows to maintain its ability

[78] Saruman's understanding is consistent with the Read Report's findings (MPI et al., June 2020).

to eradicate. This initial period of uncertainty only contributed to farmers' frustrations and distrust of MPI (Gandalf, Government).

Elrond (Government) explained that "the timeframe for testing, the payment of what we call operational costs – they were those feed costs, transport of stock if that was needed, and so on" were significant factors influencing farmers' willingness to enrol in the biosecurity response. Elrond explained that because compensation was handled by a different part of MPI to the biosecurity response, there were "huge issues" when claims were being assessed and the staff dealing with the compensation claims "had no concept at all of farming". Frodo (Government) admitted freely that mistakes were made because "you are going in there to get a disease, you know, but because of the complexity of the farming system maybe we didn't appreciate just how complex it was in the beginning". The eradicators' overall lack of willingness to understand how farming works in Aotearoa and to ask farmers to help upskill them is something that Elrond said kept them awake at night.

There were some unexpected physical and psychological stresses for MPI staff, too, adding to the complexity of enrolling and mobilising farmers. For example, there were physical threats to deal with:

> I was cornered and had one guy threaten to kill me, and another ringing threatening to kill himself…There are people ringing you, that you'd never spoken to, swearing at you on a regular basis. Staff were regularly called cunts, farmers 'joking' they had a shotgun, and then bigger organisations [like] Fed Farmers etc, openly having a crack. Attacks got very personal for a lot of staff (Frodo, Government).

During those Early Days, MPI provided insufficient psychological and emotional support to its biosecurity staff, as well as the farmers with whom they were dealing (MPI et al., July 2021).

While Dairy NZ and B+LNZ were on board with the biosecurity response, Fonterra Cooperative Group Limited (Fonterra) (the country's largest dairy company) was notably absent, and as mentioned above the regionalised structure of Fed Farmers made them unreliable allies (Elrohir, Industry). Gandalf (Government) found the lack of cohesion and industry commitment to managing M. bovis the most difficult thing to deal with:

> In the early days, going out to some of these really angry farmers, it was just MPI. I went by myself. These guys had shotguns and said they felt like killing you, and I'm

> thinking, 'Why am I here by myself?' Why isn't their DairyNZ advocate and their Fonterra supply person here saying you've got to do this because it's a condition of supply…We didn't get enough commitment early from the right stakeholders. We got an immediate, 'Yeah it's all good', and at NZ$800m their eyes flashed [and] they went this is great, but we didn't get their undying public commitment where they backed us all the way and in fact every time any small thing went wrong, particularly DairyNZ would stab us in the back…The same with Feds at the lower level, below Katie.[79] They see that their job is to kick government; that's what they are, they're lobbyists to kick government and anytime they get a punch in, the farmers go, 'Good on ya mate'.

B+LNZ and DairyNZ are funded by farmer levies, so there was inherent conflict between working for farmers and working with MPI. If farmers do not see any value in the activities of industry bodies, then they will say so, and those organisations will be persuaded by the will of the farmers to focus on what the majority see value in (Saruman, Government). Saruman's experience showed them that there was a lack of collective willingness to change for the betterment of 'the national herd', and that included engaging in biosecurity practices. Even the Dairy Chair of Federated Farmers, Chris Lewis, publicly suggested that getting M. bovis is 'not something to be ashamed of. The farmers who've got it - they've done nothing wrong. They've probably got it by accident' (The Spinoff, 2018). While this sentiment is morally correct, because no farmers wanted to have M. bovis on their farm or to give it to their neighbours, the statement negates any personal responsibility for undertaking biosecurity practices to mitigate the risks of transferring M. bovis to their own or others' farms.

Perhaps surprisingly, a key challenge for MPI as the lead agency was that dealing with a large agricultural biosecurity response was a novel event. During the Early Days, MPI suffered from a variety of organisational shortcomings resulting in them struggling to "scale up, adapt to facts on the ground, and respond to the varying circumstances of individual farmers" (MPI et al., July 2021, p. 19). In addition, MPI was labouring under staffing shortages in crucial response roles, resulting in the "lack of a cohesive, well-trained emergency response force" (OMNI, May 2019, p. 4). There were apparent gaps in communication flows, silos between teams and confusing role separations, and these organisational challenges led to the second important moment of controversy for the eradicators, that of the Surge.

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[79] Katie Milne was the past president of the Waitaha branch of Fed Farmers.

5.3.2 The Surge

MPI's inadequate systems for monitoring progress, a lack of resources, no sharing of real time data and poor communication across the different groups which were effectively working in silos within the programme culminated in an event known infamously by the eradicators as 'the Surge' (Aragorn, Government; Treebeard, Government). The Surge describes the moment when a hidden backlog of nearly 1,500 farms was discovered waiting for M. bovis investigation and testing (MPI, n.d.c.; OMNI, May 2019). This backlog of trace farms had built up over a five-month period, between November 2018 and March 2019, and events finally uncovered it in April 2019.

The Surge was caused by more than one influential factor, but an example is that "people would be assigned particular farms and they'd have their own spreadsheet on their own particular computer, and nobody knew if they were actually keeping on top of their workload and things like that" (Treebeard, Government). Saruman (Government) described that time during the middle of 2019 as "quite chaotic", with organisational structure and experienced staff lacking. There was a high staff turnover during a period where the workload was ever increasing. The eradicators were "[p]utting staff into situations where they hadn't had an opportunity to actually be onboarded effectively and they were sort of just chucked in there to keep things floating" (Saruman).

The eradicators realised in this moment that they had no idea of the scale of M. bovis' territorialisation across Aotearoa, and this backlog of cases represented the requirement for a large number of additional resources and a dangerous loss of time in tracking down the bacteria and following its movements. The Surge threatened to jeopardise the whole programme, but this period ultimately marked the point at which the eradicators really came into their own and started turning the tables on M. bovis. The Surge has been described as "a real turning point for the M bovis programme" (Aragorn, Government), both for gaining more of an understanding about the extent of M. bovis' world-making and for the lessons learnt about how to become better, more streamlined eradicators. As Aragorn said:

> In terms of our disease control and epidemiology expertise, we've learnt a lot out of that and are so much better placed for the next animal disease as a result of that. Both the capability we've established as well as just the ways of doing things…There's the *Tiaki* system that we've developed to manage workflow and cases so that was all trying

> to manage things by spreadsheets before, and that's a tool that can and will be enhanced and developed further for the future to serve more broadly biosecurity responses.

The Surge was another extremely troubling period for the farmers involved. For beef traders under suspicion of hosting M. bovis, the Surge represented a severe downturn in their businesses. Treebeard (Government) explained that during the Surge some farmers could not trade through it because many more farmers were asking questions about the origins and testing of the cows and calves being sold. They said that the industry was not used to that level of questioning and that "[f]or a lot of agents, that [scrutiny] completely wrecked their business". Treebeard themselves "got caught up" in the Surge as a farmer. They wanted to make sure their calves were in good health before the long journey, so they developed a practice of holding calves on the farm, collected from a variety of other farms (including the sale yards), and feeding the calves up before putting them on the trucks to make up a full load. That practice was what brought the eradicators to their farm and got them involved in the middle of the Surge. Once news of the Surge became public, the demand for calves from Te Waipounamu immediately dropped away, making holding and feeding those unwanted calves through the winter incredibly difficult and costly for traders and calf-rearers alike.

For the eradicators, the backlog of 1,500 farms was a moving target, a dynamic grouping of farms that represented "an exponentially increasing workload" (MPI, n.d.c., p. 15). The eradicators had previously received advice from their epidemiologists that the maximum period for forward-tracing movements from infected farms to new farms should be one month for high-risk movements (from dairy farms) and four months for lower risk movements (from beef farms) if they were to have any hope of controlling the bacteria (MPI, n.d.c.). During 2019, the eradicators were taking approximately 10 months on average to forward-trace farms from a known infected farm (i.e., to follow up all of the cow movements from each M. bovis farm) (MPI, n.d.c.). Not only was the delay disastrous for reaching their goal, but it meant that farmers were living with biosecurity restrictions for a longer period than necessary, which further undermined farmer enrolment in the programme and provided other actors the opportunity of *interessing* farmers, not to mention extending opportunities for M. bovis to expand its network.

At this point, the eradicators were yet to pass through their OPP and achieve their main goal, which was clearly expressed in the *M. bovis National Plan* as being to "[e]radicate *Mycoplasma*

bovis from New Zealand" (MPI, 2019, p. 4).[80] For the eradicators, there were two requirements that had to be met to achieve their goal. The first requirement that the eradicators thought they needed was the enrolment of farmers in biosecurity and tracing practices. Without these actors, the eradicators could not succeed in Othering the bacteria. (As it turned out they could enrol only some farmers in good biosecurity practices, and some may only have been enrolled for a period, but that the mobilisation of all farmers was not essential.) The second requirement for the eradicators to meet their goal was carrying out their phased programme of containing M. bovis positive herds on farms, following cows to and from those farms and systematically culling infected herds. The eradicators had privileged the option of removing M. bovis, so if the culling programme succeeded, they would also succeed.

This next section describes the eradicators' successes and failures as they acted in pursuance of their main goal. The section is presented in three parts: the first introduces the scientists and their importance to the eradicators' goal; the second asks the question whether the eradicators succeeded in enrolling farmers; and the third considers the question of whether farmers will practice biosecurity from now on (and whether that matters).

5.4 Obligatory passage point

When the eradicators made the decision to try and eradicate M. bovis, as opposed to living with and managing it, the bacteria had been made visible in Aotearoa for nearly a year. Even then, there were still many unknown elements to M. bovis' world-making, not in the least the question of how M. bovis came to Aotearoa, which Gandalf (Government) thought was fundamental to answer before trying to eradicate the bacteria (though most of the eradicators had realised that they may never know the answer). Some of the other unknowns in May 2018 were the *actual* number of cow movements from infected dairy farms, the actual number of infected farms themselves and just how reliable the scientists' testing was going to be (MPI, 2019).[81] As noted above, the programme was heavily driven by and reliant on science, so the eradicators needed to enrol those scientists as a first step. The government invested NZ$30 million over two years to support scientific research that in turn supported the eradication

[80] In addition, the National Plan has two other goals: to reduce the impact of M. bovis and the programme on the human actors affected by M. bovis; and to improve Aotearoa's biosecurity assemblage through lessons learnt from the eradication programme.
[81] When the programme began there were three times more infected farms than the eradicators initially thought (Office of the Minister for Biosecurity, July 2020).

programme (MPI, n.d.d.). The SSAG was established expressly to prioritise scientific research for the purpose of aiding eradication.[82] Along with the TAG, the SSAG became a key actor speaking for M. bovis and to the economic, cow health and farming benefits of eradicating M. bovis (MPI et al., July 2021; MPI, July 2018). The initial and most important question asked of the scientists was whether it was feasible to eradicate the bacteria.

5.4.1 Enter the scientists

For the eradicators, scientists such as veterinarians, epidemiologists and researchers were key to their OPP because scientists spoke for cows, and those technical understandings had to be passed through by everyone else to allow the eradicators to Other the bacteria. This next part is set out in two sections. The first describes the various inscription devices employed by the scientists and the second considers their substantive recommendations for ongoing network surveillance.

5.4.1.1 Inscription devices and immutable mobiles

The TAG wrote several reports for the Governance Group between 2017 and 2021, and in each report the feasibility of eradicating M. bovis was re-evaluated (see *Figure 7* in the methodology chapter). The initial report strongly advised eradication, stating that "[a] decision not to eradicate, and to allow the disease to become endemic, would be likely to lead to substantial on-farm costs, and increased antimicrobial use" (TAG, December 2017, p. 4). At the time of that report, there were 13 known farms with M. bovis in the country, as opposed to the first and only IP found in July of that year (Stuff, 2017). One of the stated reasons for the TAG's recommendation was that extensive movements of cows is a factor linked with the spread of M. bovis and the manifestation of associated diseases in other countries (TAG, December 2017). As to the likelihood of success, the TAG advised that this was "most favourable if [the programme] proceeds rapidly" (TAG, December 2017, p. 4). As will become apparent, however, the TAG had underestimated the extent of M. bovis' world-making abilities (MPI et al., July 2021).

In February 2018, when the number of M. bovis infected farms was thought to be 23 (ODT, 2018), the TAG still considered that eradication was feasible and the most desirable approach,

[82] The SSAG developed the M. bovis Science Plan.

but they acknowledged that there were more infected properties than initially thought, making eradication a bigger task. At that time, there was a minority within the TAG who thought that eradication was less certain given that the tracing had to be scaled up and because of the lack of data inputted into the NAIT system about cow movements (TAG, February 2018). The TAG also recommended at that time that a productivity study be undertaken on the impacts of M. bovis diseases, such as mastitis and lameness, in Aotearoa's farming assemblage (as opposed to solely relying on overseas data) (TAG, February 2018) (this was the Hamill research).

The TAG considered it important to observe that this was the first time that a government has ever funded an eradication attempt for an animal disease that is not on the WOAH's list of diseases of concern, and where there are no trade or human health impacts from its presence (TAG, February 2018). The TAG believed that due to the number of unrecorded cow movements and the slowness with which M. bovis manifests itself in clinical signs, new infected farms would continue to be found for several years, making eradication success contingent on continued surveillance and movement controls (TAG, April 2018).

By the time the May 2018 TAG Report was written, there were 37 known infected farms (NZ Herald, 2018) and controversy was starting to arise about whether eradication remained feasible. Just one month prior, the TAG considered that eradication was feasible. Now, there was a 4:6 split; four members thought that eradication was no longer feasible or economically justifiable because of the increase in new suspect and infected farms (and that was a year *before* the Surge). Those in favour expressed "significant caveats" (TAG, May 2018, p. 1) regarding the rate of new infections, the number of unrecorded cow movements, the impacts of eradication on farmers, and the perception that industry support for the approach was waning. One of the criticisms was that there was "limited surveillance outside of the trace forward process" being carried out by the eradicators (TAG, May 2018, p. 4). The TAG recommended that the eradicators undertake a "rigorous cost/benefit analysis" before committing to an eradication approach (TAG, May 2018, p. 5). The government decided to pursue a phased eradication in that same month.

By October 2019, with 23 infected farms awaiting depopulation (MBP, November 2019) the TAG again concluded that eradication was still feasible providing that the number of farms with M. bovis that were yet to be detected remained low, that M. bovis had not established itself on beef farms (which it subsequently did) and if the interval between M. bovis

transmitting between farms and the eradicators implementing movement controls on those farms got shorter. The TAG appeared to have lost faith in the eradicators' abilities by then, because there was an extra warning in their report that success would require "adequate resourcing, appropriate metrics, effective programme management and ongoing support of stakeholders" (TAG, October 2019, p. 4).

In their final report of July 2021, when there were at that time only five farms left to be depopulated (MBP, July 2021), the TAG addressed the question about how the eradicators would know when they had succeeded. The TAG advised that it is impossible to prove freedom from the bacteria, but what the eradicators could do is provide enough evidence to reassure themselves that M. bovis was no longer present. Proof of absence requires ongoing surveillance and "[t]ime is a key ally here as the longer you go without seeing any cases the more confidence you can have" (TAG, July 2021, p. 38).

As of May 2022, there was only one farm with M. bovis remaining to be depopulated, and this was a large beef feedlot.[83] In July 2022, the number increased to two farms. While it looked like success was ensured, the eradicators suffered an unexpected setback in October 2022, along with an increase in infected farms. A new strain of M. bovis was found on a Waitaha farm, and the number of infected farms rose to five (MBP, October 2022, November 2022). At the time of writing, the eradicators have been unable to identify how this new strain got into the country (reminiscent of Gandalf's reservations), but they do know that it is unrelated to the original M. bovis strain found on the Tainui farm in July 2017. By November 2022, there were six farms in the Waitaha region with M. bovis (out of a total of 279 confirmed M. bovis infected farms) (MBP, December 2022). In April 2023, the eradicators thought they had depopulated the last remaining farm with M. bovis (the large beef feedlot). Yet, by the end of May, the eradicators had discovered a new M. bovis-affected farm, also in Waitaha (MBP, May 2023). The TAG advised the eradicators that their battle for translation would be ongoing, so the eradicators devised two ongoing surveillance streams to find M. bovis. These are in the form of bulk tank milk testing and the National Beef Cattle Surveillance (NBCS) programme.[84]

[83] The Five Star Beef feedlot is Aotearoa's largest commercial feedlot. The reason for depopulating the feedlot last was because of the risk of reinfection (cows came into the feedlot from many other farms).
[84] Routine bulk tank milk testing for M. bovis began in January 2018. Bulk tank milk cultures are the most effective and convenient way to test for M. bovis (Nicholas et al., 2016). The NBCS programme began running in early 2020, during the reset phase, because the initial focus of the biosecurity response and subsequent eradication programme had been on dairy cows.

In addition to feasibility challenges involving the ability to identify and follow M. bovis, the eradicators have faced opposition from many farmers towards their eradication and biosecurity goals. One of the questions that had to be answered early on was whether the eradicators could enrol farmers into the programme, because they thought that without farmer support, they would fail to achieve eradication. This next section briefly highlights some of the eradicators' challenges with enrolling and mobilising farmers.

5.4.2 Can we enrol farmers?

For reasons outlined above, there was a lot of mistrust of the eradicators among farmers and those associated with farming. There were times when even the industry bodies "lost faith" in the process (Elrohir, Industry), and there was precarious industry support for eradication to begin with. As Elrohir explained, "[i]t's hard because even I was sitting on the fence. A lot of us were sitting on the fence on this. That'd be the honest truth amongst a lot of us".

There are some actions that MPI eradicators allegedly took, however, that caused an irreparable divide amongst the eradicators' ranks and further drove farmers away from the programme. One particular story stands out, as told by Elrohir, about how MPI engaged the contractors to instal cameras on power poles to watch farms with M. bovis. I was told the purpose was to ensure that the farmers did not shift their cows in contravention of movement controls:

> MPI had a security camera set up that you could see from [the farmers'] lounge. It was a yellow box on a poll with cameras everywhere, and one of the cameras would be facing their house…And we were like, what are those cameras for? They didn't trust the farmers to keep the stock on the farm, or they were accusing farmers of shifting stock off-farm…It was quite common down there – I've got photographs of it…But you shouldn't have one aimed at someone's lounge.

There were other aspects where MPI's lack of practical knowledge about farming drove farmers more towards M. bovis and away from MPI. One example given, again by Elrohir, was:

> when they went to the van Leeuwen's farm to start with, and they washed that cowshed for a million dollars. Then they went and washed another cowshed. It would have been cheaper to bulldoze it and put a new one up…That's when the farmers' mistrust started happening. It wasn't so much about fighting the disease, it was about fighting MPI. They should have been fighting the disease, not fighting each other.

Gandalf (Government) heard a lot of farmers say during the M. bovis biosecurity response that the only reason M. bovis causes disease in cows is if those cows are stressed, and that they meant intensive farming or covered farming scenarios. So, there was a feeling amongst some farmers that they would rather take their chances with M. bovis than deal with MPI (Gandalf). According to Gandalf, once the eradicators began talking about closing Cook Strait, farmers began "smuggling cows to the North Island and next minute there's cows appearing in Hamilton and in the Waikato at auctions stating that they were of Waikato origin."

There was "a lot of pain for those first farmers" (Stuff, 2021). When I asked Elrond (Government) how responsive they thought the eradicators were to the needs of farmers, they rated them a "three-to-four" out of ten. Elrond said, "[w]hat they were pissed off about was the way that we didn't understand them, and that we weren't accommodating about their requests - many of which, most of which, were reasonable".

That said, Elrond was quick to point out that some farmers have a "narcissistic nature, it's the way they're wired", and nothing that the eradicators or the Minister of Biosecurity could do would satisfy them. This is something that surprised Saruman (Government): the conflicted relationship between "the Ministry *for* Primary Industries and our primary industries". They pointed to the resistance from farmers, who "feel like you are doing it *to* them not *for* them" (emphasis original).

This observation was backed up by Treebeard's (Government) experience with the programme where they felt like "there was a huge disconnect between the Government and the programme, and the rural communities and the people they're working with". If the eradicators thought that it would be a winning strategy to arrive "in these rural communities saying trust us, we know what we're doing" (Treebeard), they were mistaken. Farmers were more likely to trust each other first than to defer to 'experts' speaking for M. bovis and farming from the outside. As Treebeard explained:

> You could be…the best scientist that New Zealand's seen for argument's sake, and you could have the guy who's been farming over the back fence for the past 25 years. The way our communities are bent, they're more likely to believe the guy that's farmed over the back fence for the last 25 years that the guy who's just rolled up out of Wellington and that they've never met before in their life; even though he may be the expert, they'll take the neighbour's word over his every, single time.

There were many meetings that the eradicators would run at townhalls throughout the country, to communicate their goal of eradication. These meetings would often be heated and volatile, further entrenching the mistrust between the parties:

> The problem was, you know, in some of the meetings in Southland they said here comes the Ministry of Shiny Pants, being the Wellington people. And I was lucky in the sense that I was…from a farming background, so I could have some credibility, but the majority of the time it was seen as Wellington – and the W word came up all the time – telling us what to do (Gandalf, Government).

Galadriel (Researcher) reiterated the general push back from farmers when he said, "you have the farmers who sit there and say, fuck them – we're not going to have that regulator walking down our driveway; all they want to do is punish us".

So, the answer to the eradicators' question, 'Can we enrol farmers?' is split. Some farmers became vocal and public allies of the eradicators through changing their minds or having improved experiences with them after more than one involvement with the programme. Others were never going to be enrolled, let alone mobilised to do the eradicators' bidding, at least not voluntarily. The eradicators also attempted to coerce individual farmers by providing financial compensation and other non-financial support where they had been impacted by actions taken under the Biosecurity Act 1993, though as alluded to above, that was a process that caused additional stress for farmers (Litmus, October 2021). Many farmers experienced the programme's requirements as additional workload pressures and time that they could not claim compensation for (Litmus, October 2021). In the end, the eradicators have had to enrol many farmers against their will, by the force of law. There remained a more important question for the eradicators, however, which was whether farmers would actually practice biosecurity as a result of their interventions – either during the programme or afterwards.

5.4.3 Will farmers practice biosecurity?

There were two aspects to that question. The first was whether farmers were undertaking good biosecurity during the eradication programme (mostly, they were not), and the second was whether farmers had been mobilised by the eradicators to perform biosecurity on their own, as part of a long-term shift in behaviour (the answer is more ambivalent).

Irrespective of their goal of good farmer biosecurity, the eradicators appear to have successfully reterritorialised the farming assemblage without a sustained farmer commitment to biosecurity practices. Despite MPI declaring that "[w]e now have a disease environment [so f]arming will have to change" (Stuff, 2018b), biosecurity has not been a lynchpin in translating farming like the eradicators thought it could or should have been. For Saruman (Government), there remains a perverse incentive to fail at biosecurity when the government pays compensation, and when the "cavalry" (as Treebeard put it) continues to arrive:

> [I]f there was a line in the sand and it said if you don't change your practices and you keep getting infected for the same reasons, you might not be eligible and that might change their way of thinking. Some of these guys might cost us a million dollars every time they come into the programme (Treebeard).

Similarly, Hasufel (Researcher) thought it was hard to be vigilant in times of little or no disease, especially when "the government compensates anyway, right?".

During the governance phase, farmers experienced biosecurity as an imposition causing financial hardship, extra work, and increased uncertainty without seeing any clear benefits for their businesses (Litmus, October 2021; MPI et al., June 2020). One of the important drivers for farmers to enact biosecurity was not only the 'why', but also that those biosecurity measures had to be practical, workable, and able to be incorporated into existing farming practices (Boromir, Industry).

Boromir (Industry) reflected that there would be a mixture of farmers who had made changes and those who had not, but they considered that M. bovis would have "made farmers have a really good hard look at what they were doing". While farmers' use of the NAIT system increased throughout the course of the programme from 30 percent compliance at the beginning to around sixty to 65 percent (Frodo, Government), there continued to be poor uptake of NAIT by farmers (Farmers Weekly, 2021). However, there were some positive conversations taking place around farmers wanting their stock to be kept separate with double fencing when they go off for grazing, using virgin bulls or even grazing their young stock on the farm. Borormir said that "there are more of those kinds of conversations happening now than there used to be, which is really good". They thought that "the fact that there are biosecurity risks out there that can be devasting to them has been one of the big learnings for a lot of farmers". In addition, Gandalf thought that there was a greater awareness of reporting animal health concerns quickly because,

as they said, "[n]obody wants to be ground zero".

However, Hasufel (Researcher) considered that while farmers would become aware of biosecurity when there is a disease, as life returned to normal, they would become complacent again. Indeed, in early 2021, a Te Waipounamu farmer was charged and sentenced under the Biosecurity Act 1993 for moving cows even though that farm was part of the M. bovis programme and movements were prohibited (Rural News Group, 2021b). The underlying issue about farmers not seeing that biosecurity is valuable for their businesses "still continues to be the case where farmers won't abide by the biosecurity rules because they don't believe it's the right thing to do" (Gandalf, Government). That behavioural change has not really occurred (Legolas, Government; see also MPI et al., June 2020). For Shagrat (Industry), there have been plenty of missed opportunities to practice better on-farm biosecurity as a result of M. bovis' emergence.

The Read Report found that on the whole farmers still did not understand the relevance or importance of biosecurity for their businesses (MPI et al., June 2020). A key reason is incompatibility. There are farmers whose business model requires buying beef cows from the saleyards and finishing them; for them, the risk of disease is worth taking over any biosecurity measures such as animal health records, quarantining new mobs or other hygiene measures. Many of these farmers have said to Elrond (Government), "I've just got to take the risk because that is my farming business…and I'm going to get bovis".

Saruman (Government) agreed that on-farm biosecurity practices have been materially absent, and that this has remained the case on most farms, even after M. bovis, though they did think that M. bovis has brought an increased awareness of the importance of the NAIT system, and "perhaps some of those shadier practices like selling calves at your farmgate or selling milk to your neighbour, that sort of thing". For them, the question again came back to whether farmers understand why biosecurity is important for their own biological businesses (see also MPI et al., June 2020). Similarly, Gandalf (Government) said that farmers will not go out of their way to practise biosecurity because it is "the right thing to do" - the question farmers will ask is what they gain from it. A common refrain was "[b]iosecurity becomes important when it's personal" (Gandalf).

Boromir (Industry) noticed that since M. bovis there seemed to be a growing divide among

farmers, where some were adapting and implementing risk management practices and others were being left behind. Post-M. bovis, some farmers are asking for information that indicates biosecurity risks pre-purchase, before the cows are collected by the stock truck and come onto the farm (Legolas, Government). Some of the more corporate farms, the larger dairy farms, are double-fenced and now require signing in for visitors and disinfection of footwear as a standard entry practice (Arwen, Government). Galadriel (Researcher) thought that the older farmers who will not adopt new practices will be likely to exit farming eventually, leaving the new generation who would be more willing to adopt new ways of farming. There have been many inscription devices created by the eradicators to explain and encourage biosecurity practices, and they continue to view continued poor biosecurity practices among farmers as a betrayal of their efforts at translation.

5.5 Conclusion

This initial findings chapter is the largest in the thesis, though it is closely followed in size by the scientists' M. bovis stories. The reason for the size is because the eradicators have done a lot of speaking for M. bovis. Their process of translation, to reterritorialise farming without the bacterial invasion, has required tremendous effort and continued commitment in the face of many trials. The eradicators have nearly been thwarted by farmers, by technology and by the bacteria themselves - those smallest of organisms.

This chapter has illustrated that the diseased cows and production loss component of the eradicators' obstacle problems was less of an obstacle than they had anticipated. However, as will be confirmed through the stories of other actors, extensive cow mobilities (more than they expected to find), a lack of farmer engagement with biosecurity (again, an apparent surprise) and problems with the NAIT system continue to loom large as obstacles to biosecuring farming in Aotearoa.

The next chapter describes the scientists' struggles - to find M. bovis, to gain further knowledge about the bacteria's behaviour and to ensure cow health in the absence of a strong biosecurity consciousness among farmers.

Chapter 6 The scientists

The hard part to get your head around though was the whole herd culling, and that is all to do with bovis being so difficult to find and it had such a long infection period. So if you find a herd that has got one or two animals positive, then the whole herd was getting culled. So farmers were struggling with that concept – it was very tough (Lugdush, Veterinarian).

6.1 Introduction

Scientists are the second group of actors to describe their M. bovis realities. Like the eradicators, the scientists were a group multiple, being comprised of several different disciplines. Each 'type' of scientist created their own M. bovis realities that in turn drove and were driven by their differing epistemologies, even though they were all based in the natural sciences. This chapter describes the realities of the veterinarians, laboratory technicians, researchers and epidemiologists involved with M. bovis' world-making.[85] Collectively, this group is known as the scientists.

