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Doing Actor-Network Theory: Integrating network analysis with empirical philosophy in the study of research into Genetically Modified Organisms in New Zealand

A thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy at Lincoln University by Sarah Edwards

Lincoln University 2014
Abstract of a thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy

**Doing Actor-Network Theory: Integrating network analysis with empirical philosophy in the study of research into Genetically Modified Organisms in New Zealand**

by

Sarah Edwards

This thesis provides a critical examination of the theoretical and methodological tools provided by Actor-Network Theory (ANT). It does so by applying ANT to the analysis of research into Genetically Modified Organisms (GMOs) in New Zealand: first, in the case of a particular programme of GMO research; second, by considering the organisation and control of GMO research in more general terms.

While ANT as a field of scholarship has grown substantially since its development in the 1980s, the early network analyses upon which it was originally founded still offer the most substantial methodological guidelines for researchers. The first case study presented in this thesis examines whether network methodologies can be used to study and represent a present-day environmental controversy: the development of genetically modified “tearless” onions in New Zealand. Rather than follow a single existing framework for analysis, however, it uses a network representation that combines elements taken from three different approaches. In doing so it provides an interpretation of the outcomes of the tearless onion research project, identifying how network instability ultimately leads to the overall failure of the project. It also provides practical methodological guidelines for other researchers who are using ANT to study present-day controversies.

Following this initial focus on the networks associated with a particular GMO research project, this thesis considers how more recent ANT “sensibilities” can be used to complement and extend network analysis more broadly. Prominent ANT scholars have moved away from network studies in recent years, opting instead to focus on discussions of ontological complexity, casting ANT as a form of empirical philosophy. This can be problematic for researchers in fields such as environmental management, where studies are usually driven by a need to formulate recommendations on practical concerns, and matters of philosophical enquiry are rarely an end in
themselves. While ANT in its earlier, network-focused, formulations is evident in the environmental management literature, applications of recent theoretical developments are less common. The second case study presented in this thesis uses recent framings of “the object” of ANT research to study and represent a present-day environmental controversy: the containment of GMO research in New Zealand. In doing so it provides an interpretation of the risk management practices that direct GMO research in New Zealand and uses this to make recommendations for change. On a theoretical level, this thesis both bridges the gap between different eras of ANT scholarship, and provides a practical application of ANT’s more esoteric forms of analysis.

**Keywords**

Actor-Network Theory; methodology; Genetically Modified Organisms; risk management; biosecurity; science; New Zealand
Acknowledgements

I enrolled at Lincoln University as a Postgraduate student in early 2008. Although I didn’t have a particularly clear idea of what I wanted to study, I was absolutely sure I would be finished within a year. I ended up staying for nearly seven years, largely because of the staff and students I have met here, many of whom I now count as my friends. Special thanks go to my supervisors, Roy Montgomery and Suzanne Vallance, who have helped me through what has been the most mentally and emotionally challenging time of my life. Their individual skills as supervisors made them a perfect team, and between them they were able to alert me to the bigger picture whilst still keeping an eye on the details of what I was doing. I think the time it took me to get this thesis finished would have been a concern to most people, but somehow Roy and Su always seemed confident that I’d get there in the end (or at least they did a good job of hiding their true feelings!).

I am very grateful for the financial support I have received whilst working on this thesis. When I began it as a Masters student I was supported by the Lincoln University Graduate Scholarship, the William Gao Postgraduate Scholarship, and the Heaton Rhodes Scholarship. Later, when I converted to a PhD, I was supported by the William Machin Doctoral Scholarship. I am also very grateful to my supervisor Suzanne Vallance for providing me with a steady stream of work opportunities that not only gave me an important source of income, but also broadened my skills and experience beyond the relatively narrow focus of my thesis.

The years I have spent working on this thesis have coincided with a particularly turbulent time in the Canterbury region. The series of earthquakes that have hit Christchurch in recent years have made life anything but routine, and for me they have amplified the “usual” challenges associated with PhD study. The physical shake-ups I experienced from each bout of seismic activity were accompanied by a series of emotional upheavals that at many times posed a significant barrier to the progress of this thesis. The fact that I was (eventually) able to continue after each setback is testament to the unwavering support of my family and friends. Special thanks go to my parents and grandparents who never once questioned why I was “still a student”, offering instead their whole-hearted support and belief in what I was doing. But most of all I’d like to thank my little girl, Hayley, who certainly introduced an interesting set of challenges to my life, but also gave me a very good reason to succeed at what I was doing.
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<td>Actor-Network Theory</td>
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<tr>
<td>BSO</td>
<td>Biological Safety Officer</td>
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<tr>
<td>C&amp;F</td>
<td>Crop and Food Research</td>
</tr>
<tr>
<td>CRI</td>
<td>Crown Research Institute</td>
</tr>
<tr>
<td>DSIR</td>
<td>Department of Scientific and Industrial Research</td>
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<tr>
<td>EPA</td>
<td>Environmental Protection Authority</td>
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<tr>
<td>ERMA</td>
<td>Environmental Risk Management Authority</td>
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<tr>
<td>FRST</td>
<td>Foundation for Research, Science and Technology</td>
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<tr>
<td>GE</td>
<td>Genetic Engineering/Genetically Engineered</td>
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<td>GM</td>
<td>Genetic Modification/Genetically Modified</td>
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<td>GMO</td>
<td>Genetically Modified Organism</td>
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<td>HFC</td>
<td>House Foods Corporation</td>
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<td>HGT</td>
<td>Horizontal Gene Transfer</td>
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<tr>
<td>HSNO</td>
<td>Hazardous Substances and New Organisms</td>
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<tr>
<td>IBSC</td>
<td>Institutional Biological Safety Committee</td>
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<tr>
<td>LF</td>
<td>Lachrymatory Factor</td>
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<tr>
<td>LFS</td>
<td>Lachrymatory Factor Synthase</td>
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<tr>
<td>MAF</td>
<td>Ministry of Agriculture and Forestry</td>
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<tr>
<td>MAFBNZ</td>
<td>Ministry of Agriculture and Forestry Biosecurity New Zealand</td>
</tr>
<tr>
<td>MBIE</td>
<td>Ministry of Business, Innovation and Employment</td>
</tr>
<tr>
<td>MoRST</td>
<td>Ministry of Research, Science and Technology</td>
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<tr>
<td>MPI</td>
<td>Ministry for Primary Industries</td>
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<tr>
<td>MSI</td>
<td>Ministry of Science and Innovation</td>
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<tr>
<td>OPP</td>
<td>Obligatory Passage Point</td>
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<td>PC</td>
<td>Physical Containment</td>
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<tr>
<td>P&amp;F</td>
<td>Plant and Food Research</td>
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<tr>
<td>QMS</td>
<td>Quality Management System</td>
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<tr>
<td>RCGM</td>
<td>Royal Commission on Genetic Modification</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>RS&amp;T</td>
<td>Research, Science and Technology</td>
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<tr>
<td>SSK</td>
<td>Sociology of Scientific Knowledge</td>
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Chapter 1

Introduction

This thesis is an exploration of the practices involved in research into Genetically Modified Organisms (GMOs). GMO research is controversial, and people of a range of backgrounds and affiliations have some kind of opinion on them. Furthermore, they tend to be either extremely pro- or anti-GMO. As a result of this polarisation in opinion, the debates surrounding GMOs and biotechnology are often heated and impassioned, with both sides claiming the moral high-ground and painting a bleak future for humanity if their advice is not followed. Proponents state that we need GMOs if we are to feed the rapidly increasing population of the world, particularly in developing countries (see e.g. Borlaug, 2000; Potrykus, 2001; UNDP, 2001). In direct contrast, opponents contend that GMOs could actually threaten food security in these nations, and that the introduction of “foreign” genes to new species could damage entire ecosystems (see e.g. Greenpeace, 2009; Randall, 2008; Shiva, 2000). While it is possible to analyse the debate over GMOs in terms of these conflicting arguments, there is a need for research that considers how GMO research is done in practice: to focus on the intricate details of what is being done, where it is being done, and the multitude of people and things involved in doing it. By tracing these relations we can also consider whether or not they can be done differently, and the consequences that would result from such changes.

Since its development in the 1980s, Actor-Network Theory (ANT) has provided social scientists with the means to re-imagine “the social” as a heterogeneous network of human and non-human actors. As a theoretical and methodological tool it can be used to analyse the practices involved in “doing” GMO research without being drawn into the debate and controversy that surrounds it. But ANT scholarship encompasses a diversity of approaches, and there is no prescriptive format for how it should be applied. In recent years, prominent ANT scholars have moved away from network studies, opting instead to focus on discussions of ontological complexity, thus casting ANT as a form of empirical philosophy. This can be problematic for researchers in fields such as environmental management, where studies are usually driven by a need to formulate

---

1 Genetically Modified Organisms contain DNA that has been altered using genetic engineering (GE) techniques.

2 Discussions of the extreme opinions that characterise the controversy and debate over GMO research can be found in Bloomfield and Doolin (2011), Carolan (2008), Hanley (2010), Nash (2000), Shah (2008), and Stone (2002).
recommendations on practical concerns, and matters of philosophical enquiry are rarely an end in themselves. There is therefore a need for research that will bridge the divide that has emerged in the ANT literature, considering the utility of different approaches, and formulating ways for “doing” ANT differently. The purpose of this thesis is to help address this need.

This introductory chapter sets the scene for the rest of the thesis. First, I will give an overview of the path I have taken during the course of this thesis. In doing so, I will provide valuable background information on my topic of study and also clarify the theoretical positioning of this thesis. I will then outline the overall objectives that have guided me through my research. Finally, I will provide a brief synopsis of the chapters that make up the remainder of this thesis.

1.1 Objects, subjects, and projects
When I began this thesis in early 2009, GMO research was in the New Zealand national headlines because of controversy over a field test of GM brassicas being grown by Crop & Food Research\(^3\) (C&F) at their site in Lincoln\(^4\), the same town in which I was studying. When I looked into this incident, I discovered that there was another programme of GMO research based at the same research institution that had recently attracted significant media attention: GM “tearless” onions. These onions were so called because they had been modified to produce less of the tear-inducing sulphur compound known as Lachrymatory Factor (LF; see Eady et al., 2008). Although tearless onions had so far only been grown in a laboratory, C&F had received approval to conduct a field test of this and other members of the *Allium* genus\(^5\) (see ERMA, 2008a). Given that this was also the most recent approval for a GMO field test in New Zealand, it therefore appeared to be an appropriate case study on which to base my research. I began my investigation and, as I did so, my attention was drawn to another aspect of GMO research in New Zealand: the “containment facilities” in which research is carried out. What I found particularly interesting about these places was that some of them - fields - were usually linked to highly controversial programmes of GMO research whilst others - laboratories - appeared to attract relatively little attention at all. I therefore decided to investigate these places for GMO research, and use them as a second case study for my thesis.

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3 Crop & Food Research was a New Zealand Crown Research Institute (CRI) until 1\(^{st}\) December 2008, when it was merged with another CRI, HortResearch, to form Plant & Food Research (P&F).

4 Lincoln is a small town situated approximately 20km south of Christchurch, Canterbury. See Chapter 2 for a map of its location.

5 *Allium* is the genus to which various species, including onions, garlic, and leeks, belong (see Kamenetsky & Rabinowitch, 2006).
Thus, GMO research in New Zealand became the object of my study; I, as researcher, became the subject. Together, we have joined to produce the pages of this thesis, this project that has evolved over the years until it has finally reached a stage that can be labelled “complete”. But how often do researchers write of the process of project construction? By this I refer not to the data or analyses commonly associated with academic research; I mean details of the processes we follow through in order to obtain these data or perform these analyses. It seems that in the interests of “academic rigour” we foreground our objects as “things that exist” whilst trying as much as possible to keep ourselves on the periphery. Researchers top and tail written accounts via author details and reference lists but are rarely found within the main body of text, and the story of why our research has taken a particular path remains untold.

The purpose of this section is to provide an overview of the journey I have travelled in the course of completing my thesis. At first glance, my beginning and end points are very different (and possibly back-to-front): I began by looking at the microscopic details of a specific GMO research project; I ended by considering the general conditions for conducting GMO research in New Zealand. But these can be joined together by a clear path, a path that I have traced by “doing” my research. There are two aspects to this path that I want to explore here: first, that in taking it I had to be selective; and second, that it is a result of a partial perspective.

1.1.1 Being selective
Selectivity is a necessary part of any research process: data must be ordered and sifted so as to present a story that is somewhat more comprehensible than the mess encountered during data collection. While I am not trying to suggest that this should not be done, it is important to reflect on these ordering processes, and acknowledge the role that we as researchers have in presenting a particular version of an object. As John Law observes, “the world could always be otherwise” (2004, p. 152): there are many stories that can be told about an object, and, rather than choosing one and denying that any others are possible, we should acknowledge and embrace this “multiplicity” and allow it to show through in our written accounts (Mol, 2002; Law, 2002a, 2004). While this may raise concerns about a lack of clarity, denying complexity does not necessarily result in a succinct, clear description. On the contrary:

Simple clear descriptions don’t work if what they are describing is not itself very coherent.
The very attempt to be clear simply increases the mess. (Law, 2004, p. 2)

As I have already mentioned, this research began with a case study of GM tearless onions. But to speak of Genetically Modified onions implies that there exists somewhere an unmodified onion, a foundational state upon which everything else has been built. If this is the case, it is important to
consider what this onion could be. Consider, for example, the four images shown in Figure 1.1 (below):

![Figure 1.1 Four different onions. Top left: onion cells as seen with a light microscope (kaibara87, 2012. CC BY 2.0). Top right: onions being harvested on a farm (pfatter, 2010. CC BY 2.0). Bottom left: the front cover of a children’s story that casts an onion as the main character (Ladybird Books, 2013). Bottom right: an extract from a research institution’s annual report (Plant and Food Research, 2009. Image © Plant and Food Research, reproduced here with permission).](http://members.iinet.net.au/~nicolee/ladybird_pictures/images/Garden_Gang/793_Oliver_Onion_white.jpg)
The first image shown above is taken from a teaching website. Onions are often used as a science teaching tool because it is very easy to prepare and view a slide that shows their internal structure. In this way, they are used to demonstrate that all living things are made up of cells, and that these cells have certain features in common (Clément, 2007). The second image is of onions being harvested. This is being done using machinery due to the large numbers of onions involved, a reflection of the importance of this vegetable to our diets: onions are the most widely used flavouring vegetable, and are grown in over 175 countries (growingfutures.com, 2009). The third image is the front cover of a children’s story book, one of a series called “The Garden Gang” which depicts fruit and vegetables as the main characters; this story is about an onion with a body odour problem. The final image is taken from a scientific research institution’s annual report. Scientific methods are used to develop new varieties of onions. This is an industry in itself, involving large amounts of resources, including people, technology, and money.

Each of these four images represents the onion as a different object. The first focuses on the onion as a living thing, drawing attention to its genomic structure, biochemical pathways, and taxonomic classification. The second focuses on the onion as a commercial vegetable that requires specific farming methods, a worldwide onion export market, and consumer demand to be grown. The third presents the onion as a cultural symbol, highlighting the significance of its ability to induce tears and the many layers that characterise its physical structure. The fourth shows the onion as a research project, detailing how different varieties have been developed over the years and the technologies that have enabled these developments.

So which of these representations corresponds to the “real” onion? If we assume that through research we can study a separate, underlying reality then it follows that we must select one of these, a synthesised version of them, or perhaps another onion not given above but nevertheless possible to find. Alternatively, we could assume that there is no reality outside of the activities in which the onion is involved, and as these activities change, so too does the reality of the onion. This allows for the co-existence of “multiple” (Mol, 2002) onions, meaning that any description of “the” onion will necessarily be incomplete. Whilst this may seem to be admission of failure, acknowledging the incompleteness of objects in this way actually opens new pathways of enquiry. We may then consider the complexities involved in “doing” each onion, thereby recognising each as a separate, albeit “partially connected” (Strathern, 1991), onion.

To describe objects that are at once separate and connected is to strive for what John Law has termed “fractional coherence” (Law, 2002a, p. 2), an approach that aims to provide a third way between modern and postmodern accounts. Modernism involves a search for essential qualities
and structure that can be used to make sense of and predict the world around us. It is characterised by “practices of purification” (Latour, 1993, p. 11) that serve to form categories and borders and thus create objects that appear to be singular. Postmodernism, however, rejects any turn to essentialism or the “grand narratives” that seek to explain everything in a singular form. The problem with these accounts is that they can become so decentred as to be left in pieces: a series of disjointed fragments that are united only in their pluralism (Law, 2002a).

It has been suggested that postmodernism and modernism are simply two sides to the same coin, existing as necessary opposites to one another (Law, 2002a). Furthermore, if we take Latour’s (1993) position that “we have never been modern”, the foundations upon which both modernism and postmodernism stand are suddenly removed, and we are left searching for a different lens through which to view the world. Thus we are led to a “nonmodern” approach (Latour, 1993, p. 48), which “balances between plurality and singularity. It is more than one, but less than many” (Law, 2002a, p. 3, emphasis in original). Although it does not provide neatly packaged, linear accounts of singular, tangible objects, this approach does allow us to make judgements on the making of realities. To do so is to engage in “ontological politics” (Mol, 1999; see also Mol, 2002; Law, 2004): research that shows how a particular reality comes to be more acceptable or mainstream than others; the consequences that result from the apparent singularity of this reality; and the possibilities for alternative realities. Although it deals with ontology and therefore contains a philosophical element, this type of research does not aim to remain on the pages of academic journals, to be branded as purely esoteric. It searches for differences, and in doing so it aims to provide the possibility of choice.

1.1.2 Being partial

Being partial is a necessary aspect of research; indeed, it is impossible for a researcher to be impartial. By stating this I am not trying to imply that we are inherently biased towards giving one particular version of events, or being more sympathetic to some actors over others. Obviously there is a danger of this in any research project, particularly one that is controversial; but I want to suggest that partiality runs deeper than this and is actually a necessary component of academic research. I am referring here to the relationship that researchers, as “knowing” subjects, have with the objects of their study, and how these relationships are involved in forming a research project. In conducting research we are forming a series of relationships involving ourselves and the people and things involved in the topics we study. The written form of the final

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6 Indeed, Actor-Network Theory actively seeks to avoid these issues through a commitment to the principles of agnosticism and generalised symmetry (see Callon, 1986a).
research project should be seen as an account of this object-subject relationship rather than an account of the essence of an object. Yet it is the latter that we seem to mimic, laud, and aspire to. This is not only a false representation of research, it also removes valuable aspects of data and analysis that are relevant to our research questions, particularly in the social sciences. Instead of pretending that our perspective is all-encompassing and “objective”, we should acknowledge the role we have played in creating a partial perspective, and explore the rich data we generate by becoming embedded in our research projects. This follows Donna Haraway’s call for “situated knowledges”, a method of speaking about reality that avoids the “god trick” (1988, p. 582) characteristic of objective scientific accounts whilst still managing to avoid the incoherence that results from trying to incorporate an endless number of perspectives into one’s analysis.

It was my own partial perspective that led to this research project following a very different trajectory to the one I had originally planned. I began by studying an onion, by looking for different stories of meaning, different ways of describing the progress of a programme of GMO research. But there were stumbling blocks that I didn’t foresee: many of the people I wanted to talk to would not or could not participate in my research, and I found it impossible to explore some of my original research aims in any great detail. GMO research is controversial, and those who work in this field are fully aware of this controversy and do not wish to inflame it. It was therefore impossible for me to present myself as a naïve observer interested in simply documenting their day-to-day work: the act of observing not only stripped me of my naïveté, I myself became the object of observation, someone to watch out for and avoid.

Although there were problems, I also encountered questions that had not been part of my original research proposal but were nevertheless worthy of pursuit. Many of these centred on risk: tearless onion research was seen as “risky” only when it was taken out into the field; there appeared to be very little risk associated with its development in the laboratory. I also realised that there was a lot more laboratory-based GMO research being conducted in New Zealand than I had initially been aware of, and this appeared to be a commonly held perspective of GMO research. I therefore turned my attention to the places in which GMO research is conducted: laboratories and fields. The relatively mundane details of where GMO research is done and how it is done there had been hidden by the media sound-bites on the health benefits of “tearless” onions or the potential contamination of the New Zealand environment. But I realised that the story of place mattered, both to GM onions specifically and the wider topic of GMO research in New Zealand. So my project altered course, I switched my attention from the specificities of a

7 I will consider this issue in detail in Chapter 4.
particular research programme and searched instead for the details of how research into GMOs is located, regulated, and controlled in New Zealand.

1.1.3 “Doing” Actor-Network Theory

The journey I have taken during the course of PhD study is not the only connection between the two aspects of GMO research I have chosen to focus on in this thesis. Throughout my research one thing has remained constant: my interest in exploring and applying Actor-Network Theory (ANT). While I will reserve my wider discussion of ANT for later chapters, a brief overview of the central importance of this theory to my thesis is of relevance here.

ANT uses a relational ontology to describe reality as the outcome of interactions and connections between human and non-human actors (see e.g. Latour, 1999a; Law, 2002a, 2004, 2008a, 2009a, 2009b). This allows us to explore what an object is without any recourse to essentialism: rather than existing “out there” in reality, an object is conceptualised as “an effect of stable arrays or networks of relations” (Law, 2002b, p. 91, emphasis in original). Such networks can be found at multiple levels of scale, thus providing a way in which to describe any kind of object in network terms:

For instance, a vessel can be imagined as a network: hull, spars, sails, ropes, guns, food stores, sleeping quarters and crew. In more detail the navigational system – Ephemerides, astrolabe or quadrant, slates for calculations, charts, navigators and stars – can also be treated as a network. And on a larger scale, the Portuguese imperial system as a whole, with its ports, vessels, military dispositions, markets, and merchants can also be thought of in the same terms. (Law, 2002b, p. 93)

As the above quotation demonstrates, networks can be composed of anything, be it human or non-human, living or non-living. Such “heterogeneous” networks are common in ANT analysis (Murdoch, 1997), and studies often focus on the “heterogeneous engineering” (Law, 1987) required for network construction. But this is a particular format of ANT, an early version that has since been developed in a variety of ways “to articulate new intellectual tools, sensibilities, questions, and versions of politics” (Law, 2008a, p. 150). ANT has moved from the study of things to the study of practices: it explores reality not simply in terms of the nouns that form a network, but also the verbs that describe how it is “done” or “enacted” (see e.g. Law, 2009a). The emphasis has shifted to dynamism and change: realities are not simply constructed in one network format, they are precarious and multiple, shifting and overlapping with one another (Law, 2002a, 2008a, 2008c; Mol, 2002). The goal of ANT analysis in this tradition is “to attend carefully to practices and ask how they work... To study practices [is] to undertake the analytical and empirical task of
exploring possible patterns of relations, and how it is that these get assembled in particular locations” (Law, 2009a, p. 1).

These developments in the literature have ultimately led to changes in the unit of ANT analysis. Reality is no longer necessarily the outcome of a network of relations, but can also be enacted in different arrangements: for example, as “fluid” or “fire” objects (Law & Mol, 2001; Law & Singleton, 2005). A distinctive branch of the ANT literature has thus emerged, in which object-space relations are the central focus of analysis, and philosophical considerations of the “topology”8 of the real are a recurring theme (e.g. Kullman, 2009; Law, 2002b; Law & Mol, 2001; Law & Singleton, 2005; Vasantkumar, 2013). Prominent scholars now cast ANT as a form of “empirical philosophy” (Law & Mol, 2002, p. 84), and suggest that the early network studies of ANT have been superseded by these developing modes of analysis (Law, 2008a).

But the networks of ANT are still of use in current academic research. In applied fields such as environmental management, the systematic methods associated with network analysis make it a valuable conceptual and methodological tool. Hence it has been of use in a number of recent studies that consider, for example: strategic planning processes (Bryson, Crosby, & Bryson, 2009); environmental management systems (Van der Duim & Van Marwijk, 2006); environmental dispute resolution (Jakku, 2003); and heritage landscape conservation (Foster, 2012).

As a student of environmental management, I began this thesis firmly rooted in the pragmatic application of ANT evident in these latter studies, and my focus was primarily on the “networks” of GMO research. As my studies progressed and I learned more about ANT I began to consider alternative methods of representing the objects of GMO research, and I focused on the empirical philosophy of more recent ANT scholarship. But rather than simply “follow” these different strands in the ANT literature, I also found myself reflecting on how ANT was being “done” by them, and whether or not it could be done differently. These reflections have proved significant in shaping this thesis. As such, this thesis is not only an examination of how GMO research is “done” in New Zealand; it is also an examination of how ANT research is “done” in the social sciences.

1.2 Research objectives

This thesis is a study of the practices of GMO research. It describes how the objects of GMO research are enacted, and therefore allows an evaluation of the success or failure of GMO

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8 A definition of topology and its application in ANT study is provided by Law and Mol (2001) and Law (2002b). I will discuss this in detail in Chapter 3.
research in terms of the object as a relational outcome rather than the object in and of itself. Why do some GMO research programmes initially succeed, only to fail at a later date? Why do people focus their attention on some forms of GMO research while other work goes on unnoticed? The answers to these questions are not simple or obvious; they are embedded in complex relations that must be traced in detail.

This thesis is also a study of the practices of ANT research. It considers how different approaches that have emerged in the ANT literature can be combined in a single study, using this not only for the practical purpose of studying the practices of GMO research in New Zealand, but also for the theoretical purpose of bridging the divide in ANT scholarship.

These overall objectives can be broken down into four main research questions that have served to guide this thesis.

1. **How are “tearless onions” enacted as a programme of GMO research?**

   Here, I will describe what the tearless onion is in relational terms: what people, plants, documents, or any other “things” have been involved in the making of this GMO, and what role has each of these played? I will consider how to represent the tearless onion using the tools of ANT analysis, focusing first on the laboratory phase of its development, and then on the proposal to move it out into the field. I will use this representation to evaluate the outcomes of the research programme, highlighting any differences that occur during each phase of its development.

2. **How are “containment facilities” enacted as places for GMO research?**

   My next objective is to describe the enactment of containment facilities in relational terms, again tracing the connections that must be forged between a heterogeneous assemblage of actors. I will consider how to represent the containment facility using the tools of ANT analysis, using this representation to assess the overall stability of containment facility, as well as the relationship between laboratories and fields.

3. **What are the risks involved in GMO research? How are these risks managed?**

   By examining the relational enactment of “tearless onions” and containment facilities I also aim to provide an assessment of the risks of GMO research in relational terms. This will require a consideration of the many different actors involved in enacting the objects of GMO research, this time asking how they are each “doing” risk in different ways. This will in turn lead me to consider how each actor manages the risks it faces, thereby enabling me to provide an assessment of how the risk management of GMO research is done in practice. I will consider the implications this
holds for the current system of GMO research risk management in New Zealand, and recommend changes that should be made to it.

4. How can ANT be done as a "theoretically multiple" tool for analysis?
By attending to the research questions listed above, I also aim to provide a critical examination of the theoretical and methodological basis for this study: Actor-Network Theory. In the course of my data analysis I will use analytical tools from across the ANT literature, combining network analysis with more recently developed methods of object representation. By using a variety of concepts and tools in a single study, I will consider how ANT can be “done” as both an empirical philosophy and a pragmatic tool.

1.3 Thesis overview
This thesis is organised into nine chapters. Following this introductory chapter, Chapter 2 provides detailed background information relevant to this study. Beginning with a general survey of the changing New Zealand science system, I will then consider the role of science in primary production, with a particular emphasis on the growth in GMO research as part of the biotechnology sector. I will also detail the changes to government regulation of GMO research that have occurred in recent years, focusing on the statutory documents, procedures, and decision-making bodies that currently serve to control GMO research activities. In this chapter I will also consider the societal debate over GMO research in New Zealand, detailing the various ways in which members of the public have taken action against it.

In Chapter 3 I will provide a detailed examination of the theoretical basis for this thesis, and also place this study firmly in the context of existing academic research. I begin by considering ANT, outlining the core principles that underlie this diverse field of scholarship, before discussing in more detail my particular use of ANT in this study. This entails an examination of the network approach of early ANT analyses, followed by more recent theoretical insights that can be used not only to reconceptualise network objects, but also to develop entirely different object representations. After this theoretical discussion I will move to consider literature that is of particular relevance to my choice of case studies. Given that GMO research is often discussed in terms of the risks it poses, I will consider how an ANT approach can be used to study the risks of GMO research. Then, given that I will be examining the places in which GMO research is conducted, I will consider literature that has examined the importance of place in scientific research, with a particular focus on laboratories and fields.
ANT is not only a theoretical guide for study; it also provides a set of methodological tools that can be used to conduct research. In Chapter 4 I will outline the various methodologies associated with ANT, before specifying my particular use of ANT in this study. Here I will detail the methods I have used to collect, analyse, and represent data. I will also discuss the issues I encountered in my attempt to apply ANT to the study of a present-day controversy; in particular, I will consider the instruction to “follow the actors” that is often presented as a definitive method in ANT research, yet rarely discussed in detail.

Chapters 5 and 6 present the results of the case study of GM tearless onions. Following Latour’s (1983) analysis of Pasteur, I delineate two distinct “moves” to the tearless onion research programme that are each the focus of a separate chapter. In Chapter 5 I will consider the movement of the onion into the laboratory; in Chapter 6 I will discuss the proposal to move the onion out into the field. In both chapters I will explore the merits of three different network representations, using elements taken from each of them to develop a network representation of the onion. In Chapter 5 I will use this network to explain how the tearless onion is enacted as a stable, yet multiple, object; in Chapter 6 I will use it to explain how the object is destabilised and the research project ultimately fails.

The results of Chapters 5 and 6 prompt me to consider the role of containment facilities in GMO research, and this leads to the case study presented in Chapter 7. Rather than assume that containment facilities are simply the backdrop to GMO research activities, I will consider how these places are themselves enacted in practice. I will also consider how ANT can be used to represent the containment facility, moving beyond the networks of early ANT studies to consider alternative object representations. In doing so, I will explain how the stark differences between laboratories and fields serve to hold them together as part of the same, stable object.

In Chapter 8 I will draw together the results of these three analytical chapters, providing an overall discussion of the “risks” of GMO research in New Zealand. Rather than approach risk as “real” or “perceived”, I will discuss how risk is “done” in the practices of GMO research. The heterogeneous mixture of actors involved in enacting tearless onions and containment facilities are also enacting the “risks” of GMO research in more general terms. Further to this assessment, I will also make recommendations for change to current risk management practices. Chapter 8 also provides a discussion of ANT, reflecting on how I have used ANT in this thesis and the implications this has for ANT scholarship as a whole.
Chapter 9 concludes this thesis with an overall summary of my research findings and an assessment of the practical and theoretical contributions of this study.
Chapter 2

Background

2.1 Introduction

In this chapter I will provide background information relevant to the case study material used in this thesis. This material has largely been drawn from examples of GMO research located in Lincoln, a town in Canterbury, New Zealand (see Figure 2.1 below). While the analyses presented in Chapters 5, 6, and 7 will provide many of the specific details relevant to the case studies, it will also refer to a wide variety of institutions, groups, legislation, and regulatory systems that operate New Zealand-wide, as well as a number of events that have occurred in recent history. The purpose of this chapter is to provide this contextual information.

Figure 2.1 Map of New Zealand. Much of the case study material used in this thesis has been taken from GMO research programmes being conducted in Lincoln, a small town to the south-west of Christchurch on the South Island of New Zealand. These images are based on Statistics New Zealand’s data (see www.stats.govt.nz) which are licensed by Statistics New Zealand for re-use under the Creative Commons Attribution 4.0 International licence.
In the following sections I will first provide an overview of the New Zealand science system, with a particular focus on the establishment and operation of Crown Research Institutes (CRIs), as well as the changing systems of governance that control them. This information is of particular relevance to the tearless onion case study presented in Chapters 5 and 6, as this research programme has been conducted by Crop & Food Research, a New Zealand CRI. I will then move on to consider the importance of biosecurity measures in New Zealand, and how these relate to the conduct of GMO research specifically. This information is of particular relevance to the case study of containment facilities presented in Chapter 7, as such facilities operate as part of the wider suite of biosecurity practices in New Zealand. The use of containment facilities in GMO research is also subject to decision-making processes that specifically control GMO research practices, and these will be discussed in the third section below. Finally, I will detail various instances in which members of the public have taken action against GMO research, and the impacts these actions have had. This information is of relevance to the analyses given in Chapters 6 and 7.

2.2 The changing New Zealand science system

Government-run scientific institutions have been operating in New Zealand since the mid-19th Century, but it was not until 1926 that a dedicated government department was established (Teara, 2014). The Department of Scientific and Industrial Research (DSIR) was designed to “improve the interface between pure science and its application in New Zealand industry” (Bray & Perry, 1994, p. 12), and initially served to co-ordinate research across other institutions. Over time the research operations of a number of government institutions were transferred to the DSIR, and by the 1980s it was the largest government-funded science institution in New Zealand (Bray & Perry, 1994; Edmeades, 2004; Teara, 2014). The Department was responsible not only for carrying out research but also for providing policy advice; it also received a large proportion of government funding (Davenport & Winsley, 1994). This funding was not contested, and could be spent according to decisions made by scientists themselves (Bray & Perry, 1994).

The neoliberal reforms that swept through New Zealand during the 80s and 90s led to changes to this system of government-funded science. On the basis of Treasury recommendations it was decided that a “user pays” system should be introduced. This meant that scientists had to charge anyone who used their work at the full market rate in order to recover their research costs (Simpson & Craig, 1997). There were also widespread organisational reforms following a number of government-commissioned reports that recommended the separation of science policy, funding, and performance (see Edmeades (2004) for discussion). The Labour-led government was
responsible for undertaking the first step in these changes. The Ministry of Research Science and Technology (MoRST) and the Foundation of Research, Science and Technology (FRST) were established in 1989 (Bray & Perry, 1994); they were each given separate responsibility for policy formulation and funding allocation respectively. The DSIR underwent a series of structural changes while government considered how best to implement changes to science provision (see e.g. New Zealand Labour Party, 1992; Ministerial Science Task Group, 1991). It was finally disbanded under a National-led government in 1992, and ten new Crown Research Institutes (CRIs) were introduced under the Crown Research Institute (CRI) Act (1992; see Figure 2.2 below; also Roche, 1993 for discussion). These have been subject to restructuring since 1992 and as of 2014 there are seven in existence. Of particular relevance to this thesis is the merger between the New Zealand Institute of Crop and Food Research (Crop & Food Research) and the Horticulture and Food Research Institute of New Zealand (HortResearch). This took place on 1st December 2008 to form a new CRI, Plant & Food Research (see Plant and Food Research, 2014). As such, the case study material used in this thesis, particularly that which focuses on the development of GM “tearless” onions, refers sometimes to Crop & Food Research (C&F), and at other times to Plant & Food Research (P&F). I have used both of these company names deliberately, as each is essentially a different entity given that P&F did not result from the “renaming” of C&F. Generally speaking, I have used “C&F” in reference to events that occurred or material that was printed prior to 1st December 2008. Similarly, “P&F” has been used in reference to events or printed material from after this date.

Whereas both the DSIR and the CRIs were required to undertake public good research (Edmeades, 2004), CRIs also had another mandate: to provide “an adequate rate of return on the shareholders funds” (CRI Act 1992, section 5.3(a)). Thus the focus shifted away from serving the needs of New Zealand industries (including primary production) towards developing products that could be sold for a profit, either in New Zealand or overseas. This meant that science was no longer funded as an activity but as a series of outputs. In order to receive government funding these outputs had to be aligned to specific government priorities that were set by FRST through consultation with MoRST (Roche, 1993). Failure to secure funding resulted in not only the loss of a programme of research but also the loss of jobs. This arguably resulted in a work environment where redundancies (Hunt, 2003; Lancashire, 2007a; Simpson & Craig, 1997) and early retirement (Lancashire, 2007b) were commonly used to manage staffing levels.
Figure 2.2 The restructuring of government-run science institutions in New Zealand. Until 1991, state science agencies were organised according to the structure shown to the left of this diagram. In 1992, these government departments were replaced by the ten Crown Research Institutes (shown to the right) that were established under the CRI Act (Diagram adapted from Roche, 1993, Figure 2).

These changes to the New Zealand science system have come under significant criticism over the years (see e.g. Edmeades, 2004; Hunt, 2003; Lancashire, 2007a; Leitch et al., 2014). By moving to a commercial model for research and development the aim had been to establish a balance between the push and pull of market forces in the innovation process (Bray & Perry, 1994); instead, the competitive nature of the free market came to dominate the way people and organisations operated (Weaver & Motion, 2002). Scientific research was no longer necessarily about the national interest or public good, but institutional (and individual) survival (Hunt, 2003). As a result, conservative programmes of research were often chosen over high risk options (Gluckman, 2009). Individual scientists were intensely protective of their work and there was little (if any) collaboration between different research teams (Stewart, 2002).

The New Zealand science system has recently entered into another phase of significant change. Following a number of reports commissioned by the NZ government (see CRI Taskforce, 2010;
recommendations were made to overhaul the science system, particularly the separation of policy from funding and the short-term nature of publicly funded research contracts (Leitch et al., 2014). In February 2011, MoRST and FRST were replaced by the new Ministry of Science and Innovation (MSI; see MBIE, 2014). The existence of the MSI was relatively short-lived, however, as a new “super ministry” (see e.g. 3News, 2012) was established in July 2012. The Ministry of Building, Innovation and Employment (MBIE) brought together the MSI, the Department of Building and Housing, the Ministry of Economic Development, and the Department of Labour. The MSI is still operating as a functionally distinct entity within the MBIE (Leitch et al., 2014), but the reason for establishing the MBIE is clear, as it has been described by the government to be “[a] single focused business-facing ministry” (3News, 2012). By placing scientific governance within this ministry, the government has therefore signalled that the purpose of New Zealand science is to serve business interests (Leitch et al., 2014). This purpose is also evident in the establishment of Callaghan Innovation, a standalone Crown Entity that operates separately from CRIs. Established in 2013 following the disestablishment of Industrial Research Ltd, its purpose is to “give businesses a single front door to the innovation system” of New Zealand (Callaghan Innovation, 2014), and therefore aims to draw together research and business interests from across the public and private sectors.

While the GMO research activities that have been scrutinised as part of this thesis took place largely during the MoRST/FRST era of scientific governance, these recent changes are nevertheless of significance to this study. Ongoing restructuring processes are serving to create an increasingly commercially-oriented system of publicly-funded science, and CRIs are an integral component of this system. I will use these observations in my examination of a particular research programme – tearless onions – in Chapters 5 and 6.

2.3 Biosecurity and the containment of GMO research

New Zealand is home to many “exotic” species, some introduced by early Maori settlers, others by later European colonists. The introduction of exotic species was encouraged in the 19th Century through the establishment of Acclimatisation Societies (McDowall, 1994); in more recent years, however, government policy has not only classified many of these species as pests in need of eradication, but also halted the entry of any further new species (Jay & Morad, 2006). Instead of framing New Zealand as having impoverished ecosystems in need of improvement, emphasis is now placed on protecting the distinctive indigenous flora and fauna found in this geographically isolated island state. As a result, “biosecurity” measures have become firmly embedded in New Zealand's legal and regulatory framework.

Maori are the indigenous people of New Zealand.
Zealand’s social and legislative practices, and the current biosecurity regime has been described as one of the most comprehensive in the world (Barker, 2008). Biosecurity practices are evident in everyday New Zealand life, from washing fishing equipment to halt the spread of Didymo,\textsuperscript{10} to discarding fruit before disembarking from an international flight to prevent the introduction of new pests. They are also viewed by some as necessary to the economic growth of New Zealand, given its reliance on primary production.

Few developed countries are as highly dependent on agricultural trade as New Zealand: we export 80–90 percent of the food we produce. Meat, dairy, live animal and wool exports account for 12, 30, 0.5 and 2 percent respectively of all export earnings, with a total of more than 20 billion dollars a year. Farming industry bodies see a major biosecurity event as one of the biggest risks they face. (Bingham, 2013, p. 3)

The Biosecurity Act (1993) and the Hazardous Substances and New Organisms Act (HSNO Act, 1996) provide the legislative framework for the practices by which New Zealand maintains its biological borders. They each operate in complimentary ways: the Biosecurity Act prevents the unintentional introduction of new organisms into New Zealand (through, for example, imported shipping crates) while the HSNO Act regulates the intentional introduction of new organisms into New Zealand (for example, to import an animal to live in a zoo) (Barker, 2008). GMO research represents a potential biosecurity threat because it involves the creation or importation of an organism not already present in New Zealand: a GMO is therefore defined as a “new organism” under both the Biosecurity Act (1993, Part 1, section 2) and the HSNO Act (1996, Part 1, section 2A). As such, there are overlaps between these two pieces of legislation with regards to GMO research and there is therefore also some degree of collaboration between the two government agencies charged with responsibilities under each Act. The Environment Risk Management Authority (ERMA) was the decision-making authority under the HSNO Act (1996) until this role was taken over by the Environmental Protection Authority (EPA) on 30\textsuperscript{th} June 2011 (see section 2.4 below for discussion). The Ministry of Agriculture and Forestry (MAF) was charged with responsibilities under the Biosecurity Act (2003) until these were incorporated into the new Ministry of Primary Industries (MPI) on 30\textsuperscript{th} April 2012. MAF (now the MPI) also bears some responsibility for enforcing decisions made by ERMA (now the EPA) under the HSNO Act.

The case study material presented in this thesis deals mainly with the functions of ERMA and

\textsuperscript{10} Didymo is an algal species that is responsible for water quality issues in New Zealand rivers. It is currently only found in the South Island, and people are legally obliged to stop spreading it (MPI, 2014).
MAF, but I will make reference to the EPA and MPI in relation to more recent events or documents that have also been used.

The overlap between these two Acts and the collaboration between MAF and ERMA is particularly evident in the establishment and control of containment facilities. A containment facility is a place “for holding organisms that should not, whether for the time being or ever, become established in New Zealand” (Biosecurity Act, 1993, section 2). While such facilities can be used for a number of purposes ranging from zoo enclosures to medical laboratories, there are two broad categories of containment facility used in GMO research. Physical Containment (PC) facilities are used for indoor GMO research, and are classified numerically from 1-4 according to the level of containment they provide: a PC1 facility is operated according to the least stringent of conditions. Outdoor research is conducted in a field trial facility, for which there is no sub-classification denoting the level of containment provided. Aside from these differences, both indoor and outdoor containment facilities are legally defined as providing the means for “containment” under the HSNO Act (1996; see RCGM, 2001, p.122).

A place can only be classified as a containment facility if, in accordance with section 39 of the Biosecurity Act (1993), it applies to MAF for approval. This approval will be granted after an assessment of both the physical structure of the facility and the Quality Management System (QMS) that describes in detail what the facility is and how it is to be used. The QMS is essentially a written document which covers all aspects of the structure and operation of the containment facility. For indoor facilities this is usually in the form of a containment manual that applies to the whole research campus (see e.g. Lincoln University, 2011). For outdoor facilities, this is specific to a particular field test, and is set by ERMA in the conditions attached to a field test approval (see e.g. ERMA, 2008a, Appendix 1). The QMS for a containment facility is written in accordance with one or more of five joint MAF/ERMA standards covering the containment of living things: microorganisms and cell cultures; vertebrates; invertebrates; zoo animals; and plants. Exactly which of these standards are of relevance to a particular facility depends on the nature of the work being done inside it. Indoor facilities often contain more than one research project so may be certified according to a number of standards, whereas outdoor facilities have only been used for GMO field tests of vertebrates or plants and would therefore only be certified according to one of these standards.

11 Most facilities in New Zealand offer either PC1 or PC2 levels of containment. There are only a few PC3 facilities in operation and no PC4 facilities (this is based on comments made in Interviews R and K).
In addition to the joint MAF/ERMA standards, laboratories are also subject to the requirements of the Australian/New Zealand Standard 2243.3 *Safety in Laboratories. Part 3: microbiological safety and containment* (AS/NZS 2243.3), an international standard for laboratory work that has been written into New Zealand law. In the early days of GMO research, AS/NZS 2243.3 functioned alone in providing the guidelines for laboratory work; it wasn’t until the early 2000s that ERMA and MAF developed the five standards that covered the specific needs of different types of containment facilities. AS/NZS 2243.3 still provides the most detailed account of the requirements for laboratory containment: it is not only a much longer document than any of the MAF/ERMA standards, it is also referred to by them as a source of information: “AS/NZS 2243.3: 2002 specifies the minimum requirements of physical containment (PC)” (MAF Biosecurity New Zealand and ERMA New Zealand, 2007a, p. 21).

The MAF/ERMA standards specify the physical and operational requirements that must be met for a place to be certified as a containment facility. The physical requirements for containment facilities for research involving plants (see MAF Biosecurity New Zealand and ERMA New Zealand, 2007b), for example, state that both indoor and outdoor facilities must restrict the access of people to and from the site, and also ensure that no viable genetic material is able to leave it (see section 8.1). Laboratories must be constructed with concrete floors and mesh coverings over openings such as windows and vents so that rodents and insects cannot enter (see section 8.1.2). The specific construction requirements for field boundaries are given by ERMA in the controls attached to any field test consent (see section 8.1.3). Both types of facility must restrict access to authorised personnel who have specified roles in the research project (see section 7.1.2); visitors are only allowed entry if they are accompanied by one of these people (see section 8.1.1.1 and 8.1.3.1). Access logs must be used to document the flow of people in and out of both types of facility (see section 8.1.1.1 and e.g. ERMA, 2008a, Appendix 1, control 2.1).

The MAF/ERMA standards also stipulate the operational requirements for a containment facility. As part of these requirements provision must be made for an effective training programme that teaches people how to work in a containment facility (see e.g. MAF Biosecurity New Zealand and ERMA New Zealand, 2007b, section 7.1.3). This in turn requires the appointment of a person responsible for designing, implementing, and documenting staff training. Research institutions make different arrangements for this role depending on their staffing structure. At Lincoln University, which has a number of PC1 and PC2 laboratories on one campus, this role is

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12 This is based on comments made in Interview F.
undertaken by the Biological Safety Officer (BSO) with some input from the Health and Safety Manager. Laboratory supervisors also provide training relevant to work in a specific laboratory (see Lincoln University, 2011).

The operational requirements for containment facilities also make specific reference to documents and record-keeping processes that must accompany GMO research. Figure 2.3 (below) lists the different documents that are held on file for any given GMO at Lincoln University.

| Biosecurity clearance (BACC's) |
| ERMA approvals (hold for min 7yrs after completion) |
| Export certificates |
| Import permits |
| Log of activities with respect to plants and animals |
| Major and minor changes to facility |
| Restricted cultures spreadsheet |
| Restricted imported animals spreadsheet |
| Restricted imported Biologicals spreadsheet |
| Restricted imported plants spreadsheet |
| Transfer permits |
| Transfer tracking record |

Figure 2.3 A list of the different documents that must be held on record in relation to a GMO. (Taken from Lincoln University, 2011, p. 128)

While the above list provides no detail on the content and purpose of these documents, it can be taken as an indication of the large amount of written material that is required in the conduct of GMO research. This observation, in addition to other details of the physical and operational requirements for containment facilities, will be examined in detail in Chapter 7.

2.4 Decision-making on GMO research under the HSNO Act

In 1996, the HSNO Act was introduced as a single piece of legislation designed to “protect the environment, and the health and safety of people and communities, by preventing or managing the adverse effects of hazardous substances and new organisms” (section 4). GMOs are defined as new organisms under this Act, and are therefore subject to the rules governing new organisms that came into effect from July 1998. Under these rules, any institution wishing to develop or import a GMO must gain approval from the Environmental Risk Management Authority (ERMA),
the quasi-judicial body charged with decision-making powers under Part 4 of the HSNO Act (see Nahkies (2003) for further details). On 30th June 2011, ERMA was disestablished and its functions were entirely taken over by a new government agency, the Environmental Protection Authority (EPA). This thesis deals mainly with events occurring prior to July 2011, and for this reason I will refer almost exclusively to ERMA.

The procedure by which ERMA makes an assessment of an application depends on the type of approval that is being sought. The HSNO Act (1996, section 27) delineates four main types of approval that apply to GMOs. A “development in containment” is usually conducted inside (e.g. in a laboratory), but can be conducted outside (e.g. in a field) in GM animal research. A “field test” is conducted in an outdoor containment facility in order to assess the performance of a GMO under less controlled environmental conditions. In a “conditional release” GMOs are grown outside a containment facility but must be confined to a specific geographic area and have the potential to be recalled entirely. Finally, a “release” of a GMO could be New Zealand-wide with no provisions for recall necessary.

The categories given in the HSNO Act (1996) make a distinction between two main places in which GMO research can take place prior to any type of commercial release: laboratories and fields. While there is obviously a marked physical difference between these two places, there is also a significant procedural difference in the decision-making process that accompanies an application. Laboratory developments are usually considered to be “low risk” depending on the type of GMO being developed; whether or not a GMO is low risk is assessed according to the Hazardous Substances and New Organisms (Low Risk Genetic Modification) Regulations (2003). Low risk development applications can be considered via a rapid assessment under section 42A of the HSNO Act (1996). The decision on a rapid assessment can be made by the ERMA Chief Executive; alternatively, this decision-making authority can be delegated to “any person” under section 19(2)(a) of the HSNO Act (1996). In practice, this takes the form of an Institutional Biological Safety Committee (IBSC) if one has been established at the research institution in which the application has been made. There are currently only four IBSCs in New Zealand; one reason for this is that approvals made by an IBSC are location specific, so it would be uneconomical for

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13 This category was inserted into the HSNO Act as a result of a recommendation made by the RCGM (Sustainable Future, 2008b).
14 The organisations that currently have IBSCs are the University of Auckland, Massey University, Lincoln University, and the University of Otago (see EPA, 2013a).
an organisation with laboratories in different geographical locations to have an IBSC\textsuperscript{15}. Approvals made by the Chief Executive are not subject to this limitation.

Rapid assessments cannot be made on applications to conduct research in a field (EPA, 2014a). Instead, applications must be submitted to ERMA, which is required to publicly notify the application and consider written and oral submissions on it before deciding whether to approve or decline the application (see section 53 (1)(d) of the Act). The Minister for the Environment and a number of other central and local government authorities must also be notified of the application (see section 53 (4) of the Act). This final decision is made by a decision-making committee: under ERMA, this was termed “the Authority” and consisted of up to eight members; under the EPA, this is now termed “the HSNO committee” and consists of eight members, only three of whom are involved in assessing a particular application\textsuperscript{16}. In both cases, a decision would be based on not only the application and submissions, but also an evaluation of the application submitted by agency staff (see e.g. ERMA, 2008b).

