What *is* bovine Tuberculosis? Using ethnography to explore a disease-in-the-making

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Declaration

I declare that this thesis is my own work; has not been submitted in substantially the same form for the award of a higher degree elsewhere; and that the word length conforms to the permitted maximum.

Jessica Phoenix, December 2020

I am employed part-time by the Department for Environment, Food and Rural Affairs (Defra). Some redactions have been made to this thesis to avoid a conflict of interest with Defra.

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Abstract

Bovine Tuberculosis (bTB) is arguably the most pressing and contentious livestock disease in England. Since the 1970s, controversy has developed between government, farmers, vets and wildlife groups about the role of badgers in spreading the disease to cattle and how this is managed. The controversy has intensified over the past decade with the introduction of a new statutory disease eradication strategy for bTB, which includes the licencing of badger culling.

To date, both policy and research on bTB has widely assumed the singularity of the disease, and suggested that controversy arises from different perspectives about the disease and its management. In contrast, guided by insights from ‘empirical ontology’, I investigate the multiplicity of bTB and how it is made through disease management practices. This research centres on rich empirical material gathered through a multi-sited ethnography that followed bTB through practice, including: skin testing, risk-based trading, evaluating badger culling policy, shooting and cage trapping badgers, anti-cull activism, gassing badgers, and citizen science. Each chapter traces how a practice is being undertaken and how the practice contributes to the making of bTB. I argue that these practices make disease realities which are uniform, controllable and scalable, whilst simultaneously uncertain, unstable and local. These realities are then variously foregrounded and backgrounded according to long-standing perspectives of the disease.

I suggest that interventions in practices that explicitly consider bTB as a ‘disease-in-the-making’ could shift disease realities to improve bTB management, and help to move beyond the impasse surrounding the controversy. I also put forward specific interventions in disease management practices, some of which feature in the Government strategy for the control of bTB, updated in 2020.

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To all above, this thesis is as much yours as it is mine — except any errors, they are all mine.

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Glossary

AHVLA	Animal Health and Veterinary Laboratories Agency
APHA	Animal & Plant Health Agency
BCG	Bacillus Calmette–Guérin
bTB	bovine Tuberculosis
CTS	Cattle Tracing System
Defra	Department for Environment, Food and Rural Affairs
DIVA	Differentiate vaccinated-Infected from Vaccinated-uninfected Animals
DNA	Deoxyribonucleic acid
DPP	Dual Path Platform
EU	European Union
GPS	Geographical Positioning System
ID	Identification
IEP	Independent Expert Panel
ISG	Independent Scientific Group
MAFF	Ministry of Agriculture, Fisheries and Food
NFU	National Farmers Union
OTF	Officially TB Free
OTF-S	Officially TB Free Suspended
OTF-W	Officially TB Free Withdrawn
PCR	Polymerase Chain Reaction
PhD	Doctor of Philosophy
RBCT	Randomised Badger Culling Trial
SSK	Sociology of Scientific Knowledge
STS	Science and Technology Studies
TB	bovine Tuberculosis
TVR	Test, Vaccinate or Remove
UK	United Kingdom

Preface: Position, objective and orientation

I came to work on bovine Tuberculosis (bTB) largely due to my background on an arable farm. My parents were only too happy to teach me about the intricacies of farming and I became interested in bTB through stories and reports in magazines such as the ‘Farmers Guardian’ and ‘Farmers Weekly’. This led to me study Environmental Science as an undergraduate (2010–2014) and undertake research on bTB.

Over the last 10 years I have been questioning the scientific basis for and the making of bTB as an endemic cattle disease that needs to be controlled and eradicated (see Chapter 1). This line of questioning led me to Science and Technology Studies. I have become particularly interested in how scientific inquiry does not appear to provide answers about how to manage the disease effectively (Phoenix, 2016a). I read the farming Press and animal rights Press and have become deeply interested in conversations about different management practices, such as testing and culling cattle, badger vaccination and badger culling. I have deepened my knowledge of bTB through primary research, reading articles and scouring Facebook and Twitter for ongoing debates about the issue. I have forged connections with farmers, vets, badger vaccinators, animal rights groups and people undertaking direct action against the badger cull. My objective has been to study and analysis what is going on and to share my findings with people interested and involved in bTB.

As an environmental scientist, I became interested in how scientific inquiry regarding the role of cattle and badgers in disease transmission was created and how it was being used. The first piece of research I undertook was in Pembrokeshire in 2012, as part of my undergraduate degree, when the Welsh Government had changed policy focus from badger culling to badger vaccination (Phoenix, 2012). I spent one afternoon with a farmer in his kitchen, looking across the lush green meadows of south Wales. We chatted about the lovely weather and the joy that farming could bring on days like this. This led to a discussion of times unlike this — the toils of cattle farming and the scourge of bTB:

> *in 1999 when I went down with TB, I let the land out and there were three farmers grazing it. They all went down with TB at the same time. Since I've taken action* [illegally snaring badgers] *over the last four years, we have been free of TB for two years so…I put the success down to that. I know culling is right. Especially if they vaccinate the ones left, that's perfect! Few badgers and all vaccinated…*[1]

His bringing together of bTB breakdowns (when a herd loses its officially TB free status due to bovine TB being suspected or confirmed), disease transmission, illegally snaring badgers, badger culling and badger vaccination in one short speech fascinated me. I was fascinated by how the seemingly contradictory practices of unlawfully killing badgers and lawfully vaccinating badgers were brought together, and held together, by the lived experience of having bTB on his farm.

During my undergraduate degree, in autumn 2013, I continued working on local practices and knowledges related to bTB in the Gloucestershire badger cull zone. I interviewed badger cull opponents who were undertaking direct action against the cull as well as farmers who were licenced to shoot badgers (badgers are a protected species and a licence is required to shoot them for the purpose of bTB management). One interview with a cattle farmer who was shooting badgers and his vet particularly sparked my interest. The farmer spontaneously said:

> *tell me why it is that you can go out and shoot a cow, a fox, a squirrel, a rabbit but you can't point the rifle at the badger when he is doing you harm?*

His veterinarian continued:

[1] Farmer 1, Pembrokeshire, 2012

> *it doesn't sit very comfortably with me the idea of culling badgers…likewise it doesn't sit comfortably with me culling cattle regularly, knowing that I'm not dealing with another element of the disease*.[2]

The focus of the conversation on the ethics of culling badgers and cattle surprised me. Government claimed to have introduced a bTB strategy "based on the best available evidence, scientific advice and veterinary advice" (Defra, 2014a: 28), but this was being widely refuted by members of the public, scientific and media communities. This indicated that evidence is complex and does not lead to an obvious disease management strategy. During 2013 farmers, marksmen/shooters and vets told me about the disconnect between policy and their experiences on the ground. This led to a shift in my focus from understanding epidemiology and veterinary science to examining the importance of different sources of knowledge, working with people dealing with the disease on the ground.

These experiences led me to apply and secure funding from the Economic and Social Research Council to explore the making of bTB on farms. For my Masters' dissertation, I worked with a range of stakeholders in Cheshire and Cumbria to investigate how involved publics evaluate epidemiological studies about bTB and badger culling in comparison with other knowledge sources on these issues. In one of the focus groups, a cattle farmer with longstanding bTB infection in his herd said that epidemiology can provide a solution to bTB infection and therefore *"should be a rock on which we rely"*.[3] Another farmer tutted out loud, but did not comment further. After the focus group the farmer who tutted expressed a desire for local knowledge to be recognised:

> *I struggle with all scientists* […] *they've no experience of what it really takes to manage a bacterial infection. We've* [farmers] *huge amounts of it* […] *our experience* […] *is lost on anyone because they don't have that*

[2] Farmer 7, Gloucestershire, 2013

[3] Farmer 3, Cheshire, 2015

> *experience and they just dismiss it as 'farmer knows best'. We can contribute a lot!*[4]

This remark has particular purchase since epidemiological studies of bTB have drawn different conclusions about the importance of cattle and badgers in this disease, and put forward different ideas about how the disease could be managed. As research about bTB is itself conflicting, there exists inherent and unavoidable multiplicity in accounts of the disease and its potential eradication. I came to conclude that there was a sense of 'dislocation' (Jasanoff, 1997) between groups who hold particular understandings of the disease. Knowledge claims were being made by many stakeholders involved in the controversy, using a variety of epidemiological studies, lay knowledges, experiences and emotions to formulate arguments for or against badger culling. I therefore strove to understand how bTB was being *made* in science and disease management practices.

I began my doctoral research in autumn 2015 and that winter began to learn more first-hand about disease management practices on farms by undertaking a multi-sited ethnography. One day I was in a farmyard helping on a bTB test (known as a skin test); the wind was blowing a gale and the rain was lashing down near horizontally. Holstein cattle surrounded me, waiting to be injected with tuberculosis so that the vet and farmer could ascertain whether they were infected with bTB. The vet, farmer, farm worker and I herded the cattle into the crush ready to be tested. The farmer took a deep intake of breath and muttered:

> *I love these animals too bloody much. I know some are gonna be sentenced to death today. Bloody hell. I need to get a grip.*[5]

The grief was palpable. The complex mix of helplessness, fear, and grief tied to disease management practices and bTB made me impassioned about cattle, badgers and the

[4] Farmer 4, Cheshire, 2015
[5] FN skin test 1 month radial LRA 4, 19.01.16 and 22.01.16

disease. I wanted to open the debate about what bTB is and how it is made by working with and listening to farmers, vets and badger groups. This is how the research started to take shape.

I worked across many different arenas of expertise as part of my fieldwork and research practice. I worked with microbiologists and epidemiologists in a ‘Badger Found Dead Study’; I worked with farmers and vets in testing for the disease; I worked with protestors, activists and cull contractors (licenced people cage trapping and shooting badgers or carrying out controlled shooting badgers at night), in badger cull zones; and, I worked with cattle, badgers and mycobacteria throughout. I recognise this disease as multi-faceted and consider transdisciplinary research contributions to be important in developing comprehensive disease management plans. The bringing together of disciplines (such as veterinary science, epidemiology, microbiology, geography and sociology) and expertise can lead to unexpected ventures and challenges to current modes of thinking. My interdisciplinary background and my work with researchers from other disciplines and close associations with farmers, vets and policymakers demonstrates just that.

From the beginning of my research journey in October 2015, my intention was to intervene in bTB management. In my application I stated:

> The analysis of knowledges and values of stakeholders will assist Defra [Department for Environment, Food and Rural Affairs] in the future management of the disease. The outcome of this project will be a qualitative case specific theory of bTB opinion and practice and specific advice on improving future management of zoonotic disease (Phoenix, 2015: 4).

My study changed along the way, but my focus on intervention remained throughout. This affected my orientation towards policy. For example, I undertook a six-month internship with the TB Programme in Defra to:

> develop my knowledge about policy documents, thus improving my ability to write an influential policy document as an outcome of my PhD to inform the development of TB policy in the future (Phoenix, 2016b: 2).

From the end of my internship in September 2017 to the present day I have worked part-time for Defra, mainly as a social researcher. My employment in Defra and my academic work has enabled me to orientate this thesis to inform policy development. My experience as a social researcher in the Civil Service has proved invaluable in learning how to communicate research effectively with policymakers (Phoenix et al., 2019). I situate myself as a critical friend of government. I have also presented my work to farmers, to policymakers in England and Wales, to badger groups, to badger vaccination groups and to vets. In addition, parts of my research have been published as academic articles (Benton et al., 2020; Phoenix, forthcoming) and I will create a policy briefing note with the aim of sharing information more widely. Each output has been produced to communicate information in an easy to understand and suitable format for each specific audience.

In this thesis I use Science and Technology Studies to unpick the making of bTB in the farm, in the laboratory and in the field. I reflect on how bTB is made — by which I mean how the disease is materially constructed — as opposed to assuming bTB is fixed and focusing on how it can be controlled. I propose ways in which bTB can be made differently. I aim to provide a platform for voices not usually foregrounded in research of this kind and pay attention to research participants' modes of doing bTB. I am committed to contributing to the national debate around bTB and to the development of better disease policy as well as to academic scholarship around bTB and zoonotic disease management more widely.

Chapter 1. Introduction

> *It's quite challenging when you're trying to deal with a complex disease like this,* […] *you try and look for patterns and then reasons, because you know you want to find a way out of this and it's … I think that's quite a problem. 'Cos you're always trying to prove that you've not really got it, I don't want it, I haven't got it, you know it's them bugger scientists are telling me we've got it, and we haven't. How do you know if it even exists or* [if] *it's just made up by scientists and policy dunces?*[6]

Bovine Tuberculosis (bTB) is arguably the most important and problematic livestock disease in England. It is conventionally described as an infectious bacterial disease of cattle and of the European badger (*Meles meles*). England has a statutory disease eradication programme based on practices to detect the disease, track its spread and reduce the risk of transmission between cattle, and between cattle and wildlife. And yet, as the farmer asks in the interview extract above, how is the disease 'made' in settings such as farms, laboratories and government offices? This fundamental question underpins this thesis.

As Ian Boyd, Chief Scientific Advisor for the English Government 2012–2019, stated, the disease is "primarily a sociological problem and secondarily an epidemiological problem" (Boyd, undated: 13).[7] bTB is sociological since all disease management practices are created by people and undertaken by people, and effective disease management requires a range of key social actors to be involved (Gormley and Corner, 2018). Moreover, a sociological understanding of bTB management and farming can help to achieve, and challenge, the joint policy objectives to "provide effective disease control that is proportionate to the joint objectives of maintaining both a viable industry and a viable badger population" (Boyd, undated: 12).

[6] IN Farmer Edge 5, 24.01.17

[7] Epidemiology is broadly defined as the study of how often diseases occur in different populations and why.

The importance of a sociological perspective is amplified because of the public knowledge controversy around the control, management and eradication of bTB. In particular, controversy has developed around one such disease management practice — badger culling — which has attracted substantial public attention. The link between bTB and badger activity was formed in 1971 when a badger infected with bTB was found on a farm in Gloucestershire (Muirhead et al., 1974). Two years later, the State provided licences to landowners to kill badgers for the purpose of disease control. Since then, successive governments in England have implemented contrasting policies, sparking much debate and considerable opposition (Grant, 2009; Spencer, 2011). Historian and Science and Technology Studies (STS) bTB researcher Cassidy (2010) suggests that the epidemiological evidence regarding the effectiveness of badger culling in the reduction of bTB prevalence in cattle is uncertain, widely interpreted and subject to substantial challenge. Building on the work of Callon et al. (2001), Latour (2004) and Whatmore (2009), a public knowledge controversy can be defined as when knowledges become subject to public interrogation and there is open confrontation about forms of knowledge (see Section 1.4.3 for further detail). The public knowledge controversy of badger culling has been enlivened since 2011 when a badger culling policy was implemented in South West England, considered the epicentre of bTB cattle infections in the country.

To date, academic work has recognised that bTB control is predicated on disease management practices, and that these practices have implications for groups with divergent standpoints in relation to the controversy (Atkins and Robinson, 2013a; Cassidy, 2019; Enticott, 2001, 2008a; Maye et al., 2013; Maye et al., 2014; Robinson, 2014). Yet little research has been undertaken to explore the way that these practices — in offices, fields and farms — shape the conceptualisation of bTB. To help to fill this research gap I examine the making of bTB through six disease management practices, using a multi-sited ethnography. There is a need to understand how bTB is 'made' by those groups in a range of settings and to bring their conceptualisations of bTB into conversation. In doing so, I seek to move beyond the impasse created between polarised groups and explore alternatives for bTB disease management. My primary research question is therefore:

How is bTB made in disease management practices?

This thesis draws on STS to provide case-level detail on how disease practices are productive of, and make, (unexpected) disease realities. I use my findings to unpick how three disease realities — characterised by uniformity, controllability and scalability — are made in disease management practices. These three disease realities emerge as particularly important because they are configured through all of the practices examined in this thesis and, simultaneously, have ramifications on these practices themselves. I argue that interventions in practices should explicitly consider bTB as a disease-in-the-making if we are ultimately interested in shifting disease realities to: bring versions of the disease into conversation; bring more voices into disease management; and, explore what Price (2017: 1) calls "diplomatic space for doing TB differently" by identifying where there is potential for common ground (Cassidy, 2019). In doing so, I aim to help establish long-lasting and effective disease management practices.

Below I introduce bTB, explain the analytical approach, and then present my research questions and core argument. I then define the central terms I use in this research, before outlining the overall structure of the thesis.

1.1. What is bovine Tuberculosis?

In England, bTB is conventionally described as an infectious bacterial disease of cattle which can be carried by — and transmitted between — other mammals (both farmed and wildlife) such as camelids (e.g. llamas and alpacas), deer, humans – and badgers (Godfray et al., 2013). Clinical signs of disease in cattle include weakness, loss of appetite, weight-loss, fluctuating fever, intermittent hacking cough, diarrhoea, large prominent lymph nodes and eventual death (World Organisation for Animal Health, undated). The disease is associated with the bacterial agent *Mycobacterium bovis* (*M. bovis*), which can transmit between cattle and humans through routes such as the drinking of unpasteurised milk. This transmission between cattle and humans is a public health concern: it is a zoonosis.[8] The zoonotic risk is low in England, largely due to the pasteurisation of milk and a disease eradication programme that ensures so-called infected cattle are killed before they become highly infectious. Consequently, the eradication programme renders the disease largely invisible on farms.

bTB is a notifiable disease and the way in which it is monitored and controlled epidemiologically affects a state’s ability to trade cattle and cattle products internationally.[9] The disease is thus underpinned by complex statutory measures of surveillance and control, involving both countrywide and European legislation. The European Union (EU) requires Member States to have an eradication, control and monitoring strategy for bTB if they are not Officially TB Free (VISAVET Health Surveillance Centre, 2019);[10] as a member of the EU until January 2020, the United Kingdom (UK) was required to have a disease eradication strategy.[11]

This research focuses on England, rather than the UK, because bTB is a devolved matter (i.e. decision making has been delegated to the devolved

[8] Symptoms of bTB in humans can take months or years to appear. The usual clinical signs are similar to signs in cattle. The bacteria can also lie dormant in humans without causing disease.

[9] A disease that is required by law to be reported to government authorities due to international law and UK law, under the Public Health Act 1984 and the Health Protection Regulations 2010.

[10] To note, I sometimes refer to bTB as ‘TB’, for example in an extract or when referring to a name of an organisation.

[11] EU Exit provides the UK with an opportunity to not aim for bTB eradication.

administrations for Scotland, Wales, Northern Ireland and England). In England, the Department for Environment, Food and Rural Affairs (Defra) is responsible for the governmental aspect of disease management. Due to statutory requirements for EU Member States (European Commission, 1977), animal health and public health concerns, Defra (and its agencies) frames bTB as “the most pressing animal health problem in England” (APHA, 2019a: 7), “an increasing social and economic problem in England”, and as a problem to be controlled “flexibly informed by scientific and veterinary advice, to address all likely routes of disease transmission” (Defra, 2014a: 10 and 11). The Government aims to control and eradicate the disease in farmed livestock, yet this is complicated by many issues including the difficulty of detecting *M. bovis*, the movement of cattle across the country, and the disease being present in wildlife such as badgers, foxes, shrews, mice, squirrels and deer (Delahay et al., 2007). Badgers are the principle wildlife maintenance host of concern in England because of: the estimated high number of infected animals (Santos et al., 2020); the likelihood of excreting and spreading *M. bovis* (Delahay et al., 2007); and, the field environment they share with cattle, therefore potentially enabling transmission of *M. bovis* through contamination of the environment, for example by cattle consuming grass contaminated with badger faeces (Woodroffe et al., 2016).[12]

Although almost eradicated in the UK in the 1980s, the number of cases of bTB has dramatically increased since then (Defra, 2011a). In 1986, only 235 cattle tested positive for the disease, but this increased tenfold over the following ten years (Defra, 2011b); the relatively high incidence in isolated areas observed in the 1980s spread geographically across the West and South West of England and Wales. The

[12] Infection can persist in maintenance hosts within the species, without the need for input from other species. A spillover host can have the infection only as long as there is input from an external source (APHA, 2020a). Spillover hosts for bTB include cats and pigs.

increased disease incidence and prevalence of bTB over the last 30 years has been well documented by epidemiologists and Government (APHA, 2017, 2018a, 2019a; Godfray et al., 2013; Godfray et al., 2018; Independent Scientific Group, 2007) and is variously linked to changes in disease surveillance practices, changes in the cattle industry, and changes in the badger population (detailed in Chapters 3, 4 and 5).[13] The incidence rate, already increasing since 1986, rose further still after the Foot and Mouth Disease crisis of 2001, likely due to the increased movements of untested cattle as part of restocking efforts (Carrique-Mas et al., 2008; Johnston et al., 2011). In 2018 in England the disease has been delineated numerically in various ways, including: 3,611 new herd incidents; 6,715 non-Officially bTB Free herds; 7.8 million bTB tests on cattle; 32,925 cattle killed as a result of bTB detections; costing government approximately £70 million in disease control; and, costing industry £50 million in disease control (Defra, 2019c; Godfray et al., 2018). This upward, but fluctuating, trajectory of bTB prevalence over time reflects the difficulty of controlling the disease: *M. bovis* is difficult to detect, the disease flows through multiple agents, and, the uptake of disease management practices is variable. I use the term agents as a collective term — including actors (humans) and actants (non-humans) — for anything that has agency through relation with others.

bTB also brings severe financial, practical and emotional impacts on farmers and farming families (Crimes, 2014; Defra, 2019b; Farming Community Network, 2013; Godfray et al., 2018). The suffering that bTB can inflict on families and communities was brought home to me when I was in Gloucestershire in 2015. I was

[13] Prevalence shows the proportion of herds under restriction as a result of a TB incident. This measure is the number of herds not officially TB-free due to an ongoing TB incident (nominator) shown as a proportion of the number of active cattle herds (denominator) (Defra, 2019a). Incidence is the number of new incidents, widely referred to as 'breakdowns'.

sitting with a farmer, Fred, at his kitchen table having a coffee and discussing the impact of bTB on farmers locally.

> *Fred told me about a local farmer, Paul, who was investigated by trading standards for swapping ear tags on cattle that tested positive for bTB. Paul was worried about the investigations and the situation got worse when his main customer told him they wouldn't buy his milk anymore because of the investigations; Fred said this was incredibly unfair as Paul was cleared of any wrongdoing. Paul was under a lot of financial stress and just couldn't cope. He committed suicide on farm. Fred's voice was cracking when he told me this — the emotions were raw.*[14]

Fred's account of the pain caused by bTB was devasting, but sadly not uncommon. Farming Community Network (2013), a charity that supports farmers and families within the farming community, conducted 68 interviews with farmers who had experienced a bTB breakdown (when a herd loses its officially TB free status due to bTB being suspected or confirmed) in the previous two years to discuss the stress on them and their families caused by dealing with bTB and the impact of the approach taken by the authorities. The extracts below detail some of the pain and suffering caused by bTB: [15]

> Because of the stress I am under, my family bear the brunt and I can see the fear and insecurity I am passing on to them; who knows what long term damage is being caused (Farming Community Network, 2013: 5).
>
> Pressure on the marriage, children picking up tension and friction, upsetting for children when pet cow was put down, psychological stress when young calves are shot (Farming Community Network, 2013: 19).
>
> Things are going from bad to worse with no solution in sight (Farming Community Network, 2013: 12).
>
> My husband has been seriously upset by TB. He is a real stockman and loves his animals. He hates seeing cattle taken away to slaughter without any proper attempt to prevent this happening. He has been devastated by the TB and his health has suffered due to the stress (Farming Community Network, 2013: 21).

[14] FN controlled shooting HRA 4, 15.09.16

[15] These interviews were conducted before the current badger culling policy was first implemented 2013 and therefore the findings are not fully reflective of the bTB control strategy at the time of writing.

> The government is afraid to address the situation thus costing them money and causing the farming industry undue stress (Farming Community Network, 2013: 16).

Furthermore, president of the National Farmers' Union (NFU) 2014–2018, Meurig Raymond, wrote that:

> The emotional and economic impact of this disease is huge – and as a dairy and beef farmer, I know that from personal experience. We've lost 40 cattle to bovine TB on our farm in Pembrokeshire over the past 18 months and have experienced the human misery the disease causes. Yes, we are farmers. But we're also human beings who feel great responsibility for our animals. Their health and welfare is of paramount importance and the helplessness and distress you and your family feel when you discover they have tested positive for bovine TB is devastating. Travelling round the country, I've met countless farmers who have suffered similar experiences. I've sat round farm kitchen tables with families who have been driven to despair after investing time and money building up their herds, only to see them devastated by bovine TB. I've spoken to grown men who have been reduced to tears as they load cow after cow, calf after calf, onto lorries to be taken away for slaughter (Raymond, 2014).

These extracts display the severe and painful ramifications of *doing* bTB for farmers, farming families and cattle. The pain described is widely attributed to disease management practices, for example bTB testing and slaughtering reactor animals. The disease itself is recognised to be multi-faceted, composed of, at least: *M. bovis*, bTB testing practices, investigations by trading standards, and the psychological, financial and relational implications of having the disease. Analysing each of these (see Section 1.3 for Research Questions) provides an opportunity to better understand the relations between factors, and thus the relations between practices used to manage the disease.

In 2014, under the Conservative-Liberal Democrat Coalition Government, Defra published the 'Bovine TB Eradication Programme for England' with the aim of eradicating the disease by 2038 using a multipronged approach (Defra, 2014a): "There is no single solution to tackling bovine TB – we need to use every tool in the toolbox" (Defra, 2013a: 5). Furthermore, in response to the spatial geography of disease incidence, the eradication programme was split into three management areas with spatially located tools of disease control: High Risk, Edge and Low Risk (Figure 1). These tools include measures to find and control the disease in cattle, and measures to control the disease in badgers, such as: pre-movement testing and post-movement testing of cattle; cattle movement restrictions; testing and slaughter of infected cattle, on-farm biosecurity measures; badger vaccination; and, badger culling.