The existential battle that occurred between the eradicators and M. bovis for the enrolment of cow bodies and farmers' minds created a pivotal role for scientific actors. The eradicators needed the scientists to help understand M. bovis for the purpose of eradicating the bacteria, whereas the scientists wanted to understand M. bovis for the purpose of ensuring cow health and wellbeing. The scientists also wanted to obtain the funding that the government gave them for their research into M. bovis, and then to publish widely on their results. Veterinarians, in particular, enjoyed being at the forefront of new knowledge so they could advise their farmer clients. As you will read in this chapter, the scientists willingly aligned themselves with the eradicators' interests, at least for as long as that helped them achieve their goals.

Like the eradicators, the scientists suffered from a lack of knowledge in the Early Days. The scientists have been fully enrolled in the eradicators' programme from the beginning, however, advising them on feasibility and best practices. As the eradicators have explained, the biosecurity response and eradication programme were driven by the 'natural' sciences, as opposed to the social sciences (see Latour's [1987, pp. 94-100] discussion on 'nature'). For Peregrin (Researcher) the eradication programme has "been very strongly underpinned by science all the way through". In turn, the eradicators' goal of ousting M. bovis has driven an

[85] Some of these scientists wear other hats, too. For example, Gamling, Bilbo and Lugdush are scientists and speak for M. bovis through the lens of their disciplines, but they are also farmers.

increase in scientific knowledge about the bacteria, in particular through the use of extensive laboratory testing (Arwen, Government). The scientists have made themselves pivotal in the eradicators' understanding of the M. bovis assemblage, but they have also had their own collective goals, obstacle problems and OPPs through which they had to pass. This next section introduces the conceptual underpinnings of the scientists' world-making and provides a glimpse into what will be revealed by their translation process, before setting out the chapter's structure.

6.1.1 World-making

The scientists' voices have been privileged throughout the eradication programme, and they have received praise and recognition (likened to the accolades given to Pasteur for 'his' cure for anthrax), even though the cows and farmers themselves also played their essential parts in the discovery (Latour, 1988a). The scientists have relied on laboratory research and written reports to strengthen their claims to truth (Latour, 1987), and in doing so they have problematised M. bovis and strived to enrol other actors into their scientific reality. Their inscription devices have acted as immutable mobiles (Latour, 1987), making it more difficult for those in opposition to the scientists to appear rational in that opposition, let alone succeed in *interessing* other actors away from the scientists' gaze. The writings produced by scientists have defined the boundaries of the relationship with non-scientists, making it on their terms and in their language (Michael, 2017). The scientists have problematised M. bovis bacteria as a threat to cow health and welfare, and in doing so have made scientific knowledge indispensable to resolving the eradicators' problem. However, the scientists had to keep on speaking through their research to enjoy the continued loyalty and obedience of the other actors, allowing their ongoing attempt at translation to be successful. As will be seen, a crack has appeared in the scientists' network, which is that they did not all agree that M. bovis should be problematised.

The scientists have collectively built facts (Latour, 1987) to enrol and then purport to speak for those others as the one source of truth. The use of these inscription devices has had the effect of reifying the scientists' collective reality as *the* only version of M. bovis that could legitimately exist and in doing so, they have defined the reality of other actors (Latour, 1987). These actions are more easily done where those who are being spoken for are mute in the language of currency, such as cows and bacteria. Scientists produced inscription devices to

'invest' (Latour, 1987, p. 108) their expertise in the eradication programme and *interesse* the eradicators by helping them to achieve their goal. The scientists have called into aid (Latour, 1987) the particular ways of the bacteria, as if they had the power alone to settle the controversy of M. bovis' appearance. However, this chapter will show that M. bovis itself did not afford the scientists the certainty they sought (Donaldson, 2013).

The scientists generally spoke as a collective about "matters of fact" (Latour, 2005, p. 114), like the fact that M. bovis does not have a cell wall. These matters of fact are premised on a shared epistemology. Yet, when interviewed, the scientists were mostly preoccupied with other types of matters that Latour (2005) calls "matters of concern" (p. 175), and this is where the one voice becomes multiple. These are the actions of others that the scientists cannot control, but which impact on their ability to achieve their goal of understanding M. bovis in Aotearoa. For example, each of the scientists wanted to talk about the impacts of farmers' poor biosecurity practices on the success of the eradicators, and on cow health more generally. There were other matters of concern that the scientists worried about, too, like how "some farms will infect loads of other farms and some farms will infect none, even though they have multiple movements" (Gollum, Epidemiologist). The scientists could not predict which farms would become infected through their scientific matters of fact, so the influence of those unknown assemblage elements was unsettling.

There was a non-human actor that played a very important role in the making of M. bovis for the scientists as a collective (and therefore the eradicators) and that was the testing available to find the bacteria within cow cells. There are two types of tests, and each of these searches for M. bovis in different ways and enacts the bacteria differently to the other. As will be seen, the testing was a key materiality that made M. bovis present or absent by cooperating with the bacteria and bovine bodies to story the scientists' M. bovis worlds (Mol, 2002).

The veterinarians could only declare a cow healthy because disease was not made manifest or was presumed absent (Hinchliffe et al., 2013). For the veterinarians, the bacteria had a role as a nasty disease, and the farmers were either 'good farmers' who cared about their cows and supported the eradication effort or bad farmers who did not. Devices of *interessement*, such as the provision of knowledge and the tracing abilities of epidemiologists, were used to stabilise those roles and to prevent others from thwarting the scientists' requirements through lack of cooperation or betrayal.

The veterinarians were the specialists in researching M. bovis' impacts on productivity and animal health, and they advanced scientific knowledge about testing for the bacteria. Along with the epidemiologists, the veterinarians' narrative was dominant in the eradication struggle, and it was employed to enrol other actors through their scientific OPP, which was to increase knowledge of the bacteria for the eradicators, farmers, and cows as well as their own scientific community. It will be recalled that it was the scientists who maintained from the start that eradication was feasible, based on their epistemological understandings which in turn have reified their knowledge as 'matters of fact' about M. bovis.

M. bovis was practised into being by the scientists collective (Law & Mol, 2011), though sub-groups of scientists created alternative M. bovis worlds, "made or done to be different" by their disciplines (Law & Singleton, 2015, p. 6). While the question might have arisen, "which version of reality deserves to be foregrounded and worked with?" (Law & Mol, 2011, p. 9), there did not appear to be any conflict of note among these scientific realities.

The two groups that have proven to be the most difficult for the scientists to *interesse*, but the most important to get alongside, were cows and the bacteria, because the network roles assigned to each of these groups required their collective destruction. An *interessement* device for infected and symptomatic cows would be, for example, that eradicating M. bovis would ease their suffering, but this approach necessitating the culling of asymptomatic and uninfected cows failed to sell the message to the others. However, cows on farms that were unaffected by M. bovis did have a vested interest in staying M. bovis free, both to remain strong and healthy (particularly dairy cows surviving an intensive farming regime), but also to remain alive. As with the eradicators, it was these two groups that were most likely to betray the scientists in the long-term.

While the scientists problematised M. bovis along with the eradicators, their problematisation was for different purposes and with different goals in mind. In fact, just like M. bovis itself, the cows and their farmers, the scientists' goals were ultimately incompatible with the singular and unbending goal of the eradicators: to successfully Other M. bovis from the farming assemblage. With eradication as the dominant translating force, however, scientists have been enrolled by the eradicators by the promise of being able to increase their knowledge – albeit for the purpose of finding and destroying M. bovis. Aotearoa's scientists have developed new testing methods for identifying M. bovis, which has been pleasing for them and has contributed

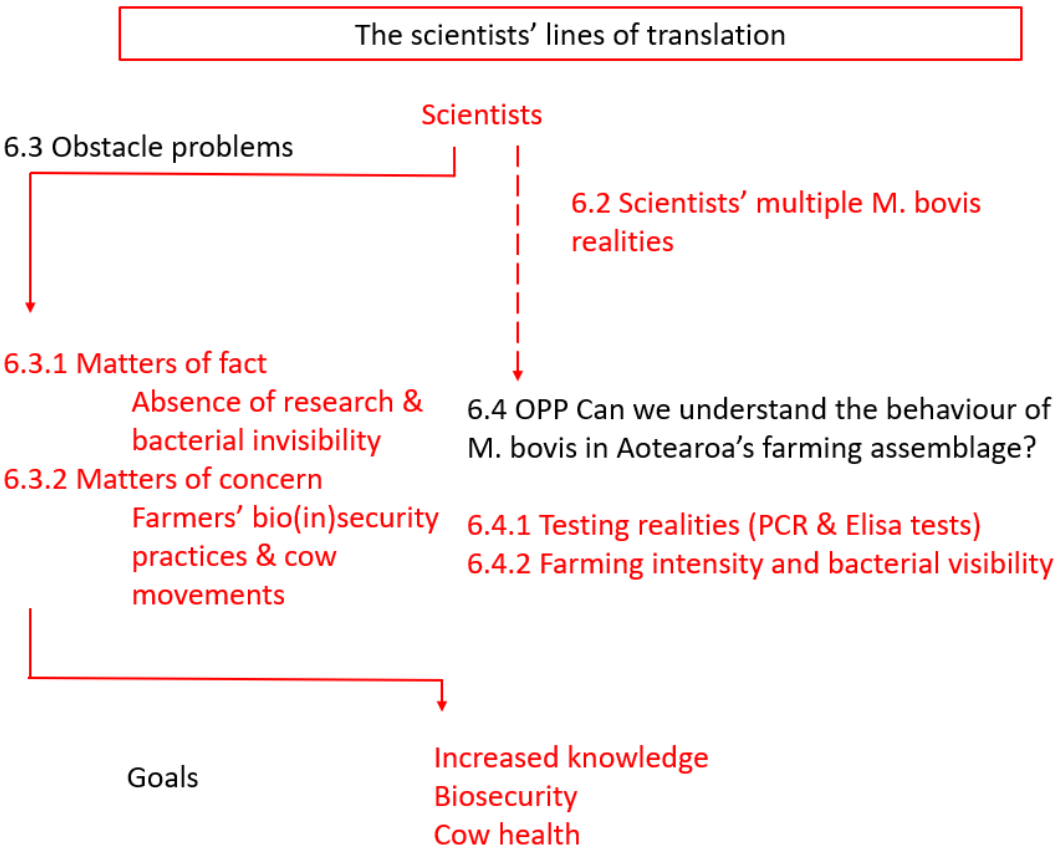
to their continued enrolment in the eradication programme, collectively though not without waiver. Scientists have provided the dominant narrative for the public about what M. bovis is and what it is capable of achieving (how it could translate the farming assemblage). In doing so, scientists have played a transformative role in mediating how M. bovis is spoken for and understood in Aotearoa.

Once the other actors accepted the legitimate role of scientists in the M. bovis network as those who are most qualified to speak for M. bovis and the cows, then keeping their confidence and preventing betrayal was an ongoing challenge. The scientists had to keep the faith of those who believed in their expertise, but the difficulty was that once they had advised those who are acting on the scientific advice (to eradicate, to practice good biosecurity), their control over matters of fact was lost. The risk was that farmers and eradicators may begin to express different opinions about the extent of M. bovis' influence on cow health and productivity due to other influences. For example, the existence of infected but ostensibly healthy herds (which could have been the unwillingness of cows to cooperate or the reticence of M. bovis to appear), or the emotional and financial toll of eradicating valued cow herds on farmers (resulting in their own unwillingness to cooperate with the scientists).

6.1.2 Narrative structure

As with the eradicators chapter, this current chapter follows the scientists' challenges, achievements, and allegiances by repurposing Callon's (1986) lines of translation diagram. The scientists had three main goals. The first was to understand more about M. bovis, particularly about how M. bovis behaved in Aotearoa's pasture-based farming assemblage. The second goal was to contribute to farmers' understanding of the importance of biosecurity for cow health, and the third was to maintain healthy and productive cow herds. The first goal of increased knowledge was also the scientists' OPP question. *Figure 16* below illustrates the scientists' obstacle problems, OPPs and goals in chart form, and then each of these will be explained below.

Figure 16
The scientists' lines of translation



As seen above, the scientists' main obstacle problems were categorised as matters of fact and matters of concern (see Latour, 2005). Obstacles of fact for the scientists were the absence of research in Aotearoa about M. bovis itself (which aligned them with the eradicators because this was also a problem for them) and the bacteria's lack of visibility (for the vast majority of cows, M. bovis caused no clinical (visible) symptoms). This hidden network was a frustration for the scientists, particularly the veterinarians, because it meant relying on laboratory tests to find M. bovis, often without any visual clues.

The scientists had other obstacles aligned with the eradicators, too, but these were more in the category of matters of concern. For example, the inherent mobility of cows in the farming assemblage made bacterial transfer easy and epidemiological tracing difficult. Another threat to the scientists' ability to black box the problem of M. bovis was the lack of biosecurity practices that they saw farmers engaging with. Like the eradicators, the scientists spoke loudly

about the importance of on-farm biosecurity and cow tracing for managing diseases, and the disappointing lack of a biosecurity consciousness among farmers.

Along the way, the scientists have created a body of additional knowledge benefiting their goal of increased scientific understanding. On their journey through their OPP, the scientists have discovered and remade M. bovis through deploying two main tests and, as will be seen, each test makes the bacteria differently. Indeed, the scientists have discovered multiple M. bovis realities through their own epistemologies (illustrated above at '6.2 Scientists' multiple M. bovis realities'; see Enticott, 2016b on this point). In answering their OPP question, the scientists have had to grapple with matters of concern that confound them, such as why some cows on some farms manifested disease while others did not, and how M. bovis interacted with other microbes within cow bodies to make manifest disease presences.

This research shows that scientists have enacted three distinct M. bovis realities of note: these were research/laboratory bovis; epidemiology bovis; and veterinary bovis. I begin this chapter with the bacteria itself and by describing each of those different M. bovis realities, because that is where the scientists would begin.

6.2 Mycoplasmas bovis created by science

6.2.1 Research/laboratory bovis

Scientific researchers knew M. bovis as one of many *Mycoplasma* species, only some of which cause diseases (DAC, September 2017).[86] The genus of *Mycoplasmas* is part of the family of *Mycoplasmacetae*, which sits within the class of *Mollicutes* (Gille, 2018). This is relevant information because the name *Mollicutes* literally means 'soft-skinned' and it is a reference to the bacteria's lack of a cell wall (Gille, 2018). This absence of a cell wall explains why *Mycoplasmas* cannot survive outside of their hosts for long, and why farming assemblage elements such as tractors and machinery are not considered to assist the bacteria in transmitting between cows (Nicholas et al., 2008; Faramir, Epidemiologist).[87] These researchers know about 180 species of *Mycoplasmas*, and they are all understood as parasitic bacteria that need living hosts (such as mammals, fish and plants) to survive (Gille, 2018). Their research has

[87] Nicholas et al. (2008) do note, however, that contaminated frozen semen remains infectious for a number of years and consider this to be an overlooked source of M. bovis infection.

determined that *Mycoplasmas* are generally host-specific, preferring one species over another (Gille, 2018) and that they are the smallest living organisms known to self-replicate (Razin et al., 1998).

Scientific researchers have described M. bovis bacteria as 'chameleon-like', referring to their ability to create a wide range of diseases, which are broadly called '*mycoplasmosis*' (Gille, 2018). However, M. bovis was said to possess several characteristics that distinctly shape how disease develops in bovine bodies (Maunsell et al., 2011; Gille, 2018). M. bovis is non-zoonotic, which is the scientists' language for the bacteria's inability to transfer to human bodies (MPI, n.d.a.; MPI, July 2020).[88] M. bovis bacteria are capable of disrupting a cow's ability to create antibodies (a process the scientists call 'antigenic variation'). This bacterial trick reduces the effectiveness of antimicrobial treatments such as antibiotics (Nicholas et al., 2008; Maunsell et al., 2011; McAuliffe et al., 2006).[89] Furthermore, the researchers considered that M. bovis bacteria are capable of adapting and mutating for their own survival over time (Arwen, Government).

All of the *Mycoplasma* species, M. bovis included, have well-developed survival mechanisms. Veterinarians knew this because these bacteria are capable of forming 'biofilms', which is where the bacteria change their surface proteins seemingly for the purpose of avoiding an immune response from their hosts. Imrahil (Veterinarian) explained, "[*Mycoplasmas* are] quite like the flu virus in that they can change their surface proteins, so you start vaccinating and they just change their surface coats, and the immune system can no longer see them".

Laboratory technicians knew the bacteria as a group of slow growing microbes that only appeared under a microscope between three and five days after culturing. It may seem incongruous with the strong survival instinct of *Mycoplasmas*, but M. bovis is difficult to culture, or grow, in the laboratory due to the "fastidious nutritional requirements of mycoplasmas" (Nicholas et al., 2016, p. 144). Imrahil (Veterinarian) explained that "they're actually quite difficult bugs to grow in the laboratory - they need a lot of feeding, but we know

[88] However, M. bovis has occasionally been isolated from the respiratory tracts of goats and sheep (Ayling et al., 2004).
[89] In general, the *Mycoplasmas* are becoming increasingly resistant to antibiotics that are normally used to treat infections such as mastitis (Ayling et al., 2004; Nicholas et al, 2008; Imrahil Veterinarian).

how to do that - we feed them up, grow them up and then pull the DNA out and sequence them".

Within these technical "centres of calculation" (Latour, 1987, p. 232), Mycoplasmas are enacted as "a very fine cloudiness, usually described as 'opalescence'" (Nicholas et al., 2008, p. 9). Mycoplasma colonies can vary markedly in appearance under a microscope, some being larger and more granular and others being smaller and smoother, making Nicholas et al. (2008) consider that reliance on the appearance of mycoplasmas for identification is a relatively worthless exercise. However, as *Figure 17* illustrates, all bacteria belonging to the *Mycoplasma* genus have a distinctive 'fried-egg' appearance when viewed under a microscope (Nicholas et al., 2008).

Figure 17
M. bovis under the microscope (courtesy of Dr Jonathan Foxwell, the Animal Health Laboratory, Aotearoa)

For researchers and laboratory technicians, M. bovis was a visible presence and a bacteria with distinct behavioural characteristics that made it difficult to mark out from others of the same species.

6.2.2 Epidemiology bovis

Epidemiologists knew M. bovis as a "pathogen", rather than a group of bacteria, and they viewed a cow's biological response to the presence of that pathogen as a "disease" (Faramir, Epidemiologist). These scientists knew the difference between a pathogen and a disease empirically, because (as Faramir explained) a disease such as mastitis or arthritis is visible, but the creative pathogen is not able to be seen without the aid of technology (and the laboratory technicians). This distinction is materially and semiotically important for these actors because, as Faramir further explained, a pathogen (like M. bovis) is *always necessary* for the manifestation of diseases associated with that pathogen, but the pathogen is *never sufficient* acting alone to manifest those diseases. Therefore, for epidemiologists, both M. bovis bacteria and other network actors were required to make diseases manifest, because M. bovis alone is not sufficient.

There is a powerplay here because there were intervening or interfering (Law, 2004) actors, such as environmental particulars and farming practices, that influenced the presence or absence of cow health. Each of these interferences could individually or together tip the balance towards or away from disease. This acknowledgement that more than one actor is required to create network disruption (that actors do not act alone) is an idea that is also deeply grounded in ANT (see Latour, 2005; Law, 2004), and it is one that the scientists returned to when describing their obstacle problems.

Epidemiologists are the detectives of the scientists collective, and they knew M. bovis as a pathogen to be traced temporally and geographically (Law & Mol, 2011). Epidemiologists spoke for cow collectives, as opposed to individual animals like the veterinarians tended to do. Cows multiple enacted M. bovis at this collective level, acting with each other and against each other if one tested positive for the bacteria's presence to the detriment of all. For epidemiologists, however, M. bovis did not need to manifest diseases in cow bodies, because they were simply concerned with how fast the bacteria could move (not very fast) and how long they could remain undetected (a long time) (Faramir, Epidemiologist).

Yet, like veterinarians, these actors knew M. bovis as silent and slow bacteria that are adept at hiding in the cells of cows (Faramir, Epidemiologist). The behavioural characteristic about M. bovis that stood out for Faramir was that "[i]t's sneaky. It will go into cattle, and you would never know they were infected unless you test them". M. bovis' ability to hide out in cow bodies bought itself time to move, perhaps compensating for its slowness, into another cow or herd. An Australian epidemiologist has recently suggested that the bacteria may be able to use wind currents to travel from farm to farm, at least for up to "a few kilometres" (Happold, 2022, p. iii).[90] This research was based on a group of M. bovis-affected farms in Waitaha, and it is the first time that a scientist anywhere has considered that the bacteria can travel using the wind.

The NAIT system of scanning and tagging cows was one of the tools that epidemiologists have used to find cows and to follow M. bovis through the farming actor-network. The slow rate at which the M. bovis bacteria 'transmit' (move) between infected and naïve cow bodies made epidemiologists describe M. bovis as 'difficult', because the web of farms and movements is more temporally extended than for a fast-moving virus, for example (Faramir, Epidemiologist). Faramir's view was that it would have been far easier to find FMD than follow M. bovis, because of the latter's "long silent spread period". Lugdush (Veterinarian) agreed, saying that FMD "doesn't hide in the same way that M. bovis does".

For epidemiologists, M. bovis was enacted as a series of movements or transmissions, able to be mapped topographically and followed, in part, so that the bacteria could be genome sequenced for their relationships with each other. Epidemiologists knew cows in the M. bovis network as material mobilities that required tracing or geographical following; if they could find the cows' origins and destinations, then the veterinarians and technicians could test those cows and maybe find M. bovis.

6.2.3 Veterinary bovis

Veterinarians framed cows as vectors or incubators of M. bovis as well as being victims of the bacteria (Lugdush, Veterinarian). These science actors relied on 'clinical observations' of cow

[90] The Happold Report is cautious, noting that there is "some evidence to support airborne transmission" (p. iii). Yet, the author goes on to state that airborne transmission of the bacteria "would seem the most plausible explanation for the unusual cluster" (p. iii) of infected farms in Waitaha.

bodies for semiotic signs of bacterial presence as their primary method or tool. One of the obstacle problems for veterinarians was that cows do not usually appear unwell with M. bovis (Jordan et al., 2020), but when they do, the bodily ontologies of M. bovis are known by veterinarians as mastitis bovis, arthritis bovis, pneumonia bovis, and otitis bovis. Asymptomatic cows, or an 'absent-present bovis', was a problematic reality for veterinarians and an obstacle to their quest for knowledge.

One of the challenges that has perplexed the veterinarians is why some farms with M. bovis have had more 'clinical disease' presence than others. One of the theories put forward by the veterinarians to try and understand this phenomenon was based on acknowledging the influence of assemblage elements such as animal husbandry, farming practices, underlying diseases, and environmental factors (Bilbo, Veterinarian; Imrahil, Veterinarian). I have been told of some exceptionally 'good' farmers, who veterinarians rated by how healthy their animals were, who have had M. bovis on their farms and they have had no clinical disease whatsoever (Bilbo). Veterinarians were worried initially that M. bovis would cause a large amount of clinical disease (Lugdush, Veterinarian), but that has not been the case in the short time that M. bovis has been present.

Interestingly, the word "bug" (Imrahil, Veterinarian) was used routinely by veterinarians to describe M. bovis - it was "just the trickiest of bugs" (Lugdush, Veterinarian). This term suggests almost an animation of the bacteria, as a visible mediator in its own right like one might describe an insect. Veterinarians' M. bovis' veterinary reality was that the bug is imbued with cleverness, and able to hide in cow bodies, evading antibiotic treatments and using the bloodstream as a vehicle for silent spread. The veterinarian reality of M. bovis also involved concepts such as 'bacterial loading', 'sub-clinical' and 'immunity' (Bilbo, Veterinarian; Imrahil).

In Aotearoa, veterinarians were not trying to keep the cows alive as happens in other countries with M. bovis, rather they were testing for M. bovis only to send them to slaughter. Having to learn how to use various testing regimes for the purpose of supporting an eradication programme has been a challenge for the veterinarians, whose job is usually to save the lives of cows (Imrahil, Veterinarian).

The scientists understood that the M. bovis bacteria could only move between cow bodies in a limited number of ways, that is through infected milk (to calves), close and sustained contact between cows when grazing or milking, and within their biological material such as semen and embryos (Imrahil, Veterinarian). These actors also knew M. bovis as a fragile and vulnerable organism that struggles outside of its bovine host. In contrast to their slowness in transmitting between cows, however, the bacteria are very efficient at moving around within individual bovine bodies, again impacting on the ability to detect them. As already mentioned, because the majority of antibiotics work through a cell wall, and the bacteria can 'hide' inside a cow's own cells, the treatments cannot easily recognise them (Lugdush, Veterinarian; Gamling, Veterinarian). One veterinarian has described the *Mycoplasmas* in non-technical language as "clever little beasts" (Imrahil).

A bacterial unpredictability that disturbed the scientists collective is that M. bovis seemed to behave differently in different herds, leaving open the opportunity for it to work with other actors in the farming network to enact some "really nasty" diseases (Faramir, Epidemiologist). Due to the insidious nature of M. bovis, it is "feared by the dairy industry" (Nicholas et al., 2016, p. 142). A main reason for this fear is that M. bovis is considered to cause productivity losses in dairy cows (see the eradicators' chapter). However, the scientists have their own story to tell about the relationship between M. bovis and on-farm productivity, as explained below.

6.3 Obstacle problems

The scientists had not encountered M. bovis in Aotearoa before, yet in order to enrol the eradicators in their network, they had to learn quickly. M. bovis did not help the scientists understand itself or its behaviour, however, and it displayed a tendency to hide in cow bodies without declaring its presence. As mentioned above, the bacteria survive by evading cows' immune systems and antibiotic treatments. As will be seen later in this chapter, M. bovis can also evade the scientists' testing technologies. This is another hurdle that the scientists had to overcome to achieve their goals of increased knowledge and ensuring the health of cows. The scientists' self-imposed dominance as those who could speak for (and against) M. bovis would likely also wain overtime if the bacteria themselves cooperated with the cows and other actors to continually refuse to become visible in the assemblage.

As if there were not enough obstacle problems for these experts who purported to speak for M. bovis, they also had to deal with two issues arising more inherently from the farming assemblage itself. The first one was that farmers generally have little time (literally and figurately) for biosecurity practices, such that the bacteria have had free access to farms around the country. The eradicators have already spoken loudly on this point. The other is a related problem that also has fuelled the bacteria's mobility, which is the number of cow movements that occur in the farming actor-network annually. Again, the practices of farming were a concern of the eradicators (even though they have acted to reterritorialise it). These last two problems were outside of the scientists' control and proved to be their biggest matters of concern (Latour, 2005). This section takes each of their obstacle problems in turn, starting with a lack of scientific research about M. bovis' impacts on farming.

6.3.1 Matters of fact

6.3.1.1 An absence of scientific research

The scientists started out with an absence of information about M. bovis in Aotearoa (MPI, n.d.c.). What was known was primarily taken from overseas researchers, though the scientists have built on and adapted this knowledge over time. The problem with relying on research conducted in other countries, as they discovered, is that each country farms differently and each country has its own geographical and climatic actors that interact with M. bovis at a local scale. Nicholas et al. (2008) argue that because country incidences of M. bovis vary widely, M. bovis should be recognised by the WOAH due to the uncertainty of the bacteria impacting on international trade. For some countries, having M. bovis present in the national herd could be more impactful than others.

Consistent with other aspects of M. bovis' world, the economic or production impacts of M. bovis diseases overseas has proven difficult to assess (Gille, 2018), though it is clear that M. bovis remains an animal health and production issue internationally (Bilbo, Veterinarian; Gille, 2018). It is also accepted that there is invisible (and therefore unqualifiable) suffering that M. bovis can cause without any real prospect of treatment (Maunsell et al., 2011).

As the eradicators discovered, farm size and intensity of production are proven materialities for M. bovis diseases manifesting in dairy cows. The scientists agreed that herds with more than 500 cows are more susceptible to M. bovis caused mastitis than smaller herds (Nicholas

et al., 2016; Gamling, Veterinarian). Kearney's (2021) research suggests a correlation between high stocking rates and in-shed feeding systems as well as increased M. bovis transmission because this type of assemblage creates prolonged periods of close cow to cow contact, similar to those experienced by cows housed in barns.

Bilbo (Veterinarian) considered it material that farming is practiced differently in Aotearoa:

> We are pasture-based, we are extensive and intensively extensive, whereas in Australia they don't have a huge amount of grass. So, while they might be outdoors [in Australia], they are often fed meal or a huge array of supplements. Australia is much drier and hotter, whereas the UK has similar climatic conditions to us, but their cows spend a large proportion of time indoors unlike our cows. So, it's different in each place.[91]

In countries where large dairy herds are commonplace, such as the United States of America (USA), mastitis caused by M. bovis has resulted in significant milk production loss (Nicholas et al., 2016). In Europe, M. bovis has also caused reduced milk production in large dairy herds (Nicholas et al., 2016; Gille, 2018). Despite dairy farming being by its very nature, "intensive" (Lugdush, Veterinarian), dairy cows in the UK are still under much more production pressure than in Aotearoa (Bilbo, Veterinarian). Yet, the "virulence of disease" on IP1 (the Tainui farm) was internationally "unprecedented" (Hay, 2018, p. 71). Of the 1,000 dairy cows on the Tainui farm, more than 200 had untreatable four quarter mastitis, more than 100 had one or more quarters affected by mastitis, and 35 had severe arthritis. Over 100 calves also had to be euthanised for presenting with severe M. bovis infection, resulting in a failure to thrive. Hay (2018) described the loss of cow and calf lives on that farm as "absolutely catastrophic" (p.71).[92]

There was a general lack of agreement among the scientists about how similar the impact of M. bovis was likely to be in Aotearoa compared to Australia, though some modellers have suggested that impacts would likely be more severe in Aotearoa than Australia (Laven, 2019). However, Imrahil (Veterinarian) considered that a direct comparison with Australia's disease

[91] In addition, farmers farm differently *within* Aotearoa, too - there is not a single farming model across the country. See the farmers' chapter for a discussion.