Only 20 applications to conduct field-based GMO research have been approved under the HSNO Act (1996), six of which have not been carried out (EPA, 2013b). These approvals have been given since July 1998 when the HSNO Act came into effect. Prior to this date the Minister for the Environment was responsible for making decisions on applications for field tests and outdoor developments following recommendations made by the Interim Assessment Group (IAG). Between 1988-1998, a total of 43 applications to conduct field-based GMO research were approved (EPA, 2013b). As yet there have been no applications to release a GMO in New Zealand.

This description of HSNO decision-making practices highlights a number of differences between laboratory- and field-based programmes of GMO research. This will be a recurring theme throughout this thesis, and will be explored in relation to practices that extend beyond the formal decision-making spaces outlined in legislation. To this end, the following section on public actions against GMO research also provides relevant background information.

\textbf{2.5 Public action against GMO research in New Zealand}

The beginnings of GMO technology can be traced back to Crick and Watson’s description of the structure of DNA in 1953. Following this, recombinant DNA techniques were developed in the 1970s, thus paving the way for deliberate manipulations of the genome (see Devos et al., 2008). However, it was arguably not until the landmark court case of \textit{Diamond vs. Chakrabarty} in 1980

\textsuperscript{15} According to contact information given on their website (www.plantandfood.co.nz), Plant & Food Research has 14 different physical addresses.

\textsuperscript{16} This is based on comments made in interview K.
that GMO research became a worldwide industry rather than an academic pursuit. This case marked the first successful patenting of a life form, and therefore meant that GMOs could be developed for commercial gain (ibid.). With the subsequent increase in commercial applications of GM technology and the growth of biotechnology companies there has been an associated rise in public controversy across the world (see e.g. Hughes, 2005; Magnan, 2007; Scholderer, 2005; Yamaguchi & Suda, 2010).

The 1990s saw rapid growth of the biotechnology industry in New Zealand, including the development of GMOs and various applications of associated GE technologies. The establishment of CRIs through the CRI Act (1992) indirectly promoted genetic engineering, and a number of public and private research institutions pursued research opportunities in this field (Weaver & Motion, 2002). By the late 1990s there was considerable public interest in GMO research (ibid.), and growing anti-GMO sentiment led to calls for the labelling of GM ingredients in food (Ashwell & Olsson, 2002) and the establishment of “GE-Free” zones throughout the country (Sustainable Future, 2008a).

While civic action in relation to GMO research was relatively sporadic during the twentieth century, this changed in the year 2000 when the many questions that surrounded GMO research led to a petition for a Royal Commission to be established (Sustainable Future, 2008a). This petition was signed by 92,000 people and presented to parliament by the Green Party in October 1999 (RCGM, 2001, Appendix 1). In response, the government announced on 21st December 1999 that there would be a Royal Commission on Genetic Modification (RCGM). The general public was invited to comment via workshops, a telephone survey, and written submissions; specifically identified “interested persons” were also able to speak at public hearings; a one-day Youth forum was held; and a series of workshops were held with Maori (Sustainable Future, 2008a).

Submitted to Parliament in July 2001, the final report was presented as a survey of the present and future options available to New Zealand with regards to GM technology, and any legislative or institutional changes that would be necessary in order to pursue these options (see RCGM, 2001). The overall conclusion was that New Zealand should “preserve its opportunities and keep its options open” but that “we should proceed carefully, minimizing and managing risks”. This was portrayed as a conservative approach to the issue of GMO research, sitting in between the two extremes of either enabling unrestricted use of the technology or keeping New Zealand completely GMO free (Sustainable Future, 2008b).
The RCGM has been the subject of critique from a number of researchers. While some have criticised the Government’s failure to fully implement the report’s recommendations (see Sustainable Future, 2008b), others have focused on the participatory processes of the RCGM itself. Although the RCGM sought to survey the views of all New Zealanders, critics have questioned whether or not the voices of non-experts were actually heard during the process. Rogers-Hayden (2004, 2005) holds that public comment was both invited and marginalised during the RCGM, with the final report doing little to incorporate wider public opinion on GM. In a similar vein, Goven (2006) suggests that the Commission served as little more than a legitimisation exercise, to give the appearance that meaningful public dialogue was influencing decision-making at the political level. Even Davenport and Leitch (2005), who do not explicitly criticise the procedures employed by the RCGM, point out that it was not intended as a forum for including the public in decision-making, but was instead aimed at supporting debate on the topic of GM.

The RCGM failed to meet the expectations of many anti-GMO campaigners, and the period directly following this process was a time when members of the public searched for other means to express their views. The Green Gloves Pledge, for example, was signed by New Zealanders who promised:

To take non-violent but direct action to prevent the irreversible release of genetically engineered lifeforms into the New Zealand environment whether this is deemed illegal or not. (Green Gloves, 2001)

A number of groups and individuals have since fulfilled this pledge to take direct action against GMO research. The People’s Moratorium Enforcement Agency (PMEA)\textsuperscript{17}, for example, was comprised of people who were frustrated that their formal protests against GMO research had not been listened to. As a result:

They have moved to take matters into their own hands. This month they held a camp with the express purpose of “training activists in direct action techniques”. After Erma approval for a field trial of GM Roundup-resistant onions, 150 people descended on Mountain Valley School in Motueka, an independent institution running outside direct government control... They learned how to blockade trucks and trains carrying GM produce and how to make life difficult for those trying to end the protests... Crucially they also learned how

\textsuperscript{17} This group was named after the moratorium that was placed on GMO field tests and releases between June 2000 and October 2003 (see Sustainable Future, 2008a for full discussion).
“decontamination” [destruction of crops] should be undertaken to minimise the risks of GM material spreading further into the environment (Nippert, 2004).

The training camp mentioned in the above quotation was targeted at a field trial of GM onions at C&F. Although there is no evidence that the skills learned at this particular training camp were ever put to use, C&F was the victim of sabotage in 2002, when a potato crop was destroyed (Nippert, 2004). Another CRI, Scion, has also been the victim of sabotage, with incidents reported in 2008 and 2012 (Stuff.co.nz, 2012; Rowan, 2008).

Numerous other individuals and groups, though not necessarily advocates of such radical activities, nevertheless actively campaign against GMO research, choosing to use the popular media, parliamentary processes, protest marches, or even court cases to voice their concerns. Examples here include the book *Seeds of Distrust*, written by the journalist Nicky Hager to expose the alleged Government cover-up of imported GM maize into New Zealand; the policy of the Green Party to “[keep] the Aotearoa/New Zealand environment free of GE organisms” (Green Party, 2011, p. 7); a “rowdy but peaceful vigil” organised by anti-GE protesters at the opening of the five-day International Conference for Agricultural Biotechnology held in Rotorua in September 2012 (Holland, 2012); and the (successful) application made to the High Court by GE Free New Zealand in 2009 for a judicial review of the approval given to AgResearch\(^\text{18}\) to import, develop and field test a range of GMOs. Shopping guides have been compiled to promote consumer boycotts of food containing GE ingredients, while some products are labelled as “GE Free” to attract the same consumers\(^\text{19}\). Furthermore, there are a number of groups in New Zealand who create their own forums for discussion through websites, the release of media statements, and written publications. These groups include the Soil and Health Association, GE Free New Zealand, Sustainable Future (now the McGuinness Institute), and the Sustainability Council.

The above examples reveal that public participation in GMO research comes in many forms, and takes place in a variety of places. While the public may have had little input into formal decision-making processes such as those involved in the RCGM, there have been a large variety of indirect and direct actions taken against GMO research. These actions should be taken into account in any assessment of the role of the public in GMO research, and will therefore feature in the analytical chapters of this thesis.

\(^\text{18}\) AgResearch is a New Zealand CRI.

\(^\text{19}\) For example, the “True Food Shopping List” was compiled by Greenpeace in order to help consumers avoid food containing GE ingredients.
2.6 Summary
This chapter provides contextual information of relevance to this thesis. It outlines the establishment and governance of Crown Research Institutes in New Zealand with a particular emphasis on their commercial orientation. It provides details of the regulatory standards that specify the physical and operational requirements for containment facilities. Alongside the description of decision-making processes under the HSNO Act (1996), this provides an overview of the legal framework that controls GMO research in New Zealand. Further to these formal, government-led processes, this chapter also considers the wide variety of public actions that have been taken against GMO research, and some of the impacts these have had. I will refer to the information provided in this chapter in my consideration of the case study material presented in Chapters 5, 6, and 7.
Chapter 3

Literature review

3.1 Introduction

In this chapter I will outline the theoretical basis for this thesis and also place this study firmly in the context of existing academic research. First I will consider Actor Network Theory (ANT), the name that has been given to a set of theoretical and methodological tools that can be used to study how reality is “done” in material relations. ANT is variously interpreted and applied throughout the social sciences, so in this chapter I will outline the core principles that underlie this diverse field of scholarship, before discussing in more detail my use of ANT in this study. In particular, I will explore how ANT has been developed over the years to provide different representations of the “object” of study. I will use a number of these representations in my analysis of the objects of GMO research: “tearless onions” (in Chapters 5 and 6) and containment facilities (in Chapter 7). The methodological application of these concepts will be discussed in Chapter 4, particularly methods that have been developed to represent network objects.

Following my examination of ANT as a general area of scholarship, I will consider two other areas of the social science literature that are of particular relevance to the topic of this thesis. Given that this is a study of the risks of GMO research, I will first consider how social science research has been used to provide reinterpretations of what risk is, moving beyond the “objective” framings provided by scientists and engineers to incorporate social interaction into the unit of analysis. This leads me to focus on how ANT can be used in the study of risk, first outlining research that has utilised early network concepts before moving on to research that resonates with more recent developments in ANT.

This thesis is also a study of the places in which GMO research is conducted, and I will survey the literature that is relevant to this topic in the final part of this literature review. A number of researchers have examined how the places of scientific research are formed in more than physical terms, arguing that boundaries, orders, and divisions are generated in practice. I will also consider how these studies depict the relationship between the laboratory and the field, as these are the two places that will be the focus of my own research.
3.2 Actor-Network Theory

The development of Actor-Network Theory is usually linked to the work of three people: Bruno Latour, Michel Callon, and John Law. Bruno Latour and Michel Callon met in the late 1970s (see Dosse, 1999): Callon was studying the development of the electric vehicle (Callon, 1980a, 1986b) at the Centre for the Sociology of Innovation (CSI), part of the École des Mines in Paris; Latour had recently returned to France after years spent at the Salk Institute in California during which time he conducted an ethnographic study of a science laboratory (Latour & Woolgar, 1986 [1979]). Their meeting led to collaboration (e.g. Callon & Latour, 1981), and Latour eventually joined Callon at the CSI. At around this time the British sociologist John Law was working in the field of the sociology of science. He began to use ANT as a tool for describing mechanisms of power and control (Law, 1986a, 1986b, 1987, 1991), and collaborated with Michel Callon in a number of publications (e.g. Callon & Law, 1995; Law & Callon, 1992).

Thus, Actor-Network Theory in its earliest formulations was concerned with tracing power relations, usually in the context of scientific research and technological change. Since the early 1990s, however, there has been such a diversity of approaches to and applications of ANT that it can no longer be described in the abstract: as Law observes, “there is no ‘it’” (Law, 2008a, p. 142). Furthermore, there are many overlaps between ANT and other theoretical approaches such as feminist standpoint epistemology (e.g. Harding, 2008), post-human geographies (Lorimer, 2009), and non-representational theory (Cadman, 2009), as well as the broader areas of material semiotics and STS (Law, 2008a, 2008b).

Although ANT scholarship is therefore characterised by diversity, there are nevertheless a set of core principles that underlie these various presentations of it. These principles broadly conceive of ANT as an anti-essentialist approach to the study of the “social” world.

3.2.1 The anti-essentialist stance of ANT

One of the most widely cited of Bruno Latour’s works, *We have never been modern* (1993), explores in detail a concept that is central to ANT: that categories, binaries, and classifications are a product rather than a cause of social organisation. Latour argues that modernity has been founded on acts of purification, in which distinct categories such as nature and society are created and made solid. The irony is, however, that the problems with which we are confronted in the modern age, such as global warming or ozone depletion, are “quasi-objects” that mix together elements of nature and society. Thus, to understand such objects we must undo the acts of purification that have become so much a part of our lives.
ANT’s solution to this problem is to re-think our basic assumptions about the social world, and therefore take a completely different approach at the outset of any sociological analysis. ANT advocates a way of thinking that avoids all a priori assumptions as to what could or should be included in analysis, or what the outcomes of an analysis should look like. Callon (1986a) describes this approach as the principle of “generalised symmetry”, an approach that builds on the “symmetry” espoused by the strong programme of the sociology of scientific knowledge (SSK). Here, symmetry is used to mean that both “true” and “false” scientific claims are made as a result of the same processes, and should therefore be studied in the same manner (see e.g. Hess, 1997). ANT, on the other hand, uses symmetry in reference to the actors involved in making these claims, holding that anything, be it human, “natural”, or technological, can be labelled as an “actor” and therefore capable of influencing the course of events. This re-imagining of social agency has led some to use the term “actant” instead of actor to provide a more encompassing term (see e.g. Castree & Macmillan, 2001). Actors and actants are defined not on the basis of a priori distinctions but on what they do. Thus “an actor is an author” (Callon, 1991, p.141); it is able to generate and transform the world around it, and can make others “dependent on itself and translates their will into a language of its own” (Callon & Latour, 1981, p.286).

The anti-essentialist stance taken by ANT is radical, even in comparison to other post-structural approaches within the social sciences. By following the principle of generalised symmetry, the social world is laid flat (Latour, 2005), and the reasons for social phenomena cannot privilege human agency, nor can they make recourse to structures, hierarchies, or underlying discourses that are prominent in other theories of the social. Indeed, ANT does not profess to be “a theory of the social” (Latour, 1999b, p. 22); it is instead a theory “about how to study things” (Latour, 2005, p.142; emphasis in original). To this end, the tools of network analysis have been developed for use in traditional approaches to ANT study.

3.2.2 The networks of ANT

As the name “Actor-Network Theory” suggests, networks have been of central importance in ANT since its development as a field of scholarship. At times this has been problematic (see e.g. Latour, 1999b), which appears to stem from the various meanings of the term, both in academic circles and idiomatic use. Social network analysis, for example, is used to map out connections between people and other social “entities”, identify patterned relations, and use this to determine macro-social structures (Knoke & Yang, 2008). This emphasis on connections is also evident in everyday conceptions of computer networks, transport networks, business networks, and so on. But this has itself led to misinterpretations of what constitutes an ANT-informed network analysis:
Being connected, being interconnected, or being heterogeneous is not enough. It all depends on the sort of action that is flowing from one to the other, hence the words “net” and “work”. Really, we should say “worknet” instead of “network”. It’s the work, and the movement, and the flow, and the changes that should be stressed. But now we are stuck with “network” and everyone thinks we mean the World Wide Web or something like that. (Latour, 2005, p. 143)

While the unit of analysis in ANT has traditionally been the network, the aim is not simply to describe what is linked together (the “net”) but to detail how these links are made and maintained (the “work”). Furthermore, a network cannot be reduced to or said to contain a finite number of elements and connections. Networks are not objects that exist in Euclidean space20 (Latour, 1996b; Law, 2002b), and can be “simultaneously an actor whose activity is networking heterogeneous elements and a network that is able to redefine and transform what it is made of” (Callon, 2012, p. 87). This conceptualisation of the network is therefore fundamentally distinct from other usages of the term and should be acknowledged and explained at the outset of a programme of research. Chilvers and Evans (2009) observe that:

...the contrasting uses of “networks” in policy and science studies imply different sets of epistemological and ontological baggage. Because the “network” is a complex concept does not mean that it cannot be used, but prompts environmental studies to more comprehensively qualify their use of the term. (Chilvers & Evans, 2009, p.358)

These comments are particularly pertinent to ANT because there are varying usages of the network concept even within this field of scholarship. In the following sections I will therefore provide a thorough examination of the usage and ongoing development of the network concept in ANT.

The construction of networks

Early ANT texts focus on the activities involved in network construction, particularly through case studies of developments in science and technology. They focus on the work that must be done “outside” the laboratory if the developments that take place “inside” it are to succeed, thus removing both the physical divide that exists around places of scientific research and also the conceptual categories that separate “science”, “society”, and “nature”. A successful scientist is a

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20 In geometry, Euclidean space is characterised by three orthogonal dimensions, commonly denoted by X, Y, and Z axes. Objects located in Euclidean space have physical dimensions that can be described in terms of Cartesian co-ordinates along these axes. These dimensions must remain constant if the object is to retain its physical form, or “shape” (Law & Mol, 2001).
“heterogeneous engineer” (Law, 1987, p. 117) who is able to weave together elements from across these categories.

Latour (1983) describes the heterogeneous engineering involved in scientific work through his analysis of Pasteur’s development of the anthrax vaccine in 19th Century France. Latour argues that Pasteur’s success is the result of his ability to draw together such diverse elements as petri-dishes, microbes, farm cattle, and hygienists. He achieves this by, first, “interesting” a diverse array of actors in the importance of his work; and, second, “translating” his work from the laboratory, to the farm, and back to the laboratory again. These processes allow Pasteur to construct a network that puts his laboratory in a position of great power: anyone who wants to control the anthrax disease must pass through Pasteur’s laboratory. Thus, although agency is distributed throughout the network, Pasteur’s ability to act as spokesperson for it puts him in a position of great power, apparently in control of all other actors.

Latour develops these theoretical insights in Science in action (1987), where he considers the activities involved in scientific endeavour in more general terms. He focuses on the strength of laboratories as the “centres of calculation” (p. 215) from which scientists orchestrate the processes of fact-building that are necessary for successful scientific research. This involves the assembly of a variety of humans, non-human, and technical devices that will “spread out in time and space” (p. 108), transporting with them the discoveries of the laboratory so that they will become part of the world “out there”. But this movement can only succeed if the laboratory is able “to enrol others so that they participate in the construction of the fact [and] to control their behaviour in order to make their actions predictable” (ibid., emphasis in original). Latour contends that this dual process of enrolment and control is only possible if the laboratory is able to provide a common interpretation of the interests of all actors: this is achieved via the process of “translation” (ibid.).

The theme of translation is central to Callon’s (1986a) seminal paper, “Some elements of a sociology of translation”. Here Callon focuses on a scallop fishery in St Brieuc Bay, France, in the 1970’s, a fishery of great importance to the tastes of French consumers but nevertheless in decline. Callon describes how a group of scientists develop a conservation strategy to increase the scallop population. His analysis focuses on the heterogeneous engineering that the scientists must undertake in order for their proposals to be transformed into reality by the community of actors at St Brieuc Bay. Callon uses the term “sociology of translation” to refer to the activities involved in network construction, which he further elaborates through the identification of four
key “moments”21. The first, “problematisation”, is where one actor (or group of actors) is able to impose the definition of a problem and the relation of every other actor to it. In order to convince other actors of this problematisation, they then engage in “interessement”, a series of processes and devices used to convince others to take on the roles assigned to them. “Enrolment” and “mobilisation” are achieved when these other actors accept the definition of their roles and act accordingly. Finally, “stabilisation” and “punctualisation” of the network is achieved when the connections within it are no longer subject to debate or dissent. The network is then said to be “black boxed”, a concept I will return to later.

A successful translation depends on stable network relations, and this can only be achieved through the successful deployment of intermediaries. Callon defines an intermediary as “anything passing between actors that defines the relationship between them” (1991, p. 134). Intermediaries are crucial to the process of interessement as they can be used to explain how one actor interests another in material terms: “they compose networks by giving them form” (ibid., p. 135). Literary inscriptions, technical artefacts, human beings, and money are the four main types of intermediary (ibid.). Intermediaries are circulated by actors, but cannot themselves create intermediaries or forge connections, this being the crucial difference between the two (Callon, 1991; Callon & Latour, 1981).

The sociology of translation can be used to explain how agency is distributed across a heterogeneous network of actors. The outcome of the scallop conservation strategy formulated by the scientists rests on the actions of all actors in the network rather than the technical expertise of the scientists. While this study is exemplary of the wider application of network analysis to the study of power and control (e.g. Callon & Law, 1995; Latour, 1991; Law, 1986a, 1986b), it is by no means the only use of these conceptual tools. Elsewhere, aspects of network construction are evident in Latour’s (1999a, Chapter 2) concept of “circulating reference”, which he uses to explain how the material form of the world can be connected to the abstracted representations given in symbols, language, and texts. Latour observes that:

> The philosophy of language makes it seem as if there exist two disjointed spheres separated by a unique and radical gap that must be reduced through the search for correspondence, for reference, between words and the world. (Latour, 1999a, p. 69)

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21 For more details on the processes involved in translation see also Callon (1991) and Callon and Latour (1981).
Latour uses network analysis to describe how a “chain of translation” (p. 27) serves to bridge the gap between “words” and “the world”. Each step in this chain performs a small change that transforms a “thing” into an abstracted “sign”; this in turn is followed by a further change that performs another small abstraction. The incremental effect of these changes is a drastic transformation that results in the appearance of a “radical gap... between words and the world”. Latour illustrates this point with his description of a group of scientists who transform the forest/savannah border at Boa Vista in the Amazon into a diagram in a scientific text. We assume that there is a clear separation between the material form of the forest and its representation in a diagram, when it is simply that the chain of translation that links them has been rendered imperceptible:

> We never detect the rupture between things and signs, and we never face the imposition of arbitrary and discrete signs on shapeless and continuous matter. We see only an unbroken series of well-nested elements, each of which plays the role of sign for the previous one and of thing for the succeeding one. (p. 56)

Thus, each individual link in the chain of translation folds together material form and representation within each transformation. This not only serves as a reason why a clear division between the two realms cannot be drawn, it also presents an alternative interpretation of the concept of “reference”. According to Latour’s argument, a word does not simply refer to a material world “out there”, thereby making a single leap that points in one direction; instead, reference circulates through the links in a chain of translations, all of which must remain intact to effect the connection between material form and representation:

> If the chain is interrupted at any point, it ceases to transport truth – ceases, that is, to produce, to construct, to trace, and to conduct it. The word “reference” designates the quality of the chain in its entirety, and no longer adequatio rei et intellectus. Truth-value circulates here like electricity through a wire, so long as this circuit is not interrupted. (p. 69, emphasis in original)

Latour uses the concept of circulating reference to describe how the Amazon rainforest is recreated in the pages of a scientific text so that “when I read the field report, I am indeed holding in my hands the forest of Boa Vista” (p. 61). Similarly, Brown (2001) uses the concept of circulating reference to explore the practices of organisational control in a large British oil company. Brown focuses on the use of timesheets, which serve to translate the work carried out by staff into data that can be used and manipulated by accountants at the firm. The day-to-day
activities of individual workers are thus folded into the “representation” of organisational management practices, which in turn enables cross-scale organisational control via documents and paper trails:

Without this work it would be impossible for systems such as databases to work. These processes, which take the form of ‘audit trails’, ‘random checks’, and such like, are widespread. This representational work establishes the fact that - for the matters at hand - a representation can be said to be linked to what it is purported to represent. For scientists the matter at hand implied careful methodology, for the accountants a process which was seen to be rigorous and auditable. It is this work which establishes representations - such as computer databases - as accurate and reliable. (Brown, 2001, p. 56)

The methodological principles that Latour’s (1999a) scientists must follow to produce a valid scientific text are equivalent to the audit trails that comprise a fully functioning organisation: each is a chain of translation that must remain intact if reference is to circulate through it. As such it provides another example of how network analysis can be used to describe the variety of processes that are involved in turning scientific work into successful research. I will use these principles in my own study of GMO research, attending to how allies are enrolled, interests are translated, the world is connected to words, and work practices are controlled. I will also use another important aspect of network construction to inform my analysis: the process of black boxing.

*Black boxes and (un)stable networks*

Given their efforts to trace networks of organisation and control, there are parallels between the work of ANT scholars and those who follow the writings of Foucault. However, whereas Foucault emphasises the structural influences of underlying *epistèmes* that are removed from every-day activity and remain relatively stable, ANT denies such foundational states (Law, 2002a; Mol, 2002). Organisational structures are a result, rather than a cause, of network activity, and the methods by which such structures are formed is therefore a topic of study. Furthermore, given the heterogeneity and contingency of network realities, it is important to consider the ongoing work involved in keeping a network stable.

If things hold steady at all it is because the positions and relations of inclusion which make them up are constantly being reworked. The problem is chronic - but perhaps more visible than it has been in the past given the demographic explosion that we are living through. Human numbers are expanding at an ever-increasing rate. But so, too, is the number of nonhumans, with an avalanche of objects and artefacts tumbling from laboratories and
enterprises, all claiming to be welcome... So how can we produce order by managing these multiple fluxes and flows? (Callon & Law, 2004, p. 5)

As mentioned earlier, a stable, punctualised network is said to be “black boxed”. A black boxed network “contains that which no longer needs to be reconsidered, those things whose contents have become a matter of indifference” (Callon & Latour, 1981, p. 285). A computer is an example of a common black box in modern Western society: most of us use them in our every-day lives without considering the complexities involved in their operation.

The concept of “black boxing” can be used to explain how power distributions and imbalances result from network building activities. It would be impossible for an actor to micro-manage every individual relation in a complex system. Instead, this complexity is simplified, or “punctualized”, so that it is “reduced to a single function” (Law & Callon, 1992, p. 24) that comes to represent that network: it is the surface of a “black box” that is never opened up for inspection. The power of an actor thus stems from this ability to simplify and black box complex networks (Latour, 1991), and the control of an ever-increasing array of black boxes allows an actor to become a “macro-actor” (Callon & Latour, 1981; Law & Callon, 1992).

Black boxed networks are also important in explaining the progress of scientific innovation. Any new programme of research is deliberately placed within a specific context; this “context” is essentially a myriad of other black boxed networks, each of which has been deliberately attached to the new project in order to provide it with a foundation (Latour, 1987, 1996a). These other networks are selected carefully, and “actors limit their associations to a series of discrete entities whose characteristics or attributes are well defined” in order to simplify the potentially infinite complexity of reality (Callon, 2012, p. 87). If this crafting of networks-within-networks is done properly, it amplifies the strength of a network, as “the networks lend each other their force. The simplifications that make up the actor network are a powerful means of action because each entity summons or enlists a cascade of other entities” (ibid, p. 90).

By being established firmly in a context, the new network is given a sense of inevitability, as it appears to follow on naturally from other developments. It is also granted a degree of irreversibility, as dissent is only possible if the connections between black boxes can be severed (Latour, 1987). Nevertheless, without enough black boxes or due care to strengthening the connections between them, a project will fail, and “those who were counting on the irreversibility of the context to keep their technologies alive wake up in the cemetery” (Latour, 1996a, p. 143; see also Latour, 1991). Furthermore, alliances between actors can change, both within and
between networks, ultimately leading to the failure of a network (Callon, 1986a; Latour, 1996a; Lien, 2005).

Even when a network has been stabilised it does not take a fixed form for perpetuity. Some studies of black boxing therefore focus on instability: how networks are threatened as a result of connections between or within black boxed networks. Lien (2005) discusses this in her study of Tasmanian salmon, an introduced species that has nevertheless become an integral part of Tasmanian culture. This has resulted from the creation of a stable network, which is now threatened by the influence of another network: Australia has been forced to lift its ban on fresh salmon imports, thereby opening the doors to diseases that could affect its salmon population. Thus, a hitherto unrelated network has become folded into that of the Tasmanian salmon, and unless relations can be re-ordered and re-negotiated, this latter network will eventually fall apart.

The re-ordering of network relations is discussed by Law (2000a) in his study of an aeroengine explosion in Britain in the 1960s. Law argues that network stability is predicated on the order of transitive relations: the nesting of the “small” or “local” within the “large” or “global”. But Law argues that “transitivity is not something that is given in the order of things” (p. 144, emphasis in original), but is instead a distribution that is performed in the course of network formation. Thus, intransitivities appear when disaster strikes: one small piece of an aeroengine can have a much greater effect on the future direction of the British Aerospace industry than a policy document drafted in Whitehall if that object does not remain in its engine, but instead careers across an airfield, cutting through a fuel line on its way. The damage done when something “leaks” out across a specified boundary in this way is therefore very difficult to repair, and requires re-orderings and the re-establishment of boundaries; and, importantly, the re-distribution of transitive relations.

Both Lien and Law deal with network hierarchies; how one factor can be placed above another in determining the overall stability of a network. But whereas Lien’s analysis could be used to argue for a conventional hierarchy that places global ahead of local, Law asserts that this interaction can not only work in the opposite direction, it is also in a state of perpetual flux. This echoes Latour’s (1996a) observation that “the topology of technological projects is as peculiar as their arithmetic” (p. 108): any given black box can switch from the most to the least important link in the chain, and a definitive map of these contextual networks can therefore never be drawn.

As this existing research demonstrates, a consideration of black boxes is an important aspect of network analysis. This requires the study of not only the processes involved in the stabilisation of
individual black boxed networks, but also the inter-relationships between them. These inter-relationships will not necessarily follow a conventional or linear hierarchical relationship; nor will they always lead to increased stability, as inter-connection can also lead to instability and breakdown.

3.2.3 From construction to enactment
Callon’s (1986a) “sociology of translation” has become one of the most well-known articles written in the field of ANT\(^\text{22}\), and some researchers appear to see it as a definitive text for understanding what ANT is and how it should be applied\(^\text{23}\). The illustrated network is key to Callon’s argument as it provides a visual representation of the channelling of various interests through an Obligatory Passage Point (OPP). However, whereas the inclusion of an OPP is intended to illustrate how the diverse goals of interested actors can be achieved by performing one activity, it can also be interpreted as the bending of many wills to the power of one. Thus, the network of actors can appear as passive supplicants as opposed to active agents. This has led to criticisms that ANT provides managerialist accounts (see, for example, Star, 1991), which in turn leads to a tension in the ANT literature: while an explicit argument is being made for distributed agency, implicit in the use of the OPP is a centring of agency (See Gad and Jensen (2010) for further discussion).

But while these interpretations focus on the techniques of network construction, others construe Callon’s message quite differently.

Callon looks at practices, and asks how fishermen, scallops, and scientists are being done in them: what these different actors are being made to be in those practices. So he describes how for a time fishermen were rendered passive and scallops active... Then he tells how this web of relations fell apart. Overnight fishermen became active and scallops passive... Callon’s argument is about the enactment of two sets of relations and, as part of this, the enactment of two versions of fishermen and scallops. It is ontological. Scallops and fishermen are effects of practices. That is what they are. (Law & Lien, 2010, p. 3, emphasis in original)

\(^{22}\) According to Google scholar, there have been 4733 citations as of 17\(^\text{th}\) September 2013.

\(^{23}\) For example, Van der Duim and Van Marwijk (2006) state that ANT is “also known as the ‘sociology of translation’” (p. 451).
Here, Law and Lien are focusing not on network construction but on network change. They point out that reality is a network effect; when the relations within a network change, so too does reality. Importantly, they imply that these changes are inevitable, that reality is always in the making and that any apparent sense of stability is fleeting and precarious. Thus, they use the term “enactment” to denote the never-ending performance of reality: reality is not made, it is done.

Law and Lien’s interpretation of Callon’s paper is indicative of a general shift in the ANT literature. Whereas the tools of ANT were once used to describe the processes of network construction, they are now also used to describe how networks enact reality. This point is perhaps best illustrated through a consideration of Anne-Marie Mol’s study of atherosclerosis in *The Body Multiple* (2002). Her ethnography of disease pays careful attention to the various sites in which different formulations of the hardening of leg arteries are done. Mol’s analysis directly confronts the notion that the reality of this disease is something that exists beyond the confines of the hospital itself; instead, it is only through the interactions between (for example) pathologists, patients, X-rays, and operating tables that atherosclerosis comes to be. The identification of a calcified blood vessel under a microscope illustrates this point. Mol explains that:

> ...when “under a microscope” is added, the thickened intima no longer exists all by itself – but through the microscope. What is foregrounded through this addition is that the visibility of intimas depends on microscopes. And, for that matter, on a lot more. On the pointer. And on the two glass sheets that make the slide. Don’t forget the decalcification that, even when it isn’t done long enough, allows the technician to cut thin cross sections of a vessel. There’s the work of that technician. The tweezers and the knives. The dyes that turn the various cellular structures pink and purple. They are all required if pathologists are to see the thick intima of a vessel wall. (p. 31)

Mol is describing a network here, but it looks nothing like the networks of early ANT texts. There is no mention of power relations, of how one actor interests other parties in fulfilling a specified role. All is relatively mundane: a technician prepares a slide which is viewed by a pathologist, who in turn identifies the presence of atherosclerosis. But Mol’s point is that the reality of this disease only exists in these practices; if they change, so too does the disease. Furthermore, at different sites in the hospital, different sets of practices yield different enactments of atherosclerosis: under the microscope of a pathology lab it is “a thickening of the intima” (p. 30), but in the outpatient clinic it is “pain when walking” (p. 54), and in the vascular laboratory it is “pressure loss” (p. 60). The reality of atherosclerosis is therefore multiple. None of these realities can be taken as foundational, as pre-existing the others; reality is distributed across them, and all are
somehow made to co-ordinate with one another such that an apparently singular disease emerges. This disease can be talked about, diagnosed, treated, researched, and discussed at conferences so that to all intents and purposes there is only one “it”.

While the objects of early ANT studies were singular and rigid, a focus on enactment leads to a description of objects as multiple and de-centred. An object is “more than one, but less than many” (Law, 2002a, p. 3, emphasis in original; see also Law, 1999, p. 12) since, although there is no single “it”, there are a finite number of enactments that are involved in “doing” the object. This also means that by describing objects as multiple they do not become fragmented or incoherent: where a multitude of different, parallel realities co-exist. Instead, objects take on a “fractional coherence” (Law, 2002a), holding together because of partial connections (following Strathern, 1991) that are made between different, locally enacted entities (Mol, 1998).

A focus on enactment and the description of realities as multiple has not merely added to the theoretical repertoire of ANT. It has also enabled it to develop into a practical tool that can be used to instigate change. What exists can be un-done, and furthermore it can be done in different ways (Law & Singleton, 2012) This capacity to make a “real” difference through social science research has been termed “ontological politics” (Mol, 1999); but researchers often stop short of making specific recommendations for change, instead leaving these choices in the hands of the reader (e.g. Mol, 1998, 2002). Nevertheless, Hinchliffe and Bingham (2008) suggest that social scientists have a responsibility to engage in ontological politics through their studies because “they offer opportunities for making more real geographies other than those that too often unintentionally promote the powerful and lead one to imagine there is nothing left to be done.” (p. 1548). These sentiments are consistent with Law’s assertion that “it is right, as a matter of political choice to interfere, to discover objects in their spatial multiplicity and alterity, to make and articulate alternative spatialities and, in particular, to rehabilitate fluidity” (Law, 2002b, p. 102). Social science research is not, therefore, an academic pursuit that is to remain on library shelves. This point is not specific to ANT, and reflects a wider concern amongst social scientists to use theoretical insights to achieve practical results (see e.g. Flyvbjerg, 2001). If we take these claims seriously, research can interfere with the realities under scrutiny and provide the possibility of choosing different ones.

In this study I will integrate the concepts of “enactment” and “multiplicity” with the more traditional tools of network analysis. I will also use my research to engage in ontological politics, using my analysis of GMO research practices to make recommendations for change to current systems of risk management. But while the shift in focus from construction to enactment can
arguably be incorporated into network analysis, other developments in the ANT literature have led to a much more a significant shift in the practice of ANT research. In the next section I will consider these developments, and also outline how I will incorporate them into this study.

3.2.4 The changing spaces of ANT

A network is usually described in terms of a variety of actors that are conspicuous by their presence. Each of these actors can be linked to a variety of others that, though not present in a particular time or place, can be linked through a trail of associations to describe a *manifest absence* (see Law, 2004, p. 157) that is just as important to network effects as any overt presence. Callon and Law use the example of a blacksmith’s role in ploughing a field by making the tools used by the ploughman to demonstrate that “a site is a place where something happens and actions unfold because it mobilises distant actants that are both absent and present” (Callon & Law, 2004, p. 6). This relationship between absence and presence can be described in terms of Deleuzian “folds” in the space/time continuum, folds that serve to shorten the physical and temporal distances that lie between disparate elements24. In this way, “the global is local; the local is global” (Callon & Law, 2004, p. 3), and differences that are assumed to result from inherent properties disappear.

The interplay between absence and presence is considered in further detail by Law (2002c) in his examination of the design of a military aircraft. Here he focuses on a formula used to calculate the “gust response” of an aircraft25, demonstrating how a mathematical formula simplifies an array of variables so that it can “be used to make sense” (p. 120) of a wealth of complexity. Law’s use of the term “complexity” is not meant to signify that the formula is complicated; instead, it refers to the heterogeneous mixture of presences and absences that are held in place by the mathematical formalism. Thus, while the formula itself asks us to attend to variables such as the weight of the aircraft and the wing area, it is a simplification that, through its presence, pushes other factors out of view, enacting them as absent. According to Law’s argument, heterogeneity can therefore be conceived as a *pattern of presence and absence*. This is significantly different to ANT’s original definition of heterogeneity, where it is used to refer to the variety of “actants” that are assembled together in “the social” world.

24 See also Latour’s (1999a, 2002) discussions of technology as the folding together of time, space, and agents.
25 Law defines this as “a measure of the response of the aircraft as it flies through vertical gusts of wind” (2002c, p. 117).
Furthermore, absence can be found in more than one form, thus adding even greater complexity to this heterogeneous pattern. Material absence, equivalent to the manifest absence described by Callon and Law (2004), can be drawn into a network by attending to that which is present. In the design of a military aircraft, Law observes that “[r]emoved from the flat space occupied by the formalism, we find ourselves in the sweating world of the aircrew” (2002c, p. 123), where vomit, sweat, and fear are the most obvious effects of atmospheric turbulence. But these human qualities are absent from the formalism itself, even though they are directly associated with any changes in the variables that are included in it. They are material absences that are nevertheless “relevant to, or represented in, presence” (Law, 2004, p. 157). In contrast, absence as Otherness is pushed beyond the boundaries of network space, and must remain “irrelevant, impossible, or repressed” (Law, 2004, p. 157). Law positions the Russians as the necessary Other in the calculation of gust response: they are “[t]he enemy excluded, the foe that is necessary, necessarily included, necessarily a part of the centre, necessarily other” (Law, 2002c, p. 126). They are “a threat” akin to Edward Said’s Orientals (p. 126); but although it is “dangerous, different, antithetical”, Otherness is nevertheless “a need incorporated in its absence into the semiotics of presence” (p. 127). The calculation of gust response, and therefore the design of a military aircraft as a whole, will only occur if there is an Other.

An attention to presence, absence, and Otherness goes some way to address criticisms that have been levelled at ANT’s early network analyses; notably that networks provide no space for that which is “Othered” (see e.g. Lee & Brown, 1994; Star, 1991; also Hetherington & Law, 2000; Law, 2008a). But this in turn leads to another issue: space must itself be re-imagined.

A network as a spatial imaginary works well when it is the relations between the different actors that are being sought, but to recognise Otherness as inside rather than leave it out requires other ways of thinking about space. We need a spatial imaginary more topologically complex and less certain in order to do justice to the uncertainty that Otherness brings with it. (Hetherington & Law, 2000, p. 129)

Topology is a branch of mathematics that studies objects, spaces, and the relationships between them (Law, 2002b; Law & Mol, 2001). But it “extends the possibilities of mathematics far beyond its original Euclidean restrictions by articulating other spaces” (Mol & Law, 1994, p. 643, emphasis in original) and therefore considers alternative dimensions, where an object can undergo change without losing its overall shape (Law, 2002b). As such, a topological interpretation of network objects describes them as “immutable mobiles” because they remain unchanged in network space even when they move or distort in Euclidean space (ibid.). But to describe all objects in
these terms would lead to a form of topological homogeneity, disregarding Hetherington and Law’s assertion (above) that we need to introduce greater topological complexity into our spatial imaginings (see also Law, 1999). Elsewhere, Mol and Law (2002) make similar observations, arguing that “[t]o make sense of multiplicity, we need to think and write in topological ways, discovering methods for laying out a space, for laying out spaces, and for defining paths to walk through these” (p. 8). Thus, it isn’t only objects that are multiple, but also spaces. ANT study should pay close attention to how both of these are done in practice, and the intersections and interferences between them.

Recent ANT literature has turned to topological considerations of objects and spaces (see esp. Law, 2002b; Law & Mol, 2001; Law & Singleton, 2005; Mol & Law, 1994). This body of work re-images the relational ontology of ANT in such a way that it is no longer necessarily network relations that enact an object. At least two other forms of relationality have been described further to the “regions” of Euclidean space and “networks” themselves. “Fluid” topologies accommodate objects that can sustain gradual changes across time and space and have therefore been described as “mutable mobiles” (Mol & Law, 1994; de Laet & Mol, 2000). “Fire” topologies, on the other hand, accommodate objects that are characterised by discontinuity: radical differences within the object that serve to hold it together (Law & Mol, 2001; Law & Singleton, 2005). It is this latter topology that can potentially be used to describe objects in all their heterogeneous complexity because it can accommodate not only presence, but also absence and Otherness (Law & Mol, 2001).

This topological turn in recent ANT literature has in part led to the distinction between “early” and “post”/ “after” ANT (see e.g. Law & Hassard, 1999; Hetherington & Law, 2000; Law, 2008a; Gad & Jensen, 2010; Vasantkumar, 2013). While these labels are by no means commonly or consistently used by researchers in relation to their own work, there is nevertheless an emerging divide in how ANT is done in practice. Network analysis provides researchers with a toolkit of methods that can be used to investigate a topic of study systematically, and use their findings to make specific conclusions. It is particularly useful in applied areas of research such as environmental management, as demonstrated in its application to the study of strategic planning processes (Bryson, Crosby, & Bryson, 2009); environmental management systems (Van der Duim & Van Marwijk, 2006); Geographic Information Systems (Harvey, 2001); and a number of studies of environmental controversies (e.g., Woods, 1997; Jakku, 2003; Foster, 2012). This body of work is not only pragmatic, but also represents valid applications of ANT; nevertheless, most of them do not contribute to ANT as a form of “empirical philosophy” (Law & Mol, 2002; Mol, 2002) or
“empirical ontology” (Law & Lien, 2013). There is of course a large body of literature that has applied these more esoteric forms of ANT analysis to practical concerns; of particular relevance to this study is the emerging body of literature on the spatialities of risk (see section 3.3.2 below). But network analysis as it was originally conceived in “early” ANT does not appear to feature in the approach taken by these studies. Indeed, John Law’s quite literal shelving of his initial network analysis of the TSR2 aircraft in favour of a set of multiple, intersecting “Aircraft Stories” (see Law, 2002a, p. 54) exemplifies this apparent succession in the ANT literature, and suggests that the theoretical development of ANT requires a move beyond the network approach.

This leads me to question whether or not these different areas of ANT scholarship can be combined into a single study. As I have suggested above, current theoretical explorations of ANT appear to have all but rejected the utility of early ANT methodological tools; but it is important to question whether the network concept still provides a useful and rigorous research tool. Furthermore, if network analysis is still relevant, how can it be integrated with ideas that have been developed in more recent ANT scholarship? To answer these questions offers the possibility of bridging the gap that has emerged in the ANT literature. Furthermore, it may lead to the formulation of new research practices and new ways of “doing” ANT.

3.3 Risk

This study provides an examination of the practices involved in doing GMO research in New Zealand, and how risk is “done” in these practices. As such, it contributes to an existing body of social science literature that examines what risk is and how it can be assessed. This literature seeks to move beyond traditional risk assessments, where risk is conceived in “objective” terms, and calculations are used to assess the likelihood of an event occurring. The problem with such calculations is that they try to distil a huge array of complex variables into a simple mathematical equation or model where “the world is constricted for analytic purposes” (Jasanoff, 1993, p. 125). This process of constriction is usually left unquestioned, and the results of a modelling exercise are taken as reality, which leads to problems when risk management practices are implemented out in the “real world” (see e.g. Whatmore & Landström, 2011).

Until relatively recently, the objective framing of risk remained unchallenged, and risk assessment remained in the domain of scientists and engineers (Hannigan, 2006). In more recent years, however, there has been a growing movement to provide alternative conceptualisations of risk. Psychometric assessments, for example, have introduced human influences into the study of risk by highlighting the role of risk perceptions (see e.g. Slovic, 2000). But this creates a divide between people and the “things” they see as risky; it separates the knowing subject from the risk
object. As Hilgartner observes, this poses a problem, because “[p]erceptions of risk are not things that get tacked onto technology at the end of the day. Definitions of risk get built into technology and shape its evolution” (1992, p. 39). Thus, evaluations of risk do more than just reflect a separate reality; they are part of that reality.

A number of approaches in the social sciences have been instrumental in redefining risk as a product of societal interactions. Notable amongst these are Douglas’ cultural symbolic approach, which defines risk as the transgressing of culturally defined boundaries (Douglas & Wildavsky, 1982; see also Hannigan, 2006; Lupton, 1999); also, Beck’s “risk society” thesis, which holds that risk is a product of modern institutions (Beck, 1992; see also Lupton, 1999). While Beck’s thesis has been instrumental in highlighting societal influences in the manufacture of risks, it nevertheless reinforces the separation between nature and society that underpins both technoscientific and psychometric accounts of risk (Healy, 2004; Williams, 2008). Beck takes an entirely anthropocentric approach, focusing on the institutions of high modernity and placing humans as agents of their own demise. Thus, nature is rendered passive, and relegated to the background. Williams (2008) argues that a “post-social understanding” should be applied to the risk society thesis, in which we recognise the role of more-than-human actors. Furthermore, he recommends a detailed examination of how these actors relate to one another in order to gain a deeper understanding of what risks and hazards are, rather than taking an instrumental approach that focuses on solutions at the outset. Healy (2004) also emphasises the need to focus on relations between humans and non-humans, arguing that risk is an outcome of these relations rather than a foundational state that exists “out there”. Both Healy and Williams emphasise the need to consider risk at the ontological level, steering away from epistemological analyses of the discursive construction of risk.

These observations are particularly relevant to the study of the risks of GMO research in New Zealand. There is an existing body of literature in this area, but these studies focus on the discursive construction of risk rather than the material relations that enact it. Some have focused on the regulatory functions of ERMA, questioning the narrow technical framing of risk that it employs and discussing the marginalisation of other world views that necessarily result (Nahkies et al., 2003; Scott & Tipene-Matua, 2004). Others have taken a broader approach; they focus not on the regulatory system but on the general debate over GMO (and other biotechnology) research in New Zealand, asking how diverse knowledge frames can be incorporated into risk assessment processes (see e.g. Shamy, 2006; Goven et al., 2008). Furthermore, the New Zealand government has demonstrated its interest in working with stakeholders outside “formal” risk
assessments by investigating ways of promoting dialogue between various stakeholder groups in order to inform the early stages of biotechnology development (Cronin & Jackson, 2004). All of these studies have made important contributions in reformulating what counts as knowledge in debates over the risks of GMO research. But these are epistemological concerns, and, as I have explained, there is a need for research that studies risk at the ontological level.

An ANT approach to the study of risk provides the opportunity to move research in this direction. A number of researchers have used ANT in their own studies of risk: to develop a method of mapping risk controversies (Beck & Kropp, 2011); to analyse methods of public participation in stormwater management (Healy, 2003); and to develop risk assessment tools (Lockie, 2007). Of particular relevance to this study is Hilgartner’s (1992) description of “risk objects” in network terms. When it was first published, this paper provided the first ANT-informed approach to the study of risk, and offered a significant departure from both techno-scientific and socio-cultural interpretations of risk. However, given that over 20 years have passed since its publication, there is a need to reconsider Hilgartner’s proposals, particularly with regards to the reconceptualisation of objects and spaces that has been developed in more recent ANT literature (as discussed in section 3.2.4 above). In the following section I will therefore outline Hilgartner’s network approach to risk; I will then discuss more recent examples and insights from the ANT literature to develop the approach I have taken to the study of risk in this thesis.

3.3.1 Networks of risk
Hilgartner identifies two discrete stages in his analysis of risk networks: first, to describe the construction of a risk object; and second, the creation of a link between a risk object and putative harm (1992, p. 42). The first of these stages is essentially the opening of a black boxed network to reveal the heterogeneous elements that have been packaged together to form something tangible that is defined as “a risk”. Motor vehicle accidents, for example, could be the result of any number of different factors, but were once attributed simply to human error; “the driver” was thus defined as the risk object to be controlled through road safety policy (p. 46). According to Hilgartner, this changed in the mid 1960s, when Ralph Nader’s (1965) Unsafe at any speed explored the tendency of a car built by General Motors (the Corvair) to lose control: Nader exposed how marketing techniques, bureaucracy, cost-cutting measures, and lack of federal regulation all combined to produce a car that was not designed with sound engineering principles at heart. Thus, a heterogeneous network was revealed that was ever-more complex than the category of “the driver”, and this in turn led to a complete overhaul of road safety policy.
If risk is conceptualised in network terms it is necessary to enquire how that network is held stable. This requires a close study of the processes of heterogeneous engineering that serve to forge and maintain network relations. Snow, for example, poses a significant risk to the stability of motor transportation networks; it is controlled via a complex array of elements including snow ploughs, grit, anti-lock brakes, and driver education (Hilgartner, 1992, p. 48). These controls are essentially risk management practices: they serve to stabilise network relations when a new actor (in this case, snow) enters into the network. Recent years have seen an “explosion” in risk management: instead of constituting a peripheral aspect of institutional practice it has become central to organisational function (Power, 2004). This is arguably an inherent feature of Beck’s “reflexive modernity”: as networks extend to encompass ever-increasing complexity and heterogeneity, one small change can reverberate throughout to cause widespread and exponential damage that cannot be predicted (see Latour, 2003). An important consequence of this is that “damage” comes in many forms: it could be the physical effects of a car crash on a road that hasn’t been cleared of snow and ice, but it could also manifest as a civil suit filed against the local authorities by people injured in that accident. Power (2004) argues that risk management practices are becoming increasingly concerned with this latter type of damage.