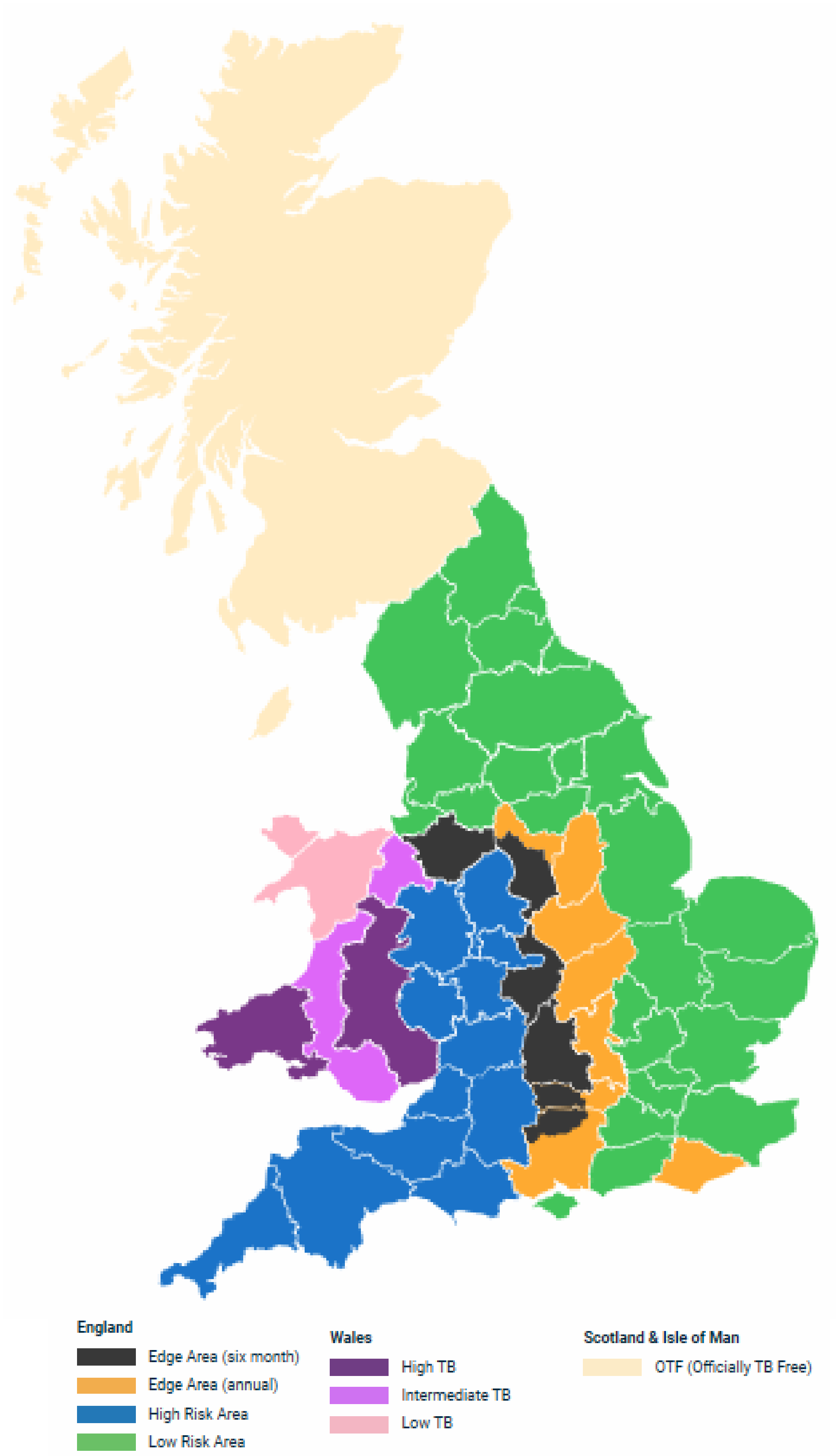

Figure 1: Strategy to eradicate bTB within 25 years (TB hub, 2015a)

The decision to cull badgers in England in 2011 was contentious (BBC News, 2011; Kaminski, 2011). Government has given a rationale for the current badger culling policy (enacted in 2012) using previous culling trials as evidence that culling badgers reduces bTB in cattle (Defra, 2011c, 2012) (I detail the chronology of badger culling trials and culls in Section 5.1). However, field studies have also implied that culling badgers may contribute to the spread of bTB as a result of perturbation, defined as the increased migration of badgers into culled areas due to the disruption of territoriality, increased ranging and mixing between social groups (Carter et al., 2007). Furthermore, multiple epidemiological studies have identified cattle movements as the most frequent risk for herd-to-herd *M. bovis* transmission, outweighing the risk posed by badger-to-cattle transmission (Griffin et al., 1993; Johnston et al., 2005; Johnston et al., 2011; Reilly and Courtenay, 2007). Some badger cull opponents draw on these findings to argue that badger culling should not be undertaken. Other badger cull opponents go further and undertake direct action against culling. These conflicts have intensified the controversy of bTB. The public knowledge controversy has generated deep divisions and tensions between groups, and led to impasses in disease management (Allen et al., 2018; Grant, 2009).

A small, but growing, social scientific research literature on bTB has developed since 2005 which approaches the issue from geographical, sociological, historical, veterinary science, agricultural and philosophical perspectives. In brief, it includes work focused on farmer perspectives of bTB control mechanisms (Bennett and Cooke, 2005; Enticott et al., 2012a; Enticott et al., 2014; Maye et al., 2014); cultural and historical representations of badgers/cattle/bTB (Cassidy, 2010, 2012, 2019); questions regarding whose knowledge counts in bTB control (Enticott et al., 2011; Enticott, 2012; Enticott and Wilkinson, 2013); farmer trust in the state (Enticott, 2011a; Fisher, 2013;

Robinson, 2017a); impacts of bTB on farmer wellbeing (Crimes, 2014; Crimes and Enticott, 2019); contradictions of evidence and policy in decision making (Grant, 2009; McCulloch and Reiss, 2017a; Spencer, 2011; Wilkinson, 2007); practices of risk-based trading (Little, 2019; Little et al., 2017); points of interconnections between polarised groups (Keenan et al., 2019; Price et al., 2017) and, the role of scientific knowledge in disease governance (Enticott, 2001). Rural geographer Gareth Enticott has conducted much social research on bTB, including on uptake of biosecurity — attempts to separate disease agents from animals in time and space (Enticott, 2008b, 2016; Enticott and Franklin, 2009; Enticott and Vanclay, 2011; Vanclay and Enticott, 2011). This research has furthered understanding of the knowledge circulations and practices of agents involved in bTB management, thereby challenging current practices and opening up space for alternative, and better, disease management practices.

Many of these studies have explored the ‘framings’ of bTB (Cassidy, 2012; Grant, 2009; McCulloch and Reiss, 2017a; Naylor et al., 2017; Wilkinson, 2007). For example, Enticott (2008a) argues that differences in understandings of biosecurity have arisen in part because the State frames bTB as a scientific and veterinary problem, and neglects social and cultural dimensions, to the detriment of disease control. In addition, Robinson (2017a) explores how bTB is known and framed in multiple ways in Northern Ireland leading to contradictions between how bTB is known by different agents. He states that stakeholders must recognise this heterogeneity, and make it visible and explicit if disease governance is to be more successful in the future.

Whilst these studies usefully investigate representations of bTB and how these differ between groups, many do not critically explore the heterogeneity of the disease itself or how it is made, and therefore reinforce the notion that there is one version of bTB which is interpreted in different ways. My approach contrasts with this, as I explore below.

1.2. Analytical approach

Many social scientific researchers of bTB focus on the multiplicity of interpretations of bTB rather than the multiplicity of bTB, and in doing so reduce the 'ontological curiosities' (Atkins and Robinson, 2013a) of the disease into epistemological explanations. What this means is that the disease's slipperiness, its indeterminacy and its sheer unruliness are explained away as policy failures and technological inaccuracies — they are seen as dimensions of bTB epistemology. By foregrounding the making and doing of bTB I place more emphasis on ontology. Ontology focuses on versions of disease that make and are made by specific sets of practices, materials and relations (Enticott, 2012; Law and Mol, 2011), whilst epistemology focuses on what we know about the disease. I consider that the epistemological approach limits our understandings of what bTB is, and limits critical exploration of the impact of practices on bTB (Section 2.2). The lack of social research on the making of this disease in disease management practice poses a gap in regards to how agents make bTB, and how practices can be altered to make better disease realities. There are two notable exceptions here. First is Atkins and Robinson's (2013a) analysis of bTB heterogeneity in five stories based in Northern Ireland, devised from secondary research. They call for a spatially nuanced policy which shows some awareness of the heterogeneities of the disease, for example as circumstantial colocation and uncooperative bacteria. Second, Enticott (2012) uses ethnographies of two veterinary practices to explore how veterinary expertise enacts different versions of bTB, specifically through the skin test. Building on their work and the work of STS scholars, I consider it vital to investigate the making of bTB to consider what bTB is, and what it could otherwise be.

STS scholars argue that realities are not singular things existing out there in the world, but are made and continually maintained or re-made through practices (Law and Singleton, 2005; Law, 2019; Mol, 2002; Singleton and Law, 2013). I orient my research around the idea that realities are enacted in materially heterogeneous practices (Law, 2008a), and therefore I work to understand what bTB comes to be through practice. This approach, combining theory and method, is known as empirical ontology (Law and Lien, 2012, 2013).

In his work on Norwegian salmon, Law (2012) uses empirical ontology to examine what objects come to be in relational practices, and reveals multiple material realities. In this style,

> Empirical studies of ontology are not trying to explain why differences arise within a single cosmological grounding. Instead, and quite differently, they are looking at what objects come to be in a relational, multiple, fluid, and more or less unordered and indeterminate (set of) specific and provisional practices (Law and Lien, 2012: 3).

With empirical ontology as my philosophical underpinning, I consider bTB to be constantly done — or 'in-the-making' — through disease management practices. In asking how bTB is made in practice, I move away from a perspective that 'The Science' (Section 1.4.2) will tell us what is true about bTB and then we can act accordingly, and towards a perspective that bTB is made through practice and we can take action by collectively aligning/appraising these realities. This statement does not mean that the disease does not exist. Instead it implies that the disease is not separable from social circumstances such as strategies for, and practices of, disease management (Kim, 2007). I consider bTB to be more than one thing to different agents in different spaces, but less than many things. This means bTB is multiple and networked, but not fragmented.[16] It is *M. bovis,* and the test and slaughter regime, and the trading of cattle, and interactions between cattle and badgers, and badger culling, and the skin test, and the list continues. The heterogeneity of the disease is traceable in the uncertainty of the skin test (Chapter 3) and the mobility of the cattle population (Chapter 4). It is further an effect of the multiple pathways by which the disease is spread both 'on farm' and in other spaces such as country shows and cattle markets. Badgers, as a wildlife reservoir of the disease, are largely invisible by day and the routes of transmission between badgers and cattle are largely unknown. In this thesis, I use *M. bovis* to refer to the bacteria that tests attempt to detect. In all other cases, I use the terms bTB or 'the disease' in reference to its multiple and networked nature.

Empirical ontology is a tool that enables me to witness, re-describe and make sense of 'bTB-in-the-making' by investigating practice (Chapter 2 presents more information about empirical ontology). My conceptualisation of bTB as being made in practice and being multiple, is distinctive from mainstream conceptualisations — by policymakers, scientists and some social researchers as detailed above — of bTB as a fixed entity created by the presence of *M. bovis* in cattle. Advancing the work of Atkins and Robinson (2013a) and Enticott (2012), I apply empirical ontology as a tool to investigate multiple, present-day disease management practices which make bTB. These realities of bTB collide — and therefore contribute to the public knowledge controversy — as various knowledges, expertise and ways of doing are debated. I argue that bTB is made in practice and therefore bTB can be made differently, and better —

[16] I use Latour's (2005: 129) definition of a network as "not a thing out there that would have roughly the shape of interconnected points", but rather as a physically traceable mesh of interwoven relations that take effort to create and maintain. Tracing the networks via descriptions is important to establish what is, and what may otherwise be.

less antagonistic, less polarised and less painful — by intervening *in practices*. This research is particularly important if we are ultimately interested in improving bTB management, moving beyond the impasse surrounding the controversy and relatedly improving animal disease management more widely. This thesis therefore makes a relevant contribution for STS scholars, bTB social researchers and researchers in policy making who aim to improve bTB management.

1.3. Research questions

In this thesis I aim to unravel what cannot easily be seen, highlighting how bTB is made in practice. The key aims for this research project are to *investigate* bTB-in-the-making in disease management practices, and to *explore* how bTB can be made differently to create different futures for the disease. As stated earlier, the primary research question is:

How is bTB made in disease management practices?

Specifically, this involves analysis of secondary research questions:

RQ1: What are farmers', vets' and government's ways of making bTB through the skin test?

RQ2: How is bTB made in cattle trading?

RQ3: How is badger culling policy made?

RQ4: How can badger culling be made differently?

RQ5: How can citizen science realise collaboration between divergent groups?

The primary research question is deliberately broad to enable the research to develop in line with research participants' interests. I undertook research with a variety of agents involved in bTB, including: policy documents, cattle farmers, large animal vets, badger cull shooters, anti-badger cull activists, protestors of the badger cull, guns, epidemiologists, a microbiologist, cattle, badgers, callipers and bacteria. These participants are referred to throughout by type (as in the above list) and as groups. I also use the term 'communities' in Chapter 8 to refer to actors, from multiple groups, that share 'worldviews' about bTB management. Building on the work of King (2002: 767), a researcher of public health policy, I define worldviews as,

> consistent, self-contained ontology of epidemic disease: its causes and consequences, its patterns and prospects, the constellation of risks that it presents, and the most appropriate methods of preventing and managing those risks. It comes equipped with a moral economy and historical narrative, explaining how and why we find ourselves in the situation that we do now, identifying villains and heroes, ascribing blame for failures and credit for triumphs. Finally, it is a universalizing template for understanding the interactions between humans and the microbial world: the rules and assumptions that it lays out are presumed to be globally applicable.

This project addresses the research questions by drawing on findings from multi-sited ethnographic work undertaken in England from 2015 to 2017. It involved working in the different inter-connected spaces in which bTB is made, and paying attention not only to policy and human practices, but also those of the bacteria and its non-human host organisms.

I followed bTB, as my object of study, across three geographical areas. The ethnography included interviews, focus groups, presentations and participant-observations of skin testing, cattle trading, badger vaccination, the 'Badger Found Dead Study', badger culling and opposition to badger culling. I give voice and space to multiple agents leading to a deeper description of practices and a way of understanding bTB that respects those involved. My multi-sited ethnography, and my analysis of the findings using the insights of STS literature, unpicks the divisions present in the disease eradication strategy and offers up points of intervention in the network of bTB to enable less polarised futures to be imagined and created.

Of central importance to the ongoing debates around bTB is the consideration of knowledges produced by different types of practice. In this thesis, I explain practices under Bloor's (1976) 'principle of symmetry': all knowledge practices should be explained in the same terms. I do not privilege one type of knowledge or practice over another. I analyse formal scientific research on bTB in the same way as a farmer's description of history of bTB on their farm. I have carefully selected the knowledge practices and evidence-making that I present in this thesis, whilst retaining and acknowledging the diversity of information and sources that are available to me as a researcher.

This thesis is primarily written for bTB researchers (in all disciplines) and government researchers working on bTB. As detailed in the Preface, I aim for this research to intervene in bTB management and I therefore situate myself as a critical friend of government policy. As a civil servant myself, I anticipate that most civil servants will likely not read this document in its entirety. Drawing on my experience of translating research for policymakers in my role as a government researcher (Phoenix et al., 2019), I will develop an executive summary of my key findings and recommendations for civil servants.

1.4. Key terms

My work is interdisciplinary, using analytical approaches from STS to investigate an epidemiological, policy-based and social disease. Given this project's focus on 'policy' (e.g. skin testing policy, risk-based trading policy, badger culling policy) and 'science' (e.g. epidemiology and veterinary science) in the 'public knowledge controversy' of bTB, it is helpful to outline my definitions of these terms at this point.

1.4.1. What is policy?

Definitions of policy can be generalised in two categories. First, policy can be understood as "a rational problem-solving instrument, and as a neutral, technical means to steer social progress" (van Gastel and Nuitjen, 2005: 86). Interpretative Policy Analysis scholars argue that this rationalising approach is based in 'instrumentalism': policy is intended to shape practice (Colebatch, 2005; Freeman et al., 2011). This approach presents policy as following a linear model composed of discrete stages which culminate in implementation. In this model, policy, as an artefact, is (at least temporarily) fixed and is the blueprint that directs action as implementation of that policy. The word 'model' is important here as policy scholars argue that this approach presents an idealised version of how policy *should be* done rather than *is* done (Cairney, 2020; Colebatch, 2005). The disparity between what policy is expected to achieve (as fixed) and what is achieved 'in practice' is widely conceived to be the 'policy-implementation gap' (Gunn, 1978). It is founded on a simple hierarchy within which policy formation is accorded more importance than policy 'in practice' (Hudson et al., 2019). Consequently, this gap is explained as being due to implementation failures and therefore capable of being remedied through formulating better policy. Despite decades of critique for being simplistic and privileging top-down approaches of policymaking (Braithwaite et al., 2018; Colebatch, 2005; Hill and Hupe, 2014; Rittel and Webber, 1973), this approach, and identification of such 'gaps', is still popular in policymaking authorities, implementation studies and policy studies (Campos and Reich, 2019; Hill and Hupe, 2003).

The second definition of policy understands it as a practice rather than an artefact. Policymaking and implementation are together considered to be constitutive of 'policy' as a set of practices. Scholars from the fields of Interpretive Policy Analysis and STS suggest that policy "rests on in-situ meaning-making practices" (Gill et al., 2017: 8). This conceptualisation shifts the focus from rationalisation and problem-solving, to show that policy is made in practices and through relationships (Colebatch, 2006). STS research emphasises how these practices necessarily make some things visible and make other things less visible, or invisible, by directing attention away from them, hiding them, repressing them, overlooking them or ignoring them (Law, 2004). In this view, the so called 'rationalisation' underpinning policy, as per the first definition, is not found in the world, but is made and sustained through practices (Law, 2004). STS and policy scholars note the practices that compose policy are continuously done and therefore policy is constantly made (Colebatch, 2006). In addition, each enactment of policy creates wider assemblages, or networks, which are themselves generative (Hay, 2009; Waterton, 2002) — policy is the constant making and production of things and realities through practices. Ironically, policy therefore adds to the complexity that it is made to simplify; it creates multiple realities that are often presented as definite and singular, but are only another layer in the multiplicities of the world.

These two approaches therefore differ in the understanding of policy as either rationalising complexity found in the world or enacting rationalisation through practices. I bring these two approaches together, conceptualising them as a policy cycle, or 'loop', as I call it. I consider policy to be a looping process between different sites and practices: policy-as-practice in the field affects policy practices in government offices and policy-as-representation-as-practice (Figure 2).

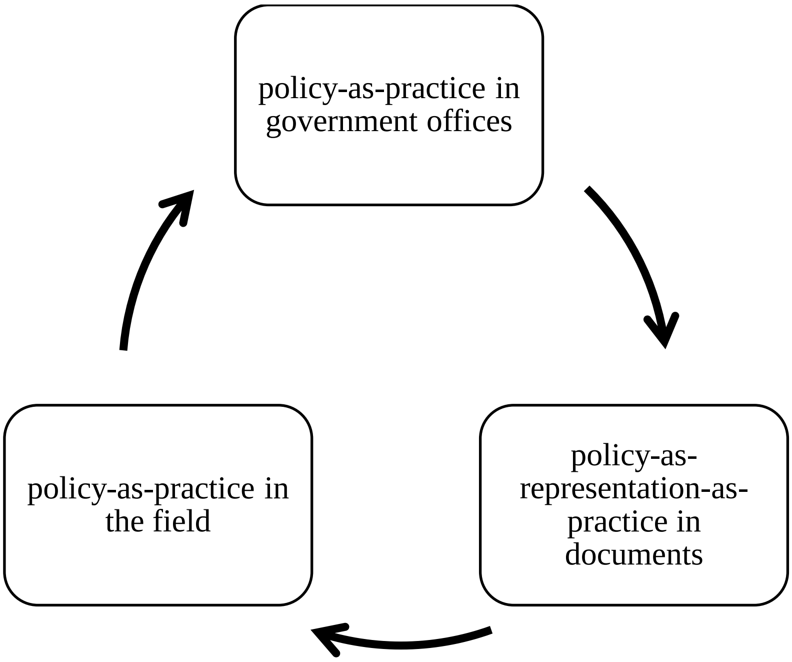

Figure 2: Loop between policy practices

I use the term policy to refer to both a thing — the ‘policy loop' as a whole — and ‘as-practice’. My work on policy resonates with Thomas Kuhn’s (1970) study of science in practices and with sociologist of science Andrew Pickering’s (1992) development of the term ‘science as practice and culture’: I use ‘as-practice’ to denote my study of policy in composite practices performed in different sites. I further analyse and expand on this loop in relation to the badger culling policy in Chapter 5 and Chapter 6.

1.4.2. What is science?

As detailed in Section 5.1, extensive research on badger culling and bTB has been undertaken from 1970 onwards, and yet the basic composition and argumentation of different interested groups remains stable (Lodge and Matus, 2014). In her book examining histories of the bTB knowledge controversy, Cassidy (2019: 14–15) suggests that the controversy has arisen in part due to the “sheer difficulty of gathering and interpreting data while integrating it with theory to find good explanations”. In her comparison of the role of knowledge between the bTB controversy and the UK’s response to COVID-19, Cassidy (2020c) writes that media coverage, popular culture and political rhetoric often present certain forms of knowledge as universal and objective, and define this as ‘The Science’, i.e. something fixed and definite which has authority over other forms of knowledge (Callon, 1999; Latour, 1987).[17] Ready-made science which is purified and decided upon, known as ‘The Science’, contrasts with ‘science-in the-making’ in which progress is being made and controversy is active (Callon, 1999; Callon et al., 2001; Knorr Cetina, 1981; Latour, 2004; Shapin, 1992). I contrast ‘The Science’ and ‘science-in-the-making’ in a similar way to policy as rationalisation and policy as practice. ‘The Science’ refers to an understanding of a singular, coherent knowledge product, as distinct to ‘science-in-the-making’ which opens up vulnerability, contingency and reversibility of knowledge claims (Latour, 1987; Latour, 2004; Shapin, 1992).

Building on the work of Latour (2004), Cassidy (2020c) argues that in the case of bTB, ‘The Science’ is monolithic, fixed and certain, and the nuances and complexities of ‘science-in-the-making’ are backgrounded. This framing of ‘The Science’ can be found in a comprehensive evidence review about bTB in cattle and badgers, in which Krebs et al. (1997: 128) note that “A proper experimental assessment is the only way […] to provide a sound basis for future policy”. This hypothetical ‘proper experimental assessment’ was instigated in the Randomised Badger Control Trial (RBCT) (see Section 5.1) and, in the final report, somewhat ironically titled as ‘Bovine TB: The Scientific Evidence’ (Independent Scientific Group, 2007). However, when the RBCT findings were published ‘The Science’ and ‘science-in-the-making’

[17] In the UK coronavirus pandemic, Cassidy (2020a) suggests Government representatives have regularly invoked ‘The Science’ to support their agendas. STS scholars note that this inferred a sense of certainty, ‘oneness’ and control (Stirling, 2020), which collided with the transparent uncertainty of ‘science-in-the-making’ and lack of ‘one voice’ (Mulgan and Chataway, 2020).

collided, causing confusion and controversy as nuances, contradictions and complexities came to light (Cassidy, 2020c).

1.4.3. What is a public knowledge controversy?

Through the collision of ‘‘The Science’ and ‘science-in-the-making’, sites of disagreements and debate may arise around scientific knowledge and expertise (Lane et al., 2009). This collision can lead to public knowledge controversies, defined as when knowledges become subject to public interrogation and there is open confrontation about forms of knowledge and forms of expertise (Lane et al., 2011).

bTB control is widely considered to be a public knowledge controversy, underscored by the creation, use and interpretation of epidemiological studies (Cassidy, 2019; Naylor et al., 2017; Price, 2017; Robinson, 2017b; Sandover et al., 2018). I consider badger culling to be a ‘hot spot’ public knowledge controversy (Pinch and Leuenberger, 2006) that has erupted on the surface of long-running controversies around how and if we manage and/or eradicate bTB. The public knowledge controversy of bTB involves multiple participants and communities claiming to follow ‘The Science’. Nuances and complexities of science-in-the-making may be used by groups to “argue that ‘The Science’ of bTB supports their arguments, while selectively drawing on different experts or interpretations of research findings to do so” (Cassidy, 2019: 20). Multiple groups can bring together experts from multiple disciplines and form different bTB realities as scientific knowledge is built and developed. Here, as in other environmental and agricultural controversies (see Cass and Walker, 2009), ‘The Science’ is understood differently by different groups.

STS scholars consider such public knowledge controversies to have potential to disrupt ‘The Science’ and the policy practices that they inform (Callon et al. 2001; Latour, 2004; Stengers, 2005; Whatmore, 2009). As philosopher of science Isabelle

Stengers (2005) notes, this disruption slows down reasoning and creates opportunities to foster alternative awareness of the issue at stake. Here, the authority assumed of ‘The Science’ is questioned and its privilege as *the* objective form of knowledge may be removed. In her examination of environmental public knowledge controversies, geographer Sarah Whatmore suggests that controversies “give rise to new ways of practising relations between science and democracy” (Whatmore, 2009: 587). Therefore, in STS, public knowledge controversies are considered to be generative events.

The generativity and creative potential of public knowledge controversies is clearly portrayed in Lane et al.’s (2011) experiment in a flooding controversy in Pickering, Yorkshire. Lane et al. enabled local people and academics to be jointly involved in producing knowledge of flood risk management and producing a public intervention for flood risk management in the local area. This experiment aimed to produce a solution for flood risk management from the outset, and consequently created a political intervention in a situation of impasse. The authors report that all forms of knowledge were debated in similar ways and knowledge was co-produced by multiple actors in the group. This experiment repositioned ‘The Science’ as ‘science-in-the-making’, redistributed expertise across groups and therefore provided an opportunity to develop different, and better, futures (Landström et al., 2011; Whatmore and Landström, 2011).

In a similar vein, political scientist Grant (2009) suggests that contested and contradictory evidence has given rise to an intractable policy failure around badger culling. This long-term policy failure has arisen due to the need to serve a ‘Government-defined end’ regarding the licencing of badger culling. Scientific expertise has been politicised as decisions need to be taken on sources of evidence, for example the RBCT, that often do not lead to an obvious workable policy option (Wilkinson, 2007).[18] However, many researchers have suggested the controversy cannot be solved by scientific studies alone because the controversy goes beyond this.[19] The public knowledge controversy is also underpinned by: different value systems and historical cultural significance of badgers and cattle (Cassidy, 2012; Gormley and Corner, 2018); a longstanding human-wildlife conflict in which badgers are framed as awkward animals (Cassidy, 2020b)[20]; moral beliefs and philosophies of nature (Buller, 2008; Enticott, 2015); gaps between multiple framings of the disease (Keenan et al., 2019; Robinson, 2017b); and, an intractable, long-term policy failure (Grant, 2009). Epidemiological, veterinary and ecological studies are only one influence on worldviews and policy decisions, weighed up against other factors such as the risk of adverse publicity, loss of goodwill by those who oppose badger culling and ethics (Andrews, 2020). Hence, scientific studies are important, but not the only influences on which polarised realties of bTB and badger culling are made by government and members of the public.

1.5. Thesis Structure

I do not include an academic literature review in this thesis, but rather interweave theory, academic and grey literature, and empirical findings in each chapter. I chose this structure for three reasons. First, I resolutely aim to avoid the "the god trick

[18] Badger culling requires a governmental licence to take place and therefore the Government has ultimate control over deciding if it should occur.

[19] For example, Enticott (2015) undertook surveys about the acceptability of badger culling with 533 respondents in rural Wales. The respondents either completed a survey presenting a dataset suggesting badger culling leads to a 28% reduction in bTB cases, or a survey presenting a dataset suggesting badger culling leads to 16% reduction in bTB cases. On average, respondents suggested a minimum level of acceptability 11% greater when presented with the former dataset compared to the latter. However, 23% and 28% of respondents respectively said a badger cull was never acceptable. This suggests the heterogeneity in scientific findings leads to different levels of acceptability of a badger cull, but that references to scientific findings alone cannot persuade publics to accept the badger cull.