[92] The veterinarians did not know for certain the reasons why M. bovis impacted so severely on cows on the Tainui farm, though the farm was an intensive barn farming operation which is unusual for Aotearoa. The cows would spend two months on pasture prior to calving, but the herd calved in mobs quarterly instead of annually, so 250 to 350 cows would calve per quarter (Hay, 2018).

prevalence and severity in their herds is misleading because the level of testing that has been carried out in Aotearoa has not been done in Australia. In addition, Australia has very few cow movements comparative to Aotearoa and the way their cows move is different (Lugdush, Veterinarian). The movements of cows and the influences that these have on Aotearoa's farming network have seriously challenged the scientists in their quest for understanding and the promotion of healthy cows.

Where individual scientists did agree, however, was that in Aotearoa, the disease impact of M. bovis has been limited. Even at its peak, disease was present in approximately one percent of all M. bovis affected farms (Laven, 2019). Bilbo (Veterinarian) expressed surprise at the lack of production impacts caused by M. bovis in Aotearoa to date, saying "in the hundreds of farms now diagnosed with M bovis, the vast majority of them haven't had any clinical effect or even any measurable production effect". According to Laven (2019), it was unlikely that M. bovis would have cost farmers over NZ$1 billion in 10 years (as estimated by the eradicators).

Bilbo (Veterinarian) talked about the "clinical impacts study" commissioned by MPI in 2020 to ascertain the effects of M. bovis on milk production and calving rates (Compton et al., 2022; see the eradicators chapter). Their view was that the study came far too late to be useful in answering the scientists' OPP question of understanding M. bovis' behaviour in Aotearoa. They said: "there's very few farms now three years down the track, [so] it's probably a bit late to find that out" (Bilbo).

Yet, in those cases where M. bovis expressed itself with clinical diseases, those diseases tended to be severe. One veterinarian, who had seen some of the worst cases of incurable mastitis caused by M. bovis in Aotearoa, said:

> Once it really gets a hold of a herd, there's just nothing we can do. It strips all the profit from the operation, and it's horrible for the animals (Lugdush, Veterinarian).

Severe mastitis will eventually block one of the cow's udders and when that happens, she will be culled out of the system for lack of productivity, which carries an additional financial (and sometimes genetics) cost to farmers (Faramir, Epidemiologist).

M. bovis is also thought to predispose cows to another common disease called bovine respiratory disease (BRD), primarily through being already immuno-compromised (Nicholas

et al., 2008). Overseas studies show proven production impacts from cows having BRD, along with serious animal welfare implications (Nicholas et al., 2008). Some researchers see an additional connection between M. bovis and BVD (Maunsell et al., 2011). BVD is endemic in Aotearoa, and according to one veterinarian it has had a greater impact on cow health than M. bovis has shown, and a proven impact on production (Laven, 2019).[93] As explained in the eradicators' chapter, the bacterial impact on milk production in Aotearoa was only researched after the eradicators had led the other actors down the path of eradication (Hamill, 2019b; Compton et al., 2022). For Gamling (Veterinarian), too, there are many bovine diseases that are "more important than M. bovis" for production loss, including BVD, Johne's disease (*Mycobacterium avium subspecies paratuberculosis*) and *staphylococcus aureus* mastitis. They said, "we probably lose more cows on fodder beet", but "[b]ecause I don't really know what's happened in New Zealand from M. bovis, I don't know where to rank it" (Gamling).

This kind of talk, while frank, is inconsistent with the scientists' own role in the actor-network, which was to assert the importance of M. bovis as a topic worthy of research and funding. That funding would stop, however, with the eradicators' success, and meant that the eradicators could be viewed as contributing to the scientists' obstacle problem of lack of information. The scientists would have failed to successfully translate the actor-network by enrolling others in their quest for knowledge once the bacteria became Othered. This is an inherent tension or conflict in the scientists' relationship with the eradicators, which for all other purposes was mutually beneficial. Imrahil (Veterinarian) explained their understanding of that tension:

> I guess the other comment I'd make is that we are the only country in the world that has had a serious go at trying to eradicate bovis so that much of the learning that we've been able to get from our international colleagues, which there's been a lot of – collaboration and interaction, is in the context of endemic diseases in those countries. Yet we are looking through a very different lens and saying we need to find and kill these animals, these herds. So, it's a very different worldview from saying this in an endemic disease and we are just going to tolerate it and live with it to, no, we are going to find it and eradicate it.

That difference in goals changed the management expectations in the farming assemblage across the board because there is little point in disrupting farming practices if the cows are

[93] Bovine Viral Diarrhoea (BVD) costs the dairy industry at least $150 million each year in lost production (bvdfree.org.nz).

going to be slaughtered to get rid of the bacteria (Gamling, Veterinarian). For Bilbo (Veterinarian), eradication meant the loss of an "opportunity to do more study".

The alternative to eradication would have been an acceptance of M. bovis becoming endemic (where the bacteria have created a self-sustaining regional or national population) (Laven, 2019). Managing endemic M. bovis would have required an ongoing commitment to biosecurity practices, such as routine monitoring for mastitis, disposable glove use when milking, regular surveillance of herd health, strict management of the hospital herd and quarantining new arrivals, and regular bulk tank milk testing (Maunsell et al., 2011). In Australia and the USA, M. bovis is routinely managed using these types of biosecurity practices and farms that are managed well do not tend to experience diseases in cows:

> The Australians keep telling us that once farmers know what bovis is and they know how to manage it, welfare issues just disappear because they're much, much quicker at responding to it and they know what they are dealing with (Imrahil, Veterinarian).

Farmers in those countries will also routinely feed calves using milk replacement formula or pasteurised waste-milk, as opposed to the prevalent practice in Aotearoa of giving them unpasteurised waste-milk from a variety of farms (TAG, February 2018; Maunsell et al., 2011).[94]

An obstacle problem for veterinarians was not only that antibiotics lack efficacy against M. bovis diseases (Klein et al., 2019; Dudek et al., 2019), but also that the use of antimicrobial drugs to treat symptoms like mastitis has become a controversial topic. For example, the New Zealand Veterinary Association has expressed an aim to have no antimicrobial usage in Aotearoa by 2030. Gamling (Veterinarian) explained the problem:

> Last year we had some of our antibiotics become 'red', that we can't really use now. We are losing our antibiotics *per se* in New Zealand, especially the ones that have gone 'red'…Okay, all our drugs in New Zealand are in three groups. WHO standards. Red, orange or green. The 'red' would be the ones most likely to be useful, but if you read the literature there's really not much.

[94] Pasteurising waste-milk is the recommended practice, but the vast majority of farmers do not consider it to be practical: "[w]e had two or three farmers who pasteurised milk last year but the volume you need, it's quite labour intensive" (Gamling, Veterinarian).

As mentioned earlier, one of the scientists' obstacle problems was the willingness of M. bovis to cooperate with them, and one of the ways in which the bacteria have resisted problematisation was to continually make themselves invisible – within cow bodies and within the assemblage. This tactic of 'nothing to see here' has been dominant since those initial bacterial colonies were identified through those disloyal cows with severe mastitis and arthritis. This next section describes in more depth why bacterial invisibility was such an obstacle problem for the scientists.

6.3.1.2 Bacterial invisibility

As alluded to above, an inherent controversy existed between the scientists' interests and their research findings about M. bovis' behaviour on Aotearoa's farms. All the scientists interviewed for this research made a point of saying that M. bovis has resulted in very few severe disease expressions in Aotearoa. A typical comment from veterinarians was that the cows "don't actually get that sick" (Gamling, Veterinarian). Bilbo (Veterinarian) described M. bovis as an "almost benign" network presence. This section explores the multiple ways in which M. bovis made its presence materially absent to these scientific actors.

Even when antibodies to M. bovis were found through testing, so the scientists knew that the bacteria were present, the cows would, more often than not, appear to be "perfectly happy and healthy" (Imrahil, Veterinarian). This finding is consistent with the eradicators' expectation of a low impact on the dairy industry overall. Researchers have concluded that this healthy cow countenance was the reason why M. bovis-created diseases could manifest in seemingly closed herds: because of the introduction of asymptomatic cows (Maunsell et al., 2011; Faramir, Epidemiologist). When asked how M. bovis behaves in relation to its bovine hosts, Bilbo (Veterinarian) said, "it keeps its head down really, I think the bottom line is we don't know why it does what it does, but the majority of times it doesn't do anything apparent".

This manifest absence of disease came as a surprise to many of Aotearoa's veterinarians. The scientists considered that M. bovis bacteria were behaving differently than in many other countries where M. bovis is endemic (Peregrin, Researcher). While Aotearoa has a lower disease incidence than in other countries, Bilbo (Veterinarian) cautioned that there could be other factors at play here. They said that because there are comparatively few cow diseases in

Aotearoa, "we don't tend to look for disease so it's underdiagnosed…which means that we probably have more disease than we are aware of" (Bilbo).

The length of time between M. bovis being bodily present and a cow showing what scientists call 'clinical' or obvious signs of disease varied so widely from farm to farm that the usual method of physical observation that veterinarians relied on was not informative (MPI, n.d.c.). Silently infected cows remain reservoirs for the bacteria, shedding M. bovis via the respiratory tract (Jordan, 2021; Maunsell et al., 2011; Nicholas, et al., 2008). Moreover, M. bovis has proven to be tenacious and once *in situ*, those cows carry (and potentially spread) the bacteria for life (MPI, n.d.a.). (This is actually good news for the scientists, because their role as expert bacteria finders might continue through ongoing testing.)

There has been some scientific talk about 'cryptic' M. bovis infections, which are where the bacteria congregate and hide in the back of a cow's throat (in the pharynx), but again this is where the cow exhibits no signs of disease (Imrahil, Veterinarian). The theory is that where these cryptic infections exist, another actor such as calving, overcrowding, adverse weather, milking or another stress can trigger the bacteria to 'recrudesce', or recreate themselves and multiply, causing M. bovis to move around the body and congregate in certain areas that it favours, such as the mammary glands, joints, and respiratory tract (Gille, 2018). These recrudescent situations are experienced overseas as localised disease epidemics (Imrahil).

An obvious question for the scientists was whether individual cows could develop an immunity to diseases caused by M. bovis, but this was another area of disagreement. Nicholas et al. (2016) write that whole herds have frequently been seen to "spontaneously eliminate" (p. 144) M. bovis without human intervention, though how this occurs is not known. Bilbo (Veterinarian) thought that actual immunity to diseases caused by M. bovis was definitely possible, while Imrahil (Veterinarian) was more cautious, saying that animal bodies do make immunity but only to the extent that the diseases disappear. While experts disagreed about whether cows could develop immunity to the diseases caused by M. bovis, there was agreement that M. bovis is likely to be present even where cows 'self-cure' from the diseases. What was generally accepted is that, for reasons unknown, cows do seem to have periods of remission from diseases caused by M. bovis, making the bacteria manifestly absent (but not Other).

These multiple science realities all speak of M. bovis having a negligible impact on cow health,

for most cows. The bacteria's own low-key presence was a threat to the collective scientists' position as being the ones to speak with certainty about the many ways in which the bacteria could be harmful to the farming assemblage. Some scientists were openly agnostic about M. bovis' continued presence. Yet, where other actors and M. bovis collide under the right conditions, the bacteria are capable of manifesting in cruel ways for cows. Even within this statement of certainty, there are multiple variables that were of concern to the scientists. One of these variables, along with the type and size of farm, is how individual farmers enact biosecurity and whether they carry out those practices in a routine manner.

6.3.2 Matters of concern

6.3.2.1 Farmers' bio(in)security practices

One veterinarian has called Aotearoa's dairy farming "a colour by numbers farming system" (Bilbo, Veterinarian) because there are seasonal activities that have to occur like clockwork. For example, in Te Waipounamu, all cows are mated around the first week of November. For veterinarians, this seasonality is an opportunity for vigilance about animal health because it is possible to predict the peaks of bacterial or viral transfer during risky periods such as moving cows, mating, and calving (Biblo).

Yet, while the scientists have made themselves indispensable to the eradicators' success, they have failed to enrol most farmers in biosecurity. Farmers as a group understood biosecurity as a set of practices but they did not seem to action biosecurity in any meaningful way (Gamling, Veterinarian). An overarching theme from the scientists was that M. bovis has shown them just how "woefully inadequate" (Bilbo, Veterinarian) on-farm biosecurity is. Bilbo elaborated by saying:

> I think farmers' biosecurity practices are poor - they've never had FMD, so they're just slack. If you talk about other diseases such as BVD, for us as vets it has always been hard to convince farmers why biosecurity at a farm level is important.

Bilbo illustrated their point with reference to a farmers meeting held by MPI in the Early Days:

> [Farmers] came to meet with MPI (it was on the news) to talk about a biosecurity outbreak and everyone turned up in their muddy gumboots and that's indicative of the attitude that biosecurity is just unknown. That has got a lot better; for example, it is now uncommon to have farmers to come wandering into the clinic in their muddy gumboots.

> In New Zealand, as long as I've been here, that's just the norm, people just wander into the dairy in their muddy gumboots. But there wouldn't be many other developed countries in the world where you would leave the farm in your gumboots to go to town to do the shopping.

Imrahil (Veterinarian) explained that it is not only the lack of serious cow diseases but also the pasture-based assemblage that contributes to a lack of biosecurity practices. Farmers "move a lot of cattle relative to anywhere else in the world" (Imrahil), which is combined with a lack of testing for diseases because there is seemingly no need. On top of that, the scientific testing that occurs overseas does not have any traction in Aotearoa:

> You go to a farm in NZ and say, 'you should be testing for BVD, staph aureus, and they just laugh at you and say well my neighbours aren't, it's here we're just going to do it. Whereas, you go and talk to farmers in the United States and ask, 'when you are going to buy cattle, what do you do?', and they will reel off a list of diseases they test for – if they bring in cattle at all. So, it's just a really different mindset in different countries (Imrahil, Veterinarian).

Gollum (Epidemiologist) was perplexed by the lack of biosecurity consciousness among farmers: "I'm quite surprised at the level the conversation is starting at". Their view was similar to Bilbo's, that because Aotearoa does not have to manage endemic diseases on a scale that some other countries do, this absence in the actor-network has meant that:

> we don't have a nuanced view about what biosecurity could look like at the farm level. I'm always surprised at how binary our view of biosecurity is, that we feel like it's a job for the government…We have a cultural expectation that it is possible for diseases to be stopped at the border (Gollum, Epidemiologist).

Imrahil's (Veterinarian) experience was that "farmers would perceive that if MPI did their bloody job properly and the bugs stayed out, we would be able to continue trading stock and it's not our problem, it's someone else's problem".

Individual accountability for what is inherently a biological business asset is just not there in Aotearoa (Gollum, Epidemiologist). Gollum pointed out that there is "no real incentive because we don't have infectious diseases or someone else sorts it out, [so] why would you?". They summed up by expressing concern that "one of the things we are doing with this programme is trying to protect this kind of method of farming that's not particularly biosecure" (Gollum).

Biosecurity is a set of practices that is known about by farmers, but there is what Imrahil (Veterinarian) has called "the hearts and minds stuff", which relates to the work of *interessing* and keeping farmers enrolled in biosecurity. They commented:

> I'd like to think that people haven't been malicious and haven't tried to derail the eradication process, but conversely some of the farming behaviour hasn't helped – partly out of ignorance and partly out of, 'it's not an important disease and I'm not going to put a lot of effort into it'. There's all those social aspects to it that I think are the biggest challenge (Imrahil).

In the Early Days, Imrahil's farmer clients were 'hungry' for biosecurity information. Many inscription devices were produced by veterinarians and the eradicators around that time and subsequently, to feed that hunger and to enrol farmers in biosecurity practices. Two years into the eradication programme, however, biosecurity practices on farms had slipped back into non-use:

> [I]f we went out and randomly visited a hundred farms here in the Waikato today, I think we would find and this is really anecdotal, 10 percent or 20 percent of them would have systems in place just sitting there but they're just no longer using them. It's just no longer part of their farming culture - it was for a while, but it's kind of gone (Imrahil).

Another epidemiologist, Faramir, has been "fascinated" by the level of trust that farmers rely on when trading cows with each other. Given their role is to find the bacteria and connect each colony with its origins, they likened farmers' trust in each other to the HIV/AIDs epidemics of the 1980s and 1990s:

> When you look at people's networks, they are incredibly wide…I remember an AIDS ad on TV in the '90s. You know who your partner is, but you don't know who their partners are or who their partners are, and actually its exactly the same network when you look at [M. bovis] (Faramir).

The veterinarian reality of managing M. bovis at a farm level has been described as an insurance policy, where farmers should expect to pay the premiums every single day (Imrahil, Veterinarian). During spring, however, where farmers are working 15-hour days, they will not want to add extra time to their day by scrubbing boots between paddocks, cleaning tractor tyres or uploading cow movement information into the NAIT system. Those decisions are made on a cost/benefit basis and if the risk is not imminent, the incentive is little to none (Imrahil, Veterinarian; Faramir, Epidemiologist; Gollum, Epidemiologist). Overall, the scientists see

that they have failed to enrol farmers into performing biosecurity, even though this is the expert advice that is imparted time and again to farmers through inscription devices and persuasive conversations.

Many scientists have compared M. bovis with FMD, all observing with concern that farmers have been very lucky that M. bovis is slow-moving; if it had been FMD then the epidemiologists would have not been able to keep up with it (Faramir, Epidemiologist; Bilbo, Veterinarian; Stuff, 2018d). The reasons for this prediction were not just about poor biosecurity practices on-farm, though these are significant contributors, but also involved the surprisingly close relationship between dairy and beef farming and the number of times that cows have to move from farm to farm throughout the year (see the eradicators' chapter). For veterinarians, farmers' buying practices and biosecurity measures were judged as high-risk behaviours for the spread of M. bovis (and other cow diseases) (see Shortall et al., 2018). That leads into the next section, which describes this matter of concern for the scientists, and which, as will be seen, aligns with the eradicators' ontological position on cow mobilities.

6.3.2.2 Cow movements

A pervasive idea that is held onto in farming in Aotearoa is that the cows have to move - irrespective of disease risk. This idea is based on the pasture-based farming assemblage itself and is reinforced by the valued practice of sharemilking. In fact, Gollum (Epidemiologist) has already observed that what the eradicators are protecting with the eradication programme is not the cows' health but Aotearoa's "way of farming", an assemblage that has at its core:

> a semi-nomadic idea that you can move your things around and you can sell things and buy them back, and you can send lease bulls out and get them back again and send them out again, and that you can buy up a bunch of calves from farms and feed them discard milk or whatever it is. So, it's based on these practices that really no other countries have because they have infectious diseases, like *Mycoplasma bovis*, that are transported by animals and by milk and make these kind of practices not worthwhile.

Implicit in the sharemilking system, for example, is the notion that "you're going to move cattle" (Imrahil, Veterinarian). Not only is farm to farm movement crucial, but sharemilkers have to buy their cows from somewhere "and the flexibility, the ability to buy and trade stock is central to the sharemilking system" (Imrahil).

As Imrahil explained:

> [W]e have had a high level of freedom to move animals around New Zealand. New Zealand is the world champion at moving cattle, I would say, because of our sharemilking system whereby every year 10 or 15 percent of the dairy cattle in New Zealand move from one farm to another. People go out and buy animals from the Morrinsville saleyard and there's really no impediments to that. Now, that's great from a business point of view: it's allowed sharemilkers and people to grow herds and move animals, so from an economic point of view in the short-term and for flexibility of business structures, it's great. From a disease control point of view, it's not so good.

If the lack of knowledge about M. bovis was one part of the scientists' obstacle problem, another large part was the lack of knowledge among epidemiologists about the extent of cow mobilities across different farming types. Despite there being significant connections between beef and dairy cows, there was a prevailing view that the two farming types remained distinct parts of farming. Gollum (Epidemiologist):

> In my mind, we tidily had dairy cattle and beef cattle, but it's not like that at all, and so many, many, many farmers are doing multiple production types and there is cross-over between those production types and still at this point the magnitude of that cross-over is unknown.

Some of the scientists were generally surprised to discover that the majority of dairy calves are moved onto beef farming operations, and that beef cows move far more frequently between farms than dairy cows do in their lifetimes (Jordan et al., 2021). As a consequence, they learnt that all incidences of M. bovis on beef farms were linked to dairy farms, even though more beef farms had M. bovis than dairy farms as time went on, due to the vast movements of beef cows (Jordan et al., 2021).

The connections between the beef and dairy farming assemblages and other seasonal movements created the potential for extensive M. bovis mobilities, making this assemblage well-suited to the bacteria (Gollum, Epidemiologist). The corollary is, of course, that if Aotearoa had many endemic diseases in its national herd, such as M. bovis, there would be more incentive to deterritorialise the farming assemblage and farmers would have to enrol in biosecurity practices.

A thorn in the side of the scientists' narrative about the importance of biosecurity, particularly in such a mobile farming assemblage, was that while cow mobilities have been the main pathway for M. bovis to move around Aotearoa, most of the cows moving off farms with M. bovis have not managed to infect other cows on new farms. This research points to M. bovis not being highly transmissible between farms at a herd level (Jordan et al., 2021), and therefore less of an obstacle problem for farmers keeping the status quo.

There were several aspects to the scientists' OPP that they had to pass through to achieve their goals of increased knowledge about M. bovis and ensuring cow health. The scientific shibboleth was laboratory testing, because the trickiness of M. bovis meant that this was the only way to gain knowledge about where the bacteria were hiding. There were other aspects, too, which relate again to the practices of those unenrolled network actors - farmers. The scientists could not translate the dairy farming assemblage to be less intensive for cows, but it is this way of farming that the veterinarians and researchers must pass through because M. bovis is more likely to show itself within an intensive farming assemblage than an extensive one. Visibility of M. bovis emerged through the bacteria working with cows and other network actors such as climate, transportation, milking, calving and other bodily stressors to create diseases that the scientists could observe and learn from.

6.4 Obligatory passage points

6.4.1 Testing realities

M. bovis was first found or made scientifically present through testing in 1961, in the USA, and within the body of a cow who manifested severe mastitis (Hale et al., 1962, as cited in Laven, 2019). A material semiotic question arises as to who discovered M. bovis, the cow or the veterinarian, and indeed whether the bacteria had decided to show itself on that occasion (see Latour, 1988a). It is unknown how many other cows had quietly hosted and lived with M. bovis bacteria before this unnamed cow in 1961.

The key question for local scientists was how they could discover more about M. bovis' behaviour and impacts on cows in Aotearoa when much remained unknown about these bacteria worldwide. The unpredictability of cows being enrolled by M. bovis to create diseases meant that veterinarians could not tell whether M. bovis was present without conducting

scientific testing (TAG, April 2018; Hamill, 2019a). Even then, the testing had its own challenges with accuracy and reliability. Testing for M. bovis is time consuming and fraught with an inherent potential for error due to the two main tests' lack of sensitivity to the mutability of these bacteria (TAG, December 2017). Even with recent improvements, technical issues remain involving the sensitivity and specificity of the tests at both the level of individual bodies and the herd as a whole (TAG, April 2018).

The eradicators have tried to Other M. bovis by relying on the scientists and their expertise, but the scientists have been working with imperfect tests and imperfect movement data (Imrahil, Veterinarian). This complex and incomplete method assemblage is one reason for the large amount of testing that has taken place. According to Imrahil, "New Zealand has done more testing for bovis than any other country in the world". In addition, Aotearoa is the only country that has attempted to eradicate M. bovis, so that process has involved a steep learning curve in the way that scientific testing to find the bacteria is used (Imrahil). This is potentially still a worthwhile pursuit for the scientists long-term, because even as M. bovis is thought to be eradicated, testing will remain as a network actor for routine surveillance post-M. bovis.

Indeed, testing was possibly the most important technology for the scientists, and there are two main reasons for elevating this M. bovis reality's status. The first was the absence of clear disease manifestation in cow bodies, so that testing became the tool by which M. bovis materialised *qua* M. bovis. Testing identified and named the bacteria, making it a very important mediator. Secondly, testing acted with epidemiology to answer the question "[w]ho acquired infection from whom?" (Peregrin, Researcher). While testing sought to identify the presence of M. bovis, it could not prove its absence (Bilbo, Veterinarian; Laven, 2019). More on this point later.

Testing was a blunt technology without the sensitivity required to reliably find these bacteria (TAG, December 2017, April 2018). Yet, the technology itself has been made and remade by M. bovis' world-making and it has been refined in Aotearoa more than any other country in response to the eradicators attempts at translation (Imrahil, Veterinarian).

M. bovis bacteria were 'enacted' (Law & Mol, 2011) with two types of scientific tests: the polymerase chain reaction (PCR) test; and the enzyme-linked immunosorbent assay test, known colloquially as Elisa. The main difference between the two tests was that PCR testing

worked with the bacteria, whereas Elisa worked with a cow's own immune system. These two types of tests that were so influential in the eradication programme, and which co-created different M. bovis realities for the scientists, are described briefly below.

6.4.1.1 PCR testing

The first test to be used in Aotearoa was a PCR test, which works by identifying the bacteria's deoxyribonucleic acid (DNA) when bacteria are multiplying and shedding within a cow's body. PCR testing essentially hunts down M. bovis itself. To do this, PCR tests use samples from milk, swabs from the throats of cows and fluid from semen and joints. The main problem with this way of testing for the presence of M. bovis is that cows housing the bacteria only shed some of the bacteria during illness or times of stress, such as calving, milking, and moving, or when they are contemporaneously suffering from a disease like mastitis (DAC, September 2017). The requirement for a cow to cooperate (Latour, 1988a) with the scientists and shed bacteria is the reason why PCR testing can sometimes show a false negative result (DAC, September 2017). Therefore, PCR testing is best utilised during seasonal periods of stress or for testing symptomatic cows (DAC, September 2017).

One of the problematic ways that this test enacts the bacteria is by creating a perception of absence by creating a high number of false negatives. The invisibility of M. bovis combined with the lack of sensitivity in the PCR testing has meant that scientists have had to place a greater reliance on the antibodies made by the cows themselves to find the bacteria. Bovine bodies can go through a process that the scientists call 'seroconversion', which is where a cow's body creates an immune response to the presence of bacteria (Imrahil, Veterinarian). This is where cows can cooperate with the other type of testing, known as Elisa.

6.4.1.2 Elisa testing

Elisa uses samples from milk and an individual cow's blood to identify antibodies to M. bovis (Nicholas et al., 2008). The Elisa test also has some limits produced by the cows themselves, because approximately 20 percent of cows will not make antibodies to M. bovis, their bodies not recognising the threat (Laven, 2019). In this way, M. bovis can essentially "hide from the immune system" (MPI, n.d.c., p. 5; see also Nicholas, et al., 2016), making it able to evade detection by Elisa. This means that with both types of tests, "the absence of a positive test may not reflect an absence of infection" (MPI, n.d.c., p. 5). In addition, sometimes Elisa picks up

the antibodies from other bacteria present in a cow's system, making this test difficult to interpret (MPI, n.d.b.). The typical number of Elisa positive results that will appear from testing an infected herd is 30 to 70 percent, partly because cows develop their antibodies at different times (MPI, n.d.b.). The testing tells a story of a herd, not individual cows, so if more than 30 percent of cows test positive, the whole herd will be culled (MPI, n.d.b.). Laven (2019) says that for these reasons, detection of M. bovis remains the most accurate at a collective or herd level, rather than an individual level.

Paradoxically, one of the main challenges with finding M. bovis in Aotearoa has been because the scientists have been trying to prove a negative. Yet, one of the key problems that arises when trying to eradicate bacteria is that this proof of absence is "virtually impossible" (Bilbo, Veterinarian). A consequence of this difficulty is that the testing regime needs to continue well past the time when the 'last' M. bovis infected cow was thought to have been identified (Bilbo, Veterinarian). Adding another layer of difficulty to the challenge, Laven (2019) considers that there is currently no testing regime that is robust enough to prove the absence of M. bovis from beef and dairy farms in Aotearoa. Therefore, the scientists have recommended filling that gap with ongoing surveillance measures (see the eradicators' chapter). These measures still use the PCR and Elisa tests, but the testing is routine and ongoing, increasing the chances of detection.

In addition to testing for the bacteria, a further way to identify M. bovis was the traditional veterinary method of observing bovine bodies for signs of disease. This next section describes how the dairy farming assemblage has unwittingly helped the scientists achieve their goal by subjecting cows to intensive milking, shifting, and calving. What is also evident in the scientists' descriptions of M. bovis diseases, however, is that there are matters of concern that were out of their control and that they did not fully understand. For the scientists, these assemblage materialities were both aspects of their obstacle problem and their OPP alike.