The experts who are being made increasingly accountable for what they do are now becoming more preoccupied with managing their own risks. Specifically, secondary risks to their reputation are becoming as significant as the primary risks for which experts have knowledge and training. This trend is resulting in a dangerous flight from judgement and a culture of defensiveness that create their own risks for organisations in preparing for, and responding to, a future they cannot know. (pp. 14-15)

One of the advantages of a network approach to risk is that it can detect and incorporate secondary risks into analysis: pre-determined categories do not drive analysis and all possibilities are considered equally according to the principle of generalised symmetry (Callon, 1986a). But if secondary risks are revealed through network analysis, it is also important to assess their significance on equal terms with any primary risks associated with the hazard in question.

The construction and stabilisation of a network is only the first step in the construction of risk; the second is to create a link between that object and a putative harm. Hilgartner argues that this involves the two-way process of “emplacing” and “displacing” risk objects. According to his definition:
...to emplace a risk object means to turn it into something to be reckoned with, something that is capable of influencing the future of the network. To displace a risk object means precisely the reverse: to strip the object, and its risks, of their significance; to neutralize them; to remove their capacity to influence the evolution of the network. (1992, p. 49)

Hilgartner gives the example of competing networks to link these processes together: while one network is working to emplace a risk object, another network is acting in opposition to displace that same risk object. But there is another interpretation of the relationship between emplacement and displacement that focuses on their complementing one another. That is, by emplacing one object as a risk, another object is displaced and therefore defined as risk-free or “safe”. The shift in focus in this latter interpretation could move beyond network presence so that absence and Otherness are also included in analysis (Law, 2004; see section 3.2.4 above), because it causes us to consider elements that have essentially been pushed beyond the boundaries of that network. It also allows us to consider emplacement and displacement in situations where there is no obvious struggle or controversy; even the most well-established categories of risk and safety can be thrown open for inspection.

By examining the dual processes of risk emplacement and displacement, we can also uncover who (or what) is instrumental in these activities, and where their work is located. Hilgartner (1992) argues that risk construction is carried out by “specialized professionals, such as scientists, engineers, lawyers, medical doctors, government officials, corporate managers, political operatives” (p. 52). Not only is the general public not involved in these activities, they are usually completely unaware of the huge amount of work involved in emplacement and displacement such that “risk objects and the networks of control that are built around them get embedded in the social fabric with almost no one noticing” (p. 52). Thus, systems of risk classification and the distributions they create are not questioned in themselves, a point that is supported by the wider literature on the invisibility of systems of classification and standardisation (see e.g. Bowker & Star, 2000).

Risk networks feature prominently in the STS risk literature, although use of the network concept is arguably different to the ANT use of the term. Network approaches have been used to reveal the “things” that hold the fabric of modern society together, and explain the changes that occur during a disaster in terms of these things. A recent special issue of Social Studies of Science deals with this topic through a discussion Hurricane Katrina, with a particular focus on the infrastructures of risk. In his editorial opening, Sims (2007) draws a parallel with scientific controversies, arguing that disasters allow the otherwise hidden workings of everyday life to
suddenly become visible and open for examination. These infrastructures are examined in a number of studies concerning (amongst other topics) flood hazard mitigation plans (Wetmore, 2007) and the rebuilding of damaged environments (Henke, 2007). Similarly, the edited collection of papers in Graham’s (2010) book *Disrupted Cities* focuses on the invisible “material networks which continually work to produce urban life” (p. xi). These networks not only become visible in times of crisis, they can also change irrevocably, leading to the creation of new political and social arrangements in order to recreate a functioning city. Beck and Kropp (2011), who also approach risk infrastructures as invisible networks that structure modern life, propose the use of “risk cartography” to trace risk networks as an aid to risk governance.

While such studies have made important contributions to the study of risk, criticisms can nevertheless be levelled at their interpretation of the network approach. The above research focuses primarily on situations where there has been a massive system failure; but the study of risk should not focus solely on these “emergency responses” (Barker, 2008, p. 1600). As I have already discussed, risk management has become a part of everyday life, which means it is important to study the regular, “successful” workings and mundane practices of it. Furthermore, the focus on the material infrastructure of risk networks is subject to Law’s (2008c) critique of the general approach taken by some STS scholars who focus on the “construction” of scientific knowledge. Following Law’s argument, if we view networks as being “constructed” through the placement of material things, we are provided with an interpretation of reality that “tends to conjure up an image of something like a building site” (p. 12). In these terms, risk takes on a singular, fixed form, and no attention is paid to the continual processes involved in the doing, or enactment, of reality.

Nevertheless, while these criticisms may indicate that the network approach is limited, it does not mean that ANT cannot make important contributions to the study of risk. As discussed earlier (see section 3.2.4), the recent topological turn in ANT scholarship has led to explicit considerations of the objects and spaces of ANT research, and network analysis has been cast as one approach amongst many. In the following section I will consider how these emerging concepts are also evident in the study of risk.

### 3.3.2 The changing spaces of risk

Conventional interpretations of risk are predicated on a Euclidean understanding of space. Often there is an implied or assumed boundary between risky/safe or impure/pure spaces; something that sits just outside this boundary would be considered “at risk” whereas something far away would be considered relatively “safe”. Contrary to this position, Bickerstaff and Simmons (2009)
argue that proximity to a risk cannot be explained in terms of distance in Euclidean space; instead, they propose that proximity is the result of “spatialised risk subjectivities... which fold together different times and spaces to bring risk close or keep it distant” (Bickerstaff & Simmons, 2009, p. 866). This position is also evident in Hinchliffe et al.’s (2013) approach to the study of biosecurity, who explain that:

This is not a world of flat surfaces, with well-defined proximities to sources of infection marked accordingly, but rather a topological landscape of embeddings and disembeddings, where disease registers its presence through the density of its intra-actions. (p. 538)

Hinchliffe et al. (2013) argue that the risk of a disease manifesting itself is always present within the very space that is being “protected” from the spread of disease. Under certain conditions there is an intense “folding” of space such that there is an increase in the number and intensity of the connections within that space: this results in the registered presence of a disease. Spatial categories that relate to boundaries - such as “near” and “far”, or “inside” and “outside” - do not determine the spread of disease. Instead, Hinchliffe et al. use the concept of the “borderlands” of disease to articulate an alternative “topological landscape” that does not correspond to physical territory.

Elsewhere in the literature, research examines how spatial categories are themselves generated by risks. Valerie November has been involved in a number of studies on topics such as fire risks, floods, pandemics, and road safety (see November, 2008). She has used these case studies to develop a position on the dual relationship between space and risk: that is, “how risks transform spaces and how spaces subsequently lead to changes in the nature of risks themselves” (November, 2008, p.1523). This relationship is also explored in a number of studies by John Law on the UK foot and mouth epidemic in 2001 (Law, 2006; Law & Singleton, 2006; Law & Mol, 2008). Law and Mol (2008) examine the activities involved in controlling foot and mouth disease: specifically, the requirement to boil pigswill. This measure is ostensibly a risk management strategy used to control the spread of disease, but in practice it also performs a spatial segregation between rich and poor countries in the EU. The practices that enact disease status have a similar effect: a country must be not only disease free but also vaccination free if it is to be able to export animals and meat without restrictions, and only rich countries are able to implement the measures that are necessary to achieve this status (Law, 2006; Law & Singleton, 2006). Thus, the spatial flows of trade are transformed according to the risk posed by foot and mouth; the nature of this “risk” is similarly changed from a concern about the spread of disease to the maintenance of disease-free status.
The dual transformation of risks and spaces leads to new challenges in risk management. Law (2006) argues that the focus on maintaining British farms as a disease-free space has served to create an agricultural system that is so tightly coupled that it has lost all resilience. Thus, by striving to create a boundary between impure and pure spaces, new risks have been created, echoing Beck’s risk society thesis. Elsewhere, Law argues that we cannot create a completely risk-free environment because “there are always matters out of control. Diversity. Diverse and incomplete centres. Unstable relations. This is the chronic state of being: system space is never secure” (Law, 2000b, p. 10). Hinchliffe and Bingham (2008) echo these sentiments by referring to the practices of “biosecuring” rather than biosecurity because “it highlights the unfinished business of making safe” (p. 1542). This indicates that the goal of risk management practices should not be to remove all risks from a given system. This is not only impossible but also builds systems that are susceptible to “normal accidents that are waiting to happen” (Law, 2006, p. 238).

This emerging body of literature on the spatialities of risk indicates that there is a need for research that considers risks in more-than-Euclidean terms. We need to look beyond the movement and barriers we can “see” in the world around us to consider the “intra-actions” (Hinchliffe et al., 2013) that are present within “secure” spaces. The ANT literature can be used to inform such work, but to do so requires an approach that moves beyond Hilgartner’s (1992) networks of risk. More recent scholarship that provides alternative interpretations of object-space relations (as discussed in section 3.2.4 above) could be used to examine risk, because it asks us to attend to not only presences, but also absences and Otherness, and ask how all of these are involved in the enactment of risk.

### 3.4 The places of scientific research

In this thesis I will be studying the places of GMO research: the containment facilities in which GMOs are developed. It is therefore important to consider existing research that explores how such places are created, looking beyond their physical form to the practices that shape (and are in turn shaped by) them. Furthermore, given that GMO research can be conducted in either indoor or outdoor facilities, research that investigates the creation of, and relationship between, laboratories and fields is of particular relevance.

The idea that science is a search for universal truths has long been contested by philosophers, scientists, and philosophers of science. The term Science and Technology Studies (STS) is used to refer to the diverse field of academic scholarship that studies science as an activity. The roots of ANT can be traced back to detailed case studies and ethnographies of scientific work, and as such...
it can be described as one of many approaches that fall under the banner of STS. Every aspect of scientific activity, from the people who conduct it to the materials and methods of their experimentation, has become part of the STS research agenda that seeks to contextualise the “view from nowhere” (Shapin, 1998). Thus, science is studied “as if it was produced by people with bodies, situated in time, space, culture, and society, and struggling for credibility and authority” (Shapin, 2010). A crucial component of this programme is an examination of the location of scientific research, from the informal spaces provided by pubs and coffee houses, to the increasingly institutionalised and controlled spaces of laboratories. This “spatial turn” in the STS literature has been noted by a number of authors (Finnegan, 2008; see also Livingstone, 1995, 2011; Powell, 2007; Meusburger, 2008; Ophir & Shapin, 1991) and underscores the point that an understanding of science as a social activity cannot be understood simply by considering what scientists themselves actually do; it must be grounded in the material setting of the workplace. “Science is not randomly or evenly distributed all over the skin of the earth” (Henke and Gieryn, 2008 p. 355); it coalesces in “centres of calculation” (Latour, 1987, p. 215), nodes to and from which the flow of knowledge and knowledge-making activities is particularly concentrated.

### 3.4.1 Creating a place for science

In post-Industrial Western society at least, the laboratory has become synonymous with science. Over time, the association of the laboratory with a series of high profile scientific discoveries has meant that “…laboratories had been demarcated... as special places from which pure knowledge emanated... Knowledge from the lab was apolitically, asocially, transtemporally, translocally true.” (Doing, 2008, p. 279). Such is the power of the laboratory that it is seen as necessary to many aspects of modern life, even in the production of milk that is safe for human consumption (Atkins, 2007).

While the STS literature as a whole serves to overturn the placelessness of the laboratory by examining the contextual factors involved in knowledge production, it is also of interest to ask how the laboratory has come to be a place that is “demarcated” from other places. What makes the laboratory a specific place? This has been the focus of a relatively small branch of the STS literature that has investigated the processes and negotiations involved in the “becoming” of the laboratory, either as an individual unit of scientific activity or within a much larger array of interacting components.

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26 For an overview of literature that has dealt with different places in which science is and has been practised, see Livingstone (2011).
Laboratories as we know them now have developed in form and setting over a number of years, and Steven Shapin has documented this trajectory in a wealth of historical research conducted on this topic\(^\text{27}\). His accounts of the activities of scientists such as Robert Boyle and Robert Hooke are deeply rooted in both the physical and cultural context in which they worked. Shapin uses these accounts to argue that “the threshold of the experimental laboratory was constructed out of stone and social convention” (Shapin, 1988, p. 383). The “social convention” to which he refers is the gentlemanly code of conduct in 17th Century England, since it was in the private houses of gentlemen living at this time that the first laboratories were created. At times, public access to these private spaces was necessary; such was the case when witnesses were required in order to legitimate experimental findings. Experimental demonstrations also took place in the meeting rooms at the Royal Society, which was arguably still a private space due to the rules of membership. Parallels with the laboratories found in residential settings are further apparent in Shapin’s observation that the code of conduct at the Society was closest “to that which operated within the public rooms of a gentleman’s private house.” (Shapin, 1988, p. 393)

The “public” who were allowed to enter these places did not include any member of society. Laboratories could only be entered freely by people of certain social standing or connection; a person’s scientific knowledge had little bearing on the rules of membership. In the case of Robert Boyle, an intensely private man, such conventions afforded him a socially acceptable space in which to work by being at once secluded from and open to a public with whom he was expected to interact. Nevertheless, in later years Boyle found his obligations to be a strain and therefore took measures to withdraw even further from society; this time he appealed to a different moral code:

When ...Boyle wished to shut his door to ...distractions, he was able to draw upon widely understood moral patterns that enabled others to recognize what he was doing and why it might be legitimate. The occasional privacy of laboratory work could be assimilated to the morally warrantable solitude characteristic of the religious isolate. (Shapin, 1988, pp. 387-388)

Thus the boundaries to the laboratory were in a constant state of flux, a situation that has carried on to the present day. Shapin makes this point by observing the stark contrast between the past and present practice of laboratory work: science has made a complete transition from the residential to the institutional setting, and what was once a private pursuit is now considered to

\(^{27}\) For a compilation of a number of his main publications see Shapin (2010).
be in the public domain. This, in turn, has led to the redrawing of boundaries, with the conventions of “a new privacy” (1988, p. 404) serving to keep aspects of science hidden from public view.

The boundary between public and private laboratory work is explored in more detail by Thomas Gieryn (1998) in an analysis of the design of a modern-day scientific research institution, the Cornell University Biotechnology Building. Gieryn treats the labels “public” and “private” as performative: they do not carry intrinsic, stable meanings upon which order can be built, but are instead simply referents used with varying meaning in order to achieve specific future outcomes in the final design and build of the facility. “Publics’ and ‘privates’ are made up by designers to enrol possibly recalcitrant but needed allies” (p. 223). Thus, for example, the lobby of the building is designed as a large space into which members of the public can be accommodated; importantly, the incorporation of this space in the building design helps to secure funding for a significant portion of the entire facility. Yet this area is carefully cordoned off from the rest of the facility to ensure that the public cannot access the private spaces deeper inside the building. Gieryn describes the lobby as a “beachhead” since it “allow[s] the public a toehold on the coastline, but not a step further into the interior” (p. 228); interestingly, however, the boundary to this beachhead is at times unclear and subject to change:

Because of the promiscuous mix that makes up “the public”, the beachhead turns out to be built on shifting sands; that is, the location of the bar between public and private spaces moves around depending on which public seeks access. Layers of accessibility are created, showing where some publics are allowed but other publics are not. (p. 229)

Rather than looking for a stable and predetermined order, a better strategy in any investigation of how categories are made and stabilised may be to attend to ordering: practices that create order in the process of being “done”. John Law uses this approach in his laboratory ethnography Organizing Modernity (1994). Although primarily a study of the management of a large scientific laboratory, this text has had far reaching influence across a range of fields, and is applicable to any consideration of material and social organisation. As in Gieryn’s study, Law’s research is predicated on the notion that there is no such thing as “pure order” (p. 39) that exists as a precursor to and structure for activity:

I want to avoid the reductionism of saying that modes of ordering stand outside their performances... they are patterns or regularities that may be imputed to the particulars that make up the recursive and generative networks of the social. They are nowhere else. They do
not *drive* these networks. They aren’t outside them. Rather, they are a way of talking of the patterns into which the latter shape themselves. (p. 83, emphasis in original)

Law identifies four main “modes of ordering” (p. 75) that are employed by scientists and their managers in the conduct of laboratory life, giving the appearance of an underlying structure that directs their activities. “Enterprise” focuses on the seizing of opportunities and the furthering of self interests. “Administration” speaks of the regulations and rules that must be followed, sometimes at the expense of enterprise. “Vision” is associated with genius and charisma, while “vocation” casts science as a set of embodied skills. Law describes these modes of ordering as “recurring patterns” that emerge from the conduct of scientific work: “[t]hey do not *drive* those networks. They aren’t outside them” (p. 83). This resonates with Gieryn’s argument that “public” and “private” areas for science are emergent categories, and suggests that it is the appearance of a pure and fixed order that can often point towards a beginning for research.

Each of the studies discussed above carry the message that places of scientific research are not simply bricks and mortar, nor are they fixed in form or static backdrops to activity. To understand the places in which science is conducted we must attend carefully to the practices, processes, and “orderings” that are all too easy to dismiss as separate contextual information. This philosophy has been applied in a number of studies that have investigated specific places of scientific research, and I will now consider two such places of relevance to this study: first, the “inside” space provided by the laboratory; and second, the “outside” space of the field.

### 3.4.2 Laboratory work

As mentioned earlier, although the subject of place features prominently in the STS literature, it is usually in a different context to the studies discussed so far. Instead of looking at how place itself is constructed, many researchers have instead chosen to investigate the role of place in the construction of knowledge. Prominent in this area are the laboratory studies that emerged in the 1970s and 1980s, in which STS scholars entered the workplaces of scientists to document what the latter actually did in the course of their day-to-day activities.\(^{28}\) One of the first of these laboratory studies was Latour and Woolgar’s (1986 [1979]) ethnographic account of the activities of scientists working at the Salk Institute in *Laboratory Life*. The basis for this study was the idea that science does not involve the *discovery* of facts that exist in a nature “out there”; instead, the vast array of activities that constitute laboratory work serve to *construct* scientific knowledge:

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\(^{28}\) For an overview of the large number of studies in this area see for example Sismondo (2004) and Hess (1997).
The problem for participants [laboratory scientists] was to persuade readers of papers (and constituent diagrams and figures) that its statements should be accepted as fact. To this end rats had been bled and beheaded, frogs had been flayed, chemicals consumed, time spent, careers had been made or broken, and inscription devices had been manufactured and accumulated within the laboratory. This, indeed, was the very raison d’être of the laboratory. By remaining steadfastly obstinate, our anthropological observer [Latour] resisted the temptation to be convinced by the facts. Instead, he was able to portray laboratory activity as the organisation of persuasion through literary inscription. (pp. 87-88)

Thus, laboratory work is “packaged” up as texts, which predominantly take the form of scientific journal articles. The production of literature is also discussed in Science in Action (Latour, 1987), where Latour stresses that “the laboratory [is] present in the texts” (p.64) that circulate scientific knowledge. A key question is how the material complexity of the laboratory can be expressed on the pages of a journal so as to convey the discovery of relatively simple facts. To this end, Latour draws attention to the use of inscriptions: graphic elements such as graphs, photographs, or diagrams. These are the direct product of “inscription devices”, defined by Latour as: “any set-up, no matter what its size, nature and cost, that provides a visual display of any sort in a scientific text” (p. 68). Inscriptions and the devices that create them are of central importance to the construction of facts, as the former appear to be a simple reflection of reality, as if the phenomenon in question is speaking for itself. Yet, as Latour is careful to point out, inscriptions are effectively silent, and it is only in combination with the commentary provided by a “spokesperson” (p. 71), in this case scientists, that their meaning takes shape.

Karin Knorr-Cetina (1999) also considers the role of inscriptions in the laboratory, explaining that they offer scientists a “purified” (p. 27) form of an object, stripped of the messiness and complexity that accompanies it in the outside world. While the aim of her laboratory ethnography is to explore the products of laboratory work, Knorr-Cetina differs from Latour in that she does not restrict herself to the material products of a laboratory; her focus is somewhat wider in scope. She observes that, whereas laboratory studies tend to treat social context as a backdrop to scientific activity, her approach combines these factors.

Just as objects are transformed into images, extractions, and a multitude of other things in laboratories, so are scientists reconfigured to become specific epistemic subjects (p. 32).

Knorr-Cetina (1999) stresses that both natural and social orders are created in the laboratory. The example she uses to illustrate her point is based on the transition of the medical profession from
the bedside to clinical setting: this resulted in massive changes not only to the locations and equipment used in medical practice, but also to the activities of and interactions between doctors and patients in the diagnosis and treatment of disease.

An emphasis on the social order produced by laboratories is also a dominant theme in Hunt’s (2003) ethnographic study of a New Zealand Crown Research Institute (CRI). Hunt’s case study is primarily concerned with the loss of individuality in the face of corporate science, and the strategies employed by individuals in order to counter such changes. In the course of her research, Hunt conducted detailed investigations of the activities of different research teams at the CRI; thus, of particular interest to this discussion are her observations of the division of labour within laboratories:

Scientists were separated from the technical workers who usually had offices within their labs. The male manager scientists were discouraged from working in the labs by the technical workers and were seen to be an almost different species. (p. 71)

The participants in Hunt’s study were somewhat territorial in their work habits, be it in relation to the particular type of research they engaged in, or where they sat in the tea room during breaks. This territoriality was not simply confined to being a “social phenomenon”, separate from the work of the laboratory; as the above quotation indicates, it had an observable effect on how work was conducted in the laboratory, and was therefore linked to the knowledge produced by that place. It should be stressed, however, that the different roles within a team of researchers also served to define it as a “Group” separate from others working at the CRI, with its own research strengths and capabilities.

As workers in the Group come from many disciplinary backgrounds and chose to come together through an interest in the same subject, they had developed a strong sense of team. They were respectful of each other’s talents and abilities and enjoyed this interaction and the contribution of their different disciplines. (p. 67)

The division of labour therefore has complex effects and draws multiple boundaries both within and between groups of people. This can be instrumental in creating and maintaining another important separation: that between “inside” and “outside” the laboratory. Various roles within the sciences are commonly associated with work conducted either within a laboratory or elsewhere. Even if they are linked by a common discipline, researchers who work in different places often form distinct epistemic cultures, and movement between these cultures is neither easy nor encouraged. Kohler (2002) emphasises this point in his historical account of the changing
places of research in the biological sciences. He charts the establishment of biological science as an indoor pursuit after its origins in the observational fieldwork carried out by natural historians. During the time of transition from field to laboratory, a “border zone of mixed practices” (p. 41) emerged in which elements of both field and laboratory science were present. Interestingly, however, this did not result in any meaningful connection between such practices. Taking the marine station as an example, although considered to be a site of field science, it had “elaborate customs for keeping laboratory and fieldwork separate, and the more prestigious the lab the more fieldwork was subtly discouraged” (p. 43). For example, specimens were collected by local fishermen “who knew where to find things”, while scientists did “real work at their microscopes” (p. 43). Thus, the clear division in labour reinforced the very separation between laboratory and field that marine stations had been set up to remove.

3.4.3 Field work
Kohler’s study leads to another place in which scientific research is often conducted: the field. It would seem plausible to assume that there is a very real and clear separation between the laboratory and the field; physically, at least, they occupy different spaces, and they usually have a very different appearance. Indeed, Richards (2011) suggests that the two places are ontologically distinct. The reason for this is due to the enclosure afforded by the laboratory that is absent from the field:

The laboratory and its apparatus narrow the field of view, and allow deliberate exercise of control to facilitate prediction and explanation. (p. 53)

Arguably, such a description of the laboratory would be applauded by scientists, given that the control of variables is a necessary aspect of a valid experiment. Georges Cuvier had a similar opinion, suggesting that it was only in a laboratory that a researcher could take the time to examine the many complex facets of nature; outside, observations were likely to be incomplete, such that reliable interpretations of natural phenomena could not be made (see Livingstone, 2003).

One problem with automatically accepting the existence of a clear boundary between laboratory and field is that fields are used by scientific researchers in a number of different ways. A cursory glance at the literature on the field as a place for scientific research reveals that such studies are often undertaken within the context of field trips, where the field is a place for the observation and collection of samples from the “real world”. This framing of the field has been studied in

29 The Frenchman Georges Cuvier was a prominent natural scientist in the early 19th Century.
relation to a number of disciplines, including geography (Driver, 2000; Powell, 2002), natural history (Kohler, 2002; Naylor, 2002; Withers & Finnegan, 2003), ecology (Cameron & Matless, 2003), evolutionary genetics (Kohler, 1994), and soil science (Latour, 1999a). What all these studies have in common is that the field in question has been chosen as a place of research by virtue of its difference to the laboratory; hardly a surprise, then, that the two places are described as “ontologically distinct”.

But even in instances where the field is chosen as a place for research because of its differences in relation to the laboratory, connections are still evident that suggest the distinction between the two places is anything but clear. Latour’s (1999a) ethnographic study of a soil science field trip serves as an example of this intertwining of laboratories and fields. In his account, he tells of the travels of a multi-disciplinary team of scientists (of which he is one) who travel to the Amazon for the purpose of studying the savannah/forest border. A botanist studies the plants; pedologists sample the soil; a geomorphologist observes land formations; and Latour, an anthropologist, observes the scientists at work in their natural habitat. Or rather, he watches them transform the field site into something that resembles their natural habitat more closely:

After a few days’ work the field site is littered with threads that entangle our feet... the land has become a proto-laboratory – a Euclidean world where all phenomena can be registered by a collection of coordinates... For the world to become knowable, it must become a laboratory. (p. 43)

The transformation of the field site does not simply involve activity in situ; it is important for the field to be transported back to the laboratory, to be studied later and in more meticulous detail in vitro. Samples of the many plant species are collected, after which they are classified and organised into a cabinet in a room many miles away. Once here, the researcher can re-arrange, re-classify, and re-order without the background noise produced in the field itself; she has only to concentrate on the samples that have been preserved. But even in the face of these manipulations, the field is nevertheless present in the laboratory; it has to be there in order for the work to continue coherently. Thus, in Latour’s analysis of a field trip, there is a continuous shuttling back and forth between laboratory and field, and traces of each place are co-present at all times.

The connection between laboratories and fields is central to Latour’s (1983) analysis of Pasteur’s development of the anthrax vaccine in 19th Century France. In this paper, Latour argues that it was because of Pasteur’s ability to create a connection between “a lab in Paris and a farm in
Beauce” (p. 145) that his work was successful. This he achieved through a series of movements: first, from the laboratory to the farm, where field observations were translated into laboratory language; and second, from the farm back to the laboratory, where he succeeded in “training microbes and domesticating them” (p. 148). Finally, he extended the laboratory back out into the field, this time to test the vaccine he had developed; as with his prior moves, however, this one also had to be carefully orchestrated:

Pasteur cannot just hand out a few flasks of vaccine to farmers and say: “OK, it works in my lab, get by with that.” If he were to do that, it would not work. (p. 151, emphasis in original)

Latour argues that the trial of Pasteur’s vaccine was successful because the field site in which it was tested was transformed into a laboratory. This again raises the theme of co-presence: in particular, for a field to be considered a suitable place for research, key elements of laboratory practice must be taken there.

It could be possible to go a step further from this conclusion and state that fields must be transformed into laboratories in order to be places in which scientific knowledge is created. However, this assertion would not be supported by Henke’s (2000) study of field trials used in agricultural research. He observes that, whereas the use of such trials “blurs the line between lab and field” (p. 484), it is not simply the case that field work is effectively outdoor laboratory work.

[F]ield trials show how places are more than just a collection of soil, climate, bugs and other local conditions; places are partly constituted by the practices that happen there, especially in agriculture. Thus, “making a place for science” means more than simply turning it into a laboratory. (p. 485)

Henke’s mention of “practices” refers to his observation of the role played by farmers in the conduct of agricultural field trials, and this leads to one main point of difference between Henke’s study and that of other researchers. The field trials observed by Henke are not simply experiments that have been trialled in a laboratory before being taken outside to test under “natural” conditions. They involve a crop that is grown on a farm under a particular set of test conditions; and, although the trial is set-up and overseen by farm advisors from a research institution, these conditions are ultimately under the day-to-day control of the grower. It is the difference between advisor and grower that can lead to problems:

The advisors typically control variables in their experiment; the growers and advisors want to control for pests of their crops. The difficulty of maintaining a field trial on a grower’s land lies in a potential conflict between these two kinds of control... if the alternative
treatment appears not to be effective in the middle of the trial, then the grower may be tempted to spray a more conventional treatment on the experimental area of the field. In this event, the grower would be “controlling” for pests, but the advisor’s distinction between “experiment” and “control” would be ruined. (p. 496, emphasis in original)

One way of interpreting Henke’s observations is that the reason why problems arise in the field trials is because the laboratory and the field become disconnected. The above quotation indicates that a connection between the two places cannot be created and maintained simply by transporting materials and practices from the laboratory and installing them in a field; the field is already a place constituted by its own materials and practices, and these are not simply waiting to be “replaced” by the more dominant form of the laboratory. Instead, Henke’s findings suggest that a field trial must blend elements of both the laboratory and the field if it is to be successful, so that both places are equally present in the research.

It therefore appears that, just as the creation of place is a result of ordering processes, so too is the separation of one place from another. The studies reviewed above suggest that in instances where laboratories and fields are both used in a programme of scientific research, they are not, by definition, separate or “ontologically distinct”. Prior studies suggest that the degree of connectedness between a field and a laboratory is the result of practices occurring within and between them, and varies greatly depending on the particular situation. By attending to these practices it should therefore by possible to ascertain not only how the order of each place is created and maintained, but also the degree of connection between the two.

These findings are of particular relevance to my exploration of how the places of GMO research are enacted. The boundaries of these “containment facilities” are created not only via physical structures, but also by a variety of practices that serve to enact order. One of these is the separation between “inside” and “outside”, but other modes of ordering are likely to be involved in the enactment of the containment facility as a stable “place” for GMO research. Furthermore, given that containment facilities fall into the two broad categories of “laboratory” and “field”, it is important to ask how these categories are enacted and what this tells us about the relationship between them. Whether they are “ontologically distinct” or somehow connected could have implications for our understanding of the practices that take place “within” these places, and this in turn could have implications for our understanding of the risks involved in GMO research.
3.5 Summary

ANT provides a diverse set of theoretical and methodological tools that can be used in social science research. It is traditionally associated with descriptions of the “social” world in terms of heterogeneous networks traced via network analysis. More recent developments in the “post-“ or “after” ANT literature have focused on developing more esoteric forms of analysis, such as the concepts of enactment and multiplicity, and the re-imagining of object-space relations.

In this thesis I will apply a variety of concepts that have been developed in ANT scholarship. Network analysis is central to the analysis of tearless onions given in Chapters 5 and 6, and I will elaborate on my use of this tool in Chapter 4. Rather than focus on the “construction” of the tearless onion network, however, I will describe how it is “enacted”, using this to explore the “multiplicity” of the onion. Furthermore, I will make use of a number of other concepts throughout this thesis that are particularly associated with network analysis, particularly the concepts of black boxing and circulating reference.

Recent conceptualisations of “the object” of ANT study move beyond network analysis to consider alternative object representations. The definition of “heterogeneity” has been widened to incorporate not only network presences, but also the absences and Otherness that lie outside network representations. This in turn has led to object representations that move beyond the networks of early ANT study. These concepts have recently been applied in literature that explores the spatialities of risk, and is therefore of particular relevance to my analysis of containment facilities in Chapter 7. This analysis also draws on the wider STS literature that examines how the “places” of scientific research are created. Of particular relevance is research that explores how the boundaries of research facilities are formed via more-than-physical means; also, those studies that question whether laboratories and fields are “ontologically distinct” or somehow connected.

By incorporating this diverse array of tools into one study my overall goal is to explore the “theoretical multiplicity” of ANT. Rather than cast it as either a pragmatic tool or an empirical philosophy, my aim is to “do” ANT as both of these. I will consider this goal further in Chapter 4, in which I will discuss the methodological approach taken in this thesis.
Chapter 4

Methodology

4.1 Introduction
As discussed in Chapter 3, ANT is based on a relational ontology, which can be used to describe reality as the outcome of a heterogeneous network of relations. But the network metaphor does not only apply to the object of study; it is also descriptive of the processes undertaken by the researcher:

a network, to prevent any objection from people not familiar with our use of the word, being not a thing in the world but the path traced by the researcher equipped with an ANT methodology during his explorations. (Latour, 2003, p. 36)

Pictured thus, ANT can be described as a toolkit for study (Law, 2008a) as opposed to a set of instructions that can be followed prescriptively in order to make sense of the world. On the contrary, “reading ANT texts for their methodology is often quite disappointing. Most texts by Mol and Strathern, Law and Latour do not say much about how to go about doing ANT, practically speaking” (Gad & Jensen, 2010, p. 73). The main directive offered by ANT is that we should “follow an actor through his construction-deconstruction of Nature and Society.” (Callon, 1986a; p.203); similarly, Latour tells us to “stick to the actors” (1996a, p. 94). But the simplicity of this instruction belies the enormous complexity involved in its execution (Davies, 1998); it gives us no indication of how to collect or analyse our data, or of how to negotiate the many twists and turns we are likely to encounter. To some ANT scholars, this is exactly the point of what it means to “do” ANT:

ANT theory isn’t reified, separate or abstract. It doesn’t pre-exist, waiting to be applied. Instead it is created, recreated, explored and tinkered with in particular research practices. Perhaps ANT is best understood as a sensibility, a set of empirical interferences in the world, a worldly practice or a craft. (Law & Singleton, 2012, p. 2, emphasis in original)

According to Law and Singleton’s argument, ANT does not exist outside of research practices; it is done through them. Any discussion of what ANT “is” should therefore be done in the specific context of a particular research project, meaning that the methodological details of the study, and how these come to demonstrate an ANT “sensibility”, should be given special consideration.
Nevertheless, commonalities are evident in the various presentations of ANT research, and these can be traced back to certain methodological roots. In this chapter I will first discuss two methodologies (and their associated methods) most commonly associated with ANT: ethnography and case study. These two methodologies overlap substantially, and elements of both are present in a number of ANT studies. Furthermore, although ANT is most commonly associated with the case study approach, there is no single format that characterises it. This leads me to define the exact methods of data collection used in this study; in doing so I will also consider the various issues I encountered whilst trying to “follow the actors” and the implications this has had for my study as a whole.

Following this consideration of data collection methods I will turn my attention to methods of representation. Scholarly research is usually presented in a written format, but this does not mean that there is a single approach to the production or presentation of a text. ANT researchers have experimented with different methods of written representation; they have also made varying use of visual representation, particularly in relation to the “network” that is the focus of a particular study. I will discuss these different approaches to the representation of research findings by drawing on examples taken from the ANT and wider STS literature. I will also outline the particular use of both diagrammatic and written representation in this thesis.

This methodological chapter has been written with a degree of a reflexivity that is characteristic of recent ANT texts (see Gad & Jensen, 2010). In particular, my aim is to put into practice recent arguments surrounding the performativity of method (Law, 2004, 2009b; 2010; Law & Urry, 2004). This approach holds that “[research methods] have effects; they make differences; they enact realities; and they can help to bring into being what they also discover” (Law & Urry, 2004, pp. 392-393). These comments apply not only to the object of study, but also the methods we use to study it. Thus, by applying, exploring, and critiquing ANT we are not simply manipulating something that exists outside of our research; we are performing ANT in a specific format, and this in turn has implications for future research (Gad & Jensen, 2010). As researchers, it is important that we not only acknowledge this, but also take an active part in this performance. As stated in the objectives of this thesis (see Chapter 1), one of my aims is to examine how ANT can be “done” as a “theoretically multiple” tool for analysis. In this chapter I will therefore detail a range of different methods available to ANT researchers, exploring the relative merits of each of them, and considering how they can be combined in a single study.
4.2 Ethnography

“Ethnography” literally means “writing culture” (Mitchell, 2007; Clifford & Marcus, 1986). Its roots can be traced back to the field of anthropology, where it was used to observe and record the activities of “other” cultures, particularly those found in so-called “primitive” societies (Mitchell, 2007). Since its development as a distinct methodology in the early 20th Century, it has undergone significant change, not least as a result of postmodernist critiques of the separation between “observer” and “observed” (Atkinson & Hammersley, 1994); the “authority” of the ethnographer in relation to an abstracted, ahistorical “other” (Clifford, 1983); and the concept of “the field” of observation as a clearly bounded physical location (Mitchell, 2007; Marcus, 1995). “Writing” has thus been exposed as an act that produces partial accounts of the “culture” that has been chosen for study, and ethnographers now deal reflexively with this “crisis of representation” (see Crang (2005) for discussion).

Researchers in the field of STS have been instrumental in the use and development of ethnographic methodology. After studying philosophy, Bruno Latour carried out anthropological fieldwork on the Ivory Coast (Dosse, 1999); this was followed by a two year residency at the Salk Institute in California, and ultimately the first laboratory ethnography, Laboratory life, co-written with Steve Woolgar (1986 [1979]). Latour’s studies of the “culture” of science, both at the Salk Institute and elsewhere in the historical analysis of the work of Louis Pasteur (1983, 1988), are illustrative of a key feature of ethnography as it is practised today. Rather than being limited to a single physical and temporal location, Latour follows trails of association, such as those that link Pasteur to microbes, hygienists, and farm animals. Thus he is taken from the laboratory, out to the field, back to the laboratory, and again out to the field in the course of a single ethnography (see Latour, 1983). According to Marcus’ (1995) definition, this makes it a “multi-sited” ethnography:

> Multi-sited research is designed around chains, paths, threads, conjunctions, or juxtapositions of locations in which the ethnographer establishes some form of literal, physical presence, with an explicit, posited logic of association or connection among sites that in fact defines the argument of the ethnography. (Marcus, 1995, p. 105)

Here, Marcus argues that the “site” of ethnographic study is constructed by the researcher as he/she traces connections. The process of construction is reliant on a starting point or guide to the researcher which must then be “followed”: this can be a person, thing, metaphor, story, life, or conflict. Marcus lists Latour’s (1987, 1988) studies as exemplary of the move to “follow the thing”, a technique that “involves tracing the circulation through different contexts of a
manifestly material object of study (at least as initially conceived), such as commodities, gifts, money, works of art, and intellectual property” (Marcus, 1995, pp. 106-107). This definition has distinct parallels with ANT’s charge to “follow the actor”, given the post-human interpretation of what an actor (or actant) can be (see Chapter 3). There is therefore an alignment between the methods used in a number of ANT studies and this ethnographic technique, for example: Latour’s studies of a French public transportation system (1996a) and the soil of the Amazon rainforest (1999a); Gorur’s (2011) investigation of European educational assessment tools; and Hindmarsh and Heath’s (2000) ethnography of workplace objects.

While ANT has been used to construct multiple sites of research, it has also revealed that the “thing” or “actor” being followed is itself multiple. This latter form of multiplicity is a more significant feature of recent ANT thinking than any related to the physical location of the research. Mol’s (2002) study of the multiplicity of atherosclerosis is confined to a single Dutch hospital, although she does move between different locations within that site. More importantly, she studies how disease is enacted differently in each of these locations. Law and Lien’s (2013) study of the multiplicity of salmon is similarly confined to a single fishing farm. Like Mol, they reveal that different fish are enacted by different practices; however, these practices are not tethered to entirely separate physical sites, and the construction of a “multi-sited” space for ethnography is less apparent. This is also the case in Law’s (1994) ethnography of a scientific research laboratory, where physical divisions within the fieldwork site are not used as the basis for analysis. Instead, Law makes recourse to the network metaphor to define the multiple locations within his research site:

There are endless different locations in the laboratory. And endless different modes of organizing. And this is why managerial definitions of what the organization “really” is do not help. For it is, amongst other things, a network of different worlds. (Law, 1994, p. 43)

Here, Law is making a general reference to multiplicity: the laboratory he studied was not a single place, but in fact a number of “different worlds” that, though connected, were essentially “doing” the research laboratory in different practices. Thus we can conclude that the use of a multi-sited ethnographic approach within the ANT literature is really just a sub-set of the overall sensibility to multiplicity that has entered into ANT thinking. This argument also resonates with Hine’s (2007) observation that “the laboratory” should not be treated as a distinct “site” for ethnographic research, as this only serves to reify what are culturally determined boundaries. Instead, she follows Law and Mol (2001) in proposing that the boundaries to such sites and the spatial
categories they create should themselves be the subject of study, an approach that stands in direct contrast to that of laboratory ethnographies:

Whilst it was once of a vital strategic importance to “go inside the laboratory”, it is now often more timely for STS to pursue the ways in which science is practiced across sites and the ways in which it practices sites. (Hine, 2007, p. 669)

Debate over just what constitutes a “site” of research is apparent in the wider ethnographic literature. Lee and Roth (2001) have described human communities as “a patchwork of partially connected places” (p. 322) that are not rooted in a single physical location. These observations are particularly relevant in studies of the internet: the concept of multi-sited research has limited use in these “hybrid” ethnographies, which explore both physical and virtual worlds, as well as the digital interfaces between them (Jordan, 2009). By studying more than human worlds, “multi-species” ethnographies (Kirksey & Helmreich, 2010) similarly reconceptualise research space, which in turn provides an alternative topology for considering human knowledge practices (Hinchliffe et al., 2013). Whether these changes in the sites of ethnographic practice signify a fundamental shift in this methodological approach is a matter of debate (Hine, 2007). Nevertheless, ethnography as it is practised today is accepting of a much more diverse methodological toolkit than it was a hundred years ago.

4.2.1 Ethnographic methods

Ethnography is typically associated with long periods of participant observation during which time extensive field notes are made for later analysis. In early anthropological studies fieldwork involved a prolonged stay in a foreign society, the researcher needing sufficient knowledge of the local language and customs in order to achieve cultural immersion (Armstrong, 2008). STS and ANT studies, though not usually involving fieldwork in such extreme geographical locations, have nevertheless required admission to a “foreign tribe” and the learning of a new “language” (see especially Latour and Woolgar, 1986 [1979]). They have also involved extended periods of fieldwork, during which time the researcher has essentially become part of that community. For example, Latour is listed as a co-author on the paper written after his ethnography of a fieldwork expedition to the Amazon (Latour, 1999a); furthermore, during her medical ethnography, Mol (2002) not only co-authored an article, but also supervised a student and was assigned a research assistant. Ethnographers straddle the divide between “insider” and “outsider”, such that they can appear to be fully integrated into the sociotechnical networks under study; Mol makes this point clear when she describes the time she spent studying atherosclerosis at a hospital in the Netherlands:
For four years I went there once or twice weekly. I had an identity card that allowed me to leave my bicycle behind a fence and drink free coffee from the omnipresent vending machines. I had a library card and the use of a desk in a succession of crowded rooms. I had a white coat. And I observed. (Mol, 2002, p. 1)

Despite Mol’s white coat and identity card, she was nevertheless not quite an “insider”, and was treated with some scepticism and unease by those she observed. This means that her study was not the result of pure observation; it arose from her interaction with the people she encountered in the field. Law (1994) raises this issue when he speaks of his horror at being asked whether or not the research facility in his study should be closed:

In the end I found myself saying “Would you close your tribe?” And this is, indeed, how I felt... You could argue – as perhaps the man who posed the question about closing the Laboratory – that I had gone native. And I would respond: we all go native; we all interact with what we study. The question is: which tribe or tribes do we choose to join? (pp. 38-39, emphasis in original)

Researchers are thus *part of* their data; but at the same time, this data is also *partial*. Just because it results from total immersion in the field, does not mean that the researcher is able to witness all relevant activities. Law observes that during his own fieldwork “I had a terrible anxiety about being in the right place at the right time. Wherever I happened to be, the action was not” (1994, p. 45). To a certain extent, this problem can never be solved, and ethnographers must deal with it reflexively instead, acknowledging that there will always be another story that remains untold.

In some cases, traditional methods have been adapted to suit the requirements of a particular study. Knorr-Cetina’s (1999) comparative ethnography of the cultures of High Energy Physics and molecular biology required such a wealth of data that it would have been impossible for one person to conduct the study alone; hence, three researchers were involved: a permanent observer placed at each field site as well as another responsible for performing the overall comparative analysis. Similarly, Hinchliffe et al.’s (2013) ethnography of biosecurity practices involved a team of researchers who visited a number of sites, including wildlife reserves, farms, and food processing plants. “Hybrid” sites present yet another challenge: because they exist in both physical and virtual domains, researchers must use mixed methods of data collection, combining online “virtual” participant observation with offline interviews (Jordan, 2009).
Even with these changes, the ethnographic method of participant observation can be impractical, meaning that it has been used in only a relatively small number of studies in the wider social science literature (Cloke et al., 2004). Of these, many have been conducted over a short time-frame (Thrift & Dewsbury, 2000). Within the field of STS, the paucity of traditional ethnographies is perhaps to be expected, given that many studies are of specific events or developments that have already occurred. In these cases, researchers rely heavily on document analysis, augmenting this with interviews with key informants if possible. Such is the approach of Enticott (2008), who uses ethnographic content analysis (following Altheide, 1987, 1996) to study controversy and debate over the control of bovine tuberculosis. His data comprises primarily of documents from a wide array of sources including parliamentary hearings, scientific papers, and agricultural media articles; this is triangulated with notes taken during six public meetings and key informant interviews. Altheide (1987) argues that these methods are comparable to the fieldwork component of a traditional ethnographic study, thereby substantially broadening the definition of this approach. Nevertheless, while these alternative approaches to research undoubtedly provide deep understandings of their subject matter, it is arguable as to whether or not we should label them as “ethnographies”, or if it is more appropriate to call them “case studies”. This latter approach has a much broader definition and is the methodology most commonly associated with ANT. Furthermore, although I have aimed to follow a number of the principles associated with ethnographic work, this thesis is a case study of GMO research in New Zealand, and as such it follows the approach detailed in the following section.

4.3 Case study

The case study is a commonly used qualitative approach in the social sciences. The nature of the “case” varies widely, and can range from an individual person through to a complex, multi-layered social system (Mabry, 2008). The methodology informing the methods of study is equally ill-defined; Hammersley and Gomm (2000) note that in some instances, “the meaning of the term [case study] has overlapped substantially with that of others – notably with ‘ethnography’, ‘participant observation’, ‘fieldwork’, ‘qualitative research’ and ‘life history’” (p. 1). Furthermore, Platt (2007) asserts that the term is used inconsistently: while some studies identified as “case studies” do not actually follow appropriate methodology, others that could be labelled as case studies are attributed to other research approaches.

ANT does its theoretical work... through carefully articulated case-studies. (Law & Singleton, 2012, p. 15)
Case study methodology has been used in numerous ANT studies, and it is regarded as the standard approach within both this field of research and the wider discipline of STS (Beaulieu, Scharnhorst, & Wouters, 2007; Law, 2008b, 2008c). As already discussed, ethnography has been identified as the approach of many scholars working in these areas. Nevertheless, Law (2008c) asserts that laboratory ethnographies are exemplary of the case study approach; this argument can presumably be extended to other study sites such as hospitals (Mol, 2002) and fish farms (Law & Lien, 2013). Thus, ethnographies can be viewed as one form of the much more diverse case study approach of STS and ANT scholars. As such, it is simply defined as the in-depth investigation of a particular instance of scientific work. This scientific work could be the development of an object such as the bicycle (Bijker, 1995), or a concept such as germ theory (Collins & Pinch, 1994); similarly, the activities involved in scientific work (e.g. Latour, 1987) or the use of technology (e.g. Woolgar, 1991) can also form the basis of the case study.

One reason for why STS and ANT make use of detailed case studies is that, although they often deal with philosophical considerations of scientific activity, they do so in empirical terms. There is therefore a requirement for detailed investigations of the material form and practical “doings” of scientific work; any theoretical conjecture by the researcher is done through these descriptions, not in an abstract form that stands apart from it. Thomas Kuhn’s (1962) *The structure of scientific revolutions* is one of the earliest works to achieve this:

> Kuhn cannot take us into Lavoisier’s laboratory, but he does the next best thing. He describes it in its material and theoretical complexity, and asks us to see that the formal articulations of science are about seeing, manipulating, and noticing – even perhaps creating – systematic similarities and differences between otherwise diverse sets of circumstances. Scientists experiment, and historians of science work through case-studies. This is all of a piece. (Law, 2008c, p. 6)

This link between theory and data in the case study approach has led to criticisms of its value. As a whole, case studies are by definition a study of a specific instance, and the ability to generalise from them is a topic of methodological debate (Platt, 2007). Within the field of STS this is not necessarily an issue, given that scholars are reluctant to make recourse to or offer to provide “grand narratives” (see e.g. Law, 2002a, 2008c; Mol, 2002). However, this in turn leads to a deep-seated tension in the STS literature between the rejection of “a universalizing fallacy” and the need to inform future work (Beaulieu, Scharnhorst, & Wouters, 2007, p. 673). In ANT, there is a consistent and specific assertion that the results of one study cannot and should not be applied to other cases (see e.g. Latour, 2005); but at the same time there is a directive to engage in
“ontological politics”, using research to interfere with reality (Mol, 1999; see Chapter 3 for discussion). In this study I have chosen to take this directive seriously, using the results of two overlapping case studies on GMO research to make broad recommendations for change.

4.3.1 Case study methods
Since case study research in the social sciences requires deep understanding of a complex phenomenon, it usually requires the use of a variety of materials and qualitative methods (Mabry, 2008). Such methods can be separated into three main categories: observation, interviews, and document analysis (ibid.). As already discussed, observation can involve a lengthy period of time spent living and interacting in the study area; however, not all forms of observation have to be participatory, nor do they necessarily take place over a long period of time. Observation can involve the use of focus groups or in-depth discussion groups (Cloke et al., 2004). It may also entail attending (and participating) in activities and events related to the case study, such as attending Environment Court hearings in the analysis of a planning dispute (Foster, 2012), or taking part in community planting projects in the analysis of ecological restoration activities (Washington, 2002).

Observation is viewed as the ideal method of data collection in case study research, since it allows a researcher to study not only what people say they do but also what they are seen to do (Cloke et al., 2004). Nevertheless, observation is not always possible, nor does it necessarily provide a researcher with all of the required information for a rigorous in-depth case study. For reasons that I will discuss later (see section 4.3.2), the use of observation methods was not possible in this study, so I have relied on the two other methods commonly used in case study research: interviews and document analysis. In the following sections I will provide a general discussion of these methods, and will detail my specific application of them in section 4.3.2.