[20] Badgers have important cultural associations for the English public (Cassidy, 2012; Cassidy, 2017; Cassidy, 2019), exemplified through representations of badgers in tales such as 'Wind in the Willows' (Grahame, 1908) and 'The Tale of Mr Tod' (Potter, 1912).

of [claiming to] see … everything from nowhere" (Haraway, 1988: 581) and therefore do not pose grand theories or large-scale generalisations. Instead, I "think through materials" (Law, 2008b: 6) to extend ideas of bTB through empirical stimulus. My exploration of bTB through these descriptive case studies challenges, extends and generates theory related to the multiplicity and heterogeneity of bTB, and what this means regarding disease management.

Second, I consider the interweaving of literature, theory and findings to be more reflective of my own way of working. The traditional thesis layout of 'Introduction, Literature review, Method, Results and Discussion' (Kamler and Thomson, 2014) is rooted in positivistic assumptions which assume a well-defined problem at the start of the research process (Kember, 2018). This did not feel appropriate because I did not read all the literature, then read all the theory, then decide on my research question, then decide to do an ethnography, then undertake fieldwork and finally analyse my findings. Instead, I began this research with an idea to explore relations between disease management practices and the concept of bTB, iteratively referring to theory and literature, and evolving my method in light of my findings. To reflect this process, I use a 'topic-based' layout (Paltridge and Starfield, 2007) and draw on relevant literature in each chapter to approach the research question.

Third, I want to bring you, the reader, into the research participants' stories and worlds, but without expecting them to fit neatly together. As Carrithers (2018: 2) puts it:

> excellent ethnographic description enables access for the reader to someone's world.

I use my findings to reflect on the literature and to give voice to the complex situations — including people, animals and things — involved in the disease and living with its ramifications.

This thesis, then, is thematic and presented as a series of practice-based stories from the field. As shown in Table 1, each chapter contributes to the primary research question and addresses one of the secondary research questions by focusing on a particular practice.[21]

Table 1: Research questions addressed and practice examined in each chapter

Chapter	Research Question(s) addressed	Practice examined
Chapter 3	RQ1: What are farmers', vets' and government's ways of making bTB through the skin test?	Skin testing
Chapter 4	RQ2: How is bTB made in cattle trading?	Risk-based trading
Chapter 5	RQ3: How is badger culling policy made?	Assessing the effectiveness of badger culling policy
Chapter 6	RQ3: How is badger culling policy made?	Culling badgers and opposing the killing of badgers in the field
Chapter 7	RQ4: How can badger culling be made differently?	Culling badgers by alternative methods
Chapter 8	RQ5: How can citizen science realise collaboration between divergent groups?	Conducting citizen science related to bTB

The layout reflects my commitment to following practices and using the findings to intervene in bTB management, policy and evidence creation. Each practice-based chapter details how the practice is being undertaken, how the practice contributes to the making of bTB and how it could be done differently to make a different kind of bTB. I use multiple analytical lenses from empirical ontology to highlight the central

[21] The practice of badger vaccination was also explored in this research. However, this thesis does not draw on findings related to badger vaccination because the research has instead been written into a journal article (Benton et al., 2020).

components of my data-driven arguments. I present my reasoning for choosing specific analytical lenses in Section 2.5.

I have shared my findings and provided recommendations to Defra at a number of points and have found some reflected in the policy paper ‘Next steps for the strategy for achieving bovine tuberculosis free status for England’ (Defra, 2020a), and this shows that my research has influenced policy. To account for this, in many of the proceeding chapters I include a ‘post note’ to outline how my findings have influenced policy development and how they may be used to influence policy in light of the 2020 publication.

Chapter 2 presents the methodology through which this research has taken form. I detail my philosophical framework of empirical ontology and my multi-sited ethnography of bTB, undertaken from 2015 to 2017. The chapter situates my ethnography in STS methods in relation to public knowledge controversies, relational ethnography and multi-sited ethnographies. It aims to help the reader follow bTB through diverse networks, across sites and with agents. As outlined in Section 2.2, my symmetrical approach and my focus on bTB-in-the-making deviates from the way that bTB is often conceptualised — as a fixed disease caused by *M. bovis* which is managed through practices, but not shaped by practices. Consequently, I defamiliarise bTB by changing the mode through which it is most commonly known i.e. moving from investigating knowledge or ‘framings’ to investigating practice. Therefore, according to literary critic Lodge’s (1992) notion of originality as defamiliarisation, I provide an original contribution to knowledge.

Six empirical chapters follow this one: each is based on a different practice and each address at least one of the secondary research questions (Table 1). Chapter 3 explores the practice of the Single Intradermal Comparative Cervical Tuberculin Test (more commonly known as the ‘skin test’) on cattle herds to test for bTB. In my investigation of skin testing, I argue that English policy props up a narrative of control by suggesting that the skin test makes the disease detectable and visible, whilst occluding some of its uncertainties, complexities and multiplicities. I investigate and draw together these uncertainties to argue that bTB is not a fixed and identifiable bacillus, but rather a disease deciphered through sociotechnical and sensory perception.

Although the disease of bTB is made temporarily visible on farm through materials and practices related to the skin test, it also mobilises through landscapes, into farms and between cattle without detection. One route of such invisible disease mobility takes place through the movement of undetected disease-infected cattle across England (APHA, 2018b). Chapter 4 examines the mobilities and materialities of bTB related to the practice of risk-based cattle trading, drawing on Hinchliffe et al.’s (2013) concepts of borderlines and borderlands. It compares government’s attempts to control the risk of *M. bovis* transmission through the implementation of skin testing borderlines between risk areas with one farmer’s attempts to control the risk of disease detection through the use of ‘leaks’ produced by the testing borderlines. By analysing risk-based trading using theoretical framings of borderlands and borderlines, I show how bTB and risk are practised in different ways. Finally, I describe one farmer’s proposal for risk-based trading that draws together the risk of *M. bovis* transmission and disease detection in a reshaping of risk-based trading. The chapter details different ways of practising disease risk.

Chapter 5 and Chapter 6 explore the badger culling policy. Chapter 5 explores policy documents and government reports to present a sociotechnical history of policy, specifically concentrating on the calculations of effectiveness of the badger cull. I describe the changing calculus of badger cull effectiveness. Drawing on the policy loop detailed in Figure 2 and the work of Lippert and Verran (2018) on the exploration of calculation [redacted]. Building on the control narrative in Chapter 3, I argue that the 'numbers' and 'calculations' of effectiveness allow government to appear to calculate and control the badger culling policy.

Chapter 5 is complemented by Chapter 6, which draws on findings from fieldwork in the Gloucestershire and Cotswolds badger cull areas to explore the practices of badger culling with shooters/contractors, cull companies, vets, farmers and anti-cull badger protectors. No other qualitative research has been undertaken with shooters and badger cage trappers, and therefore this chapter presents a unique insight into badger culling practices in the field. Badger culling is taking place under licence conditions with the aim of reducing bTB, but somewhat unexpectedly, the badger culling policy has weak associations with bTB. Instead it bears strong associations with fox hunting, rurality, fear, thrill, communities, money, business and morality. I present five vignettes spanning multiple practices and sites which reveal the centrality of affect to the badger cull. I detail what the policy supports, generates and entangles, alongside bTB. In an original theoretical contribution, I argue that these affects are generated by the policy and generate the policy in turn, in an affective policy loop.

Chapter 7 details two alternative methods and philosophies of culling: a) 'test, vaccinate or remove' (TVR) and b) gassing of setts that are deemed to be infected. I present these practices to show how the relations underpinning badger culling can be woven in different ways to create different practices. TVR revolves around removing *M. bovis*, whilst gassing of infected setts centres on removing an agent that *M. bovis* can travel through, the badger. I explore how these practices enact *M. bovis* and badgers in different ways, thereby creating different ways of ‘doing’ disease control. I display these different disease management practices to outline future alternative possibilities for badger culling.

Chapter 8 also poses alternative futures to bring together communities who hold oppositional worldviews on bTB management through the case of a citizen science project. Drawing on ethnographic data from a ‘Badger Found Dead Study’, I argue that participatory veterinary epidemiology, as a form of citizen science, can enable divergent communities to work together towards a common goal. It can develop better, more meaningful knowledge for communities, help to dismantle the certainty painted by ‘The Science’ in the controversy, and create space for connections between oppositional communities. Such a realignment of relations may be temporary and mobile rather than enduring and fixed. The role of citizen science in the bTB public knowledge controversy has previously not been explored and this chapter therefore provides a perspective on how evidence may be created differently.

In the Conclusion (Chapter 9) I address my primary research question to consider how bTB is made through the different practices explored in Chapter 3 to Chapter 8. In particular I draw out themes from my empirical chapters to illuminate how three disease realities are made by: creating uniformity from heterogeneity; foregrounding disease control and backgrounding uncertainty; and, enacting disease on different scales. I suggest how my research can be used to inform how bTB could be done in ways that strive for less antagonisms, less polarisation and less pain. This contemplation of different disease futures may pose a challenge, one that is offered in the spirit of hoping to improve disease management.

The next chapter justifies my approach and methodology, and — further to the Preface — details my positioning in the research.

Chapter 2. Approaching bTB: theory, methods and relations

As detailed in Section 1.2, I consider bTB to be multiple, but not fragmented: it is a bacillus, an infection, the cause of badger culling and the cause for opposition to the badger cull. I also consider each enactment of the disease to be relational and material. For example, the water trough is a source of infection due to the agglomeration of *M. bovis* within it and is thought to transmit infection to cattle when they drink. Hence, the water trough gains agency in relation to cattle through the act of drinking; drinking is the relational translation of the disease from trough to animal. To help explain my conceptualisation of bTB as relational and multiple, in this chapter I introduce relational ethnography and the main tenets of STS research that run throughout the following chapters. This chapter outlines empirical ontology as my overall philosophical and methodological framework. The framework is expanded differently in each of the following chapters, which draw on aspects of STS literature to help analyse the findings and draw out key themes.

Furthermore, this chapter reflexively details my ethnography, in which I followed bTB through diverse networks, across sites and with agents. I share examples of the challenging ethics in the research process and state the sources upon which my arguments are based. I also describe my analysis and presentation of findings before accounting for my relations with Defra.

2.1. History of relational ethnography

Ethnography is close and sustained fieldwork, leading to rich and detailed understandings of practice (Atkinson and Hammersely, 1994). It can include an assemblage of methods including: life history interviews, open-ended interviews, oral history, observation studies and participant observation (Delamont, 2002). Ethnography originated as an approach in anthropology to explore cultural settings from the point of view of the subject of the study. This approach counters more positivistic research methods which are often disconnected from day-to-day experiences (Enticott, 2011b). Polish anthropologist Bronislav Malinowski is widely considered to be the ‘founding father’ of ethnography when, after the First World War broke out, he ‘interned’ on the Trobriand Islands in the Pacific and had no contact with other Europeans. He proclaimed that for anthropologists to understand other people’s cultures, they must learn their language, live with them over a considerable period and take part in their everyday life. Therefore in anthropology, ethnography was traditionally undertaken to make the strange familiar (Miner, 1956) and understand another way of life from a ‘native’ point of view.

This methodological approach was transposed into Sociology of Scientific Knowledge (SSK) research via what came to be called the ‘laboratory studies’ in the late 1970s and early 1980s. Similar to anthropologists, this first generation of SSK ethnographers made the strange familiar by exploring laboratory practices and relations, and questioning assumptions about how new knowledge is made in the laboratory (Fujimura and Fortun, 1996; Knorr Cetina, 1981, 1999; Latour and Woolgar, 1979; Lynch, 1985; Traweek, 1988). Many of the laboratory studies focused on scientific and technical controversies because they were “especially valuable sites for carrying out research into the nature of scientific knowledge” claims (Martin and Richard, 1995: 4) and to explore ‘science-in-the-making’. The use of ethnography in laboratory studies created both detailed descriptions of laboratory practices and general theory about how scientists create knowledge (Hess, 2001). These SSK ethnographers examined how versions of truth are established and the implications of this process (Latour, 1987; Latour and Woolgar, 1979). For them, the laboratory was both a site of knowledge exchange (Shepherd and Gibbs, 2006: 671) and a physical space which extended through networks and relations to shape public knowledge controversies beyond its walls (Beaulieu, 2010). The work showed the messiness of science-in-the-making; exposing ambiguity, complexity, contingency and internal uncertainty. Their work was pivotal in the development of STS, which this thesis draws upon. STS ethnographer Beaulieu (2010: 455) notes that:

> Significant concepts in STS, such as the construction of facts, the role of inscriptions, and what counts as a contribution to scientific work and knowledge have been addressed and refined through ethnographic investigations.

The questions explored by what David Hess (2001) calls ‘first generation’ science studies ethnographers are primarily epistemological — concerned with what we can know about the world and how we can know it. Their work provides scholars with the opportunity to learn about “the underlying dynamics of science and technology and their relations with wider society” (Pinch and Leuenberger, 2006: 2). Their work inspired the second generation of science studies ethnographers who began to look in more detail at the public and political implications of scientific knowledge in society. Second generation ethnographers recognise that “the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it” (Jasanoff, 2004: 2). The second generation also recognise that truths are established through relations between agents. Hence, STS has turned to focus on how ways of knowing and ways of doing make particular realities. This led to the ontological turn.

2.2. From epistemology to ontology

Law and Lien (2012) note that the turn to ontology in STS is characterised by considerations on perspectives of reality. Those with a positivist epistemology generally consider that “objects look messy because people have different perspectives on them” (Law and Singleton, 2005: 333). Those with this consideration may try to “explain (away) the different perspectives to reveal the 'real object'" (Law and Lien, 2012: 2). This essentialist positioning assumes that objects are fixed, true and can be 'discovered'; for example that a true version of bTB history can be told. For this way of thinking to work an assumption is required that there is one reality and a definitive, singular, ordered material world 'out-there'.

In terms of bTB, a commonly held perspective is a positivist epistemology of *M. bovis* as the causative agent of bTB, as outlined in Section 1.1. For example, chronological histories have been written about bTB which provide a comprehensive analysis of the development of understanding of the same, epidemiological disease through time (APHA, 2017, 2018a, 2019a; Godfray et al., 2013; Godfray et al., 2018; Independent Scientific Group, 2007; Krebs et al., 1997; Waddington, 2004, 2010). The assumption goes that there is one version of bTB, which has been managed differently.

STS scholar Law (2004) suggests that we create the idea of one single ordered material world to help us find some sort of meaningful pattern in complexity. We therefore enact order, rather than discover order. The practice of enacting order makes visible or foregrounds some ways of knowing and consequently necessarily backgrounds or makes other things invisible by directing attention away from them, concealing them, ignoring them, or silencing them (Law, 2004). STS ethnographers critique the assumption of a single, ordered material world by using case studies to detail how realities emerge through practices (Law, 2008b). For example, second generation STS ethnographers Mol (2002) and Moser (2008) have shown how atherosclerosis and Alzheimer's, respectively, are 'done' or enacted differently through different practices. Mol (2002) followed different enactments of atherosclerosis around a hospital, asking the question 'What is atherosclerosis?'. Mol describes the condition in a variety of ways. To the medical professionals, atherosclerosis is caused by long term changes in the blood which may lead to build up of atheromatous plaque and thickening of the intima, consequently leading to pain whilst walking. She shows how the realities of atherosclerosis are related to blood for a haematologist and related to thickening of the intima for a pathologist. Mol foregrounded practices in her investigation and found multiple realities in which the different versions of the disease “hang together” in a variety of ways, but were not the same, single thing. For example, the development of a new medical detection device for atherosclerosis brought about a new enactment of the disease. Consequently, Mol shifts the emphasis: if realities are enacted through practices and in relation, realities become a contingent set of ontologies that co-exist, overlap and entangle (Law, 2004; Mol, 2002; Waterton, 2010). Ontologies can be understood as “relational effects that arise in practices” (Law, 2017: 43) and therefore questions of reality become a matter for empirical investigation. In this style,

> Empirical studies of ontology are not trying to explain why differences arise within a single cosmological grounding. Instead, and quite differently, they are looking at what objects come to be in a relational, multiple, fluid, and more or less unordered and indeterminate (set of) specific and provisional practices (Law and Lien, 2012: 3).

The relations that underpin practices are different but overlap and therefore the realities and things they generate are different but overlap. Mol suggests that the enactments of atherosclerosis exist together and therefore things “hold together so long as those relations also hold together and do not change their shape” (Law, 2002: 91).[22] Hence, an object is always more than just itself as it is held in place by relations, and is always less than many as these relations are dependent on it. Thus, empirical ontology considers that all objects are multiple:

[22] This work is an advancement of relational ethnography developed through Actor Network Theory. Actor Network Theory recognise that agents gain agency and characteristics in relation with one another, rather than in and of themselves (Callon, 1986).

> The objects we study, the objects in which we are caught up, the objects which we perform, are always more than one and less than many (Law, 1999: 11).

Returning to the bTB public knowledge controversy, the everchanging state of bTB and badgers has been historically explored through 20th century debates of human-badger conflicts (Cassidy, 2019). Cassidy outlines how three groups frame bTB differently — as an animal health issue, a disease ecology issue and an animal protection issue — and how this leads to different versions of bTB coming to life. These heterogeneities of bTB help explain the difficulties in managing it (Atkins and Robinson, 2013b). Furthermore, Robinson (2019) ontologically explores the agency of *M. bovis*, detailing how it out-manoeuvres efforts to control it, and yet deflects blame away from itself and onto state actors.

Advancing this work and embracing the sense of dislocation between different versions of bTB (Jasanoff, 1997), I trace how multiple versions of bTB are enacted through practices. Therefore, I employ the STS tradition of empirically studying the making of the entity of bTB in practice (Haraway, 1989; Latour, 1988; Singleton and Michael, 1993) to anticipate how bTB comes into being and disappears through practice. I use the relational philosophy and methodology of ‘empirical ontology’ to make sense of bTB-in-the-making.

To my knowledge, three other academic publications use relational approaches to understand bTB. As detailed in the Introduction, Atkins and Robinson (2013a) analysed bTB heterogeneity in five stories based in Northern Ireland, devised from secondary research. Enticott (2012) undertook ethnographies of two veterinary practices and explores how veterinary expertise enacts different versions of bTB, specifically through the skin test. Similarly, Robinson (2014) used STS style approaches to analyse disease networks (see footnote 16) and the role of agents in the spread of bTB in Northern Ireland. In their primary research, both Robinson and Enticott consider agents such as cattle, bacteria and badgers, but these considerations stem from a humanistic framing of disease control and from farmers' and vets' perspectives. In contrast, my ethnography is practice focused and agent driven rather than human focused or site focused. I advance their work by investigating bTB through practice, focusing on inherent multiplicity of the disease rather than multiplicity in how the disease is known.

I have undertaken an ethnography on farms, in fields and in a laboratory, and analysed my findings using analytical lenses from empirical ontology to explore how versions of bTB are enacted. I centralise practices, relations and objects in a multi-sited ethnography following bTB through cattle testing, cattle trading, badger culling and a 'Badger Found Dead Study'. I draw attention to the multiple versions of bTB that exist in different sites and understand them as different but inter/intra-related; bTB "enacted is more than one- but less than many" (Mol, 2002: 55). Each enactment of the disease is bound to a specific site and situation, but these enactments are connected through material relations. My focus on practices and relations accounts for versions of bTB that are endlessly brought into being through relations between materials such as syringes, needles, crushes, races and yokes. Specifically I examine how uncertain, material multiplicities come to be ordered into a certain singularity. I explore the uncertainty that is being occluded within the presentation of bTB as singular disease to be 'controlled' and 'eliminated'. Tracing networks via my descriptions, I deepen an understanding of bTB-in-the-making, and, adopting the words of Latour (2005), how this can be made otherwise.

2.3. Multi-sited ethnography

I undertook a multi-sited ethnography to confine and define my 'networks' relationally, rather than geographically. I explored bTB beyond the confines of a single site — e.g. the farm — to further explore the politics and practices of the bTB public knowledge controversy. My work reflects anthropologists' understanding of the potential for multi-sited ethnography to 'follow things' rather than to follow actors through society (Marcus, 1995). I used the three geographically defined risk areas (Low Risk Area, Edge Area and High Risk Area) demarcated in 'The Strategy for achieving Officially Bovine Tuberculosis Free status for England' (Defra, 2014a) as a device for my fieldwork. I did this to connect my research to participants' framings of bTB (farmers, vets and official documents all consistently refer to these demarcated risk areas), hence enhancing the relevance of my project for potential participants. I followed bTB, as my object of study, across the risk areas to gauge the making of bTB as in Table 2.

Table 2: Location, timings and duration of fieldwork

Location	Timing (inclusive)	Duration
Cumbria, Low Risk Area	October 2015–May 2016	8 months part time
Gloucestershire, High Risk Area	September 2016–November 2016	3 months full time
Edge Area	November 2016–February 2017	4 months full time

Within each risk area my fieldwork took place on multiple sites including farms, veterinary practices, fields and farmhouse kitchens. The diversity of methods and involvement in practices allowed me to examine bTB networks from the viewpoint of multiple agents (including bacillus, badger, cow and water trough), rather than being limited to the viewpoint of the farmer and the vet. A 'symmetrical approach'

(Bloor, 1976) to knowledge making about bTB means I provide explanations from all sides of the public knowledge controversy and I explain all knowledge practices in the same terms.

A central component of STS is that the context of knowledge creation should be expressed in each research project because findings are co-constructed by the researcher and participants (Law and Williams, 2014). As Woodward (2008: 557) writes in reference to her ethnography in a boxing gym: “This is not to devalue the research, but to situate the knowledge so produced and acknowledge its partiality”. Accordingly, in the next three sub-sections, I describe my fieldwork in each of the three risk areas.

2.3.1. Low risk area: skin test and cattle trading

I undertook fieldwork in Cumbria from October 2015 to May 2016. First, I established connections with the local NFU county advisor and with the ‘Lancashire/Cumbria TB Eradication Group’ comprising farmers, NFU, Animal & Plant Health Agency (APHA), large animal vets and wildlife groups. Second, I sent an email to all members of the group informing them of my research and asking if I could observe skin tests. One veterinary practice and two farmers replied. One of these vets became a vital gatekeeper for my fieldwork on skin testing.

I called each of the email respondents to introduce myself, gain some background information about them and arrange farm visits. The phone calls were an important part of gaining access to farms as it enabled me to describe my research and establish my academic role. The gatekeeper vet asked how the data would be used and whether those would be shared with the Government. I informed him that the data would not be shared with Defra. I later learned that his hesitation was founded on the fear of losing his job if any of his practices were found not to align with Defra standards. At the time I paid little attention to this fear, but the ramifications of his fear became more and more obvious as I worked with him on farms. These unexpected ramifications of 'malpractice' became a core part of my fieldwork (Section 3.4).

The fieldwork I undertook in the Low Risk Area is shown in Table 3.

Table 3: Fieldwork in the Low Risk Area

Aim	Method/Activity	Approximate number of days/hours	Source ID (denoting activity or interviewee, site and date. FN= fieldnote, IN= interview)
To investigate the making of bTB.	Participant observation of 12 skin tests on farm	22 days	FN skin test 1 month radial LRA 1, 25.02.16 FN skin test 1 month radial LRA 2, 07.03.16 and 10.03.16 FN skin test 1 month radial LRA 3, 04.01.16 and 07.01.16 FN skin test 1 month radial LRA 4, 19.01.16 and 22.01.16 FN skin test 1 month radial LRA 5, 02.05.16 and 05.05.16 FN skin test 1 month radial LRA 6, 08.03.16 FN skin test 6 month radial LRA, 26.04.16 and 29.04.16 FN skin test 12 month radial LRA 1, 26.01.16 and 29.01.16 FN skin test 12 month radial LRA 2, 11.04.16 and 14.04.16 FN skin test short interval LRA, 07.05.16 FN skin test routine LRA 1, 25.02.16 FN skin test routine LRA 2, 25.02.16
	1 semi-structured interview	3 hours	IN Farmer LRA, 26.05.16
To explore the barriers and enablers to risk-based trading at auction marts.	1 visit to cattle auction mart	1 day	FN cattle auction mart LRA, 26.02.16

Aim	Method/Activity	Approximate number of days/hours	Source ID (denoting activity or interviewee, site and date. FN= fieldnote, IN= interview)
To observe the local governance of bTB and relations between people with differing views on bTB management practices.	Attendance at two meetings with local bTB groups	8 hours	FN meeting LRA 1, 22.09.15 FN meeting LRA 3, 25.03.16
To understand the recording system for the skin test.	Participant observation of inputting skin testing data into APHA’s automated recording system	0.5 day	FN vet practice LRA, 25.02.16

The vet invited me to attend skin tests with him, thereby providing access to multiple farms. The farm setting helped me to “examine, uncover, dig into the ‘facts’ and ‘counter-facts’” (Cooper 2016) surrounding skin testing. I attended 12 whole or part-day skin tests with four vets from three veterinary practices. This usually involved participation in the skin test on Day 1 and Day 2 (see Chapter 3).

I often undertook the role of ‘scribe’ on the skin test (see Chapter 3), finding animal IDs in paperwork and writing down their skin thickness, thereby speeding up the testing process by relieving the vet or farmer of a monotonous task. My role in the skin-test made me a necessary part of the team as a participant-observer, rather than a research by-stander. I filled in the paperwork and asked questions as we went along, jotting down notes in between cattle entering the cattle crush (Figure 3). These conversations were ancillary to the practice of the skin test and allowed respondents to lead conversations towards topics of their choosing, typically resulting in a discussion of farm-level practices. I consider this to have led to a more open and frank discussion about the disease than we might have otherwise engaged in should we have been in a more formal setting.

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Figure 3: Photographs from skin test in Cumbria. (a) Cattle race, crush and yoke. (b) Myself scribing for the skin test and writing fieldnotes in the rain on top of a water tank (Author, 2016).

My role as scribe often saw me positioned adjacent to the crush and, dependent on the crush and race layout (Figure 4), I often released the neck yoke — a bar around an animal's neck used to catch the animal and hold them 'stock still' — to let cattle in and out of the crush. This helped to establish a level of respect with farmers and vets as I illustrated my competent use of equipment and showed I was willing to get involved. Once the test was complete and cattle were released from the crush, I was often surrounded by cattle; this was especially the case on dairy farms as the cattle are more conditioned to constant handling. I had to be confident around the cattle which further increased my credibility with farmers. In partaking in these events, I learned to:

> move among strangers while holding …[myself]…in readiness for episodes of embarrassment, affection, misfortunate, partial or vague revelation, deceit, confusion, isolation, warmth, adventure, fear, concealment, pleasure, surprise, insult, and always possible deportation (Van Maanen, 2011: 2).