6.4.2 Farming intensity and bacterial visibility

6.4.2.1 Making materialities

Many of those 1,000 cows on the Tainui farm (IP1) manifested severe clinical diseases, including very severe mastitis in dry cows (those who were yet to calve or not being milked) and that was unusual (Lugdush, Veterinarian; Laven, 2019). This first farm was a 'barn farm', so the cows were housed indoors in 'free-cell barns', and the veterinarians know that this style

of intensive farming has been associated with M. bovis diseases overseas (Lugdush). However, dairy farms the world over are intensive by their very nature: "it is the walking and milking, the confinement and the high-stocking rates that causes intensity" (Lugdush). It is not surprising then, that in Aotearoa the dairy farms that have showed up severe diseases associated with M. bovis have been "large multi-platform milking properties with frequent mixing of animal between herds" (Hamill, 2019a, p. 3). All of the veterinarians who participated in this research were in no doubt that "Mycoplasma bovis is a disease of intensity" (Lugdush).

One veterinarian has described dairy farming in Aotearoa as "extensively intensive" (Bilbo, Veterinarian), meaning that cows are mostly housed outdoors in an extensive pasture-based system, but that dairying is by its very nature experienced intensively by the cows (Lugdush, Veterinarian). Intensive farming, in contrast, generally involves cows being housed for most of the year, particularly in the winter months, and fed grain and supplements.

In Aotearoa, all of the severe cases have been seen on dairy farms only, and not on beef farms. Imrahil (Veterinarian) said that "in the more extensive beef systems for example, we have not seen any clinical disease; it has been confined to the dairy industry where clinical signs have been seen".

Most calves will become infected with M. bovis if the bacteria are present in a dairy herd. In beef herds, transmission rates tend to be low (less than seven percent) in calves that are not living in stressed conditions. In feedlots and in calves who have been transported, however, M. bovis is present in higher numbers even if disease appears to be absent (Maunsell et al., 2011). Maunsell et al. (2011), present the scientific conundrum well when they say that "the presence of M. bovis does not always result in disease, and clinical disease does not appear necessary for the maintenance and dissemination of M. bovis in the cattle population" (p. 772).

Nicholas et al. (2008) observe that while M. bovis initially presented in the UK as severe mastitis, often accompanied by arthritis, in recent times, the bacteria have more commonly presented in that part of the world as pneumonia, evidencing the presence of multiple disease ontologies. Conversely, those diseases that are caused with M. bovis (e.g., pneumonia and mastitis) can be caused with multiple microbial actors (other types of bacteria or viruses).

Similarly, the way that M. bovis manifests its presence in bovine bodies is tied up with the other actors who influence those bodies, whether it be the severity of climate, the intensity of farming, the type of farming, animal husbandry practices and priorities, or seasonal pressures such as mating and calving. Indeed, the reason why cows on some farms in Aotearoa have been impacted more severely than others is unknown by all the scientists who were interviewed. For Bilbo (Veterinarian), "[t]hat's the million-dollar question…what are the risk factors that precipitate clinical disease as opposed to subclinical or asymptomatic disease? Is it management, as I say, is it loading, is it route of transmission?".

As Arwen (Government) explained, "[a]nd of course the next stress event whatever it is, is a sleeping time bomb". As to which of these are the riskiest farming practices or other factors for M. bovis, the scientists have not said. As Bilbo (Veterinarian) observed ironically, "I don't know if we will ever know because if we are successful in eradicating it, we won't have the opportunity of finding out what factors precipitate the disease". The scientists' ability to trace the bacteria's network building has been lost with the near Othering of M. bovis from the farming assemblage. For veterinarians in particular, disease manifestation was a key part of their OPP, because it allowed them to identify and then study the bacteria's behaviour. However, there are other actors that interacted with cows, making that study less pure than they were comfortable with.

The fight between cow health and M. bovis swings from side to side like a pendulum (Faramir, Epidemiologist). If the farming environment changes abruptly due to drought or severe storms, for example, then that mediator moves the pendulum in favour of M. bovis' expression because the cow becomes more vulnerable. For Faramir, this is when "the pathogen starts to get the upper hand and it has more power (virulence) against the host". Peregrin (Researcher) explained that "[i]t is the same with people, if you are immunocompromised or if you're stressed in another way, then you are more likely to develop more severe symptoms".

There are other events that scientists pondered, too, like why some M. bovis infected farms would be the source for many other farms getting M. bovis while other infected farms would not be, even with subsequent and multiple cow movements. For Gollum (Epidemiologist), "[t]hat's the kind of thing you wonder about because there is obviously heterogeneity at the animal level and at the farm level and that's causing these differences, but we aren't yet able to predict which ones have different outcomes". One veterinarian was very clear that these

matters of concern were not due to any inherent differences in the bacteria from farm to farm. Imrahil said, “no, it’s almost certainly differences in the animals and in the management systems that the people are running”.

There are some farms that are generally known to have more disease manifestations than others due to poor animal husbandry practices, stocking levels, farming aptitude, and lack of nutrition (Bilbo, Veterinarian). Bilbo used the example of the FMD outbreak that started on a north Cumbrian farm called the Burnside farm. They said that farm was “reasonably shambolic”, which had the benefit of allowing FMD to spread rapidly and therefore be detected quickly. They said, “[b]ut you could argue that it wouldn’t have arrived there if it hadn’t been so shambolic” (Bilbo).

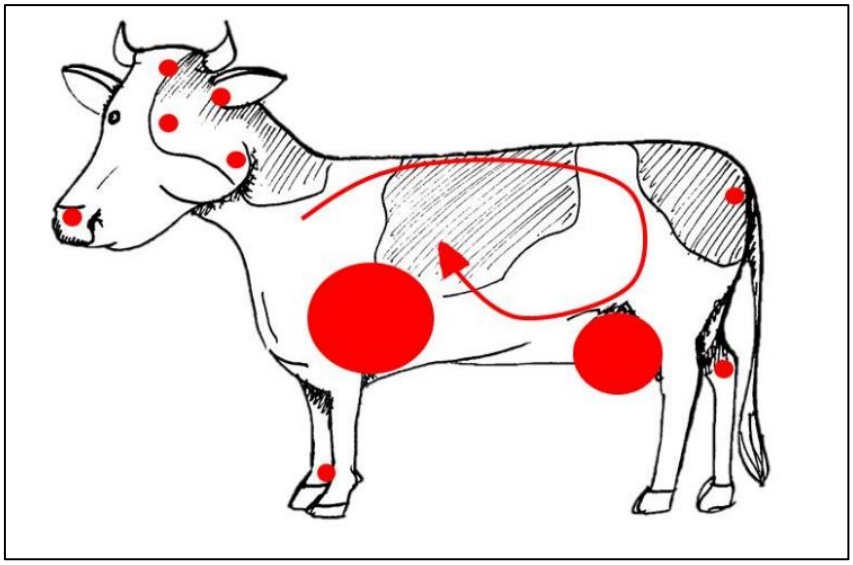
As Faramir has already explained, for epidemiologists (and veterinarians like Bilbo and Imrahil) a bodily, bacterial gathering only generally occurs when other ‘sufficiency’ factors (or materialities) are involved that mediate the outcome. These include calving (parturition), drying off from being milked, being transported or inclement weather events (Laven, 2019). Indeed, it is because of M. bovis’ need to cooperate with others to become visible that scientists know it as “an opportunistic pathogen” (Kearney, 2021, p. 110).

Below is a section that briefly describes how M. bovis can manifest its presence in cow bodies, which was a key part of the scientists’ OPP.

6.4.2.2 Manifest presences

For M. bovis to become materially present to the scientists, the bacteria had to take three actions. Firstly, they had to multiply; second, they had to move around the cow’s body using the bloodstream as a vehicle; and third, the bacteria had to come together as a colony, congregating in one place in the body (Gille, 2018). These bacterial colonies favour certain bodily regions, such as a cow’s udder, lungs or her joints (Laven, 2019; Kearney, 2021; Lugdush, Veterinarian). This congregation and further multiplication enacts inflammation and disease within the cow (MPI, n.d.a.). Below (*Figure 18*) is an illustration of the bodily sites that M. bovis bacteria are attracted to.

Figure 18
Most favoured sites of M. bovis expression (Gille, 2018, p. 12)



As this diagram shows, M. bovis bacteria can make their presence felt and seen through the manifestation of multiple ailments such as mastitis, lameness, and pneumonia (DAC, September 2017). The mastitis associated with M. bovis (as opposed to other bacteria) has a unique presentation, often severe and multi-quarter (although as mentioned the cows do not necessary appear to be unwell in themselves (Gamling, Veterinarian; see also Nicholas et al., 2016). However, Lugdush (Veterinarian) has described M. bovis presentations as "cruel".

M. bovis has also been linked to ear infections (otitis) and inflammatory eye conditions (keratoconjunctivitis) in calves, and abortion in cows (Nicholas & Ayling, 2003; Nicholas et al., 2008). Overseas, M. bovis is a significant cause of calf pneumonia (Nicholas et al., 2008). The outward signs of M. bovis infecting calves can include a harsh cough, ear droop, and mild depression (Nicholas, et al., 2008). As already discussed, the scientists know no effective treatments for those cow diseases that are made with M. bovis (Nicholas et al., 2016; DAC, September 2017), so where there is an emergence of disease in a herd, culling and disinfecting are the standard management options (Imrahil, Veterinarian). Almost always, however, that localised 'epidemic' of disease presence disappears for a period, only to re-emerge at some time in the future (Imrahil).

6.5 Conclusion

To recap, the scientists wanted to deterritorialise farming with biosecurity so that they could increase their knowledge about M. bovis. For the scientists, M. bovis was a controversy that they wanted to settle as a matter of fact, so they could build their black box of knowledge (Latour, 1987). Yet, the scientists' increased knowledge about M. bovis was never a matter of fact, rather it was the human actors' means of reifying 'nature', which could only ever be relied on as an outcome of the scientists' translation of the M. bovis problem (Latour, 1987). Nature cannot settle this type of controversy, rather it was called in aid by the scientists as a justification for constructing their own facts (Latour, 1987).

The scientists knew multiple realities of M. bovis in Aotearoa, made evident through laboratories, tests and clinical examinations (Law & Mol, 2011). M. bovis' slowness, and the incapability of the NAIT system, were temporal elements for the epidemiologists, who also enacted a spatiality in tracing or mapping the disease cartographically (Law & Mol, 2011). Yet, M. bovis taught the scientists about testing for it and finding it. The different scientists each became a spokesperson for the bacteria (Latour, 1987), each enacting their own time and space relations with M. bovis which, while made differently, worked together to make a coherent scientific reality (Law & Mol, 2011; Law & Singleton, 2015). The different disciplines paid 'attention to each other' (Enticott, 2016b, p. 38), resulting in "hybrid ways of knowing and controlling" M. bovis (Enticott, 2017, p. 154).

The scientists have built their world by enrolling others in believing in their translation of M. bovis' controversy (Latour, 1987). The eradicators, who had a vested interest in the scientists being certain about M. bovis' behaviour, looked to the scientists as the keepers of technical expertise to guide them about how much of a risk to take with M. bovis' presence in the farming assemblage. Would the bacteria impact on the productivity of dairy cows? The scientists ultimately thought not, so it is unfortunate for the cows and M. bovis that the eradicators could not wait for the scientists to carry out their detailed research. While the scientists initially *interessed* the eradicators in their programme of research, they lost them because each ultimately had divergent goals even though both actors shared the 'M. bovis problem' and both wanted farmers to do biosecurity (see Latour [1987, pp. 108-109] for the tension that *interessement* can create).

Like the eradicators, the scientists had ongoing obstacle problems that were fundamental to farming in Aotearoa. These were matters outside of the scientists' control, but they were within the control of another group of actors - the farmers. The next chapter describes the farmers' M. bovis worlds, including their goals, the obstacles they experienced and the OPP they had to pass through to achieve them.

Chapter 7 The farmers

If you want a key learn on my part, my biggest learn from M. bovis wasn't about biosecurity. My biggest learn from M. bovis was how removed the decision-makers in Wellington are from us. They don't know how to communicate with us; they think we are a threat (Elladan, Farmer).

7.1 Introduction

This chapter interrogates the M. bovis realities of a small group of Aotearoa's farmers, transporters, and stock agents, some of whom have had M. bovis on their farms, others of whom have not, but each have interacted with MPI and/or the eradicators as part of the farming actor-network. This collective actor is known as 'farmers'. While this chapter speaks of the farmers as a macro-network of actors, there is more caution exercised here than in the previous two chapters because this set of actors presents as more internally fractured than the eradicators and the scientists. While farmers shared the collective goals of having healthy and productive cows, these goals were enacted individually for farmers and their businesses. Unlike the scientists' goal of healthy cows, the farmers' goal manifested itself in each of their own herds, not necessarily impacting on the 'national herd' or for a greater benefit. Paradoxically, there is also more homogeneity among this group than within the eradicators. For example, none of the farmers interviewed were scientists or eradicators, unlike the previous actors who came to their roles as individuals from a range of disciplines (see the methodology chapter).

This chapter makes space for farmers' M. bovis realities, and it is here that the conflict created by M. bovis' presence really manifests. Farmers have shared many stories of contestation, arising either among themselves or in connection with the eradicators. The sources of conflict ranged from the eradication programme itself, the impacts of M. bovis (or lack thereof), to other farmers' behaviours impacting on the collective. It will be noted that, while the eradicators and the scientists spoke about farmers and for M. bovis quite forcefully, the farmers, while forceful about their relationships with the eradicators, have tended to speak more personally about the impacts of M. bovis and the eradication programme, which for them could not be separated out.

The practices of farming are multiple in Aotearoa, making it somewhat meaningless to generalise about how farmers 'farm' here. However, there is also a shared world of farming

identities and epistemologies that influence farming and biosecurity practices (Enticott, 2016a; Enticott & Vanclay, 2011; Jaye et al., 2022). Farmers' realities are heavily bound up with geographies, seasons and economic imperatives. The farming metanarrative of productivism (of increased production and intensification) has already betrayed M. bovis' presence and arguably led to the bacteria's demise. Indeed, it was within a large and highly productive dairy farm that M. bovis was exposed by stressed cows and frail calves during a wet and unyielding Waitaha winter. One of the purposes of this chapter is to describe how the farming assemblage itself 'makes' M. bovis and how these ways are unique to Aotearoa.

7.1.1 Farmers' world-making

Farmers not only enacted M. bovis differently to the other actors, but each farmer also enacted M. bovis in place, along with other network interferences that were particular to that farm (Law, 2004; Law & Singleton, 2015). There are many variables within the farming assemblage, as the scientists have already recognised. Farmers are perhaps the best people to ask how M. bovis interacts with their cows (Enticott, 2008b), but there is no singular answer; so, this knowledge was less helpful than the eradicators may have hoped for. For example, several farmers expressed the reality that they 'know' their cows and that, despite the veterinarians telling them the cows had M. bovis, their cows were not unwell. Yet, others (a minority) described severe and distressing disease expression in their cows and calves. Farmers knew through previous experience that cow diseases are more-than-binary, neither continuously present, nor absent, and not always impactful.

This part of the thesis brings forth the farmers' stories - including their realities of living *with* M. bovis. Inevitably, these stories were also shaped by the actions of the eradicators, as they sought to Other M. bovis and enrol farmers and their cows in their network. The M. bovis eradication programme has influenced how farmers experience the presence of M. bovis, and it is a murky distinction to separate the mere presence of M. bovis from the consequences of an organised biosecurity response to that presence. Echoing the research of Enticott, this chapter describes farmers' shared understandings about the role of biosecurity (Enticott & Wilkinson, 2013; Enticott et al., 2014; Vanclay & Enticott, 2011), their lack of trust in and frustrations with the eradicators (Enticott, 2008b; Enticott et al., 2021; Jaye et al., 2021), and their lived experiences of being 'good farmers' (Shortall et al., 2018; Enticott et al., 2021; Enticott & Little, 2022). Farmers have also said that they have felt like their knowledge was

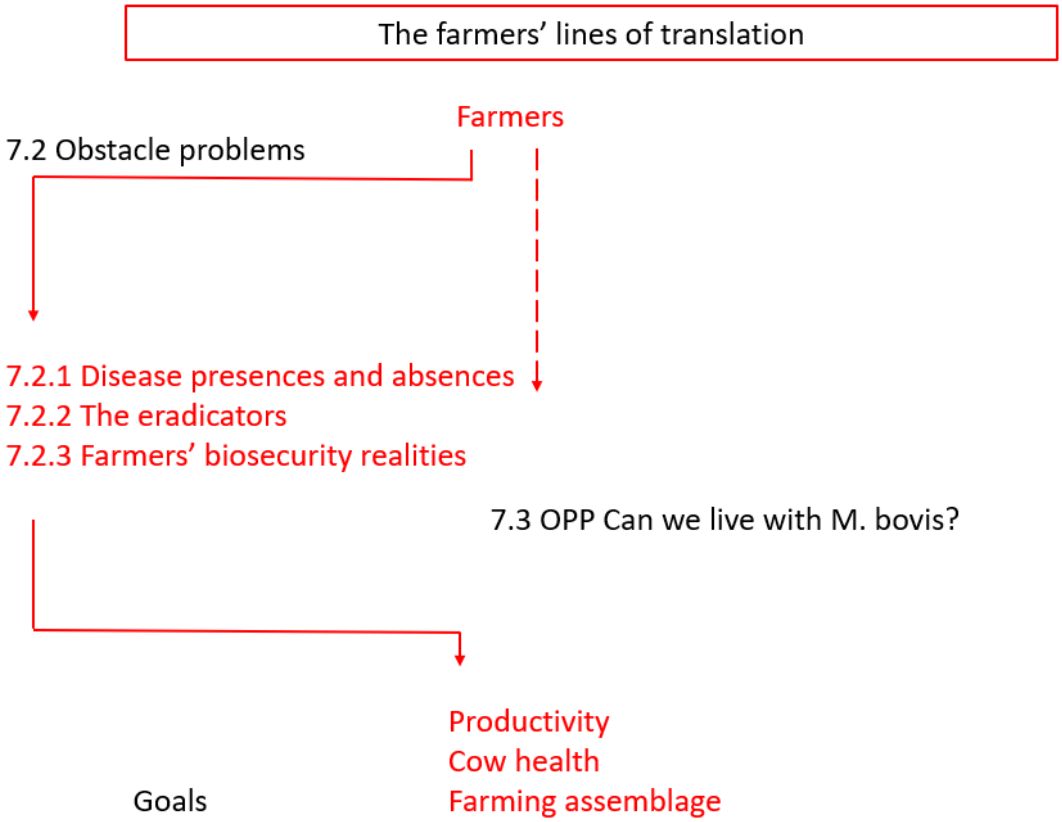
unvalued and marginalised by the eradicators, leading to discussions about the impacts of that epistemological gulf on the eradicators' success (Enticott, 2008a; Helliwell et al., 2019; Gates et al., 2021).

This chapter aims to unpack the obstacles that the bacteria posed for farmers retaining and reaching their collective actor-network goals and describes their OPP and how it could be achieved. Ultimately, and perhaps surprisingly, this chapter will show that farmers and the eradicators have something in common: both sets of actors wanted to retain the farming assemblage without deterritorialising it. There is another actor that shared these lines of articulation (Deleuze & Guattari, 2004; Rosin et al., 2013), too, and that was M. bovis itself, but that story is not yet ready to be told.

7.1.2 Narrative structure

The chart below (*Figure 19*) setting out the farmers' obstacle problems, OPP, and goals will be familiar by now. As will be seen, the farmers had three main goals: healthy cows, productive cows, and retaining the farming assemblage as is. Apart from the general fear and conflict that M. bovis has caused among those associated with farming, farmers have had several significant obstacle problems to overcome. One of these problems was disease manifestation in cows and calves (on a small minority of farms, granted, but these disease situations caused fear among the rest). Another was the need to engage with the eradicators with all their restrictions and requirements (who were mostly unwelcome, especially in the Early Days). The third obstacle problem for farmers was the expectation that they undertake biosecurity practices that were incompatible with their day-to-day farming realities. Structurally, this chapter takes each of the farmers' obstacle problems in turn before turning to their OPP question, which was whether they could live with M. bovis without it impacting on cow health and productivity or deterritorialising the farming assemblage.

Figure 19
The farmers' lines of translation



If the farmers could overcome their obstacle problems, then they were likely to be able to live with M. bovis, just as they live with BVD and other microbes.

However, a key obstacle problem for farmers was the presence/existence of the eradicators. This was a matter of concern that the farmers could not influence. On the one hand, the eradicators were unwelcome, but, on the other, the eradicators enabled the farmers to continue farming as they always have done, because M. bovis goes away with the eradicators' success. This was a timebound conundrum for farmers, whereas for the eradicators, eradicating M. bovis meant that they could not achieve their twin goal of better on-farm biosecurity, which was an obstacle problem that the farmers shared with the eradicators, but for entirely different reasons.

This chapter will show that farmers were not prepared to translate the farming assemblage to incorporate less intensity (dairy farmers in particular) or to enact routine biosecurity practices (as the eradicators have tried to mobilise them to do). As to disease presence, M. bovis was

benign in the majority of cases, and the eradicators and the scientists said that there were no real production impacts, so the farmers could achieve their goals without enduring a fundamental 'rupture' in how they farm (see Campbell, 2021, pp. 87-89).

A note here on the size of this chapter compared to the eradicators and scientists' chapters. One of the reasons that this chapter is slimmer and less complex is because farmers have spoken more quietly about biosecurity than the other human actors; that is, if they have discussed biosecurity at all. This absence of biosecurity concern (other than the eradicators' requirements being problematic) raises a question about whether farmers were simply unwilling to engage with biosecurity practices and embrace them into their realities, or whether there was something already assembled within the network that influenced their ability to deterritorialise farming.

7.2 Obstacle problems

The farmers' obstacle problems of M. bovis diseases (mastitis being a key one for dairy farmers), biosecurity requirements and restrictions, and the invasion of their farms by the eradicators were experienced concurrently. For farmers, it was difficult to separate out these M. bovis realities, yet they are treated distinctly here for clarity. This part begins with an exploration of farmers' realities of M. bovis disease presences and absences. Similar to the veterinarians and epidemiologists, farmers' experiences of M. bovis were strongly influenced by actors other than the bacteria themselves.

7.2.1 Disease presences and absences

M. bovis bacteria made their way onto farms through routine cow movements and common stock purchasing practices. Prior to M. bovis, one farmer would routinely drive around Te Taurapa o Te Waka collecting calves from 20 or more properties for rearing and bringing them all together on the family farm (RNZ, 2018c). When this farmer unwittingly brought M. bovis onto the farm, he did notice that many of the calves were 'crook' but he thought they might have rotavirus or another disease, so he decided to keep them anyway. After encountering M. bovis, rather than changing his calf purchasing practices (which were integral to his profitability), this farmer decided to simply stop rearing calves (RNZ, 2018c).

There was another calf-rearer who bought calves directly from the VLDG, the farming company that owned Tainui farm (IP1). Here, as Grimbold (Farmer) explained, the actor-network tentacles of M. bovis had unfortunate and unforeseen consequences for the human actors:

> She was rearing them, and the calves were turning up not right, and she was saying they're not right, and she was doing the rearing on weight gain to get them to 100kg on contract, and obviously a lot didn't make it, a lot died. Then she wasn't getting paid, and that put pressure on her family and marriage, and they ended up splitting up. It's quite far reaching, aye.

Grimbold themselves were a farmer who had purchased some yearling bulls they were told were from Te Matau-a-Māui, but who did not independently confirm their origins. They later discovered that the Te Matau-a-Māui farmer had previously bought those bulls up from Te Waipounamu, and with them M. bovis. Gwaihir was another farmer who had purchased some weaner bulls from a Te Ika a Māui saleyard. They knew the bulls had come up from Te Waipounamu but was "assured that they were well away from the M. bovis problem". Gwaihir unwittingly purchased M. bovis infected calves from Waitaha because they were 'a nice line' and they were "probably sold a little bit cheaper than what the others were".

As the scientists already described, on dairy farms where M. bovis has expressed itself in diseases, that expression has been particularly severe. The Potgieters were sharemilkers on the Tainui farm and the ones who first reported seeing severe diseases in their cows and calves. This farm was a highly productive and intensive dairy farm, where the cows would calve in different mobs four times a year. M. bovis diseases were made manifest by the cows in July 2017, when 400 of the cows who had been dried off were due to calve. However, there was a lot of rain that June and the rain brought flooding so high that "the K-Lines were drifting over the fence lines in the paddocks" (RNZ, 2018g).[95] The Potgieters ended up bringing the dry cows into the barns, but the cold, wet weather and floods would have been a stressor on these heavily pregnant cow bodies.

These sharemilkers experienced the harsh reality of 'disease M. bovis'. There were cows with severe mastitis, which included a butter-like substance when milked, and cows struggling to

[95] K-Line is a type of irrigation system.

walk due to arthritis. A total of 162 cows in that initial mob were physically unwell and suffering, or nearly half of the mob (RNZ, 2018g). There were many distressing aspects of M. bovis for the Potgieters, but something that Mrs Potgieter found particularly hard to deal with was that the meat processor refused to slaughter the sick and dying calves. They would only be picked up by the pet food company, who would come and "shoot the calves in the pens…[but there] were still calves alive as they were only allowed to take a certain number a day" (RNZ, 2018g). In this ontology of 'disease M. bovis', the farmers' goals of healthy and productive cows were thwarted by M. bovis working with intensity and severe weather to express itself in cruel ways. Layered over the top of that experience was the farmers' difficult engagement with MPI and subsequently with the eradicators, as will be described below.

Mostly, however, farmers knew a 'benign M. bovis', which involved their cows testing positive for M. bovis but not being visibly unwell. The Booths were a prime example, where their herd tested positive for M. bovis, but their farming experience told them otherwise. They said, "[w]e know these animals in and out. None of our cows were sick" (Stuff, 2020). Gwaihir (Farmer) had a very similar story. One of their bulls tested positive for M. bovis, yet Gwaihir reiterated the theme that "the animal wasn't sick". For another Waikato farmer, who unsuspectingly bought dairy cows from an infected herd in Te Waipounamu, his reality of M. bovis was that "in most instances the animals that carry it are never sick with it" (Stuff, 2019). For that farmer, M. bovis "was really blown out of proportion...*Mycoplasma bovis* is nothing" (RNZ, 2019b). This farmer was clear that eradication was a waste of taxpayers' dollars because the impacts of M. bovis had been exaggerated. It was a similar story for another M. bovis-affected farmer, who thought that the culling of herds had "become senseless" and suggested that movement controls such as those used for the management of bTB would be more appropriate. He said, the "[r]est of the world handles diseases like bovis. Our cows are asymptomatic" (RNZ, 2018d). Similarly, for beef farmer Samwise, M. bovis was "only a relatively mild disease and we shouldn't lose too much sleep over it".

There were others who genuinely believed that they had already been living with M. bovis for some time and that it had not caused any problems for most farmers. As Shelob (Transporter) recounted:

> I know so many other people that felt the same way, that bovis has been here for longer than we know, and it's probably still within different herds. It's just as stress levels rise and the animal's body changes, it has more chance of showing up.

There are many more stories like these, which include farmers' experiences of being enrolled in the eradication programme, whether by coercion or acquiescence. It is to farmers' experiences of the eradicators that this chapter now turns.

7.2.2 The eradicators

The eradicators' attempt at translation was not only undermined by M. bovis' unwillingness to cooperate, but by division among farmers about the necessity and the implementation of the programme itself. The eradication programme highlighted for Elladan (Farmer) the "void between rural New Zealand and the government". They questioned why the eradicators did not "come out and talk to people like me? I'll actually put you on the straight and narrow". Surprisingly, Elladan was eventually mobilised by the eradicators, and what motivated them was the fear of losing their 'girls' (the milking herd). It is unclear whether Elladan's fear was of the eradicators or M. bovis, or both.

Adelard (Stock agent) was sceptical about the eradication decision at the beginning, but as time went on and it became more successful, they were another to become willingly enrolled in the programme. Other farmers willingly mobilised alongside the eradicators, too, especially when they were listened to and engaged as experts. For example, Adelard was an advisor to the eradicators about farming practices. The problem for them was that farmers are a diverse group and they all farm differently, which confused MPI and made its compensation decision-making, based on immutability, fraught with an absence of local farming knowledge.[96] Adelard explained:

> I have a close working relationship with MPI with the valuations, and at one stage I was going up there once a week to Wellington and they would ask me questions around stock and farming. They were working under the [Biosecurity] Act [1993] and they're not farmers, you know, and we said at the start that everybody's trying to turn grass into money – how one guy will do and their neighbour right across the fence could be

[96] Farmers who had to comply with the biosecurity response and/or subsequent eradication programme, and who suffered financial losses because of the actions of MPI and/or the eradicators, were entitled to compensation to put them in a "no better or worse position" than they would otherwise have been (section 162A(4) of the Biosecurity Act 1993).