Interviews
An interview is essentially a conversation between the researcher and a person (the respondent) who has been identified as a source of knowledge relating to the case study. In practice, interviews come in many forms depending on the researcher’s approach to gathering information. If respondents are viewed as “passive vessels of answers” (Gubrium & Holstein, 2002, p. 13, emphasis in original), the interview is likely to comprise of a series of direct questions aimed at eliciting specific details; in theory, if the right question is asked of the relevant person, the researcher will learn the desired information. Pictured thus, the interview is “a highly controlled, asymmetrical conversation dominated by the researcher” (ibid., p. 16).
In contrast, qualitative interview techniques used in the social sciences position respondents as active “meaning makers” (Warren, 2002, p. 83). The goal of the interview is to provide respondents with the opportunity to speak, and the role of the researcher is “to understand the meaning of respondents’ experiences and life worlds” (ibid.). This shifts the balance of traditional interviews, placing more emphasis on the active role of the respondent, encouraging them to narrate a story on their own terms rather than produce a report that conforms to a pre-determined structure given by the researcher (Chase, 2003 [1995]). Thus, semi-structured interviews have become a commonly used method in the social sciences, as they allow a researcher to direct the overall course of an interview without restricting what is said.

Semi-structured interviews can be a useful tool in case study research. In practical terms, they are relatively quick, and a respondent will have to spend less time on it than, for example, an in-depth written questionnaire (Cloke et al., 2004). For the researcher, however, they represent a large investment of time, as interviews must be thoroughly prepared for, undertaken, transcribed, and interpreted (ibid.). In terms of the data obtained, since the respondent is encouraged to speak freely on a particular subject, he or she may divulge information that the researcher would otherwise not have found out; if the researcher is able to recognise and respond to this information in the form of probative follow-up questions, even more data could potentially be gained (Mabry, 2008). Interviews can also be used to determine further respondents: the “snowball” sampling method involves asking someone to suggest further people who may be able to help with the study (Warren, 2002; Cloke et al., 2004).

Nevertheless, interview data should always be viewed with a critical eye, as it is not a simple reflection of reality “out there”. People do not speak completely freely even when they are unrestricted by the style of interview, and in controversial situations this is even more likely to be the case. This may even mean that potential respondents are unwilling or unable to be interviewed, and researchers may instead be directed to “gatekeepers” of information who have been positioned to mediate information flow regarding a group or organisation (Cloke et al., 2004). Furthermore, even if people speak freely, they may not speak accurately or truthfully, and there is a potential discord between what people say and what they do (Hammersley, 2008). Despite these potential issues with interview data, this does not mean it should be completely discounted; instead:

...researchers must exercise greater caution in their use of interview material, not that they should abandon all, or even the more orthodox, uses of it... like other sources of data, interviews are far from unproblematic. As a source of direct information, we cannot treat
them as automatically giving us the low-down on what has happened, even less on what typically happens, in particular situations... Scepticism, in the sense of a generally heightened level of methodological caution, rather than sustained epistemological doubt, is therefore always required. (Hammersley, 2008, pp. 98-99, emphasis in original)

Interviews should therefore comprise one of a number of methods used for data collection in a particular case study (Hammersley, 2008). This enables the triangulation of data and thus enhances the reliability of the research findings (Mabry, 2008).

**Document analysis**

Some ANT case studies have dealt with historical events, making it impossible to obtain interview data (e.g. Pétursdóttir’s (2007) study of Viking Age graves). While interviews can be used in the study of both current and recent events, they still should not be relied on as the sole source of data for reasons discussed above. Documents therefore provide a very useful source of information, and are commonly used in case study research. They can be gathered from a wide array of sources, including government departments (e.g. policy documents), the media (e.g. newspaper articles), and scientific journals. Recent developments in information technology not only facilitate access to such documents, they also mean that there is now a wider array of documents available for collection (Altheide, 1996). Websites, blogs, and e-journals are all potential sources of data, although they should be treated with more scepticism than printed materials due to the potential for inaccuracies in electronic publications.30

One problem that can arise from collecting all these sources of information is finding a strategy to deal with it. Hinchliffe’s (2001) case study of the UK BSE enquiry relies on records taken during 138 days of public hearings; similarly, Duncan’s (2004) case study of the Basslink project in Australia made use of numerous reports and public submissions documents amounting to a total of many thousands of pages of text. Hinchliffe (2001) deals with the logistical issues of handling such a vast archive by “following controversies, arguments and debates through the empirical materials” that thereby allow him to “focus on particular episodes and on particular issues” (p. 6). The aim in such analyses is not, therefore, to present an overview of the entire documentary content; it is instead to piece together an analysis that is both clear and robust. This is necessary even in case studies that rely on relatively small amounts of written data. Hilgartner’s (2000) analysis of the credibility of the scientific advice produced by the US National Academy of the Sciences centres on two key documents, but it nevertheless deals with a complicated and

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30 By this I’m referring for the potential for anonymous or assumed authorship, the general lack of peer review, and the ability for essentially anyone to publish on the internet.
controversial series of events. Nevertheless, Hilgartner’s book is cited as presenting an exceptionally clear (although arguably limited) examination of the controversy (Campbell, 2004; Eriksson, 2004). This suggests that the written representation of the final research report should be considered at the outset of case study research, an issue that I will discuss in detail in section 4.4.2.

Documents can be treated not only as repositories of information but also as active components of the case being studied (Prior, 2008). ANT is particularly useful in such instances as it makes specific claims relating to the importance of texts in the construction of heterogeneous networks. Texts coordinate action, removing the need for someone to issue instructions or enforce guidelines in person: “[r]uling relations consist of textually based systems of control” (Campbell, 2004, p. 435). In some cases, the text simply acts as the “intermediary”, conveying the intent of its “author” (see Callon, 1991; also discussion in Chapter 3) and thereby enabling action at a distance. At other times, a text can be described as an actor in its own right, as it comes to take on new meaning and lead to new, originally unintended, actions. This framing of texts requires the researcher to pay particular attention to the “context” within which the document is found: thus, it involves tracing the network of actors to which it is linked and exploring what is done with and to the text in question.

4.3.2 Methods of data collection used in this study

Like many prior ANT studies, this thesis can be broadly described as a case study. I have used data from a wide variety of sources, primarily relying on publicly available documents, but also making use of interview data. The controversial nature of my research topic meant that participant observation was not a feasible choice, as I will explain below. My materials and methods were not entirely pre-planned, however; research is an iterative process (Allen, 2003), and the more I learned the more my original research objectives changed, thus leading me to seek out different sources of information and analyse them in originally unplanned ways. Furthermore, this case study comes in two distinct parts: the first is a fairly specific exploration of the tearless onion research programme; the second is a more general examination of the use of laboratories and fields to conduct GMO research in New Zealand. While these two cases are obviously intertwined, they represent two separate phases of data collection. This separation arose as part of the research process itself, and is therefore a topic of methodological discussion. In this section I will provide an overview of the methods and materials used at each stage of this case study, whilst also detailing the twists and turns I negotiated during the research process.


**Following the onions**

At the time of beginning this research (early 2009), the recent ERMA field test application had brought debate over GM onions into the public arena, and a controversy was thus evident. On the one hand, the C&F scientists who had submitted the application touted their work as being of vital importance to the horticultural industry; on the other, the many people who submitted against the application believed that GM onions could destroy New Zealand’s horticultural export market. Given this situation, the logical place for me to start my research was the field test application submitted to ERMA in 2008: this included the original application made by C&F (Crop and Food Research, 2008b) and the final decision made by ERMA (ERMA, 2008a). It also included a wealth of submissions that had been made following public notification of the application. Two government departments (DoC and MAFBNZ) made submissions that were included as appendices in the final ERMA evaluation of the application (see ERMA 2008b); and Ngā Kaihautū Tikanga Taiao, a statutory committee established under Part 4A of the HSNO Act (1996), submitted a report on Maori concerns (Tuau, 2008). In addition to these reports, a total of 124 public submissions were made on the application. Due to the large volume of submission documents, I narrowed my focus to a subset of them: the 34 submitters who had indicated a wish to present their submission at the ERMA hearing31, as well as six other submissions that did not indicate a wish to be heard but had been made on behalf of a group or organisation. By indicating a wish to be heard or designating group status these submissions had separated themselves from other submissions, and I took this as an indicator that they were also more influential than other submissions in the final ERMA decision. In order to learn more about these people and groups I conducted some basic background research (via internet searches): this information is given in the table in the Appendix.

In addition to ERMA documents I also collected a wide range of other documents: media articles related to both tearless onion and other GMO research in New Zealand; articles from sources within the onion industry in New Zealand; New Zealand government policy and strategy documents relating to GMO research and development; and C&F/P&F in-house publications, including annual reports.

My initial analysis of this data was aimed at forming an idea of who and what was involved in enacting the reality (or realities) of tearless onions. Additionally, I planned to conduct interviews with people who could supply me with further information that I could use to triangulate and

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31 Only 14 of these submitters actually presented at the hearing.
extend my initial ideas. Accordingly, I compiled a list of people I would like to speak to and contacted them to try to arrange an interview.\textsuperscript{32}

The responses I received to these requests for interviews were mixed. Some people were interested in what I was doing. Aside from agreeing to be interviewed, they sent me e-mails with extra information and even asked to see what I finally wrote. There were times when I felt just as John Law did during his study of the TSR2: “I was being constituted as the person who would document this project ‘definitively’” (Law, 2002a, p. 54). In contrast, others were somewhat wary of my request for help. They consulted other people, checked employment contracts, asked me for further information and eventually declined to participate. It wasn’t that they weren’t interested in what I was studying; on the contrary, they had a great deal of “interest” in tearless onions and therefore a lot to lose should things go wrong. In these instances I was constituted as the person who would prolong or inflame the controversy: talking to me may have unintended consequences. Still more people took absolutely no interest at all in my research. They either ignored my letters, e-mails and/or phone calls or gave me a very short reply declining to participate. Tearless onion research and my investigations of it were of no interest to them, and I was therefore constituted as a waste of time.

Eventually I conducted a total of five interviews with people who filled one or more of the following descriptions: one person was an anti-GMO spokesperson; two people had worked as GM onion scientists; three had worked at C&F; one had worked at another CRI; one had been involved in the RCGM; and one had been a member of ERMA. Three of these respondents were people I had identified during my initial scoping of documentary material; the names and contact details of the other two were given to me by other respondents via snowball sampling. Interviews lasted for between one and two hours, except for one that extended to almost three hours across two sittings. All were tape-recorded with the respondents’ consent and later transcribed. For the first two interviews, I transcribed the entire interview verbatim, after which I re-evaluated my approach. As Cloke et al. (2004) note, interviews are not a “soft option” (p. 151) in qualitative research due to the time consuming process of transcription. In this study, the use of semi-structured interviews meant that I had very little control over the direction of the interview and at times this meant that the respondent was talking completely off-topic. After conducting two interviews I realised that I was transcribing large amounts of data that had no relevance to my research questions. In subsequent interviews I therefore only fully transcribed the parts of the

\textsuperscript{32} These interviews were approved by the Lincoln University Human Ethics Committee: refer to application number 2009-18 approved on 1\textsuperscript{st} July 2009.
interview I deemed as being of direct relevance to my research objectives; anything I did not transcribe was paraphrased. The only other convention I adopted in typing these transcripts was to signify a short pause in speech with a comma and a long pause with three dots. The interview transcripts were returned to the respondents to be checked and any changes they made were incorporated into the final transcript.

Most people I spoke to were able to tell me about the conduct of GMO research in New Zealand on a general level, but only a few people were able to give me specific details about the tearless onion research itself. Thus, while these interviews were crucial in developing my understanding of the topic as a whole, they did not provide me with a great deal of concrete data for analysis.

At the time of these interviews I also attended two meetings that debated the topic of GMO research in New Zealand. One of these was organised by the New Zealand Institute of Agricultural and Horticultural Science Inc. (NZIAHS), an organisation that represents and promotes the views of agricultural and horticultural scientists in New Zealand (see NZIAHS, 2014). This forum was held at Lincoln University on 30th June/1st July 2009 and was attended by over a hundred people, many of whom were involved in conducting GMO research. The first day provided a forum to debate initiatives to improve the New Zealand Science System, while the second day considered Genetic Modification research in New Zealand. A number of prominent figures in the New Zealand scientific community spoke at this forum, and their presentations were later published in two issues of AgScience, the journal of the NZIAHS. I have used the articles published in these proceedings as part of my data analysis. The second meeting was organised by the Soil and Health Association of New Zealand, an organisation that promotes organic food and farming in New Zealand (see Soil and Health, 2014). This meeting was held at a residential address in Christchurch on 6th August 2009 and was attended by a small number of people, most of whom were members of the local branch of Soil and Health. Two prominent anti-GMO spokespeople gave presentations at this meeting. I used this information to gain an understanding of the sorts of activities in which anti-GMO groups engage as part of their opposition to GMO research. In addition to using the material presented at each meeting, I also took each as an opportunity to make personal connections with people who were in some way involved in the debate over GMO research. I later interviewed some of these people, either as part of the tearless onions case study, or my subsequent investigation into containment facilities.

33 The proceedings of day 1 (“Improving the science system”) were published in Issue35, November 2009. The proceedings of day 2 (“Genetic Modification revisited”) were published in Issue 36, March 2010.
At this point I felt that I was at a crossroads in my research, and I took the time to stop and assess my situation. What was the value of the data I had collected? Could I still fulfil my research objectives? Did I need more data; or did I need to reassess my research objectives? I started to reconsider my choice to use the controversy surrounding tearless onions as the starting point for my analysis, and I returned to the literature to reconsider my aims. Was I mapping a controversy over different versions of the same object or was I exploring a single object? I was beginning to understand that I was doing neither of these things, but I had to understand why and what I was in fact doing before I could make any further progress. So I read of objects: in particular, atherosclerosis (Mol, 2002) and military aircraft (Law, 2002a). Central to both of these texts is the concept that objects are not singular, rigid “things” that exist separately from the world around them. Instead, the many different practices of arterial disease on the one hand and the development of the TSR2 on the other enact different objects; but these enactments overlap to form fractionally coherent objects. Returning to my data I found a new direction. Instead of looking upon the ERMA hearing as the starting point for my research I realised that multiplicity had been present from the earliest stages of the research programme; I therefore needed to look much further back and piece together the steps taken by the C&F research scientists in creating a GM tearless onion. Multiplicity need not be overt; it doesn’t shout at us in the protest marches outside a government building, demanding our attention. It can be found in an annual report or a scientific journal article and is revealed as much by absence as it is by presence. So I widened the scope of relevant data, trawling through material such as scientific journal articles, annual reports, and government policy documents to try to piece together how multiple tearless onions were being “done” in New Zealand.

The final analyses given in Chapters 5 and 6 were written primarily using these publicly available sources of information, with interview data used to augment and support my claims. In the interests of producing an ANT text that exposes the “mess” of the research process itself (Law, 2004), I have chosen not to hide the change in direction I took during the course of data analysis: instead, I have woven these different paths into the fabric of my analysis so that it too becomes a topic of discussion.

**Entering the containment facility**

While the process of following tearless onions was very convoluted, the second part to this study was relatively straightforward. I performed a detailed analysis of the tearless onion data before moving on to this second stage of data collection, and this is what led me to formulate the questions that drove it. I therefore had a clearer idea of what I was going to do at the outset. Furthermore, I encountered very few problems when collecting my data: the less specific nature
of my topic meant that it was much easier to secure interviews. I had also become much more adept at presenting my research to potential respondents: rather than framing my research as aiming to document a “controversy”, I stressed that I was hoping to gain an understanding of how laboratories and fields were operated as containment facilities. By switching focus from a particular programme of controversial research to the day-to-day operation of places of research respondents were therefore subjected to much less personal risk by consenting to an interview.\textsuperscript{34}

Interview data comprises a much larger component of the materials collected in the second part of this case study. Very few of the people I contacted declined to be interviewed, and I spoke to ten people in total. These were: two current ERMA employees; a past member of ERMA; an MPI inspector; a laboratory containment facility manager; a Biological Safety Officer; a CRI employee involved in a programme of GMO field test research; a University employee using GM technology in laboratory facilities; and two anti-GMO campaigners. Most of these respondents were people I had identified after an initial scoping of documentary material; I was put in touch with two others via mutual contacts; and the names and contact details of another two were obtained via snowball sampling. As in the first period of data collection, most interviews lasted for between one and two hours. They were tape recorded with the respondents’ consent and I later transcribed the parts of the interview that were of direct relevance to my research objectives, paraphrasing the rest. The only convention I adopted in typing these transcripts was to signify a short pause in speech with a comma and a long pause with three dots. The interview transcripts were returned to the respondents to be checked and any changes they made were incorporated into the final transcript.

I also collected a wide range of documents for analysis, allowing me to triangulate and augment the information I collected in interview. These included New Zealand legislation relating to the control of GMO research; other documents written in accordance with this legislation; ERMA documents, including applications for GMO field tests and information from their website; newspaper articles; web-based media; and press releases.

The resulting analysis has been pieced together from these multiple data sources; as with the tearless onions analysis, it provides a narrative that weaves together multiple storylines that are more-or-less centred on the object of study. Furthermore, there is a degree of discontinuity between this second analysis section and the tearless onion analysis: not only were the questions guiding my analysis different, the manner in which I have presented these analyses is also

\textsuperscript{34} This second round of interviews was given a separate approval by the Lincoln University Human Ethics Committee: refer to application number 2011-05 approved on 11\textsuperscript{th} April 2011.
different. As such, there is a degree of “non-coherence” (Law, 2002a) to my analysis, but this is a style of representation I have actively chosen over other, more conventional forms of academic writing. I will consider this choice in the following section as part of a wider discussion of the methods I have used to represent my research findings.

4.4 Representing ANT research

Methodological considerations do not stop at the initial phases of research design, when we are deciding on our research questions or planning which methods of data collection to use. Analysis and interpretation requires a similar degree of methodological choice, as our “results” do not present themselves to us the moment we have left “the field” and begun to consider the wording of our written report. And yet, the neatly packaged analyses of academic texts belie this crisis of representation: it can appear as if there is only one possible answer, one presentation of the research findings that is somehow separable from the person writing it. Nevertheless, just as the use of different representational forms in scientific texts has become a topic for critical analysis (Lynch & Woolgar, 1990; Coopmans et al., 2014), it is also important to apply these same principles to representation in social scientific practice.

Alongside other postmodern approaches within the social sciences, ANT holds that research provides a representation of reality, and as such is no more or less real than any other account of “the facts”. What allows ANT to stand apart from many other methodological approaches is its ability to critically reflect upon and make specific choices with regards to the form of this representation (Gad & Jensen, 2010). Furthermore, this reflexivity is evident within individual texts, as researchers expose the choices they have made in order to retain some of the “mess” involved in conducting social science research (Law, 2004). Thus, ANT can be viewed as a form of “reflexive anthropology”, defined by Ashmore (1989) as “the joint project of writing self-consciously experimental ethnography together with the study of ethnography as writing” (p. 50).

ANT scholars have experimented with a number of different representational forms. In some cases, illustrations have been of central importance, as is the case with the use of network diagrams in studies that follow ANT’s methods of network analysis. Others have used non-conventional forms of writing both as a means of conveying research findings and also to engage in critical reflection. In this thesis I will use both network diagrams and writing to represent the “objects” of GMO research. The following sections provide an overview of different approaches that are of relevance to this study.
4.4.1 Network diagrams

Use of the “network” metaphor in ANT study presents a pictorial image of the object of study, and this lends itself to the use of visual representation in ANT analysis. A number of ANT studies incorporate a distinctly visual element in their accounts. Latour uses graphical illustrations to describe the series of steps taken by a hotel manager to make sure that guests leave their key at the front desk each time they leave the hotel (Latour, 1991); Law and Callon (1992) plot the course of an aircraft design project on axes to represent the involvement of local and global networks; and Latour’s (1987) exploration of Science in action is filled with diagrams used to illustrate both abstract and specific details of scientific work. Applications of ANT in the environmental management literature also make use of network diagrams, for example: Busch and Juska’s (1997) study of the globalisation of agriculture; Martin’s (2000) study of GIS implementation in Ecuador; and Comber, Fisher, and Wadsworth’s (2003) study of land cover mapping in the UK.

Whereas the above examples are simply visual aids that support the words of a text, in some cases the use of a diagram has come to be meaningful in itself. In particular, Callon’s (1986a) diagram of the forging of alliances between actors has arguably provided the most symbolic and widely reproduced image of an Actor-Network (see Figure 4.1 below). In this diagram, Callon represents the central argument of his paper: that otherwise unrelated actors can be brought together in a network that “translates” their diverse interests into a common goal (see Chapter 3 for discussion). Although not shown on this diagram, this “translation” can only be achieved through the deployment of “interessement” devices that serve to interest each actor so that each accepts the Obligatory Passage Point (OPP) as the only means of achieving its goals. The arrows on the diagram are used to convey this “channelling” of interests through a single point.

One of the strengths of this approach is that it can be used to explain how one particular viewpoint or “thing” comes to be an accepted “fact”. This means that it can be particularly useful in the study of controversies, where there are two (or more) “sides” to an argument, each of which is trying to gain widespread acceptance of a particular version of the facts. A number of researchers have used Callon’s diagram in this way, and it has been used as a template to represent a number of controversies, including: conflict over stag hunting in south west England (Woods, 1997); dispute over river dredging in Brisbane, Australia (Jakku, 2003); and the contested classification of penguins and baches in Canterbury, New Zealand (Foster, 2012).35

35 A bach is a holiday home in New Zealand, often by the sea.
As I have already discussed in Chapter 3, there are contrasting interpretations of Callon’s (1986a) sociology of translation. Nevertheless, the visual representation of the Obligatory Passage Point and the arrows passing through it suggest that network stability results from the “bending” of many wills to the power of one. This is perhaps one reason why network approaches have been criticised as being managerialist and centred (Star, 1991), and suggests that it may not be possible to use a network diagram to represent objects that are multiple and decentred.

Although Callon’s diagram is exemplary, it is not the only network diagram that has been developed in the ANT literature. Latour (1999a) also develops a visual representation of an Actor-Network in *Pandora’s Hope*. His “circulatory system of scientific facts” (see Figure 4.2 below) represents the “object” of scientific research as the outcome of five interrelated activities that each involves a wide array of actors. “Mobilization of the world” (p. 99) details the expeditions, surveys, instruments, and equipment that are used in scientific research. It also includes the sites where all this equipment is assembled, such as laboratories, museums, and databases. “Autonomization” (p. 102) describes the construction of scientific professions, disciplines, and institutions that support and contribute to this research as colleagues. “Alliances” (p. 103) are a
further group of actors from outside the scientific community that must also support a programme of research, such as politicians, industrialists, and the military. The role of the public is considered in a separate loop of “public representation” (p. 105). Finally, the scientific content of the project is depicted as the “links and knots” (p. 106) that tie all the loops together but which cannot exist in isolation from them, serving as the conceptual “heart” of the network. In contrast to Callon’s use of the OPP, this apparent “centre” is not what draws the network together, but is instead an outcome of their interactions.

Figure 4.2 Latour’s network diagram of the circulatory system that keeps scientific facts alive (Latour, 1999a, p. 100 Figure 3).

Although there is very little detail in the diagram shown in Figure 4.2, Latour’s circulatory system of scientific facts is by no means a “simple” representation of network activity. An understanding of it requires reading a theoretically dense chapter that, unlike Callon’s (1986a) paper, is not grounded in a single empirical example but is instead discussed in the abstract. Furthermore, although it has been used to represent the “vascularisation” of ecology (Fitzsimmons, 2004), Latour’s (1999a) network diagram does not appear to have been widely cited or replicated, and this could be why it has not been widely critiqued. It would therefore be of interest to assess how
this network representation could be used in practice by applying it to a particular case study of scientific research.

The use of network diagrams is not restricted to ANT scholarship. In the STS literature, Star and Griesemer’s (1989) representation of “boundary objects” is perhaps of most relevance to this discussion as it was developed in response to Callon’s (1986a) “sociology of translation”. In their case study of the Museum of Vertebrate Zoology in Berkley, California, Star and Griesemer (1989) trace the diverse group of “professional scientists, amateur naturalists, patrons, hired hands and administrators” (p. 388) that are involved in establishing it. In contrast to Callon (1986a), Star and Griesemer (1989) hold that a heterogeneous network of actors is not necessarily united by a common interpretation of an issue, contending instead that collaboration is possible in the absence of consensus. They use their concept of the “boundary object” to convey this argument, objects that “are both adaptable to different viewpoints and robust enough to maintain identity across them” (p. 387). Rather than assume there is a single translation to which all interested actors must agree, Star and Griesemer therefore allow for more than one translation of the same object. These translations are depicted in a network diagram of the boundary object (see Figure 4.3 below), one that incorporates a number of Passage Points rather than a single “Obligatory” Passage Point.

Figure 4.3 Star and Griesemer’s network diagram of the boundary object (Star & Griesemer, 1989, p. 390, Figure 2).

This definition of the boundary object provides a direct contrast to ANT’s use of the term “translation” and has therefore been used for different analytical purposes. Whereas ANT uses translation to denote the stabilisation of facts, the boundary object employs multiple translations to convey the flexibility and ambiguity of its boundaries (Fujimura, 1992). This contrast has led some researchers to combine Star and Griesemer’s (1989) ideas with traditional ANT network approaches (see e.g. Alatout, 2010; Kaljonen, 2010); however, others have argued that the
ontological position that underpins each approach make them fundamentally incompatible (Law & Singleton, 2005). Nevertheless, this diagram provides an interesting counterpoint to the “sociology of translation” due to its inclusion of many Passage Points, none of which are “Obligatory”. It should therefore be included in a consideration of how networks can be used to represent objects.

The three network diagrams discussed in this section represent three quite different conceptualisations of “networks” as applied in the ANT and wider STS literature. I will use each of them in this study, considering how they can be used to “represent” the GM tearless onion in the analyses given in Chapters 5 and 6. By providing this overview my aim has been to show that none of these diagrams should be applied uncritically, as each approach has strengths and weaknesses. As Hacking points out, when we look at diagrams we should “ask whether the point of the representations is to convey information at all, or rather to convince us that this is solid stuff, not to be challenged, not challengeable” (Hacking, 1991). It is therefore important to “challenge” the format of network representations, using and adapting them for our own individual purposes.

4.4.2 Writing
Social scientists have long been aware of the importance of critically engaging with the written form of research reports. As I have already mentioned (see section 4.2 above), the “crisis of representation” has led ethnographers to acknowledge that writing can at best produce only a partial account of the field of study. But this is not to say that the ultimate goal of academic writing is to produce an impartial account of reality; researchers always write with the aim of making some kind of difference to the world. As Law observes, “[s]ometimes words, stories, and no doubt pictures are also actions” (Law, 2002a, p. 177, emphasis in original). At the very least we hope to use our writing to say something about our own abilities:

As ethnographers, for example, we tend to pick stories from our field notes, weave them into a larger story for the argument and at the same time try to craft a story about ourselves as smart and capable authors (Ziewitz, 2010)

Academic writing therefore represents a blurring of the boundary between object and subject because researchers are always “present” in the texts they produce. This is something that should be recognised by using, for example, a first person perspective in order to “subtly and continuously remind the reader that the narrative is the product of the researcher’s mind” (Mabry, 2008, p. 219). But the overall structure of the final written report also warrants careful attention, as academic texts do not come in one specific format. Disciplines are in part shaped by
the written presentation of published research, and it is therefore important to assess what is considered an appropriate writing style in a given field of scholarship (Murray & Moore, 2006).

Academic writing in the natural sciences is characterised by an impersonal, objective style that discusses complex subject matter through the use of syntactically simple sentences (Gross, Harmon, & Reidy, 2002). It is therefore stylistically different to other forms of writing, particularly works of fiction. However, Law (2004) argues that social scientists should approach the written representation of their work with a greater degree of creativity so that their texts can be read for “the pleasure of the read itself” as opposed to “the destination, where it will take us, where we will be delivered” (p. 11). Similarly, Richardson (2003 [2000]) recommends that students should nurture their creative writing abilities throughout the course of their research by engaging in a number of activities; for example, they should keep a research journal in which they experiment with different styles of written presentation, such as autobiography or drama.

In some cases, such alternative literary forms have been used in the final presentation of academic work. Latour’s (1996a) examination of the “Aramis” rapid transport system is exemplary in this regard: Latour fuses the literary form of the detective novel with the study of the life and death of a scientific artefact to create a new hybrid genre: “scientifiction” (p. ix). The end result is a text that reads partly like a novel, partly like an academic text, partly like a scrap-book of information drawn together with a central narrative provided by the dialogue between the professor and engineering student charged with investigating Aramis’ demise. Latour uses literary styles of humour and intrigue to draw the reader along what is nevertheless a serious academic journey.

Although Aramis occupies a relatively unique position in the academic literature, there are numerous other examples of texts that challenge the boundaries of conventional academic scholarship. Dialogue is often used in STS texts (see e.g. Ashmore, 1989; Knorr-Cetina, 1999), and ANT also uses this tool to convey and discuss ideas (see e.g. Callon & Law, 1995; Latour, 1996a, 2005; Law & Singleton, 2012). The final result can read much like the script of a play, thereby replacing formal academic language with idiomatic expression. Furthermore, by casting the researchers themselves as central characters it replaces the objectivity of a third-person perspective with a subjective, first-person interaction.

This use of dialogue to introduce more than one “voice” into the pages of an academic text is arguably an attempt to practice a literal form of multiplicity. But this is not the only method of achieving such an end, and the use of different narrative styles are evident in the literature. In
such cases, the writer follows various overlapping stories that apparently centre on the same “thing”, but are as alert to difference as they are to similarity. The result is not a singular coherent description of reality but a “patchwork” that is linked together by “[p]artial and varied connections between sites, situations, and stories” (Law & Mol, 1995, p. 290, following Strathern, 1991).

Mol’s (2002) examination of The body multiple is perhaps the best known example of this style of writing. In this book she presents two texts: a discussion of the empirical results of her hospital ethnography; and a “subtext” (p. ix) that discusses relevant literature. Although these two texts are physically separate, they are nevertheless interconnected and designed to be read in concert with one another. Mol does not impose or even recommend a reading style on her audience, stating simply that it is up to individual readers to decide this for themselves.

In a similar vein, Lavau (2013) alternates between two separate narratives in her analysis of sustainable water management in Australia. The first tells of intersecting practices that enact the multiple realities of river management traced in this study; as such, it is a more conventional approach to academic writing. The second takes a reflective tone, focusing on the materiality of the river and considering how realities come to be. Lavau describes this second narrative as “a playful experiment in taking the river seriously as a thing that forces thought” (p. 418). By using these two different narratives, Lavau argues that this method of writing “functions as a literary strategy for interrupting and disrupting that which is certain, simple, and smooth” (ibid.), thereby providing a written representation of the multiplicity that lies at the heart of her study.

Lavau’s comments echo Law’s (2002a) observation that “smooth narrative makes more or less smooth objects” (p. 197). Here Law is referring to what are commonly referred to as “grand narratives”, singular representations that seek to provide an overarching report on reality, but in doing so also perform actions, thereby bringing that reality into being. Law’s solution is also to experiment with the use of alternative narrative structure in academic writing, and he does this by providing a “fractionally coherent” text in his book Aircraft Stories (2002a). This examination of the British military’s plans to build the TSR2 aircraft in the 1960s was begun in the spirit of early ANT texts, and Law initially focused on the processes and outcomes of heterogeneous engineering, publishing a number of papers on this topic36. But as he progressed with his research, he found that the heterogeneous network he sought to describe was more than just a socio-technical assemblage; it had a rhizomatic structure formed from “a tissue of little

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36 For a description of this phase of his research and a list of the associated publications see Law (2002a, p. 54 and p. 210 note 24).
narratives” (2002a, p. 164) that incorporated “[d]iscontinuities and stutterings” (p. 185). Rather than smoothing out these jagged edges to produce a grand narrative, Law embraced them. His final text is thus doubly performative: Law not only considers the fractional coherence of the TSR2 aircraft, but also examines the fractional coherence of the stories he produces.

Following Law (2002a) I have adopted a rhizomatic structure in the presentation of my written results. In each of my results chapters (5, 6 and 7) I begin with a number of intertwining narratives that relate to the case study material I have collected and analysed. Following these separate narratives about the “object” of my study, I then consider how to draw them together in a single representation that nevertheless preserves the fractional coherence of the object. In these discussions of how to represent the object another discontinuity is apparent, as a different approach has been taken in the study of tearless onions (Chapters 5 and 6) in comparison to containment facilities (Chapter 7). The former put particular emphasis on the use of network diagrams to represent the tearless onion, and there is a large degree of symmetry between the two chapters. But the latter makes no use of network diagrams, and considers a variety of object representations that have been developed in the ANT literature. While this does not make for a “smooth narrative”, it does allow for discussion and critique, both in relation to the GMO research objects I have studied, and the theoretical and methodological tools I have used.

4.5 Summary
This thesis is a case study of GMO research practices in New Zealand. As such, it makes use of data that has been collected from a wide variety of documentary sources, as well as a number of key informant interviews. The use of this variety of information sources has enabled triangulation of data; it has also resulted from the difficulties I encountered in my attempts to “follow the actors”. Rather than serve as an obstacle to progress, these difficulties have become part of my study, not only providing further data for analysis, but also leading to further questions for investigation. I will reflect on these experiences and discuss their implications in more detail in Chapter 8.

ANT also provides the methodological tools used to represent the results of this study. Chapters 5 and 6 make use of network diagrams to represent the enactment of GM “tearless onions”. Rather than reproduce an existing approach, however, these chapters will consider the relative merits of three different network diagrams that have been developed in the ANT and wider STS literature: Callon’s (1986a) “sociology of translation”, Star and Griesemer’s (1989) “boundary object”, and Latour’s (1999a) “circulatory system of scientific facts”. All three analytical chapters make use of
Law’s (2002a) “rhizomatic” structure to present research findings as a series of interweaving narratives.

In addition to the methodological tools outlined in this chapter, the theoretical concepts outlined in Chapter 3 have also been used to sort, interpret, and represent the data I have collected. In this way, this thesis employs a variety of methods that have been drawn from across the spectrum of the ANT methodological toolkit. This is partly because it incorporates two different case studies that have required slightly different approaches to data collection and analysis. But it is also because I do not want to enact a singular version of ANT, presenting one set of methods as if it were the only way to “do” ANT. Instead, the methodology employed in this thesis recognises that ANT is multiple, and encompasses a variety of tools that can be used to complement one another. This is particularly relevant to the study of GMO research practices, since there is a need to explore the layers of complexity that characterise such research whilst at the same time providing practical recommendations for change.
5.1 Introduction

The laboratory development of tearless onions was announced to the world in a number of different media between 2007 and 2008. Members of the C&F GM onion research team first presented their results at the 5th International Symposium on Edible Alliaceae (ISEA) held in October 2007 in the Netherlands; this presentation was later reported in the trade journal *Onion World* in December 2007 ("‘Tearless Onion’ technological breakthrough announced", 2007). C&F published a media release in February 2008 summarising some of the information in the *Onion World* article (Crop and Food Research, 2008a); and further articles were written around the globe as news of the development became widely known (see e.g. Highfield, 2008). On the academic front, a peer reviewed article on the development was published in *Plant Physiology* in June 2008 (Eady et al., 2008) and a PhD student who had been working on the project submitted his thesis detailing the development of tearless onions in December 2008 (Kamoi, 2008).

In this chapter I will begin my analysis by using this group of documents to identify the actors involved in enacting tearless onions. There is some degree of overlap between these articles: the details they contain appear to cohere and form a singular tearless onion, even a singular onion. But where there is singularity there is also multiplicity; where there is simplicity there is also complexity (Law, 2002a). This complexity becomes more and more apparent as I go on to consider each actor in more detail, and begin to layer in a more diverse array of information including interview data, government reports, and company documents. So rather than tell a singular, linear story, I will relate multiple, intertwined accounts in order to explore these “layers” of the tearless onion.

In order to identify these actors I will begin with a diagram published in the *Plant Physiology* paper mentioned above (Eady et al., 2008, Figure 1). This diagram is presented as if it reflects a reality “out there”, a starting point for experimentation and modification by the researchers. But the creation of tearless onions does not begin here; in many ways this diagram can be conceptualised as a kind of end-point, just as the pathology of leg arteries is an outcome as opposed to the cause of atherosclerosis (Mol, 2002). This diagram is only a starting point in that it
provides a place for me to start as I “follow the actors” involved in the enactment of tearless onions.

5.2 Pathways

![Figure 5.1](http://www.plantphysiol.org/content/147/4/2096.long)

**Figure 5.1 Representation of onion biochemical pathway (Eady et al. 2008, p. 2097, Figure 1).**

The diagram shown in Figure 5.1 (above) is the first diagram to appear in the scientific journal article outlining the development of GM “tearless” onions. It is a schematic representation of a biochemical pathway found in onion cells. Although it may seem far-removed from every-day human experience, according to these scientists it details the chain of reactions that occur after slicing up an onion. The molecule labelled “LF” (lachrymatory factor) is responsible for inducing a tearing response in anyone whose eyes come too close to the newly chopped onion pieces.

Since the beginning of time, consumers have complained about the reactions they experience when cutting onions. (“’Tearless’ onions will be the consumer choice”, p. 7, 2007)

Whether or not people have always had problems when cutting onions, tears have become synonymous with this vegetable; crying whilst cooking with them is an unwritten step in any recipe. The diagram above reveals why we have had these problems: LF is formed due to the action of a specific enzyme, aptly named lachrymatory factor synthase (LFS). Thus we can
conclude that the problems we have been having “since the beginning of time” are in fact due not to the onion as a whole, but to a microscopic component of it.

While this may appear to be a logical conclusion, Latour’s account of the “historicity of things” would suggest otherwise (Latour, 1999a, Chapter 5). Through what he terms “the puzzle of backward causation” (ibid., p. 168), scientists have a habit of rewriting the past with their accounts of the present. Thus a scientific discovery made today comes to account for observations made “since the beginning of time”.

Nevertheless, the fact that LFS has been identified as the substance that causes our tears whilst chopping onions is in itself an important point. All we need to do is modify our definition of “substance”:

The word “substance” does not designate what “remains beneath”, impervious to history, but what gathers together a multiplicity of agents into a stable and coherent whole.

(Latour, 1999a, p. 151)

Portrayed in this way, the value of LFS is that it will help me identify the actors involved in enacting tearless onions. But to do this requires a closer attention to other details included in this journal article. The next place to look is the place where this diagram is mentioned in the main body of text:

Imai et al. (2002) discovered that the conversion of 1-propenyl sulfenic acid to LF is mediated by an enzyme they named lachrymatory factor synthase (LFS; Fig. 1). (Eady et al., 2008, p. 2096)

This sentence reveals that LFS was discovered and named six years previously, in 2002, by a team of researchers headed by “Imai”. This is one link in the chain of translation through which reference “circulates” (Latour, 1999a; see Chapter 3 for discussion): Eady et al.’s “thing” was preceded by Imai et al.’s “sign”, and the rupture between the two is visible here. Within this gap we find more matters of substance, as a close inspection of the following will reveal:
Figure 5.2 Title of journal article detailing the development of tearless onions (Eady et al., 2008, p. 2096).

Shinsuke Imai is one of the eight co-authors of this paper, the same person who led the discovery of LFS\footnote{This point is made in Kamoi (2008).}. The information above also reveals that he works for a company called House Foods Corporation (HFC) in Japan. There are therefore two research institutions involved in the enactment of tearless onions: Crop and Food Research (C&F) and HFC. Further information is contained in the footnote to the article’s title:

Figure 5.3 Footnote from journal article detailing the development of tearless onions (Eady et al., 2008, p.2096).

It’s easy to overlook this statement. It’s written in small typeface at the bottom of the front page of the article, in amongst the contact details for the researchers. It lies outside the main body of text, implying that it has nothing to do with the scientific substance that can be found inside the article. But it indicates that the project has received financial backing from two different sources: one domestic (the Foundation for Research, Science, and Technology (FRST)), the other foreign (the aforementioned Japanese company, HFC).

The substance of LFS has revealed four actors so far: C&F; the GM onion scientists who work there; HFC; and FRST. A fifth actor can be identified by considering another diagram included in the \textit{Plant physiology} journal article:
This diagram appears to be very similar to the diagram shown in Figure 5.1. This, too, is a representation of a biochemical pathway in onions, but there is one major difference: the absence of both LFS and LF. This is because the diagram above represents a modified pathway due to the fact that it is found in a "transgenic onion" (see original caption in Figure 5.4 above).

The reason for making this point is that the use of genetic engineering techniques draws in a final actor who isn’t explicitly mentioned in the pages of any of the texts I have looked at here: the Environmental Risk Management Authority (ERMA). Under the Hazardous Substances and New Organisms (HSNO) Act, anyone who intends to modify an organism using genetic engineering techniques must apply to ERMA for approval to do so (see Chapter 2). Thus ERMA becomes the final actor that is involved in enacting tearless onions. In the following sections I will outline the role of each actor in this enactment.
5.2.1 The Crop & Food Research scientists

Figure 5.5 Cover of *Onion World* magazine (December 2007) depicting (L-R) Colin Eady (C&F senior scientist) with Takahiro Kamoi (PhD student) standing behind a number of laboratory-grown onions. Image © Columbia Publications, reproduced here with permission.

C&F has a long history in onion research, involving methods that include traditional plant breeding, integrated pest management and, more recently, genetic engineering. Although the GM onion research team has been investigating the genetic transformation of various *Allium* species for a number of years, the technology is far behind that of other “commercially important vegetable species” (Eady, 2002b, p. 655). Various methods have been developed and trialled over the years (see Eady 1995; 2002a; 2002b), and some successful transformations have been
achieved, including: herbicide resistance (Eady et al., 2003); reduced alliinase activity (Eady et al., 2005); and, “at last”, the reduced LFS activity of tearless onions (Eady et al., 2008; Kamoi, 2008).

The C&F team is well experienced in GM onion research, as evidenced by the summary of some aspects of their work given above. But rather than take this as evidence that they know everything there is to know about onions, I will instead adopt the position that they are well practised in “doing” onions (Mol, 2002, Chapter 1). Once I do this, an interesting contradiction emerges: it appears that the scientists’ role is contingent on the onions being both wild and domesticated.

As monocotyledons, the *Allium* species were predisposed to be recalcitrant to transformation. (Eady et al., 2000, p. 376)

Onions are described as a “recalcitrant” crop in a number of scientific papers to have been produced by the C&F laboratory (see above; also Eady, 1995; 2005; Eady, Weld, & Lister, 2000; Eady et al., 2005; 2008; Kamoi, 2008). This casts it in almost human terms, portraying it as something that is disobedient and uncooperative. Furthermore, a number of papers have been written highlighting the potential for the genetic transformation of onions whilst also acknowledging the many difficulties involved in doing so (see for example Eady 1995; 2002a; 2002b). Although the onion is thus portrayed as untamed, it is also shown to be known and controlled; but only at the hands of the C&F team. There are only “a few” laboratories that have “persevered” with research into the genetics of onions (Eady, 2002b, p. 656); implicit in this statement is that C&F is one of those few. Furthermore, this practical knowledge of how to “do” GM onion research is not something that can necessarily be translated into words in an academic text. Take, for example, the following:

In lines that did not produce transformants, genotype influence was probably not the main cause. Subculture pressure and health of the embryo starting material was critical and we believe, due to our success in transforming other *Allium* species (unpublished observations), that these were stronger influences on transformation success than genotype. (Eady et al., 2003, p. 215-216)

This paragraph implies that there is a *culture* of knowing onions, an “epistemic culture” (Knorr-Cetina, 1999) that has been gradually built up over the years by the C&F research team. The complexity of this knowledge means that it cannot necessarily be distilled into words on a page, and those who want to “know” the onion will have to deal directly with the research team. This places the laboratory at C&F in a position of power, a “centre of calculation” (Latour, 1987, p.
in the study of GM onions. This is reflected in the number of research collaborations the research team has established; including Seminis Vegetable seeds (see Eady et al., 2003) and an American Institute (Interview E).

The C&F research team is keen to link the benefits of GM onion research to the much wider benefits of GMO research as a whole. In an opinion piece written for Grower magazine, the lead researcher in charge of the GM onion programme is keen to stress the environmental benefits that could result from GMO research:

As a biology student in the early 80s I was taught the horrors of current intensive farming practices and the damage that was being wrought upon the environment. Rachel Carson wrote in “Silent Spring” about the death of millions of birds due to the accumulation of DDT in the food chain... As a strong Green sympathizer [sic] (at the time I was a member of Friends of the Earth, a radical UK green group) and a geneticist I saw potential of genetic engineering to use Nature’s own systems to deter pests and disease (Eady, 2001, p. 23)

These sentiments are echoed in a television documentary (“The onion pickle”; TVNZ, 2003) in which Dr Eady likens his values to those of the anti-GM campaigner chosen to represent the opposition to the C&F GM onion research project. Both are concerned about the environment, health, and nutrition; they just had different ideas about how to achieve their goals. These points have again been raised in more recent reports on the development of tearless onions:

Dr Eady says although the “tearless onion” is an exciting project, he is most interested in sustainable and efficient production and will want to be sure that the onions he is working on are also capable of being grown in an efficient manner. “We have a burgeoning population to feed, and with climate change and other challenges, available resources are being reduced. The gene silencing system can also be used to combat virus diseases and biotechnology in general can help us produce more robust crops.” (Crop and Food Research, 2008a)

Once again we are asked to focus on the wider benefits of GMO research. Furthermore, the specific details of the tearless onion research are pushed to one side in this statement, with greater importance placed on onions that can be “grown in an efficient manner”. It is therefore reasonable to assume that other actors have influenced the particular course of the GM onion research programme, which has in turn led to the development of a “tearless” onion.
5.2.2 House Foods Corporation

So far I have spoken of the scientists at C&F, but it is important to remember that some of the tearless onion developers are identified as House Foods Corporation (HFC) employees (see Figure 5.2 above). HFC is a large Japanese company that manufactures and sells a range of processed foods. It is a multinational company with offices and other facilities in a number of countries, particularly in South-East Asia (House Foods Corporation, 2010). It is also the parent company of House Foods America Corporation (House Foods America Corporation, 2010).

As a private company, HFC aims to make a profit from the sale of its products. To do this it must constantly develop, market, and sell new food products; as part of its development programme it has a research laboratory (the Somatech Centre) in Chiba, Japan.

In 2002 a research team led by Shinsuke Imai and based at the Somatech Centre published an article in the journal *Nature* in which they described the discovery of a hitherto unknown enzyme: lachrymatory factor synthase (LFS). At the time of their discovery they speculated “that it might be possible to develop a non-lachrymatory onion by suppressing the lachrymatory factor synthase gene” (Imai et al., 2002, p. 685), clearly indicating the future value of their research. Such an onion would appear to fit in with their company philosophy of creating products that are “tastier, more convenient and healthier” (see Figure 5.6 above). The HFC team has filed for a number of patents in relation to their discovery\(^{38}\). Effectively, they “own” the LFS gene and are therefore able to control research that involves it; in Actor-Network terms, they have succeeded in black boxing LFS.

Since the discovery of LFS, Imai and his colleagues have conducted preliminary work *in vitro* indicating that an onion with decreased LF levels could, in principle, be created (see Kamoi, 2008, p. 14). It would be reasonable to question why this research team hasn’t developed a GM onion

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\(^{38}\) For example, United States Application US20090081754 and European Patent EP1482047
displaying decreased LF levels, choosing instead to move this research to a different laboratory in a different country. While it could be suggested that strong anti-GMO sentiment in Japan could impact negatively on HFC if it were to openly engage in GMO research, it is more likely that the strengths of the GM onion research team at C&F have led to this move. As I have already discussed, the C&F researchers have tamed the “recalcitrant” onion, and have placed their laboratory as a “centre of calculation” in GM onion research as a result. It would therefore appear that the development of tearless onions has resulted from a “trade” between laboratories: the C&F scientists have successfully black boxed the onion and the HFC scientists have black boxed LFS. But whereas this may explain why HFC needs to collaborate with C&F, it still doesn’t fully clarify why the C&F scientists have chosen to develop a tearless onion instead of some other GM onion variety. To do this requires a consideration of the organisation in which they work.

5.2.3 Crop & Food Research

![Organisational Structure of C&F]

Figure 5.7 Diagram showing the organisational structure of C&F taken from its statement of corporate intent (Crop and Food Research, 2008c, p. 1). Image © Plant and Food Research, reproduced here with permission.

The image above is a direct copy of a diagram included in the C&F 2008 annual report. It portrays C&F as a “black box”, an analogy that is particularly relevant to this analysis. This is because the organisation of scientific activity is something that is usually not attended to in popular conceptions of science: it remains an unopened “black box”. Nevertheless, in the case of tearless

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39 Japan has turned away an import of New Zealand bread found to contain GM ingredients (Walsh, 2003). More specifically, HFC itself tries to promote a “clean green image” (Interview E).
onions, these processes appear to be an important factor in determining the outcome of the tearless onion research project.

CRIs such as C&F are an important component of the New Zealand Research, Science, and Technology (RS&T) system (see Chapter 2 for discussion). Since the disestablishment of the DSIR and the creation of CRIs under the CRI Act (1992), the focus of the RS&T system has been to deliver specific outcomes of benefit to New Zealand. Such “outcomes” are widely interpreted to have a dollar value as illustrated in comments by Murray Bain, the CEO of FRST, when praising the performance of the RS&T system of countries in Scandinavia:

The Scandinavians are clear about the role of innovation and I quite like this catch phrase: “Research is the conversion of money into knowledge and competence” and “Innovation is the conversion of knowledge and competence into money”. (Bain, 2009, p. 5)

Although this comment was not made about CRIs in particular, the central role of CRIs in New Zealand’s RS&T system makes it directly relevant to the function of institutes such as C&F. CRIs are thus constructed as a “black box” of innovative processes that can somehow transform research funding into a larger value of commercial profit. This has been translated into the specific financial requirements that have been placed on CRIs: they are bound by legislation to operate as commercial entities and must deliver a 9% annual return on equity (see e.g. Hickford, 2009). It is also evident in the company slogans used by C&F, two of which are shown in Figure 5.8 below:

![Figure 5.8 Two screen shots taken from the C&F company website (Crop and Food Research, 2010). Images © Plant and Food Research, reproduced here with permission.](image)

Our purpose:
To lead New Zealand innovation in food and food production

The trouble is that these representations obscure the complexity involved in the function of a CRI. There is a multitude of different people working there, each with different beliefs and goals that may or may not align with the overall commercial orientation of the company. This can result in
employees taking a different view of “compliance” with company philosophy: as Hunt (2003) observes in her study of the organisational structure of a particular CRI, “scientific workers will work around the structures when they do not suit them” (p. 276). Nevertheless, in the case of the GM onion research, there does appear to be some overlap in the objectives of both the scientists and their employers.