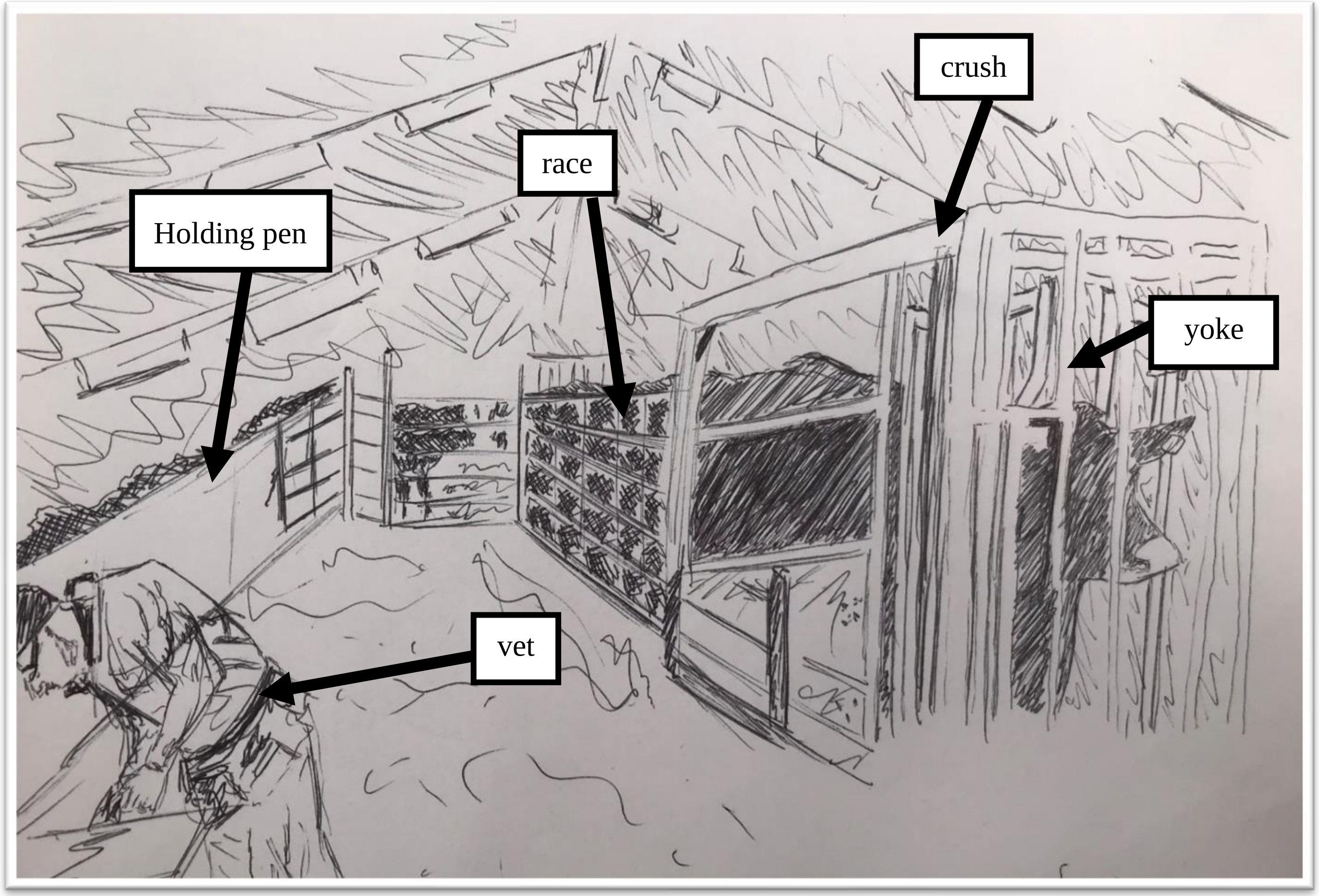

Figure 4: Labelled sketch of an example cattle handling system used for the skin test (Author, 2020)

On one occasion, I was unsuccessful in handling the cattle on a dairy farm with two herds: one herd managed by the father and one herd managed by the son. The son had petted his cattle when they were calves resulting in friendly animals. I let the first heifer out of the crush and it immediately began licking me.[23] As more heifers passed through the crush, more licked me and I became drenched with cattle saliva. No matter how much I pushed the heifers away, they would not leave me alone. The farmers and vet thoroughly enjoyed this turn of events and proceeded to recount the tale to other farmers I was scheduled to visit. As expected, this story was received with widespread laughter. Importantly, moments of embarrassment such as this facilitated my inclusion in the farming community.

The skin test was a full day affair: I frequently had lunch with the farmer and their family. Eating together forged personal relationships and offered a setting for shared stories surrounding bTB. Furthermore I often helped wash the dishes after lunch, a task typically done with women farmers, which gave us the opportunity to discuss the emotional and financial impact of bTB on their family.[24] This confirmed the benefits of doing ethnographic fieldwork as we often shared moments in the kitchen, both dreading the thought of finding a reactor in the skin test. With participants' permission, I have used the findings from these conversations in this research.

2.3.2. Edge Area: 'Badger Found Dead Study'

I planned to conduct research in a badger vaccination zone in Cornwall, but badger vaccination in England was suspended in 2015/16 due to a global shortage of Bacillus Calmette–Guérin (BCG) vaccine (Case, 2016). I therefore wanted to explore

[23] A heifer is a female that has not borne a calf.

[24] Feminist rural geographers have written extensively about gender identities created, and patriarchal gender relations displayed, through gendered farm work (Little and Panelli, 2003). In short, agricultural domestic work, most often undertaken by a woman, is vital to the survival of the family farm business (Whatmore, 1990) and therefore domestic work is part of the labour of being a farmer.

bTB-in-the-making in a different practice. My PhD supervisor Professor Maggie Mort had worked with Professor Malcolm Bennett (researcher of Zoonotic and Emerging Disease at University of Nottingham) in the 'North West Zoonoses Group' and arranged for us to meet. Professor Bennett told me about his work on a Defra funded 'Badger Found Dead Study' (hereafter referred to as 'the BFD Study') in the Edge Area and I informed him of my research. He offered the BFD Study as an ethnographic site for my PhD and in return asked if I could help with the recruitment of collectors for the BFD Study and with the communication of results. I agreed and we worked together at the University of Nottingham from November 2016 to February 2017. I predominately worked on the BFD Study in: Cheshire, Derbyshire, Nottinghamshire, Leicestershire, Northamptonshire and Warwickshire.

The fieldwork I undertook in the Edge Area is shown in Table 4.

Table 4: Fieldwork in the Edge Area

Aim	Method/Activity	Approximate number of days/hours	Source ID (denoting activity or interviewee, site and date. FN= fieldnote, IN= interview)
To investigate bTB-in-the-making in the Edge Area and the motivations for taking part in the BFD Study.	17 semi structured interviews	21 hours	IN Wildlife Group Edge 1, 27.01.17 IN Wildlife Group Edge 2, 05.01.17 IN Wildlife Group Edge 3, 06.01.17 IN Wildlife Group Edge 4,18.01.17 IN Wildlife Group Edge 5, 15.02.17 IN Wildlife Group Edge 6, 16.01.17 IN Farmer Edge 1, 03.02.17 IN Farmer Edge 2, 17.08.17 IN Farmer Edge 3, 20.01.17 IN Farmer Edge 4, 21.01.17 IN Farmer Edge 5, 24.01.17 IN Vet Edge 1, 15.01.17 IN Vet Edge 2, 16.01.17 IN Vet Edge 3, 16.01.17 IN Vet Edge 4, 04.02.17 IN Farming Representative Edge 1, 20.12.16 IN Farming Representative Edge 2, 06.02.17 IN Farming Representative Edge 3, 27.01.17
To investigate bTB-in-the-making and making of *M. bovis* in the laboratory.	3 informal interviews	4 hours	IN Microbiologist The BFD Study, 20.02.17 IN Disease Scientist The BFD Study, 12.12.16 IN Pathologist The BFD Study, 02.12.16
	participant observation culturing bacteria from four badgers	3 hours	FN culture The BFD Study, 12.12.16

Aim	Method/Activity	Approximate number of days/hours	Source ID (denoting activity or interviewee, site and date. FN= fieldnote, IN= interview)
	participant observation preparing mycobacterial DNA for spoligotyping	2 hours	FN spoligotype The BFD Study, 10.01.17
	participant observation undertaking Polymerase Chain Reaction (PCR) and gel electrophoreses on culture positive samples	4 hours	FN PCR The BFD Study, 20.02.17
	participant observation of 15 badger necropsies including: weighing the badger, setting our equipment, observing the necropsy and cleaning the cabinet after the necropsy	5 hours	FN badger post mortem 1, 29.11.16 FN badger post mortem 2, 29.11.16 FN badger post mortem 3, 29.11.16 FN badger post mortem 4, 06.12.16 FN badger post mortem 5, 06.12.16 FN badger post mortem 6, 14.12.16 FN badger post mortem 7, 14.12.16 FN badger post mortem 8, 17.02.17
To contribute to the BFD Study.	Picking up 3 dead badgers from a knackers yard for the BFD Study	1 hour	FN collecting badgers The BFD Study 1, 08.12.16
	Collection of approximately 70 dead badgers for the BFD Study	70 hours	FN collecting badgers The BFD Study 2, 01.01.16–28.02.17
	Recruitment of 4 farmers and 2 badger groups to collect dead badgers	10 hours	
	Delivery of 6 presentations regarding the BFD Study	10 hours	FN presentation The BFD Study 1, 01.02.17 FN presentation The BFD Study 2, 06.04.17 FN presentation The BFD Study 3, 19.06.17 FN presentation The BFD Study 4, 22.06.17 FN presentation The BFD Study 5, 26.06.17 FN presentation The BFD Study 6, 29.06.17

In brief, I undertook participant observation of all stages of the BFD Study: from picking up dead badgers, to undertaking post-mortem examinations on the carcasses, to culturing bacteria and to presenting the findings. Detailed notes of the practices for each of these stages are presented in Chapter 8 and Appendix 2. I analyse the associated findings in Chapter 8.

I worked closely with NFU county advisors, many of whom knew of me from my involvement in the Gloucestershire badger cull and my interaction with their colleagues in South West England (see Section 2.3.3). Reflective of Hannerz's (2003: 209) anthropological article on multi-sited ethnography, I found myself in a "translocal network of relationships" in which the "identification of common acquaintances" between myself and participants granted me access to their conceptualisations on bTB. Whilst respecting anonymity, I hinted at who I had spoken to (by role not by name) within organisations in order to build trust. For example, I told an NFU county advisor that I had spoken with other NFU county advisors. In doing so I built my network through referrals and associations.

I used topic based interview guides for semi-structured interviews (an example interview guide is shown in Appendix 1) and allowed the conversation to flow into areas of interest for the respondent. Most interviews were audio-recorded.

2.3.3. High Risk Area: badger cull and skin test

I conducted fieldwork on badger culling from September to November 2016 with cattle, badgers, guns, contractors (licenced people cage trapping and shooting badgers or carrying out controlled shooting of badgers at night), torches, farmers, vets and badger protectors (people undertaking action to stop the cull). I chose to work in the Gloucestershire cull zone as I had established connections in the area from previous research I conducted in 2013 (see Preface). I revived contact with a gatekeeper for the veterinary and farming professions in July 2016. On arrival in Gloucestershire, I met him to renew our relationship and he invited me to a skin test on his client's farms. Once in the cull zone, I emailed and called the central groups involved in opposing the badger cull. I had undertaken research with some of these groups in 2013 and so word quickly spread that I was in the area.

I informed all actors that I was undertaking research with the cull company, trappers, shooters, protestors, saboteurs and activists in order to understand the diversity of practices associated with badger culling. However, as I go on to describe, this information often raised concern because I was considered a threat to the workings of polarised 'pro' and 'anti' badger cull groups. The veterinary gatekeeper advised me to establish communication with actors involved in, and supportive of, badger culling (the cull company, farmers, vets and contractors) before informing them that I was also undertaking research with people opposing badger culling (protestors, saboteurs and activists). On his advice, I sent the former group a brief email describing my research and followed this up with a phone call in which I informed them of my research with opponents of badger culling. This strategy helped me to build rapport with individuals. To my benefit, the tight knit community involved in and supportive of badger culling meant my name was quickly shared. Once I had shown myself to be competent on farm (see Section 2.3.3.1) and with a well-known contractor, I was generally considered to be a trustworthy individual. Consequently, I was invited to spend nights with contractors when shooting badgers and interview people involved in the cull company.

Four groups protesting against the badger cull agreed to take part in my research and invited me to go on night-time walks and 'sett sits' in the cull zone. After establishing a relationship with these badger cull protest groups, I slowly began to build relationships with people undertaking direct action against and sabotage of the badger cull. However, my efforts to expand my network into saboteur groups was hindered by their distrust of me; I did not manage to undertake research with as many activist groups as I would have liked because they were concerned I would share information with supporters of the badger cull. I reassured them of the confidentiality statements in the consent form (see Appendix 3) and allowed them to check my notes at the end of the night to ensure I had not written down anything they considered private. Sometimes they asked me to erase my notes and other times I was explicitly told not to make any notes if something sensitive occurred or was said. I always respected their consent and deleted the information. The fieldwork I undertook in the High Risk Area is shown in Table 5.

Table 5: Fieldwork in the High Risk Area

Aim	Method/Activity	Approximate number of days/hours	Source ID (denoting activity or interviewee, site and date. FN= fieldnote, FG= focus group, IN= interview)
To explore the making of badger culling and motivations for undertaking action against the badger cull.	5 semi-structured interviews	7 hours	IN Badger Protector HRA 1, 29.09.16 IN Badger Protector HRA 2, 13.09.16 IN Badger Protector HRA 3, 08.09.16 IN Badger Protector HRA 4, 08.10.16 IN Badger Protector HRA 5, 23.11.16
	Participant observation sabotaging the cull	2 nights	FN sabotaging the cull HRA 1, 13.09.16 FN sabotaging the cull HRA 2, 05.10.16
	Participant observation sett surveying	1 day	FN sett surveying HRA, 14.09.16
	Participant observation protesting the cull	3 nights	FN cull protest HRA 1, 23.09.16 FN cull protest HRA 2, 28.09.16 FN cull protest HRA 3,08.10.16
To explore the making of badger culling and the motivations for culling.	Participant observation shooting badgers	7 nights	FN controlled shooting HRA 1, 03.10.16 FN controlled shooting HRA 2, 04.10.16 FN controlled shooting HRA 3, 06.10.16 FN controlled shooting HRA 4, 15.09.16 FN controlled shooting HRA 5, 20.09.16 FN controlled shooting HRA 6, 22.09.16 FN controlled shooting HRA 7, 27.09.16
	Participant observation checking cages	2 morning	FN checking cages HRA 1, 12.09.16 FN checking cages HRA 2, 25.09.16
	Participant observation laying bait and cages	0.5 days	FN laying bait and cages HRA, 11.09.16
	Rifle shooting practice	1 afternoon	FN shooting practice HRA, 12.10.16

Aim	Method/Activity	Approximate number of days/hours	Source ID (denoting activity or interviewee, site and date. FN= fieldnote, FG= focus group, IN= interview)
To investigate the creation of badger cull targets.	Interview	2 hours	IN Biologist, 15.11.18
To investigate bTB-in the-making in skin tests, the effects of badger culling on other bTB practices in a High Risk Area.	8 semi-structured interviews	8 hours	IN Farmer HRA 1, 11.10.16 IN Farmer HRA 2, 05.10.16 IN Farmer HRA 3, 29.09.16 IN Farmer HRA 4, 16.09.16 IN Farmer HRA 5, 21.09.16 IN Farming Representative HRA 1, 14.09.16 IN Farming Representative HRA 2, 15.11.16 IN Vet HRA, 05.06.16
	Participant observation 4 skin tests	8 days	FN skin test short interval HRA 1, 20.09.16 FN skin test short interval HRA 2, 30.09.16 FN skin test routine HRA 1, 10.10.16 FN skin test routine HRA 2, 11.10.16
	2 farm visits	2 days	FN farm visit HRA 1, 09.09.16 FN farm visit HRA 2, 08.11.16
	1 focus group	2 hours	FG Farmers and Vets HRA, 21.09.16
To understand the governance of the badger cull and the motivations for culling.	7 semi-structured interviews	16 hours	IN Cull Organiser HRA 1, 19.09.16 IN Cull Organiser HRA 2, 27.09.16 IN Cull Organiser HRA 3, 28.09.16 IN Cull Organiser HRA 4, 09.09.16 IN Cull Organiser HRA 5, 22.09.16 IN Cull Organiser HRA 6, 16.11.16 IN Cull Organiser HRA 7, 15.09.16

Fieldnotes were taken for activities involving participant observation and non-recorded interviews. It proved difficult to make fieldnotes when out at night with badger protectors and contractors as we were constantly on the move. I could not use a light when with contractors as it would have alerted badgers (and activists) to our presence. The following fieldnote was written the morning after a night spent in the cull zone with a contractor and buddy (uses thermal imagery to spot badgers). The fieldnote records the events over six hours and shows why it was so difficult to take notes at the time of the events:

> *We passed a parked car when entering the field. Peter* [buddy] *and Sam* [contractor] *mentioned the car in passing. Peter and I got out of the truck and started getting the gear out of the boot. Peter was searching round the field with his thermal whilst Sam unloaded his gun from the car. Peter saw someone in the middle of the field and worriedly called us to get back in the truck. We hurriedly got back in the truck. Sam drove near to the person with the truck lights on full beam to check who it was and saw the person had a radio — they assumed it was an 'anti'. We left the field and reported it to the cull operations control room.*
>
> *Peter rang a neighbouring friend to see if we could park at their house and re-enter the land from the other direction. Sam said that the anti won't think we will go back to the land as they 'caught' us. We drove to the friend's house and parked up. As we chatted, a car started crawling the lanes and passed the house 3x. We all crouched low to the ground and hid behind the trees. To get back into the land, we had to walk 25m up the road, climb up a bank and get across a barbed wire fence. Peter and I went first so that Sam kept the gun off the road. I helped Peter over the fence whilst I waited on the road side. I then clambered over, and my trousers and leggings got caught on the barbed wire! I tried to manoeuvre myself and as I was doing so, the car lights became visible.*
>
> *Peter pulled me over the fence and we lay face down on the soil whilst the car passed by. The crotch of my trousers and leggings had ripped on the fence– that's one way to break the ice! Sam ran over, passed his gun to us and climbed over. The car went past again and we all fell to the floor as we were highly visible on the brow of the hill. The same car passed the field another 3x whilst we were in it. It seemed the anti that had seen us and rung for back up.*
>
> *We could see another anti sat on their car bonnet next to the field we wanted to go into. To avoid them, we walked a 1 mile diversion to get back into the field we started in. Peter said it seemed like the anti had walked the land already as there was hardly anything about. When we were in the field, the anti did a one hourly patrol of the land. We hid in the hedge and they walked past us totally unaware. We didn't see a badger on the land which was annoying after all the stress we had taken to get onto it.*

> *The farm gateway was open all night so as we left the field, Peter and Sam shut the gate to tease the anti's and make them wonder if we were in the field. Peter was playing a game with them to confuse them. Peter and Sam were in stitches as we left — the small things!*[25]

To capture my experiences, I jotted notes when we returned to the vehicle to travel between sites. I noted down "little phrases, quotes, key words" (Lofland and Lofland, 1995: 90) and a timetable of events. Figure 5 shows my jottings that, when combined with my headnotes/remembered observations (Jackson, 1990), created the full fieldnote detailed above.

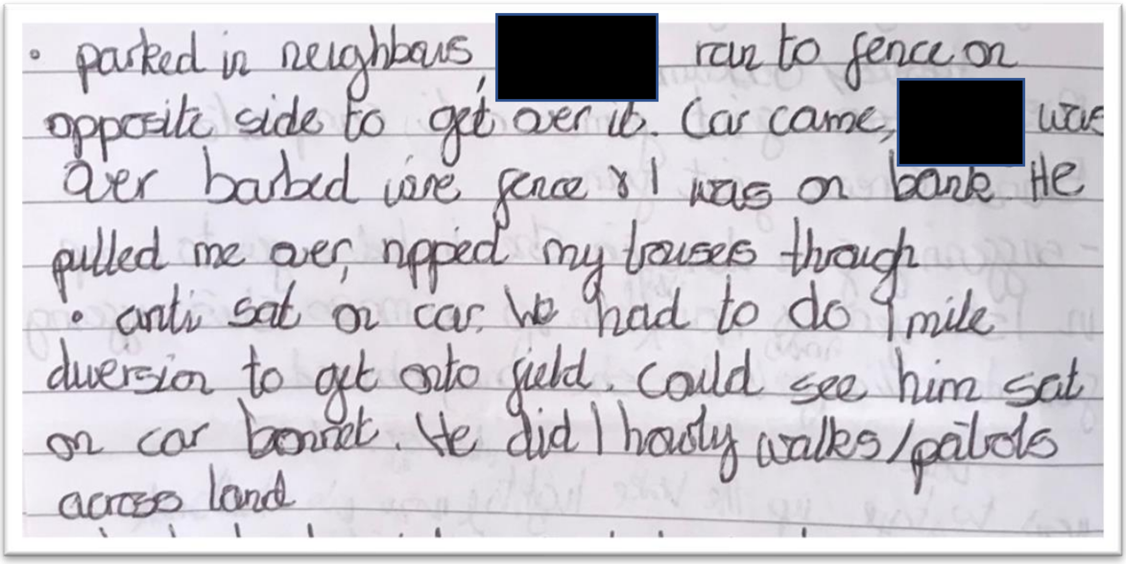
• parked in neighbours [redacted] ran to fence on
opposite side to get over it. Car came, [redacted] was
over barbed wire fence & I was on bank. He
pulled me over, ripped my trousers though
• anti sat on car. We had to do 1 mile
diversion to get onto field. Could see him sat
on car bonnet. He did 1 hourly walks/patrols
across land

Figure 5: Jottings (Author, 2016)

I generally spent more time in the car when with badger protectors and was therefore able to take more detailed notes. In addition, I spent a few nights sett-sitting with people opposing the cull — with a clear vantage point of a sett and the surrounding area in order to deter contractors — in the darkness of night. Sett-sitting provided an ideal environment in which to have a conversation about badger culling and bTB, but it was difficult to write down detailed notes without a light source. I often scribbled core

[25] FN controlled shooting HRA 2, 04.10.16

phrases and words in my notepad and tried to comprehend my handwriting when next near a light source, often when back in the car.

I tried to make more detailed notes when I returned home from shooting badgers or sett-sitting anytime between 01:00 and 05:00, but was often too tired to do so. Instead, I typed up my jotted notes from a night with badger protectors or contractors the following morning and added information from my headnotes.

2.3.3.1. "Fitting in" and rites of passage

My research in the High Risk Area was reliant on my positioning and my associated acceptance into differing networks. Much research relating to a researcher's positioning refers to 'insider' and 'outsider' roles. The insider role refers to the need for qualitative researchers to be immersed into networks to enable them to 'get inside' the field of inquiry (Hammersely and Atkinson, 1983). It is vital to develop trusting relationships with participants and 'fit in' to their everyday routines so as to observe their practices (Bonner and Tolhurst, 2002). Alongside this, the 'outsider' role is required to establish sufficient distance from participants in order to make sense of the observations and be able to critique findings (Hammersely and Atkinson, 1983). Ethnographers recognise that the insider/outsider dichotomy is too crude because positioning is context dependent, often multiple, requires interrogation and depends on how the researcher is perceived by others (Labaree, 2002; Soni-Sinha, 2008; Wilkinson, 2009; Woodward, 2008). My positioning was temporary, unstable and continuously navigated in the field.

As described by Labaree (2002), librarian for international relations and political science at the University of Southern Carolina, I was in a process of continual negotiation and alignment with participants. I began my fieldwork from a position on the 'outside' and I developed relationships with participants, often investing much time and patience to do so. For example, I asked a vet involved with a badger cull in the High Risk Area if he could put me in contact with other people involved in the cull. He responded by inviting me to attend a skin test with him. During the test, he invited me to take part in a pregnancy diagnosis.[26] After a moment's hesitation considering whether I wanted or needed to do this, I said yes. My research was more important to me than my apprehension. Wearing arm length latex gloves, I inserted my arms into the heifer's rectum and vagina to perform a palpation for the purpose of pregnancy diagnosis. Irvine and Vermilya (2010) consider veterinary medicine to be gendered masculine and acts such as pregnancy diagnosis, artificial insemination and castration are key examples of this. Like many vets who are women (Irvine and Vermilya, 2010), I reacted to this masculine act by distancing myself from generally defined femininity, such as gentleness and kindness, and adopting a masculinised demeanour of strength in order to prove myself to the vet. My response and this act strengthened my relationship with the vet and I earned his respect. The vet subsequently put me in touch with more of his clients, the cull company and contractors. On reflection, I deem this experience to have been a 'rite of passage' into the badger cull company. I had requested to meet the vet's clients and he therefore wanted to be sure that I was competent on farm and able to handle myself in a variety of on-farm situations. This experience was troubling, but I accepted the vet's 'terms and conditions' to enter the group for the benefit of my research. I use my emotional response to experiences like this as analytical tools throughout my writing; my reactions to situations provide insight into the agent's world that I describe.

Initial acceptance became an important aspect of my fieldwork, particularly given the range of oppositional agents with whom I wanted to engage. In some instances

[26] FN farm visit HRA 1, 09.09.16

I strategically positioned myself to gain participants' trust and group membership (Harrington, 2003). For example, in initial email correspondence with farmers I disclosed that I grew up on a farm to show I had practical knowledge of agricultural systems and that I could relate to agricultural problems. As described by Adler and Adler (1987) in regard to membership roles in field research, I was therefore trusted due to my affiliation with agriculture. Additionally, my ability to drive a tractor helped me gain credibility with research participants.

However, I found this 'insider' negotiation and alignment difficult because I developed close relationships and wanted to thank participants for their investment in my research. Labaree (2002: 113) notes that a researcher is not a "detached recording instrument that merely synthesizes the data and disseminates the findings", as qualitative research inherently depends on developing meaningful relationships. For example, I went to a contractor and cull organiser's house when the cull ended for a celebration. We ate together, drank together and I described what I had learned. I felt like I was thanking these people for their kindness and companionship. However, this made me more invested in the respondents and I found it harder to question their truths. To manage this investment, I regularly questioned my relations to stop myself from becoming a full 'insider'.

Undertaking research with agents who held different perspectives regarding badger culling granted me exposure to points of cohesion and contention. My work with a broad range of agents with differing views of bTB control helped ensure I did not become a permanent insider in any group. Despite my work across the network, I was frequently asked "*Are you pro or anti badger culling?"*. In her ethnographic research on mountaintop removal in Virginia, Scott (2010) describes how she was regularly asked 'which side she was on'. She tells how the dualistic, reductionist logic forecloses people into categories and leads to dead ends in thoughts. Similarly, the dualistic ‘pro and anti’ badger culling divide does not allow for diversions of viewpoints. In response to this question, I said that I refused to define myself in the polarised categories of ‘pro’ and ‘anti’. This often meant I was accepted as a researcher and maintained some ‘outsider’ distance from which I could analyse the practices I witnessed.

2.3.4. Other fieldwork

In addition to the site-based fieldwork described above, I also built connections in the wider network of bTB. I do not deem much of this to be ‘fieldwork’ as it was often undertaken with the intention to further my connections with decision makers and explore future career opportunities. However, I consider it important to reflect on this work as I was in the bTB public knowledge controversy, and of the controversy. Not only was I studying the controversy, I was ‘ensnared’ by, stickily entangled in and reinforcing it (Cassidy, 2019).

In 2015 I received the BCG vaccine at a health clinic to protect myself against the zoonotic risk of bTB from my likely interaction with infected cattle and badgers. Whilst receiving the BCG vaccine I spoke with a nurse about my research and she invited me to have a chat with other nurses at the health clinic. I spent two hours with two nurses discussing their experiences of caring for people with bTB. The discussion is not directly drawn upon in this thesis, but it developed my understanding of bTB as a zoonosis.