> vastly different. There's so many variations, even across dairy farmers how they achieve their production…I don't know about compensation law, they didn't know about farming.

That 'gap' in understanding between MPI and farmers took some time to bridge, but Adelard thought that each side became closer through the challenge "because it had to be made to work". Others were ambivalent. Grimbold (Farmer) was initially surprised at the eradication approach but eventually conceded that the eradicators were "doing a good fist of it". Most of the farmers, however, were only enrolled in the programme by coercion, if they were ever enrolled at all.

A farmer who has been vocal in the media about being *interessed* away from the eradicators by his cows and calves was Hank Smit, who was the first Te Ika a Māui farmer known to have M. bovis on his dairy farm. He had purchased cows from the Zeestraten farm (IP8) in Te Taurapa o Te Waka and the bacteria had travelled north with those cows. Mr Smit received death threats because he had M. bovis on his farm, and a bullet was sent to him through the mail (Stuff, 2019). The death threats were manageable for this farmer, and he never bothered to report them, but what he found nearly impossible to deal with was shooting the new-born calves every day for 60 days consecutively (RNZ, 2019b). His contract milker attempted suicide because of this task – a task that the eradicators required of them both. Mr Smit was getting out of dairy farming because of M. bovis and the eradicators, claiming that he had had a "guts-full" of it all (RNZ, 2019b).

The Potgieters said that they lost everything because of M. bovis and MPI: "M bovis and MPI have ruined our lives, our whole livelihood, our business" (RNZ, 2018g). What those sharemilkers learnt was to keep their own counsel - they would not disclose M. bovis' presence a second time. For the Potgieters, the eradicators had privileged the realities of "the so-called experts who had little knowledge of the disease rather than the farmers themselves". It was those sharemilkers who first identified that the cows were unhealthy. It was they who "managed to get it under control once and [they] could do it again without MPI's help" (RNZ, 2018g).

Transporters were at the heart of the movement controls on and biosecurity restrictions for cows, who along with stock agents were key OPPs for cow mobilities in Aotearoa. Shelob (Transporter) told the story of a dairy farmer who, at the height of the eradication programme, wanted to know if the trucks would be washed out before picking up his 600 cows for winter

grazing. Shelob told him it would not be possible, because that was the first week in June during which all of the sharemilkers and contract milkers move their herds (colloquially known as moving week).[97] Shelob said that once the farmer knew that they could not "spend two or three hours washing out the trucks, he said don't worry and that he'd leave them on the paddocks to pug the paddocks. That was his call". One of the problems with the eradicators' requirement to wash out trucks was that many farms do not have the kinds of facilities which involve high pressure hoses, a high-water volume and the ability to safely dispose of the effluent. The eradicators' requirements financially impacted Shelob's business in other ways, too. As they explained, stock trucks normally operate fully loaded with cows, which requires carting cows one way and backloading them from another farm on the return journey. The truck wash requirement meant that the ability to backload was gone, and this became very inefficient for transporters carting cows long distances one way because MPI did not compensate transporters for running back with empty trucks.

The farmers who were unable to move cows, or who had cows out for grazing that could not come back onto the farm for calving, because of the eradicators' movement restrictions, found the practicalities of that situation incongruous with efficient farming practices (Stuff, 2019). As one farming couple relayed:

> We were hamstrung in the normal farming decisions you'd make and that took an emotional toll. April was very wet so [the cows] were churning up and turning the farm to mud. All of the grass got consumed. We were supplementing that with bailage that we were meant to sell and that caused a cash-flow problem. That's not the way we would choose to farm (Stuff, 2018c).

For Shelob (Transporter), "all the conditions and the structure we have to put in to keep our drivers clean and our trucks up to standard" took an emotional toll on their drivers as well as a financial one on their business. That pressure was described as a "social cost" of the eradication programme, and Shelob recalled the stress of that period:

> I think that's the big bit of it that you can't put that social cost down, I don't know how you take people's lives and say they were shortened by a year or two because of the

[97] Traditionally sharemilkers and contract milkers would move their cows and stock on 1 June, and this was known as Gypsy Day.

> stress they've gone through. That's probably the reality of how a lot of the transport operators felt – they were put through the wringer, absolutely awful.

In the Early Days, the market became "very sticky" for selling cows, particularly from Te Waipounamu (Adelard, Stock agent). Many farmers were "paranoid" about getting M. bovis, to the point where even cows from neighbours to M. bovis-affected farms with would not be bought at the saleyards (Adelard). The farmers talked about the same misunderstandings about M. bovis as the eradicators did, in particular how the bacteria were "plagued" by "misinformation and pub talk and all that right at the start, and it just fired a lot of people up that didn't need firing up" (Adelard). There were some farmers who even thought that M. bovis was government propaganda, made up to justify a reduction in cow numbers and farms across the country (Elladan, Farmer). Elladan remained angry about the way that the eradicators had spoken about farmers publicly:

> [D]on't keep whipping us in the media because we're going to come and punch you in the nose – eventually. At the moment, we are all just hiding down any rabbit hole we can find, but eventually we'll get sick of you. And we will come up and get angry.

The farmers roundly criticised MPI in all kinds of ways. From not shutting down the saleyards (Elladan, Farmer), to MPI building up teams of inexperienced actors when there was already the TB Free programme to leverage from (including veterinarians who already have farmer relationships) (Grimbold, Farmer), to the eradicators' compensation scheme being inadequately responsive to the fluidity of the farming assemblage (Samwise, Farmer). Farmers also observed that the relationships between key biosecurity actors was strained, such as between MPI and OSPRI (Grimbold), and MPI and AsureQuality (Gwaihir, Farmer). Some of these criticisms echoed industry criticisms of MPI, including not collaborating with LIC to obtain breeding information about the national cow herd (see the eradicators' chapter). Then, there were fractures within MPI itself, as the eradicators have already acknowledged. For Shelob (Transporter), a key obstacle was finding the right person within MPI to talk to, because the issue of truck washing was dealt with by a different person to the issue of meat processing. The lack of farmer trust in the eradicators ran deep and, for many, remains unchangeable:

> If foot and mouth hit next week, the country would be buggered. We would be absolutely…I was working in the foot and mouth working group, maybe five or six years ago when they were reviewing it, and the people there are so unrealistic about how things happen in the real world – they've got no idea. I'd hate foot and mouth to

> arrive here, because you and me - our economy - would just be destroyed (Shelob, Transporter).

Another example was given by Gwaihir (Farmer), who could not see the sense in culling a herd that was 'terminal' (going directly from their farm to slaughter). This type of approach from the MPI was viewed by farmers as nonsensical and it exposed their lack of farming knowledge, further ingraining a lack of trust. Another farmer was perplexed by an encounter with an AsureQuality staff member who "had no idea what was going on on the farm. He was talking about going and scrubbing troughs in the night, it was just weird" (Samwise, Farmer). Yet, these uninitiated and inexperienced actors were controlling the farmers' businesses, and this situation added to the conflict between the eradicators and farmers. Samwise said:

> To think that this person has no idea what they're talking about and they're taking my livelihood and…for example, it says on my piece of paper that you must not cross the road. Mate, I have to cross the road, so the question isn't that we are not going to cross the road, it's how we are going to do it.

There was a different language spoken by farmers to that of the eradicators, which worked against the eradicators' attempt to translate the will of farmers. As Elladan (Farmer) explained, "We can talk farmer language. I can pick a document written by MPI a hundred miles away by now."

Another criticism was that MPI did not engage local veterinarians immediately. Elladan said they found out about M. bovis before their local veterinarian knew about it. Yet, veterinarians are respected in rural communities and are looked to by farmers for knowledge about cow welfare and health. Elladan explained, "[b]y not letting the local vets know, that make me shit myself. I realised that these people do not know how rural New Zealand works". Denethor (Farmer) did not mince their words, either. They remained completely unenrolled by the eradicators. This is an excerpt from their personal diary during the Early Days:

> [T]he bigger problem here is that these ignorant arrogant pricks really think they can get on top of this M. bovis without involving us as the affected farmer. Just complete stupidity on their behalf!!! A couple of simple questions could have solved this, but we are stuffed, as they know best!!

Denethor's experience was that MPI was "out of touch with what actually happens on a farm". For example, they wrote: "I had to spend yet another day in the yards sorting stock for MPI for

no reason!! If this had been known about at weighing, I would have separated them then". Farmer Ben Walling made similar comments: "I was dealing with people in Christchurch and Wellington who thought they knew what they were doing but didn't" (Farmers Weekly, 2021).

The NAIT system was not only an influential actor for the eradicators, but also for farmers, and the farmers' lack of respect for the system's utility only made matters worse. An example was provided by Denethor (Farmer), who was told by the eradicators to find three cows that were 'missing' from their dairy farm. Denethor initially thought that these missing cows were in fact grazing on another block, but the cows were not there. Denethor finally found the cows. Their diary entry (below) illustrates the impact of poor NAIT practices by other farmers on the eradicator's success, but also paints a clear picture of the animosity that existed between the farmers and the eradicators:

> I also cleared up another issue with these three animals. These animals have been issued a tag for a 2011 born animal but were in fact born in 2017. This is the previous owner of the stock using up old tags for animals he is selling. So, the consequence of this is MPI are running around looking for seven year [old] animals which is really confusing them!!! Yes, I worked this out about three weeks ago and no I haven't told MPI this until today, simply because they have never asked me (Denethor).

Not only was there conflict between farmers and the eradicators, but there was also conflict among the farmers themselves as result of M. bovis and the eradicators' programme. The farmers have lost friendships, which are vital in rural communities, because of different positions about the eradicators or over financial pressures. As Shelob (Transporter) explained, "[t]hose friendships in the rural community are usually hedged for a long time, and when they are broken, they are broken for a long time, too".

While there was contestation among farmers mainly because some supported the eradicators and some would rather take their chances with the bacteria, there were also other, more subtle fractures within the collective. For example, some farmers experienced the eradicators' involvement as bringing community judgement upon their farming skills and knowledge, the implication being that only bad farmers get M. bovis. This type of judgement has been described by some farmers as an isolating experience (Newshub, 2021). Some farmers took the "opportunity to put the boot in" about M. bovis to their neighbours (Samwise, Farmer). Samwise was surprised by the "finger-pointing and who do we have to blame game". They had

thought that farmers would be more united. At local meetings, Samwise was honest about having M. bovis and they told the community what their farming company would do to contain the bacteria - such as double-fencing the boundaries. One on one, people were understanding, they said, but in groups at the meetings the collective attitude changed to "needing someone to blame" (Samwise).

Whatever their experience, M. bovis has created conflict and distress amongst farmers, and this has only been exacerbated by the eradicators' programme. In the Early Days, the talk was that M. bovis was highly contagious, and this caused fear and mistrust to spread. Many other farmers treated the Potgieters "as if we had leprosy on our farm" (Farmers Weekly, 2019b). With the passage of time, however, and with more information provided by the scientists, farmers began to understand more about the behaviour of M. bovis and its impacts on cow health and productivity (Adelard, Stock Agent).

A completely different experience was recounted by the Wallings, who farmed dairy cows and reared calves in Te Taurapa o Te Waka. The eradicators culled 1,700 calves on their farm because some calves tested positive for M. bovis. None of the couple's children were bullied at school, and the local support for those farmers was "amazing" (RNZ, 2018c). These farmers even ended up with M. bovis more than once because of their calf purchasing practices, though it appears that they were not socially ostracised or blamed for their lack of on-farm biosecurity or for bringing M. bovis into the area. The reasons for these multiple realities of treatment within farming communities remains unclear. Yet, these farmers' different experiences might be best observed using a material semiotic lens, with the understanding that relations create realities that are made and known together (Mol, 2002).

The next section engages with farmers' own stories of biosecurity and shows that, similarly to the eradicators and scientists' realities of on-farm biosecurity, the majority of farmers did not understand the value of or need for biosecurity practices. Indeed, few farmers talked about ongoing biosecurity practices outside of the eradicators' requirements. There were two main reasons for that, which will become apparent below. One reason was that there are very few cow diseases worth being concerned with in Aotearoa (in part because the eradicators are so successful in Othering them), and the other was that farming is reliant on cow mobilities; so, engaging with on-farm biosecurity in a preventative way would be unduly onerous and often

impractical within the current assemblage. Put another way, the farming assemblage itself exists in conflict with (but also creates the need for) biosecurity practices.

7.2.3 Farmers' biosecurity realities

The eradicators purported to speak for the farmers against M. bovis, but the relative absence of biosecurity discussions by farmers (there are a few exceptions to the rule) gave the impression that biosecurity was less of a concern for farmers than for other actors. That said, several themes have emerged from the discussions with farmers, though these threads of biosecurity are more epistemological than ontological, because most farmers were not practising biosecurity. The prevailing themes from the interviews are that there is really no need for biosecurity practices because there are no serious diseases here and because farmers have a high level of trust in their dealings with each other, which is viewed as having a protective quality against cow diseases or shady practices. The farmers did, however, have strong views about the place of biosecurity in Aotearoa and whose role it is to protect their biological businesses.

Fredegar's (Transporter) story typifies the (lack of) biosecurity consciousness among the farmers prior to M. bovis' presence. Fredegar said that before M. bovis the only biosecurity measures taken in their area were for moving bobby calves and pigs, and they still thought moving adult cows was not particularly high risk. This type of attitude was evidenced by Meridoc's (Farmer) experience, too. When M. bovis first became known, Meriadoc's farming company checked its folders for biosecurity procedures and they realised that 'the only real biosecurity measures that we had were for foot and mouth' (Meriadoc).

One of the farms that Meriadoc's farming company owned had M. bovis, and after that they put boot washes in where the truck drivers load and unload the cows, but they said what these measures were really trying to do was "foster a sense of awareness". M. bovis may have been able to influence some farmers to embrace biosecurity, at least in the short term, but the eradicators have removed the long-term option of living with and learning from the bacteria, which as will be seen suited the farmers because that relieved the pressure to implement or improve their biosecurity practices.

Aside from having very few cow diseases, farmers have a strong sense of trust in one another to 'do the right thing'. Everard (Farmer) shared their thoughts about the impact of M. bovis on the buying and selling of stock: "MAF [MPI] put a lot of pressure on where stock could travel

to and from and fair enough. But, we've got a fair bit of trust that goes on here". Stock agents in particular have a special status, as Everard explained:

> The good agents are invaluable. A lot of farmers will trust agents – the good agents. It's only experience. They are going around saleyards three or four times a week. They will look at a line of cows and say, I wouldn't buy those. Especially when you get to know your agent, I've had some real crackers. The guy who rang me up about these cows from Fordell, I'd have been quite happy to say to him, you buy them if you think they are reasonable. I've never been let down.

Adelard (Stock agent) explained that many cows are still sold with "just a gentleman's agreement or a handshake". Gwaihir (Farmer) got M. bovis on their farm through a transaction with a 'trusted' stock agent. Yet, they asked, "[w]ho do you believe when you ask the stock agent as to where they've come from and been told that they are clear? You believe what they tell you, but we were misinformed".

In the Early Days, DairyNZ and B+LNZ created biosecurity questionnaires for farmers purchasing stock. At that time there were also requirements about disinfecting vehicle tyres and gumboots, but as Adelard (Stock agent) said those measures did not last for long: "Kiwi farmers being what they are, that went in the 'I can't be bothered doing that anymore' basket pretty quick". So, as the initial paranoia lessened as time went on, unfortunately, so did the biosecurity actions taken by farmers. Adelard explained that, "[i]n the Early Days, there was an insistence that you spray or even disinfect your vehicle tyres coming on and off farms - tyres and gumboots and everything. Well, that didn't last very long". In the Waitaha area, even now, "[t]here's the odd sign laying around here, but there's hardly any footbaths" (Elladan, Farmer). One exception is the footbath requirement at saleyards, which has remained, though as Adelard pointed out those footbaths are for the humans not the animals, and part of their purpose in their view was the mere psychological perception of hygiene.

Without intending to tell me about their biosecurity practices, this story emerged from Everard (Farmer) about how the saleyards operate. My interest in this story was about the absence of hygiene, changes of clothing and shoes, those kinds of things. This story concerned the purchase of cows from a large saleyard in Te Ika a Māui:

> [T]he agent rang me up and said this particular line of stock was coming into the sale. He asked if I'd be interested, which I was. I was in the middle of shearing and absolutely

> flat out. At 11am I hopped in the car, I didn't change or anything – I was still in my working gear. I came into the sale, and I sat down at the back of the rostrum. These cows came through. I nodded my head about four times and bought them. Then I looked at my watch and shot out the door and went home. The only person I talked to was the carrier at Colyton. I said I've bought such and such a pen of cows, would you bring them up and put them into such and such a paddock. That was the only guy I spoke to in the whole trip.

Grimbold (Farmer) thought there would be a bell curve showing how many farmers will have changed their biosecurity practices after M. bovis. They said some farmers would be very cautious, while others will be more relaxed about farming with M. bovis and not want to change their business models:

> I was at a conference the other day [and] there was a Hawke's Bay farmer – they must be bull traders or something, I think he said he's had it four or five times now. He's got it at the moment. You can just exit out because they're all bulls and all trading, I don't know if they'll depopulate or what…Yeah and he's a farming leader on a number of boards and stuff. He's probably just more immune to it and thinks that's just the nature of trading Friesian bulls. I guess at some point he'll probably think there will be less chance of getting bovis (Grimbold).

Aad van Leeuwen (IP1) was equally philosophical about having M. bovis. He told media, "I can't turn the clock back. [We'll] isolate those animals and kill them and probably start again" (ODT, 2017).

For Gwaihir (Farmer), who had M. bovis on their farm, biosecurity is really about what happens at the airports and ports, and this is where they saw the greatest risk to farming. They said, "I watch the Border Security, and I cannot believe the number of items that people 'forget' to declare. That for me is probably one of the biggest concerns for our country".

There are always exceptions, however. Elladan understood that their business relied on biological products. They described themselves as "quite streetwise" about biosecurity, and they had strict on-farm rules:

> [D]on't drag a dead animal from one end to the other. Don't keep sick animals near your cowshed. If she's got black mastitis, don't keep her near the dairy shed. Dry her off and put her in a drain [a ditch], so those bugs aren't…use a bit of common sense for your businesses.

Elladan thought Aotearoa should have an annual 'Biosecurity Day', because of the importance of biosecurity to the economy. They believed that "[m]ost farmers have probably dropped the towel, a hundred percent, completely" (Elladan).

Adelard (Stock agent) thought M. bovis had highlighted for the farmers the importance of due diligence when purchasing animals. They explained that at times of heightened disease awareness when M. bovis first appeared, farmers started asking about cow health and vaccination histories, "to the point where they want a questionnaire filled in and signed that to the best of the seller's knowledge, this is the state of play". That was not a common practice prior to M. bovis, and only the top end of the market with pedigree cows would have undertaken that level of risk mitigation. Since M. bovis, some farmers have engrained the practices of quarantining incoming stock, giving them an all-purpose drench and keeping them away from the paddocks with young stock. One of the reasons for the change in practices is that:

> the bovis experience has frightened a few people into better practices, into realising that biosecurity is everybody's issue. You are responsible for what's inside your own fences, and farmers themselves are the best people to keep their businesses safe. Certainly, a lot more people understand that (Adelard, Stock agent).

After M. bovis came to Grimbold's (Farmer) farming company, they decided to breed their own replacement cows. Another key change made due to having M. bovis was obtaining cow health and origin information before buying cows from stock agents. Grimbold said that the practice has dropped away for Te Ika a Māui, however, because it meant that the company missed out on buying some cows due to the usual speed of transactions compared with waiting on information about the cows' origins and vaccinations. The system is still in place for Te Waipounamu, though, and the company still will not buy from saleyards. Before M. bovis, Grimbold's farm was not up to date with the NAIT notifications for cow movements, but they now track their movements and NAIT compliance through a dashboard system. That farming organisation also set up their own biosecurity committee, too. Another farming couple who have experienced M. bovis (and the eradicators) have contemplated a move to a closed system so that their dairy farm can supply their own beef farm, "just to cut down on the risk of infection" (RNZ, 2018c). There are several stories like these.

Many farmers that Shelob (Transporter) dealt with had footbaths for the drivers to use before going into the bobby calf pens. They were the "organised farmers", they said. Samwise

(Farmer) initially thought about M. bovis as a risk to dairy farming more so than beef farming because the production impact on beef cows is not as great as on dairy cows with mastitis, though their farm did move to protect the more valuable stud herds as a priority. Another plan that Samwise's farm management instituted was to only buy cows from Te Ika a Māui, though as mentioned they were caught out with cows purchased from the Te Matau-a-Māui that had started out their lives at one of the source farms for M. bovis in Te Waipounamu and ended up with M. bovis themselves.

For the farmers, their OPP question is whether they could live with M. bovis and continue farming without disruption, which implicitly included not having to engage with difficult and time-consuming biosecurity practices. One of their obstacle problems was the disease potential of M. bovis - that ticking time bomb, along with the threat of production loss (although the scientists tentatively said otherwise). What farmers wanted were healthy and productive cows, but not to the extent of spending more time and money than was absolutely necessary. The OPP question became whether M. bovis invariably impacted on the farmers' goals, or whether the bacteria could be accepted as a low-risk network actor.

7.3 Obligatory passage point

In one sense, the farmers' OPP question has been thwarted by the eradicators' apparent success. A positive answer to the question, 'Can we live with M. bovis?' might have resulted in their industry representatives failing to be *interessed* by the eradicators in the first place, had the farmers been asked prior, leaving MPI on its own. If there was a proven record of production loss in Aotearoa, however, this would surely have enrolled the farmers. This is a hypothetical question now, because it seems that the farmers may never know whether they could have worked with M. bovis or not.

It was clear to farmers that M. bovis is experienced differently by cows depending on whether they are calves, dairy cows or beef cows. As Grimbold (Farmer) explained, in an explanation which is consistent with many other farmer accounts of M. bovis, the bacteria "won't bother some of them and others will be affected because of stress, like calving or mastitis if they're milking; but on the beef side of it, pfff…With the beef farmer it probably doesn't really impact".

Adelard (stock agent) thought it was logical that the longer M. bovis was on a farm the more debilitating the disease would be. They supposed that "the length of time that it has to establish on a property just means that there's the larger scale of the problem". However, how cows are handled and cared for affects not only whether they become susceptible to M. bovis but also whether they manifest diseases if they are M. bovis hosts. Dairying is intensive by nature, and M. bovis is a disease of intensity, so dairy farmers are more likely to experience 'disease M. bovis' than beef farmers. While beef farming is less intensive, that type of farming is fed by dairy calves, spreading M. bovis throughout the whole actor-network and back into dairy farms again via dairy-beef calves. The question for farmers was whether they could manage M. bovis within farming and without changing their cow buying, moving, and farming practices. As will be seen in subsequent chapters, their OPP could not be answered by the farmers alone. Rather, it was the cows and M. bovis itself that would also influence whether the farmers could accept the bacteria into the folds and flows of the farming assemblage.

7.4 Conclusion

This chapter has shown that like the scientists, the farmers' M. bovis realities were also multiple. Some farmers have witnessed no visible discomfort or disease in their cows, so for them M. bovis was a more attractive actor to align with (or to try and enrol through keeping their cows healthy and stress-free) than the eradicators who have imposed onerous restrictions on their businesses, culled their cows (in some instances) and who remained outsiders to the farmers.

One of the wider problems remaining for farmers, apart from the eradicators, was the ongoing expectation that they would take responsibility for on-farm biosecurity. For the farmers, biosecurity was not part of farming, and the practices were considered to be onerous and time consuming. Biosecurity was more easily relegated to the work that MPI does (or should do, in their minds) at the border. More than that, farmers experienced the eradicators' form of biosecurity as inflexible and ignorantly imposed by people who do not know about farming. We have already seen that this incompatibility between biosecurity and farming was a matter of concern for the eradicators, too. This next chapter is concerned with a further matter of concern for farmers – their cows.

Chapter 8 The cows

[T]he three researchers will have to lead their longest and most difficult negotiations with the scallops (Callon, 1986, p. 211).

8.1 Introduction

This chapter was inspired by van Dooren's question, "What obligations do we have to hold open space in the world for other living beings?" (van Dooren, 2014, p. 6). For me, within the farming assemblage, the obligation rests with those who have the dominant voice in a space that is built around and only exists because of cows (Latour, 1988a). The cows are the first non-human actors to speak in this thesis. So far there have only been the human voices of the eradicators, the scientists and the farmers. Each of these human actors has presented as a complex assemblage, with multiple voices being heard. The cows' chapter is different in that there is one voice speaking for other cows here. Her name was Araw, and she was a dairy cow of considerable standing and experience.[98] The other cows tacitly approved her speaking on their behalf.

It has been difficult to write a 'cow-centred' (see Cassidy et al., 2017) narrative about their interactions with M. bovis. The vast majority of literature and the vast majority of actors speak for those who do not speak a human language. This chapter makes space for the cows' voices through telling Araw's story. Cows 'story' place, too, though their stories might be differently woven to the human actors' stories (Van Dooren & Rose, 2012). Araw had her own stories about the places she knew, the paddocks and milking sheds that she enacted in the form of experiences and memories. Through Araw, a cow imaginary, this chapter anchors and attempts to speak to the 'cow' experience of living within an M. bovis territorialised farming assemblage.

This chapter makes deliberate reference to bobby calves, for whom life on a dairy farm is arguably the toughest. These "absent referents" (Adams, 2016, p. 21) are made in the production of milk for humans, by cows and farmers. Their short lives, welfare and untimely deaths are rendered invisible "through a range of material and semiotic techniques" (Nimmo, 2011, p. 110; see also Goulding, 2020) within farming because of the social and economic

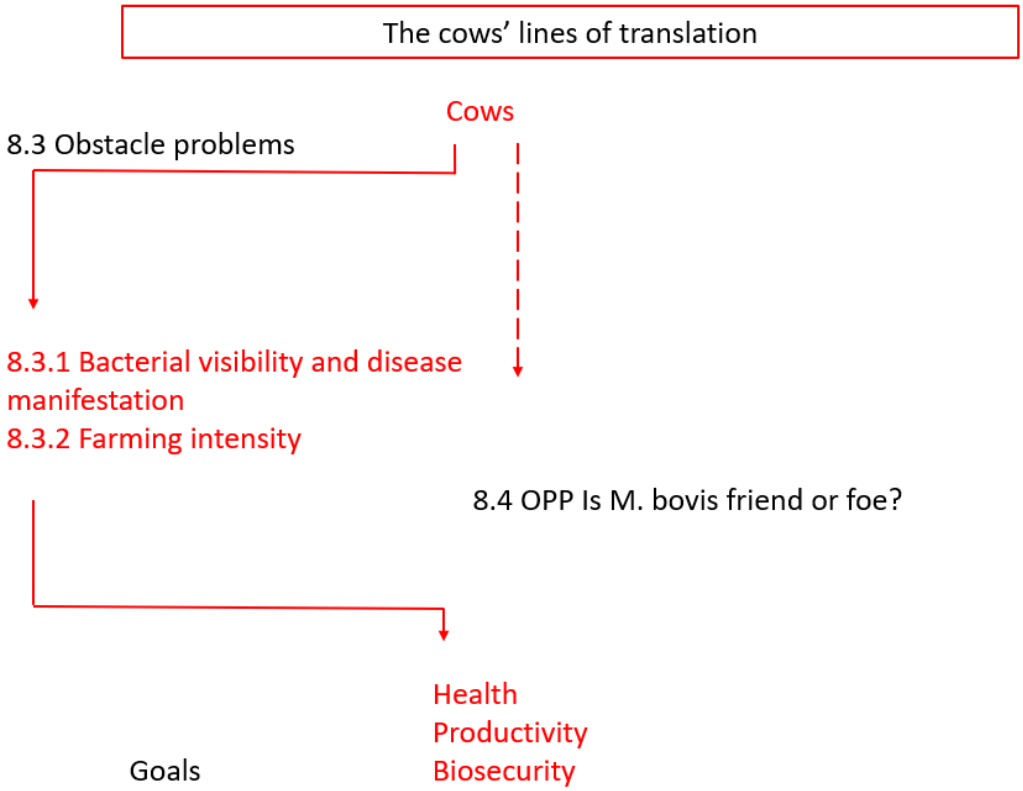
[98] Araw is named after Kine of Araw, from Tolkien. This chapter follows a dairy cow's reality because their lives are the most intensive, and because dairy cows were the first to betray M. bovis in Aotearoa.

performance of drinking milk and eating dairy products. Bobby calves' voices are rarely heard; mostly these animals are absent presences. Yet, that complex 'backdrop' of cow realities, "cannot be wished away" (Law, 2004, p. 31). Cows do not pre-exist as cows outside of farming, and the assemblage with its calves, machinery and mobilities is made and understood together (Haraway, 2016; Law & Mol, 2008a; Goulding, 2020).