Why do they bother to do... GM onions and... the gossip around basically is because they’re funded... money they bring money in and then you come back to what are the incentives in CRIs particularly and Universities and the incentive is to bring money in... that’s what gets you recognition that’s what gets you promotion that’s what keeps your job going... if you don’t bring money in you cease to have a job... and... given how tight funding is in New Zealand... and how difficult it is to have a research career... if Japanese people turn up offering you lots of money... you’ll do it. (Interview T)

This comment is interesting, not least because it isn’t totally clear who “they” are. If you read it closely it is evident that “they” are the researchers working at CRIs, but the role of scientists as it is defined here is tightly linked to the role of CRIs. Thus the speculation here is that the GM onion scientists have accepted foreign investment because it will advance their careers as CRI employees.

For C&F there is a different incentive. Tearless onions are not only an attractive research project because a foreign company is investing in their development, but also because GM onions can be patented and sold. If a commercial product can eventually be developed it stands to provide C&F with a future source of revenue, unlike the products of some other forms of onion research.

To get money from overseas for a product that you can sell overseas... is much more interesting than just working out that if you cultivated your soil in a different way and threw a bit of compost on... you can produce wonderful tasting onions... cos all you’ve got to sell at the end of it is more onions. (Interview T)

In many ways this is an oversimplification. There is no guarantee that a programme of GMO research will yield a commercial product; nevertheless, there is a desire to explore the possible applications of this technology and see what happens. GM onions are a potential source of income, but to realise this C&F must take a risk. It is therefore part of C&F’s overall research strategy, where investment is spread across a number of areas with the hope of making an overall

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40 This is based on comments made in Interview E.
financial gain. This is illustrated by the extract shown in Figure 5.9 below, taken from P&F’s 2009 annual report in a section outlining funding allocation.

The image above suggests that C&F spreads its research investments over a number of areas with the aim of making a net gain. There is obviously some potential for tearless onions to contribute to this financial gain, and they are therefore a calculated risk. Pictured in this way, it would seem that C&F assesses the tearless onion research in terms of costs and benefits to the company, and it uses this assessment to decide on whether or not to proceed with the research programme.

5.2.4 The Foundation for Research, Science, and Technology

As outlined earlier (see Chapter 2), the governance of New Zealand science is divided between two departments: one that is responsible for formulating policy (MoRST), another that is responsible for allocating public funds to research (FRST). Eady et al.’s (2008) mention of the use of FRST funding to develop tearless onions indicates that the government has an interest in the project, but there is no detail in this paper as to why this is the case. To ascertain these reasons it is necessary to look elsewhere. Take, for example, the following screen shot taken from FRST’s website:
Tearless onions have been modified to produce less of the tear-inducing compound LF, and as such it appears to have been designed to fulfil a “niche” requirement in the market. The text in the above image specifically links the development of such niche products to the overall benefit to the New Zealand economy, as opposed to other research that may seek to improve the “environmental or social conditions” of New Zealanders.

While I am not trying to suggest that there is anything wrong with developing a product for economic gain, these observations can be used as an indication of how the government would assess the tearless onion research and, importantly, whether or not they would choose to fund it. FRST funding is contestable (see Chapter 2 for discussion), and scientists of all disciplines must engage in “grantsmanship” (Interview X) if they are to secure it; that is, they must link the outputs of their research to priorities identified by FRST. But in addition to these priorities, it is likely that another aspect of the tearless onion research was a significant factor in FRST’s assessment of it:

   Government funding can lay down that… you’ve got to have other… stakeholders before you get any money… so the onions would probably be quite nicely funded by FRST because they managed to raise other funding. (Interview G)

   A lot of the government funding now you have to have both commercial funding to get government funding so you need to demonstrate that you have commercial funders on board. (Interview E)

Both of these quotations suggest that FRST is more likely to fund a project that has attracted private investment. If this is the case, C&F and the scientists who work there would have known this when they were considering the overall direction of their GM onion research programme. By
developing tearless onions they would have secured commercial funding, which was in turn necessary for securing public funding from FRST. In this way, tearless onion research fulfils C&F’s needs to be commercially sustainable, and for the scientists it ensures the sustainability of their careers.

5.2.5 The Environmental Risk Management Authority

Each of the four actors described above is involved in the overall success of tearless onion research. But there is a fifth actor that, while not specifically interested in tearless onions, is nevertheless necessary to the success of any kind of GMO research in New Zealand. As discussed in Chapter 2, all research institutions must gain approval from the Environmental Risk Management Authority (ERMA) to conduct GMO research. This means that ERMA is also necessary to the success of the tearless onion research.

At the time of the public announcement of its development, tearless onions were only being researched in “the laboratory and a greenhouse setting” (“Tearless Onion’ technological breakthrough announced”, 2007). The classification of tearless onions as a GMO means that they must have been developed in containment, which means that “the laboratory and greenhouse setting” in which they were developed was a containment facility (see Chapter 2 for discussion).

Containment facilities are defined and controlled by the HSNO and Biosecurity Acts. In accordance with this legislation, specific details of the physical and operational requirements for containment are outlined in a series of joint MAFBNZ and ERMA standards (see Chapter 2 for discussion). The containment facility in which tearless onions were developed must have been built according to these standards, meaning that C&F would have had to define a place within their complex that could be kept physically separate from others through the use of material structures such as walls, a concrete floor, and wire meshes on the windows. They also had to devise a number of operational procedures such as training programmes, logs and registers, and a multitude of protocols; all aimed at ensuring people working in the containment facility “behave” correctly41. Once these material and operational requirements had been arranged, an inspector would have approved the facility and issued it with a certificate. This certification process would essentially “black box” the complex assemblage involved in creating the containment facility, and it would no longer be questioned during considerations of the tearless onion research project.

41 Details of these procedures are included in application GMF06002 (Crop and Food Research, 2008b, Appendix 2).
Thus, ERMA’s link to tearless onions can be traced to its control of a black box that is vital to the success of the project. But there is another black box under ERMA’s control that is of equal importance to the success of tearless onions. As discussed in Chapter 2, all GMO research conducted in New Zealand must gain approval from ERMA before it can commence; the decision-making process involved differs depending on the type of research in question. Tearless onions are classified as a “low risk GMO” (see Crop and Food Research, 2008b, p. 17), which means that a decision on them can be made via rapid assessment: ERMA considers the application on a non-notified basis, or they may delegate their decision-making powers to an Institutional Biological Safety Committee (IBSC; see Chapter 2) if there is one at the facility making the application. In this case it was an IBSC at C&F’s Lincoln campus that approved the development application relevant to the tearless onion project. The decision form would have looked similar to that shown in Figure 5.11 (below).

Material removed due to copyright compliance


Figure 5.11 Application decision form issued by the IBSC at C&F in relation to GM onion research (ERMA, 2000).
This decision document comprises a single page, and contains very little information about the application that has been approved. In contrast, applications that do not involve “low risk” GMOs and which therefore cannot be considered on a rapid assessment basis involve a very different decision-making process. Some of these latter applications must be publicly notified, and there is a lengthy, costly, and highly publicised decision-making process that accompanies them. The classification of tearless onions as a “low risk GMO” therefore allows the research to progress without the necessity for a detailed examination of what is involved in the project. As such, it is another black box controlled by ERMA that is important to the overall success of the tearless onion research project.

5.3 Representing the object
In the above sections I started with individual actors, telling the story of how each is specifically involved in the creation of tearless onions. Each of these stories is different; but each of them overlaps, revealing the connection and co-definition of the actors. In doing so, it is possible to learn something about what tearless onions are as an object: how it becomes a reality through the practices of each actor. But as yet, there is no coherence to the representation of this object, and it remains as separate fragments given in each of the stories above.

In this section I will therefore consider how to combine the data I have collected into something that is more ordered, something that is “more than one, but less than many” [emphasis in original] (Law, 2002a, p. 3). To this end, I will consider the use of network representations, focusing in particular on three different approaches: Callon’s (1986a) “sociology of translation”; Star and Griesemer’s (1989) description of “boundary objects”; and Latour’s (1999a) circulatory model of “science’s blood flow”.

5.3.1 The translation of tearless onions
Callon’s (1986a) study of the scallops of St Brieuc Bay provides a complete reformulation of how to analyse the power relationships involved in scientific research. As such it provides me with a seemingly ideal way in which to combine the threads of the stories outlined above. How have the actors and the intermediaries under their control been brought together to ensure the success of tearless onions? The moments of translation described by Callon provide a method of breaking down the complexity of the GM onion research project and discerning the relationships between each of the actors.

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42 See Chapter 2 for some discussion. I will also consider this contrasting decision-making process in depth in Chapter 6.
Key to the process of translation is problematisation: when one actor is able to impose the definition of a problem and the relation of every other actor to it. In his analysis of the scallops of St Brieuc Bay, Callon (1986a) creates a visual representation of this in his diagram of the actors in relation to an Obligatory Passage Point (OPP) defined by the scallop researchers (ibid., Figure 2). Thus in problematising scallops, the researchers define the obstacles faced by each actor, whilst simultaneously presenting their research question (“does pecten maximus attach itself”, ibid., Figure 1) as the only means of overcoming these problems.

To perform a similar analysis on tearless onions would require the identification of who or what is responsible for problematising them: the “primum movens of the story” (ibid., p.203). An obvious choice would be the scientists at C&F. The press releases, journal articles, conference presentations and PhD research have all originated from the C&F laboratory; furthermore, I identified my own starting point for analysis by looking at a paper they had written, which in turn led me to each of the actors involved in the network.

If this approach is taken then it seems logical to assume that the OPP is the research question of the C&F scientists: i.e., “will the onion stop producing LFS?” The success of the research project is therefore reformulated as a result of the C&F scientists interesting all other actors in their research question so that they are forced to pass through the laboratory in order to achieve their individual goals. Figure 5.12 (below) provides a diagram of these pathways.

Although the network diagram shown in Figure 5.12 is based directly on Callon’s (1986a) original, one significant difference should be noted. Callon included scallops as an actor in his diagram, which would suggest that onions should be included as an actor in Figure 5.12. However, the evidence presented earlier in this chapter indicates that onions are not an actor in this network; instead, they play a significant role in another, related network. The success of the GM onion research programme at C&F has arguably been built on the successful translation of the “recalcitrant” onion into a tame, knowable object. The GM tearless onion is simply one instance of how this “translated” onion has been of use; other GM varieties such as herbicide resistance and reduced alliinase activity (see section 5.1.2 above) also rely on the stability of this onion. If the onions were to become dissidents in the same way as Callon’s scallops, it would not just be the GM tearless onion network that would fail: all GM onions would become unstable. My decision not to include onions in this network diagram should therefore not be taken as an indication that the onions lack agency. Instead, it illustrates that the successful translation of the

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43 Indeed, they have successfully inserted themselves into the pages of this thesis, as indicated by 534 occurrences of “onion(s)” in the main body of text.
GM tearless onion is reliant not only on the actors depicted in Figure 5.12, but also other stable networks.

Although Figure 5.12 appears to represent a number of the themes discussed in the narrative accounts of each actor’s role, significant details are nevertheless missing from it. It implies that the scientists have “interested” HFC, even though my examination of HFC’s role indicates they were the first to identify a “need” for tearless onions. Similarly, the scientists are employees of C&F, a CRI that needs to develop commercial products; given that the C&F scientists themselves appear more concerned with developing more sustainable farming practices, it seems more likely that C&F and/or HFC have interested them in developing a tearless onion so that the GM onion project as a whole is able to continue.

This issue is common in the ANT literature; as discussed in Chapter 3, it has led some to criticise the approach as providing centred or “managerial” accounts. It highlights unresolved questions of Callon’s own study such as: why did the researchers want to study the scallops of St. Brieuc Bay?

Figure 5.12 Network diagram showing the relationship between each of the main actors and a common interest. The research programme is represented by the Obligatory Passage Point (OPP). (Diagram adapted from Callon, 1986a, Figure 2)
Callon states that it is to “advance knowledge and repopulate the bay to the profit of the fishermen” (Callon, 1986a, Figure 2), but where did this goal come from? Actor-Network theorists speak of interressement as though it is actively deployed by an actor with the purpose of diverting the interests of another. But who or what was using the promise of “knowledge” to interest the researchers? Similarly, Latour’s (1983, 1988) account of the Pasteurisation of France may show that Pasteur’s success was the outcome of a heterogeneous network, but Pasteur is still cast as the central actor in that network. Hygienists, politicians, farmers, and bacteria are all interested by Pasteur. Proponents of ANT argue that these early studies of heterogeneous engineering are demonstrations of distributed agency, but the central role played by a single actor is typical in many accounts.

It may be that a central actor or an OPP works for some situations but not others. And when we are confronted with the latter, then what? It may be possible to find a different way of formulating this network so that a single actor is not responsible for its definition. Indeed, Latour does deal with this to a certain extent in *Science in Action*, where he elaborates on the various different types of translation (see Latour, 1987, Chapter 3). But this approach to network formation still requires the actors to be funnelled through one OPP, and we are forced to search for a single definition of reality that has been accepted by all actors in the network. Yet we know from Mol (2002) that reality can be multiple and distributed, that different realities can co-exist and cohere without any recourse to singularity. I will therefore turn to another method of assembling a network of actors, one that seems to allow tearless onions to retain their multiplicity.

### 5.3.2 Tearless onions as a boundary object

If tearless onions are conceptualised as a “boundary object” (Star & Griesemer, 1989), they become something that is “both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites” (ibid., p. 393). Under this model, it is not that a number of actors are brought together into an alliance with one common objective; rather, the object of their interest is flexible enough to accommodate their goals.

The concept of the boundary object is appealing as there is no need for one actor’s problematisation to be imposed on the network as a whole. Sometimes it makes more sense to say that an actor can see something in an object that interests them; thus interressement is a function of the interaction between subject and object, a “network effect” in much the same way as agency. Of course, different actors see differently, and some are of course made to see in a
certain way. Nevertheless, we cannot understand interessement in isolation from what the actors are interested in.

The data presented earlier in this chapter considered the role of five main actors involved in the tearless onion project. It is possible to use this data to identify a number of different “social worlds” (Star & Griesemer, 1989, p. 388) that, though separate, have been joined together through their focus on a single programme of GMO research. Star (2010) explains that researchers can detect the presence of a social world by looking for “special language used in the location, metaphors, mots justes, turns of phrase, private codes used by one group and not another” (p. 605, emphasis in original). Thus, C&F scientists portray the onion as recalcitrant yet under their control, placing themselves as the gatekeepers to further knowledge of it. C&F present it as an important asset, handling it in much the same way as an accountant who is attempting to balance the books, issuing statements in company documents that report on the return on this investment. ERMA’s goal to contain the onion is in part achieved by the use of various black boxes, such as the containment facility, that are closed from view, denying us access to witness the inner workings of GMO research as it is done in practice.

This separation between social worlds and the ability of the tearless onion to find a place in each of them is a function of the “interpretive flexibility” (Star, 2010, p. 602) that can be attributed to it. The tearless onion means many things to many actors, and there is therefore no need for a single “Obligatory” Passage Point that must be universally accepted. Cooperation is possible even without consensus (ibid.), and the actors work together to achieve the success of the tearless onion research project even though they have different definitions of the problem it will overcome. Instead of a single Obligatory Passage Point, the boundary object model relies on the presence of multiple Passage Points, each of which represents a different “vision” of the object (Star & Griesemer, 1989, p. 396). The data presented earlier in this chapter can be used to identify the different visions each actor has of the tearless onion. For C&F scientists, they are not only something to know, but also something that provides a stable source of employment. For C&F and HFC, they are something that could generate a return on investment if they pool their respective resources together; thus, for FRST, tearless onions fulfil current science funding criteria in New Zealand as it creates a public-private partnership. Finally, for ERMA, they are something to contain in a laboratory, where the risks of GMO research are reduced to a negligible level.

Although I have argued that the concept of an OPP is problematic, I nevertheless maintain that Callon’s (1986a) presentation of it is of use. Callon uses a question to represent the OPP, and this is arguably a much better way of explaining how an actor comes to enter into and take part in a
network. Answering a question requires active participation; “vision”, on the other hand, can be achieved via passive observation. Given that the focus of my analysis is on the actions and practices involved in scientific work, it is therefore more appropriate to use a question to represent the Passage Point for each actor. These have been incorporated into the network diagram shown in Figure 5.13 (below).

Figure 5.13 Network diagram showing the relationship between each of the main actors and their individual interests (Passage Points). Each interest is shared by more than one actor, but no two actors have identical interests. All actors accept the boundary object (the tearless onion) as the means of achieving their goals. (Diagram adapted from Star and Griesemer, 1989, Figure 2)

The first question, “will the onion stop producing LFS?” is the focus of the scientists working at C&F and their colleagues at HFC. It is the question that forms the basis for their research, joining eight researchers together in a scientific collaboration. While the evidence in this chapter suggests that the HFC scientists are particularly interested in LFS, the C&F scientists have a broader interest in manipulating the onion genome. This is represented by the second question, “will the scientific community recognise C&F as GM onion experts?”, because success in the tearless onion project could serve as a demonstration to other research institutions of their abilities in this field. C&F are also interested in this second question because a demonstration of research capabilities may attract future funding partners; hence they are also interested in the third question: “will industry partnerships be created?” This question also interests FRST, as evidence of public-private partnerships is taken into account when assessing funding applications. The requirement for CRIs to operate under a commercial model means that both FRST and C&F
are interested in the fourth question: “will GM onion research generate a return on investment?” HFC, as a private partner in this project is also led through this Passage Point. Finally, the legislative requirement to conduct GMO research in a containment facility means that both ERMA and the C&F scientists must focus on the fifth question, “will the laboratory contain the onion?”

Although this approach to network representation is not subject to the criticisms of Callon’s sociology of translation discussed earlier, a further set of issues are evident. First and foremost is the concept of “interpretive flexibility” (Star, 2010, p. 602) that underpins this model. Each actor views the object from a different perspective, thus creating a different interpretation of it; at the same time, the object’s ability to fulfil these interpretations is a measure of its flexibility. Studies of boundary objects tend to adopt a constructivist approach (Star, 2010) in which a representation of an object is built up inside the mind of an observer, separate from material reality. This is incompatible with the relational ontology that informs this thesis, in which the object/subject divide is collapsed and there is no disjuncture between the realms of reality and representation (Law & Singleton, 2005; see also Chapter 3 for discussion).

The division between subjects and the boundary object also means that it is not possible to use this concept to convey the multiplicity of the tearless onion. As discussed in Chapter 3, multiplicity can only be achieved through a fine balance: it must avoid the limited scope provided by singularity without confronting the endless possibilities of plurality. Figure 5.14 suggests that this balance has not been achieved because the object still stands apart from the subject: it exists independently of them rather than resulting from their interactions. It appears possible to remove actors from this diagram and still be left with a functionally equivalent object; similarly, we should be able to introduce further actors who have additional visions of the object without disturbing the other actors. Thus, even though Star and Griesemer’s (1989) model appears to fulfil my goal of describing an object without making recourse to a single passage point, it instead crosses over into plurality, and this in turn leads to an account that can become fragmented and incoherent (Law, 2002a).

It is also likely that tearless onions are not a boundary object, and this is why my attempt to represent them as one has failed. As Star (2010) observes, although it appears to have unlimited scope, the concept has been of most use in the study of certain types of objects, especially organisations. But the above discussion shows the utility of considering many Passage Points instead of just one “Obligatory” Passage Point. In the next section I will therefore use this observation to develop a third network representation of the tearless onion.
Figure 5.14 Network diagram showing the actors as a circulatory system that gives "life" to tearless onions. Diagram (a) shows the three different loops of the circulatory system, each of which involves pairs of actors interested in a common Focus Point. These Focus Points are given in diagram (b). (Diagrams adapted from Latour, 1999a, Figure 3.3)
5.3.2 The circulatory system of tearless onions

In Chapter 4 I outlined Latour’s (1999a) account of “science’s blood flow”, in which he describes how a network of actors keeps a scientific fact “alive”. While the conceptual “heart” is visible to the outside world, the rest of the “circulatory system” remains hidden from view. In the context of this study, Latour’s model can be used to represent the tearless onion network: the C&F scientists, C&F, HFC, FRST, and ERMA are joined together in a circulatory system that brings the tearless onion to life. The network diagram for this circulatory system is shown in Figure 5.14 (above).

Although Figure 5.14 is based on Latour’s (1999a) circulatory model, there are a number of significant departures from this original version. As I have already discussed in my consideration of other network representations, both the sociology of translation and the boundary object models include some kind of “Passage Point” for the networked actors. While I have argued against both singular and plural Passage Points, I nevertheless maintain that the inclusion of a similar feature is crucial: it can be used to convey the specific “interests” of each actor, and can therefore be used to explain why this particular group of actors have joined forces in a network. For this reason, the first alteration I have made to Latour’s original diagram is to include a number of “Focus Points”: questions that certain actors want to answer and which therefore serve to draw them into the network. These Focus Points are represented by a question mark in Figure 5.14 (a); the question itself is shown in the simplified network diagram shown in Figure 5.14 (b).

Second, I have not used Latour’s five circulatory loops per se, although the principle they represent is fundamental to my own diagram. Latour uses his model to emphasise that five different types of activity are involved in the creation of a scientific fact: “mobilization of the world”, “autonomization”, “alliances”, and “public representation”, all tied together by the “links and knots” of scientific content (see Chapter 4 for discussion). His use of these loops was not meant to indicate that the activities occur in isolation from one another; on the contrary, the “[f]ive loops have to be taken into account simultaneously for any realistic rendering of science” (Latour, 1999a, p. 100). In constructing my own network representation I have found it more appropriate to concentrate on particular themes evident in the data rather than impose Latour’s broad categories as a kind of framework for analysis. These themes are identified and discussed in detail in the following section; as part of this discussion I will also make reference to the loops of Latour’s model in order to demonstrate that the activities he identifies are still fundamental to the integrity of this circulatory network. The only loop that is not mentioned below is “links and knots”, this being the tearless onion research project. This project is everywhere, but at the same
time it is nowhere: there is no single part of the network that can be used to explain the success of the research, because it is distributed throughout the entire network.

My decision to use loops based on observed categories leads to a third significant alteration: each loop represents the relationship between specific actors. Instead of a continuous loop I have chosen to use separated lines that travel in one direction only (as denoted by arrows); the reciprocal relationship between the actors in a loop is represented by using a pair of lines between each actor pair. The reason I have made this change is that it shows that a trade occurs between actors within each loop. Hence I have also added a level of detail by including the black boxes and intermediaries involved in the network. The general nature of Latour’s original diagram means that it does not include this information, but it is an important addition as it can be used to understand how the dynamic “flow” of circulation is achieved.

The following sections give specific details of the circulatory loops I have used in Figure 5.14 to represent the tearless onion network. This information has all been drawn from the data presented earlier in this chapter, as well as the background information covered in Chapter 2.

**Organisation**

The first loop on the tearless onion network is a three-way relationship between C&F, the GM onion scientists who work there, and FRST. I have called this loop “organisation” because it represents how the overall organisation of scientific work in New Zealand is involved in the specifics of the tearless onion research project. This loop closely resembles the “alliances” identified by Latour (1999a, p. 103) as crucial to the success of scientific work because it explains how a diverse array of actors such as scientists, managers, and bureaucrats are all involved in creating GM onions. In Latour’s original model, however, he intended a much wider array of actors to be included in this loop: in the context of this study, onion farmers, exporters, and onion industry representatives would have been other relevant allies. The data presented earlier in this chapter do not indicate that such actors have a direct influence on the tearless onion research project, however, and the alliances that have been forged appear to be restricted to actors involved in the organisation of New Zealand science.

As discussed both through the evidence in this chapter and in Chapter 2, New Zealand science operates under a commercial model: CRIs are required to generate a return on public investment. To this end, the government has mobilised a number of intermediaries by which it can act upon CRIs such as C&F: the CRI Act (1992) and various policies relating to RS&T. While the Act directs CRIs to operate under a commercial model, policies such as the Biotechnology Strategy (MoRST, 2003) outline what research the government is likely to fund. These government-controlled
intermediaries serve to influence both the overall strategic direction of CRIs as well as the decisions they make with regards to specific research programmes. But C&F is not passive in this relationship; it mobilises intermediaries specifically targeted at influencing government policy (formulated by MoRST) and funding decisions (made by FRST). It interests the government with the money it generates; it also actively engages in lobbying the government through the Association of CRIs. This Association circulates publications and presumably sends representatives to engage in face-to-face meetings with government officials to influence the direction of future policy and funding priorities.

The negotiations between government and C&F are translated into the working conditions of the GM onion research team at C&F. The length of their employment contract is dependent on whether or not a project is funded, as is the provision of material resources such as laboratories and equipment. In order to secure their position, scientists therefore have to mobilise a number of intermediaries to interest their employer. Scientific journal articles and commercial patents are useful in this sense, but of particular relevance to this study is evidence of collaboration. The GM onion researchers have managed to establish relationships with a number of commercial partners over the years, including the current relationship with HFC. This brings external funds into the company, enabling C&F to fulfil its own role as a commercial entity.

Scientists also have a direct relationship with the New Zealand government via the administration of funding applications at FRST. Scientists apply directly to the Foundation for public funding of their research; thus, a written funding application serves as an important intermediary. Embedded within this intermediary is the above mentioned evidence of collaboration: the decision made by FRST is influenced by the presence of commercial partners. But these partnerships are themselves forged partly because they have such an important influence over the FRST decision: thus, FRST funding acts as an intermediary that interests C&F researchers in attracting private investment.

All of these activities can be understood as having a single focus: C&F, the GM scientists, and FRST are all interested in finding out if GM onion research will lead to commercial gain. This is the Focus Point for their relationship, as shown in Figure 5.14 (b).

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44 This is based on comments made in Interview X. The Association of CRIs has since been renamed Science New Zealand.
**Collaboration**

The second loop in the tearless onion network is that of “collaboration”. This loop is similar to Latour’s description of the “autonomization” (p. 102) of scientific work, whereby an area of expertise is created by collecting together numerous scientific colleagues who are all convinced of the importance of a particular line of research. As in the previous loop, however, I have narrowed my particular focus for analysis: instead of considering the much wider area of GM onion research I have chosen to focus on the relationship between scientists at HFC and C&F. My data is useful for understanding how tearless onions have been created rather than other types of GM onion; the relationship between HFC and C&F are therefore the only colleagues included in this analysis.

“Collaboration” does not simply involve a group of scientists putting their heads together and solving a problem. Here it is represented as a trade of interessement devices and black boxes that one actor or the other is able to control. The two laboratories perform an exchange: the scientists at C&F provide the black boxed network known in their laboratory as “the onion”; HFC provide a similarly black boxed network known as “LFS”. HFC also provide financial support and another crucial intermediary, the PhD student who travels from Japan to live in Canterbury for three years whilst “developing an optimal method for producing a tearless onion” (Kamoi, 2008). This trade of black boxes and intermediaries allows both actors to fulfil a goal that neither can achieve alone: both the C&F scientists and HFC are interested in finding out if the GM onions will stop producing LFS. This is the Focus Point for the relationship, as shown in Figure 5.14 (b).

**Containment**

The final loop in the tearless onion circulatory network is that of “containment”. As discussed earlier in this chapter, ERMA is drawn into the tearless onion network through the absence of LFS in tearless onions: the genetic modification that leads to this trait means that ERMA must grant approval for the research to take place. This approval is only given if ERMA assess that the risks of the research will be managed to a negligible level; this assessment is the Focus Point for both ERMA and the C&F scientists (see Figure 5.14 (b)), and the interaction between them is represented by this circulatory loop.

Unlike the other two loops, this one has no direct correlate with Latour’s (1999a) original model, although it incorporates elements of both “mobilization of the world” (p. 99) and “public representation” (p. 105). The first of these, “mobilization of the world”, is perhaps most obviously involved in this circulatory loop. The black boxes of “containment facilities” and “low risk GMOs” are heterogeneous networks of humans and non-humans that form the foundation of “the logistics that are so indispensable to the logics of science” (ibid., p. 102, emphasis in original):
without these black boxes in place the scientific “substance” of the GM onion research cannot even begin. The scientists need to be able to conduct their research in laboratory and glasshouse facilities, but these must be certified as approved containment facilities if the project is to proceed. Similarly, they need to be able to manipulate the genome of allium species, but unless these manipulations are classified as low risk modifications they will not qualify for a rapid assessment of their application, and this would create a barrier to their progress.

In order to proceed with their research programme, a network of documentation, equipment, protocols, plants, places, and people are assembled by the C&F scientists, and a written representation of them is submitted to ERMA (which in this case delegates its decision-making powers to the IBSC at Lincoln C&F). This application to develop a low risk GMO in containment is the intermediary that is passed from the scientists to ERMA. By approving the application, ERMA essentially forms two black boxes that enter into circulation: GM onions are black boxed as a “low risk GMO” and the place in which they are developed is black boxed as a “containment facility”.

This process of black boxing also reveals the link to “public representation”, although in quite a different way to Latour’s original definition. Instead of interesting the public in tearless onions and convincing them of the importance of this area of research, the containment loop serves to exclude the public from the network as a whole. The decision-making process employed by ERMA in its rapid assessment of low risk GMO research is crucial: it takes place in a private hearing where the public, though arguably represented by the particular membership of the committee, is nevertheless not present and therefore unable to act or influence the network. Furthermore, the use of black boxes serves to divert public attention should anyone choose to inspect this research programme more closely. By classifying a GMO as “low risk” or by certifying a facility as “contained”, complex networks are able to hide behind simple words with taken-for-granted meanings. Representations are formed that the public has no choice but to accept, and the tearless onion network remains stable.

There are many reasons why this network representation of the tearless onion is preferable to the other two networks considered in this section. The absence of a Passage Point, obligatory or otherwise, serves to decentre the object of the network without leading to fragmentation. Each actor is necessary to overall network stability because if any of the loops were to be broken, the “flow” would be stopped through the entire circuit. At the same time, different onions are enacted in different loops. Thus the actors are better conceptualised as nodes where a local representation of the onion is formed, which in turn feeds into a global network (cf. Mol, 1998; Law & Callon, 1992). Following from this, it is clear that there are networks within networks. I
have identified four important black boxes upon which the tearless onion network has been built. Each is under the control of a different actor, which reveals where the power is concentrated: ERMA, due to its control of the “containment facility” and its classification of the onion as a “low risk GMO”; the C&F scientists due to their taming of “the onion”; and HFC due to their discovery of “LFS”.

Finally, factors seen as negative by the New Zealand scientific community are integral to the creation of tearless onions. If public funding wasn’t so contestable, or if CRIs weren’t obliged to seek a profit, tearless onions may never have been developed. The particular actors involved in this network, and the relationships between them, are what have made tearless onions a reality; or, to quote Latour:

The alliances do not pervert the pure flow of scientific information but are what makes this blood flow much faster and with a much higher pulse rate. (Latour, 1999a, p. 104)

This network also represents how connections are made and established by detailing the various intermediaries circulated and controlled by each actor. This is a strength of network studies: it allows researchers to focus on the “hows” rather than the “whys” of the social (Law, 2008a), detailing the connections that must be made and maintained in the enactment rather than assuming there is an underlying reality to it. The network activities described in the above section therefore “do” reality. And, just as reality can be done in a particular way, so too it can be re-made or un-done, so that objects are always “in the making”. It is to this topic that I will turn my attention in Chapter 6.

5.4 Summary and conclusions

When the development of tearless onions was announced to the world, reports focused on the onion, and they described the efforts of a small group of scientists working in a laboratory in Lincoln, New Zealand. But the analysis presented here reveals the involvement of a greater number and variety of actors, extending far beyond the walls of the laboratory to include a heterogeneous mixture that breaks down the divides between “science”, “society”, and “nature”. This arrangement was neither accidental nor inevitable; a great deal of work has been involved in drawing these actors into a stable network, and it is this work that has been the focus of this chapter.

I have focused on five key actors involved in the tearless onion project: the C&F scientists; their employers, C&F; their Japanese partners, HFC; the science funding arm of the New Zealand government, FRST; and the authority that regulates GMO research in New Zealand, ERMA. First I
have identified their connection to the tearless onion project, before detailing the specific role played by each of them. At times these stories have overlapped to reveal similarities in purpose and vision; but it is nevertheless obvious that the GM onion research carries different meaning for each of these actors. In ANT terms, it isn’t just the meaning of the GM onion that differs; the reality of this object varies, as the practices in which each actor engages serves to enact a different tearless onion into being.

The tearless onion can therefore be described as multiple; but as with other explorations of multiple objects in the ANT literature, analysis does not end with a simple presentation of difference. It is also necessary to consider how these differences are held together to form a fractionally coherent object (Law, 2002a, Mol, 2002). The five different stories of each of the key actors had to be brought together in some way that displayed how an apparently singular object could be brought into existence. To this end, I considered three different methods of representing the tearless onion, each of which presents it as a network of actors. The first of these, Callon’s (1986a) “sociology of translation”, provided a plausible representation, but it failed to convey the multiplicity of the onion due to its reliance on a single translation of it and the inclusion of an Obligatory Passage Point. The second, Star and Griesemer’s (1989) “boundary object”, allowed for more than one translation, but it replaced singularity with plurality which, while more nuanced, imposed a divide between subject and object and suggested the existence of a single object in a reality “out there”. But the inclusion of multiple Passage Points in Star and Griesemer’s model had merit, and this feature has been incorporated into a third network representation based on Latour’s (1999a) “circulatory system” of science’s blood flow. This network depicts a number of relationships between pairs of actors, who are joined together through the deployment of interessement devices and a shared interest in a common Focus Point. The essence of the tearless onion cannot be located at a single point in this network, but its presence is nevertheless evident everywhere within it. It is this final network representation that conveys the tearless onion as a multiple and decentred object.

The analysis presented in this chapter has not only allowed me to gain an understanding of the tearless onion research project, it has also proved to be a valuable methodological discussion. ANT’s approach to network analysis is deemed by some as a valuable tool, while others view it as an early step in the development of this area of scholarship (see Chapter 3 for discussion). Here I have performed a critical application of network analysis, considering the relative merits of a number of different approaches and following no single format unquestioningly. Thus, I have used the network approach as a guide to analysis without suggesting that it provides an
underlying structure to it. I have also incorporated aspects of recent ANT scholarship, showing how multiplicity can be represented using analytical techniques that have previously been criticised for performing singularity. In this way, this study engages with recent discussions regarding the place of network analysis in ANT (e.g. Law, 2008a) and the social sciences as a whole (e.g. Hinchliffe et al., 2013), demonstrating that the systematic and methodical techniques outlined in early ANT studies are still of use today. I will consider these overall findings further in Chapters 8 and 9.
Chapter 6

Moving tearless onions from the laboratory to the field

6.1 Introduction

Chapter 5 ended with a comparison of three different ways of approaching the tearless onion network. The third analysis showed how actors collectively achieved their common goal of creating a stable, black boxed network, and in this way the tearless onion research could be described as a success. This allowed the tearless onion to be represented as a more-or-less coherent object, a representation that nevertheless conveyed the multiplicity of the onion as it was enacted in various parts of the network. But although a network can be described as “black boxed” it is never truly static; all it takes is for one small change and the relations between all actors can change, thus affecting the translation of the network as a whole. As Law (1992) notes, “[p]unctualization is always precarious, it faces resistance, and may degenerate into a failing network” (p. 385). And, just as a network requires constant maintenance, so too is the study of science in action an ongoing endeavour.

This chapter follows the tearless onion network beyond its initial laboratory development during an attempt to move it out into the field. According to Latour (1983, 1988), Louis Pasteur’s successful “Pasteurization of France” resulted from successive movements between the laboratory and the field, each location being used to strengthen the position of his discoveries.

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Material removed due to copyright compliance

View image of “4x20 onions” on page 33 of document available at: http://www.epa.govt.nz/search-databases/HSNO%20Application%20Register%20Documents/GMF06002_GMF06002%20application.pdf

Figure 6.1 Two different “tearless onions”: a biochemical pathway developed in a laboratory (left; see Eady et al., 2008, Figure 9) and a plant grown in a field (right; see Crop and Food Research, 2008b, p. 33). To move from left to right requires a renegotiation of the tearless onion network.
within French society. Accordingly, the logical progression for the tearless onion research project is for the actors to take the onions outside: they need to move from their black boxed laboratory version of tearless onions to a new onion, this time grown in a field. Figure 6.1 (above) depicts this move. The image on the left is the diagram of the altered biochemical pathways present in the laboratory-developed tearless onion (see Chapter 5; also Eady et al., 2008, Figure 9). The image on the right is a diagram of a field test of these GM onions (Crop and Food Research, 2008b, p. 33). Movement from the onion on the left to that on the right is not simply a matter of physically moving the onions from one place to another; as I will discuss in this chapter, it requires a complete renegotiation of the tearless onion network.

6.2 GMF06002

The regulatory processes that control GMO field tests are substantially different to those that govern laboratory-based work (see Chapter 2 for discussion). While both places are legally defined as “containment facilities” and are therefore built and operated in accordance with the same regulatory standards, the decision-making process that accompanies each form of research is significantly different. In Chapter 5 I discussed how the laboratory-based development of tearless onions was approved under a rapid assessment of the application; such an assessment cannot be applied to a field test of the same GMO because “[d]evelopments that take place in outdoor containment facilities, do not fall under the ‘low risk’ criteria” (EPA, 2014a). The movement depicted in Figure 6.1 is therefore partly dependent on the scientists’ ability to negotiate a different application process, and it is this that provides the starting point for analysis in this chapter.

In Chapter 5 I presented the data I had collected as a number of “pathways” by which five different actors had become joined in the tearless onion network. Similarly, in this chapter I will relate a number of different accounts, each of which deals with the application to field test tearless onions. This application is known by the code assigned to it by ERMA: GMF06002 (Crop and Food Research, 2008b). First I will consider the application itself: documentation submitted by the C&F scientists to ERMA. These documents will not be the sole source of information, however, as contained within them are references that link together a much larger number of documents, actors, and previously black boxed networks. Each of these lends strength to the field test application, increasing its chances of stabilisation. Decision-making documents are also the focus of the second account, in which I consider a number of the written submissions made in relation to GMF06002. The emphasis here is on debate and controversy: the submissions not only offer divergent views on the effects of the GMO field test, they also link these effects to the
future socio-economic development of New Zealand. In the third section I look beyond the formal decision-making space provided by ERMA. ERMA can only make decisions based on the presence of a field test application, but it is important to recognise that there is a paucity of such applications in New Zealand, and consider why this is the case. This leads me to examine alternative decision-making processes, a theme that carries through to the fourth and final narrative, in which I consider the events that follow ERMA’s decision on GMF06002. Here I trace a much less visible network of actors, revealing connections that serve to decrease the stability of the tearless onion network, ultimately leading to the failure of the research project.

6.2.1 Application

On 8th April 2008, C&F lodged an application with ERMA to conduct a GMO field test. The research had the following purpose:

To field test over 10 consecutive years, the vegetable allium species onion, garlic and leek with genetically modified agronomic and quality traits in order to assess their performance in the field and investigate the environmental impacts of these plants. (Crop and Food Research, 2008b, p. 7)

Tearless onions aren’t specifically mentioned in this description, they’re included in the reference to “quality traits”. This link is made more clearly later in the application document, where a description is given of the quality traits that will be modified:

(b) the silencing of specific traits (e.g. sulphur or carbohydrate pathway genes such as sst-1 or lfs or Alliinase) either through the inhibition of enzyme activity (through the production of an inhibitory molecule) or by altering the levels of the protein (at either the transcriptional, post transcriptional, translational or post translational stage, e.g. through the use of RNAi or antisense based gene silencing). (ibid., p. 20, emphasis in original)

There is no mention of tearless onions here either; but the biochemical pathway that produces LFS is explicitly mentioned, and in doing so it brings the entire tearless onion network into this one application document.

But it is not only the laboratory development of tearless onions that is drawn into this document. Other research projects are also mentioned in its pages and these are used to confer stability to this field test application. A previous field test of GM onions is one such project: in 2003, the C&F scientists successfully applied to ERMA to run a field test of glyphosate-tolerant onions (GMF03001). As part of the consent conditions (and as is usual for such approvals) they were required to file a report with ERMA once a year giving details of the progress of the research
programme. The extract below has been taken from the last of these reports, written after the field test had been completed:

Information that in the approval holder’s view will assist the Authority with future considerations

The trial and controls were in general well suited to the programme of research that was applied for, with the following exception. From the approval holder’s viewpoint the sowing of seeds would have greatly facilitated the ability to obtain more relevant impact data on potential new management strategies for herbicide-tolerant crops, because testing the efficacy of weed control at the early stages of onion growth (e.g. between emergence and first true leaf stage) is an important component of effective weed control in onion. However, applying for permission to do this was judged by the applicant to be too great a risk to the success of the application (due to the political and social climate at the time) and so it was not requested. In future, greater dialogue with ERMA prior to submission of the application may help to clarify the relative merits of such requests. Such prior dialogue could help applicants who are feeling pressured by such external factors (recent dealings with ERMA over a new application would indicate that this prior dialogue is already being implemented).

(Crop and Food Research, 2008e, p. 2)

The contents of this extract indicate the continuum within which a single field test application sits. While the “future considerations” mentioned in the title no doubt apply to any applications to field test a GMO, the details provided clearly show that by conducting this earlier field test, the C&F team were able to enter into “dialogue” with ERMA over a “new application” (presumably GMF06002). This “dialogue” is not a formalised component of ERMA processes as outlined in the HSNO Act; yet it is here acknowledged as an important tool, both to ERMA as decision-maker, and C&F in the planning of research trajectories. We can see here that the approval for one field trial is used to form the application to conduct the next, thereby transferring stability from one to another.

A field test links together successive research projects, and in doing so it also creates connections between research partners. In Chapter 5 I portrayed the scientific collaboration between C&F and HFC not as a meeting of minds, but as a trading of resources in order to achieve mutually beneficial goals. A field test provides the opportunity for a stronger collaboration because it enables them to generate more resources:
Seed production is necessary for some lines to enable us to effectively collaborate with our research partners... Whilst it is possible to produce seed within PC2 glasshouse facilities it is difficult due to disease pressure, space requirements and sub-optimal thermal and light units. (Crop and Food Research, 2008b, p. 30)

Due to the general nature of the GMF06002 application there is no way of knowing whether reference to “some lines” includes tearless onions, nor if “research partners” include HFC. Even so, the situation outlined above makes it clear that there are certain products - be they seeds, intellectual property rights, or some other research output - that research collaborators require in exchange for their support. Growing tearless onions in a field will allow C&F to fulfil their contractual obligations, and both parties will be satisfied that they have each profited from this partnership.

But the opportunity for collaboration provided by the field does not stop at the partners involved in a single contract. Field-based research provides an opportunity to forge connections with new partners, which can in turn lead to new avenues of research. The laboratory programme to develop tearless onions was itself begun in this manner:

The success of the [GMF03001] trial has also led to the successful development of additional Allium based research projects with several international companies that are also interested in pursuing biotech approaches to try and improve the Allium industry. For example, the tearless onion research (Eady et al. 2008) was sprung from our success in developing and assessing the glyphosate-tolerant lines. (Crop and Food Research, 2008e, p. 6)

Furthermore, the field test of tearless onions may generate new research partnerships:

This will enhance our ability to attract research funds, both from NZ and possibly overseas (the previous trial has contributed to the securing of over half a million dollars of international funding). Several valuable research proposals, both government and industry funded, will be severely compromised if this application cannot proceed. (Crop and Food Research, 2008b, p. 60)

ERMA recognises that the ability to create connections between research programmes is a valid reason for conducting a field test:

The Committee heard from Crop & Food Research’s applicant team... how this application fitted into the larger picture of its research projects. The Committee acknowledges that the
The applicant is a world leader in this technology and wishes to retain this position. (ERMA, 2008, p. 6)

The links between past, present and future research projects are explicitly recognised here. Also evident is that the scientists’ desire to remain “world leaders” in GM onion research is not enough to achieve this status; after all, this is why they are making an application to ERMA to continue with their work beyond the boundaries of the laboratory. ERMA acts as the gatekeeper to the field, which in turn secures funding, status, and eventually the means to make future field test applications. The connection of networks continues; as it does so, GM onion research strengthens, bound together by the additional intermediaries that are circulated with each move from the laboratory to the field.

6.2.2 Consultation

Upon receipt by ERMA, application GMF06002 was publicly notified, and any person in New Zealand was able to submit their opinion on it (see Chapter 2 for a discussion of this process). Many submissions were strongly opposed to the research, some were strongly in favour of it, and some were neither for nor against it but wanted to comment on particular aspects of the application.

In their application, the C&F scientists acknowledge that some people may have objections to the field test:

A few members of the community may feel personal spiritual adverse effects from this trial proceeding in NZ and some may consider that opportunity costs are being lost as monies spent undertaking this research could be used elsewhere. Potentially such research may be perceived detrimentally by export markets. (Crop and Food Research, 2008b, p. 56)

Implicit in this statement is a separation between objective scientific facts and subjective perceptions. While it is true that some submissions fit this assessment, it is also evident that the arguments made by others are just as technically-informed as those of pro-GMO actors. Many submissions appear well researched and referenced; one interviewee (Interview A) even commented that it was the applicants who did not display an adequate understanding of the scientific details of the research. The joint submission made by Soil and Health/Physicians and Scientists for Responsible Genetics was written by someone who previously worked as a GM onion scientist and offers scientific arguments against the field testing of GMOs. GE Free New

45 Chapter 4 and the Appendix provide details of the submissions I have used in this analysis.
Zealand also gives a scientific analysis of the application, providing a detailed commentary on the specific contents of it. The Sustainability Council focuses on other aspects of GMF06002 by providing an in-depth economic analysis of field test research. Sustainable Future provides details of two high-profile social science analyses of GMO research in New Zealand (Sustainable Future 2008a, 2008b); these reports are also referred to by other submitters. Thus, “members of the community” are able to express opinions that extend far beyond “personal spiritual adverse effects”. Furthermore, these community members are not all standing as individuals: many have formed groups who appear to be highly organised in their approach to advocating against GMO research, and some have shared the content of their own submissions in order to encourage others to submit on the application. As such, they are positioning themselves as alternative authorities on GMO research in New Zealand, ones that stand in direct contrast to the dominant scientific establishment.

In many of the submissions, the GM onion research itself is not specifically debated; instead, the field becomes the object of conflict. Some submitters explicitly state that research should be kept in the laboratory; that if it is taken out into the field it will “contaminate” New Zealand. Thus it is argued that field tests will prove detrimental to New Zealand’s position in agricultural production.

It is paramount that we safeguard NZ’s unique position as solitary GE Free first world ag producer – this gives us a tremendous advantage for our products with consumers who increasingly are rejecting genetic modification of food.

There is an absolute need to have only the complete confinement of any GE trials.

(Submission ID 9982)

A focus on the field is evident not only in submissions made against the application, but also those in favour of it. Supporters of GMF06002 argue that field tests are a necessary tool in agricultural science. It will allow for the development of new cultivars, new breeding techniques, and also strengthen the research capabilities of scientists working in this country.

HortResearch supports the proposed field trial on the grounds that such trials are a natural and necessary element in progressing the scientific study of genetically modified plants.

(Submission ID 10021)

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46 The Giant Experiment website (Giant Experiment, 2008) posted a submission template that was used by a number of people in their own submissions. Interview A also spoke of sharing submission content with others.
The direct contrast between these two positions can be portrayed as a variable interpretation of the recommendations made by the RCGM (2001). Although there were a total of 49 recommendations in the final report, these were prefaced with the overall conclusion that “New Zealand should keep its options open... we should proceed carefully, minimising and managing risks.” (RCGM, 2001, p. 2). The wording of this conclusion is evident in statements made by supporters of the field test application:

Scion notes that the Royal Commission on Genetic engineering have in their report stated that “New Zealand should keep its options open” with regards to the application of genetic engineering technology. (Submission ID 9926)

In addition to the *Allium*-specific data sought by C&F, their field trial will also generate valuable knowledge in the wider sphere of applied crop biotechnology that will enable New Zealand researchers to keep the options open for the future of New Zealand agriculture. (Submission ID 10021)

Supporters of GMF06002 invoke the words of the RCGM to argue in favour of the application, focusing on the recommendation to keep options open. Those against the field test also refer to the need to keep options open, although the context they place this in is quite different:

The suggestion by the applicant that New Zealand may be forced to grow GM (under ‘Free trade’ rules) is offensive. This cannot be a reasonable consideration given governmental acceptance of the recommendations of the Royal Commission on GM to preserve options including GM-free production. (Giant Experiment, 2008)

Not surprisingly, each side of the debate is emphasising the need to keep options open that they personally support. Furthermore, those against the submission also stress the unacceptable risks involved in the field test, which can in turn be linked to the RCGM’s recommendation to “proceed carefully”:

The Royal Commission recommended ‘cautious release’. This application does not meet even a reasonable standard of caution. (Submission ID 9944)

The submissions made by those for and against GMF06002 therefore display a high degree of symmetry. On both sides of the debate we can find organised groups who claim to provide

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47 The exact wording of this quotation appears to have originated from the submission guide made available at the Giant Experiment website. This paragraph was included in eight of the submissions used in this data analysis (Submission ID: 9928, 9959, 9993, 9994, 9995, 9997, 10000, 10015).
authoritative knowledge on the application. There is also symmetry in the argument itself, a slight change in emphasis leading to a complete change in opinion. Thus it appears that ERMA is being asked to choose between two entirely different tearless onion realities.