Five organisations leading badger vaccination in the Edge Area agreed to take part in the BFD Study and three were keen to be involved in my research. I first described my research when I visited their houses or offices to pick up badger carcasses and/or deliver collection kits (Chapter 8). I undertook four semi-structured interviews and two individuals invited me to take part in badger vaccination. From these connections, I made two trips to Derbyshire in spring and summer 2017, for two days and three days respectively, each time pre-baiting and vaccinating badgers with a group of 10 volunteers. I took fieldnotes throughout these visits regarding the activities, conversations and practices I witnessed. I also undertook five conversational interviews with people involved in badger vaccination; two were audio recorded and three were not as they resulted from spontaneous conversation. This fieldwork fed into an article detailing the uptake of vaccination by non-government groups, their motivations, potential disease control benefits of the practice, and barriers to the expansion of badger vaccination (Benton et al., 2020).

I also engaged with and was a member of multiple groups on social media that either explicitly supported or opposed the badger cull. I do not draw on social media findings in this thesis, but it indirectly affected my fieldwork. For example, one activist told me they had checked my Facebook account before agreeing to let me undertake fieldwork with them in the cull zone. They checked my online friends and saw that I had a few friends in the protester community (from my fieldwork in 2013). They rang these protestors to gain information about me and this boosted my credibility in the community.

In addition, I presented my work and discussed bTB with the Welsh Government Chief Veterinary Officer and the North Wales regional board for bTB (including Welsh Government officials) in June 2016. I also presented to the TB Programme in Defra in early 2017 to secure myself a research internship with the TB Programme (see Section 2.6). Moreover, in 2018 I was exploring spoligotyping (Appendix 2) and recognised a gap in my findings regarding mapping of bTB spoligotypes. I contacted APHA staff members about genetic mapping (people I knew from my work in Defra, see Section 2.6) and undertook four semi-structured interviews. Due to a change in research focus in late 2018, I do not draw on these interviews in the proceeding chapters, but they provided important context for my understanding of bTB epidemiology.

2.4. Unfolding ethics

I undertook Lancaster University's formal ethical process before conducting fieldwork. I was granted approval for this research from Lancaster University Ethics Committee in October 2015 (FL18044). All human research participants were provided a project information sheet and asked to sign a consent form (reproduced in Appendix 3). Ethnographers of healthcare Willems and Pols (2010) define this formal process as 'applied ethics': as attempting to anticipate and address ethical issues by applying rules and principles to complex situations. And yet, in addition to the ethical issues that I foresaw and mitigated for in my ethics forms, ethical issues arose unexpectedly when in the field. I was part of multiple unexpected situations throughout my research which gave rise to different ethical responses. My ethical decisions were informed by the 'applied ethics' of Lancaster University (for example always disclosing my positioning to research participants), but were also dependent on the specificity of relations I was a part of. Willems and Pols (2010) term this process 'empirical ethics': that is, how notions of 'what is ethical' unfold in practice.

An example of my unfolding ethics is shown through my response to the act of 'fishing'. Undertaking research with a multitude of agents meant I was sometimes 'fished' for information about 'the other side'. For example, the following extract is from an interview with a badger saboteur about the number of badgers killed inside the cull zone. At the point of the interview, the cull was in its 5th week and a text message had been sent to people involved in the badger cull regarding the number of badgers needing to be killed in the final week of the cull (each area received a cull licence for six weeks):

> Saboteur: *"We're expecting them to get just a little bit more than their minimum target, if it ends at 6 weeks"*
>
> JP: *"And why are you expecting that?"*
>
> Saboteur: *"We've had intelligence supposedly that says they're 50* [badgers] *off their minimum target and they've got a week to go. They will meet it."*
>
> JP: *"Right ok"*
>
> Saboteur: *"Is it true?"*
>
> JP: *"*[laughing] *I can't tell you that!"*
>
> Saboteur: *"well you've gone bright red so I'm taking it as good intel!"*[27]

The saboteur told me that someone involved in the cull had received the text message and shared the information with the saboteur group. I knew the text message had been sent out because I had been with a contractor the day before who had shown me the message and its content. I abided by confidentiality and did not share any information about the text, but seemingly could not hide the shock from my face.

These fishing conversations became a common occurrence. My responses would disrupt the flow of conversation because it reminded the participant that this was a research interview rather than a casual chat. Some cull organisers, farmers and contractors were concerned that I was being fished for information by anti-cull activists and that I could be passing on information about their practices. I reassured research participants of my adopted approach of confidentiality by referencing my 2013 fieldwork; in 2013 some people involved in the cull told me information about the badger cull, none of which was leaked to protestors as they feared.

In addition to concerns about 'fishing', some cull organisers and contractors became concerned that anti-badger cull activists may have attached a Geographical Positioning System (GPS) tracker to my car. In 2014 and 2015, saboteurs had placed GPS trackers on contractors' vehicles to track their movements. Saboteurs would go to

[27] IN Badger Protector HRA 2, 13.09.16

the location of the vehicle and disrupt the contractors before they had the chance to shoot. As a result of this experience, cull organisers suspected that saboteurs had put a tracker on my car and that I was passively providing saboteurs with GPS locations of all farmers involved in the cull. I quickly became suspicious and checked my car after every night spent with saboteurs. Three farmers also checked my car for a GPS tracker when I arrived at their property.[28] Although I never found a GPS tracker, my fear of being tracked meant I never took my car on a shoot, instead leaving it on the contractor's property.

The two examples above exemplify how ethics unfolded in the field. Doing research in, and on, a public knowledge controversy posed challenges as I was positioned as a possible source of information to all sides, about all sides. Reflective of Goodwin et al.'s (2003) ethical dilemmas in her ethnography of anaesthesia, these ethical issues arose spontaneously and I had little control over the events. As shown, I managed these challenges by abiding by the rules I had established in my applied ethics, and by developing empirical ethics.

2.5. Analysis and presentation of findings

The ethnographic descriptions included in the following chapters have arisen from recording of experiences, categorising experiences into findings, analysis and writing. In total I had two A5 notepads and four A4 notepads filled with notes from informal interviews, participant observation activities and personal diary notes taken during my fieldwork (Figure 6). Diary notes have been analysed as an additional source of information to support my interviews and participant observations.

[28] FN controlled shooting HRA 6, 22.09.16; FN controlled shooting HRA 7, 27.09.16; FN shooting practice HRA, 12.10.16

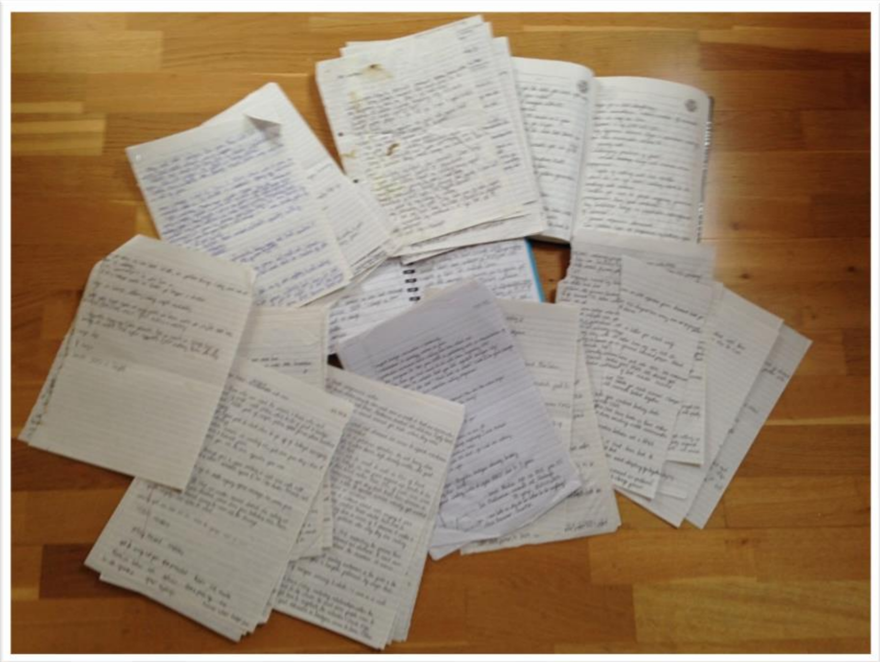

Figure 6: A selection of fieldnotes (Author, 2018)

Audio files were transferred from the recording device to my encrypted laptop on return from the field. Text files were stored on an encrypted laptop to protect the privacy and confidentiality of the research participants. Most interviews were audio-recorded and I planned to transcribe as I conducted fieldwork. However, the intensity of my fieldwork meant I had little time for complete transcription, instead turning to thematic analysis of audio recordings to optimise my time. This approach allowed me to identify key themes to identify relevant sections of interviews to transcribe to a level of intelligent verbatim once I completed my fieldwork in March 2017.[29]

All jottings and fieldnotes were typed into NVivo (version 10; QSR International Ltd.) on return from the field, most often within the space of two working weeks.[30] I typed up, and sometimes wrote up, fieldnotes as soon as possible to ensure I could add information from my headnotes to create a more detailed ethnographic

[29] Where 'ur', 'um' etc. are omitted.
[30] NVivo is a data analysis programme which I used to code sections within fieldwork findings.

account. I also uploaded photos, policy documents and newspaper articles to NVivo to create a central database from which I could access relevant information. I re-read my notes before I conducted in-depth and iterative analysis of my findings. I undertook coding and fieldwork simultaneously from 2015 to 2019. For example, when in the High Risk Area I coded my findings from the Low Risk Area and when in the Edge Area I coded my findings from the High Risk Area.

Given my farming background, my interest in the subject and my knowledge of the disease, I approached the findings with a ‘preunderstanding’ of what I might find (Gummerson, 1991). I was aware that this might risk organising findings into preconceived categories and therefore neglect relevant themes in the findings (Corbin and Strauss, 2008). To ward myself against this tendency in collection and analysis, I iteratively developed the codes.

In the first interrogations, the primary findings were organised into axial codes for each practice of interest, for example: skin testing, badger vaccination, badger culling, cattle trading etc. Subsequently, in a grounded theory approach, the first level codes were divided into second level codes arising from the findings themselves and my reading of related literature. The codes allowed me to identify findings relating to different phenomena, thereby helping me to identify repeated concepts and connections between concepts. In a second interrogation of the findings I specifically analysed codes for consistencies and inconsistences. Each code was labelled, defined and given examples from the findings (Boyatzis, 1998). I used these elements for each of my codes to ensure their relationship with the findings could be traced. My coding framework is shown in Table 6.

Table 6: Coding framework (115 primary sources total including those identified in Table 3, Table 4 and Table 5, and those detailed in Section 2.3.4)

First level codes	Second level codes	Number of primary sources	Number of references
Badger culling	Evidence	18	44
	bTB	8	31
	Affect	43	95
	Direct action	16	63
	Shooting and/or cage trapping	40	172
	Badgers	75	197
	Government/policy	60	101
	Unlawful culling	12	20
Badger vaccination	Effect	20	24
	Badger cull	23	51
	Enablers	8	15
	Barriers	11	39
	Badger Edge Vaccination Scheme	13	31
	Landowner	7	7
Cattle trading	Risk-based trading	19	29
	Infrastructure	12	12
	Enablers	9	18
	Barriers	15	23
	CHeCS	12	40
	Evidence	11	16
Skin testing/ gamma testing	Sensitivity and/or specificity	26	30
	Practice	18	45
	Miscellaneous	8	8
Badger Found Dead Study	Epidemiology	31	82
	Disease	25	44
	Enablers	17	18
	Barriers	19	19
	Transformation of information	6	18
Bovine TB	*Mycobacterium bovis*	14	24
	Disease and/or zoonosis	17	28
	Emotions	54	91
	Biosecurity	28	43
	Cattle vaccination	7	7
	Transmission	52	68
Miscellaneous	Regulation	34	57
	Governance	15	30
	Evidence	29	71
	Vets	13	16

Second-level codes were added to, refined and combined throughout 2017 and 2018 as clusters of issues emerged from the data. The first level codes formed themes around which my chapters are based. Undertaking coding and developing research questions amid fieldwork meant there was a process of iterative engagement with the empirical findings, policy and analytical lenses. My first level coding highlighted a distinction between government conceptualisation of disease management strategies in official documents and the practising of these disease management strategies on the ground. I undertook further analysis to compare conceptualisations and practicing of disease, which led to the layout of this thesis. Each chapter presents a different disease management practice and utilises a different analytical lens from the philosophy of empirical ontology.

My approach of using multiple analytical lenses is somewhat unusual, but I used this approach to highlight the central components of my data driven arguments. The process of deciding which analytical lens to use for each chapter began at the start of my doctoral work in October 2015 and continued until October 2019. I began my research journey by familiarising myself with SSK and STS research and developing ideas as to how it could be used in bTB research to further understand the making of disease.[31] I took these ideas into the fieldwork and developed my arguments whilst undertaking fieldwork and analysis. I presented the philosophy and methodology of empirical ontology in Sections 1.2 and 2.2, and I present each specific analytical lens in the corresponding chapters.

[31] I explored more analytical lenses that those used in the proceeding chapters and there are plenty of 'analytical routes not taken'. One of the most important routes not taken was multi-species STS research. I explored multi-species relational ethnography in animal geography and STS (Buller, 2014, 2015a, 2015b; Davies et al., 2016; Emel et al., 2002; Greenhough and Roe, 2010; Harbers, 2010; Philo and Wilbert, 2000), but decided not to use this lens as I primarily focused my research on practices and their relationality. I do not detail the routes not taken in each chapter, but instead justify my use of the chosen analytical lens.

As a researcher in the Civil Service and a doctoral researcher (see Section 2.6) my work involves writing reports and academic papers. This thesis pulls together both forms of writing to appeal to bTB researchers (in multiple disciplines) and government researchers working on bTB. This thesis presents arguments through empirical stories. As recognised by sociologist Les Back (2020) in his reflections on the task of being a writer, I attuned myself to recognise vibrant and lively stories from my fieldwork, and assembled the findings to tell further compelling stories and arguments.

The proceeding chapters draw on primary findings including audio transcripts from interviews, handwritten notes from interviews, photographs, jottings taken whilst in the field, personal diary notes, and revisited jottings and headnotes written into fieldnotes. I present extracts from my findings to illustrate my argument. I present some photographs of the source jottings and fieldnotes as evidence in figures. Fieldnote extracts are presented in italics and indented, or in italics and double quotation marks. Where the extract contains direct speech from a research participant, double quotation marks are used. Square brackets enclosing non-italicised text are occasionally used within fieldnote extracts and interview extracts to provide additional clarity. The source ID for each extract (as per the lists in Table 3, Table 4 and Table 5) is presented as a footnote. Speakers are identified where direct speech is recorded; ‘JP’ denotes myself as the interviewer. I have used pseudonyms for all research participants (bar one, with their consent) throughout to preserve participants’ anonymity. I have not changed Bryan Hill’s name because he is identifiable as the author of a published book (Hill, 2016a) within the context of the fieldnotes and interview presented in Chapter 7.

2.6. My dual role as a PhD researcher and a researcher in the Civil Service

In autumn 2016 I secured 'Economic and Social Research Council' funding to undertake a six-months' internship with the TB Programme in Defra from March to September 2017. As such, I knew I would be working with Defra when I commenced fieldwork in badger cull zones. To be transparent with my human research participants, I informed them that I would be working with Defra the following year. Most farmers reacted positively as they felt I could give them a voice in Westminster policymaking. However, some cull protestors and activists were concerned that I would inform Defra of their 'tactics'. I explained that I would be working in the TB Programme on policy and would not explicitly share my research findings. For organised groups this was often enough information for them to trust me and invite me to work with them. Nevertheless, some individual anti-badger cull activists refused to take part in my research for fear of being 'found out'. I therefore struggled with my dual roles of PhD researcher and Civil Service intern from the start of my fieldwork.

Prior to the internship, myself and a staff member in the TB Programme established 'ground rules' for my time in the Civil Service in line with the Civil Service Code (Civil Service, 2015). For example, not to use any information I acquired at work to further my research and not to disclose official information without authority. During my internship I worked on launching the Badger Edge Vaccination Scheme 2, implementing changes to cattle testing in the Edge Area and evaluating risk-based trading. The experience was invaluable, awarding me:

- first-hand experience of policy making and evidence sources that are involved in decision making
- opportunities to apply my research skills in employment

- relevant work experience
- a network of established stakeholders with the TB Programme

The internship meant that I was not employed by Defra; it granted me the freedom to challenge assumptions, request evidence and offer alternative opinions. For the most part, this was gratefully received by the team, with whom I built strong relationships.

I applied for, and secured, a part-time post at Defra in 2017, towards the end of my internship. From 2017 to the present day I have continued to work part-time for Defra, predominately as a social researcher. I have shared my doctoral research with Defra as it has been produced (through personal communications, presentations and publications) and some of my findings are reflected in the Government's updated strategy to achieve bTB free status in England (Defra, 2020a).

The following chapters offer a multi-sited ethnography of disease management practices of bTB. I continue to draw on the theoretical work of STS scholars and to make my methodology visible as I narrate bTB through my fieldwork findings.

Chapter 3. Testing and making bTB: farm practices and the narrative of control

> *I asked the vet, "What is the relationship between the skin test and bovine TB?" He said that the Ministry seems to think that it detects M. bovis, but vets know that it doesn't.* […] *I asked what the skin test does to bovine TB if it doesn't detect M. bovis. He replied that the skin test "brings the disease to life". He said that the skin test and bovine TB can't be separated as the skin test results make what bTB is.*[32]

Throughout my doctoral work I participated in and contributed to 16 Single Intradermal Comparative Cervical Tuberculin Test (more commonly known as skin tests) on cattle herds to test for bTB; 12 in Cumbria, the Low Risk Area, and four in Gloucestershire, the High Risk Area. I took part in the skin tests by recording lump sizes, reading cattle identification (ID) tags, herding cattle into appropriate shed space, and holding a cattle crush shut with all my strength when a bull was close to tipping it over. In this chapter I explore the practices of four vets from different veterinary practices in Cumbria and, to a lesser extent, three vets in Gloucestershire to detail how bTB is made through the skin test. This chapter addresses RQ1: 'What are farmers', vets; and governments' ways of making bTB through the skin test?'.

Specifically, this chapter analyses the relations of the skin test with farms, vets, farmers, infection and *M. bovis*. The skin test is positioned between policy-as-representation (which seeks coherence and certainty in order to act) and those who enact the test in policy-as-practice (who witness the uncertainties and incoherencies of the test). I argue that the English Government produces a narrative of control through the skin test. This narrative — defined as a way of apprehending the world and giving it a coherence (A Dictionary of Sociology, 2009) — suggests that the skin test makes *M. bovis* detectable and visible for the purpose of control and eradication, whilst

[32] FN skin test 1 month radial LRA 3, 04.01.16 and 07.01.16

occluding some of the test's uncertainties, complexities and multiplicities. I argue that this process is a 'proxification' of bTB.

I begin by introducing the policy background to the skin test and the associated narrative of disease control. I then explore the practices of skin testing and the formation of certainty from uncertain practices regarding the detection of *M. bovis*. I detail how uncertainty arises related to the design of the test and its practising. I show how these uncertainties arise in Day 1 and Day 2 of the test, and how they are occluded through the narrative of control. I conclude by drawing together these uncertainties to argue that skin testing does not detect *M. bovis*, but instead detects an animal's immune response to tuberculin. This is a proxy. I argue that bTB is not a fixed and identifiable bacillus, but rather a disease deciphered through sociotechnical and sensory perception.

3.1. Policy background to the skin test

'The Strategy for Achieving Officially Bovine Tuberculosis Free Status for England' (Defra, 2014a) includes many cattle-based disease control mechanisms, such as regular testing for cattle's immune response to *M. bovis* and the consequent compulsory slaughter of cattle that react to the test, known as the 'test and slaughter regime'. Skin testing is presented as a surveillance technology to "find infection early" (Defra, 2014a: 42) and to enable the removal of infection with the aim of achieving Officially TB Free status for the country. The bTB testing protocol is written into the European Commission (1964) Directive 64/432/EEC, from which Defra details precise instructions for use (APHA, 2016a, 2016b).

Most cattle herds in England are subject to the test and slaughter regime.[33] Cumbria has approximately 3,080 cattle herds, around half of which are beef, the other

[33] Approved Finishing Units and Licensed Finishing Units are exceptions. These units provide a route for rearing, fattening or finishing cattle from bTB restricted and un-restricted farms. No testing of cattle is carried out on the units as all catle from these units are sold to slaughter (TB hub, 2015b).

half dairy. The size of herd is variable, ranging from smallholdings with one or two animals to large dairy herds with up to 1,000 animals per herd (APHA, 2018c). By default, cattle in Cumbria undergo a routine whole herd test once every four years due to its Low Risk Area status (Defra, 2014a).[34] There are also additional testing regimes linked to the trading of cattle, designed to reduce the risk of passing infection from farm-to-farm (see Chapter 4). Cattle may need to undergo: trace testing if moved from herds that are determined to be infected with bTB (known as 'breakdowns') prior to restrictions; pre-movement testing before being moved to another farm; and, post-movement testing once moved onto a farm.[35] Additionally, Cumbria is part of extended bTB surveillance in the form of the radial testing regime whereby the skin test is used on all cattle holdings falling within, or straddling, a 3 km radius circle from a herd experiencing a 'breakdown'. These holdings are required "to undertake an immediate radial test of all the cattle on the premises" (AHVLA, 2012: 2). If the farm is declared bTB free —termed Officially TB Free (OTF) (Table 7) — the whole herd is subject to another "radial test six-months later and a final test 12-months thereafter" (AHVLA, 2012: 2). If the farm is suspected of having bTB in the herd — termed Officially TB Free Suspended (OTF-S) — the farm is subject to more testing. If the farm is a breakdown — termed Officially TB Free Withdrawn (OTF-W) — it is subject to more testing and becomes the centre of another radial. Defra implemented radial testing in 2013 to check for local sources of infection and for secondary spread of infection from OTF-W herds. These skin testing regimes have dramatically increased the amount of testing on Cumbrian farms compared to the early 2000s.

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[34] By default, herds in the High Risk Area and Edge Area are subject to annual testing. Certain counties (or parts of counties) in the Edge Area and High Risk Area are on a six-monthly testing frequency.

[35] The skin test is used in 32 different test types, each undertaken according to different criteria (APHA, 2016c).

3.2. Skin test design and fallibility

The test takes place over two separate days which are 72 hours apart. On Day 1, skin thickness measurements are recorded for each animal, and avian and bovine tuberculin (an extract of bacterial growth products and not the bacteria themselves) are injected into two areas of the animal's skin at the top and bottom of its neck using Mclintock syringes. On Day 2, the reaction to the injections, in the form of lumps, are measured and compared. The difference in skin thickness indicates whether the animal is deemed to be infected and determines the status of the animal. It can either be a 'reactor', 'inconclusive reactor' or a 'pass'. A farm is said to experience a 'breakdown' if animals react to the test (known as 'reactors'), said to be bTB free if all animals 'pass' or said to be TB free suspended if any animals do not clearly react or pass the test (known as 'inconclusive reactors'). Figure 7 and Figure 8 show step by step guides to the skin test, created from APHA guidelines.

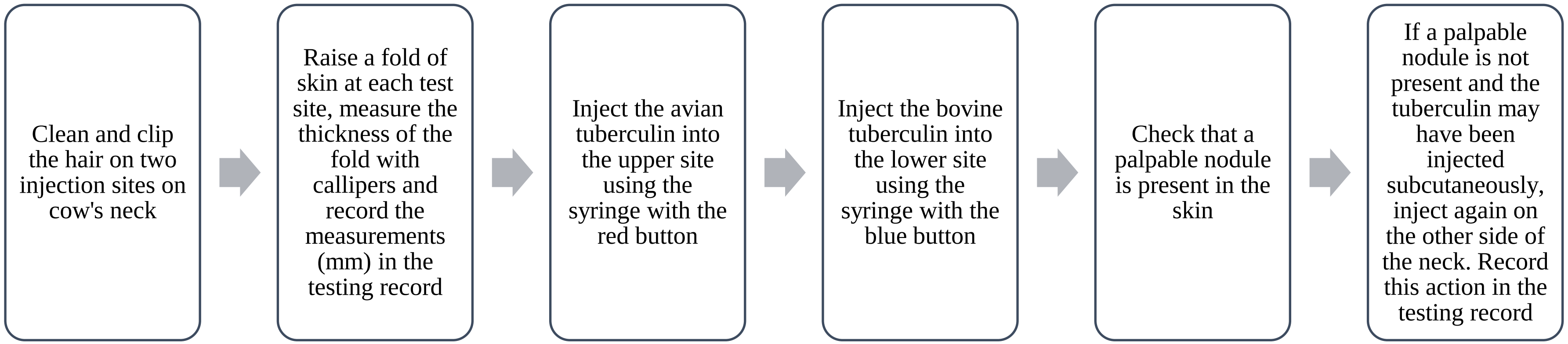


Figure 7: Day 1— injection of avian and bovine tuberculin (APHA, 2016a)

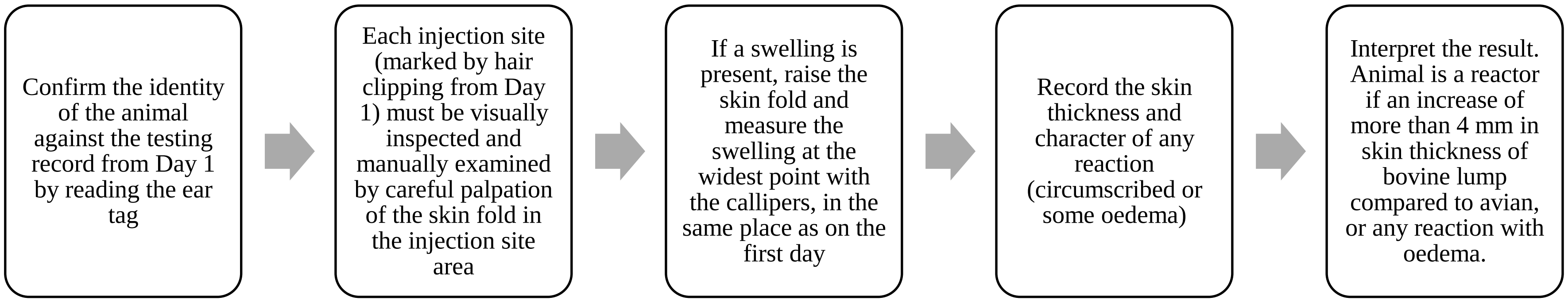


Figure 8: Day 2— reading of test 72 (+/- four) hours later (APHA, 2016b)

The test can be interpreted at two levels of severity — this means altering the level of reaction that defines whether an animal is classified as a reactor (Table 7) (TB hub, 2015c). The lower level of severity is defined as the standard interpretation. This is applied to all herds which are OTF or on animals which are inconclusive reactors on OTF-S farms. The higher level of severity is classed as 'severe interpretation', which is undertaken on herds where bTB is strongly suspected or confirmed (OTF-W). The use of severe interpretation increases the sensitivity of the skin test (Table 7). This means that some animals considered inconclusive reactors at standard interpretation may be re-classified as reactors under severe interpretation.