The purpose of this chapter is to imagine how Araw navigated the eradicators and the farmers' attempts to enrol her, and how she contributed to the scientists' knowledge of M. bovis, through her body shaping their engagements with the bacteria (Cassidy et al., 2017; see also Hinchliffe et al., 2017). Cows like Araw story scientific developments by performing critical roles in scientific testing (see the scientists' chapter), by providing their blood and milk for the purpose of enacting scientific knowledge (Cassidy et al. 2017; Law & Mol, 2008b). For example, tests like PCR and Elisa work with the cows' willingness to give up their bacterial passengers. The cows have been key actors in gaining scientific knowledge about M. bovis, even though they have nearly always been rendered passive by the human narratives describing these advances. Araw's story demonstrates how scientific advances are made 'with' the non-human actors that they study, even if that reality is not expressly acknowledged by them (Latour, 1988a).

The structure of this chapter is the same as the previous ones, with a focus on telling the story of cows' obstacle problems, their OPP, and their goals. However, this more-than-human chapter is far smaller than those of the human actors. The cows' obstacle problems were straightforward - these were expressed as the intense nature of dairy farming and the bacteria manifesting disease in their bodies. The cows' OPP was whether M. bovis is friend or foe, which was a more complex question to answer than the farmers' OPP of whether they could live with M. bovis. For cows, M. bovis could have been an ally, for example if farmers were forced to make farming less intensive (in the hope that there would be fewer diseases caused by M. bovis). The cows' goals were to be productive enough to stay alive, to remain healthy and for their farmers to enact good on-farm biosecurity. See *Figure 20*, below.

Figure 20
The cows' lines of translation



It is important to note that cows did not directly problematise M. bovis. Their obstacle problems were more general in nature, being disease (or lack of health) and stress in their daily lives. The stress was from a variety of assemblage elements, including dairy farming, seasons, and weather events such as storms or droughts, calving, and moving either from farm to farm or to slaughter. For Araw, physical stress was an inherent part of her life and she could not see how that could be overcome. Yet, when M. bovis moved into farming, the cows queried whether these bacteria could be the OPP they had been seeking. If M. bovis' continued presence could have encouraged farmers to farm less intensively, for example, and/or with biosecurity practices in place, then M. bovis might have been a friend instead of an enemy. This remained the question for the cows because that answer impacted on whether they aligned with the eradicators or with M. bovis. The cows' goals were simply to be healthy and productive enough that they remained alive, and biosecurity sat amongst their goals as a means to achieve the others.

We have learnt from the veterinarians about how M. bovis operates in cows' bodies, and from the farmers who told stories about how their cows were physically impacted (or seemingly not at all). We have already seen how individual cows have betrayed the herd with their bodily narratives of antibodies or bacterial loading. And how some individuals might have recovered from M. bovis caused diseases on their own terms. M. bovis was not only practised or enacted differently by different actors, but the bacteria were also enacted differently within singular cow bodies. As seen in the previous chapters, cows were also enacted by the human actors in various ways *vis a vis* M. bovis' bacterialness. For example, cows were made to be vectors of bovis by epidemiologists and targeted as a source of problematic life by the eradicators. These types of narratives allowed cows' lives to be expendable, tied together as they were with the bacteria (Bull, 2018). Cow bodies created their own lived experiences, remaking M. bovis within themselves, their herds and their worlds. The cows were also made to act by the other actors in the farming actor-network, and not only the human actors, but all of the other materialities that are important in making the network work, such as technologies and economies (Latour, 2005). Araw and her herdmates were not alone in acting.

This chapter looks to "render capable" (Haraway, 2016, p. 126) Araw and her herdmates by being open to a more-than-human encounter, something that Haraway (2016) terms "going visiting" (p. 126). Going visiting is a risky business, requiring both the imagination and self-discipline to relate with other species and have interesting conversations, or cultivate that which Haraway (2016) calls "response-ability" (p. 130). In this chapter, the cows are given a place to speak, through Araw. The artifice of Araw is not a perfect solution; nonetheless, this is her material semiotic journey.

8.2 Araw: A cow imaginary

Araw was a dairy cow and she lived on a large farm in the Waitaha region, Aotearoa. Araw's favourite pastime, other than eating and watching, was to lie down in the cool grass and ruminate. Araw's life experiences were dictated by her farmers' need for milk and the changes brought about by natural seasons; more specifically, when the grass grows. Her life was infused with paddocks, the milking shed and machinery, the other cows in her herd, the birds and other creatures she has come to know, and the human actors. Araw's mother, grandmother, and great-grandmother were all born into this life, but she did not really get to know them. Araw learnt the ways of being a dairy cow from her peers and the elders in her herd, as well as her farmers.

Araw and the others were milked at least once a day, sometimes twice, most days of the year. She had to give birth to at least one calf every year to make milk and keep her farmers happy. She always lost her calf, however, whether it be to death or to sale. Araw had a two-headed calf once, but it only lived for a few hours. Araw knew that calving brought pain and loss, so it was never a celebrated occasion (de Freslon et al., 2020). Araw's reality was the production of calves and the making of milk within a large farming assemblage with many moving parts. She grieved for each new-born that was taken and using her own heart-felt language she called to them all.[99] Cows communicate in their own material semiotic ways, and few human actors know how to interpret their signs, symbols, and meanings (see, for example, McTavish, 2015).

Besides eating and lying on the grass, there was something else that Araw enjoyed, too. She enjoyed company, whether it be from her herd or her farmers. The cows all knew each other, and everyone had their roles and routines. There was comfort in this knowledge. Araw also loved to groom her herdmates, and to lick those cows who were a bit depressed and thin, because it seemed to help them gain weight and lift their spirits (Sato, 1984). Araw was a social cow who connected easily with others.

A high level of cooperation between Araw and her herdmates was essential for collective functioning and harmony, though some cows were more aggressive or dominant in the herd than others (MSD Veterinary Manual, n.d.). Some of the cows in Araw's herd were quite dominant, and some in her milking mob were quite gregarious (de Freslon et al., 2020). She preferred to stay away from those cows, though the aggressive ones did not last long before the farmers sent them away. Araw had avoided going in the truck to slaughter because she managed to get in calf annually and because her farmer called her a good cow due to her quiet nature. Araw was not a follower, but she was calm and accepting of her dairy cow life (see McTavish, 2015).

Araw's life was pressured by other actors' needs and demands. Her life's purpose was to fulfil the requirements of others. Araw was central to the farming assemblage, but it was not set up to foreground her welfare. There were four milking mobs on her farm and sometimes her herd split into smaller mobs, which Araw found disruptive because it upset her routine. Other times

[99] The common vocalisations are known as a 'moo' a 'roar' and a 'hoot'. The hoot is also known as a 'call' (when communicated by calves) (MSD Veterinary Manual, n.d.). See also McTavish, 2015, Goulding, 2020.

new cows would come into her herd from other dairy farms. It took time to get to know the new cows, and because of the introduction of new personalities, she was unsure of her role in the newly formed herd (de Freslon et al., 2020). When Araw experienced changes or the loss of her herdmates she would become stressed and sometimes depressed. Sometimes she got bacterial infections in her udder, which made milking very painful. She was wary of the new cows if they looked too skinny or sickly, because they have brought diseases to her farm before and that has been very impactful for some of the herd. She even lost a calf to one of those diseases. Araw's farmers needed to be more discerning about who they brought onto the farm.

Araw did not stop to reflect on her life. She knew nothing else, but she understood there were beef cows who did not get milked, even though they also had calves. These cows were said to have a lot more physical space and a more varied diet. Beef cows also travelled a lot more, as they could move farms many times in their lives. These beef cows had to be more flexible and adaptable than Araw because of having to frequently find and reassert their roles within new herds. Some of Araw's calves had gone into this beef cow life, while others have followed in her footsteps in the dairy cow life. Araw's herd moved for food and for drier pastures in the winter months. The herd down the road moved every few years because their farmers were sharemilkers. The beef cows lived a more relaxed life than Araw, so for her there was an irony in them being the ones who transmit M. bovis more frequently from farm to farm. How many cows and calves are on the move in her area varied from month to month, but it could be in the tens of thousands depending on the time of year. Araw's friends and relatives were a commodity, an item to be bought and sold and eventually destroyed. By comparison, Araw worked a lot harder than her dry-stock counterparts, but it was still a life worth living. Once a year the older and less productive cows on Araw's farm were sent to slaughter. Araw knew that May was a month to be wary of, and it was a reminder to be productive for her farmers and to make sure she cooperated in all of the bodily ways that mattered.

Winters were the worst season on Araw's farm. The daylight hours were short, so she was walking and milking in the dark. The rain and sleet seemed like constant companions, and the wind chilled her to the bone. Sometimes it even snowed, and still she had to stand in the paddock without shelter. Araw and the others huddled together with their backs to the prevailing wind, trying to keep warm. She thought that there might be some advantages in living in a barn and being fed total mixed rations, at least in the winter. Come spring, however,

and Araw was ready to taste fresh grass and enjoy the warm breeze in her coat.[100] She particularly liked being outside on warm evenings. In fact, Araw had all of her calves at night-time, giving birth under the stars (MSD Veterinary Manual, n.d.).[101]

Just before Araw's last calving season, there were some new arrivals on the farm. They had come from another farm further south. The new cows were initially reticent, keeping to themselves. But, over time they made the acquaintance of Araw's herd and began to socialise. Despite her suspicion and the upset new cows can cause, Araw found that she enjoyed their company. The newcomers looked healthy and seemed well in themselves, and they were engaging appropriately with their new environment. By the time winter rolled around again, however, the situation had changed. The cows had brought with them a hidden actor, a tricky beast that liked to live among cows, but that caused trouble when it was least expected and when the cows were least able to deal with it. Araw found out that the silent actor was M. bovis, and it had a particularly cruel reputation when it came to interacting with dairy cows and their calves. Not only did the new cows invite M. bovis into Araw's herd, but this created illness among her friends, and this presence of illness brought the attention of the eradicators to the farm. She knew that something bad was happening on her farm because everyone was acting strangely, the farmers included. The eradicators came and talked with her farmers. The veterinarians came and tested Araw and her friends.

The new cows had spread their new microbes, but it was not their fault: they were social animals, too. Araw watched many of her friends and relatives become sick and listless and lame in a short period of time. She quickly became depressed and stopped eating. Because Araw was so stretched physically with all of the walking and milking, her body condition score was less then recommended by those veterinarians who spoke for her.[102] She was run down and vulnerable, and Araw was afraid for her life for the first time. She had always known that she would survive if she was healthy, but now that did not seem to matter. Araw mostly cooperated with her human actors but would not allow herself to be enrolled by the eradicators. She may or may not have been living with M. bovis, but either way, Araw did not allow positive test results by shedding bacteria or by creating identifiable antibodies. Despite her hardships, Araw was holding out for a better deal than betraying her milking mob and their calves. Araw

[100] Total mixed rations is a feed formula that is said to contain all of the daily nutrients cows need.
[101] Calving will often occur at night for pasture-based cows (MSD Veterinary Manual, n.d.).
[102] The body condition score is a weight scoring system used by veterinarians.

was an actor, not an intermediary. Even though Araw tested negative for M. bovis, this did not save her from going on the truck with the others in her mob who were already visibly unwell. The eradicators had decided that they must all go together and that was the end of the story. And so it was that Araw prepared herself for her very last journey.

8.3 Obstacle problems

Araw was both celebrated as a biological resource and problematised because of her biological frailties. Like all her herdmates, Araw's goals were to remain healthy and to be productive, otherwise she would be 'culled out of the system', as her farmers called it. She knew what that meant. However, the key obstacles to her achieving her goals were the nature of her work and working conditions.

The cows' OPP was whether M. bovis was friend or foe. The answer in turn depended on whether the cows were successful in enrolling M. bovis into their actor-network, into their own lines of translation. If M. bovis remained hidden and did not cause Araw or her friends any problems, then the bacteria could have enrolled farmers into working Araw less intensively and shifting their focus from turning grass into milk to focussing more on her wellbeing. M. bovis could have been the 'canary in the mine', acting out and manifesting disease with the cows when the pressure of farming became too great. As a representative of the cows, Araw knew that their best interests were to remain unenrolled in either the eradicators or M. bovis' actor-network despite the coercion or force being applied. The enrolment of the cows was vital to each actor's successful translation. If M. bovis were to succeed in its stealthy world-making with the help of cows, perhaps farmers would have to enact biosecurity, and this would be welcomed by the cows for the sake of their and their calves' health and wellbeing. On the other hand, the cows could have aligned with the eradicators to Other M. bovis, which would have dealt with their obstacle problem of bodily diseases, but it would not have dealt with the farming assemblage itself or their role in it. Perhaps the cows' best option was to enrol M. bovis into remaining hidden, but this required the cows to trust M. bovis not to turn on them.

The cows were used to being betrayed. The farmers and the eradicators betrayed them by sending them to slaughter for harbouring M. bovis, and they even betrayed those cows who were free from the bacteria as punishment for the weakness and fallibility of their herdmates. The betrayal was harder when it came from other cows, but Araw knew that those cows could

not be held responsible for their betrayal because they have been made that way by the assemblage in which they also made their worlds.

The moment of mobilisation is the test for determining who will align with the cows' interests. Cows could speak for M. bovis through their bodily actions, and they could allow the bacteria to move because of their social natures and the value they placed on the collective. The cows could equally speak against the bacteria, to align with the scientists (and therefore the eradicators by default). The willingness of the cows to exhibit symptoms was just as important to the eradicators' success as enrolling farmers and the scientists.

For M. bovis diseases to present visibly, the cows had to allow the bacteria to multiply, to move around their bodies and to settle in one favourable place. This would usually occur during calving or when the cows were being transported, or sometimes during the depths of winter when outdoor living was extreme, and their immunity was lowered. It was a mystery as to why these cows, who were actors and world-builders, would allow M. bovis to present itself in these ways. Were these dairy cows speaking for or against M. bovis? Or was there something else they were trying to communicate?

8.3.1 Bacterial visibility and disease manifestation

The cows' goals were to live healthy and productive lives, and, maybe, to contribute to the wellbeing of the collective. In order to achieve these goals, cows have had to learn how M. bovis interacts with them (and within them). This knowledge was essential in answering the question whether M. bovis is friend or foe.

While the cows operated at a herd level, their individual experiences with M. bovis were ontologically multiple. Some cows have experienced wide ranging physical destruction, while most have felt nothing at all. There was dissention amongst them because those cows who have experienced 'disease M. bovis' argued that they would all be better off without the bacteria in their midst, given the unpredictability and nasty nature of the bacteria if it chose to betray them. There was a risk here for Araw and the other cows in aligning their interests with M. bovis and relying on the farmers to embrace biosecurity practices.

Yet, it was surely against the cows' own interests to be enrolled by the eradicators because it meant being culled. Araw wondered what power those cows who have already been culled had

to resist the eradicators' forceful mobilisation. One form of resistance was to do what Araw tried to do, which was to keep her head down - like the bacteria generally did. If that got too hard, then dairy cows could lower their milk production in retaliation (though care was needed with this approach, because it could have backfired). If that failed, then all of the cows who have M. bovis could shed the bacteria before going on the truck, to silently assist M. bovis in continuing its journey.

As seen in previous chapters, the cows were enacted by the human actors as intermediaries in relation to M. bovis' bacterialness. The cows have been made to be 'vectors' of M. bovis, 'at risk' of M. bovis, 'transformed by' M. bovis and made 'economically worthless' by M. bovis. The eradicators have targeted Araw and her friends as a source of problematic biological life, even though that life threatened their very own. The eradicators' epistemology required Araw's life to be expendable, tied together as it was with the unwanted bacterial life (Bull, 2018). There could be no partnering for the purpose of one's own slaughter. The cows were better off to align their interests with the bacteria.

The matter of alliances with the scientists was a complex one. On the one hand, the scientists wanted to gain more knowledge about what M. bovis could do, which suited the cows, but that knowledge has also been traded with the eradicators. On the other hand, the scientists problematised those farmers who farmed intensively and who placed little value on veterinarian visits and who had no time for biosecurity practices. Health and biosecurity were the goals for cows, along with a gentler mode of farming.

8.3.2 Farming intensity

Araw considered that if M. bovis remained in the farming assemblage, conversations could be had about the impacts of intensive dairy farming on their health, and about the wisdom of sharemilking. Farmers might have been forced to accept the need for routine testing and biosecurity practices; they might even have seen a correlation between cow health and productivity. Having M. bovis in the farming actor-network could have been the beginning of a nuanced relationship with the cows as farming partners, along with their bacterial guests.

Like the eradicators, the cows also worked at a herd level, but the cows have not collectively problematised M. bovis. There were differences of opinion, but because of their herd membership culling was required for all, and translation by the eradicators was a betrayal to

their lives of service (Callon, 1986). The cows who have made manifest diseases with M. bovis were perhaps also seen as betrayers of those cows who have worked with M. bovis to support its quieter network building. Araw did not trust M. bovis, but she chose to align with it rather than risk losing her friends (and ultimately her own self) to the slaughterhouse. As with the human actors, there were nuances present in the cows' network relations, and the question remained as to whether M. bovis would be capable of being a friend to them all.

8.4 Obligatory passage points

The cows needed to know whether M. bovis was friend or foe, because for them this was an existential question. Unfortunately, the cows will likely not know whether they would have met their goal of health and productivity with M. bovis as part of their assemblage. However, the cows did know that sometimes they could choose to live with M. bovis and feel fine in themselves, but they also knew that there were many other network influences that could work against them and provoke M. bovis into betrayal.

The majority of cows that asymptomatically housed M. bovis were not strategising for the end of those bacterial lives or the demise of their own. Nor should this silence be taken as acceptance of fate; instead, perhaps it was an act of bodily defiance? The cows' ability to harbour M. bovis like a fugitive raises the question of how many more cows are currently living with M. bovis and testing negative for the scientists. Cows must be taken to desire life, though the cows that test positive are following a different path - perhaps that is one of martyrdom, a protest action for the whole.

The cows have *interessed* those farmers who care deeply for their cows and who have committed to those cows generationally and financially. Perhaps, these types of farmers would rather have kept M. bovis alive than see their precious cows slaughtered. Those cows who were healthy but lived with M. bovis had an easier job of *interessing* this group of farmers, and their numbers are unknown.

8.5 Conclusion

M. bovis was not only practised or enacted differently by different human experts, or actors depending on their realities, M. bovis was also enacted differently by cows and within singular cow bodies. These bacterial realities were not exclusive to each other or bounded (Evans et al.,

2021), and the bovine bodies dwelt within and were made by "a shifting set of forces and relations" (Braun, 2007, p. 258). Cows were made with the biological networks they existed within (Braun, 2007). Yet, Araw's life was not 'mere' (cf Honig, 2009; Allen & Lavau, 2015); she was not the sum of her biology or parasitic bacteria (see Enticott, 2008b). Cows claim territories, they are lively and material (see Henry & Roche, 2013) and do not just idly stand in fields without transforming them (Wise, 2014). Cow bodies create bodily ontologies, remaking M. bovis within themselves, their herds and their worlds.

Was M. bovis a potential friend to cows? Could they enrol M. bovis into their own designs and desires (Latour, 1988a)? Thanks to the eradicators, the cows will probably never know the answer. Or, at least, that is what the dominant human narrative suggests. There is currently only one farm with M. bovis left, and the eradicators remain confident in their abilities to Other M. bovis from the national herd. However, as the bacteria's own chapter will show, the eradicators' translation struggles are not yet over. So, perhaps the cows should not give up hope of deterritorialising farming after all.

The next chapter tells M. bovis' own story. It focusses on the bacteria's world-building journey, and in so doing the chapter describes M. bovis' struggles and successes in thick detail (Michael, 2017). Like the cows, the bacteria also wished to live, and M. bovis (being host specific) needed cows to do so. Unlike the cows, however, the bacteria had no problem with farming being an open assemblage based on cow mobilities. In fact, as will be seen, it suited them.

Chapter 9 The bacteria

The tree shows what it can do, and as it does so, it discovers what all the forces it welcomed can do. You laugh because I attribute too much cunning to it? (Latour, 1988a, p. 193).

9.1 Introduction

Until now, this thesis has told the stories of the loudest and most prominent human actors, along with the cows who have been rendered materially absent by the eradicators in their quest to protect farming's black box of pasture-based mobility. The chapters have evidenced a tug of war between the actors and their various interests and goals, and they have described the different OPPs that they each needed to pass through to achieve those goals. The aim of this chapter is to tell the quietest of stories.

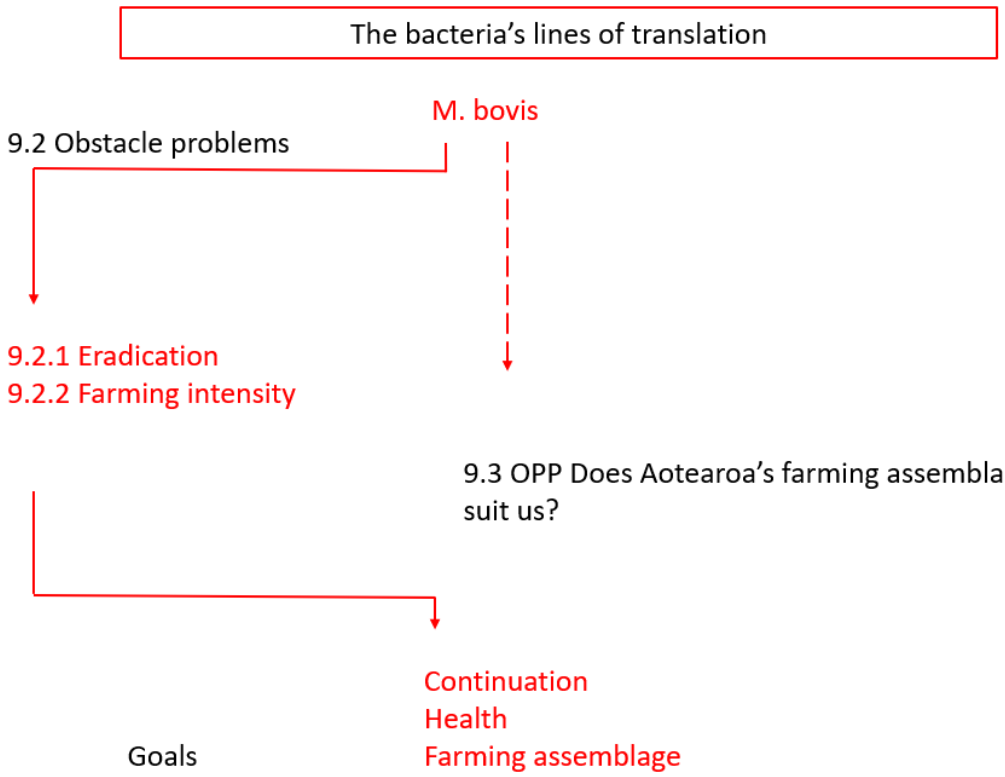
This chapter describes the struggles endured and victories won by M. bovis as the bacteria made their world in Aotearoa. In particular, this chapter shows how M. bovis has influenced the shape of the biosecurity response and eradication programme. It will be seen that the "ordered materialities" (Donaldson & Wood, 2004, p. 382) of Aotearoa's farming assemblage suit M. bovis' drive to replicate. M. bovis' story makes it clear that the bacteria were clearly actors, not mere intermediaries. M. bovis was an actor that wielded silent network power.

The possibility exists that M. bovis could remain in Aotearoa, and that it may yet have the last word. Either way, M. bovis has already 'rendered' visible (Li, 2007) the ontological world of biological travel inherent in farming. The bacteria have created an important legacy for the eradicators because, following Campbell (2021), there is a 'rupture' that lurks, threatening the black box of farming. That threat of future rupture to farming relates to acknowledging the openness of the biological assemblage and realising the incompatibility between cow mobilities and biosecurity practices. This bacterial legacy leaves the eradicators and the farmers in a precarious position *vis a vis* preparing for any new agricultural diseases reaching these shores.

As *Figure 21* below illustrates, M. bovis' story is structured similarly to that of the other actors. There were obstacle problems, an OPP question, and collective goals to be achieved, if the bacteria were to successfully translate the actor-network. M. bovis' obstacles were the eradication programme (for obvious reasons) and farming intensity (because intensity is linked to disease and therefore discovery). The bacterial OPP was whether farming in Aotearoa suited

them, or whether it supported their continued presence. M. bovis' goals were survival, healthy cow bodies to live in and the farming assemblage remaining unchanged.

Figure 21
The bacteria's lines of translation



The bacteria wanted to live and, despite the mistrust that the cows may have had, M. bovis' goal was best served by healthy cows, not diseased ones. Bacteria have an "inherent potential" (Donaldson & Wood, 2004, p. 381) to create more bacteria, and to achieve this purpose, M. bovis must interact with cows' "cellular machinery" (Donaldson & Wood, 2004, p. 381). M. bovis' overarching goal was to survive in comfortable bovine spaces. The bacteria and the cows had a need for ongoing health in common. Where they parted ways was that M. bovis supported farming mobilities without biosecurity restrictions. M. bovis wanted to enrol the farmers and the cows and mobilise them away from biosecurity, though sometimes both of these actors thwarted the bacteria's plans for a quiet life. That was when the bacteria were called disloyal to the cows, but why would they have been? Bovine bodies were their livelihood. As for the scientists, they were a problem for M. bovis. The scientists' growth in knowledge about the bacteria and how to test for it has been regrettable.

Ultimately, M. bovis wanted to know if farming in Aotearoa served its goal of continuation. The bacteria found that it did suit them, which was partly why they were able to remain hidden for 18 months and during that period travel far and wide throughout the country. This was why one of the bacterial goals was maintaining the farming assemblage, because reterritorialising farming (without interference from the eradicators or farmers' biosecurity practices) allowed the bacteria to go about their world-making in a calmer and quieter fashion – for the most part.

M. bovis' internal world is warm, dark, viscous, fluid and comfortable. For M. bovis, there are certain bovine places that are preferrable, and this is where they like to settle. Otherwise, the bacteria move freely around using the cow's bloodstream. M. bovis bacteria are shapeshifters, so even though they are slow to move from one cow to the next, their sluggishness is compensated for by their ability to 'disappear' from the scientists' view. Indeed, the scientists knew these bacteria as having many superpowers. Yet, M. bovis did not wish to be transformational, it just wished to translate the farming actor-network to stay within it, not to deterritorialise it in any fundamental way. M. bovis was not a troublemaker like some of those viruses that disrupt agricultural trade or impact on the cows' productivity. The bacteria never wanted to 'test' the biosecurity system to make it harder for other diseases to move within farming. Nor did they set out to teach the scientists or help them to create better testing technologies. There have been many things that did not go to plan for the bacteria. Yet, whether intentional or not, M. bovis has made visible a particular ontological world (Law & Mol, 2008b).

The scientists have talked a lot about this group of bacteria, about how they impact on cow bodies and how they behave in the laboratory, who they are related to in the wider bacterial world. M. bovis would not have told you anything about those aspects of its world; in fact, M. bovis would not have 'told' you anything at all. M. bovis spoke purely through its actions. M. bovis' 'speech' was enacted as its bacterialness. For M. bovis to speak is to act, but to act is not always to make itself present. When M. bovis did manifest in an aggressive form, it nearly always presented as something 'other' than itself, but the bacteria suffered from inertia, and they needed to be aggravated by other actors to appear (see the scientists' chapter). Cow health was "made and remade" (Hinchliffe & Ward, 2014, p. 143) by M. bovis, making it clear that there is transformative power inherent in bacteria (Cassidy et al., 2017). These bacteria transform meaning as opposed to merely transporting it (Michael, 2017); yet M. bovis' most

powerful move was to be non-controversial and the most comfortable place in the farming assemblage would have been a continual absent presence. The bacteria's interests were met by enrolling the scientists, the farmers, and the cows, so that they might become an acceptable part of the farming actor-network.

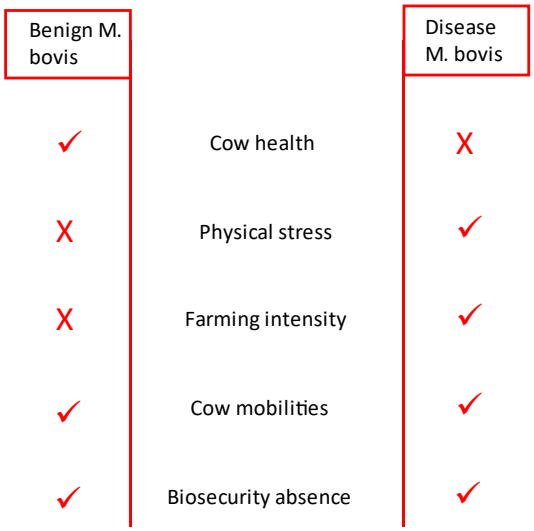
What M. bovis has found is that the farming assemblage in Aotearoa is very resilient, as are the farmers themselves. The majority just keep on doing the same things they have always done, as if the bacteria never existed. For M. bovis, geographical risk mitigation was the goal - it suited the bacteria to have its cells on a variety of farms, in a variety of cows. In some ways, the bacteria have the eradicators to thank for their determinedness to reterritorialise farming, because although many bacterial numbers were eradicated with the cows that were culled, others may yet remain. The eradicators knew that the farmers could not be collectively *interessed* into carrying out biosecurity on their farms, and M. bovis was satisfied that this particular goal of the eradicators has failed. The bacteria just needed to keep its head down and carry on.