6.2.3 Absence
So far I have considered the conspicuous presence of a GMO field test application by analysing the large number of documents associated with it. But alongside this presence is an equally conspicuous absence: GMF06002 is one of only a handful of applications that have been made to field test GMOs in New Zealand in recent years. Since ERMA was established in 1998, the number of approvals for research in outdoor containment has declined, and this decline is most apparent in the period following the RCGM. Since the publication of the report of the RCGM, only three applications had been approved by ERMA prior to their consideration of GMF06002 (i.e. between July 2001-April 2008; see EPA, 2014d). This situation has become a source of debate for those who work within this industry.

Very few agricultural or horticultural-related GM trials are under way... If the New Zealand economy is to benefit from GM, however, then these trials will have to be conducted at some point. (Slim, 2010, p. 4)

George Slim made this comment while he was the Director of Emerging Technologies at MoRST; it thus serves as an indication that the government is generally in support of field tests. It also indicates that, while the government may be able to promote field tests as important to the New Zealand economy, this is not a sufficient reason for research institutions to actually conduct them. Some argue that the cost and complexities of the ERMA process pose a significant barrier, warning that New Zealand is approaching a “moratorium by stealth” because of this (Glare, 2010, p. 3). But there are other reasons that are perhaps not so openly discussed.

I don’t think it’s the ease of... whether or not... how easy the process is I mean the expense is one thing but it’s also the public perception thing that goes with it about whether or not you want to go ahead with it or whether you’re going to do it... the trial offshore or whether you’re going to keep it in the lab and do more on it in a glasshouse or something so... I don’t think it’s the ease or difficulty. (Interview E)

Although field tests are technically conducted “in containment”, for companies such as C&F they are still a very “open” form of research. They serve as a public demonstration of an institution’s research capabilities, and while this can lead to benefits, it can also lead to problems. In many cases, such problems mean that an institution decides not to take its research out into the field.
There were lots of other players in New Zealand who were very supportive and were doing the same thing but weren’t going to the field trial stage because of... the public perception and also because they didn’t want to upset clients who were opposed to GM. (Interview E)

The implication here is that an application to conduct a field test has wide reaching effects throughout an entire research institution. To understand why this is the case it is important to consider the research institution as a whole, a company that employs not only GMO researchers but also many other scientists working on other research programmes. In some cases, the financial backers, or “clients”, of these other research programmes may themselves be opposed to GMO research: if they do not want to be associated with a pro-GMO company, they may withdraw their support from it. The reason for this can be tied to “negative publicity”: companies that fund research must ultimately be developing products for commercial sale, and somewhere down the line “the public” will be making the decision whether or not to purchase a product or service provided by that company. As discussed in Chapter 2, there are many examples of consumer boycotts on companies associated with GM products; others proudly label themselves as “GE-Free” to attract these same consumers. Thus the “purse power” of a supermarket shopper can ultimately have a similar effect to the physical power of a militant eco-terrorist. In both instances, public action is influencing a company’s decision-making processes.

But even for companies such as C&F who are known to conduct GMO research, it is still necessary for them to take measures to control information that is made publicly available. For field test applications, this means that the ERMA application document is itself closely scrutinised by non-scientific personnel before submission:

So he needs to fulfil the requirements of ERMA but he also needs to make sure that the things he’s saying are not going to cause the organisation a problem later... there’s certain things you need to say and things you don’t need to say... and because they’re publicly available documents so it’s how do you make sure the messages in there are consistent with what the organisation is thinking and that [a scientist’s] application is in line with the organisation... I mean his managers and science managers have that role too but we put our media aerials up and say... is there anything in this from a media perspective that would cause a problem. (Interview E)

This level of intervention isn’t always necessary; but neither is the monitoring of scientists’ language restricted to ERMA field test applications. The following comments were made by a GM scientist whose work is restricted to laboratory-based research:
H fell out with Crop & Food because they wanted H to go through a media training programme so that he’d use the correct language when talking to the media about GM. H thinks that Crop & Food were doing this so as to manipulate public perceptions of GM as they had a lot to gain from public perceptions of this technology (through research funding). (Extract from interview notes, Interview H)

GMO research involves many different techniques, applications, and outcomes, and certain amongst these are acceptable to the public whilst others are not. Communications advisors can present information in such a way that it is more likely that a research programme will be publicly accepted, but issues may still arise. The most effective strategy is to keep GMO research absent from public view, which can be achieved by not conducting a field test. Even the process of applying to conduct a field test can lead to an unacceptable level of publicity, which is a significant reason for the small numbers of such applications in New Zealand.

6.2.4 Decision

On 27th November 2008, ERMA issued its decision on application GMF06002 (ERMA, 2008). The field test was approved (with controls), thus allowing C&F scientists to take tearless onions out of the laboratory and into the field. Nevertheless, this approval has never been activated, nor are there any plans to do so. Furthermore, there is evidence that the laboratory research programme has itself run into difficulties.

The image shown in Figure 6.2 (below) is part of a presentation made at the California Garlic and Onion Symposium by the lead scientist in charge of the GM onion research at P&F (Eady, 2012). Addressing the topic of “Biotech approaches to [Allium White Rot]: perils and pitfalls”, he discusses the issues encountered during the course of the GM onion research programme. As Figure 6.2 indicates, these issues have resulted in an almost entire dismantling of it: plants have been destroyed; commercial collaborations have been lost; and both the field and laboratory facilities at P&F have been closed down. In all, 5 years’ worth of work has been lost. Given that this presentation was made in 2012, “5 years work” is presumably the work done since 2007: this is roughly when tearless onions were being developed in the laboratory, as discussed in Chapter 5. Although I assessed this network to be a stable black box, the information presented here suggests that instability has nevertheless entered into this network, and the project has ended up “in the cemetery” (Latour, 1996a, p. 143).
Figure 6.2 Extract from a presentation on the “perils and pitfalls” of biotechnology research (Eady, 2012, p. 14). This slide lists the consequences to the GM onion research programme that have resulted from various issues encountered during the course of the research.

The question is, how could this have happened? The presentation gives a number of “perils and pitfalls” that have beset the GM onion research programme. In addition to the scientific challenges involved in modifying onion germplasm, a number of other issues (ostensibly “non-scientific”) are highlighted that have made it difficult to make progress. These are shown in Figure 6.3 (below).

Figure 6.3 Extract from a presentation on the “perils and pitfalls” of biotechnology research (Eady, 2012, p. 8). This slide lists non-scientific issues that have impeded the progress of GM onion research at P&F.
The first item in this list specifies “Unrelated? Related compliance problems”. This point is elaborated upon elsewhere in the presentation: Figure 6.4 (below) shows two slides that outline two separate incidents at P&F’s Lincoln research campus.

Figure 6.4 Extract from a presentation on the “perils and pitfalls” of biotechnology research (Eady, 2012). The image on the left relates to a breach of containment conditions at P&F’s GM brassica field test site in 2008 (p. 9); the image on the right relates to a breach of containment conditions at P&F’s laboratory containment facilities in 2009 (p. 11).

These slides give details of issues that were encountered in two other GMO research projects being conducted at P&F. The first of these involved the detection of a flowering GM brassica plant in a field test; this was a breach of the consent controls issued by ERMA and therefore represented a “compliance issue”. The second incident involved the detection of GM Arabidopsis plants growing outside an indoor containment facility; again, this was a breach of consent conditions and was also a compliance issue. While both of these incidents could be described as “unrelated” to GM onions because they were separate programmes of research, they have nevertheless been identified here as “related” to the failure of the GM onion research project. A reason for this can be found in Figure 6.3, where the “company response” to these compliance issues is mentioned. There is no other information given in the slides of this presentation, but elsewhere a direct link has been made between one of these incidents and the discontinuation of other GMO research at the institution.

Plant & Food spokesman Roger Bourne said the [GM brassica] trial would not be reactivated and Plant & Food had no plans for other GM field trials in "the foreseeable future". Bourne said Erma had recognised the hard work the Crown research institute undertook to correct its procedures. "We do, to a certain extent, have to put the issue behind us, but we can only do that if we make sure it doesn't happen again," he said. "It's embarrassing and it breaks the trust with the general public. We need to do better."

(Williams, 2009a)
The above extract is taken from a newspaper report on the GM brassica containment breach, and reveals that the problems encountered during this field test caused C&F to cancel all other GM field tests. The extract also mentions that the incident lead to a breakdown in the trust between C&F and the public: this links back to points I have already raised in section 6.2.3 concerning the public image of GMO research. Here I discussed how negative publicity associated with GMO research can be translated into impacts that are felt across a research institution, which is why many companies choose not to conduct high profile field tests. In the past, C&F has tried to manage the impacts of negative publicity by controlling media communications; in this particular instance, however, communications strategies are not sufficient, and the decision has been made to cease all field testing. While this benefits the company as a whole, it has led to the dismantling of the GM onion research project. The once stable network is therefore destabilised, and tearless onions cease to be a reality.

6.3 Representing the object

As in my analysis of the laboratory phase of tearless onion research, my task is now to provide a method of representation that can be used to describe and understand the object of my study. Each of the four narratives presented above focus on application GMF06002, but as yet they are disjointed and incoherent. The goal of this section is therefore to explore whether network analysis can be used to join these narratives together, providing a representation of the object that nevertheless conveys its multiplicity. Once again, I will consider three different network approaches taken from the ANT and wider STS literature, discussing how each of them can be used to represent the tearless onion when it is taken out into the field.

6.3.1 The translation of tearless onions

The description of the ERMA application and decision-making process reveals an important aspect of the space in which it takes place: it is a space in which only experts are found. I make this point in a somewhat different way to other researchers (such as Rogers-Hayden, 2004) who have considered the role of experts in debates over GMOs in New Zealand; my aim here is to point out that both sides of the debate are occupied almost exclusively by experts. Regardless of whether or not they are in support of the field test, most (if not all) people who speak at the hearing have a great deal of experience in similar situations. This conclusion can be drawn by considering the information in the Appendix: some people have spoken in relation to other field test applications; others have made public submissions on unrelated matters; still more are involved in campaigning on a range of topics; a few own or manage businesses that have some relation to GM onions. Each submitter uses his or her position to speak on behalf of a multitude
of silent actors: New Zealanders, farmers, export markets, onions, and soil microbes to name but a few. Thus, these experts are equivalent to Latour’s (1987) “spokespersons”. Each spokesperson presents a different picture of reality; each tries to make ERMA “see” what will happen if the onions do or do not move to the field. Depending on ERMA’s final decision, the tearless onion network could be successfully connected to the field; or it could be completely destroyed.

The presence of spokespersons at the ERMA hearing, each putting forward competing interpretations of the field test application could be indicative of a struggle between opposing networks. If this is the case, it would be appropriate to use the data I have to describe the two parallel processes of network building, and then analyse the strengths and weaknesses of each network to explain the overall outcome of the hearing.

Figures 6.5 and 6.6 (below) show how these two different networks could be visualised using Callon’s (1986a) concept of the Obligatory Passage Point. Although I was critical of the singularity performed by this method in Chapter 5, here it provides a useful representation of the conflicting processes of network building that take place during the ERMA application. This is possibly a reason why Callon’s diagram has been used to model other controversies (see Chapter 4 for discussion). The scientists are keen to interest a number of actors in the need to grow tearless onions in the field; anti-GMO groups are just as keen to interest many of the same actors in the need to keep tearless onions in the laboratory. Both of these needs have the same premise: the RCGM’s recommendation that New Zealand should “proceed with caution” in the area of GMO research (see Chapter 2 for discussion). The difference, as emphasised in the diagrams, is that the scientists at C&F stress the need to proceed, whereas the anti-GMO groups stress the need to be cautious.
Figure 6.5 Network diagram showing the problematisation of the tearless onion field trial by the C&F scientists. The main argument presented at the ERMA hearing is represented by the Obligatory Passage Point (OPP). (Diagram adapted from Callon, 1986a, Figure 2)

Figure 6.6 Network diagram showing the problematisation of the tearless onion field trial by anti-GMO spokespeople. The main argument that they present at the ERMA hearing is represented by the Obligatory Passage Point (OPP). (Diagram adapted from Callon, 1986a, Figure 2)
An appeal of this approach is that it shows the arguments of the two groups in comparable terms; not only does this reveal symmetry in the arguments used at the hearing, it also points towards a symmetry in the organisation and role of the pro- and anti-GMO camps themselves. But the presence of a highly public conflict and the symmetry within that conflict does not necessarily indicate two directly conflicting processes of network building. A successful translation is contingent on the ability to enrol and mobilise allies (Callon, 1986a), but the ERMA hearing does not provide the space in which these processes take place. Even if submitters invest considerable time and effort into explaining the need to keep the tearless onion research in the laboratory, their words can only be taken into account in the final decision if they fulfil certain criteria. The Authority highlights this point in its decision:

Some submitters expressed their frustration with the process and in particular raised concerns that they do not feel listened to. The Committee wishes to assure those submitters that their concerns were listened to and that the Committee has taken full account of the issues raised. However, the Committee is required under the Act to consider the application in accordance with the Act’s provisions, which include taking into account benefits as well as costs and risks. (ERMA, 2008, p. 7)

My aim is not to evaluate whether or not ERMA is correct in how it makes its decision; this is the topic of a debate that lies beyond the scope of this thesis. The point I wish to make is that to portray pro- and anti-GMO networks in the way I have done above is to imply that, in its role as decision-maker, ERMA “chooses” one network over the other. But there is no such choice to be made. ERMA’s role is to manage the risks of GMO research, not to question the validity of a particular research programme. Thus, the main area for debate is the conditions that must be placed on the field test in order to minimise the risks associated with it. This may explain why the only influence the anti-GMO spokespeople have relates to the details of these conditions:

The Committee wishes to thank Claire Bleakley and Jon Carapiet who, submitting on behalf of GE Free NZ, suggested a number of controls they would wish to see considered if the application were to be approved. In the section on controls (Appendix 1) the Committee comments on the specific suggestions. (ERMA, 2008, p. 7)

But this observation leads to another possible representation of the network that again makes use of Callon’s (1986a) Obligatory Passage Point. The key is to reformulate the role of ERMA in the application process.
In the end when the government had decided what it was going to do with the recommendations [of the Royal Commission] it basically said... the commissioners said proceed with caution... the process of proceeding with caution is for it to go through ERMA processes... and this is the framework within which ERMA has to make its decisions.

(Interview T)

This quotation points towards a different way of conceptualising the network: with ERMA itself as the OPP. All actors involved in the promotion or opposition of tearless onions research must pass through the ERMA process if they are to either take onions into the field or keep onions out of it. Figure 6.7 (below) shows how the network diagram could be drawn with this new OPP; there is no longer a need to use two conflicting networks, as the actors can all be incorporated into one.

Figure 6.7 Network diagram positioning ERMA as the Obligatory Passage Point (OPP). All actors are interested in passing through the ERMA decision-making process on GMO field trials as they are convinced there is no other way of achieving their individual goals. (Diagram adapted from Callon, 1986a, Figure 2)

Although this network incorporates the diversity of actors present in the ERMA application process, it is nevertheless limited in scope. It assumes that the physical and temporal boundaries of the hearing correspond directly to the boundaries of the tearless onion network as a whole, and as such it does not take into account a significant amount of the data presented in this section. We cannot see the connections to other field tests, or the decisions made by C&F as a
company, or the role of consumers who respond to negative publicity. Thus, while it attends to presence, there is no room in this network for absences, which are instead effaced from analysis.

6.3.2 Passage Points

In Chapter 5 I argued that Star and Griesemer’s (1989) concept of the boundary object was not suited to my analysis of tearless onions. On a theoretical level it is at odds with the relational ontology that informs this thesis; furthermore, according to Star’s (2010) criteria, the tearless onion does not itself appear to be a boundary object. Nevertheless, there is utility in considering this approach to network representation. Star and Greisemer’s (1989) inclusion of multiple Passage Points stands in direct contrast to Callon’s (1986a) use of a single OPP and therefore provides a useful counterpoint to any interpretation based on the sociology of translation.

A representation of the tearless onion network in terms of multiple Passage Points is given in Figure 6.8 (below). Once again, instead of “visions” I have framed the Passage Points as questions: this is comparable to Callon’s representation of the OPP as a question that serves to interest more than one actor, thereby denoting a process of active participation.

![Network Diagram](image)

Figure 6.8 Network diagram showing the relationship between each of the main actors and their individual interests (Passage Points). Some interests are shared. All actors accept the boundary object (the tearless onion) as the means of achieving their goals. (Diagram adapted from Star and Griesemer, 1989, Figure 2)

The first Passage Point in the network is represented by the question “will the onion stop producing LFS when it is grown in a field?” This is what interests the scientists at C&F and HFC, and is the empirical question that drives their research. As such, it is directly comparable to the question “will the onion stop producing LFS?” used to represent the laboratory development of tearless onions, the difference being that the field introduces more complexity to the programme
of research. Alongside this complexity we also find connectivity: by moving to the field it is possible to create longer and stronger links between research programmes. A field test enables seed production, which facilitates collaboration with existing partners; a successful field test is also likely to interest future commercial partners. This is of interest to the C&F scientists because it provides job security in years to come; to C&F because it provides future revenue streams; and to FRST because it makes science a profitable activity. These three actors are therefore all interested in the question “will connections between research programmes be created?”

As with the laboratory phase of tearless onion research, the question “will GM onion research generate a return on investment?” is of interest to the actors who are funding the research project: C&F, HFC, and FRST. A field test offers the possibility of greater financial returns; but there is also the chance of much greater losses as there is greater risk for unrelated research programmes at C&F to be negatively affected. Thus, the question “can C&F demonstrate its strengths in GM onion research without compromising any other aspects of its business?” becomes a Passage Point in this network. It is of particular importance to C&F and their employees, the GM onion scientists. HFC is also interested in this question as negative publicity associated with the field test could possibly affect their wider business ventures if their links to it become widely publicised.

The final Passage Point also deals with the issue of risk, but this time in relation to the assessment of the field test application. ERMA asks “will the field contain the GM onion?” in the course of its decision-making process; in doing so, it asks the scientists to provide evidence that the risks of a containment breach will be adequately managed, and also invites the public to submit their views on the scientists’ proposals. As discussed, “the public” is largely absent from proceedings, instead represented by anti-GMO spokespeople. But alongside this formal decision-making process there is another informal process that asks that same question: this time it is C&F who ask “will the field contain the GM onion?” They, too, require evidence that the risks of the research will be adequately managed, only this time they are more interested in the financial risks to the company itself. If their assessment reveals that containment is not possible, the field test will not proceed.

The identification of these multiple Passage Points is a useful step in developing a final network representation based on Latour’s (1999a) circulatory system of scientific facts.

6.3.3 The circulatory system of tearless onions

As in Chapter 5, I have taken Latour’s (1999a) original network diagram as a starting point, departing from the five circulatory loops depicted in the original and instead using themes identified in the data I have collected. Once again, the network is composed of three circulatory
loops, each of which involves actors that share a common interest. The presence of different interests within the same network follows Star and Griesemer’s (1989) use of various Passage Points in their boundary object model, and as such the analysis given in the previous section has been useful in the development of this network representation.

Figure 6.9 Network diagram showing the actors as a circulatory system that gives “life” to tearless onions. There are three different loops of the circulatory system, each of which involves actors interested in a common Focus Point. The question that represents each Focus Point is given in the centre of each loop. (Diagram adapted from Latour, 1999a, Figure 3.3)

Figure 6.9 (above) shows a diagram of the tearless onion network as a circulatory system. There are three interests, or Focus Points, that drive the move to take the tearless onion research out into the field: each of these is shown in the centre of each of the three circulatory loops. Due to the increased complexity of this network diagram in comparison to that given in Chapter 5, intermediaries and black boxes have not been shown in the diagram; instead their deployment and control is described in the sections that follow.

Collaboration
This circulatory loop bears the most similarity to that described in the original, laboratory-based development of tearless onions. Once again, this loop represents the relationship between the
scientific colleagues working at C&F and HFC; again they are interested to find out if the GM onion will stop producing LFS, but this time it will be grown outside. The Focus Point for this loop is therefore represented by the question “Will the GM onion stop producing LFS when it is grown outside?” The relationship is formed by the exchange of resources. The C&F scientists circulate the black boxed onion as well as seeds produced during the field test; in return the HFC scientists provide the black boxed LFS enzyme as well as funding for the research.

**Organisation**

The loop representing the organisation of scientific work is also largely unchanged in comparison to the original circulatory network. Again we can see that C&F, the scientists who work there, and FRST share a common focus; the methods of interessement travelling between each actor-pair are also the same as in my prior analysis. The reason for this similarity is that the field test of tearless onions is still predicated on the same organisational structures and roles as before. C&F must still operate as a commercial entity; the scientists are still C&F employees; and FRST still administers the public funding of scientific research.

There is, however, a small but significant change as represented in the Focus Point for this circulatory loop. Whereas before all actors were interested in the possibility of commercial gain, here they are focused on finding out “will a long-term research programme be established?” By establishing itself firmly in a context of past, present, and future research projects, the three actors will be able to fulfil slightly different goals: C&F will attract commercial partners in the long term; the GM onion scientists will be retained as C&F employees; and a significant criterion by which FRST judges funding applications will be met. A field test enhances the ability to create and strengthen connections and it therefore provides each of these three actors with the opportunity to achieve its goals.

**Containment**

It is in the containment loop that we can see the most significant changes to the original tearless onion network. At first glance it is obvious that more actors are involved than before. In addition to the interaction between ERMA and the C&F scientists, C&F has become directly involved; furthermore, anti-GMO spokespeople have entered into the network. These additional actors have become interested because of their involvement in the field test application process, which essentially asks the question: “will the field contain the GM onion?” This question therefore represents the Focus Point for this loop, although the reality it enacts varies depending on which part of the loop we are specifically attending to.
ERMA and the C&F scientists are joined together in their focus on containment through the application to field test GM onions. The scientists must assemble a network of humans and non-humans to fulfil the physical and procedural criteria for containment; once approved, this network is black boxed as a containment facility under the legislative standards controlled by ERMA (in partnership with MAFBNZ). But tearless onions can no longer be black boxed as a low risk GMO: by moving beyond the walls of an indoor facility and out into the field this category is no longer applicable. The absence of this black box means that the field test application is open to scrutiny: it is publicly notified, and this notification serves as an intermediary between ERMA and the public. In return, a number of anti-GMO spokespeople who represent the public submit on the application: they circulate written and oral submissions that are considered by ERMA before making their decision. Although these submissions offer a wide range of views, it is only in relation to the Focus Point for this network loop that they are heard: thus, arguments made against the field as a suitable place for GMO research are disregarded, whereas specific comments made in relation to its ability to contain GM onion material are considered. Public submissions therefore have some influence over the final ERMA decision; but the black boxing of the field as a containment facility means that the scope of the Authority’s decision-making powers is arguably limited, as the field itself cannot be the subject of this debate.

The connections between ERMA, the C&F scientists, and anti-GMO spokespeople represent the “formal” decision-making process involved in the field test application; but the evidence presented in this chapter indicates that other “informal” decisions also influence the tearless onion network. The C&F scientists and their employers are involved in negotiations that take place before a field test application is even submitted: C&F management will only allow the application to be made if they are satisfied it won’t have a detrimental effect on the business as a whole. The scientists must therefore consult their managers and submit documents to be checked; they must also undergo media training so that any communications they have with the public are carefully monitored and controlled. In return, they receive an “approval” to proceed with the application, but this can potentially be revoked at any time, even if ERMA has already issued a decision that the field test may proceed. The reason for this is that the public can influence the operations of C&F: either by direct actions such as destroying field tests, or by indirect actions such as consumer boycotts. C&F tries to mitigate these risks through various communications strategies, but if all else fails it must discontinue its field test operations.

As in Chapter 5, the representation of tearless onions provided by the circulatory network addresses the issues I have highlighted in each of the previous approaches. The inclusion of more
than one Focus Point means that there is neither a singular onion nor a central actor who is managing network activity. At the same time, plurality and fragmentation are avoided by the finite proportions of the assemblage. Each actor is necessary to overall network stability, and no more can be incorporated into it without causing changes that would essentially lead to a different enactment of reality. After all, it is this latter type of change that has led to the events described in this chapter: the original tearless onion network has altered as a result of the proposal to move the research out into the field.

Whereas the network described in Chapter 5 was stable, the network described in this chapter did not become black boxed. The circulatory model provides a useful method for analysing the source of network instability, and provides insights that the other two approaches fail to convey. The network representations based on Callon’s (1986a) “sociology of translation” use the controversy of the ERMA hearing as a basis for analysis, but this is not where the instability of the network stems from. Instability is found in the absences of the network, but the networks of early network approaches are not sensitive to these, instead effacing them through their over-emphasis on presence (Law, 2008a; Law & Singleton, 2005; Star, 1991). While Star and Griesemer’s (1989) approach can incorporate both presence and absence into the descriptions it provides, the lack of detail regarding the mechanics of network construction means that we do not know how actors become interested in specific features of the “boundary object”; we therefore do not know how such interest is diverted. Latour’s (1999a) approach, which is rooted in the traditional ANT approach to network construction, can be used to provide a detailed account of how each actor is joined together through the circulation of various intermediaries and black boxes. This network representation reveals that the “containment” of tearless onions alters considerably following the proposal to move it into the field: an additional actor is drawn into the network, a black box is lost, and the role of another actor changes significantly. Thus, although instability does not result from a single factor, it does originate from a single loop of the tearless onion network. In answer to the question that serves as the Focus Point for this loop, the field cannot contain the GM onion: thus, instability is introduced and ultimately leads to the breakdown of the entire network.

6.4 Summary and conclusions
In this chapter I have detailed the attempt to take the tearless onion research project out of the laboratory and into the field. Movement to the field is only possible following an application to ERMA, the decision-making body that regulates GMO research in New Zealand under the HSNO Act (1996). I have therefore examined the written application submitted by the scientists; I have
also studied public submissions on the application and a variety of other written documents that relate to it. But my explorations have not been confined to statutory processes, nor have I assumed that ERMA is the only decision-maker during the move to the field. Instead, I have looked beyond the temporal and physical boundaries of the field test application process, considering other factors that influence the movement of a GMO from the laboratory to the field. Thus I have discussed the absence of other field test applications, as well as the eventual dismantling of the tearless onion research programme.

The data presented in this chapter have been used to tell a number of different stories about the attempt to take tearless onions out of the laboratory. As in Chapter 5, however, my goal was to weave these stories into a single representation that conveys the multiplicity of the onion. Again, I have used network representations to achieve this goal, considering three different methods taken from the STS and ANT literature. Callon’s (1986a) “sociology of translation” was applied in two different formats, each of which focused on the controversy and debate of the ERMA hearing. Since this could account for only a portion of my data, I then considered the Passage Points that feature in Star and Griesemer’s (1989) “boundary object” model, identifying the different reasons why each actor is interested in moving tearless onions out into the field. These Passage Points have been incorporated into a third and final network representation, which uses Latour’s (1999a) “circulatory system” of science’s blood flow to convey the distribution of interests that can be co-ordinated to perform a fractionally coherent object.

Unlike the object described in Chapter 5, however, co-ordination was not achieved in the network-building attempts traced in this chapter. Tearless onions have not been moved out into the field, indicating that some part of the network did not act in concert with the rest of it, instead destabilising it by disrupting the “blood flow” keeping this scientific fact alive. My analysis indicates that the source of this instability can be found in the containment loop of the circulatory network, which is the only part of the network that is significantly different to that described in Chapter 5. Relational changes in this part of the network alter the enactment of “containment”: the containment facility is now a field, which draws anti-GMO spokespeople into the network and also alters the role of C&F. The question of whether the onion will be contained is therefore not only a focus for the ERMA risk assessment, but also the corporate risk assessment undertaken by C&F which is mindful of public opinion. This latter assessment is performed before the field test application is lodged with ERMA; it also continues to factor into C&F management decisions even after the ERMA approval has been given. Ultimately it appears to be a management decision that
led to the failure of the tearless onion research project, although this decision was a relational effect that is distributed throughout the containment loop.

This analysis has focused on a particular programme of GMO research and it would be inappropriate to generalise these findings to GMO research in New Zealand as a whole. But the difference in the outcomes of the laboratory- and field-based stages of tearless onion research indicates a further area for investigation, one that focuses on the places in which GMO research is conducted. While the tearless onion remained in the laboratory the safety of the research remained unchallenged, but the proposal to take it out into the field led to a corresponding rise in the level of risk associated with it. Furthermore, these risks came in a number of different forms, from the risk of genetic material escaping to the risk of C&F attracting negative publicity. It would appear that the assessment and management of these risks is a crucial aspect of the control of GMO research in New Zealand; at this stage, however, I am unable to perform a rigorous analysis on this topic, nor am I able to provide any specific conclusions.

In Chapter 7 I will turn my attention to these issues, moving on from the analysis of a specific research programme to a more general consideration of the containment of GMO research. So far, the containment facility itself has remained a black box: it is a component of the tearless onion network, but as yet I have not considered the intricacies of its own enactment. My goal is therefore to open up the black box of containment and trace the relations that enact the places of GMO research.
Chapter 7
The containment of GMO research

7.1 Introduction
In the previous two chapters I have focused on the specifics of a particular programme of GMO research; I have discussed the outcomes of the project in terms of the network enacting it. In Chapter 5 I considered the laboratory phase of the research, concluding that a stabilised network had been achieved. In Chapter 6 I followed the efforts to move tearless onions out into the field, tracing how instability was introduced into the tearless onion network, ultimately leading to the failure of the research project. These chapters provide a useful examination of the rise and fall of a particular programme of GMO research in New Zealand; they also provide an important theoretical and methodological discussion of network approaches in the ANT literature. As such, they are a discrete unit of this thesis, both in terms of the case study they explore and the theoretical literature they discuss. But they also provide the foundation for this chapter: the answers they provide lead to further questions, the connections they make reveal further gaps in our knowledge (Strathern, 2004). This chapter, although it deals with different subject matter and involves a different application of the theoretical literature, is therefore connected to these earlier chapters.

The presence of a “gap” in the analyses presented in Chapters 5 and 6 is perhaps best illustrated by my separate consideration of the laboratory- and field-based stages of the tearless onion research project. This separation did not guide my research from the outset, but instead emerged during the course of my data collection and analysis; but so far I have no evidence to suggest that this separation is enacted by anything other than my own academic practices. Indeed, an important connection between these two places is fundamental to GMO research in New Zealand, as both places are defined as “containment facilities” under the HSNO Act (1996; see Chapter 2 for discussion). In this chapter I will therefore turn my attention to laboratories and fields, questioning how they are enacted as the places of GMO research in New Zealand. As discussed in Chapter 3, the spatial turn in the STS literature has explored the relationship between the laboratory and the field, although there is no consensus as to whether these places are ontologically distinct or co-present and connected. Here I will argue that both separation and connection are necessary to the enactment of containment facilities: the laboratory and field exist as necessary “Others” as part of the containment facility. But to arrive at these conclusions
will require a move beyond the networks of ANT, and this reveals another gap that is evident in the analyses of Chapters 5 and 6. Thus far I have stayed largely within the realm of network representation, primarily using earlier applications of ANT as the basis for my analyses. In contrast, in this final analysis chapter I will consider alternative forms of object representation that have been developed in the more recent ANT literature (see Chapter 3 for discussion). In this way I will explore how such representations can be used to augment network studies without standing firmly apart from them, thereby reconciling the gap that has emerged between “early” and “post” ANT approaches.

7.2 Boundaries

In New Zealand, the containment facilities within which GMO research takes place are issued with a certificate to designate their status. Two examples of such certificates are given in Figure 7.1 (below): one has been issued in relation to an indoor facility, the other outdoors. In each case, the certificate serves to black box the facility: it gives no indication of the structures and functions that are found within it, instead hiding this complexity behind a single page of writing that designates its official status.

But the words on each page give some indication of where to start looking if we are to open the black box of containment. Both of these certificates make reference to a “MAF Biosecurity New Zealand Standard”: in particular, standard “155.04.09”, that applies to containment facilities for plants. This standard is one of five that together provide the legislative basis for the structure and operation of containment facilities. In Chapter 2 I outlined the contents of these standards, describing the requirements that must be met if a place is to be legally defined as a containment facility. The certificates shown in Figure 7.1 indicate that these criteria have been met; but this does not mean that the contents of these legislative documents provide a sufficient description of what a containment facility is. These documents are “standards”, implying an unwavering uniformity, a one-size-fits all approach to the difficulties involved in keeping an organism within the boundaries of a particular place (see Bowker & Star, 1996, 1998, 2000). They do not convey the complexities involved in establishing and maintaining a containment facility: they do not reveal how containment is done in practice (see Law & Mol, 2002).
Figure 7.1 The boundaries of containment facilities. Top left: a number of doors open off a corridor in Lincoln University’s “Biotron”, a purpose-built facility that houses a variety of GMO research programmes (Lincoln University Living Heritage: Tikaka Tōku Iho, 2014. CC BY-NC 3.0 NZ). Top right: a certificate issued in relation to this building identifies it as a containment facility (Lincoln University, 2011, p. 38). Bottom left: a field situated in Canterbury farmland that has been used for an outdoor development of GM onions. It is surrounded by a fence that separates it from other paddocks (Eady, 2007, p. 4, Figure 3). Bottom right: a certificate issued in relation to this field identifies it as a containment facility (Crop and Food Research, 2008b, Appendix 2, p. 48).
Rather than focus exclusively on the contents and enforcement of legal standards, this section provides an alternative approach to the description of containment facilities. As in the previous two analytical chapters, I will first present a sequence of different narratives that, although separate, nevertheless overlap. They do not stay within the confines of legal definitions and formal procedures, instead following actors and trails of information wherever they choose to go. Once again, the result is not a singular grand narrative, but a “tissue of little narratives” (Law, 2002a, p. 164) that each tell us something about what containment facilities are.

The theme of boundaries is common to each of the four narratives given in the next section. The first two narratives consider how the boundaries to containment facilities are established, looking beyond standardised categories and definitions to reveal the complexities involved in fulfilling the legal requirements for containment: first I will consider physical requirements, then I will consider operational requirements. The third narrative moves on to consider the flexibility of these boundaries, and the many and varied boundary crossings that must take place if containment is to be effected. Finally, I will consider how the world outside a containment facility is nevertheless present within it, discussing how the boundaries of containment facilities are a product of these interactions.

7.2.1 Creating boundaries
The physical structure of a containment facility needs careful and deliberate planning. For indoor facilities, the usual options are either to refurbish an existing building or to design and build a purpose-built facility. While the latter may appear to be the preferred solution (depending on the availability of funds), it can also lead to a new set of problems:

Lots of new facilities... have these things that they want and put down on paper and design and then somewhere in between that... and, what you end up with is a physical structure that design consultants have got hold of it and, and they [change it] sometimes. (Interview N)

Indoor containment facilities are used by scientists, but first they must be constructed by designers and builders who don’t just build laboratories, they create a wide variety of structures that are used for various purposes. What is a useful addition in one building may not be so useful in another; hence laboratory managers find that features are either added to or removed from original plans by people who are making design-based decisions (see above quotation). This conflict between design aesthetic on the one hand and scientific practicality on the other can lead to problems in creating a building that functions as a containment facility. It means that the final result is often one that does not simply mirror the “ideal” scientific reality:
Some of the initial issues with [the research facility] have been fixed; others just have to be lived with (such as the small space for bringing in soil). In all, everything has worked out ok in the end; maybe this is because N kept tabs on how things were progressing throughout the design and build process. This is in contrast to some other facilities though – N knows of a PC2 greenhouse facility in Western Australia that couldn’t be used for its initial purpose due to how it was built. It can only ever be used in the same way as a normal greenhouse, even though it would have cost millions of dollars. (Extract from interview notes: Interview N)

The facility mentioned in the above quotation had originally been designed to have a two-stage entry system in the loading bay. This would mean that a trailer-load of soil could be brought in through the outermost set of doors, these doors shut, then the inner doors opened so that the soil could be taken into the main part of the building; during this process there would never be an open pathway between inside and outside the building and it would therefore meet the physical requirements for containment at all times. Unfortunately, the dimensions of this loading bay were changed slightly during the build process, and on completion, a trailer could not be parked in it with both doors shut. In this particular case, the issues with the physical structure of the building could be overcome by practical (and labour-intensive) means, but the reference to the facility in Western Australia reveals that such adaptations are not always possible.

While the above example indicates that rigid physical boundaries are an absolute requirement for containment, elsewhere we can see that there is much more flexibility in their creation. The common definition of an indoor containment facility is a structure with six sides (EPA, 2014b), but there are times when this is not the case:

D had to get the MAF inspector to come and certify a region (a corner) in the lab where GMO work could be done – it was impractical to certify the whole lab given that it was only 10% of the work to be done there and was only going to be for a short period of time.

(Extract from interview notes: Interview D)

Here we can see that the legally defined boundaries of an indoor containment facility have been modified from six sides to just four: the containment “corner” in the laboratory mentioned above has a floor, a ceiling, but only two walls surrounding it. Although this particular containment facility was only classified as a PC1 facility and could therefore only be used for low risk GMO research, it nevertheless demonstrates that the physical requirements for containment can be
achieved through more-than-physical means. Boundaries can be created without actually building them, and they may be present even if we can’t see them.

Field facilities also challenge the conventional definition of containment as an impenetrable enclosure in that they do not completely physically surround the GMOs contained therein. Fields are by definition outdoor places, and research is conducted in them in order to measure some degree of interaction between a GMO and the uncontrollable variables of the outside environment. In contrast to the six sides of a conventional indoor containment facility, field facilities have no roof or floor; furthermore, walls must be substituted by fencing (EPA, 2014b). But the “sides” of the field are not the only physical barriers involved in creating the boundaries to the containment facility. The physical form of the GMO itself is also a factor.

Animals are really containable... and they’re very valuable, so they’re not going to let them go wandering around the countryside... so I think while there might be a bit more public reaction, I think you can demonstrate... containment... pretty well with animals. (Interview F)

The animals used in GMO research in New Zealand are large farm animals such as cattle and sheep; because of the size and structure of these animals, a “body” could arguably be taken as providing the physical boundary for containment. GMO plants are also relatively large organisms; furthermore, their sessile nature means that it is potentially easier to restrict them to a given location. As discussed in Chapter 2, however, pollen provides a potential pathway for the escape of heritable material. Flowering structures are therefore not usually allowed to form on the plant because of the difficulties involved in keeping pollen within the boundaries of a field containment site.

There has been an exception to this “no-flowering” rule, but it involved the creation of yet another type of physical boundary. In their approval of C&F’s 2008 application to field test GMO allium species (GMF06002), ERMA issued consent for seed production in one species of plant to be studied (ERMA, 2008a). This meant that flowers would be allowed to form and pollinating insects would be allowed on the plants. Although this provided the only means for natural seed production, it also created a significant pathway for the escape of GM pollen (section 2.5.9); this could lead to the spread of genetically modified material not only through plants growing outside the field perimeter, but also through honey if bees were to act as the pollinating insect. This could potentially harm the honey industry in Canterbury (section 2.5.16). Nevertheless, the ERMA
approval included seed production, but only on the condition that the structure pictured in Figure 7.2 (below) was used:

![Material removed due to copyright compliance](http://www.epa.govt.nz/search-databases/HSNO%20Application%20Register%20Documents/GMF06002_GMF06002%20application.pdf)

Figure 7.2 Pollination cage planned for use in the field test of GM onions (Crop and Food Research, 2008b, p. 29)

Figure 7.2 shows a “pollination cage”, constructed from a double layer of fine mesh impenetrable by pollinating insects that would be placed over any plant in the early stages of flowering. Insects would be introduced to these cages to act as pollinators; honey bees, however, would not be used for this purpose (control 9.1) so that there would be no risk of GE honey being produced in the region. Any insects used as pollinators would be killed with insecticide capable of penetrating the mesh of the cage (control 7.4). Thus, the cage would restrict the passage of organisms in such a way as to effectively become a containment facility itself.

Although this pollination cage is specific to a particular field test approval, there are other instances where alternative thresholds are necessary to effect containment. It is arguably the presence of these boundaries rather than the sides of the containment of the facility itself that stop genetic material escaping into the world outside. Even in laboratories, which appear to satisfy the requirements for physical containment by virtue of their “six sides”, there are additional thresholds that each serve to create a barrier between inside and outside.

It might be you know someone’s got a keyboard like that [points at computer keyboard on desk] but it’s within a laboratory and so it’s either then got to be labelled so that when it leaves that laboratory it’s got to be destroyed or it’s got to be covered with plastic film or it’s got to be a washable keyboard. (Interview D)

A keyboard in a laboratory provides a pathway for the escape of GM material, and the precautions listed above are designed to control each of them. People, too, become pathways for possible containment breaches, and must therefore be controlled if they are to enter (and later
leave) the containment facility. Unlike a keyboard or insect, people cannot be destroyed before they leave the facility; instead, steps are taken to erect a barrier between a person and whatever he/she may come into contact with while inside it. In laboratory facilities, coat hooks are needed so that protective clothing is left inside; wash basins must be installed so that people can wash their hands before leaving; and food and drink should not be brought into or consumed within the facility (see Lincoln University, 2011, p. 58). In field facilities, shoes should be cleaned thoroughly with a brush before exiting (see Crop and Food Research, 2008b, Appendix 2, p. 11).

Each of these protocols controls a particular pathway for the escape of heritable material, and each therefore creates a different boundary between inside and outside a facility.

The creation of boundaries is an ongoing process that changes in accordance with the identification of pathways for escape. The early days of GMO experiments were conducted in containment facilities that had a very different physical form to those used today. Field tests, for example, were not conducted in fenced-off paddocks, and GM plants were grown alongside other, non-GM lines:

We need to remember that NZ had tamarillo trees being grown up in Northland, GM tamarillo trees that... people were free and safe to walk among, you know, that has been forgotten about- GM trails have been done for many years before HSNO, there was no need for fences as they have today, which are to protect the plants from humans, not the other way around. (Interview K)

There was GM sugarbeet... and the interesting thing about GM sugarbeet is that they were growing it alongside the non-GM sugarbeet and they were doing standard... companies like that what they were trying to do is that they were getting two seasons’ research so they do Northern hemisphere Southern hemisphere... and what they were looking at was that they were looking at the GM lines to see how robust they were in terms of going through and bolting... so they were actually letting it go through. (Interview F)

Thus, plants were not only “out in the open”, but control over the formation of flowering structures was not as strict as it is now. This has led some people to speculate that GM material may have been transferred to other non-GM plants during this time\(^{48}\); it also adds fuel to claims made by opponents of GMO research that field-based research cannot be contained\(^{49}\). Regardless of whether or not these accusations are true, it is important to note that laboratory-based

\(^{48}\) This was suggested in Interview F.

\(^{49}\) This was suggested in Interview A and Interview L.
research has gone through an equivalent metamorphosis over the years. Early laboratories were not constructed to current standards:

[At a particular research institution] there was a PC2 laboratory that actually had an open vent... at that stage of it PC2 requirements were not thinking in terms of microbiology... and how microorganisms could get out... they were thinking more in terms of mice.

(Interview F)

These changes should not be taken as an indication that containment was not taken seriously in the past. Rather, it demonstrates that the physical boundaries of containment facilities are in a perpetual state of re-definition. Until a laboratory vent is identified as a hole in the enclosure of the laboratory it does not provide the possibility for a containment breach, and it therefore cannot feature in the definition of containment. The reality of present-day containment standards is a result of this ongoing process of re-definition:

And what [the inspectors] want kind of changes too you know it’s like when, when they first came through... it was, they were quite happy that, that I had a copy of these [ERMA decisions] outside the growth rooms... in those individual folders so when [the inspector] came through I’d take [the inspector] to the growth room and say hey look here’s the ERMA decisions blah blah blah, and that was fine, and then in the last couple of years... last couple of audits... [the inspector]’s decided that that’s... not sufficient anymore and so the, the first time what happened is that, is that right up until then that had been fine and then [the inspector] came through and did an audit and said right, well from now on we want, copies of those in your file as well and so I got a corrective action request for that.

(Interview N)

Changes made to a particular file do not result in a significant change to the overall translation of containment in the short term; however, taken cumulatively over a longer period, we can see how containment can be effected so differently now in comparison to thirty years ago. What we can also see from this example is that physical structures are only one aspect of containment. Paperwork and the keeping of files are procedural aspects of containment, and these too must be closely defined and monitored.

7.2.2 Controlling boundaries

A lot of PC1/PC2 work could probably be done in a standard laboratory without any risk of containment breach, provided the correct procedures and protocols were followed. On the
other hand, even the most modern PC2 laboratory would almost certainly experience a
containment breach if the correct procedures and protocols aren’t followed. (Interview N)

While the physical form of a facility is undoubtedly important, it is actually a relatively small part
of what’s involved in the containment of GMO research. No matter how well-designed a facility is,
if people don’t follow the correct procedures whilst inside it they can easily do something that
would render the physical boundaries to the facility useless. This could be something like
throwing plant material into the rubbish, which would result in viable GM material being taken to
landfill and therefore leaving the containment facility. Thus, perfectly ordinary actions must be
monitored and controlled, and entry into a containment facility necessitates the adoption of
behaviours that are quite different to most other workplaces.

In order to work in a containment facility, a person must therefore undergo specific training in
order to learn how to conduct his/her job without compromising the physical boundaries of the
facility. Whereas laboratory training places particular emphasis on generic skills, training
requirements for work in field facilities are specific to a particular project. Work on a GM onion
field trial, for example, requires learning techniques such as the identification of *Allium* species,
planting GM onions, and how to dispose of their remains (see Crop and Food Research, 2008b,
Appendix 2, p. 47). This emphasis on the specific could mean that work done in a field is more
likely to comply with containment protocols:

> Non-compliances in field trials are not common... because they tend to be one-off events,
> that... an organisation puts significant resources into, and, they get trained up and do it as a
> one-off, they tend to know what’s needed... often with some of the containment facilities...
> not the field trials... some of the non-compliances or non-conformances, tend to be around
> them getting a little bit slack, because they’ve been doing it that way for so long and they
> know they’ll fill it in when they get there sort of thing. (Interview R)

It is important to note, however, that this quotation is not equating “non-compliances” with the
escape of genetic material into the environment. While this can, and sometimes does, happen,
“non-compliances” with containment conditions are often the result of inadequate
documentation. For example, in September 2011 a GM cell line was transferred between two
facilities without MPI approval; the resultant action was for the facility to make sure its records
were up-to-date (EPA, 2012a, p. 4).

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50 Non-compliances are recorded and made publicly available by the EPA (including on their website).
Records and record-keeping are a fundamental aspect of containment, and the certification of a containment facility is largely dependent on this procedural requirement. The MPI audits records periodically: every 6 months an inspector will visit a facility to check that it is complying with the physical and procedural requirements of its containment certification. Audits require preparation, and a large part of this is to make sure that the paperwork for all the different research programmes taking place in that facility is up-to-date. This is no small task, as the total volume of paperwork across all research programmes conducted within a facility is potentially huge.

I just counted yesterday I’ve got... 20 lever arch files with records in them... you know and that covers every EPA approval that we hold here, every item that we’ve ever imported, where it is, who it belongs to, why they’ve got it [laughs] so you know... it’s a significant chunk of work. (Interview D)

If it’s a New Organism we’ve got to have a record of it so, we need to know, when it arrived in the building and then everything we’ve done with it subsequently so... you know like the plants that are in the growth rooms... we have to have a list of all of those plants in the growth room, and they’ve all got to be labelled so when, when [the MAF inspector] comes through [the inspector will go to our culture collection and] say right find me this plant, and so we have to be able to go into the growth room and find that plant in amongst the, you know hundreds of onions or garlic or whatever’s in there... and then that way they know we’re actually keeping good records of our plants, and on that culture collection you know we’ve got to keep that list for 7 years so, there’s 7 years of records and, and most of those the thing will be crossed out because it’s dead, [the inspector] will still see the numbers and all the rest of it but it’s got a... a tag at the end of it that says that it’s been destroyed, and so we’ve got to have, basically, start to finish records of what’s happened to it and then, documentation that we’ve actually destroyed it once we’ve finished with it, whether it’s been harvested or something like that, and so for the, for the plants it’s relatively easy, with these guys coming in... because they’re... dealing with the molecular side of things it becomes a little more awkward because, you know they’ve got, thousands of, you know little wee eppendorf tubes and, and petri plates. (Interview N)

As the above quotations indicate, every single different GMO within a facility can only legally exist if it is accompanied by a sizeable amount of paperwork; even after a GMO has been destroyed, its prior existence must still remain visible on written records. Different forms must be filled out for different purposes, and the amount of paperwork that accompanies a particular GMO depends on what exactly has been done with or to it during the course of a research programme. A
transfer permit, for example, allows a GMO to move from place to place, thus leaving the confines of the containment facility without actually breaching containment conditions. Obviously a document alone is not sufficient for such a movement to take place: the GMO must be double packaged, a vehicle must be used to transport it, and the BSOs of both facilities must communicate with one another to arrange the exchange (see Lincoln University, 2011, sections 4.4.2 and 4.4.6). But unless a very public accident occurs along the way which incidentally reveals that (for example) only one layer of packaging was used, the only way in which faults can be detected are at the time of an MPI audit, which essentially involves looking through a facility’s written records.

How [MAF have ensured compliance] has varied over the years in terms of... it’s mainly paperwork, they will work through paper trails. (Interview F)

This suggests that documents and record-keeping processes are essential to the integrity of containment facility boundaries. MPI inspectors do not make direct assessments of the work being done in a research facility, relying instead on written records of this work. Documents therefore serve to translate the “real” activities of the containment facility into a “representation”. For these translations to hold their form (and therefore withstand the interrogation of an MPI inspector), a strong link must be made between reality and representation. Crucial to this is the approval number given to a GMO when the EPA issues a consent for a programme of research. This number comes to stand for the GMO itself: it moves beyond the confines of the laboratory as it is written on forms in offices, is sent to the MPI, or appears on the EPA website. It is also used to label every instance of the physical form of that GMO, be it a plant growing in a field, or a colony of bacteria growing in a petri dish. It is only through the presence of this label that a GMO can be linked to the multitude of papers that translate it; if it is removed or attached to a different GMO, the translation breaks down. Thus, containment breaches may result from labelling errors within a containment facility51, oversights that essentially leave researchers blind, given that there is no way to detect a GMO by simply looking at an organism itself.

People, too, must be represented by documents, and the strength of these links is also checked during an MPI audit.