Table 7: Impact of the skin test results on the status of animals and status of the farm (APHA and Welsh Government, 2018)

Status of animal	Skin thickness reaction at standard interpretation	Skin thickness reaction at severe interpretation	Status of farm
Reactor	Animals showing a +ve bovine reaction more than 4 mm greater than a -ve or +ve avian reaction.	Animals showing a +ve bovine reaction and -ve avian reaction. Animals showing a +ve bovine reaction more than 2 mm greater than a +ve avian reaction.	OTF-W if reactor(s) is found at the skin test and if either visible lesions are identified at post mortem inspection, or culture results are positive for *M. bovis*. OTF-S if one or more reactors, but no visible lesions at found at post mortem inspection, and the culture results are negative for *M. bovis*.
Inconclusive reactor	Animals showing a +ve bovine reaction of 1-4 mm greater than a +ve avian reaction. Animals showing a +ve bovine reaction and a -ve avian reaction where the difference is 4 mm or less.	Animals showing a +ve bovine reaction of not more than 2 mm greater than a +ve avian reaction.	OTF-S if one or more inconclusive reactors (in a test with no reactors) in herd with a TB breakdown leading to OTF-W status in the previous three years.
Pass	Animals showing a -ve bovine reaction and a +ve or -ve avian reaction. Animals showing a +ve bovine reaction equal to or less than a +ve avian reaction.	Animals showing a -ve bovine reaction and a +ve or -ve avian reaction. Animals showing a +ve bovine reaction equal to or less than a +ve avian reaction. Animals showing a +ve bovine reaction and +ve avian reaction, where the avian reaction is more than 2 mm greater than the bovine reaction.	OTF if all animals pass

At standard interpretation, cattle that show a positive bovine reaction more than 4 mm greater than a negative or positive avian reaction are slaughtered (as per Table 7). The carcasses are checked for visible lesions and a tissue sample(s) is taken for culture of *M. bovis* in a government laboratory. If the tissue sample is negative, OTF-S status is applied to the farm. If the sample is positive, OTF-W status is applied to the farm "with the aim of preventing further spread of disease and clearing the infection from the herd as quickly as possible" (Defra, 2014a: 43). An infected farm can only regain OTF status when no cattle are found to be infected for two consecutive tuberculin skin tests, with a minimum period of 60 days between each test. OTF-W status means cattle cannot be moved on or off the farm before the first clear skin test, unless going directly to slaughter.

The skin test is the internationally accepted standard for detection of *M. bovis* infection in cattle and considered the best test currently available for determining the presence of bTB in live animals (APHA, 2020b). Tuberculin, injected into cattle on Day 1, was first created by physician and microbiologist Robert Koch at the turn of the 20th century and has been used in the skin test for over 40 years (Strain et al., 2011). The skin test has not materially changed during this time so farming and veterinary communities have historical familiarity with the test. This historical familiarity has made the detection of *M. bovis* and bTB inseparable from the skin test. However, like all disease screening tests, skin testing produces uncertainties.

The fallibility of the skin test has been recognised for as long as tuberculin has been used as a surveillance technology for bTB (Waddington, 2004). This fallibility is mostly associated with two characteristics of all disease tests:

- Specificity – the proportion of non-infected animals that will be correctly identified as negative (true negative). In epidemiological terms, specificity quantifies the avoiding of false positives.
- Sensitivity – the proportion of infected animals that will be correctly identified as positive (true positive). In epidemiological terms, sensitivity quantifies the avoiding of false negatives.

Ministry veterinarians de la Rua-Domenech et al. (2006) state that the median specificity of the skin test is 96.8% (range between 75.5% and 99%) and the median sensitivity is 80% (range between 52% and 100%). On one hand, the high specificity means the test has a strong ability to correctly identify non-diseased animals, and therefore a low chance of creating false positives. On the other hand, the low sensitivity means around one in five bTB infected cattle do not correctly test positive and therefore the test has a high chance of creating false negatives, otherwise known as undetected infected cattle (Conlan et al., 2015; Strain et al., 2011). In a focus group, one vet told a story about a visibly clinically infected cow which went undetected in the skin test:

> *I go and look at it* [a cow] *as a clinical case and it's got blood pouring from the nose and I said my advice on this one is to get it gone, and he says "well I can't sell it because it's under restriction as an inconclusive* [reactor]", *and at that stage you didn't have to isolate them, so it was running with the herd. So I said "ok well" and he said "but it's due for testing", I said "right well I'll test it today and read it on Monday and then as long as it's clear on Monday on the test it can go". Monday it's clear* [on the skin test], *so off it goes to the market. Another one of my clients stupidly bought it and it went down* [as a reactor] *at his next test a month later. At inspection it was totally condemned from TB throughout the carcass.*[36]

There are several reasons why false negatives are created in the skin test. For example, the skin test may miss infected animals because they are in the pre-allergic period (most animals take 3–6 weeks after infection with *M. bovis* to develop an immune response that can be detected by the skin test), have Johne's disease, have a suppressed immune

[36] FG farmers and vets HRA, 21.09.16

system, are desensitised to tuberculin or are anergic[37] – as per the animal in the extract above:

> Cattle in the terminal stages of TB can have a depressed immune response that prevents them from reacting to the skin test – so called ‘anergy’. Despite having extensive lesions of TB in their internal organs, these anergic animals can still pass repeated skin tests and show no outward signs of ill health (TB hub, 2015d).

The lack of ability of the skin test to detect all infected animals means there is a ‘hidden burden of infection’ (Conlan et al., 2012) through which undetected infected cattle have the capacity to infect one another and wildlife in the future. This was realised in Cumbria in 2018 when it is hypothesised that an unidentified infected animal from Northern Ireland was moved to the area and subsequently infected badgers and other cattle in the local area (Defra, 2019d).

It has long been recognised that sensitivity is increased by injecting animals in the neck or caudal fold in the tail of the animal compared to other sites (Francis, 1947; Paterson and Ritchie, 1959) and is higher at the herd level compared to the individual animal. The sensitivity of the skin test can also be increased by using a single tuberculin skin test (only injecting an animal with bovine tuberculin) instead of a comparative skin test (injecting an animal with avian and bovine tuberculin and comparing the results) (de la Rua-Domenech et al., 2006). England uses the comparative skin test because specificity and sensitivity are inversely related. In other words, if the test is made to be more sensitive, it is less specific. Consequently, a more sensitive and less specific test creates more false positive reactors and it is more difficult for a country to be determined OTF as false positive reactors increase the number of breakdowns. Therefore, there is a sense of ‘over-reaction’ to the disease.

[37] Johne's disease is a chronic enteritis of ruminants, caused by *Mycobacterium avium* subspecies *paratuberculosis*. The skin test is impaired by cross-reactivity with *Mycobacterium avium* subspecies *paratuberculosis* (Picasso-Risso et al., 2019).

Furthermore, a central characteristic of the skin test is that it detects an animal's immune response to the injection of tuberculin (as detailed earlier, an extract of bacterial growth products and not the bacteria themselves) rather than detecting the presence of *M. bovis* in an animal (Strain et al., 2011). The skin test is an indicator or proxy diagnostic of bTB infection because it does not affirm the presence of *M. bovis*. An immune response may occur in infectious animals and infected animals, but also animals that are immune to bTB.[38] The test and slaughter regime may therefore be killing some animals that have immunity to bTB and other animals that may be infected, though not infectious.[39] Despite this uncertainty in whether a reactor animal is infected, Defra conceives the skin test to detect *M. bovis* and to send infected cows to slaughter "with the aim of preventing further spread of disease" (Defra, 2014a: 43). For policymakers, testing is a tool to help eradicate infection across the country. It has authority in the national bTB eradication programme to define and identify infection. However, the inability of the skin test to show conclusively if an animal is infected, infectious or immune and to what extent, means it does not show the full risk of the animal being on farm. Although the skin test is presented as certainly detecting infection, I argue that its fallibility means it is a proxy of disease. The tying together of skin testing with the disease control narrative (portrayed in Defra, 2020a) eclipses farm realities by focusing on the national picture of the disease, rather than the farm level picture of disease. Consequently, this national, certain and fixed use of the skin test

[38] This ambiguity is currently of high political importance as the English Government needs a test that can distinguish the Difference between Infected and Vaccinated Animals (DIVA test) if it rolls out a cattle vaccine for bTB (see Section 9.2). Scientific work to create a DIVA test is ongoing.

[39] In veterinary research, this uncertainty is portrayed in the 'positive predictive value', defined as "the probability that an animal with a positive test result is truly infected" (TB hub, 2015d). The positive predictive value is influenced by the sensitivity and specificity of the skin test, and the level of disease in the population being tested, calculated to be approximately 92 % in the High Risk Area, 88 % in the Edge Area and 77 % in the Low Risk Area (TB hub, 2015d). According to government calculations, this means that a reactor in the Low Risk Area has a greater than 2:10 probability of not being infected with *M. bovis*.

occludes on-farm uncertain realities of disease. I argue that the skin test ‘proxifies’ the national policy picture of infection. I now turn to explore farm realities on Day 1 and Day 2 of the skin test.

3.3. Skin testing practices: Day 1

I undertook four skin tests with a vet, Ian, in Cumbria in winter 2016. Two of these tests were undertaken on dairy cattle entering or exiting the milking parlour, and two were undertaken on beef cattle that were inside the farm sheds for winter. If more than 20 cattle on a farm are to be tested, the skin test often begins by assembling the holding pen, race and crush into a unit. Metal fencing railings are locked into position using pins, twine is tied around the fencing to connect it to the wall and the race is constructed without sharp angles, to be inviting to the animals. Depending on the size of the race, cattle are herded from the shed or parlour into the holding pen. The gate between the holding pen and the race is opened, and some cattle are encouraged into the long narrow corridor constructed with metal fencing on either side. When the race is full, the gate between the holding pen and the race is shut (Figure 9). The first animal moves forward into the crush and the gate is shut behind it. The animal is now in position for the skin test.

Figure 9: Cattle herded from the holding pen into the race (Author, 2016)

Ian first waited for the cow to stand still in the crush to minimise the risk of his hand being caught between the cow and the yoke — the yoke prevented it from moving backwards and forwards to any extreme (Figure 4 and Figure 10).[40]

[40] FN skin test 1 month radial LRA 1, 25.02.16

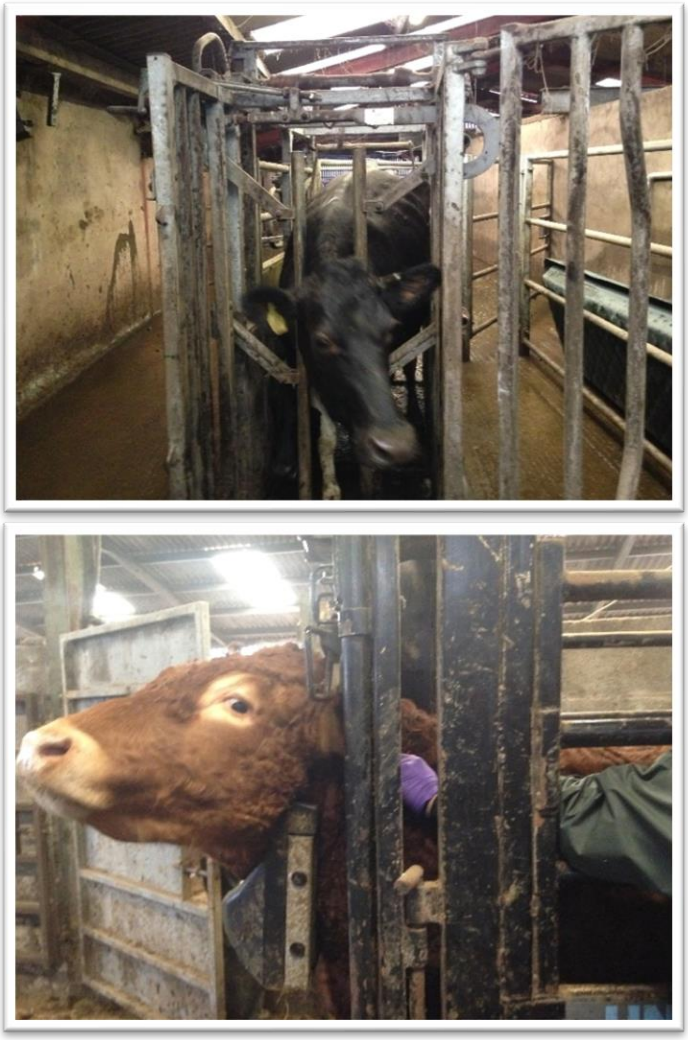


Figure 10: Cattle in crush and yoke for a skin test (Author, 2016)

During Day 1 of a skin test on a dairy herd, Ian wore a waist belt containing his most necessary equipment (Figure 11). Each item had its place in the waist belt and carried a routine. Ian did not look at the belt when extracting equipment; his hands knew where to reach for what he needed.[41]

[41] I worked with another vet who, like Ian, did not look at his belt when extracting the Mclintock syringes. On Day 1 of a test, the avian and bovine syringes were in the incorrect positions in his belt. Therefore, instead of injecting avian tuberculin at the top of the neck using his left hand and bovine tuberculin at the bottom of the neck using his right hand, he injected some animals the other way round. He only realised this error when he looked at his syringes and saw that they were in the wrong hand. He did not know how many animals he had injected like this. This error meant that he would struggle to identify if any animals with reactions on Day 2 were reactors or clear. To manage the error, we inspected the animals that had been injected and identified 15 that could have been injected incorrectly. He asked me to draw an arrow next to these animal IDs on the recording sheet so we could identify them if they had reactions on Day 2. On Day 2, none of the animals had reactions that were large enough to be classified as reactors and so, in this case, the error did not have significant consequences in the potential misidentification of reactors. He did not inform the farmer of what he had done for fear of repercussions on his reputation and fear of losing a client (FN skin test 1 month radial LRA 5, 02.05.16 and 05.05.16).

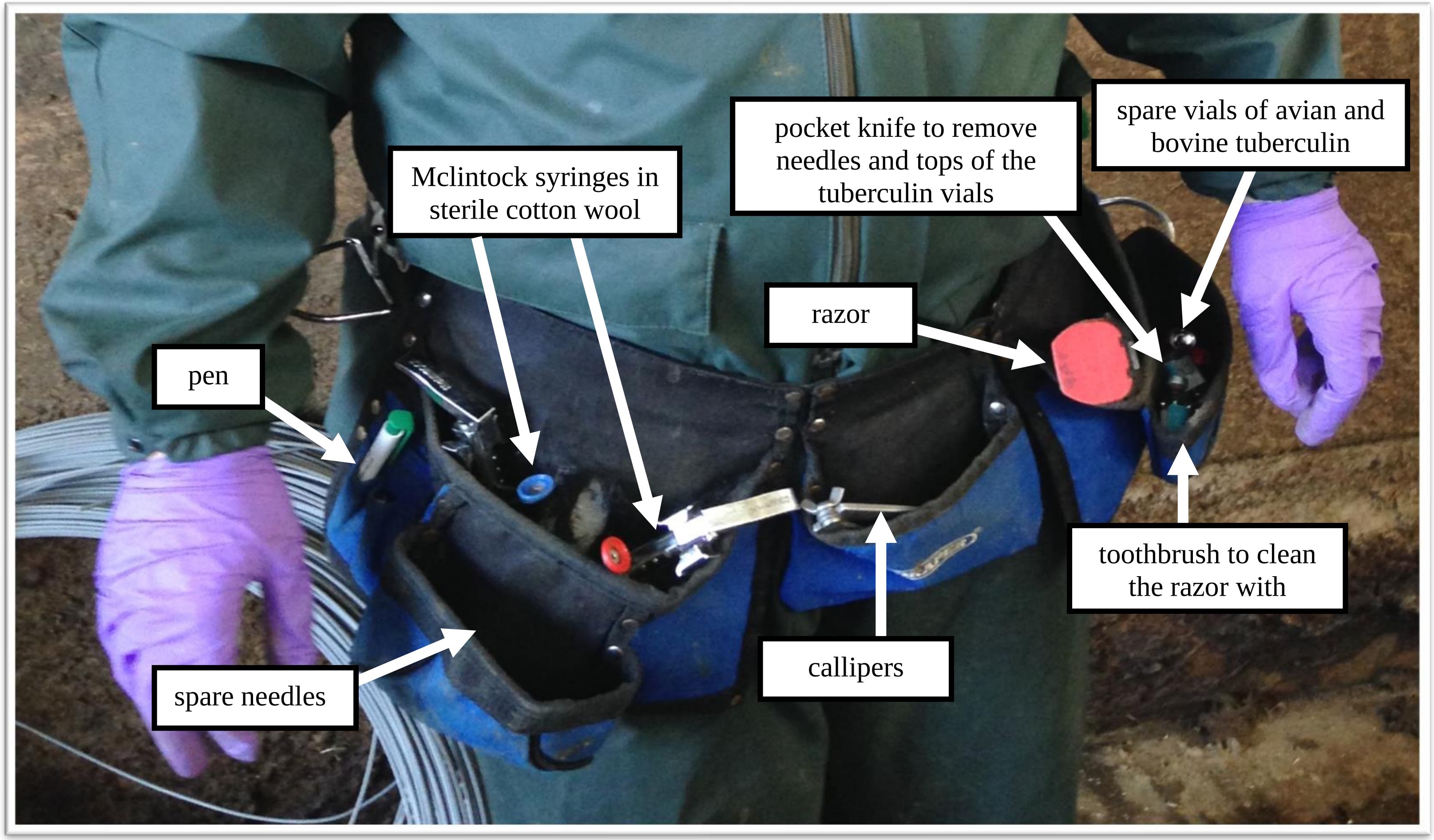


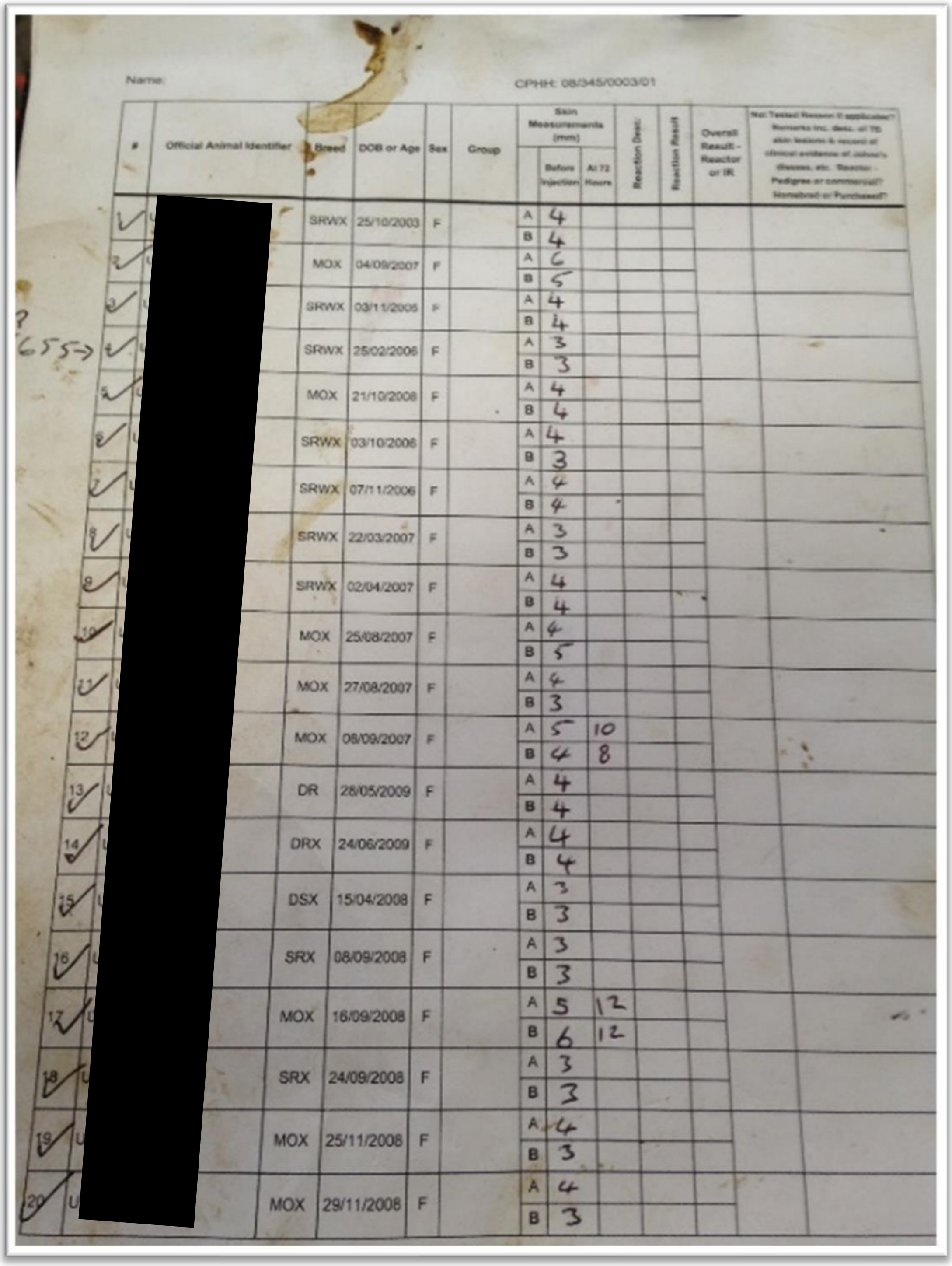
Figure 11: Labelled waist belt (Author, 2016)

Ian took up position on the right-hand side of the cow and then withdrew his battery operated razor from his waist belt. He shaved two areas on the right-hand side of the cow's neck, although as can be seen in Figure 12, the cow sometimes thrashed while he worked, meaning more than two areas were shaved. Ian always shaved the right-hand side of the neck so that on Day 2, when reading the test, all cows could be checked on the same side; shaving on the right-hand side sped up Ian's processing of animals through the test.

Figure 12: Montbéliarde cow after being shaved, skin thickness measured and injected with avian and bovine tuberculin (Author, 2016)

Whilst Ian was shaving the cow, the farmer (Pete) read out the cattle ID from its ear tag and I looked up the cattle ID on the paperwork. Each animal has a 12-digit ID, the first six digits identify the herd and the second six digits identify the animal. Pete read out the final four digits of the ID by which the cattle were ordered on the paperwork (Figure 13). Often I asked Pete to repeat the ID as I had forgotten or wanted to double check. Ian used his callipers to measure the skin thickness and I wrote the measurements down next to the cattle ID. At one point we confused the ID of two cows (0690 and 0790) and I wrote the skin thickness next to the incorrect ID (0790). I only realised my mistake when 0790 entered the crush, by which time it was too late to find the cow I misidentified earlier. We recorded the error and attributed it to 0690 after all cattle had passed through the crush and 0690 had no skin thickness recorded.[42] Such cattle ID confusion occurred on 11 of the 16 skin tests farms I visited when I variously recorded numbers, read out numbers or did not partake in the activity. It is a common occurrence and one that must be resolved (however possible) before the completion of the test.

[42] FN skin test 1 month radial LRA 1, 25.02.16



Name: CPHH: 08/345/0003/01

#	Official Animal Identifier	Breed	DOB or Age	Sex	Group	Skin Measurements (mm)	Before Injection	At 72 Hours	Reaction Desc.	Reaction Result	Overall Result - Reactor or IR	Not Tested Reason if applicable? Remarks inc. desc. of TB skin lesions & record of clinical evidence of Johne's disease, etc. Reactor - Pedigree or commercial? Homebred or Purchased?
1 ✓	[redacted]	SRWX	25/10/2003	F		A	4					
						B	4					
2 ✓	[redacted]	MOX	04/09/2007	F		A	6					
						B	5					
3 ✓	[redacted]	SRWX	03/11/2005	F		A	4					
						B	4					
4 ✓	[redacted]	SRWX	25/02/2006	F		A	3					
						B	3					
5 ✓	[redacted]	MOX	21/10/2008	F		A	4					
						B	4					
6 ✓	[redacted]	SRWX	03/10/2006	F		A	4					
						B	3					
7 ✓	[redacted]	SRWX	07/11/2006	F		A	4					
						B	4					
8 ✓	[redacted]	SRWX	22/03/2007	F		A	3					
						B	3					
9 ✓	[redacted]	SRWX	02/04/2007	F		A	4					
						B	4					
10 ✓	[redacted]	MOX	25/08/2007	F		A	4					
						B	5					
11 ✓	[redacted]	MOX	27/08/2007	F		A	4					
						B	3					
12 ✓	[redacted]	MOX	08/09/2007	F		A	5	10				
						B	4	8				
13 ✓	[redacted]	DR	28/05/2009	F		A	4					
						B	4					
14 ✓	[redacted]	DRX	24/06/2009	F		A	4					
						B	4					
15 ✓	[redacted]	DSX	15/04/2008	F		A	3					
						B	3					
16 ✓	[redacted]	SRX	08/09/2008	F		A	3					
						B	3					
17 ✓	[redacted]	MOX	16/09/2008	F		A	5	12				
						B	6	12				
18 ✓	[redacted]	SRX	24/09/2008	F		A	3					
						B	3					
19 ✓	[redacted]	MOX	25/11/2008	F		A	4					
						B	3					
20 ✓	[redacted]	MOX	29/11/2008	F		A	4					
						B	3					

Figure 13: APHA recording sheet containing columns for: cattle ID, breed, DOB, sex, skin thickness on injection of avian and bovine tuberculin, and skin thickness 3 days later. Cattle ID is hidden to protect the farmer’s anonymity (Author, 2016).

The IDs are part of the Cattle Tracing System used to order, sort, define and arrange animals for the ease of tracing cattle movements (Singleton and Law, 2013). Whilst instilling order, the system also creates uncertainty. If the skin thickness between two misidentified cattle is drastically different on Day 1, the impact of recording information next to the incorrect ID can make the difference between an animal that passes the test and an animal that is a reactor. Some vets I worked with mitigated this uncertainty by putting a mark next to a misidentified animal ID enabling us to return to the error at the end of the test.

Whilst I found the cow ID on the recording sheet, Ian extracted callipers from his waist belt and measured the cow's skin thickness in the shaved area.[43] Ian read out the skin thickness measurements and I recorded them onto the sheet next to the cattle ID. Skin thickness is measured before the tuberculin is injected to decipher the base level before injection. The accurate recording of skin thickness is of high importance for the reading of the test as a 2 mm increase can make a cow an inconclusive reactor and subject to more testing. APHA deems test results to be invalid if "skin measurements are grossly inaccurate or inconsistent or not made at all" (APHA, 2016d) and the vet will not be paid for the test.

Many of the vets I met considered the emphasis on test accuracy to be exaggerated. Ian's callipers measure in 2 mm intervals leading to a ±1 mm margin of error inherent within the measuring tool itself. There is also a large discrepancy between methods of testing. My fieldnotes record one such event:

> *On one cow,* [Ian] *measured lumps of 8 mm and 5 mm using the callipers. I then measured the lumps and recorded 10 mm and 7 mm.* [Ian] *said: "That's why it's important the same person does the measurements first and second time". There is variation between people's measurements.*[44]

To reduce the chance of comparative human error, APHA (2016a) notes in the skin testing protocol that the test must be carried out by the same vet and "the same set of

[43] FN skin test 1 month radial LRA 1, 25.02.16

[44] FN skin test 12 month radial LRA 1, 26.01.16 and 29.01.16

callipers, or the same type of calliper calibrated to produce identical readings, must be used on both test days". APHA created this protocol to eliminate practitioner bias in measuring skin thickness and not compromise the reliability of the test or the test results. The testing protocol attempts to manage uncertainties in the practice of measuring lumps by linking uncertainty to the relations between the official veterinarians and the technology of callipers.