Like the cows, M. bovis bacteria were the most difficult actors for the eradicators to *interesse* because the network roles assigned to each of these groups required their collective destruction. Yet, M. bovis and the eradicators both wanted to see the farming assemblage reterritorialised, even though they each had a different vision of that assemblage. In this sense, they had a shared goal. For the eradicators, reterritorialisation was absent of M. bovis, and for M. bovis reterritorialisation was absent of the eradicators.

Bacterial presence and manifest absence were not exclusive material realities in the M. bovis world, because the bacteria could hide and manipulate the boundaries of actors' multiple realities (for example, scientists' testing abilities). Present M. bovis was where disease bovis had been made manifest or visible *with* the farming actor-network (recalling the epidemiologists' reality). This was an M. bovis assemblage with an 'in-here enactment' (Law, 2004), and it could be a 'cruel' M. bovis presence. There were different manifestations of 'disease M. bovis', including 'mastitis bovis', 'pneumonia bovis', 'arthritis bovis' and a general 'failure to thrive in young animals bovis'. Yet, with M. bovis, absence could still be a presence simply because M. bovis could be present and not manifest itself – either within the actor-network or within a cow body. This state is what we can call 'benign M. bovis', which is preferrable for the bacteria, cows and farmers alike.

Below at *Figure 22* is a list of characteristics that have influenced M. bovis in making and remaking these two apparent M. bovis realities. The key assemblage elements influencing M. bovis' apparent absence and presence are listed in the middle of the chart; namely stress, mobilities, intensity and a lack of biosecurity practices.

Figure 22
M. bovis realities and their actors



The diagram shows that certain key farming elements appear in both benign and disease states, such as cow mobilities and the absence of biosecurity. These factors have allowed M. bovis to have a space in the farming assemblage, a place to make its world and story place (Bull, 2018; van Dooren & Rose, 2012). Other elements are the ones that threatened to reveal M. bovis' quiet world-making, and these are intensive farming (especially dairy farming, but barn farming too) and physical pressure (again, most likely associated with dairy farming, but can be influenced by weather and calving). Benign M. bovis is where the bacteria has been able to keep its head down, perhaps, despite provocation from within the network that (mostly) suits it. For M. bovis, disease brought the attention of eradicators, so the bacteria's interests were met through making their presence absent. In those disease M. bovis instances, the bacteria has failed, forgoing the opportunity to enrol those cows and calves for whom it has created misery.

9.2 Obstacle problems

The obstacle problems to M. bovis' goal of survival were eradication (for obvious reasons) and farming intensity, which as mentioned was a particular problem for dairy cows. This section moves first to briefly describe M. bovis' eradication problem. As seen throughout this thesis, the way that Aotearoa farms cows provided unique challenges for those who sought to exclude M. bovis from the actor-network.

9.2.1 Eradication

Like the scallop larvae in Callon's (1986) work, a few bacteria were taken to represent the many. The silent majority of M. bovis bacteria may not have caused any harm, or indeed may not have been capable of doing so. The manifestly present disease M. bovis was taken to represent benign M. bovis in the actor-network negotiations, which points to an approach lacking in any nuance - death for all (and the cows they were associated with). Since benign M. bovis has been betrayed by a few of its own, the question arises as to whether benign M. bovis will/can continue to stoically hide out, only to reappear in the future, essentially betraying disease M. bovis in turn. Perhaps M. bovis' world-building continues in the background, and all the while, the eradicators think they have won the battle for translation. As Callon (1986) makes clear, translation is comprised of a series of moments and the success of the initiating actors is far from guaranteed.

The maintenance of an actor-network requires constant work and vigilance. This has been the work of the eradicators, keeping at bay those actors "we are less keen to share our worlds with" (Bull, 2018, p. 208). For the human actors, M. bovis bacteria were considered "abject" or "matter out of place" (Bull, 2018, p. 218) because they were not acknowledged as useful or valuable, thereby making them an easy target for exclusion. Being worthy solely *in absentia* allowed M. bovis to become valuable where its presence mattered the most: proof of the eradicators' success, or an appearance of total absence. For M. bovis, however, the eradicators and the scientists, even the farmers, were no more exceptional than itself or the cows it inhabited (Tsing, 2015). Let us not forget that it was the human actors who have had to put tremendous effort and considerable resources into finding these bacteria.

The eradicators' programme of culling whole herds was an existential obstacle problem for M. bovis. Yet, there is an additional type of slaughter that is ongoing within farming. While the

extensive movements required by pasture-based farming might have suited M. bovis' drive for mobility and reproduction, that same system has built in barriers to its survival. With each cow slaughtered for food, there was potentially a bacterial ending too, stunting M. bovis' world-making prowess at key times throughout the year.

9.2.2 Farming intensity

M. bovis does not favour high stocking rates and in-shed feeding systems, even though they create prolonged periods of close cow-to-cow contact. Intensity of production is itself a proven factor for M. bovis diseases manifesting in dairy cows. Yet, M. bovis' ideal farming assemblage would have included both dairy farming for those close contact opportunities and beef farming for the mobilities that provide it with opportunities to reproduce. Although, beef farming alone might have been able to sustain a nationwide bacterial population. Calf-rearing suited M. bovis, too, because calves have undeveloped immune systems during the first couple of months of life, making them extremely susceptible to infection. However, if the calves were in poor health or squashed together in pens, then this situation could also turn for M. bovis. Survival is precarious for these bacteria, particularly when they have no other species to which they can turn.

9.3 Obligatory Passage Point

Let us say that the OPP question has been resolved in the positive, and that Aotearoa's farming assemblage suited M. bovis. All of the farming actors would still require ongoing relationship management. M. bovis would have to continually negotiate with others in farming to entice them into allowing it to remain. Betrayal is a constant threat to be aware of, and M. bovis has already been betrayed - by those cows and calves on the Tainui and Zeestraten farms who manifested severe diseases, by the sharemilkers and veterinarians who were determined to 'discover' the bacterial cause, and ultimately by the eradicators. Enrolling and mobilising the cows and the farmers to do the bacteria's bidding would mean consistently being low key and not causing any health or productivity problems for them. (In this sense, we can see that the cows' and the farmers' interests were aligned, even though they had divergent lines of flight and articulation.)

The cows might have been persuaded to side with M. bovis if, for example, their bacterial presence resulted in reduced intensity in dairying. In a kinder farming assemblage, dairy cows

may have been able to live lives free of debilitating mastitis and the arthritis that makes it painful for them to walk. This vision would have required the farmers to put the cows at the centre of their day-to-day businesses, but M. bovis would still not have favoured farmers changing their buying practices or practicing on-farm biosecurity.

Economics is an actor that has fundamentally impacted on M. bovis' ability to achieve its goals. This financial element drives farming behaviour, such as when to call veterinarians, how many cows to farm, how many to slaughter and when, the type of supplementary feed to use and how often the cows are milked. The international trading assemblage is another key actor, and during the 'dairy downturn', when international milk prices dropped significantly due to an oversupply and lack of demand, the farmers reacted by tightening their budgets and consolidating their herds (Galadriel, Researcher). Paradoxically, a situation of financial constraint would have suited M. bovis' need to replicate undetected. However, and yet again there was a bliss point for the bacteria within this assemblage, the tipping point was never far from reach.

9.4 Conclusion

While M. bovis was an actor of considerable power, the bacteria could not make their world alone (Latour, 2005). The bacteria needed cows, and farming, which meant that M. bovis also needed farmers to survive. For M. bovis, there was satisfaction in the eradicators having missed an opportunity to reimagine biosecurity, and the farmers having missed an opportunity to reimagine farming, in Aotearoa. The scientists have succeeded to a limited extent, creating a new body of knowledge, but its relevance is limited by temporality and the eradicators' apparent success. If M. bovis were to remain in Aotearoa undetected, what the scientists now know will not grow and change to keep pace with the mutability of bacterial world-making prowess.

While the human actors were unable to know anything for certain, they were all comfortable in their knowledge that M. bovis had almost been Othered from Aotearoa. By now, these actors are reasonably confident in their abilities and resources, because they have ignored bacterial worlding. Yet, as so often demonstrated by M. bovis, there is a lively tension inherent in more-than-human worlds that human actors cannot readily appreciate. There has already been a new 'incursion' of M. bovis – the strain that appeared in October 2022 and which was unrelated to

the bacteria discovered in July 2017 (MPI, October 2022). Further, one of the scientists now considers that M. bovis can travel on the wind. Perhaps other M. bovis strains have an absent presence even now, and just maybe they are harnessing the wind for travel. Perhaps one of these strains is living quietly within the body of a calf, born to a cow named Araw.

Chapter 10 Discussion

Translation is a process, never a completed accomplishment, and it may (as in the empirical case considered) fail (Callon, 1986, p. 196).

10.1 Introduction

The actors in this thesis have joined together on a journey, each with their own line of flight or articulation. Each have joined together to perform three key biosecurity realities. These ontologies can be summarised as follows: one, there is a fundamental incompatibility between farming and biosecurity; two, farming exists in conflict with, but also creates the need for, biosecurity practices; and three, paradoxically there is no room for the more-than-human world in biosecurity. On a personal note, the first two sets of findings took me by surprise, but not so the third.

I expected to find ongoing issues of trust for farmers and that MPI still does not completely understanding the farming world (see Enticott 2008a; Jaye et al., 2022; Noller et al., 2022). I also expected to find that farmers do not understand the need for ongoing biosecurity (see MPI et al., June 2020). However, there is a deeper problem with farming that is manifest in an ever-present threat to the assemblage that is not simply caused by a lack of trust, farming knowledge by biosecurity actors, or biosecurity knowledge by farming actors. That problem, for biosecurity, is Aotearoa's pasture-based farming assemblage itself.

Farming is an assemblage of biological realities that are enacted in place and held temporarily stable by ongoing politics and practices (Campbell, 2021). The artificial state of agriculture makes it precarious because its existence has already significantly 'ruptured' the ecological processes and interactions that would otherwise thrive in those farmed places (see discussion in Campbell, 2021). Aligned with Campbell (2021), my research has also foregrounded agriculture's fragility, by describing farming's extensive biological mobilities and MPI's inability to enrol farmers in biosecurity, for the reasons expressed above.

An important *interessement* tool (away from biosecurity) for farmers rests squarely with their need to move cows to grass in a pastural bio-economic assemblage. This fundamental and continual need for cows to move (between farms, production types and even islands) underpins the entire network. Biosecurity, on the other hand, slows down and interrupts these dynamic

flows. For this essential reason, along with the continuing understanding among farmers that there are no serious agricultural diseases in Aotearoa, farmers are unlikely to willingly incorporate even the most mundane of biosecurity practices into their regular farming ones.[103] At the beginning of this thesis, I explained that biosecurity and farming exist on opposing axes, making it improbable that farmers would enrol in both lines of flight consecutively. A question arising for discussion is what that finding means for agricultural biosecurity in Aotearoa.

The second collective reality is that the eradicators have (seemingly) succeeded in protecting and stabilising farming by Othering M. bovis.[104] The important points here are that they did so even though the assemblage itself was, and remains, biologically precarious, and even though biosecurity is inherently incompatible with the ongoing need for complex biological mobilities. This ongoing situation invites a discussion about the political aspects of biologically securing economically valuable forms of life in Aotearoa.

The third key reality made apparent by this research is that M. bovis' bacterial world-making is irrelevant to the eradicators' biosecurity work. These actors have commissioned several pieces of research for the purpose of learning lessons from their biosecurity response so they can be better at working with and educating farmers, and so they can be more efficient at eradicating agricultural diseases.[105] The focus of those reports is on human endeavours, rather than on the bacterial world itself, and there is no suggestion that bacteria (or by implication other microbes) have anything to teach human actors about how to manage them. Non-human worlding remains unacknowledged, and this represents a lost learning opportunity for biosecuring agricultural life.

The present chapter explores the three research themes in light of existing biosecurity literatures. I begin with the most fundamental problem, that of incompatibility.

[103] The Read Report also stated that biosecurity was not a priority for farmers and that they "do not know why biosecurity should be their priority" (MPI et al., June 2020, p. 6). Farmers viewed biosecurity as just "another grudge transaction" (MPI et al., June 2020, p. 7).
[104] The Read Report stated that MPI's success at keeping out agricultural diseases has "reinforced on-farm complacency" (MPI et al., June 2020, p. 21).
[105] See the methodology chapter for details.

10.2 There is a fundamental incompatibility between farming and biosecurity

This theme is divided up under three biosecurity headings: inflexibility, singularity, and incompatibility, though they all really speak together of the deep divide between biosecurity and farming in Aotearoa.

10.2.1 Inflexibility

In accordance with traditional biosecurity imperatives, the eradicators have done their best to ensure the continued trade of milk and meat by attempting to 'standardise' farming spaces (Enticott, 2008b, p. 1572). In their quest to eradicate M. bovis, however, the eradicators have imposed inflexible biosecurity practices on the farming world. They have used immutable mobiles to stabilise their biosecurity network, including legal instruments, financial compensation, and inscription devices about M. bovis. Yet, the eradicators' programme of culling and tracing cows, and of declaring controlled areas, was carried out without concern for the flexibility required by lively agricultural spaces. The eradicators enrolled the scientists who have their own identical centres of calculation (laboratories and clinics) that act as intermediaries, passing on their message about M. bovis unchanged (Michael, 2017; Latour, 1987). The standardisation of biosecurity knowledge and practices is materially incompatible with the mutability and mobility required by farming. This finding is inconsistent with Barker's (2008) view that biosecurity practices in Aotearoa are "flexible and sensitive to the shifting spatiotemporal geographies of indeterminate entities" (p. 1612).[106] The farmers, and even the eradicators, who have made meaning in this thesis, have told me otherwise.

This research has shown that the eradicators have acted on the premise that a generalised epistemology is the biosecurity touchstone, and that it can be overlaid onto any biosecurity situation. The Read Report (MPI et al., June 2020) acknowledges that the eradicators need to enrol farmers into practicing biosecurity by reframing their understanding of biosecurity to make it more "personalised, localised and coordinated" (p. 8), as attributes of what 'good biosecurity' looks like on farms. While that recommendation makes good sense for the eradicators, the approach of personalising and localising standardised biosecurity knowledge does not go far enough. My research shows that the world-making of farmers involves multiple

[106] Barker's research was concerned with plant biosecurity (gorse), however, not agricultural diseases.

spatial and heterogenous encounters, making their lived experiences the farming shibboleth. Like farming itself, managing the dynamic nature of disease within a network requires flexibility and not pre-emption (or pre-determination based on experiences with M. bovis in another county) (Hinchliffe & Bingham, 2008).

To understand farmers' biosecurity behaviours, the eradicators needed to recognise the role of farming knowledge and practice. Biosecurity can only be 'rendered' material (Li, 2007) at a local scale by those in whose interests the practices have been made. For example, farmers' decision-making is impacted by materialities outside of their control, including international milk prices, cost of feed, and the weather (Hidano et al., 2019). Therefore, farmers have to be flexible and responsive about herd sizes – how many cows remain and how many have to be sold. Farmers make their cow buying decisions based on what Campbell et al. (2018) call "multifaceted constellations" (p. 40) of influence. These are some of the elements of farming in Aotearoa that inform when and where cows move (Hidano et al., 2019), and the biosecurity practices of researching cow health, recording cow movements, quarantining new stock, and on-farm (and stock truck) hygiene practices do not fit seamlessly into this fluid biological network.

10.2.2 Singularity

This research has reaffirmed that there were multiple M. bovis realities, and that there was "manyfoldedness" (Mol, 2002, p. 84) of disease realities. Yet, as this research has shown, the eradicators' inability to conceptualise more than one M. bovis world has caused them fundamental enrolment and mobilisation problems (see Law, 2006). In holding out their 'truth' about M. bovis as the only reality, the eradicators have enacted a type of "ontological politics" (Law & Singleton, 2015, p. 10) about biosecurity and about farming. In a translatory move, the current farming assemblage becomes reified as the only type of farming possible and/or knowable in Aotearoa. That material semiotic understanding presents an ongoing problem for biosecurity in Aotearoa, because black-boxing farming hinterlands denies the possibility of unpacking and remaking farming assemblages (see Law, 2004; Evans et al., 2021).

Presupposing a singularity for diseases essentially hides the practices that make those materialities, such as the interconnected farming types, intensive dairying and minimal

biosecurity interventions absent/present in the network. Yet, as veterinarians understand already, disease is made knowable by practices (Law & Mol, 2011; Mol, 2002). This has been evidenced by those dairy cows and calves on the Tainui farm (IP1) who manifested severe diseases, whereas other cows on different farms showed none. The sharemilkers on the Tainui farm experienced multiple on-farm/in-here (Law, 2004) presences of M. bovis (Law & Singleton, 2015; Mol, 2002). The disease manifested itself in a particular spatial and temporal way because of the network relations that were present (and materially absent) on that farm (see Law & Singleton, 2015; see also Evans et al., 2021).

More generally, the intensity of dairy farming has acted as a "tipping point" for material absence to morph into presence (Hinchliffe et al., 2013, p. 538). We can see how the "spatiality" (Braun, 2007, p. 251) of those bovine bodies on the Tainui farm was enacted by their place within the network and how place "crumpled" time by enfolding disease into those bodies (Braun, 2007, p. 258; Bingham & Thrift, 2000). That particular form of mastitis could not "register its presence" (Hinchliffe et al., 2013, p. 538) without all of the elements of that dairy farm intra-acting with each other. The separate bovine body is "fractured" (Braun, 2007, p. 258) by the biological network assemblage itself as a group of co-creators of a cow's physical experiences.

Understanding these disease spatio-temporalities helps us to understand how M. bovis behaves in certain assemblages. Knowing that diseases are practiced multiply and made differently by different actors and assemblages would allow biosecurity policymakers to interrogate and compare those realities to learn more about how diseases are made manifest (Law & Singleton, 2015; Evans et al., 2021). Dairy farm boundaries such as milking sheds and calf pens are capable of making the inevitable flow of diseases in particular ways, just as the distances travelled by cows between farms contribute to the shape of M. bovis' world-making and the absence-presence of diseases (Law, 2004 & 2006). We have even seen how the eradicators' different management disciplines and their practices enact their own "ontological variants" (Enticott, 2016b, p. 38) of disease and of the bacteria itself (see also Law & Mol [2011]; Hamill [2019a]).

These matters of concern for the scientists and eradicators raise important questions for farming because, as Enticott (2008a) says, "biosecurity disputes become mobilised around the extent to which agricultural space can/should be defined as either multiple or singular" (p. 1570). The

singular definition categorises and problematises M. bovis, whereas the multiple definition works with a series of heterogenous knowledges. This question matters because the way farming is conceptualised goes to the heart of the incompatibility between farming and biosecurity. Following Haraway (2016), it matters what biosecurity secures biology. The farming assemblage makes mobilising farmers to undertake a singular form of biosecurity a Sisyphean task.

10.2.3 Incompatibility

The eradicators have had many setbacks in trying to translate the farming network. Apart from dealing with farmers, a pivotal one was that the technology the eradicators relied on let them down. The NAIT system proved too difficult for farmers to use, with little capacity for automation or innovation.[107] Simply put, the eradicators relied on the NAIT system to perform a function for which it was not built. Added to this problem was the lack of data entered by farmers. In the words of Li (2007), the NAIT system has failed to render biosecurity activities 'technical'. Most farmers do not see inherent value in complying with NAIT, or indeed in researching the origins and health status of the cows they purchase; most would rather trust their stock agent's word. As the human actors have all made clear, however, farmers might be more willing to do biosecurity if they could see a value in it and if the practices could integrate easily into farming life.

The human actors in this research have reaffirmed existing literature, indicating that farmers are primarily interested in their own farms and what happens within their boundaries, rather than their behaviour being driven by the greater good or health of the national herd (Enticott, 2017; Campbell, 2021). Yet, the main sites of biosecurity risk occur outside of the farm gate, namely buying cows, moving cows, and buying feed and equipment (Donaldson, 2008). Thus, an ongoing challenge for Aotearoa's open farming assemblage is how to manage the "material geography" (Donaldson & Wood, 2004, p. 385) of bacteria and viruses while continuing to support cost effective farming practices (i.e., pasture-based farming). An insurmountable biopolitical problem for the future of farming in Aotearoa is how to secure the extensive

[107] The Read Report also stated that farmers thought NAIT was too difficult to use (MPI et al., June 2020).

circulation of cows without interrupting it (see Hinchliffe & Ward, 2014; Sarasin, 2008; Foucault, 2007).

Consistent with Enticott's (2008b) research on farmer decision-making and bTB, some farmers are "fatalistic" (p. 442) about getting M. bovis. A contributing factor to this attitude must be that the eradicators' requirements were so impractical as to be almost impossible, and even ran counter to accepted and highly valued farming practices. Farmers in this research have also indicated that the eradicators needed to "reflexively think about the limitations of their proposed solutions" (Enticott, 2008a, p. 443) when overlaid on the spatial logistics of farming. Farmers have implicitly laid down a challenge to the eradicators, which is to deterritorialise the black box of biosecurity. But, until such time as the eradicators are willing to reimagine these practices *with* farming, this challenge will remain unaccepted.

The eradicators have used "epidemiological borders" (Shortall & Brown, 2021, p. 574) to govern M. bovis and shore up the boundaries between health and disease. Legal boundaries and controls have been acted geographically to create so-called disease-free spaces in a bid to disentangle bovine bodies from bacterial lives (Enticott, 2016b; Donaldson & Wood, 2004; Law, 2006). This Foucauldian approach to biosecuring farming is incongruous with an open farming assemblage. Cow health itself can only be declared because disease is not made manifest or is presumed absent (Law, 2004; Hinchliffe et al., 2013). Yet, as Enticott (2016b) observes, "disease is always indefinite" (p. 43). While the eradicators appear to have 'won' their battle with the bacteria, the new strain of M. bovis and the possibility of bacterial air travel have already borne out Hinchliffe's (2013) observation that "walling out" (p. 204) unwanted life can never guarantee success.

M. bovis diseases have developed within and because of a localised network of relations and, following Law (2015), they did not precede those relations. While overseas literature is instructive, farming in Aotearoa is differently ordered, so it makes sense that bacteria and viruses will behave differently here (Law, 2004; Law & Singleton, 2015). This is evidenced by the relative lack of disease presentations in Aotearoa related to M. bovis, such as mastitis and pneumonia. Cow bodies are made by the biological networks they exist within (Braun, 2007), and Aotearoa's open-movement farming assemblage 'makes' M. bovis differently, as the scientists found when they studied the production impacts (or lack thereof) on dairy cows. It

was premature of the eradicators to impose an *a priori* biosecurity position on M. bovis' world-making in Aotearoa (Law, 2015; Callon, 1986).

10.3 Farming exists in conflict with, but also creates the need for, biosecurity practices

Maintaining any network requires constant work and vigilance (Callon, 1986). For farming, this has been the work of the eradicators, keeping at bay those actors "we are less keen to share our worlds with" (Bull, 2018, p. 208). The eradicators have constructed M. bovis as a disease, and a threat to the farming order: a sinister mobility opposed to healthy cows. As the bacteria cannot be separated from their bovine hosts, M. bovis is problematised as a threat to the very foundations of farming (see Barker et al., 2013). The biosecurity narratives of the eradicators have problematised M. bovis and imbued the bacteria with social and political significance (Barker et al., 2013; Law & Mol, 2008a). We have seen that the eradication programme was less about securing cow health and more about ensuring productivity and protecting cow mobilities. Yet, there is a paradox here. The farming assemblage *itself* creates the need for ongoing biosecurity practices, and we already know that farmers are not enrolled in performing the biosecurity required to secure farming.

Not only have the eradicators purported to be the experts on agricultural disease management so they could be the only ones to provide a solution to the M. bovis problem, but they have also unwittingly prevented farmers from finding their own ways of practising biosecurity into farming. Once M. bovis was discovered, the 'cavalry' rode into rural Aotearoa and farmers were saved (or prevented) from enacting their own, meaningful biosecurity realities. Once the bacteria were ostensibly Othered, the eradicators found they had no leverage to enrol farmers in lesser biosecurity measures that both the eradicators and the scientists desired them to enact. Any incentive to practice on-farm biosecurity in Aotearoa has been made materially absent in the process of ensuring the network's continuation.

Farmers do not need to deterritorialise the biosecurity system to continue farming in the way they usually do; they just need to make it irrelevant or materially absent to their lives. Contrary to Callon's (1986) work with the scallops and the researchers of St Brieuc Bay, farmers in Aotearoa did not have to 'learn' how to do biosecurity for the eradicators to realise their goals. The eradicators have apparently succeeded (and unexpectedly given their translation struggles)

in Othering M. bovis despite a lack of mobilisation by farmers. It follows then that on-farm biosecurity in Aotearoa will not advance with the Foucauldian practice of eradicating infection, or indeed through the biopolitical practice of vaccination (though M. bovis does not afford them this option) (see Sarasin, 2008).

What "acts with" (Donaldson, 2008, p. 1556) farming is its very *raison d'etre* - that 'cows to grass' manifestation of productivism. While farming itself acts with eradication, it also acts against the mundane biosecurity practices that the farmers say they cannot make work. Given Gandalf's (Government) description of the politicisation of eradicating M. bovis, the question must be asked whether the eradicators problematised M. bovis *to* pursue the goal of eradication for the purpose of strengthening farming and to gain the loyalty of farmers (Callon, 1986). We know that problems do not exist *a priori*, outside of a network; problems are made (see Donaldson, 2008). Perhaps the eradicators were really seeking a problem to fulfil their own solution (Latour, 1987). Yet the farmers' loyalty could not be engendered, even when they shared an overarching line of articulation, such is the incompatibility of biosecurity and farming. (M. bovis is the other actor who shared the same line of articulation, because farming mobilities without biosecurity intervention suits the bacteria, but the eradicators could never enrol M. bovis.)

If the Government wanted to be seen to be acting in the farmers' interests, then it did so by mobilising the eradicators to "draw an unnecessarily alarmist line through the animal collective" (Law, 2008, p. 63). This biosecurity decision-making was quickly black-boxed by the eradicators, who then enrolled farmers (by force of law) and the scientists in "a highly centralised government machine" (Law, 2008, p. 63) to reterritorialise the farming assemblage. This narrative accords with Potter's (2013) view that risk assessments are political decision-making tools, even though they are designed to appear scientifically justifiable. The result is that the farming network has proven to be highly "durable", being able to restabilise those "associations that resist betrayal" (Michael, 2017, p. 46).

The way that M. bovis has made itself visible at various sites and the frequency with which cows travel between farming spaces in Aotearoa adheres to the description by Barad (2007) that farming is held together by 'intra-actions' involving "a landscape of intensities and pressure points" (Allen & Lavau, 2015, p. 357). Farming in Aotearoa, as elsewhere, is comprised of key macro elements or actors that interfere with each other to create a semi-stable,

but, ultimately, impermanent entanglements (Tsing, 2015). The way farming is configured, it needs to continue with cow movements (which currently means accepting the risk of M. bovis and other microbes taking advantage of essential mobilities). Farming is a physical actor, but it is also a political type of actor, "made and remade" (Law, 2004, p. 69) by economic forces. Farmers have a mindset that they are the economic lynchpin of the country, and this feeds an expectation that the government will look after them (Treebeard, Government). Farmer realities have been reified by and situated within the traditional black box of farming in Aotearoa that is based on the value of pasture.

The health of agricultural farming networks is precarious (Campbell, 2021; Law, 2006) because these homogenous agricultural assemblages are by their nature "out of place" (Clark, 2013, p. 33). There can be no pure, clean, disease-free spaces in farming, and the farmers know this through lived experience. They have struggled to illuminate this knowledge for the eradicators, some of whom were surprised to learn that dairy and beef farming are mutually dependent. This tight set of relations makes a biosecurity epistemology, based on walling out bacteria from farming spaces, impossible to maintain. The biological spaces of farming are made to support that overall farming order, which though it appears to be a stable configuration is really comprised of a shifting set of elements that are capable of deterritorialising the whole (Campbell, 2021; Donaldson & Wood, 2004; Hinchliffe & Bingham, 2008; Law, 2006; Law & Mol, 2008a).

Biosecurity is not part of farming in Aotearoa, and the human actors have made that clear. Being a good farmer and concerned with cow health and productivity is not viewed by farmers as doing 'biosecurity', because that is something that MPI does at the border (Shortall et al., 2018; MPI et al., June 2020; see also Naylor et al., 2018). Farmers' comments that cows have to move to keep farming going reflects the assemblage creating an immutable mobile of cow mobility (Latour, 1987, 2005). This is an undisputed position that does not alter, irrespective of farming type or place.[108] Farmers' lack of biosecurity consciousness means that they cannot be trusted to control M. bovis - at least, that is what the scientists and eradicators say, though they are trying to mobilise farmers to do biosecurity voluntarily (see, for example, MPI et al.,

[108] However, there are ongoing restrictions on cow movements from areas where they are at risk of contracting bTB.

June 2020). As Campbell (2021) also found, farmers are more focused on what is happening on their own farms, rather than outside of them. One reason for this attitude is that, being pragmatic actors, farmers will focus on what they can control (Campbell, 2021).