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51 Take for example the following incidents (see EPA, 2013c): June 2011: inadequate labelling of a pine plant; January 2012: need for additional identification procedures; November 2008: incorrectly identified algal samples were transferred between facilities.
The inspector would go to a laboratory and... on the door of every lab we’ve got a sign which... defines the standards to which that lab is certified, but there’ll also be a name a list of names of who’s actually working in that lab so... the inspector will say oh well there’s... Jim Jones... when we get back to your office can you show me his training records... and... so if he’s... in the lab and he’s not trained... you know that’s... not... complying with the standards so I’ve got a running schedule of training... and so the moment somebody either... wants to work in a lab... they have to go through an induction course and then that gets registered with me but then they have to come to the next full workshop... or if I find that their training is now going to lapse because it’s more than twelve months old... I’ve got a spreadsheet where the names go from green to red... you know as their training expires... so I can fairly... easily just see who’s on the list and who’s current and who’s expired... and that’s fully auditable, the inspector will sit there and go through my list... and I actually have to pull out my hard copies and say well there’s the assessment and that’s how I marked it. (Interview D)

The scientists conducting GMO research must be translated into people who are authorised to work in containment facilities. The training of staff is a complicated and time-consuming process, and successful translations are key to managing this complexity. People have slightly different training requirements depending on their role and place of work; training must be updated every 12 months; and someone has to administer, assess, and record the training received by each individual staff member. A list of authorised personnel on the door of a laboratory translates all these activities into one document that signifies who can enter; this connection is then checked in detail by an MPI inspector, who could potentially go so far as to query the marking schedule for a particular assessment. Obviously, is not done every time “Jim Jones” or any other GMO researcher wants to gain entry to a laboratory or field and carry on with his or her work. Instead, the list of authorised personnel confers access to certain people; it also denies access to anyone who is not named on it. As such, it is an important component of the boundary of a containment facility, as it separates who is allowed “inside” from who must stay “outside” the facility.

7.2.3 Crossing boundaries

But is the boundary between who is allowed “inside” and who must stay “outside” a containment facility represented by a single list of names? The above quotation suggests that it is only people

52 This point was made in Interview D.
conducting research who enter containment facilities; furthermore, it gives the impression that there is a single, unwavering definition of authorised personnel. This is not the case, however, as the following extract demonstrates:

Claire Bleakley for GE Free New Zealand expressed concern over the nature and numbers of personnel permitted to enter containment facilities. She proposed that “Only the people directly involved in an experiment should be able to enter those facilities... if you have a look at a lot of the training manuals at the end, I mean the audits, you’ll just see this whole list of people who have been going in and out of the facility. We have no idea who they are, we don’t know if they are dedicated to the team, if they are part of the organisations that are funding it, or whatever.”

In response to Ms Bleakley’s concerns the Committee notes that control 11 states: Unauthorised persons must be excluded from the containment facility.

(EPA, 2012b, p. 8, emphasis in original)

This extract deals with the question of who should have access to a containment facility; it demonstrates that the answer is dependent on the criteria we use to divide those who can and those who cannot access a facility. It is taken from an EPA decision document and includes a comment made in an oral submission on a GMO development application (ERMA200706). The submitter speaking at this hearing makes reference to “people directly involved in an experiment” who should be able to access the facility. Additionally, there is a “whole list of people” who are also accessing facilities for unknown reasons; the speaker implies that these people should not be allowed to gain entry to a containment facility. Thus, access is linked to the specifics of a research project: if, and only if, you are working with a particular GMO, you may enter a containment facility.

On the other hand, the decision-making committee of the EPA has very different criteria for access, and these are linked to the operational requirements of the containment facility rather than any scientific knowledge or skills. They make reference to “unauthorised persons” who must be excluded from the facility. We don’t know exactly who these people are, but we know from elsewhere in this document that an authorised person is “someone who has completed training relevant to the responsibility of that individual on the containment practises at the containment facility” (p. 21). This definition suggests that there is a variety of roles and responsibilities taken on by people who must have access to a facility. In contrast to the clear-cut distinction used by the submitter in the previous quotation, we are therefore presented with a more complex set of criteria that governs access to a facility.
People other than the scientists enter containment facilities for various reasons. Some are visitors to the facility who need to see something or someone inside it. Such people are classed as “accompanied persons”: they can enter only if they are chaperoned by someone who is fully trained to work in that particular containment facility. Entry requires adherence to specific rules, including to sign in and out of the visitor’s book; to wear a lab coat in the facility; not to eat or drink whilst there; and washing hands just prior to exiting. These people must also be accompanied at all times during their visit (see Lincoln University, 2011), effectively conferring “authorised” status to them via physical proximity to the person accompanying them.

Maintenance personnel, grounds staff, and cleaners usually fall under the category of “accompanied persons”. They have nothing to do with the specific details of a GMO research project, yet their activities are vital if the facility itself is to continue operating. Equipment must be serviced and fixed, grass must be mowed, toilets must be cleaned; this work remains largely invisible when we consider GMO research, but becomes apparent if it is not carried out. Furthermore, this work must be conducted in accordance with containment protocols.

Having people come in to service the equipment I mean that’s... you know I’m lucky with [a particular service engineer] you know he’s a, he does a lot of other facilities so he’s well aware of the, the protocols... some of the guys that come and look after the fridge plant you know they... you know they’re really nice guys they’re really good at their job but... you know they don’t do a lot of work in PC2 facilities so it’s a... that’s a level up in terms of risk if you’ve got to have those people coming out all the time to fix stuff. (Interview N)

Accompanied persons tend to be people who don’t usually work in containment facilities, and for this reason they pose a potential risk. In the case of the service engineers mentioned above, someone who is unused to containment protocols may move something out of a refrigeration unit or switch a piece of equipment off simply because it will allow them to do their job; this can lead to a breach of containment conditions further down the line. This risk must be taken into account by a laboratory manager, who is ultimately responsible for the actions of anyone coming into a containment facility. At times, the risk may be judged to be too great, and an accompanied person may be excluded from all or part of a facility:

I don’t let the cleaners in to do cleaning... I do it all myself, because for me that puts, that’s peace of mind for me... so the cleaners come in and they will, they do the toilet they replace the toilet rolls... and that’s it, I don’t, I don’t let them do anything else in the
building at all... just purely for my peace of mind you know it’s just one less risk for me, to deal with. (Interview N)

Cleaners pose a risk to the operation of a containment facility simply because of the nature of the work they must do. Mopping floors and cleaning benches requires the use of water which must then be disposed of. This water could potentially transport genetic material out of the containment facility and therefore cannot simply be poured down the drain; it must be sterilised first.

The chances are that most of the time they would do that but it only takes them once to... to forget or, or for one of them to be sick and you get a replacement come in... and then... you don’t know what happens. (Interview N)

Protocols associated with the management of containment facilities do not require laboratory managers to mop the floors themselves; in fact, this interviewee did not know of anyone else who cleaned their own laboratories. But this point in itself illustrates that there is no single, unwavering definition of an “authorised person”. Further evidence for this can be found in instances where authorisation to enter a facility has been extended to facilitate access:

So you know that’s... you know with the earthquakes say for instance we’ve found... that ‘cause strictly speaking... we’ve mainly just trained scientists and the undergrad students or postgraduate students to access the the labs but what we found was that at 4 O’Clock on Saturday morning... you actually want the plumbers and the electricians and those guys to get in the labs and... strictly speaking, they’re not allowed to enter... the only way you can enter a PC, which is a physical containment lab, is either being trained or accompanied by a trained person... so... the Health and Safety Manager was here and so the trades guys you know were allowed in under that... rule but what I’ve done since then is actually put all the [maintenance] guys through another module which I designed which allows them to access a lab for maintenance purposes... so they’re not allowed to touch anything in the fridges or the freezers or the lab benches or anything like that but if there’s an emergency they now have access. (Interview D)

The earthquake referred to in this extract was of magnitude 7.1 and occurred in Canterbury, New Zealand, on September 4th 2010 at 4:35am. Obviously this is outside the normal operating hours of a laboratory, but they nevertheless had to be entered by maintenance personnel in order to be checked for damage. Under the rules at that time, maintenance people could only enter the laboratory containment facilities as accompanied persons, which meant that another, fully
trained, member of staff had to make the trip in to work. This extra layer of complexity proved a complication in this case, prompting the research facility to review its training and operating procedures and create a further category of access: an “unaccompanied person”, someone who can enter and work inside a laboratory as long as they follow certain rules.

So containment facilities are not only accessed by scientists; a wide variety of people are authorised to enter these places. Furthermore, the access of these people may be limited by keeping them out of certain areas of a containment facility, or it may be facilitated by enabling their unaccompanied entry. But there is another category of person who can access a containment facility: people who have a Master Key to the door. The usual mode of entry for authorised, unaccompanied personnel is via a swipe card, a system that automatically generates an electronic log of who enters and exits the facility. Accompanied personnel gain access via the swipe card of whoever is chaperoning that person around the facility; given that this is not automatically recorded in the electronic log, they must sign in and out of a log book kept by the door of the facility. Both accompanied and unaccompanied personnel must therefore use a swipe card to access a containment facility, and this system relies on electricity: the card scanner, door-release mechanism, and electronic log are all powered by an electric current which, if stopped, would mean that no-one can enter or leave the facility. Master Keys provide the back-up to this system, and are held by people such as maintenance staff, security guards, and the local fire department. While the exact number and location of these keys is a known factor, use of them cannot be completely controlled or detected. Master Keys leave no written trace when they are used, and MPI inspectors do not carry out any checks in relation to them during an audit. There is no representation of them in an MPI audit and containment is therefore not dependent on their presence or absence; but they are nevertheless a necessary part of what the containment facility is.

7.2.4 Transcending boundaries
The existence of Master Keys indicates that beyond the formal boundaries of containment facilities there is a world that, although apparently kept on the “outside”, nevertheless influences what happens “inside” these places. So far I have mainly followed scientists, laboratory managers, maintenance personnel, and MPI inspectors; actors whose roles are largely given “within” formal definitions of containment. In this final narrative I will approach containment facilities from the “outside”, considering how actors who have no allocated role within their boundaries nevertheless influence the activities that take place within them.
As discussed in Chapter 2, the destruction of field tests causes damage worth many thousands of dollars, and this is a significant cost for research institutions to bear53. Although there is no evidence that such direct action has been taken against laboratory-based GMO research in New Zealand, measures are nevertheless also taken to protect laboratories from intruders. While the walls and roof of a containment facility offer it a level of protection that a field cannot achieve, additional measures are sometimes also taken:

Part of the logic of this facility is, is obviously the security of it, but also the isolation of it, you know it’s not in the general area of [this research institution] where people, generally go unless they’ve got a reason to go. (Interview N)

The implication here is that the building within which this containment facility is housed has been put in a place that is out of sight. Where possible, outdoor facilities are designed with similar aims in mind, and “facilities try and keep [field tests], as low-key as possible, so they don’t stand out” (Interview R). Before the HSNO Act (1996) was enacted, keeping a field test “low-key” was relatively easy, as research may have been conducted in an ordinary paddock in which GMOs were found alongside non-GM lines (see discussion in section 7.2.1 above). Provisions for security may also not have drawn attention to the field in question, with arrangements made on a somewhat ad-hoc basis:

We were concerned and ready for... action against... field tests but... it didn’t actually happen here... there was security like for instance [a GMO] which was [growing at a particular location]... one of the guys running the trial lived over the road from where it was and was keeping a pretty close eye on things. (Interview F)

It is arguably no longer possible to keep a field test “low-key”. In Chapter 6 I discussed how field tests have become increasingly conspicuous, and how this in turn is leading to fewer ERMA applications. In this earlier analysis, I identified the publicity associated with a field test application as the reason for this situation: negative publicity can have far-reaching consequences throughout a research institution, ultimately impacting on its overall financial return. But field tests conducted under the HSNO regime are also highly conspicuous in a more conventional sense: they look different to other fields, and this in itself can impact on the research contained within them. Although early GMO field tests in New Zealand were relatively difficult to distinguish from other forms of field-based research, ERMA approvals now require that measures are taken

53 Destruction of a potato trial at C&F in 2002 led to $300,000 worth of damage (Nippert, 2004). Comments made in Interview P also suggest that damage to field test research is costly to an organisation.
to protect the field test site from intruders, be they human or non-human. These measures are outlined in ERMA applications and subsequent approval conditions:

The registered contained field test site is completely enclosed by fencing. Only authorised personnel will have access to the field test site and be allowed to operate on the site...

Appropriate measures to prevent sabotage and detect human disturbance on the site have been arranged (Crop and Food Research, 2008b, p.38).

The above quotation specifically mentions measures that are aimed at preventing “sabotage”: direct action taken by anti-GMO groups against GMO research. But as I have already discussed in Chapter 2, there are many other “indirect” methods by which such groups can take action, and these do not require people to cross over the physical boundaries of a containment facility. They can submit on the ERMA application itself, or even challenge an approval at the High Court; but probably the most effective form of action available to them is their “monitoring” of existing field tests, something that they suggest is a necessary addition to the formal monitoring conducted by MAFBNZ:

[The president of GE Free NZ] accused authorities of being slack in their monitoring of field trials, and said the organisation maintains visual and photographic reports of all field trials in the country. (Harper, 2012)

I recently revisited the Scion GE tree field test site to independently appraise how well Scion (previously CRI Forest Research) were meeting the containment requirements set by the Environmental Risk Management Authority (ERMA). (Browning, 2008)

Given that anti-GMO group members are essentially members of the public, it would seem unlikely that they would be capable of conducting monitoring on a par with that of MAFBNZ. How would they even know where to look, let alone what details to check? The nature of applications to ERMA means that details of field tests can be found in publicly available documents. Although the exact location of the field itself is given in a confidential appendix to the main application document, it is relatively easy for someone with a good knowledge of the particular research programme to work out exactly where the GMOs are being developed. New Zealand is a small country with a small population, and GMO field tests are conducted at a small number of sites across the country. And as I have already mentioned, the controls attached to an ERMA consent

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54 The HSNO Act (1996, sch. 3, p.1) specifies that an ERMA approval must impose controls that are designed to exclude “unauthorised people” (s. 2) and “other organisms” (s. 3) from a containment facility.
mean that a GMO field test looks very different to other fields. This was a crucial factor in identifying the site of a GM brassica field test at C&F’s Lincoln research facilities in December 2008:

There was this massive fence, and yet, all the roadside was just fields... do you see what I mean? There was this massive fence, and it had on one of the fences, biosecurity area... we walked down, and there was, an area, big area... and it had been sectioned off, and around the area was these, coloured brassicas which was the buffer zone... and then I looked and there was a gate and on the gate was one of those... brushes, that you, for a little brush and dustpan, and a little hedgehog, and one of the things, on the controls was they had to clean their shoes before they left the site... and it was as simple as that, this little blue brush, I thought I have lived and farmed for years and my Dad was a farmer and no way would you find a twee little brush sitting on a fence in the middle of farmland. (Interview J)

A large fence with a brush at the exit made a certain field stand out as different from all others near it. The onlookers therefore determined that this particular field was a containment facility; they then used other sources of information to check whether the field test was being conducted according to containment protocols:

So I [went to the field test site] and, had a look and, I thought I was going to see the next year’s plantings, because, you know the first ones had happened and... they should have been in the ground if you were planting... and all I saw was a pile of weeds and, stuff, and you could see the odd brassica flower, in amongst that, and... so I... took a lot of photos... and, I think I climbed the fence, and took photos, that evening, late in the day... and then I went back to my accommodation, where I was staying over, down there and, I... looked again at the conditions... and realised a lot of what I’d seen were buffer... plants, plants had regrown from, cut-off stumps... and but then I realised oopsy, this one here is, actually within the row area, and is... most likely, you know a GE plant or it could well be. (Interview L)

Cross-referencing between photos taken at the site and publicly available documents associated with the ERMA consent meant that the person observing this field test site was able to judge whether or not consent conditions were being adhered to. In this particular case, a breach of containment conditions was detected: a GM brassica plant was in flower, even though the ERMA conditions clearly stated that this should not be allowed to occur (see ERMA, 2003, Appendix 1, control 1.11).
This discovery initiated a chain of events that ultimately led to the discontinuation of the GM brassica field test. A reporter working for the local Christchurch newspaper *The Press* was contacted; he subsequently took photographs of the flower that were sent to C&F to indicate that a breach of containment conditions had been detected (Interview L), and he reported the incident in the newspaper (Williams, 2009a, 2009b). A MAF investigation shortly followed, and this led to the discontinuation of the GM brassica field trial (Williams, 2009a; Soil and Health, 2009). As I have already discussed in Chapter 6, this incident contributed to the suspension of all GM field tests at the C&F laboratories at Lincoln, including the consented application to field test GM tearless onions (GMF06002). Since December 2008, C&F has been subject to repeated investigations and monitoring by MAFFNZ, and the local media has reported a number of incidents in which rogue plants (GMOs or otherwise) have been found to be growing beyond the boundaries of old field test sites (Gorman, 2009; Williams, 2011). There has also undoubtedly been a period of unease for GMO research staff given that an internal review of procedures laid much of the blame for the containment breach with an individual person (the trial manager; see Stevens et al., 2009) who subsequently lost her position within the GM brassica research programme. Thus we can see that the actions of anti-GMO activists were instrumental in determining the course of a research programme: if they had not been conducting informal monitoring of field test sites, and if they had not contacted the media upon discovering the flowering brassica, it is likely that this containment breach would never have been detected, reported, or shut down.

It is important to point out that all of the activities listed above have been directed at field tests of GMO research. Although it is not true to say that anti-GMO activists are completely unconcerned with laboratory-based research, they appear to put most of their energy into opposing field-based experiments55. In contrast, laboratory research is described as an acceptable place for GMO research:

> [We do] not oppose safe research; we oppose open, risky experiments with something as fundamental as our food and the environment we depend on for life. Greenpeace does not oppose GM research in the lab, but we do oppose experiments known as ‘GM field trials’. These ‘GM field trials’ involve open, genetic experiments in the environment. (Greenpeace, 2011)

55 Comments made in Interview J support this claim.
The Green Party supports [the] use of genetic science as a tool in diagnostics, understanding of heredity, and development of medicines, provided any genetically engineered organisms are completely contained in an indoor laboratory. (Green Party of Aotearoa New Zealand, 2011, p. 7)

Others were prepared for research to continue in containment, but were more concerned about field tests (trials) or release into the environment. Their main concern was the safety of the environment. For instance, the Golden Bay Organic Employment and Education Trust [IP104] considered there is an unacceptable risk once research moves outside a strictly defined, monitored and enforced laboratory environment. (RCGM, 2001, p.111)

Thus we can see that anti-GMO spokespeople make a clear division between different forms of GMO research, and this depends on where that research is being conducted. On the one hand, laboratories provide an acceptable venue for research; on the other hand, fields are unacceptable. This division is not simply a discursive construction, something that exists in written and spoken words that is separate from an underlying reality. This division is a reality: it enacts a difference between laboratories and fields that is in turn serving to structure the way in which GMO research is being conducted in New Zealand. This point is best explained through consideration of the following comments made by a genetics researcher:

Those who are using GM and see the value in GM, have learned to keep their heads down and go and do it, and those that are anti-GM... think that they’ve probably won some battles, but you know they may have won the battle but lost the war sort of thing in terms of, of where we’re going with GM, and that it’s virtually impossible now to, live your life without having, without seeing an impact of GM, or technologies that will be called GM, in some impact in your life, but you’re probably unaware of it. (Interview H)

When asked to elaborate on how researchers can “keep their heads down” in GM research, this participant responded as follows:

Two ways, one you obviously don’t put your science out there publicly, I mean science, is something that can occur... in a laboratory somewhere, and be utilised... I mean you don’t shout out from the... lampposts this is what we’re doing and why we’re doing it, then it’s very easy to do science where it will be notified, somewhere, that’s not to say that they’re doing it illegally, but it’s just not publicly obvious... there’s a whole lot of other people using GM techniques, who... are never seen, and they’re using it, but you could, go onto the... websites now which will be all at the... new environment Ministry, what’s it called, the
EPA... and there will be a pathway, there will be a pathway [at this research institution]... it surprised me the other day actually when I saw all the... people who have to be registered to use PC1 facilities, which is, often because they’re doing genetic modification work, and the list of names was probably 50-odd names... here at [this research institution]... but most of them don’t take on a public persona with it it’s just a tool. (Interview H)

The person speaking in this quotation is talking about the division between public and private in the conduct of GM research. Laboratories are described as offering a place where scientists can “keep their heads down”, getting on with their work away from public scrutiny and therefore without the possibility of raising public “anxieties”. Thus, there is a large laboratory-based industry associated with the use of GM techniques in scientific research; but this is not attended to in the “war” against GM. Instead, anti-GMO activists are focusing their efforts on the small portion of research that is conducted in “public”; I have already suggested that field-based research is the main target of such activism. The implication is that GM researchers can choose where they work, and if they want to get on with their research in relative peace they will choose to work in the seclusion provided by a laboratory. Thus there is a very real division between laboratories and fields; one that is enacted by activities that lie “outside” the boundaries of containment facilities.

7.3 Representing the object

These four narratives each focus on the boundaries of containment facilities. First I have shown that the physical boundaries of containment facilities are not fixed, but are found in multiple spaces and are always “in the making”. Then I have considered how the control of these boundaries depends on numerous successful translations: connections between reality and representation that are forged by documents and record-keeping processes. Next I have discussed the permeability of these boundaries, not only in terms of the physical threshold that is regularly crossed by humans and non-humans, but also as a result of the changing categories that define what is allowed into the containment facility. Finally I have moved beyond the boundaries of containment facilities to ascertain how the world “outside” is nevertheless part of what is found “inside”.

As in the two analytical chapters preceding this one, I must now consider how to draw together the different narratives presented above into a less fragmented representation of the object. Unlike Chapters 5 and 6, the object I am considering is not a scientific fact, but a regulatory system: the definition of a containment facility and the delineation of its boundaries provide a system of classification by which GMO research is organised and controlled. While anything can
arguably be taken as the “object” of ANT analysis, it has nevertheless been argued that a focus on
the processes involved in network building is particularly suited to studies of the stabilisation of
scientific facts (Fujimura, 1992). Systems of classification and standardisation have been studied
elsewhere in the STS literature, the work of Susan Leigh Star and colleagues of particular
relevance (e.g. Star & Griesemer, 1989; Bowker & Star, 1996, 1998; 2000; Timmermans, Bowker,
& Star, 1998; Star, 2010). Although these studies have found widespread application, it has been
argued that the ontological assumptions that underpin them are irreconcilable with those of ANT,
and ANT theorists have therefore developed alternative methods of object representation in
recent years (Law & Singleton, 2005). So, whereas the tearless onion analysis explored different
approaches that were all forms of network analysis, here I will consider other object
representations that have been developed in the ANT literature. My goal, first and foremost, is to
ascertain what type of object the containment facility is.

The first part of this analysis will consider the containment facility as a network. I will begin with a
general application of the literature, identifying themes and ideas from network-oriented ANT
studies that can be used to interpret the data I have collected. Following this, I will identify what
is missing from a network representation of the containment facility. Finally, I will move on to
consider an alternative representation that, although taken from the ANT literature, is
significantly different from the singular rigid structures that characterise early forms of network
analysis.

7.3.1 Networks of containment
In each of the narratives related above it is clear that containment facilities are not simply
“places”, points in space that can be grounded in a particular physical setting. In addition to the
physical form of a laboratory or field there is a vast array of people, machines, documents,
protocols, and equipment that, when acting in concert, give effect to the requirements specified
in legislative documents. Pictured thus, containment facilities can be described as a network of
heterogeneous elements.

These networks of containment are similar to those traced by John Law (1986a) in his analysis of
the Portuguese extension of trade routes to India. Law describes how sailing vessels were turned
into durable, mobile objects through a particular combination of “documents, devices and drilled
people” (p. 22), thereby allowing the Portuguese to exert power and control over long distances.
Similarly, a place can become a containment facility if it is accompanied by strict documentary
procedures, constructed according to certain criteria, and people are trained to use them
appropriately. This allows the legislative criteria defined in the HSNO Act (1996) to extend from
the centre of New Zealand government in Wellington to (potentially) anywhere in New Zealand whilst still remaining intact.

As with any network, there is work involved in keeping it stable. In the case of containment facilities, many disparate elements must be brought together and made to perform in accordance with legislative criteria. Just as the dissent of scallops and fishermen led to the break-down of scallop fishing in St Brieuc Bay (Callon, 1986a), a place cannot remain black boxed as a “containment facility” if any part of its network fails to perform its given role. This leads us to question how such stability is achieved and who (or what) is instrumental in orchestrating it.

As discussed in section 7.2.2, the control of the boundaries to containment facilities is dependent on numerous successful translations. Each of these translations is a chain of processes that link together “words and the world” (Latour, 1999a, p. 69; see Chapter 3 for discussion). These processes tend to involve paperwork and associated record-keeping activities. An application to conduct a programme of GMO research translates a research proposal into a number, which, when attached to a petri dish, allows the research programme to be conducted. A training programme, tests, a spreadsheet, and a name on a sign translate a person into someone who can enter into, and conduct specified tasks within, a containment facility. In each case, there is a gap between an object and its representation; this is bridged by a chain of interlinking translations that must remain intact if the overall transformation is to be effected. MPI inspectors routinely check that this maintenance is being conducted properly. This is done by checking through paperwork: each step in the chain of translation is documented and filed, thus making it possible to travel the path between words and the world via a paper trail.

This presents a picture of the control of scientific research that differs to common sense interpretations. Although we tend to focus on the scientists who carry out GMO research, these are not the people who are responsible for maintaining the chains of translation detailed above. Others working “backstage” are the key to this process: Biological Safety Officers, laboratory supervisors, and technical officers are responsible for the oversight of containment facilities, and must take care of any matters that relate to their function. At times this role concerns the physical structure of the facility, from being involved at the early stages of the design process through to making sure that it is adequately maintained. In terms of day-to-day operations, however, these actors are more concerned with the procedural aspects of a containment facility: a large part of this is ensuring that scientists are not only able to conduct GMO research, but are

56 The texts that result from this process can also be described as “inscription devices” (see Chapter 3 for discussion) given that they serve to simplify a wealth of complexity to produce durable, mobile objects.
doing so in a manner that complies with containment protocols. This is a difficult task, because the HSNO Act has essentially been imposed upon a scientific system of research that was already in operation, and there is potential for discord. Supervisors therefore have to ensure that this doesn’t happen; one participant who worked in this capacity observed that “a big part of my job is to be... between the... scientists and I’m a scientist too so... and the bureaucrats... of negotiating... compliance” (Interview D). Supervisors are continuously “negotiating compliance” between otherwise incongruous elements of the networks they manage: they are therefore “heterogeneous engineers” whose work is instrumental in maintaining the stability of the containment facility.

7.3.2 Heterogeneity and presence/absence/Otherness

When tracing a network, we attend to, and thus foreground, certain elements that are clearly involved in the processes of network stability; these are network presences. In this analysis, the presences in GMO networks of containment are those aspects specifically mentioned in legislative documents such as the joint MAF/ERMA (2007b) standard *Containment facilities for Plants* or the conditions attached to an ERMA approval. 6-metre fences, air vents, training records, and controls to prevent the spread of pollen are not only involved in the construction of a containment facility, they are what anyone who is analysing the performance of a containment facility will focus on. Thus, an MPI inspector will examine the adequacy of training provision at a particular facility; similarly, a beekeeper may express concern about the effects of GM pollen on local honey production. These actions may lead to changes that involve the introduction of ever more elements into the network, re-making it as an increasingly complex and heterogeneous assemblage.

Beneath this surface layer of dense connection are successive layers of ever more complexity and heterogeneity. This is because the presences we attend to do not constitute elemental foundations; “What is being made present always depends on what is also being made absent” (Law, 2004, p. 83, emphasis in original; see also Law & Singleton, 2005). But network representations provide no space for absence, and this has led to criticisms of early ANT studies (Star, 1991; Law & Singleton, 2005). There is also a rigidity to their structure that is necessary for stability. The sailing vessels that were the focus of Law’s (1986a) study of the Portuguese expansion have been described as “immutable mobiles” (Latour, 1990): “mobile” because they are able to move in Euclidean space, but “immutable” because they remain unchanged in network space (Law, 2002b).
The evidence I have presented in this chapter suggests that the stability of the containment facility is dependent not on rigidity but on flexibility. A GMO can be grown in a laboratory or a field; it can be surrounded by different “sides”; and sometimes it can be in transit between different locations. The GMO nevertheless remains “in containment” in all these instances; but it does so only because the heterogeneous assemblage that enacts the containment facility is able to adapt and change.

Similarly, this stability is not the result of network presences alone: absences are also necessary, but they must remain absent from view. For example, the distinction between accompanied and unaccompanied persons does not feature in common understandings of the operation of a containment facility. Instead, we focus on the presence of scientists who we can “see” working in laboratories and fields and assume that all aspects of a GMO research programme are carried out by them. But there could be no research programme if refrigeration units weren’t maintained, lawns weren’t mowed, or even if the soap in a handwashing facility wasn’t refilled. These latter are manifest absences: they correlate with and result from presence (Law, 2004). We only become aware of them if they don’t fulfil their role in a network: if a cleaner fails to sterilise the water used to mop a laboratory floor or if a contractor puts design aesthetic ahead of containment requirements.

The supervisors of containment facilities are directly responsible for managing material absences, making sure that they don’t rise to the surface but instead remain invisible. These supervisors are therefore heterogeneous engineers in a sense that extends beyond a network-based interpretation of their role: they have to negotiate the “oscillation between absence and presence” (Law, 2002a, p. 96, emphasis in original) that is folded within an object. Nevertheless, these supervisors also remain absent from view, and this has significant implications for risk management practices. I will discuss this point in detail in Chapter 8.

But an attention to material absence cannot account for the full range of heterogeneity that enacts the containment facility. The data presented in this chapter indicates that there is something else that must be incorporated, something that is neither present, nor absent; something that “simply does not fit” (Law & Singleton, 2005, p. 341). This “Otherness” is enacted as “irrelevant, impossible, or repressed” by network presences (Law, 2004, p. 157; see Chapter 3 for discussion). Nevertheless, alongside absence, Otherness is a necessary counterpart to presence (ibid.) and must also be kept in (or out of) place for an object to remain stable. Otherness is what spills over the boundaries of formal definitions and defies the structure and
control of not only Euclidean space, but also network space. But it is still “there”; and it is still part of what an object is.

The data I have presented in this chapter indicates that the stability of containment facilities is dependent on not only presence and material absence, but also Otherness. For a place to function as a containment facility, we have to Other its existence as a workplace that is subject to Health and Safety requirements: thus Master Keys and the access they confer to unknown people do not enter into discussions over containment facility access, and there is no written record of their use. Anti-GMO spokespeople are assigned a role within formal decision-making processes, and while this gives them a voice at ERMA hearings, it also serves to restrict their influence on the outcome, Othering their objections to GMO research as a whole. Nevertheless, they find alternative methods of acting against GMO research, including consumer boycotts and the informal monitoring of field test sites. These activities have a significant effect on the outcomes of GMO research, such as the dismantling of research programmes directly and indirectly related to their activities. But this in turn has implications for the careers of GMO scientists, who appear to be choosing to stay within the confines of the laboratory because of the controversy that surrounds field-based research. Furthermore, the presence of this laboratory-based research is effaced from popular conceptions of GMO research in New Zealand, which proudly labels itself as “GE-Free”. But this research hasn’t “disappeared”; it has been “Othered”.

The role of Otherness in the establishment of stable categories has not been the traditional focus of attention for STS or ANT scholars (see Singleton, 1998). But recent literature has examined the role of instabilities in the continuity of laboratory work (ibid.), and this has been extended to more general considerations of how to incorporate Otherness into object representations. The “fire object” is neither rigid nor fluid, but is instead characterised by discontinuity, disjunction, and a dependence on difference (Law & Singleton, 2005). Law and Singleton (ibid.) illustrate their portrayal of the fire object through a consideration of alcoholic liver disease: they argue that this object folds together three different versions of the same disease, each enacted by different patterns of presence/absence that are irreconcilable with one another.

Similarly, in my research, the containment facility folds together two different places that appear to be completely different: the laboratory and the field. Each is enacted through a pattern of presence/absence, but these patterns are different for each type of facility. Thus we find that their characteristics are completely contradictory in that the laboratory is safe, private, and acceptable and the field is risky, public, and controversial. But these contradictions are not the result of separation but because they are connected “Others”. To paraphrase Law and Singleton:
“the pattern of absent presences over the [two] locations is itself a pattern of absent presence, of necessary otherness. [Laboratories and fields] are other to each other. They cannot be included in each other. At the same time (and this is the difficulty and the complication), they are also necessarily related to one another because they are part of the same [risk management] system and interact with one another” (2005, p. 347, emphasis in original). Thus laboratories and fields depend on and feed off each other. This indicates that the safety, privacy, and acceptability of the laboratory are only afforded by the risk, publicity, and controversy of the field.

These observations have significant implications for current understandings of the “containment” of GMO research. They lead us to question what the boundaries of containment facilities are and how they are created. According to the HSNO act, containment is defined as “restricting an organism or substance to a secure location or facility to prevent escape” (1996, Part 1, section 2). This definition focuses on the construction of a discrete physical boundary, and the delineation of what lies “inside” and “outside” that boundary. When ERMA considers applications to conduct GMO research, it focuses on the boundary of a containment facility: it considers whether or not a GMO will remain “inside” a containment facility or if any part of it is likely to somehow “escape” into and establish itself in the world “outside”. This approach to containment is essentially aimed at maintaining the physical separation between inside and outside; to borrow from Mary Douglas, a containment breach is genetically altered “matter out of place” (1966, p. 36).

But this emphasis on boundary maintenance is an inaccurate definition of containment. My results demonstrate that containment is enacted by relations that transcend the physical and operational boundaries of containment facilities, folding together that which lies “inside” and “outside” the containment facility. Furthermore, the separation between laboratories and fields is also enacted through these practices, meaning that they are an outcome of them rather than a precursor to activity. These observations have further implications for the risk management of GMO research, which I will consider in detail in Chapter 8.

7.4 Summary and conclusions
In New Zealand, all programmes of GMO research are conducted in “containment facilities”. This chapter has tested the boundaries of containment facilities, exploring the practices that are involved in creating and controlling them. The results indicate that there is no single, fixed boundary to the containment facility; nor is it purely physical. Furthermore, this boundary is permeable: it must be crossed if the facility is to operate effectively. Some of these crossings are specified in legal definitions of containment; but others are not, even though they too are
necessary to the stability of this object. Finally I have shown that the world “outside” the containment facility is also involved in enacting its boundaries.

These multiple overlapping narratives on the boundaries of containment facilities lead me to dispute the notion that GMO research is conducted in a physically enclosed and impenetrable “place”, whether a field or a laboratory. The boundaries of containment facilities do not enclose a physical location; they are enacted by a heterogeneous assemblage that folds together presence, absence and Otherness. While this object can be interpreted using ANT, it requires a different approach to the analysis of tearless onions. Instead of common Focus Points there are discontinuities; instead of collaboration there is contradiction. Rather than try to efface these by smoothing out “anomalous” results, ANT directs us to embrace such ruptures in any representation of the object. To do this requires a move beyond the networks of early ANT studies to consider increasingly varied topologies. My analysis shows that the “fire object” provides a means of representing the containment facility: characterised by discontinuity, disjunction, and a dependence on difference it encompasses not only presence and absence, but also that which has been Othered. Thus, apparently contradictory aspects of GMO research can be brought together under the banner of “containment”: risk and safety; public and private; controversy and acceptability. Each of these is a discontinuous pairing, an either/or choice; and yet they co-constitute the containment facility as an object, each responsible for making it what it is.

This analysis therefore disputes the notion that laboratories and fields are entirely distinct places of GMO research, arguing instead that their apparent separation is enacted by the relations that co-constitute them. These conclusions have implications for understandings of risk and the practice of risk management. In the Chapter 8 I will therefore discuss the topic of risk in more detail, using the results of all three analytical chapters to present a re-interpretation of the risks of GMO research as well as indicating possibilities for change. I will also discuss the theoretical and methodological findings of this study, using the lessons learned from the two different case studies presented in this thesis to provide a re-interpretation of ANT.
Chapter 8
Discussion

8.1 Introduction

In this chapter I will discuss a number of cross-cutting themes and issues that have emerged in the course of this thesis. Thus far, the analytical discussions presented in Chapters 5, 6, and 7 have focused on the results presented in each individual chapter: Chapters 5 and 6 have examined how tearless onions have been created first in the laboratory, and then in the field; Chapter 7 has considered how containment facilities are created as a place for GMO research as a whole. Here I will draw these results together through two discussions. First, I will use my results to redefine the “risks” of GMO research; I will then use this understanding of risk to suggest changes to current risk management practices. Second, I will consider the various tools I have used in the course of my research, drawing from my experiences to redefine how ANT can be used as a theoretical and methodological guide for social science research.

An overarching theme for this discussion chapter is that of “reassembling”. I borrow this term from Latour’s (2005) book Reassembling the social, in which he discusses how ANT can be used to reassemble, or redefine, what we mean by the “social” world. Latour contends that there is no underlying structure to society, and that the role of researchers is to trace the complex connections and activities that serve to enact it. ANT is a tool for doing just this, as it begins with no predetermined categories or structures that exist as a precursor to activity. In this chapter I will use this concept of reassembling to discuss both risk and ANT itself. Although the use of each of these terms suggests the existence of an underlying structure that determines what they are a priori to activity, they are each enacted in practice and can therefore only be understood in terms of these practices.

8.2 Reassembling the risks of GMO research

I’ve always seen the risk there... animals out in the paddock, good old Waikato weather... water running, down and then going off-site, is that a risk, you know faeces, urine... embryonic material whatever in the field, cell material going out into, where, conventional sheep and other animals are grazing birds are coming and going. (Interview L)

Field trials... by their own nature, tend to be deemed low-risk things, EPA is not going to let them out if there’s any, significant risk. (Interview R)
The issue of risk is pervasive in discussions of GMO research, and the results of this thesis are no exception. On the one hand, those against GMO research see a multitude of risks involved, each of which pose a credible threat to the integrity of the New Zealand environment (see first quotation above, Interview L). This position can lead to speculations that the risks of GMO research are overlooked or not considered seriously by scientists. This issue has recently been raised following the publication of a scientific report that has severely criticised the handling of HGT monitoring during a field test of GM cattle, arguing that the methods used to detect HGT were inherently flawed (Heinemann, Kurenbach, & Bleyendaal, 2011). This report has led some to label the risk management of GMO research in New Zealand as “corrupted” (Soil and Health, 2011).

In contrast, others view the GMO research currently being conducted in New Zealand as very low-risk and therefore of negligible threat to the environment (see second quotation above, Interview R). This position can lead to suggestions that there is an overly strict and bureaucratic system that regulates GMO research, effectively stifling the ability to make real progress in this area of biotechnology. Comments made by a number of speakers at a recent forum held by the NZIAHS echo these views, with suggestions that it is “time to proceed with less caution” (Glare, 2010) and “relax the regulations” (Rolleston, 2010) if GMO research is to develop effectively.

While the observations above demonstrate that the debate over GMO research is polarised, they can also be used to suggest a conceptualisation of the risks of GMO research that differs to common theorisations (as discussed in Chapter 3). Although the opinions portrayed in the above quotations are fundamentally opposed to one another, they also display similarities that are characteristic of the wider debate over GMO research. People on both sides of the debate claim to understand the “reality” of GM risks; similarly, they both accuse the other of skewed “perceptions” of this reality. Rather than resolving this situation by assuming a separation between reality and perception, an alternative approach is to view them as intertwined. The consequences of this are illustrated through a consideration of the following quotation:

There’s a really common misperception about GMOs, that, you know it’s all about putting frog genes into potatoes... and creating, you know like, I don’t know your monster organisms and stuff like that... and that’s the risk that we face... you know one of our big risks I guess in terms of running a facility like this is dealing with that perception of what people think... and so if people... think that, that we’re growing something really nasty in

57 Details of this forum are given in Chapter 4.
here that’s going to escape from the building and, and you know turn all your garden tomatoes into, you know cat-killing ravenous animals or something then, then we face a big risk you know it’s... they’re going to come in and, destroy the facility and, and our plants and, I guess in the firm belief that they’re actually doing humanity a favour. (Interview N)

The person speaking here is making a distinction between the “real” risk that resides in a GMO and the “perception” of that risk that resides in people’s heads. Here we are told that if people think that “something really nasty” is being developed within a containment facility, they will “come in and destroy the facility”. Escape of the organism is not itself the issue; but neither does it matter if members of the public ever actually break in. The perception that they might do this is influencing the management of the containment facility: as discussed in Chapter 7, measures are taken to keep containment facilities as low-key as possible so as not to attract attention. So we can see here that perceptions have effects, and the divide between reality and perception is collapsed in the practice of risk management.

Furthermore, there is a variety of practices associated with the risks of GMO research: risk is not a singular construct, but is instead multiply enacted. In the case study of tearless onions (Chapters 5 and 6) I considered how an apparently singular object was better conceived as a multiple, fractionally coherent network. This material similarly demonstrates that the risks and risk management of GMO research are multiple: the different actors involved in the tearless onion network each engage in practices that enact risk in different, but overlapping and interacting, ways. For ERMA there is a containment risk: genetically modified material cannot be allowed to cross the boundary of a containment facility, and ERMA’s role is therefore to propose controls that will reduce the risk of this occurring to negligible levels. Anti-GMO spokespeople have a similar focus on the ability to contain GMO research, except that they are specifically concerned with the risk of contamination that would result: any genetically modified material that is able to escape from a containment facility will contaminate the New Zealand environment. In contrast to these positions, research institutions such as C&F and HFC focus on financial risk: there are potential costs and benefits associated with any programme of research, and an ongoing assessment of these is used to decide what type of research to support. In a similar vein, GMO research represents an opportunity risk to the New Zealand government (through FRST) because the funds used to support GMO research could be allocated elsewhere. Finally, for scientists there are career risks involved in GMO research, and the opportunity to develop innovative products is offset by the various barriers to progress that could serve to limit their professional development.
By recognising that risk is multiple it is possible to accommodate difference within an object. Thus, each of the actors mentioned above are involved in different enactments of risk; but these enactments coalesce to form a single, fractionally coherent, object. A similar premise was used to direct the analyses given in Chapters 5 and 6, where I developed a network representation to convey the multiple enactments of the tearless onion. But by using a network representation I primarily attended to *presences*; the analysis of containment facilities given in Chapter 7 demonstrates that absence and Otherness are also involved in the enactment of the objects of GMO research. For a comprehensive discussion of the risks of GMO research I must therefore consider the significance of not only presence but also absence and Otherness.

### 8.2.1 Presence, absence, and Otherness

The risks of GMO research are partly dependent on absence: if GMO research can be hidden from view the associated risks will be minimised. In some cases this is achieved via physical methods. In Chapter 7 I discussed how the location of an indoor containment facility had been chosen to afford it a degree of isolation so that people wouldn’t know it was there. Such aims are aided by the material form of indoor containment facilities, which essentially look the same as any other building used for scientific research: they have six sides that make it very difficult for people to see what’s going on within them. In addition, procedures serve to keep GMO research away from public scrutiny. In Chapter 6 I suggested that some research institutions are choosing not to make ERMA field test applications because they don’t want to be identified as pro-GM. Instead, they keep their work in the laboratory, conducting “low risk” developments that can be evaluated via rapid assessment without public input. As discussed in Chapter 5, this serves to black box laboratory developments so that any details of the research are hidden from view; the presence of this type of research is usually not attended to as a result. And as I discussed in Chapter 7, these factors influence the particular career paths of GMO researchers, with many now choosing to conduct research that keeps them in the laboratory because it allows them to progress with their work away from the public spotlight.

But absence is never absolute, and inevitably there is “leakage” (cf. Law, 2006) across the boundaries that divide invisible spaces from the world outside. Laboratories are the places where this capacity for sudden change is perhaps most apparent: research facilities (or even entire organisations) can change from being invisible to visible as a result of a single event:

> We haven’t had any incidents here but... you know the, the risk... for us is that, we only have to have one outbreak one, one release, that gets publicised, and then we become... a... a public icon I guess. (Interview N)
The above quotation suggests that a containment breach isn’t simply the escape of a GMO from a containment facility; it is the public knowledge of that escape and the damage this can do to the research institution itself. Thus, the uncontrolled flow of information poses a risk, and this is particularly relevant when research is being conducted in outdoor facilities. The physical form of a field highlights the presence of GMO research: they are surrounded by only four sides, usually composed of fencing, that not only allow people to see inside, but also serve to demarcate the field within the enclosure as different to others (see Chapter 7). Regulatory protocols also make it difficult to effect absence: the ERMA decision-making process is publicly notified, meaning that members of the public will learn of a research project’s existence before it even begins. But although the complete invisibility of field-based research cannot be achieved, the degree of visibility can be managed by controlling information that is made publicly available. Thus, media and communications staff were involved in the preparation of the ERMA application to field test tearless onions; they also train their GM scientists to use specific language when dealing with the media (see Chapter 6). This need to control the flow of information can also be used to explain why successful GMO research can end up being discontinued. In Chapter 6 I presented evidence that suggested that the dismantling of the GM onion research programme resulted from containment breaches involving unrelated GMO research at C&F. The resulting negative publicity would have made operations at C&F highly visible, creating an imbalance in the pattern of presences and absences required for the research institution to function. The decision to discontinue the high-profile GM onion research programme can therefore be interpreted as an attempt to correct this imbalance.

As highlighted in Chapter 6, anti-GMO spokespeople are also integral to the enactment of GMO research objects; it therefore follows that they are involved in the enactment of the risks associated with these objects. The evidence collected in this thesis suggests that even anti-GMO spokespeople are selective about what arguments they make public and how they present them. As discussed in Chapter 7, some staunch opponents of GMO research nevertheless state that laboratory-based research is acceptable. But these official statements do not necessarily reflect privately held opinions:

In discussions with NGO’s, we encourage open communication, they say are not opposed to the research that goes on in laboratories, but it is of my opinion that is more of a public stance, not to sound too radical, it’s not what they really feel but it’s definitely what they say in the public forum.

When you say it’s not what they feel what do you mean?
From certain conversations, my take is they are anti-everything.

(Interview K)

This quotation implies that anti-GMO spokespeople are making deliberate choices in the types of GMO research they are campaigning against. It may be that to oppose all forms GMO research would cast them as too radical in the eyes of the general public; their “private” opinions could be very different:

I’m pleased when I hear... of very stringent conditions, around labs, I think there’s some real risk, out of labs, and we’ve seen leakage, from labs...we’ve seen leakage of Arabidopsis, but when you start, when you are doing virals, and... microbial stuff... and you’re generally using non-pathogenic but not always... looking at disease pathways and just all sorts of things, you know that... have, real potential... for understanding life and... maybe health issues and stuff like that... and, the development of, new normally bred plant species you know there’s heaps of potential... but there are still, some serious risks and possibly... some of the worst risks are happening in laboratories, as opposed to field trials.

(Interview L)

This suggests that anti-GMO spokespeople may be managing the information they choose to make public in much the same way as research institutions; in doing so, they too are managing patterns of presence and absence. And, just as research institutions have carefully orchestrated communication strategies (see Chapter 6), GMO spokespeople are mindful of how they release information to the public. In Chapter 7 I considered how the breach of containment conditions in the GM brassica field test was detected and made public: although the breach was discovered by anti-GMO activists, they chose to contact a journalist to publicise their findings. This choice was deliberate, as there had been problems in a previous incident where they had chosen to release news of a containment breach without media involvement:

By using The Press and that... it was much better... I was not... there was not the comeback, on me as just, me standing out on my own... very vulnerable individuals or even organisations you know, if, if you don’t have... either the authorities on your side or, some independent... oversight which was, was the media in [the GM Brassicas] case. (Interview L)

This discussion of the risks of GMO research leads to a number of conclusions. First, it is apparent that each of the actors mentioned above is concerned with the risk of damage to their reputation. The significance of reputational risk to modern-day risk management practices has been discussed elsewhere: Power (2004) has labelled it as a “secondary risk”, arguing that, as part of a
culture in which the risks of “everything” must be managed, reputational risk is now just as influential as any “primary” concerns (p. 14). The difference in my argument is that there is no inherent difference between primary and secondary risks, with risk being an enactment of an assemblage of heterogeneous practices that extend across commonly held categories.

Second, it shows that the relative risks of laboratory- versus field-based research can be understood in terms of differences in visibility. It is difficult to effect absence in field-based research, and this means that fields are enacted by presences that make them highly visible places of research. The ERMA decision-making process draws attention to field tests, as do the physical characteristics of its location; research institutions are reluctant to move research out into the field; and anti-GMO spokespeople specifically target their opposition at field-based research. But for each of these activities there is a corresponding activity that enacts the laboratory; the difference being that these are absences that make the laboratory a relatively invisible place of research. ERMA decision-making processes are usually not made public; laboratories and their contents can be kept physically hidden; scientists are able to develop successful careers by remaining in the laboratory; and by focusing their attention on fields, critics of GMO research draw attention away from laboratories, which serves to amplify the latter’s invisibility.

Third, this description of risk implies that by making some places of research visible others are rendered invisible, and this has significant implications for our understanding of the risk management of GMO research. As mentioned in the above paragraph, for each practice that enacts field-based GMO research as visible, there is a corresponding activity that enacts laboratory-based research as invisible. This observation has important implications for the risk management of GMO research as part of a wider suite of biosecurity practices. Biosecurity has been described as “a powerful system of surveillance” (Donaldson & Wood, 2004, p. 373); but we should be wary of assuming that surveillance techniques operate as an all-seeing eye rendering everything visible. Gad and Lauritsen (2009) use Latour’s (2005) concept of the “oligopticon” to argue that surveillance can only provide a partial, situated view. Their study of changes to the system of Danish fisheries inspection reveals that this can ultimately be used to offer protection from view:

Fishermen worried that the system would be like a camera, filming their cargo holds.
However, their uneasiness evaporated as the system was implemented. This could be interpreted as a successful implementation of a surveillance technology that only becomes more effective as it is integrated into everyday life. A more likely interpretation, however,
is that the fishermen discovered that they were not dealing with an effective surveillance machine, but with a fragile oligopticon that can be bypassed and resisted. (p. 54)

Parallels can be drawn here with the surveillance of GMO research programmes described in this thesis and the connection between visible and invisible places of research. Field-based research is highly visible and therefore comes under scrutiny through a variety of practices. But this is a partial view that is itself a “fragile oligopticon”, and it is being “bypassed and resisted” by those scientists and institutions that are actively choosing to remain out of its range by keeping their research inside the laboratory. Pictured thus, the relative risk of the places of GMO research is an outcome of risk management practices themselves, and this means that we should examine the current system of risk management in more detail and suggest ways in which to change it. This is a consideration of the “ontological politics” (Mol, 1999) of the risks of GMO research: given that realities are done in practice, they can be “done” differently, and the limits of reality are determined only by the possibilities that we choose to consider. It is to these questions that I will turn in the next section, using not only the results of this discussion but also the findings I have presented in earlier chapters of this thesis.