However, it is not only the relations between a vet and their callipers that determine a reliable test. Experience, time, senses and embodied skills also affect how a test is conducted by each vet in each circumstance. I undertook fieldwork with a vet called Roger who did not use mechanical callipers, but rather used his thumb and forefinger to measure skin thickness. When I asked Roger why he didn't use callipers, he replied *"I do use callipers, my fingers are my callipers"*.[45] Roger had conducted skin tests on more than 40,000 animals and said that he can measure the skin thickness better with his touch than with callipers. Roger used callipers when he first began skin testing in 1970s, but quickly changed to his fingers to speed up the process. He now only uses callipers on animals whose skin thickness is outside of his recognisable limit (2–8 mm), such as bulls.

The use of fingers rather than mechanical callipers emphasises the importance of embodied touch and haptic knowledge (Barad, 2012; Grasseni, 2007; Myers and Dumit, 2011). Roger derided Defra's understanding of callipers as the best testing device in terms of accuracy by demonstrating the faults associated with callipers. He used his hands to show me how exerting different pressure onto the callipers drastically changes the skin thickness measurements and told me that the use of callipers prevents

[45] FN skin test 1 month radial LRA 6, 08.03.16

vets from learning the feel of different skin thicknesses which can be used to check the mechanics of the callipers.

Embodied skills affected the vet's conceptualisation of disease as cattle's reaction to the test was understood by a change in sensation between Day 1 and Day 2. This sensation was formulated through the interaction between measured and measurer, not through following exact rules in order to make 'accurate' measurements. Reflective of Enticott's findings from participant-observation of skin testing, Roger did not feel the skin after injecting the tuberculin, described as best practice in the protocol, because he had an:

> embodied understanding of when the tuberculin enters the skin by feeling the feedback in the injecting gun. Only when this feeling is absent do they palpate the skin as required by the protocol to check whether the injection was successful (Enticott, 2012: 81).

Roger had developed skilled vision "embedded in multi-sensory practices, where look is coordinated with skilled movement, with rapidly changing points of view, or with other senses, such as touch" (Grasseni, 2007: 4). Skilled vision is developed through heterogeneous material-semiotic relations (Gill et al., 2017) between callipers, cattle, vets, farmers, fingers and eyes. The heterogeneity of the skin test cannot be controlled through a testing protocol because the heterogeneity exists not only between vets, but also in one person's practice. For example, on a herd of four cattle, Roger felt each injection site on Day 1 and measured each cow's lump on Day 2 as there were no time constraints.[46] On a herd of 200 cattle, Roger did not feel each injection site or measure each lump on Day 2, but rather used his eyes to check if lumps were visible.[47] Here, heterogeneity exists in an agent, is contextually dependent and therefore cannot be controlled in a testing protocol. Crucially, the enactment of skilled vision in the skin

[46] FN skin test routine LRA 1, 25.02.16

[47] FN skin test 1 month radial LRA 2, 07.03.16 and 10.03.16

test may not only fail to detect *M. bovis*, but also enacts bTB. I suggest that many of these complexities in the test are due to the multiple translations of information that are inherent within the test from an ear tag to an ID, from skin to calliper measurement, and from touch of the hand to quantitative display of skin measurement.

3.4. Skin testing practices: Day 2

When reading the test on Day 2, all vets looked at the injection area and/or felt the injection areas with the palm of their hand. If no lump was felt or seen, the animal passed through the crush with no further examination. However, if a lump was sensed, the lump was meant to be measured and the change in size noted on the recording sheet. The skin measurement changes between Day 1 and Day 2 are classified onto a chart (Figure 14), which provides a standardised interpretation of bTB lumps to determine infection.

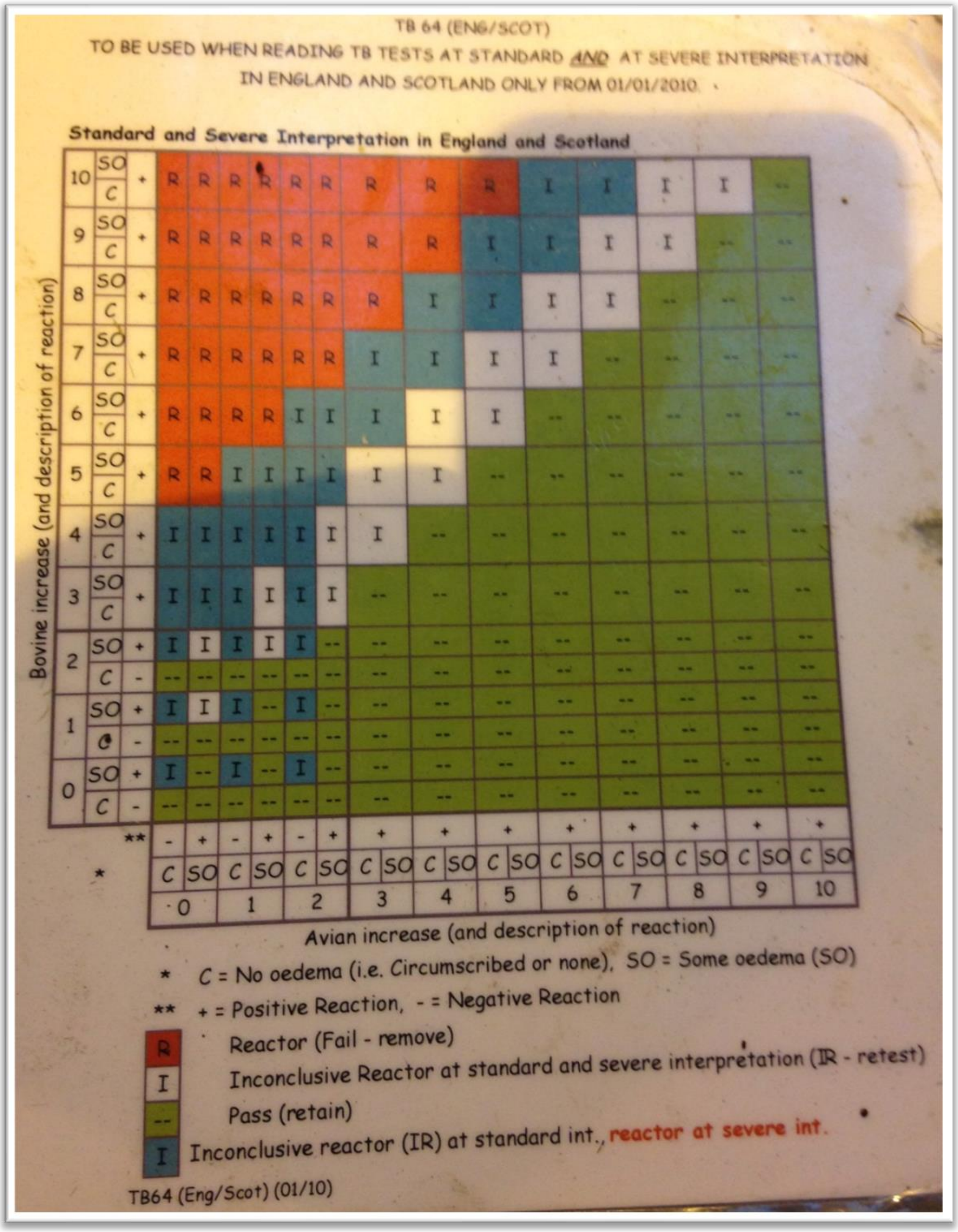


Figure 14: Test chart on which cows are classified to be a reactor, inconclusive reactor or pass dependent on changes in skin measurement (Author, 2016)

The written mm change was compared with the test chart to interpret if the cow is a reactor (shown in red), inconclusive reactor (shown in blue or white) or pass (shown in green). The mm measurement of skin thickness becomes the object of focus, whilst the vet, the tools, the test itself, the cow and the tuberculin fade into the background. The written mm change and the test chart provide visible evidence for the likely presence of *M. bovis* within the animal. From this, the classification of an animal as a reactor is determined by the lumps on the skin and the scrutiny of measurements. The lumps condemn the animal as a reactor by supposedly making visible, to prescribed limits, the presence of the bacillus in the body. The rarity of obvious clinical signs of bTB in cattle means the disease is virtually never seen in the animals, except through the skin test. Robinson (2017c: 289) suggests that this lack of visibility means that farmers "may no longer believe in the disease's existence beyond the results of a bTB test". What the farmers are witnessing, however, is the way that bTB has been remade. It is not signified by clinical signs, but rather by the results of the test. This signification is particularly important since the results are consequently used as a proxy of bTB across England.

The lumps become consequential through the categorisation system and reinforce the credibility of the categorisation system as cattle are deemed to be infected based on the test chart. For example, a bovine lump which has grown by 5 mm compared to a stable avian lump condemns a cow to death. A bovine lump which has grown by 5 mm compared to an avian lump which has grown by 2 mm makes a cow an inconclusive reactor and thus subject to further testing. A bovine lump which has grown by 5 mm compared to an avian lump which has grown by 5 mm makes a cow pass the test. In other words, the lumps and the categorisation system are worked together.

Like Enticott (2012) I consider the test chart to be an 'inscription device' (Latour, 1987). The chart establishes professional vision so as to create "socially organised ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group" (Goodwin, 1994: 606). As Grasseni (2004) writes in her work on the translation of cattle traits into numerical statements for the purpose of cattle breeding,[48] numerical grading of lump sizes “actively constrain, shape and allow the perception, conceptualisation and computation of reality” (Grasseni, 2004: 47). The test chart organises and orders how the lumps are interpreted and gives ultimate authority to the lumps themselves as indicators of infection. The chart actively shapes the practicing of the skin test as the cow is categorised according to the increase in lump size.

APHA’s (2016b) skin testing protocol details that the skin thickness, character of reaction and interpretation of reaction needs to be recorded for any reaction to the avian or bovine tuberculin. None of the vets I worked with recorded all this information. A few vets did not measure an avian lump if it had increased in size and the bovine lump had not. One vet rationalised this by explaining that whatever the avian measurement, the cow passes the test so there is no need to measure the lump. Instead, he asked me to draw a star next to the cow ID to ensure he invents a measurement for the avian lump when inputting the data into the digitised recording system.[49] Therefore, the skin test results are related to the cow, but are shaped by the conceptualisation and classification system that the cow is networked into. The test chart helps to make bTB certain based upon uncertain information.

In relation to his discussion of the history of sexuality, Foucault (1978: 93) speaks of the mechanisms of power as a “a grid of intelligibility of the social order”. In this case, the chart is a mechanism of power as it categorises cattle as ‘reactors, inconclusive reactors or pass’ according to the change in lump size; the test chart is an

[48] Scientists have identified genetic traits in cattle which indicate increased bTB resistance (Raphaka et al., 2017). These traits can be filtered when selecting sperm for artificial insemination of dairy animals through an index called ‘TB Advantage’ (Agricultural and Horticultural Development Board- Dairy, 2016). The index indicates the degree of resistance to bTB a bull is predicted to pass on to its offspring.

[49] FN skin test 1 month radial LRA 5, 02.05.16 and 05.05.16

instrument that determines relatively regular large scale pattern of infection. The test chart is transformed into the skin of the animal and the reality of bTB changes from an invisible bacillus, to a measurable lump comparative to a chart, to a visible lump from which classification is assessed. The chart has ultimate authority in defining the presence of infection in individual animals and enabling this information to be compared at a national scale. The chart occludes uncertainty and differences in practices by transforming skin test results into three fixed categories: OTF, OTF-S or OTF-W. This occlusion of uncertainty creates certainty at the national scale, based on complex and uncertain practices that are linked to the official version of bTB. Meanwhile, the complex presence or absence of *M. bovis* remains obscure.

In addition to the obscurity of defining a lump as infection, complexity is potentially created in the skin test due to the bonds between a farmer, vet and animals. For example, on one farm on Day 2 a cow escaped through the yoke without being checked for lumps. The farmers managed to turn it back around into the holding area to come through the race again. As I searched for its ID on the recording sheet (Figure 13), the farmer told a tale about that cow. He told me that during the 2001 Foot and Mouth Disease epidemic, he was walking the cows down the road and she decided she wasn't going to go and ran through a stone wall: *"she's a bulldozer that one"*.[50] The cow was no longer just an ID on a recording sheet: *she* had a history and a personality, and she and the farmer had a relationship because they worked together (DeMello, 2012). After hearing the tale about the 'bulldozer cow' I felt both care for the animal, and a bond with the farmer for sharing a personal tale. These tales are shared continuously throughout a skin test and help to form a strong bond between individual animals, the vet and the farmer (Fisher, 2013). Ian, a vet, noted that these bonds can lead to

[50] FN skin test 1 month radial LRA 4, 19.01.16 and 22.01.16

uncertainties being created deliberately by farmers to ensure that their *"good cows"* (often cows with 'good genetics') are not found to be reactors. The following reflection is taken from my fieldnote when I was in Ian's office inputting the skin test results into APHA's online recording system:

> *If vets do not ID all of the animals on Day 1 and Day 2, animals can easily be hidden and paperwork can be changed. If the farmer is filling in the paperwork on Day 2, he could easily tick next to a cow ID to say it is a pass when he is hiding the animal because it is a reactor. Or, he could read out the ear tag ID for an animal he has hidden to make it seem like it has been tested. Ian marks an 'X' on the sheet next to cows that were not given the injections on Day 1. Then, Ian knows which cows were not tested. Ian then leaves the paperwork with the farmer between the test on Day 1 and the reading of the test on Day 2. If they have written measurements next to that cow ID, Ian knows they are doing something dodgy. It is all about trust.*[51]

Farmers' trust in vets has been the focus of research in relation to bTB (Enticott, 2008a, 2015; Enticott et al., 2012b; Fisher, 2013). However, I could not find any research *vice versa* on the importance of vets' trust in farmers when conducting a skin test. This seems a strange omission considering the utmost need for accuracy in the skin test and the ample opportunities for deliberate mis-recording of information. The trust conferred on a farmer is a contributing factor to the management of uncertainty related to the skin test results. Ian had mechanisms in place to check that farmers filled in the paperwork correctly, but could not guarantee accuracy or prevent the deliberate incorrect recording of information. He therefore trusted the farmer to record the information correctly and present all his animals for testing.

I worked with a vet that undertook most skin tests with a colleague who filled in the paperwork because *"some farmers aren't as trustworthy as others"*.[52] It is easy for a farmer to hide an animal that has a large bovine lump on Day 2 and fill in the

[51] FN vet practice LRA, 25.02.16
[52] IN Vet HRA, 05.06.16

paperwork or read out an incorrect animal ID to deceive the vet into thinking they have tested that animal. To reduce some of this uncertainty, another vet I worked with asked the farmer to walk them around the farm buildings on Day 2. He tells the farmer this 'farm walk' is to help them with disease biosecurity, but he also does it to check that a farmer has not hidden any animals in the farm buildings to avoid the reading of the skin test.[53] The deliberate hiding of animals and incorrect recording of skin measurements may have been done on the tests that I attended without my knowledge.

Alongside the bonds formed between vets and farmers through stories and shared experiences, there are other variables which might affect the way vets use skin testing tools — including the continued success of their own local practice. In an interview at a knowledge sharing event about bTB, a Government Veterinary Surgeon (commonly referred to as 'the Ministry') told me that the bonds between farmers and vets may affect the vet's measurement of the skin on Day 2 to ensure a farm is OTF:

> Government veterinary surgeon: *private vets often have a vested interest in making sure farms are clear of TB*
>
> JP: *ok, and why does this happen?*
>
> Government veterinary surgeon: *Well, the farmer is the vet's client. The vet practice needs to keep the farmer as a client to stay in business. They're more likely to stay as a client if the vet doesn't find TB.*[54]

"'Making sure farms are clear of TB" refers to a vet measuring all animals on Day 2 to make them passes, and not reactors. This does not mean that *M. bovis* is not present in the herd, but rather it is not detected. The Ministry attempts to mitigate some of this 'vested interest' by conducting re-tests if an inconclusive reactor is found on Day 2. A private vet thought this was done because the Ministry does not have a vested interest in the farm and are therefore "*more likely to follow the testing protocol to the letter"*.[55]

[53] IN Vet Edge 3, 16.01.17
[54] FN meeting LRA 3, 25.03.16
[55] IN Vet Edge 4, 04.02.17

This reduces the potential for private vets to pass an animal when its lump size means it should be designated as OTF-W or OTF-S. Implied within this response was the notion that following the testing might produce more certain results. Equally implied is the idea that the protocol is not followed to the letter when tests are not conducted by the Ministry.

An audit in Northern Ireland showed that when conducting tests on herds at the same risk level, Ministry vets were 1.5–1.8 times more likely to classify a herd as a breakdown than private vets (Northern Ireland Audit Office, 2009). Following the audit, the Northern Ireland ‘Public Accounts Committee’ (2009) made 10 recommendations regarding skin testing: six of these recommendations were aimed at private vets who are found to deviate from the testing protocol. None of the recommendations are aimed at reviewing the testing protocol. The Northern Ireland Audit Office (2009) report does not question whether Ministry vets are interpreting the test results (in)correctly, but rather states that private vets may have a potential conflict as they conduct bTB testing on their own clients’ animals. This conflict of interest is presumed to mean that private vets are potentially incorrectly interpreting the test results. This illustrates the certainty that is attributed to the skin test — if undertaken according to the ‘correct procedure’ — and the uncertainty that is attributed to farmer-vet relations; it is the vets that are deemed responsible for an inaccurate result, not the protocol. In other words, the testing protocol, if followed to the letter, is considered to iron out uncertainties in the skin test and create certain and reliable results. In his work on skin testing with vets, Enticott (2012: 84) details how the testing protocol “posits not only is there a right way of testing, but there is also only one way of testing”.

Even when the testing protocol is carried out to the letter, however, uncertainty embedded in this protocol — as outlined in the beginning of this section related to the transformation of touch of the hand to identification of *M. bovis* — is occluded by the official narrative of control. In part, uncertainty in the practices of the skin test is occluded because a vet's skilled vision and subversions of the skin test testing protocol are not witnessed, practised or understood by the Ministry. For example, Roger — the vet described in Section 3.3 as using his fingers as callipers — noted that if he was being audited by XL Farmcare[56], he would use mechanical callipers to show that he was conforming to the *"prescribed rules"* of the testing protocol so as to not lose his licence to test.[57] This change in practice to fit protocol, against an individual's experience, demonstrates incoherence in embodied realities. Moreover, the incoherence between Government and veterinary enactments of bTB, infection and *M. bovis* is not overcome because the Ministry undertakes repeat tests on inconclusive animals, but rarely conducts skin tests on entire herds. Testing only one or two inconclusive reactors does not allow the Ministry to experience all the test complexities which are often magnified with herd size. For example, as shown earlier in this chapter, the misidentification of animals is more likely to occur, and go unnoticed, in large herds as it is easier to make mistakes in identifying animals and writing down measurements on the recording sheet. With reference to Law's (2004) work on empirical ontology in the doing of social science research, there are uncertainties manifestly absent from specific testing procedures carried out by the Ministry. Because they are missing from the Ministry's procedures, they are absent in the policy narrative. Yet they are seen, described and manifestly relevant to the skin test in practice.

[56] TB testing in England is undertaken by five regional Veterinary Delivery Partners. The Veterinary Delivery Partners are regional companies owned by rural veterinary practices and are responsible for allocating local vets and ensuring that TB testing is carried out to a high standard. All five of the Veterinary Delivery Partners are part of the national company XL Farmcare.

[57] FN skin test 12 month radial LRA 2, 11.04.16 and 14.04.16

3.5. Narrative of control

The findings detailed above have outlined the design of the test and its practising. I have detailed farmers', vets' and government's ways of making bTB through the skin test, specifically by examining the management of heterogenous complexities and uncertainties related to: the test's sensitivity and specificity; positive predictive value; the testing protocol; the use of callipers and/or fingers to measure individual animal's skin thickness; and, the recording/interpretation of lump sizes. These uncertainties are differently made manifest, managed and occluded in the test as either defining the presence of infection in individual animals, or as a proxy for bTB nationally. I now focus on the inherent tension between government's attempts at representing coherence and control of bTB via inherently uncertain and incoherent practices. In doing so, I problematise how the multiplicity of bTB is made into a singularity underpinning the official narrative of control.

Government conceives the skin test to be a technology that detects *M. bovis* and uses its results as the authoritative source for describing the spread of bTB throughout the country. However, as detailed above, this technology is imbued with incoherency and uncertainties. The testing protocol attributes many uncertainties to the relations between callipers and vets, and attempts to eliminate some of these uncertainties by defining a method for doing the skin test. Applying the work of STS scholar Bruno Latour, the testing protocol can be understood as attempting to sufficiently purify social-material relations (Latour, 1993) between skin, callipers and vets to create certainty and accuracy. However, farmers and vets often do not enact the testing protocol on farm because, as shown, it is difficult to follow. It therefore cannot purify relations as planned.

In a paper analysing findings from participant-observation of skin testing, Enticott (2012) describes the transformation of the testing protocol into on-farm practices of the skin test. Enticott uses the concept of local universality to show how local variation in veterinary practice effectively allows a governmental, uniform approach towards testing to work on farm. Local universality reflects how "standards are always transforming and emerging in and through localised negotiations and pre-existing material relations" (Enticott, 2012: 79). He demonstrates how it is normal for the detailed precision of testing protocols to come "unstuck in practice" (2012: 75). My research corroborates Enticott's (2012) findings as I have observed that much of the testing protocol comes unstuck in practice; official documents present the skin test as a technology that ascribes *M. bovis* as certainly detectable and as the source of bTB, but on-farm experiences do not. Enticott (2012) suggests that vets have expertise in managing the balance of relations between agents in the doing of the skin test. Aligning with this, my findings show how vets' skilled vision compensates for many of these uncertainties by navigating relations, but this compensating skill does not create certainty. Rather, skilled vision allows the vets to comprehend uncertainties in the technology, process and the disease, develop informed judgements about the likelihood of disease being on farm and develop alternative methods for practising the skin test. In Enticott's (2012) words, the vets develop a 'situated epidemiology' of the disease. I argue that these uncertainties and differing practises mean bTB is not a fixed and detectable bacillus. Rather, bTB is a disease deciphered and conceptualised through particular modes of sociotechnical and sensory perception. The following extract is from a fieldnote recounting a conversation with a vet on Day 2 of the skin test, after detecting an inconclusive reactor:

> *I asked the vet "What is the relationship between the skin test and bovine TB?". He said that the Ministry seems to think that it detects M.*

> *bovis, but vets know that it doesn't. I asked him how he knew this. He pointed to the inconclusive reactor in front of us and said that it could be infected, could be immune or it could be a false positive because he had incorrectly measured the lumps or because the test wasn't specific enough, and we will never know. I asked what the skin test does to bovine TB if it doesn't detect M. bovis. He replied that the skin test "brings the disease to life". He said that the skin test and bovine TB can't be separated as the skin test results make what bTB is: stress on farm, the prevention of trading and difficulties in his relationship with his clients.*[58]

This extract details different relations between the skin test, *M. bovis* and bTB compared to that which underpins the government narrative. Furthering Enticott's work on the role of the protocol in skin testing, here the vet suggests that instead of detecting *M. bovis* infection, the skin test makes the disease as it *"brings the disease to life"*. For the vet here, *M. bovis* exists on its own whilst the skin test and bTB are one and the same. The vet suggests that bTB cannot be equated to *M. bovis*. Rather, *M. bovis* is the bacteria that causes infection and bTB is a product of relations with (at least) farmer wellbeing, cattle trading, farmer-vet relationships, and the skin test.

In contrast, government describes the skin test as "surveillance for bTB" (Defra, 2014a: 42) within cattle herds by the "detection of exposure to M. bovis infection in a herd" (Defra, 2014a: 72). In its translation of skin test results into national statistics of bTB infection, Defra presents and understands the skin test as certainly evidencing the disease through detecting *M. bovis*. Policy projects certainty and control of bTB in the production of maps and statistics for bTB infection rates, based upon the results of the skin test. Maps, policy documents and statistics confer certainty upon the skin test through quantification and "turn a qualitative world into information and render it amenable to control" (Enticott, 2001: 151). In his exploration of the role of numbers in rural governance of bTB, specifically in relation to badgers, Enticott (2001: 156) suggests that statistics deny complexity given their "mobile, stable

[58] FN skin test 6 month radial LRA, 26.04.16 and 29.04.16

and combinable characteristics”. Advancing this work, I suggest that the transformation of the skin test results into bTB incidence enforces the narrative of control by removing uncertainty and creating fixity. I argue that presenting bTB incidence using the skin test results is a ‘proxification’ of *M. bovis*. This, aided by technologies of official guidance and recording tables, deftly enables the standardisation of knowing bTB at scale that underpins governmental calculations of control. This narrative of control obscures the skin test’s lack of reliability in determining animals as truly infected or not infected by handing it ultimate authority in determining what counts as a diseased animal. Policy observes uncertainties in the skin test at the scale of the individual animals, but projects certainties at the scale of the nation. This process of scaling (un)certainties contributes to an organisation of spatial scales, in which hierarchical control is maintained – referred to as a scalar fix (Brenner, 2001; Smith, 1995; Swyngedouw, 2000). When uncertainties are recognised, for example by the Northern Ireland Audit Office (2009), vets are deemed responsible. Uncertainties and inaccuracies are ascribed to vets’ practices and considered to be correctable by following the protocol. Vets are structured as a handy foil on which to ascribe sources of uncertainty in order to maintain the purity of policy rationalisation. The formation of certainty at a national scale from uncertainty at a farm scale is central to policy control and eradication; an undetectable and uncertain disease cannot be controlled. This is a notable scalar fix, which contributes to and maintains the narrative of control.

I argue that the skin test does not make *M. bovis* infection detectable and visible, but rather makes bTB detectable and visible. For government, *M. bovis* and bTB are the same, and the skin test sits apart from them, and helps to eradicate them both. For farmers and vets, *M. bovis* is defined by the skin test and bTB includes the policy ramifications of the skin test. bTB is made visible through the relations of the skin test with: the classification of animals as reactors, inconclusive reactors and passes; compulsory slaughter; and, the prevention of cattle trading (see Chapter 4). The skin testing policy makes the disease relationally visible on farm. I recognise that “no screening test for animal diseases is perfect” (APHA, 2016e), but displaying the spread of *M. bovis* in technologies of governance based on testing results formulates a false sense of certainty in the accuracy of the skin test, the detectability of *M. bovis*, and the link between *M. bovis* infection and bTB as a disease.

3.6. Conclusions

This chapter has contributed to the overarching research question of ‘How is bTB made in disease management practices?’ and specifically addressed RQ1: ‘What are farmers’, vets’ and government’s ways of making bTB through the skin test?’. I have argued that the transformation of information from an ear tag to an ID, from skin to calliper measurement, and from touch of the hand to quantitative display involves many translations of information in which uncertainty and complexity is multiplied. This uncertainty is amplified by the skin test’s fallibility in determining whether an animal is, in fact, infected with *M. bovis*. In practice the skin test is not rational and logical, but is rather a process based on contingent relations of trust. Some of these uncertainties are occluded within an official narrative of control and eradication, which relies upon the skin test identifying infection and simultaneously ordering the fate of every individual animal. For government, the skin test enacts *M. bovis* infection as identifiable and visible, whilst for farmers and vets it enacts the disease as detectable and visible.