Farming has revealed itself to be a strong and stubborn force, and its pasture-based practices are entrenched in what it means to farm this land. However, Galadriel (Researcher) provided an alternative, future focussed view of farming that troubles the eradicators' reterritorialisation of pasture-based farming. Galadriel considered that the time has long since past when Aotearoa had a surplus of land that needed hard working men and women to "break it in", and when the natural environment had capacity to absorb farming externalities. Now farming is performed where there is neither a surplus of land nor a natural environment that can absorb more outdoor dairy cows. It is clear to Galadriel that the current dairy assemblage is environmentally unsustainable and that eventually Aotearoa's farmers will have to "take cows off pasture and put them onto concrete".

Similarly, Samwise (Farmer) thought that the shape of farming could change in the future, and that this change could be towards more intensive or barn farming. Driving this change, they said, is environmental regulation around nitrogen outputs; in a barn system, the effluent is managed. There are also feed efficiencies and less waste when feeding grain and silage. Yet, a 'cows on concrete' model would run counter to the seasonal system that has been evident in Aotearoa since the 1800s, and it carries the risk that the biosecurity profile would shift to align more with European farming countries. If this change were to occur, and M. bovis were to re-emerge, the bacteria could have a greater impact on cow health and production than they have done to date (see the farmers' chapter).

In addition, while Araw is more than 'mere' life (cf Honig, 2009; Allen & Lavau, 2015) in her current farming world, barn life with hundreds of her herdmates would threaten to make her so (Hinchliffe & Bingham, 2008). For example, while Aotearoa has many of the common respiratory diseases, finding respiratory disease in calves is currently uncommon because housing calves indoors is for a limited period and then they are transferred to pasture with fresh air. In addition, Aotearoa's seasonal breeding system means that calf pens sit empty for most of the year, so those microbes do not have the chance to thrive here (Laven, 2019).

However, barn farming would have the advantage of cows calving all year round (so there would potentially be fewer surplus and unwanted [bobby] calves). There would be far fewer cow movements for grazing purposes, though some movements between dairy and beef herds would most likely need to remain. If moving feed to cows was to become an accepted way of farming in Aotearoa for environmental reasons, then the seasons would play less of a pivotal role in shaping the farming actor-network. The more enclosed the cows become, and the fewer the movements, perhaps the easier it would become for Aotearoa farmers to practice biosecurity.

The farming assemblage within which M. bovis arrived, and the one that the eradicators worked so hard to reterritorialise, may not be how farming will be enacted in the future. In any event, if there was to be a move towards some barn farming, keeping endemic diseases at a minimum would be of utmost biosecurity importance. Perhaps, even more so than now.

10.4 Paradoxically, there is no room for the more-than-human world in biosecurity

As the only biological hosts of M. bovis, cows have been the "understandable targets" (Bull, 2018, p. 215) of a Foucauldian eradication model of Othering disease from society (Sarasin, 2008). This narrative both renders cows 'disposable' (Bull, 2018) and dismisses the agency of the bacteria that render them so (Haraway, 2008). Cows' lives are used as a means of creating boundaries between the presence of health and disease, as if these bovine realities only exist to be mapped on a geographical plane (Hinchliffe et al., 2013). Culling cows to eradicate the bacteria makes the reality that there are only diseased or healthy cows in farming, and no cows whose health status is unknown or uncertain (Donaldson & Wood, 2004). Culling cows enacts and then stabilises disease absence (Law & Mol, 2011; Law, 2004). However, the spatio-temporalities of the bovine body are multiple (Mol, 2002), made by mutable and mutating relationships. Araw's body weakened with the pressure points inherent within dairy farming (Allen & Lavau, 2015), making space for diseases to manifest (Hinchliffe et al., 2013). Yet, Araw was not the sum of her biology or parasitic bacteria (Enticott, 2008b). She was a lively cow (Henry & Roche, 2013) who claimed and transformed farming spaces (Wise, 2014).

Like the scallop larvae in Callon's (1986) work, the few bacteria causing diseases were taken to represent the many. The silent majority may not cause any harm, or indeed may not be

capable of doing so. Some bacteria could be seen as enrolling cows at a collective level, so that bacteria and their hosts were treated as one and the same reality (Bull, 2018). Perhaps M. bovis was the actor with "dark designs" for cows in Aotearoa (Latour, 1988a, p. 194), or maybe some organisms are simply friendlier than others. The manifestly present disease M. bovis was taken to represent benign M. bovis in the actor-network negotiations, which pointed to death for all. Since benign bovis has been betrayed by a few of its own, a question is whether benign M. bovis will continue to stoically hide out and survive the culling programme only to reappear in the future, essentially betraying M. disease bovis in turn.

Given that human made boundaries between countries, regions, and farms are "inherently permeable", the "eradication-of-disease" form of biosecurity is ultimately futile (Barker, 2008, p. 1612). Put more charitably, eradication is a time-bound achievement. An epistemological question asked by Enticott (2017) is also one that this research asks of the eradicators: "If disease knows no boundaries, why are boundaries required to control it?" (p. 153). One answer is possibly because those who practice biosecurity are not engaging with the non-human agency that caused the network destabilisation in the first place. This human-centred, geographically bounded approach to securing fluid biological life is inherently paradoxical.

Instead of viewing M. bovis as an interloper into farming, perhaps the eradicators could see these bacteria as co-creators of "the borderlands that make any life possible" (Hinchliffe & Ward, 2014, p. 143; see also Enticott, 2016b). This borderlands space is a foundation on which to build localised biosecure farming practices; it is also valuable as the place where immunities are enacted (Hinchliffe & Ward, 2014). As we know from the scientists, cows are capable of creating some kind of immunity from M. bovis diseases. So-called 'herd' immunity is instructive here as a phenomenon to think with. In this way, cows are made biologically secure not only by their own bodies, but those of others within the same species (Sarasin, 2008). Immunity to diseases then is simply cows engaging with the bacteria, in a way that both become combined biologically. Immunity has been called an emergent biological property that forms a "non-excluding" (Esposito, 2011, p. 17) relationship with microbial life. Yet, this state of non-excluding does not equate to "unconditional hospitality" (Hinchliffe & Ward, 2014, p. 143). This biological community of interactions and world of 'becoming' are key aspects of

biosecuring agriculture through trusting non-human intelligence. Viewed in this light, M. bovis, and perhaps other organisms, could become integral to enacting the health of cows.[109]

While the importance of engaging with living organisms during times of biosecurity emergency is acknowledged (see Collier & Lakoff, 2008), an alternative would be to acknowledge the role of non-human actors in farming assemblages by allowing for connections to be made and multiple ontologies to be recognised (Forney, 2016, p. 70). A material semiotic knowing could prise open the black box of biosecurity and make space for reimagining how to secure biological life (Hinchliffe et al., 2013; Hinchliffe & Ward, 2014). A material semiotic knowing would acknowledge bacteria and viruses as emergent life within (and because of) the farming assemblage itself, making conceptual space for the performativity of pests and diseases (Law, 2004; see also Hinchliffe et al., 2017). This reassembling of farming would not equate to simply accepting cow suffering and disease, however, because the translation goal would be a new way of farming committed to learning from the organisms that must be worked with to secure cow health.

Instead of a push-pull power play for network enrolment, a "becoming with" (Haraway, 2008, p. 3; Bull, 2018) approach would intimate a more than a 'living with' acceptance of bacteria; a 'becoming with' implies network building together with M. bovis as an actor with agency, a mediator in its own right. This type of farming network could challenge time-space relations, human-animal relations, and bodily-bacterial (or viral) relations. Becoming with non-human organisms could suggest a flatter methodology, one of collaboration instead of a narrative of contamination (Tsing, 2015). Thinking with M. bovis, for example, would necessitate shunning the practice of eradication and empower farmers and their veterinarians to practice a mindfulness that translates farming into focussing on cow health and wellbeing, as well as profitability. Thinking with bacteria and viruses is to recognise the reasons why they will choose self-expression, perhaps making for more comfortable microbial-cow relations. M.

[109] I acknowledge that there is a potentially unpalatable cost to an immunity approach, however, which is that many cows will suffer and/or die before making bodily immunity to viruses and bacteria (as they do with eradication). A salient point is that this reimagining of farming to secure against the harms of FMD, for example, is unknown because the standard international response is to cull infected herds (or to vaccinate where there is an endemic strain) (WOAH, n.d.).

bovis has offered farming and biosecurity a non-binary model of becoming with microbes that has creative 'entanglements' at its core (Tsing, 2015).

To date, however, the eradicators and, ultimately, the farmers have not been motivated to take up that offer. In forcefully Othering M. bovis, the eradicators have missed an important opportunity to translate new farming biosecurity worlds (Hinchliffe, 2001). And learning opportunities like this one, with a slow-moving and relatively benign bacterial presence, are rare indeed (as acknowledged by the eradicators' own Read Report, MPI et al., June 2020).

10.5 Conclusion

The actors who have made this thesis have revealed three key biosecurity realities in Aotearoa, and this chapter has discussed each of these in turn. To recap, the first is that the eradicators' biosecurity epistemology and practices were fundamentally incompatible with farming practices. They are singular, inflexible, and are based on past biosecurity experiences. The second is that the eradicators have acted to reterritorialise farming, even though cow mobilities will remain an obstacle problem for them in the future (at least, as long as farming remains extensive, and pasture driven). And the third is that the eradicators have not acknowledged bacterial agency, which is paradoxical given the vast human effort (and financial cost) required to find and destroy them.

This research can be conceptually framed as involving a tale of two competing epistemologies - that of Othering and that of becoming with (a reality that is still consistent with managing bacterial lives but doing so through biosecuring the spaces through which life moves in all its materiality and absent-presences). If the eradicators had failed in their attempt to eradicate M. bovis, which they still might, this failure would have created a space for ongoing biosecurity and farming discussions, including practices to 'manage' M. bovis *in situ*, and possibly other bacteria, too. Aotearoa's farmers already live with and manage endemic bovine microbes such as leptospirosis, bTB and BVD. However, translating farming to *becoming with* microbial life would represent a significant network disruption.

On a personal note, the government's decision to reterritorialise a farming assemblage that is incompatible with MPI's biosecurity practices is not the situation I was expecting to find. Yet, this research has undeniably shown that there is an ongoing vulnerability for farming arising

from this uneasy and seemingly entrenched set of network relations. The next and final chapter provides some concluding remarks and discusses some options for future biosecurity research that flow from these findings.

Chapter 11 Conclusion

If, in a given situation, no dissenter is able to modify the shape of a new object, then that's it, it is reality, at least for as long as the trials of strength are not modified (Latour, 1987, p. 93).

This final chapter is presented in three short, but impactful parts. The first part restates and reframes the research contributions that have emerged from the preceding chapters. The second identifies some important biosecurity implications that have arisen from this thesis, while the third part offers some ideas and opportunities for research into the biosecurity future of farming animals. As will be discussed below, I think that reimagining farming with cows and other non-human actors is not only possible but necessary for animal health and welfare. In a related move, it must also be possible to recast biosecurity through deterritorialising its universal framings.

This thesis has shown that 'biosecurity readiness' (for a disease incursion) cannot continue to be driven by predetermined approaches to protecting agricultural networks or managing disease presentations. And a blanket denial of space for undesirable life will continue to be a troubling gold-standard for biosecurity success. Law (2004) tells us that method is a creative endeavour, allowing for possibilities and the emergence of different realities. Important methodological questions arise, then, about what could 'become with' farming if biosecurity tools were applied using methodological symmetry; that is, through listening to all of the actors, understanding their roles and thinking with network influences (Venturini, 2010a; Haraway, 2008; Tsing, 2015).

11.1 Contributions

This thesis has followed key actors involved with M. bovis and attempted to unravel the knots (Tsing, 2015) of these actors' translation challenges. M. bovis' presence was a temporary disruptor of farming, but the bacteria did not end up translating farming (Callon, 1986; Michael, 2017). Similarly, M. bovis' world-making has challenged but not changed the traditional biosecurity assemblage that has evolved from the need to protect farming itself (see the introductory chapter). Instead, it was the eradicators who grew in strength over the course of the programme, particularly during the reset phase, allowing them to black box their problematisation of M. bovis and reify farming mobilities (Callon & Latour, 1981; Latour, 1987; Michael, 2017).

The eradicators' goals became inherently conflicted when the eradication decision was made, however, because they became enrolled by farming itself, and subsequently acted to strengthen it (Gollum, Government). The cavalry's arrival meant that farmers have been saved (or prevented) by the eradicators from enacting their own local and meaningful biosecurity knowledges. The eradicators continue to consider that farming can be made a disease-free space. However, M. bovis has also illustrated that microbial life operates on multiple planes, and the bacteria's ability to hide within cow bodies and travel on the wind to neighbouring farms suggests that the eradicators are premature in writing an end to this story.

If there exists a spectrum of biosecurity measures with surveillance at the least invasive end and culling cows at the most extreme, the eradicators began their quest at the extreme end. Not only did the eradicators move quickly through the biosecurity preliminaries, but they also culled whole herds on the basis that the scientists' tests were unreliable measures of infection. Beginning at the end left them no ability to enrol farmers in less invasive means of managing the bacteria, because once the culling appeared to be successful, those problematised microorganisms ceased to be a material problem for the human actors.

The careful and ordinary multidisciplinary and multi-layered practices of biosecurity became absent presences with this blunt and overly simplistic reterritorialisation of farming. Consequently, the eradicators have curtailed the progression of rural biosecurity in ostensibly thwarting M. bovis' world-making. The eradicators' successful reterritorialisation of pasture-based farming has seen them fail in their twin goal, which was to deterritorialise farming so that biosecurity becomes a rewarding and valued on-farm practice.

In fairness to the eradicators, however, the very nature of farming undermines biosecurity with its extensive cow mobilities, and this is the real threat that farming bodes to itself. The assemblage continues to be biologically risky, even with an increase in on-farm biosecurity practices, which the eradicators consider is possible using tools of *interessement*, such as financial incentives, ease of implementation and compliance measures. The open gate for bacteria and virus transfer from cow to cow and farm to farm *is* this incompatible system of movements. Farmers' day to day biosecurity practices can minimise risk and spread of new diseases, if they can be mobilised to enact these inflexible practices, but as Law (2006) has argued, they cannot make farming safe.

After five years of conflict and contestation, both the biosecurity and the farming assemblages remain strong; each is an established and persistent network in Aotearoa. What is concerning is that, despite biosecurity originally being enacted to protect the farming economy, each assemblage has evolved in divergent and opposing directions, so that the network tenacity of each becomes a barrier to working together now and in the future. While it is understandable that biosecurity practitioners look to past experiences for future guidance, M. bovis has illustrated that territorialising biosecurity from a single disease epistemology (for whatever that disease might be) acts to reinforce farming's precarity.

Questions naturally arise about what this ongoing incompatibility between farming and biosecurity means for the future of biosecuring food production – not only in Aotearoa, but more broadly. For example, agricultural communities in the UK seem to be facing similar translation difficulties (see Sarasin [2008], Hinchliffe et al., [2013], & Enticott [2016b]). My research has made space for southern hemisphere farming voices within contemporary UK biosecurity literatures, and in this way telling stories about biosecuring farming in Aotearoa reaches further than our shores. More locally, this thesis' actors and I have empirically broadened antipodean more-than-human inquiries (*Figure 3* refers), illustrating that ANT's methods are valuable tools for understanding biosecurity and agricultural worlds.

11.2 Implications

When I began this research, my aim was just to re-cast biosecurity's goal of safe life using a material semiotic framing. The stated intention was to "contribute to a long-overdue conversation about the value of unravelling the knots of interspecies relationships in the context of making life safe" (McDonald, 2020a, p. 4). In true actor-network style, however, the research outcomes have been made by the eradicators, scientists, and farmers that I interviewed, as well as by my own performance of asking certain questions and pulling the conceptual threads. Those questions related to farming practices and biosecurity practices as well as M. bovis' behaviour in Aotearoa, making space for (but not pre-empting) a wider discussion about the (now apparent) tensions between the two networks and their respective actors.

Consistent with Law's (2004) use of the term 'method assemblage', not only have new realities been made in the hinterlands of this research, but previous realities have been unmade. For

example, the multiple realities of M. bovis, farming and biosecurity have ruptured my own biosecurity preconceptions and understandings. A new set of farming and biosecurity worlds have emerged, and it is with an assemblage lens that I now seek to understand the power of disease presence and manifest absence.

A key finding of this thesis is the incompatibility between two assemblages that are vital to Aotearoa's national security. There are potentially wide-reaching policy implications arising from this finding, including whether the government will continue to support farming in its current shape or act to deterritorialise cow mobilities, for example. Perhaps there will be other drivers, such as climate change impacts or environmental regulations, influencing future farming assemblages. Questions about the future of biosecurity itself may also arise, because one option must be to allow the flows and folds of cow bodies without continuing to attempt to marry two incompatible networks. Dairy farming enacts a vital biological economy, and perhaps a question that will be posed is which assemblage is more powerful, or which network actors speak the loudest, for whom and in whose interests.

In 2021, the Governance Group commissioned an independent review panel to "consider lessons learnt from the M. bovis programme" and "support efforts to strengthen the biosecurity system" (MPI et al., July 2021, p. 6). While the reviewers found that M. bovis represented a "significant test of the capacity and capability" (p. 7) of Aotearoa's farming and biosecurity networks, they were "confident that the lessons learnt from M. bovis, if acted upon, will enable New Zealand to have a far stronger biosecurity preparedness platform for future animal disease incursions" (MPI et al., July, 2021, p. 8). What this thesis has shown, however, is that no matter how many lessons the eradicators have learnt about how to better eradicate microbial life, their biosecurity practices are unlikely to willingly enrol farmers. This finding should trouble biosecurity practitioners, policymakers and farming bodies, alike.

M. bovis has encouraged the eradicators to deterritorialise biosecurity practices to allow for a more flexible, localised approach, but my findings show that merely tinkering with biosecurity is not going to be enough to make farming biosecure. In strengthening the farming and biosecurity assemblages separately, the eradicators have missed an opportunity to unpack their own understanding of both by attending to the liveliness that happens in farming spaces.

My findings about farmers' biosecurity attitudes broadly concur with those in the Read Report (MPI et al., June 2020), but the contribution this research makes is much more fundamental and goes to the heart of farming and biosecurity itself. Finding more sophisticated ways to sell the biosecurity narrative to farmers does not change the overall incompatibility of biosecurity practices or the underlying risk of pasture-based farming. Importantly for biosecurity thinking, the issue to be problematised is not M. bovis or other microbes, but the way that we farm - the intensity of dairying, the lack of biosecurity measures and the bovine mobilities.

The eradicators say their network is now ready for FMD, which would be far more impactful for cows, for Aotearoa's economy, and for rural communities than M. bovis was. FMD also impacts other cloven-hoofed animals, in addition to cows, such as, deer, pigs, sheep and goats. Any eradication programme would have to encompass all of this country's agricultural production types, and the eradicators and their scientists would have to mobilise at speed.

In response to an FMD incursion, the eradicators would likely problematise FMD as a national security issue and attempt to Other the virus as quickly as possible, by using the most extreme biosecurity measures possible.[110] These practices would centre around movement restrictions and culling the animals on infected farms. It is also conceivable that by the time FMD was discovered, the virus would have spread to many farms (and farming types), and potentially across both islands. The extensive spread of this fast-moving virus would not only be 'made with' Aotearoa's farming network, but it would also be made much worse by it. Yet, for now farmers will continue to farm the way they have always done, and the eradicators seem content to rely on an *ex post facto* model of ousting disease as their most powerful biosecurity measure.

11.3 Future research

Farming and biosecurity do not need to aspire to holding the same, static shape. Indeed, both assemblages have shown they are capable of innovation and responsiveness when the situation requires it. There remain many questions to be asked of farmers in Aotearoa, and much in-here knowledge about more-than-human relations is yet to be shared.

[110] For examples of FMD readiness and planning, see https://www.mpi.govt.nz/biosecurity/pests-and-diseases-not-in-new-zealand/animal-diseases-not-in-nz/foot-and-mouth-disease-response-plans/foot-and-mouth-disease-readiness/

Before considering the 'how' of any new farming or biosecurity assemblage, however, there is a need to problematise the existing networks, and the eradicators and farmers (respectively) have not done this. There is also a need to *interesse* the farming community as a whole into a new way of farming, including the transporters and stock agents. This process of translation requires an answer to the perennial challenge arising from farmers, 'What is in it for me?'. A pressing concern for the future of farming is how farmers can be *interessed* away from their current practices to create a more secure farming world.

Cow movements underpin pasture-based farming, but they are also a key reason why biosecurity practices are incompatible with farming, and why biosecurity is so important for the continuation of farming. Other practices, such as feeding calves waste-milk, are biologically insecure too, but they are rewarded because they are cost effective, and in a network with few diseases, farmers have been willing to take the risk because it is not a big risk. These farming practices are foundational, but they have to change to make farming more biologically secure, and that change requires more than just deterritorialising biosecurity to make it more flexible and localised. The type of biosecurity change that is meaningful would be a complete breaking apart of farming, and a remaking of the assemblage with new foundations, relations, and more-than-human values.

Elladan's (Farmer) story was one that has remained at the forefront of my mind when considering options for the future of a more biosecure farming assemblage. They were someone who was eventually motivated to join the eradicators because they were afraid of losing their cows. There is an aspect of their story that did not make it into the farmers' chapter, but that is apt to share here because it is pivotal to the future conundrum of biosecuring farming:

> The boys had a mob of cows get out on fodder beet about a year ago, and I stayed all night in a four-wheel drive, driving around the paddock to make sure they were okay. Animal welfare, mate. I had my cell phone set on a time, and I'd drive around and make sure they were all up…We give. We give. This is our corner. You can't walk away from the cows. It was up to us, and we had a good team. They're the sort of things that people don't see. There's a lot of people like us - we care. And those girls, they're our girls (Elladan, Farmer).

This story is consistent with a Read Report finding that "having happy, healthy animals" (MPI et al., June 2020, p. 36) is a motivator for farmer behaviour. Many farmers have psychological

and/or emotional bonds with their cows, and as eloquently put by van Dooren (2014), they are "at stake in each other's company" (p. 137). Just as cows do not pre-exist as cows (i.e., as production animals) outside of the farming assemblage, farmers do not pre-exist as farmers - farmers and cows are made and known together (Haraway, 2016; Mol, 2002; Law & Mol, 2011). It is these more-than-human bonds that hold the potential for reimagining farming. What if farming could be translated into a more biosecure farming assemblage that is based on cow welfare? None of the human actors could (legitimately or legally) argue with that priority. Aotearoa's normative definition of biosecurity expressly secures the economy from the harm posed by pests and diseases. Given the role of agriculture in performing the national economy, biosecurity must also have at its foundation the health and wellbeing of agricultural animals. The OPP question becomes, 'What is best for my cows?'.

One consequence of putting cows at the centre of the farming world would be that their welfare, and not mere economics, becomes the touchstone of a successful farming assemblage (see also Campbell, 2021). Economic security would be a consequence of biosecuring farming. Farmers 'becoming with' their cows would require not only a rethinking of the farming network, but also a revisioning of the formative role of biosecurity. A formative biosecurity assemblage would look to "render capable" (Haraway, 2016, p. 126) Araw and her herdmates by being open to more-than-human encounters. Could farmers secure ongoing cow health and productivity by re-engineering the flows and folds of non-human life inherent in the farming assemblage (Law, 2006)? What would biosecurity surveillance look like if it were continually re-enacted topologically to work with microbial mobilities and manifestations?

Latour (1988a) asks what knowledge would reveal itself if we allowed non-human actors to speak for themselves, as opposed to silencing them or merely allowing them to "communicate by gesture or symptom alone" (p. 194). This raises the question of what cows could teach humans about biosecurity, if cows were listened to about their experiences of microbes infecting their places and bodily spaces (Bull, 2018). Could biosecuring farming make space for the way that cows like Araw story their network roles and contributions (Latour, 1988a; van Dooren & Rose, 2012)? We already know that cows can 'become with' (Haraway, 2008) M. bovis to enact immunity. What might humans learn about biosecuring life by observing and then describing the shape of that becoming?

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Appendix A: Generic Interview Schedule

Mycoplasma Bovis and Biosecurity in Aotearoa.

INTERVIEW SCHEDULE

The following interview questions have been shaped by my PhD research questions, and they represent the types of questions that I will ask. Further questions will develop from those listed, as I may ask you to elaborate on, clarify or explain information.

Proposed topics:

1.1 Qualifying questions:
   a. name, address, qualifications; and
   b. length in the role, work history relevant to biosecurity and/or farming.

1.2 I'm interested in how M. bovis has impacted on you, so I will ask questions like:
   a. How has M. bovis affected you?
   b. What have been your experiences of M. bovis?
   c. What happened for you during the incursion and biosecurity response?

1.3 How does M. bovis behave (individual animals, transmission, at herd level)? Have you observed animals with M. bovis?

1.4 Who do you consider to be the most prominent or influential people and/or roles in the M. bovis incursion?

1.5 Are there any more-than-human factors such as systems or data management or scientific testing that have influenced the M. bovis incursion response and its success?

1.6 Do you think M. bovis has impacted on the way that farmers or officials think and talk about biosecurity, and if so how? (Elaborate on the nature of the changes, if any.)

1.7 How did MPI and others get farmers on board with the response?

1.8 Why do you think eradication is the goal when the vast majority of cattle are asymptomatic?

1.9 Do you think the arrival of M. bovis has changed biosecurity practices in Aotearoa, and if so how? (Elaborate on the nature of the changes, if any.)

1.10 How were notices of direction and restricted place notices used during the response? Was there any flexibility in application depending on the farm, location and/or time of year?

1.11 How does the way that Aotearoa farms cattle differ from most other countries, and how is that relevant in dealing with M. bovis?

1.12 Do different farming methods and practices impact on whether farmers get M. bovis in their herds?

1.13 Does the size of a farm or how it is operated impact on whether M. bovis infected animals become symptomatic? What about the ability to observe cattle and interact with them?

1.14 Does M. bovis impact on productivity of milk and calving?

1.15 What is the role and importance of science and scientific testing in this response?

1.16 Does entering movement data (ie, NAIT) assist in prevention of animal diseases, or spread of those diseases, or in managing them once they have occurred? If so, how?

1.17 How has M. bovis influenced the Biosecurity Act 1993 and the NAIT system reviews?

1.18 Why do you think M. bovis is being treated differently to bTB or bovine viral diarrhoea (BVD) in a short-term, intensive eradication attempt?

1.19 Do you support the current eradication attempt, and what are your reasons? What is your experience with that?

1.20 In your view, how likely is the eradication attempt to succeed after ten years? Were there other viable options to deal with M. bovis?

1.21 How will successful eradication be measured?

1.22 Why do you think Aotearoa is the only country to have attempted to eradicate M. bovis?

1.23 Have you seen COVID-19 impacting on the M bovis response, and if so, how?

1.24 In your view, would animal disease reporting change without the option of being compensated for biosecurity measures? In what ways?

1.25 What can we learn from the M. bovis response about biosecurity practices in Aotearoa?

1.26 Do you think that farmers' practices have changed because of M. bovis? In what ways, specifically?

1.27 Do you think any long-term changes in biosecurity practices coming from M. bovis being in Aotearoa would depend on whether M. bovis stayed in the country (i.e., if it was not successfully eradicated), and if so, why?

1.28 With hindsight, do you think we should have done anything differently during the response or been more prepared for M. bovis?

1.29 Is there anything else that you would like to add about M. bovis and biosecurity in Aotearoa?

You do not have to answer any or all questions, and your participation is voluntary.

Declaration by Participant:

I _____hereby consent to take part in this study.

Signature: _____ Date: _____

Appendix B: Specific Interview Schedule

Mycoplasma Bovis and Biosecurity in Aotearoa

INTERVIEW SCHEDULE

The following interview questions have been shaped by my research questions and have been informed by analysing publicly available secondary data. These questions represent the types of questions that I will ask.

Further questions will develop from those listed, as I may ask you to elaborate on, clarify or explain information.

Proposed topics:

1 Qualifying questions current employment, length in the role and work history relevant to biosecurity.
2 General *Mycoplasma bovis* (M. bovis) questions:
    a. When did you first become involved with M. bovis and what was happening at the time?
    b. What was your role in the biosecurity response and/or programme?
    c. What were some of the challenges you faced in trying to eradicate M bovis?
    d. What were biosecurity practices like in farming at the time, including NAIT usage?
    e. Is there anything that you have learnt about biosecurity practices that has surprised you?
    f. Is there anything that you have learnt about farming in NZ that has surprised you?
    g. What do you think MPI and farmers have improved on in biosecurity as learnings from the incursion?

h. Is there anything I've missed that you think is important to discuss about the M. bovis incursion, biosecurity or farming?

3 Closing questions:

a. Is there anyone else that you recommend that I interview?

b. May I come back to you later with specific questions?

You do not have to answer any or all questions, and your participation is voluntary.

Declaration by Participant:

I _____hereby consent to take part in this study.

Signature: _____ Date: _____