8.2.2 “Doing” risk management: current practices and future possibilities

Prior to the enactment of the HSNO Act (1996) there were no statutory regulations that had been specifically designed to control GMO research in New Zealand; but this did not mean that there were no risk management practices. As the use of GMO technologies in biotechnology research developed, “researchers realised they were heading into new territory and they felt that they needed some peer review, internal regulation of a kind” (Interview F) and this led to the establishment of a number of different bodies that advised on the risks involved in GMO research. An Advisory Committee on Novel Genetic Techniques (ACNGT) was appointed by Cabinet in 1978 to make recommendations on the risks involved in a range of laboratory-based research, including work involving GM techniques (McGuinness Institute, 2014). At about this time, research institutions were required to appoint a Biological Safety Officer to provide safety advice and an Institutional Biological Safety Committee (IBSC) to approve research proposals (ibid.). The Interim Assessment Group (IAG) was established by the Minister for the Environment in 1988 to make recommendations on field test research and GMO releases (Pollak, 2003). Arguably, ERMA was successfully established not simply as a result of an Act of Parliament, but because of this existing network of advisory bodies and risk managers.

Since the establishment of ERMA in 1998, risk management practices have become more centralised and standardised, and this trend could be set to continue under the EPA. The IAG and
ACGNT no longer exist; and although IBSCs were originally established at all Universities and some CRIs (Interview F) there are currently only four in operation, all of which are at Universities (Auckland, Massey, Lincoln, Otago)\textsuperscript{58}. One reason for this is the number of organisations that now have split campuses\textsuperscript{59}, as an IBSC can only operate at a specific physical location. It can also only make decisions in relation to one institution, which means that decisions on collaborative research must be made by the EPA (Interview K). The EPA therefore handles a significant number of applications for low risk GMO research, which means that important risk management decisions are made in Wellington, far removed from the places where research is actually taking place. Furthermore, there is evidence that the EPA is looking for ways to standardise some of its processes. A recent application (ERMA200706) made on behalf of nine New Zealand research institutions was made in order to gain a generic approval for work involving \textit{Arabidopsis}, a plant that is commonly used for GMO research and teaching purposes (see EPA, 2014c). There are numerous development applications made to ERMA each year involving this organism\textsuperscript{60}, with a high degree of overlap between them (Interview K). This application was approved, and is the first instance where a particular programme of research has not been the subject of the ERMA decision-making process; instead the approval covers any number of potential research projects that fall within the parameters of the approval. This application did not appear to attract significant media attention, nor did many people make a submission on it; those who did were against the combined nature of the application, which is what the EPA and the applicants were in favour of:

\begin{quote}
I think it’s a really positive thing when a new application comes into the EPA having multiple organisations as applicants. It reflects a more general understanding of cost/benefits of the research to NZ. It also enhances a broader understanding of any controls and mitigation methodology across New Zealand’s research community. (Interview K)
\end{quote}

The results of this thesis are critical of the notion that it is possible to create a standard approach to the risk management of GMO research on the basis of a “general” or “broader” understanding of the issues involved. This is because standardisation is predicated on the ability to create containment facilities (and the GMOs contained therein) as “immutable mobiles” governed from a single “centre of calculation” (Latour, 1987; see Chapter 3 for discussion). But this portrayal

\textsuperscript{58} This information was provided in interview K.
\textsuperscript{59} For example, the information given on the P&F website indicates that they currently operate from 14 different sites across New Zealand.
\textsuperscript{60} Between 1998-2012 about 125 approvals had been given (Interview K).
concentrates only on network presences; the stability of a containment facility is equally dependent on absence. It is the people who pay attention to the specific details involved in constructing and operating a containment facility who are instrumental in the practices of risk management. As discussed in Chapter 7, the supervisors of individual facilities can be viewed as “heterogeneous engineers” who must manage the patterns of presence and absence that enact containment. They operate in accordance with statutory regulations whilst also managing issues that are not covered in these documents but are nevertheless crucial to the operation of a facility. The work they do is vital to the successful operation of a containment facility, although this isn’t always officially recognised:

It would be nice... if... it was an automatic reaction to say ok if we’re doing this, better get in the Biosafety Officer, we’d better get in this guy better get in the plumber, better get in the electrician, you know... that it’s an automatic, and that doesn’t, quite happen, yet but... and that’s probably because we’ve never had any serious incidents... if you know say for instance we had a major, non-compliance then I think everybody would very quickly get on the... on-board and realise that all of these guys... carry some responsibility. (Interview D)

These comments were made in relation to the construction of a containment facility, highlighting the crucial role played by supervisors in the planning of a new facility. It would seem logical to assume that similar comments could apply to the research conducted in these facilities: supervisors should have some direct input into the risk management plan for any programme of research they are expected to oversee. At present, this is possible at institutions that have an IBSC: the Biological Safety Officer sits on the committee and is therefore directly involved in the decision-making process. But as I have already mentioned, IBSCs are dwindling in number; furthermore, the centralisation and standardisation of low risk applications (as exemplified by the Arabidopsis application) may further reduce their role in risk management decision-making.

The results of this thesis suggest that this trend should be reversed, and that the function of local decision-makers should be reinforced rather than reduced. The wider social science literature on biosecurity practices supports this recommendation. Bingham, Enticott, and Hinchliffe (2008) note that although global approaches to biosecurity issues are trying to formulate uniform solutions that can be applied across time and space, these are unlikely to be successful and may generate further risks. Similarly, in his study of the control of bovine tuberculosis (bTb) on British farms, Enticott (2008) argues that there should be less reliance on uniform, technically-determined barriers to disease, and more emphasis on local solutions, where “farmers [work] out for themselves what measures they need to take to ensure that their animals stay healthy” (p.
Although the implementation of this is likely to meet a range of difficulties, “opening up this flexible space might prove productive - prompting innovative and non-uniform solutions”, and ultimately leading to the creation of biosecurity as a “multiple and ultimately nonuniform practice” (p. 1580).

There have been some moves to increase the ability to manage GMO research at the local level: through regional planning mechanisms that operate under the Resource Management Act (RMA). The RMA does not define genetically modified organisms and could therefore be interpreted as having no jurisdiction over them. Nevertheless, it could be argued that local councils may be able to use their ability to control the effects of “land use” activities to make specific reference to the conduct of GMO field tests in planning documents (see Fuiava (2004) for discussion). This argument was recently tested by the Environment Court, which ruled that the Bay of Plenty Regional Council could insert a paragraph in its Regional Policy Statement that advised a precautionary approach in the release, control, and use of GMOs in the region (NZ Forest Research Institute Limited v Bay of Plenty Regional Council, 2013). Some have heralded the Environment Court’s decision as setting a precedent to “[empower] local body protection against GMO risks” (Soil and Health, 2014b; see also GE Free NZ, 2014), although the wording of the verdict explicitly states that it is not intended as a directive to local authorities to make specific references to GMO research activities. Other upcoming cases are set to test the ability of local authorities to set more specific controls on GMO research activities (see Anderson Lloyd, 2014), so significant changes to GMO risk management could occur in this area of governance.

Even if local councils are able to exert some control over the land that is being used for GMO research, this will only apply to field tests of GMO research. But this would serve to reinforce the enactment of laboratories and fields as necessary Others, strengthening the position of the laboratory as a result of the weakened position of the field. Other practices similarly reinforce the enactment of Otherness, including current methods of public participation in GMO decision-making. Under the HSNO Act, public submissions are invited in relation to certain applications, but the results of this thesis indicate that these submissions do not in themselves constitute public participation in the risk management of GMO research. The public is largely represented by a relatively small number of spokespeople, and their opinions are usually only taken into account if they deal with the specific details of the risk management plan given in the application. Nevertheless, the process of public notification is itself influencing risk management practices,

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61 This point is raised in the Environment Court case verdict referred to in this paragraph (NZ Forest Research Institute Limited v Bay of Plenty Regional Council, 2013).
largely because it draws attention to certain research programmes, increasing the chances of negative publicity and making them more likely targets for the activities of anti-GMO groups. Given that it is usually only field-based research that is publicly notified, public participatory processes are therefore reinforcing the enactment of laboratories and fields as Others. The activities of anti-GMO spokespeople can be interpreted along similar lines given that they too focus primarily on field-based research programmes. As discussed in the previous section, the enactment of Otherness is creating a “fragile oligopticon” of risk management; changes therefore need to address the imbalance between visible and invisible places of GMO research rather than reinforce them.

Given the various issues identified above, a number of changes should be made to the current system of risk management in GMO research. First, local bodies that operate under delegated authority from the EPA should be established as decision makers for the bulk of GMO research. These bodies could be similar to the IBSCs currently in existence, except that the current use of Institutional boundaries to define their jurisdiction would need to be altered. A Territorial Biological Safety Committee which is responsible for work conducted in a specific geographical area may be a good idea in areas where there is a high concentration of GMO research. Christchurch and its immediate surroundings (which includes Lincoln) is an example of one such area because it would cover the activities of a number of different research institutions that each engage in GMO research. As part of these changes, the role of containment facility supervisors should be acknowledged, supported, and strengthened. This includes people such as Biological Safety Officers, laboratory supervisors, and technical officers: the people who are directly responsible for the operation (and therefore the stability) of containment facilities. Reviewing and updating regulatory standards, decision-making pathways, and auditing processes are important; but if it wasn’t for the efforts of those who can translate words into practice and “negotiate compliance” between incongruous parts, containment facilities would cease to cohere.

Second, the categorical divide between laboratory developments and field tests should be removed; although each of these forms of research are still defined as a “containment facility” under HSNO definitions, the different decision-making processes that accompany each type of research are significantly different. While I am certainly not suggesting that public input should not be sought on any GMO research applications, the current system of public participation

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62 This includes Lincoln University, the University of Canterbury, Plant and Food Research, and AgResearch.
should be changed, and it should not be determined by a categorical divide. Alternative methods of public representation in GMO research decision-making should be investigated; these could take the form of, for example, the particular membership of decision-making committees, or the use of ongoing consultation processes to engage with the local community. This is an area for further investigation as it lies beyond the scope of this thesis. Nevertheless, my results suggest that whatever form of participatory method is chosen, it should be applied to decisions made on both laboratory- and field-based developments.\(^{63}\)

Finally, anti-GMO spokespeople should rethink their current focus on field-based research. Although they give reasoned arguments for targeting their opposition efforts in this area, they should be aware that in doing so they are affording laboratory-based research a degree of invisibility. Even if research is kept out of the field, New Zealand is not, and never will be, “GE-Free”. The public face of GMO research is situated in open fields, but this is only a very small proportion of the research that is conducted in this country, a “beachhead” (Gieryn, 1998) that affords some public control over research. But in doing so it enacts Otherness: research is displaced from the field to the laboratory, where it is inaccessible and unquestioned. At present, anti-GMO spokespeople are not attempting to breach the boundaries of the laboratory; but in the interests of enacting a different system of risk management it may be time that they did.

8.3 Reassembling Actor-Network Theory

As stated in Chapter 1, one of the primary goals of this thesis has been to explore how ANT can be done as a “theoretically multiple” tool for analysis. During the course of my investigations I have used a number of tools from across the spectrum of ANT research, acknowledging the apparent divide between “early” and “post”/“after”-ANT approaches (see Chapter 3 for discussion) and choosing to cross it. Central to my approach has been to apply none of these tools uncritically, and I have taken many opportunities along the path of my PhD research to pause and reflect on what my research can tell me about ANT itself. In the following sections I will therefore discuss how my research findings can be used to inform ANT research practices.

8.3.1 Following the actors

ANT has been described as a toolkit of research methods that allows researchers to study “social” realities without making recourse to foundational structures (Law, 2008a). Given that ANT has been used by researchers in many disciplines, the use of many different tools is evident in the

\(^{63}\) It should be noted that field releases are a different matter entirely and have not been considered in this thesis. The distinction between different categories of approval for GMO research under the HSNO Act (1996) is given in Chapter 2.
ANT literature, and this often reflects an individual’s prior experience and training in social science research (see for example Davies, 1998). There is, however, one feature common to many ANT studies: the directive to “follow the actors” (Callon, 1986a; Latour, 2005). This apparently simple statement masks a wealth of complexity: it tells us nothing of who or what “the actors” are, nor how we should go about “following” them. The issues encountered in the course of this thesis have given me the opportunity to learn about and reflect on ANT research methods, and as such it provides a valuable resource for others who are using ANT in their own research.

As discussed in Chapter 4, I encountered many difficulties during my attempts to “follow the onion”. At the outset, I had recognised that GMO research, including the programme of tearless onion research being conducted at C&F, was a controversial topic of study. My aim was to study this controversy from the “outside”, as a naïve, passive observer, but it quickly became apparent that this would be impossible, and instead I was drawn into the networks I was hoping to study. My initial efforts to talk to people who were directly involved in the research programme led to problems very early on in my data collection; the following extract is taken from an e-mail response to my request to interview one of these people:

I have had discussions with your supervisor and my Chief Operating Officer and have been granted permission to speak to you about the GM onion debate. Your supervisor indicated that [Plant and Food Research] could check that all comments quotes etc are to be expressed within the context that they were intended and not taken out of context. In addition, she indicated that we would have right to withdraw our comments at any point if we so wished.

I am sorry to have to ask for the above but in this sensitive area we find that often material is taken out of context or that people use the information in a manner that was never intended at the outset of such interviews.

Also with the nature of the media, proponents and opponents to this technology it is inevitable that only the scare or negative components of any such report will be presented.

(E-mail received 13.09.2009)

In contrast to the hesitancy and concern expressed in the above e-mail, others were enthusiastic about taking part in my study. One participant in particular, who could be described as an anti-GMO spokesperson, consented to an interview that took almost three hours over two sittings; following this I received 42 e-mails containing further information of relevance to the topics raised in the interview. Thus we can see that my research became part of the controversy over GMO research: scientists expected my work to inflame the controversy, leading to further
problems for them in the long-run; on the other-hand, anti-GMO spokespeople saw the potential for my research to contribute to their wider agenda, and therefore lent their support to it. Instead of maintaining some distance from the networks I wished to study, I had become enrolled in them, and this posed a significant barrier to my ability to achieve my research goals.

In response to these early issues I made a number of changes to my research agenda, particularly with regards to my preferred sources of information. Instead of aiming to speak to those who were directly involved in the GM onion research I spoke to others who were located on the periphery: people who had been linked to the research project in the past or were involved in related areas of expertise. Furthermore, I found media releases, journal articles, conference presentations, and other forms of written information that had been made publicly available by people who were directly linked to the tearless onion research project. In some instances (such as conferences), this information may have been intended for a specific audience, but the growing use of the internet meant that such information was available to anyone who chose to look for it. Thus I was still following the actors in a sense; I was simply doing so at a greater remove than I had originally anticipated. As such, there is very little similarity between the data used in this study and that used in the rich ethnographies of early ANT study; nevertheless, it demonstrates how the use of a variety of written sources of information can be triangulated with interview data to perform detailed and robust case studies.

My use of such a wide variety of data sources was a significant factor in the change of research direction that I undertook mid-way through my research project. By speaking to people on the periphery of the GM onion research I tended to have conversations that dealt with the wider topic of GMO research in New Zealand. In doing so, I started to think about the issue of risk and how its assessment appeared to correlate with the spatial segregation between laboratories and fields. Thus I was led to embark on a second case study of the containment facility, exploring how it was enacted and using this to reinterpret the enactment of the risks and risk management of GMO research.

These methodological experiences illustrate an important theoretical premise of ANT: that there is no divide between the object and the subject. But rather than confine this observation to a report of theoretical findings, here I raise it as an important methodological issue that has implications for how research is conducted. Researchers cannot “simply follow” (Latour, 1996b, p. 4) because we too can be followed, enrolled, and mobilised in the networks we study. Thus, we become part of the objects of study, enacting realities we think we are watching from some remove. But rather than treat this as a “problem” that must be overcome in order to conduct
effective research, we should acknowledge the “mess” that we encounter as part of the research process, and discuss how it leads us to unforeseen yet important areas of study. This leads me to suggest that the “actor” we should follow is the research project itself: in this way we can incorporate the multiple twists and turns that result from object/subject interactions into the body of our research, using it as a methodological strength that sets our research apart from others.

8.3.2 Representing the object
In addition to considering tools of data collection, this thesis has also examined different methods of data interpretation and representation that have been developed in the ANT literature. In the case study of tearless onions (Chapters 5 and 6) I have concentrated particularly on the use of networks. ANT scholarship was built on network analysis, with early studies focused on examining how stable relationships are forged between groups of heterogeneous actors in order to achieve a common goal. While these studies formulated a radically different interpretation of social agency, in doing so they represented objects as rigid and centred. This has led to criticisms, and some scholars have questioned the utility of network analysis altogether, positioning it as a stepping-stone in the development of ANT that is no longer of specific use in itself. Nevertheless, the systematic techniques associated with network studies are still being used by social scientists, and it is of particular use in applied fields such as environmental management (see Chapter 3 for discussion). My goal has therefore been to ascertain whether the pragmatic tools of network analysis can be brought up-to-date to provide a theoretically robust methodological guide for research.

The approach taken in this thesis is eclectic, and I have blended together a number of different ideas that have been developed in the ANT (and wider STS) literature. In the analysis of tearless onions I have used a network representation that combines elements taken from three different network representations. I have blended together Callon’s (1986a) use of interessement devices to explain how actors are joined together in their efforts to achieve a mutually beneficial goal; Star and Griesemer’s (1989) use of multiple Passage Points to explain how cooperation can be achieved without the need for consensus; and Latour’s (1999a) use of circulatory loops to explain how a diverse array of actors can be joined together in a single network that nevertheless enacts a multiple, decentred object.

Although the final network representation used in both Chapters 5 and 6 is relatively novel, it nevertheless displays characteristics that are fundamental to network analysis. In both networks I have portrayed the links between actors as dependent on a trade of interessement devices, thus
conveying the core tenet of ANT that reality is enacted through material relations (Law, 2008a). Furthermore, these links are two-way relationships, thus representing each relationship as dynamic, and the overall stability of the object as a finely balanced equilibrium. This means that a subtle change anywhere in the network has repercussions throughout it, and an object can easily be destabilised. Chapter 6 demonstrates this point through a consideration of the proposal to move the tearless onion research project out into the field. The network analysis I performed indicated that, while most of the original network remained unaltered, there was a significant change in the enactment of the onion as a “contained” GMO; this change ultimately led to the destabilisation of the entire network and the failure of the tearless onion research project.

My evaluation of the tearless onion research project has also relied on the concept of “black boxes”, another core feature of early ANT analysis. These stable, “punctualised”, networks are an important component of the tearless onion network, and they are implicated in the rise and fall of the project. In Chapter 5 I identified four black boxes upon which the stability of the laboratory development of tearless onions relied: “the onion”, “LFS”, “low risk GMO”, and “containment facility”. Furthermore, in Chapter 6 I argued that the proposal to move tearless onions out into the field was partly aimed at linking it to other black boxed networks: movement to the field enabled the creation of links between past, present, and future research programmes, thereby “tying bigger and bigger pots and pans, and more of them, to the project’s tail” (Latour, 1996a, p. 143) and situating the GM onion research within a stable and irreversible context. The eventual dismantling of the research programme can be explained as a reversal of this process: a series of containment breaches at C&F’s GMO research facilities caused it to disassociate itself with the high-profile GM onion research programme in the interests of preserving its overall function as a CRI.

The analysis in Chapter 6 also indicates that to describe an object in network terms requires a research space that transcends the boundaries of conventional forms. I began this analysis (and indeed my thesis as a whole) by focusing on the ERMA application process, and I was able to formulate a representation of it by using Callon’s (1986a) sociology of translation. But this failed to take into account certain activities that were instrumental in the breakdown of the tearless onion network: the direct and indirect actions of anti-GMO spokespeople, and the corporate risk assessment made by C&F. These activities lay beyond the decision-making space delineated by the HSNO Act but were nevertheless crucial to my final network representation. These observations should act as a warning to any other researcher who chooses to study a controversy, whether or not they are using ANT. When following actors we should not be swayed by the size of
the *audience* of a controversy; indeed, if everyone else is looking in one direction, it may be an indication that the real action is taking place elsewhere.

Even though the analytical methods of Chapters 5 and 6 have been taken largely from the network literature, I have nevertheless incorporated some aspects of more recent ANT thought into the final object representation. Latour’s (1999a) circulatory system incorporates a number of circulatory “loops” that are involved in keeping a scientific fact alive. Although I have modified Latour’s original model, I have nevertheless retained the use of different loops to convey the different enactments of the onion that were evident in my data. This network therefore represents the onion as multiple (following Mol, 2002) and decentred (following Law, 2002a), without leading to pluralism or fragmentation.

The results of Chapters 5 and 6 therefore provide some evidence that network analysis can be integrated with more recent developments in ANT research. But it is Chapter 7 that provides the most significant contribution to this agenda. My analysis of containment facilities has allowed me to explore the merits of recent re-imaginings of object-space relations that have been developed in the ANT literature, but I was only led to do this as a result of my initial network analysis of tearless onions. My analysis of the containment facility revealed that, although a heterogeneous network of documents, devices, and drilled people was immediately apparent, this was only a small portion of the activity that enacted this object. Thus I was led to consider these as network “presences” that could be traced to material “absences” that were also necessary to the stability of the object. Furthermore, this pattern of presences and absences generated Otherness *within* the object: it led to a separation between laboratories and fields. This description of the containment facility as a fire object was not simply a theoretical exercise, but has been used to inform the interpretation of risk management practices given earlier in this chapter.

To end this discussion I will consider a quotation from Law and Singleton’s (2005) aptly titled “object lessons”, a paper that considers the variety of object representations that have been developed in the ANT literature.

Objects are shapes that hold their shape, but they do so in four radically different ways: as volumes; as stable network configurations; as gentle relational reorderings; and as patterns of absent presence. However, if we think about it in this way it becomes difficult to imagine that objects subsist in only one of these versions. Indeed, it may be a defining character of an object that it subsists in several forms and that it flows (or discontinuously jumps) between them (see Law and Hetherington, 2000). But this is important, because these are
spatial forms that are both other to each other, different, and at the same time partially connected. (Law & Singleton, 2005, pp. 347-348)

This quotation resonates with the findings of this thesis on a number of levels. The opening sentence corresponds with my decision to combine different methods of object representation within the pages of the same thesis. By representing the tearless onion as a network and the containment facility as a fire object, I have used two “radically different” ways to show how objects are enacted as stable; in the case of tearless onions, I have also shown how an object becomes unstable. But these object representations do not only display difference: they are also “partially connected” because I was led (or discontinuously jumped) from one to another through the course of my investigations.

Furthermore, the connections between different object representations used in this thesis are not simply a result of the data I have collected and analysed. They have also resulted from my examination of the ANT literature, which led me to the apparent divide between “early” and “post” ANT approaches and consider a means to cross it. This leads me to suggest that the words of this quotation do not only relate to the different object representations that have been developed by ANT over the years; they also relate to ANT itself. For some researchers, ANT is a stable “framework” for study; for others, it is much more ephemeral, providing only a “sensibility” that can be used to guide researchers in their examination of the social world. But as the above quotation suggests, these formulations of ANT are “both other to each other, different, and at the same time partially connected”. Pictured in this way, ANT is itself a “fire object” that is stable because it incorporates discontinuity and difference within it. The goal of ANT scholarship should therefore not be to choose between different approaches that have been developed over the years. Instead it should be to explore connections between them and use these to provide increasingly diverse representational forms. Thus, ANT should itself always be in the making, and be enacted as a theoretically multiple tool for research.

8.4 Summary
The results of this thesis can be used to provide an assessment of the risks of GMO research. Rather than approach risk in objective or subjective terms, I have traced how risks are done in GMO research practices. In doing so, I have argued that actors involved in GMO research each engage in practices that are aimed at minimising their exposure to “secondary risks” to their reputation, and these practices are highly influential in determining the outcomes of GMO research programmes. Furthermore, the relationship between laboratories and fields within the “fire object” of the containment facility can be used to re-interpret risk, where the relative
“invisibility” and “safety” of laboratory research is afforded by the “visibility” and “risk” of field research.

These observations have led me to evaluate current risk management practices in New Zealand and provide recommendations for change. In doing so, I have drawn attention to the roles currently played by the EPA, IBSCs, containment facility supervisors, and the HSNO Act, and how each of these should be changed in order to enact the risks of GMO research differently. I have also looked beyond the boundaries of these formal risk management practices to assess the role played by anti-GMO spokespeople, arguing that these actors should reassess the strategies they currently use in their opposition to GMO research.

The results of this thesis also provide valuable theoretical and methodological insights into how ANT can be used in social science research. In this chapter I have considered the directive to “follow the actors” that is commonly presented as a standard method in ANT research. While I have acknowledged that the simplicity of this statement belies the difficulty in applying it, I have also argued that these problems should be incorporated into research and used as to determine its overall direction. I have also reflected on my use of various analytical tools taken from across the breadth of ANT scholarship. In particular, this study combines network analysis with more recent conceptualisations of “the object” in the pages of one study. As such, it bridges an emerging gap in the ANT literature, and enacts it as a theoretically multiple tool for analysis.
Chapter 9
Conclusions

9.1 Summary of research findings

ANT scholarship has been built on detailed case studies of scientific controversies. They argue against the “discovery” of scientific facts, instead showing how accepted knowledge is the result of a meticulously organised, heterogeneous network of humans and non-humans. But in the quest to distribute scientific knowledge across a network, ANT scholars performed a centring of scientific agency and a singularity of purpose, thus effacing the differences that lay within their objects of study. More recent ANT research has addressed these issues by describing multiple, decentred objects that fold together presence and absence; but in the process, the network approach of early studies has itself been effaced. The goal of this thesis is to draw together this bifurcation in the literature, showing how network analysis is still of relevance to the study of scientific controversies, whilst also integrating it with more recent developments in ANT thought.

The starting point for this study was the controversy surrounding GM “tearless” onion research. Initially I focused on the public debate staged by the ERMA field test application process; but as I explored this debate I realised that it was simply a “way in” to a network that extended far beyond the physical and temporal boundaries of the ERMA hearing. As I began following actors and tracing connections I noted that there were two stages in the development of tearless onions: its initial development in a laboratory facility at C&F, Lincoln; and the ERMA application that proposed further developments as part of a field test. Following Latour’s (1983) analysis of Pasteur, I therefore delineated two “movements” involved in the development of the onion: first, the movement to bring it into the laboratory; and second, the movement from the laboratory out into the field. In Chapters 5 and 6 I have examined the enactment of the tearless onion during each of these stages.

In Chapter 5 I followed the actors involved in the laboratory development of tearless onions. I identified five main actors, each of whom played a significantly different role in the research project. Obviously there were the scientists accredited with the project’s success, but these were employees of two different research institutions: Crop & Food Research, a New Zealand Crown Research Institution charged with undertaking public good research; and House Foods Corporation, a multinational company based in Japan that manufactures and sells a range of
processed foods. The New Zealand Government’s Foundation for Research, Science and Technology had also provided public funding that had been used in the GM onion research. Finally, the Environmental Risk Management Authority had approved the research under relevant statutory regulations that control GMO research activities in New Zealand.

Each of these actors had a different role in the tearless onion research project; furthermore, the project enabled each of them to fulfil different goals. It would allow the scientists to develop successful careers; the research institutions employing them would be able to develop commercial products; for FRST it would create a public-private partnership and generate a return on public investment; and ERMA would be able to contain it in a laboratory facility. Each of these goals was a different “reality” of the tearless onion, but none represented a foundational state that described the essence of it: thus, the reality of the onion was multiply enacted. Furthermore, these multiple realities were partially connected, linking each actor to the others in such a way that they were all indispensable to the project’s outcomes. Thus they formed a network; and the activities of this network served to enact the tearless onion as stable object.

My next task was to use an appropriate network to represent the tearless onion, one that would be able to convey the multiple realities of the onion that I had identified whilst also presenting it as a stable, fractionally coherent, object. To this end, I considered three different network representations taken from the ANT and wider STS literature. Callon’s (1986a) sociology of translation provided tools that were could be used to describe the processes involved in network building, but in doing so it represented the onion as singular and centred. Star and Griesemer’s (1989) concept of the boundary object addressed these issues, but it replaced them with a representation that was plural and fragmented. However, by incorporating elements of both these models into Latour’s (1999a) circulatory system of scientific facts, I developed a network representation of the tearless onion that is both multiple and decentred. The network is composed of three loops: “organisational structure” deals with the systems that direct scientific research in New Zealand; “collaboration” represents the partnerships between scientific colleagues; and “containment” deals with the regulation of GMO research under the HSNO Act. Each of these loops enacts a different onion, but these onions overlap and interact to enact a stable, fractionally coherent object.

In Chapter 6 I followed the tearless onion during the ERMA application to move it out into the field. Once again I encountered the same five actors that had been involved in the laboratory stage of its development. I also identified the presence of another actor: anti-GMO spokespeople. Their entry into the tearless onion network required the incorporation of yet another enactment
of it, this time as an impure organism that could contaminate the New Zealand environment. As in Chapter 5, I then considered three different network representations of the tearless onion. Once again I found it appropriate to use a network based on Latour’s (1999a) circulatory model which also incorporated aspects of Callon’s (1986a) sociology of translation and Star and Griesemer’s (1989) boundary object. The final network is very similar to the original network outlined in Chapter 5, but significant differences are apparent in the “containment” loop. In Chapter 5 there had been a simple two-way communication between ERMA and the C&F scientists that involved the creation of two black boxed networks: the GM onion was black boxed as a “low risk GMO” and the laboratory in which it was developed was black boxed as a “containment facility”. While the field test of tearless onions would still take place in a containment facility, it could no longer be classified as a low risk GMO, and this latter black box was therefore absent from the network. This meant that ERMA employed a different, publicly notified, decision-making process to assess the application: this brought anti-GMO spokespeople into the network and also altered the role of C&F in relation to other actors. Ultimately these changes destabilised the network and it eventually broke down: the tearless onion research failed because it could no longer be “contained”.

The results of the tearless onion case study indicated that the “containment facility” was an object that warranted closer inspection. When it was a laboratory it lent stability to objects that were connected to it; but when it was a field it could destabilise these same objects. In Chapter 7 I therefore turned my attention to the containment facility, exploring how it was enacted with a particular attention to the stark contrasts between laboratories and fields. I found that at first glance it could be described as a network of “documents, devices and drilled people”, resembling the immutable mobiles of early ANT studies. But although this network represented the “heterogeneous engineering” involved in maintaining a stable object, other aspects of heterogeneity were effaced. I therefore attended to the patterns of presence and absence that were evident in my data, noting that the containment facility was not only enacted by network presence, but also by keeping certain absences in their place. These patterns of presence and absence enacted laboratory facilities as private, safe, and acceptable venues for GMO research, whilst fields were enacted as public, risky, and controversial. Rather than destabilising the containment facility, these contradictory features served to bind it together to form a stable whole: the laboratory and the field could therefore be portrayed as necessary Others. This meant that the containment facility could not be represented as network object, but was instead a “fire object”: an object that is characterised by discontinuity, disjunction, and a dependence on difference; that thrives on sudden change rather than holding a steady, immutable form.
Taken separately, these case studies provide an examination of how two different objects of GMO research are enacted, and are also an application of two contrasting methods of object representation that have been developed in the ANT literature. Taken together, they can also be used to discuss how the risks of GMO research are enacted, and to suggest how these risks can be done differently. In Chapter 8 I therefore considered how my data could be used to provide a reinterpretation of what “risk” and “risk management” are in the context of GMO research in New Zealand.

I concluded that “risk” is enacted by patterns of presence and absence, and “risk management” techniques are used by a variety of actors to manipulate these patterns. Individual actors engage in practices aimed at reducing their visible “presence” in the enactment of GMO objects, thereby minimising the damage that may result to them on a personal level. But taken as a whole, this variety of risk management practices is generating Otherness, which has emerged as a separation between different places of GMO research. Thus, fields are “risky” places of research because they are enacted largely by presences: the ERMA decision-making process draws attention to field tests, as do the physical characteristics of their location; research institutions are reluctant to move research out into the field; and anti-GMO spokespeople specifically target their opposition at field-based research. But for each of these activities there is a corresponding activity that enacts the laboratory; the difference being that laboratories are relatively “safe” places of research because they are enacted largely by absences. ERMA decision-making processes are usually not made public; laboratories and their contents can be kept physically hidden; scientists are able to develop successful careers by remaining in the laboratory; and by focusing their attention on fields, critics of GMO research draw attention away from laboratories. Pictured thus, the safety of the laboratory is afforded by the risk of the field: current GMO risk management practices are therefore enacting both safety and risk. Following these conclusions, I have provided recommendations for change to current GMO risk management practices. I have suggested that the role of local decision-makers and managers should be strengthened, as these actors are better placed to attend to the absences involved in GMO research. Furthermore, both HSNO decision-making processes and the activities of anti-GMO spokespeople should be altered so that they do not reinforce the division between laboratories and fields.

Chapter 8 also provides a reinterpretation of ANT in light of my research experiences. The issues I encountered in the course of data collection has enabled me to provide a critical evaluation of the charge to “follow the actors”, and I have suggested some practical measures to aid other researchers who are choosing to study a present-day controversy. I have also reflected on the
emergence of a division within ANT in the social science literature, arguing that this serves to enroll ANT itself as a “fire object”. Thus, rather than interpret “early” and “post” ANT approaches as separate objects, we should embrace their connection as part of the same theoretical approach, using the tools associated with each of them to develop new forms of representation.

9.2 Contributions of this study

The findings of this thesis make a number of important contributions that each relate to the research objectives identified in Chapter 1, as well as the wider literature.

**The enactment of tearless onions**

This study contributes to the STS literature on the materials and methods of scientific innovation. In particular, it contributes to the body of ANT literature that travels into scientific institutions to examine how the objects of scientific research are enacted. The analysis of the tearless onion research project shows that successful research is not simply the result of technological prowess in the laboratory, but is instead enacted by a heterogeneous network of actors that extend across commonly held categories of “science”, “society”, and “nature”. By tracing the rise and fall of this research programme I have demonstrated that the commercial interests of research institutions are instrumental in determining research success; similarly, the outcomes of corporate risk assessments are instrumental in determining research failure.

**The enactment of containment facilities**

My study of the containment facility contributes to the STS literature on the places of scientific research. As part of the spatial turn in STS, scholars have explored the relationship between laboratories and fields in the production of scientific knowledge: while some have suggested that they are fundamentally distinct, others have argued that they are connected and co-present in programmes of scientific research. Similarly, common portrayals of GMO research position laboratories and fields as fundamentally different venues for research, while the HSNO Act (1996) connects them under the legal definition of a “containment facility”. The results of this study suggest that laboratories and fields are connected, but appear to be separate, places with contradictory characteristics because they are part of the same “fire object” of containment.

The description of the containment facility as a fire object has wider application to other situations in which both the laboratory and field are joined together through scientific research. Of particular relevance to this thesis is the development of agricultural science and technology, where laboratory science is being applied to the production and distribution of agricultural goods and services. GMO research is one example of how countries such as New Zealand are looking to
grow their economies through the development of value-added exports; research institutions are positioning themselves as the providers of these technological fixes, thus placing the laboratories under their control squarely in the field of production. Prior studies from the ANT literature have demonstrated that this move serves to strengthen the position of the laboratory, making it indispensible to success out in the field (see e.g. Latour, 1983, 1988). Furthermore, this thesis indicates that with this comes an increasing disjuncture between the visibility and invisibility of scientific research. This is because the field serves as the “beachhead” of scientific research: a public arena that is separated from the private laboratories where “actual research goes on” (Gieryn, 1998, p. 228-229). These laboratories will remain hidden from view unless we challenge their boundaries, opening up the black boxes that surround them to examine their workings.

The risks and risk management of GMO research

By tracing the practices that enact the risks of GMO research in New Zealand I have provided a conceptualisation of risk that differs to more common assessments of risk in “objective” or “subjective” terms. This framing of risk transcends the boundaries of categories such as “formal” and “informal” decision-making spaces, or “primary” and “secondary” risks to encompass a much wider range of actors and activities than are usually incorporated into understandings of risk. It also indicates that the “risk” or “safety” of a programme of GMO research is a relational outcome, and can therefore be “done” differently.

My discussion of the risk management of GMO research provides recommendations for change to current practices in New Zealand and also contributes to the social science literature on biosecurity. The changes I have proposed to current systems of GMO risk management in New Zealand echo calls from the wider literature in this area of research to look for local, non-uniform solutions to biosecurity issues. Uniform, technically-determined solutions rely on the creation and maintenance of discrete boundaries that separate pure and impure spaces; but this means that risks emerge from within the systems that are being protected. Similarly, the results of this thesis indicate that there can be no clear demarcation between risky and safe places for GMO research, and we cannot use these categories to determine effective risk management strategies. Instead, we can strengthen the position of those who to attend to the complexities of GMO research practices: containment facility supervisors and decision-makers that are based within institutions have been highlighted as two potential candidates, although further research is needed in this area before specific recommendations can be made.
The theoretical multiplicity of ANT

My approach to network analysis provides an important contribution to methodological discussions within the ANT literature. Network analysis is commonly used in the applied literature, but in such cases it is rarely done so with a critical or reflexive style. In contrast, discussions in the theoretical literature often cast network analysis as a step in the development of ANT as it is practised today, thus essentially rejecting it as a valid approach. This thesis shows that a third way between these two contrasting positions is possible, and this conclusion is of importance to both the applied and theoretical ANT literature. I have performed a critical application of network analysis, considering the relative merits of a number of different approaches and following no single format unquestioningly. Thus, I have used the network as a guide to analysis without suggesting that it provides an underlying structure to it. I have also incorporated aspects of recent ANT scholarship, showing how a multiple, decentred object can be represented using analytical techniques that have previously been criticised for performing singularity. In this way, this study engages with recent discussions regarding the place of network analysis in ANT and other approaches within the social sciences, demonstrating that the systematic and methodical techniques outlined in early ANT studies are still of use today.

The analytical approach taken in each of the two case studies in this thesis further demonstrates the merits of theoretical and methodological multiplicity within ANT study. Whereas the initial case study of tearless onions uses more traditional, systematic network analysis techniques, the second case study of containment facilities engages primarily with more recent, esoteric discussions taken from the ANT literature. The implications of this are twofold. First, it shows that there is no single version of ANT. This point has been made before, notably in recent arguments that ANT is a label that has been attached to a wide variety of approaches, or that it provides researchers with a toolkit of methods. But in this thesis I have demonstrated that it is possible to engage with literature that spans across the spectrum of ANT scholarship within the same research project. This leads me to my second point, that there should be no preferred version of ANT. Latour’s (1999b) move to “recall” ANT implies that at some point in its development ANT morphed into a dysfunctional item that needed to be fixed. This suggests that ANT should be “done” in a certain way, and that anything else is substandard. But I have demonstrated that the strengths of ANT lie in its multiplicity, and the differences that lie within it should not be effaced.

This thesis also provides a valuable discussion of the methods required to “follow the actors” in the course of an ANT case study. It is therefore of particular use to other researchers hoping to explore the networks of present-day scientific controversies. ANT is traditionally associated with ethnographic techniques, where the researcher enters into the “foreign tribe” under study and
fully immerses him/herself within it. The particular issues I encountered in my case study of tearless onions meant that this approach was neither possible nor ethical; but instead of altering my research objectives, I was able to follow the actors via other means. In the present day, controversies generate large quantities of written material that are available in the public domain; at times, this can include information that was originally intended for a private audience. With the growing reach of the internet, access to such material is relatively easy, and it is therefore possible to collect a wide range of information from a variety of sources without having to “participate” with the actors themselves. Thus, following the actors at a distance is a productive and reliable method that should be added to the “toolkit” of ANT researchers.

9.3 Concluding comments

There are a number of layers to this thesis. On the surface, this is a study of controversial scientific research. It draws on material taken from a wide variety of GMO research practices in New Zealand, focusing primarily on the development of “tearless onions” and also the containment facilities in which such research is conducted.

But although GMO research is controversial, the focus of this study has not been to study the controversy itself. Instead, I have attended to the practices involved in “doing” GMO research, tracing the heterogeneous, complex relations that enact multiple, decentred, or even “fire” objects. As a result, I have been able to make practical recommendations, not on how to resolve a controversy, but on how to “do” GMO research differently.

By exploring these objects I have also been led to reflect on the practices involved in “doing” ANT research. Rather than choose one particular approach, I have used a wide variety of tools that have been developed by ANT scholars. Furthermore, these tools range from the systematic, rigid methods of early network analyses through to the more esoteric forms of empirical philosophy common in more recent texts. As a result, I have bridged the gap between these different approaches, thus enacting ANT as a theoretically multiple tool for analysis.
References


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Crop and Food Research. (2008e). Final report to ERMA on the GM onion field trial approval no. GMF03001.


Environmental Risk Management Authority (ERMA). (2008a). Decision on application GMF06002.


Shapin, S. (2010). *Never pure: historical studies of science as if it was produced by people with bodies, situated in time, space, culture, and society, and struggling for credibility and authority*. Baltimore: Johns Hopkins University Press.


'Tearless' onions will be the consumer choice. (2007). *Onion World, 23*(8), 7.


Appendix

The following table provides details of the public submissions made on C&F’s 2008 application to field test GM alliums (GMF06002) that have been included in the data analysis for Chapter 6. Only submitters who indicated a wish to be heard and/or submitted on behalf of a group/organisation have been included.

The first column gives the Submission ID as assigned by ERMA upon receipt of the submission. Any quotations used in Chapter 6 use these numbers as references. The second column gives the name of the organisation the submission was made on behalf of (if applicable). The third column gives some relevant background information about the submitter; this was largely obtained from the submission itself or via internet searches in late 2009. The final column gives the decision sought by the submitter (if indicated). Shaded rows indicate those submitters who actually presented at the ERMA hearing (14 in total).

<table>
<thead>
<tr>
<th>Submission ID</th>
<th>Organisation</th>
<th>Relevant background information about submitter</th>
<th>Decision sought</th>
</tr>
</thead>
<tbody>
<tr>
<td>9993</td>
<td>GE Free Northland</td>
<td>Organisation that opposes GE research/food in New Zealand Regional branch of GE Free New Zealand</td>
<td>Decline</td>
</tr>
<tr>
<td>10000</td>
<td>Submitter 9993 speaking as an individual</td>
<td>Decline</td>
<td></td>
</tr>
<tr>
<td>9971</td>
<td>GE Free New Zealand Inc</td>
<td>Spoke at the hearing for GMF03001</td>
<td>Decline</td>
</tr>
<tr>
<td>9988</td>
<td>GE Free New Zealand Inc</td>
<td>Organisation that opposes GE research/food in New Zealand Spoke at the hearing for GMF03001</td>
<td>Decline</td>
</tr>
<tr>
<td>9983</td>
<td>DM Palmer</td>
<td>Onion exporter</td>
<td>Decline</td>
</tr>
<tr>
<td>9928</td>
<td>National spokesperson for GE Free New Zealand Green Party candidate</td>
<td>Decline</td>
<td></td>
</tr>
<tr>
<td>9986</td>
<td>The Soil and Health Association of New Zealand Inc and Physicians and Scientists for Responsible Genetics (PSRG)</td>
<td>Soil and Health promotes organic food and farming methods The PSRG promotes awareness of the risks of GE research Spoke at the hearing for GMF03001</td>
<td>Decline</td>
</tr>
<tr>
<td>9899</td>
<td>Has written an anti-GE book Spoke at the hearing for GMF03001</td>
<td>Decline</td>
<td></td>
</tr>
<tr>
<td>10011</td>
<td>Teacher, Buddhist</td>
<td>Decline</td>
<td></td>
</tr>
<tr>
<td>10015</td>
<td>Green Party candidate</td>
<td>Decline</td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>Name/Group</td>
<td>Description</td>
<td>President/Role</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>9981</td>
<td>Aoraki (Canterbury) Province of ‘The Green Party of Aotearoa’</td>
<td>The Green Party is a New Zealand political party known for its strong environmental focus. Spoke at the hearing for GMF03001.</td>
<td>Decline</td>
</tr>
<tr>
<td>10022</td>
<td>Manager of JB onions Ltd</td>
<td></td>
<td>Decline</td>
</tr>
<tr>
<td>9997</td>
<td>Chairperson of GE Free Northland</td>
<td></td>
<td>Decline</td>
</tr>
<tr>
<td>9938</td>
<td></td>
<td>Linked to lots of activist groups, especially Justice for Palestine. Co-presenter of “Earthwise” on Plains FM. Spoke at the hearing for GMF03001.</td>
<td>Decline</td>
</tr>
<tr>
<td>9959</td>
<td>Nuclear-free campaigner</td>
<td>Linked to the Green Party, Forest and Bird, and Buller conservation group.</td>
<td>Decline</td>
</tr>
<tr>
<td>9996</td>
<td></td>
<td>Runs True Earth – grow organic produce, including onions. Chairman of Hawke’s Bay Vegetable growers. Board member of Landwise. Past board member of Bio Gro. Linked to JB associates.</td>
<td>Decline</td>
</tr>
<tr>
<td>10009</td>
<td>Submitter 10010 speaking as an individual</td>
<td></td>
<td>Decline</td>
</tr>
<tr>
<td>10010</td>
<td>GE Aware Nelson</td>
<td>Spoke at the hearing for GMF03001.</td>
<td>Decline</td>
</tr>
<tr>
<td>9985</td>
<td>Sustainable Future</td>
<td>A New Zealand non-governmental think-tank that conducts research and policy analysis on a variety of sustainability-focused issues. Has published two high-profile reports on Genetic Modification in New Zealand (Sustainable Future 2008a, 2008b). Spoke at the hearing for GMF03001.</td>
<td>Decline</td>
</tr>
<tr>
<td>9994</td>
<td></td>
<td>Appears to have made submissions in relation to other issues. Linked to Green Party (Executive Networker).</td>
<td>Decline</td>
</tr>
<tr>
<td>9995</td>
<td>Partner of submitter 9994</td>
<td></td>
<td>Decline</td>
</tr>
<tr>
<td>9910</td>
<td></td>
<td></td>
<td>Decline</td>
</tr>
<tr>
<td>9901</td>
<td></td>
<td>Appears to have been involved in the Save Happy Valley campaign.</td>
<td>Decline</td>
</tr>
<tr>
<td>9991</td>
<td>Ngati Kahugunu Iwi Inc</td>
<td>The governing body of a North-Island based “Iwi” (Maori tribe/peoples).</td>
<td>Decline</td>
</tr>
<tr>
<td>9954</td>
<td></td>
<td>Member of PSRG – signed letter to government re. GM.</td>
<td>Decline</td>
</tr>
<tr>
<td>9951</td>
<td></td>
<td>Appears to be involved in the Transition Town movement.</td>
<td>Decline</td>
</tr>
<tr>
<td>10001</td>
<td></td>
<td>Appears to have made a number of submissions in relation to other issues.</td>
<td>Decline</td>
</tr>
<tr>
<td>9998</td>
<td>Federated Farmers of New Zealand Inc</td>
<td>A farming advocacy group in New Zealand.</td>
<td>Support</td>
</tr>
<tr>
<td>10012</td>
<td>Sustainability Council</td>
<td>A New Zealand non-governmental organisation that conducts research into and advocates for a sustainable New Zealand.</td>
<td>Not stated</td>
</tr>
<tr>
<td>9935</td>
<td></td>
<td>Member of Labour Party (Mt Albert). Has submitted on labelling of GE food.</td>
<td>Decline</td>
</tr>
<tr>
<td>10006</td>
<td></td>
<td>Organic grower (mainly flowers).</td>
<td>Decline</td>
</tr>
<tr>
<td>Submission ID</td>
<td>Organisation</td>
<td>Relevant background information about submitter</td>
<td>Decision sought</td>
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<tr>
<td>---------------</td>
<td>--------------</td>
<td>-------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>10007</td>
<td>Owner of “Flowerpower” in Northland</td>
<td>Partner of submitter 10007</td>
<td>Decline</td>
</tr>
<tr>
<td>9926</td>
<td>The New Zealand Forest Research Institute Ltd (Scion)</td>
<td>A New Zealand CRI that also undertakes GMO research involving field tests</td>
<td>Approve</td>
</tr>
<tr>
<td>9952</td>
<td>Te Runanga o Ngai Tahu</td>
<td>A tribal representative body for the largest Iwi of the South Island of New Zealand, including the Canterbury/Christchurch geographical area</td>
<td>Neutral</td>
</tr>
</tbody>
</table>

**Submitters who did not wish to be heard**

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<th>Submission ID</th>
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<th>Relevant background information about submitter</th>
<th>Decision sought</th>
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<tbody>
<tr>
<td>9944</td>
<td>Royal Forest and Bird Protection Society (Nelson/Tasman Branch)</td>
<td>A non-governmental conservation organisation</td>
<td>Decline</td>
</tr>
<tr>
<td>9977</td>
<td>Brett and Jane Dewar Partnership</td>
<td>Organic farmers</td>
<td>Decline</td>
</tr>
<tr>
<td>10021</td>
<td>The Horticulture and Food Research Institute of New Zealand Ltd (HortResearch)</td>
<td>A New Zealand CRI that also undertakes GMO research involving field tests</td>
<td>Approve</td>
</tr>
<tr>
<td>9982</td>
<td>DMPalmer</td>
<td>Allium grower and exporter</td>
<td>Decline</td>
</tr>
<tr>
<td>9902</td>
<td>AgResearch Ltd</td>
<td>A New Zealand CRI that also undertakes GMO research involving field tests</td>
<td>Approve</td>
</tr>
<tr>
<td>9912</td>
<td>Dubalar Orchard</td>
<td>Organic farmers</td>
<td>Decline</td>
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