Whether officials should aim to eradicate bTB is contested (Little, 2019), with some epidemiologists proposing that disease eradication is unrealistic and unnecessary because “cattle-to-human transmission is negligible” (Torgerson and

Torgerson, 2009: 67) and therefore bTB is considered to be irrelevant as a public health issue. I have exemplified how the dependence of the narrative of control and eradication upon the skin test is troublesome. Indeed, some scholars are critiquing the logic of disease eradication and instead advocating for living with disease (Bingham and Hinchliffe, 2008; Donaldson, 2008; Mather and Marshall, 2011).

What I am beginning to argue, in this chapter, is that bTB is not a fixed and detectable bacillus, but rather a disease that is deciphered through sociotechnical and sensory perception. Vets learn the uncertainties in the equipment, process and the disease, whilst government renders absent these uncertainties at a national scale by using technologies of governance to quantify bTB and enable it to be detectable, measurable and therefore eradicable. I have shown how the proxification of the presence of *M. bovis* through an animal's immune response is central to the singular narrative of control. After all, how can a disease be eradicated if it cannot be detected? I argue that the skin test is part of the making of the disease, it 'brings the disease to life', but that at the same time, it cannot accurately tell us whether *M. bovis* is present.

In the following chapter I detail how the uncertain qualities and practices of the skin test shown in this chapter mean that undetected infected animals may be bought and sold, thereby potentially transferring disease between herds and across the country. I further examine policy control narratives in regard to cattle trading and examine the practice of risk-based trading to account for how risk is created in relation to disease detection in the skin test and disease transmission in the trading of cattle.

3.7. Post note

Recognition of vets' and farmers' experiences may help to create a more informed understanding of the abilities of the skin test, and how it deciphers bTB as knowable. In recent updates to its strategy Defra (2020a: 48) has placed the "development of new diagnostic tests for bTB in cattle as a priority". This is in part to enable differentiation between an infected and a vaccinated animal, and therefore contribute to the use of a cattle vaccine for bTB. The use of a more sensitive and less specific skin test needs to be discussed with farmers in all risk areas to learn more about their reality of removing infection from individual animals and their herd.

In addition, APHA (2020c) announced that from November 2020 it will authorise para-veterinary professionals (in other words not fully qualified veterinarians) to undertake skin testing in private veterinary practices. Para-veterinary professionals are required to undertake theory and practical training to become Approved Tuberculin Testers. Can their training include the uncertainties of the test, and how these uncertainties are managed by veterinarians? Some may consider that this will undermine the 'control' narrative. It may, but it may also help to dismantle disease fatalism (see Section 4.1) and enact more practical recommendations about how the disease can be managed.

Chapter 4. Borderlines or borderlands: the transmission and detection of *M. bovis*

> *you tend to have a pre-movement test and get rid of what you need to get rid of before you have your main* [skin] *test,* […] *just in case I get shut down and get stuck with them all* […] *So I'll get rid of 30 or 40 before, or I make sure then that the ones I want to sell in the next couple of months are gone before I do the whole herd test, just in case it's a bad result* [OTF-S or OTF-W].[59]

As portrayed in Chapter 3, bTB is made temporarily visible on farm in part through the materials and practices of the skin test. However, for the most part bTB mobilises through different landscapes, into farms and between cattle without detection. *M. bovis* imperceptibly moves between species and networks. Although *M. bovis* constantly flows through materials, it is difficult to track; there are many uncertainties and indeterminacies about these flows. Nevertheless, in 2016 APHA implemented a methodology to define the 'routes' by which herds become infected (APHA, 2017).

One route of disease mobility is the movement, across England, of infected cattle that have gone undetected in the skin test. The movement of cattle has long been considered a critical factor in the spread of disease, including bTB. The qualities and practices of the skin test (Chapter 3) mean cattle can be unknown harbourers of bTB, unknowingly taking on and transmitting the mycobacteria to (at least) other cattle and badgers. As a result, undetected infected animals may be bought and sold, potentially transferring disease between herds across the country. Farmers, vets, cattle auctioneers and government have established different practices to manage the interconnectedness of cattle businesses, the extent of the cattle trade and the risk of *M. bovis* transmission. In this chapter I discuss one of these: a practice known as risk-based trading to address RQ2: 'How is bTB made in cattle trading?'.

[59] IN Farmer HRA 3, 11.10.16

Social research investigating disease mobilities has largely focused on conceptualisations of how to control disease mobility *from* other species *to* livestock (Hinchliffe et al., 2013). For bTB, this has predominately focused on the implementation of biosecurity between badgers and cattle (Enticott, 2008c; Enticott and Franklin, 2009). With the exception of Convery et al. (2005; 2008) and Law (2006) on Foot and Mouth Disease, relatively little research exists on the sociomaterial movement of disease between livestock. Research on disease mobility specifically in and between cattle has tended to focus on the risk of transmitting disease and how to limit this through risk-based trading. For example, research has been conducted by government and academics about farmers' perspectives on possible risk-based trading schemes to limit transmission (ADAS UK Ltd, 2012; Adkin et al., 2016; Defra, 2018a; Hinchliffe et al., 2016; Little et al., 2017; The Bovine TB Risk Based Trading Group, 2013). However, controlling 'transmission' is only one way of enacting risk-based disease, and is founded on a narrative of being able to control *M. bovis*. This enactment of risk is largely accepted and is not often challenged. Drawing on Law's (2006) and Hinchliffe et al.'s (2013) work on flows, barriers, borderlines, and borderlands, I analyse and challenge this singular way of making disease risk by focusing on the risks of disease transmission *and* disease detection.

I explore the mobilities and materials of bTB in the cattle trade, and I deliberately separate the risk of disease detection (in the skin test) and *M. bovis* transmission (through cattle trading) through two cases. First, I introduce cattle movements and bTB movements in England. Second, I build on Chapter 3 to explore the Government's population approach to controlling and eradicating the risk of *M. bovis* through the use of skin test results to control cattle movements. I argue that skin testing establishes borderlines between risk areas in an attempt "to separate healthy life from diseased bodies" (Hinchliffe et al., 2013: 531) and to bio-secure physical space from *M. bovis*. I draw on the work of Hinchliffe et al. (2013) to show how these borderlines produce leaks, and I demonstrate how the establishment of testing borderlines is a form of "geo-biopolitics" of disease risk (Hinchliffe et al., 2013: 534). I then reveal how a farmer uses the leaks produced by the testing borderlines to enact risk in relation to disease detection.

I also review how risk is practised in different ways and in different contexts. These multiple ways of practicing risk relating to *M. bovis* transmission and disease detection means that any national conceptualisation of risk-based trading schemes will likely not relate to all situated and contingent farming practices. Therefore, I argue that such national schemes must be able to adapt to local contexts. Finally, I put forward one farmer's proposal for a risk-based trading scheme that draws together the risk of *M. bovis* transmission and disease detection in a reshaping of risk-based trading as part of *borderlands*. I argue that testing borderlines attempt to limit *M. bovis* transmission risk in the trading of cattle spatially, whilst borderlands broaden risk to include relational networks of bTB as a disease. I use Hinchliffe et al.'s (2013: 532) work on biosecurity borderlands to show how this alternative conceptualisation of disease risk can "engage with infected life as part of a borderlands within a mutable disease environment". Taking inspiration from Enticott's (2017) work on epidemiology as a borderland practice, I link the Government's narrative of disease control with farmers' local contexts to meld different versions of the disease in risk-based trading borderlands.

In all sections I explore both the flows and the barriers for *M. bovis* transmission through cattle movements and disease detection through skin testing. I want to stretch disease mobilities research to account for the transmission of bacteria and detection of disease in cattle across testing borderlines, and propose borderlands as an alternative enactment of disease risk.

4.1. Cattle movements and bTB movements

National level understanding of the relationship between cattle trading and bTB transmission is underpinned by cattle ID tags (Section 3.3) as part of the established approach to recording cattle movement: the Cattle Tracing System (CTS). In 2016 CTS showed there were approximately 5.5 million cattle in England of which 1.7 million were moved between locations (excluding cattle sent to slaughter) (Godfray et al., 2018). The highest number of cattle movements that year occurred within risk areas and the highest number of cattle movements between risk areas was from the High Risk Area to the Edge Area. Generally, cattle movement is from west to east in response to the improved quality of cattle feed grown in the eastern counties of England, and the lesser cost of moving cattle to feed once rather than moving large amounts of feed to cattle repeatedly (Godfray et al., 2018). bTB is considered to be endemic in western but not in eastern England, hence the transport of cattle between these areas poses a risk for the spread of the disease.

In their review of the current TB Programme, Godfray et al. (2018: 49) note that the movement of cattle has been shaped by numerous factors, including the increasing specialisation of the rearing process:

> Farms often specialise in different stages of the production process: calf rearing, growing, finishing for beef, and milk production. This specialisation and consequent improved industry efficiency requires movement between farms with some cattle moving through multiple farms over their lifetime.

Between 2001 and 2015 the number of cattle movements between farms in England stayed relatively stable, despite a reduction in the number of cattle farms overall (Fielding et al., 2019; Godfray et al., 2018). As a result farms are more connected than they have been previously. In their analysis of contact chains of cattle farms, Fielding et al. (2019) state that the risk posed by a small number of farms which act as hubs (with many more direct trading partners than the majority of farms) might facilitate epidemic bTB spread by creating multiple and high risk transmission routes. The movement of cattle between farms is a key aspect of the industry in its current form, yet the interconnectedness of farms means that movement is problematic for disease transmission.

Multiple studies have identified cattle movements and trading as the most frequent risk for herd-to-herd disease transmission (Griffin et al., 1993; Johnston et al., 2005; Johnston et al., 2011; Reilly and Courtenay, 2007), particularly the trading of cattle from the High Risk Area to the Low Risk Area (Bessell et al., 2012). Gilbert et al. (2005) modelled the way that individual cattle movements predicted the bTB breakdowns in 2002 and 2003 and found that movement outperformed other variables in predicting bTB distributions.[60] Disease prevalence was most closely associated with the proportion of movements from (the previously classified) ‘infected areas’ arriving at a location outside of the ‘endemic area’ (now referred to as the High Risk Area, see Figure 1). Furthermore, using modelling techniques, Green et al. (2008) report that breakdown data for 2004 were best explained by a model attributing 16% of herd infections directly to cattle movements. The disease risk posed to cattle by cattle movements is bolstered by APHA’s (2018a) attribution to cattle movements of 15% of farm breakdowns in the High Risk Area, 33% of breakdowns in the Edge Area and 51% of breakdowns in the Low Risk Area in 2017.

[60] In 2002-2003 many farms restocked their cattle after the Foot and Mouth Disease culls. Cattle were bought from all over the country and this resulted in the spread of bTB, particularly in North West England.

In a telephone survey with approximately 200 farmers in England about risk-based trading, Little et al. (2017) found that, when buying cattle, farmers consider the risk of bTB transfer to a lesser extent than that of livestock quality and market price. In their longitudinal mixed methods study investigating farmers' behavioural responses to badger vaccination, Enticott et al. (2020) report that farmers' low levels of perceived self-efficacy (known as a sort of fatalism in disease management) is significantly related to the number of on-farm cattle movements. In other words, when "farmers lose faith in disease management and their ability to do anything about disease, their actions may increase disease risk" (Enticott et al., 2020: 2). This suggests that alongside farmers' de-prioritisation of bTB risk in trading decisions, their loss of faith in disease control programmes undermines their proactive management of disease risk by minimising on-farm cattle movement.

Much social research of bTB shows farmers' feelings of fatalism towards bTB control (Enticott, 2008a; Enticott and Vanclay, 2011; Enticott and Wilkinson, 2013; Naylor and Courtney, 2014). In his previous work, Enticott (2008a) suggests that this loss of faith and fatalism has come about due to a contrast between the certainties of disease management practices (specifically in relation to biosecurity, including risk-based trading) by official channels, and farmers' own experiences of biosecurity not working effectively to stop the movement of disease. Enticott (2008a) argues that government use a population approach to disease control that revolves around setting universal rules and providing generalised advice for the farming population to follow to reduce the likelihood of disease transmission. However, the population approach has a significant drawback known as the prevention paradox (Rose, 1985); the approach offers little to each participant because most were going to be alright anyway. The strategy is therefore demotivating for farmers because success is marked by a non-event

(Enticott et al., 2012b). Furthermore, farmers that implement biosecurity — such as risk-based trading — and experience breakdowns are considered to be exceptions to these rules and become 'candidates' to show that the system is fallible and disease incidents are dependent on luck (Enticott and Vanclay, 2011; Enticott et al., 2015); this is further explored in Section 6.2.1 in relation to badger culling. The population approach therefore instils a sense of fatalism in which "nothing could be done to prevent animal disease" (Enticott et al., 2012b: 6). The approach also creates low trust and confidence in government in relation to bTB control (Fisher, 2013) as many policies are deemed to be unworkable on farm (Enticott, 2008a).

In summary, the movement of cattle is deemed a significant route by which bTB is spread, influenced by changes in the rearing process, trust in disease management and sense of control over the disease. bTB moves with cattle in a 'disease assemblage': when cattle move, bTB can move. Yet, as noted by Barker (2015: 358) in her review of biosecurity studies "biosecurity must negotiate a balance between too much and too little regulation" as the need to move cattle for the production of food is the basis on which biosecurity is implemented (Bingham and Lavau, 2012). In this context, restricting cattle movements would be commercially undesirable. The current Government considers that bTB management practices need to be tailored to the needs of England's beef and dairy sectors in relation to cattle movements, "rather than force them to change" (Defra, 2020a: 53). The interweaving of bTB with the cattle industry's reliance on cattle movements in its current business model suggests there is no quick-fix to reduce *M. bovis* transmission.

4.2. Skin testing borderlines

In the 'Bovine TB Eradication Programme for England' policymakers committed to "look at the feasibility of options for a TB risk-based trading system for cattle" (Defra, 2011d: 9). Since then, management of *M. bovis* transmission through the movement of cattle has been a core concern.[61] In an attempt to enable cattle movements whilst removing its risky element of *M. bovis* transmission, policymakers have created testing borderlines between risk areas.

Since March 2006 compulsory pre-movement testing has been enforced for most cattle 42 days old and over moving out of an annually (or more frequently) tested herd (Defra and Government Statistical Service, 2018). Farmers who are selling cattle are responsible for organising the pre-movement testing within 60 days before the cattle are moved, subject to exemptions. Unless undertaken as part of other compulsory and government funded tests, such as whole herd testing, the farmer is responsible for the cost of the pre-movement test. Furthermore, since 2016 post-movement testing has been compulsory for cattle moving into the Low Risk Area from herds in annual (or more frequent) surveillance testing areas in England and Wales. All herds in the High Risk Area and Edge Area (Figure 1) are tested at least annually and are therefore subject to pre-movement testing and post-movement testing needs to be undertaken if any associated animal is bought by a farmer in the Low Risk Area. In the guidance for pre-movement and post-movement testing, APHA states that the testing is in place to reduce the risk of transmitting disease through movements and trading of cattle:

> ……movements of cattle from high bovine TB incidence areas of GB pose a substantial risk of introducing the infection to the lower incidence areas of England. […] Our current strategies are based on maintaining the Officially TB Free status in Scotland and eradicating TB in England and Wales. TB movement testing contributes to these strategies by reducing the

[61] In 2020 the Government reframed 'risk-based trading' into 'responsible cattle movements' to reflect its notion that "movements of cattle for any purpose, not just sale, constitutes a risk that should be managed" (Defra, 2020a: 54). Despite this change of terminology, in this chapter I use the term risk-based trading for two reasons. First, many of the studies I draw upon use this term. Second, I wrote this chapter prior to the 2020 policy update. Some of my recommendations related to risk-based trading are reflected in the policy update. I reflect upon where and how my work is reflected in policy in the 'post note' section of this chapter.

> risk of disease spread through movements and trading of cattle (APHA, 2018a: 4).

As I argued in Chapter 3, APHA's references to "eradicating TB in England" and "disease spread" portray bTB as controllable. Although APHA uses the terms 'disease' and 'TB' instead of *M. bovis* in this extract, the terms emphasise the narrative of control and eradication through the prevention of *M. bovis* transmission between risk areas. Pre- and post-movement testing reduces the risk of *M. bovis* transmission from the High Risk and Edge Area to the Low Risk Area in two ways. First, more skin testing increases the likelihood of detecting infected animals and slaughtering them. Second, pre- and post-movement testing makes it more difficult, and therefore less appealing, to trade cattle between the risk areas. Subsequently, pre- and post-movement testing are both disease surveillance mechanisms and levers to encourage behaviour change.

As detailed in the extract above, pre- and post-movement testing have been established through an understanding of difference between the policy-defined geography of high incidence (aka High Risk) and low incidence (aka Low Risk) areas. The classification of disease by geographical area infers a need for biosecurity, or spatial barriers/borderlines, that attempt "to limit the flow of undesirables across territories and bodies" (Hinchliffe et al., 2013: 534). The (pre- and post-movement) testing borderlines can be considered as entities that prevent the incursion of pathogens from higher risk to lower risk areas; the borderlines attempt to *bio-secure* physical space (Bingham et al., 2008). The implementation of testing borderlines between risk areas contributes to the geo-biopolitics of disease risk (Hinchliffe et al., 2013), constructing the 'physical space' of disease through spatial categorisation and segregation of risk according to area (Enticott, 2008b). This 'walls off' the Low Risk Area from 'outside' areas at higher risk of infection (Hinchliffe et al., 2013) and enables a narrative of disease control, evidenced through APHA's annual epidemiological analysis of skin test data and trends according to risk area (APHA, 2017, 2018a, 2019a).

Whilst the spatial categorisation of disease is relatively simple to implement, there are several interesting issues to discuss regarding this approach. First, an individual herd's disease risk does not always correspond to the categorisation of risk areas; Defra estimated that in 2016, 15% of farms in the High Risk Area had not had a breakdown in over 10 years and are therefore defined as 'low risk' herds (Defra, 2017). Second, the testing borderlines are imbued with different purposes from those for which they were formed. For example, a dairy farmer in the Low Risk Area told me at a cattle auction mart that pre- and post-movement testing had given him confidence in buying cattle from the High Risk Area because the testing borderlines meant he was purchasing animals of reduced bTB risk:

> *Well now with post-movement testing and pre-movement testing at least I know the animals I'm buying are clear of TB. It's helped. I'm more confident buying heifers from farms in the High Risk Area as I know they don't have TB.*[62]

The farmer conceived the skin test to be sensitive enough to detect all infected animals and the pre-movement testing borderline had therefore given him confidence that he was only buying uninfected animals. As detailed in Chapter 3 the limited sensitivity of the skin test and the uncertainties in the testing process means the testing borderlines cannot definitively prevent disease flow; the skin test misses on average 20% of bTB-infected cattle at each test (de la Rua-Domenech et al., 2006). This farmer did not recognise the possibility of undetected disease movement through the pre-movement testing borderline. Ironically, his confidence in borderline measures to prevent disease

[62] FN cattle auction mart LRA, 26.02.16

spread increased his cross-borderline trading activity — exposing his farm and the industry to potentially greater risk.

For policy, pre- and post-movement testing are borderlines to reduce *M. bovis* transmission between risk areas (TB hub, 2015e). However, the flow of *M. bovis* and the flow of cattle intersect in the testing borderlines because “borders are always also contact points, they join worlds together and act as conduits as well as barriers” (Hinchliffe et al., 2013: 535). The borderlines are thereby multiple. They are both barriers *against* the flow of cattle and conduits *for* the flow of the cattle-bTB disease assemblage due to buyers’ increased confidence in the status of uninfected animals.

The ‘seeping’ of *M. bovis* at breach points of this porous testing borderline and the movement of cattle across the borderlines do not cohere with the narrative of ‘controlling disease transmission across risk areas’. In an attempt to further control *M. bovis* transmission through cattle trading, in 2012 the ‘Bovine TB Risk Based Trading Group’ recommended that Defra limit the leaks at the testing borderline by investigating how to increase the skin test’s sensitivity:

> …look into options for increasing the sensitivity of the pre-movement test to enable farmers to place more emphasis on the value of a negative test when purchasing an animal (The Bovine TB Risk Based Trading Group, 2013: 12).[63]

In 2020 Defra took up this recommendation, also put forward in the review of the bTB strategy (Godfray et al., 2018), and announced that it will “assess the costs and benefits of adopting more sensitive approaches for statutory pre- and/or post- movement testing of cattle” (Defra, 2020a: 44). A potential policy change to use a more sensitive test will likely detect more infected cattle, but it does not recognise the conduits that the testing borderlines create. The testing borderline is underpinned by an official perspective of

[63] The Bovine TB Risk Based Trading Group was a Defra advisory group comprised of industry stakeholders including veterinarians, farmers and livestock auctioneers.

reducing the risk of bTB transmission that is fixed and controllable, which is not widely shared by farmers and vets (Chapter 3). This categorisation of risk flattens both the diversity of disease within risk areas and the different uses of the borderlines, and does not thoroughly account for the importance and influence of existing trading and testing practices. Like Law (2006), Hinchliffe et al. (2013) and Bingham et al. (2008) I consider that biosecurity *borderlines* are not an effective mechanism to reduce *M. bovis* transmission because they rely upon and reinforce disease as spatialised between geographical areas and uniform within risk areas. Thus there is a need for a shift in the conceptualisation of disease risk and its enactment in disease risk management practices. I propose an alternative conceptualisation and enactment of disease risk later in this chapter.

4.3. Reducing disease detection in a business

In their work on cattle trading in New Zealand, Hidano et al. (2019) suggest that there is a need for a paradigm shift in the conceptualisation of cattle trading and disease risk away from an outcome-based approach of reducing risk and towards an approach that ties together events, situations and attitudes towards risk. The need for this paradigm shift in the conceptualisation of risk-based trading became visible in my ethnography in relation to the risks of disease detection and *M. bovis* transmission. Below a farmer reveals he is less interested in reducing the risk of *M. bovis* being transmitted onto his farm and more interested in reducing the risk of bTB being detected on his farm.

I undertook research with Richard in Gloucestershire who took me on a tour around his farm and invited me into his home for an interview. He told me that he had previously run a beef suckler herd, but that his entire herd was culled during the Foot and Mouth Disease outbreak in 2001. He restocked his herd after the outbreak and none of the animals were skin tested when brought onto the farm. He experienced a breakdown which he attributed to an undetected infected suckler cow that he had purchased:

> *It seems strange that that's the only one we ever had, and we bought her at the time* […], *because we got taken out with foot and mouth so we had a fresh start then if you like. And the only one we ever had go down after was one we bought as an older animal, 'cos she'd calved and got three quarters or something so we bought her off the farm we buy a lot of calves off, he said "why don't you have her and suckle some calves on her?" So that's what we did. I say a few years later she went down with it. So it was just we were thinking well* [my vet] *was chatting one day and he said "it could be that she had it when she came to you and it just took a few years to work its way through and show up".*[64]

Richard and his vet believed that the cow brought bTB into the herd but the infection remained undetected by the skin test until a few years later when *"she went down with it*"; in other words it was detected as a reactor at the skin test and caused a breakdown. Richard and his vet suspect the sensitivity limitations of the skin test in detecting disease mean farmers may unknowingly purchase disease when purchasing animals. Due to Richard's and his vet's understanding that this breakdown was caused by the purchase of a cow, he changed his entire business model to a calf rearing unit:

> *From baby calves I rear them up, some are sold at sort of four months, five months old, and then some are kept that are two years old, well I've got three lots in the field now, so there's 120 that would be over two years old, or around about two years old sort of age.* […] *It's all beef, but it would be sold as stores, so they go back to a market. So I've got to pre-movement test everything out.*[65]

Richard was therefore purchasing and selling greater numbers of animals (300–400 calves) each year compared to his previous beef suckler herd. This may sound as though Richard had increased, not decreased, his risk of importing bTB into his herd. However,

[64] IN Farmer HRA 3, 29.09.16
[65] IN Farmer HRA 3, 29.09.16

Richard made this decision in order to decrease his risk of experiencing a bTB breakdown:

> *Yeah everything's bought in, we don't calve anything on the farm anymore, I got rid of the suckler herd because of the risk of the older cows, or older cattle being the higher likely ones to get the TB, so I sort of, you hold your nerve for so long and you think it only had 30 or 40, about 30 cows I suppose, and it was getting harder work calving them and you just think it's going to be the risk, if I've had them 10 years, they're going to be out on the same pasture every year, there is that thinking that the older they get the more chance it shows up then, so yeah we got rid of that.*[66]

The decision to transition from a beef suckler to a calf rearing unit was undertaken in relation to bTB risk management. He considered his primary risk to be sending the herd *"out on the same pasture each year"* which he deemed to be infectious due to bTB being recurrently detected in animals which used that pastureland; Richard told me that the cause of the infection in the pasture was an infected badger cete (group of badgers). In other words, the risk of a breakdown did not stem from moving cattle, but rather from not moving cattle in his pasture. He could not rear a beef suckler herd without using his pastureland, he could not prevent infection moving in the pasture (prior to the badger cull) and he wanted to reduce the risk of experiencing a bTB breakdown. In response, he changed his business model. He considered that this change reduced his risk of bTB being detected in his herd because the calves were on the infected pasture for a short amount of time and were quickly sold on. As a result, there was little time for the calves to have an immune response to *M. bovis* and therefore he had reduced risk of disease being detected in the skin test. Advice on the skin test suggests:

> Most animals take 3–6 weeks after infection with M. bovis to develop a full immune response that can be detected by the skin test. If an animal happens to be tested during this so called 'pre-allergic' (unreactive) period soon after infection, then it may not react to the skin test and hence will be missed (TB hub, 2015d).

[66] IN Farmer HRA 3, 29.09.16

The delayed immune response following exposure to *M. bovis* (Section 3.2) means that the skin test will fail to identify any cattle that have acquired infection and an immune response shortly before the application of the skin test (The Bovine TB Risk Based Trading Group, 2013). Richard had not changed his business with the intention of reducing the risk of bringing bTB into his herd through cattle movements, but rather reducing the risk of bTB being detected in his herd.

To further reduce the risk of a breakdown, Richard had changed his trading practices:

> *you tend to have a pre-movement test and get rid of what you need to get rid of before you have your main test, so I'll get a group in and test them, to make sure that they're gone before I do the whole test, just in case I get shut down and get stuck with them all. So it's you've got to work it a bit, but that seems to, well that's what we do, it just limits your risk a little bit. So I'll get rid of 30 or 40 before, or I make sure then that the ones I want to sell in the next couple of months are gone before I do the whole herd test, just in case it's a bad result* [OTF-S or OTF-W].[67]

A breakdown restricts the movement of cattle off farm as animals from breakdown herds cannot be sold unless directly to slaughter.[68] As noted by Robinson (2014: 214) in his ethnography of bTB in Northern Ireland, "This is regarded as one of the most unfortunate and unwelcome aspects of having the disease by farmers" because the movement restriction often leads to a build-up of cattle on farm which would otherwise have been moved on, often having financial, practical and emotional consequences. Richard was limiting this unwelcome aspect of bTB by undertaking pre-movement tests on a group of calves prior to his whole-herd test. This practice secured an income and reduced the number of calves on his farm in case he had a breakdown and therefore

[67] IN Farmer HRA 3, 29.09.16

[68] Movement restrictions are also automatically put in place on OTF-S herds until the test result is reviewed by APHA. If the herd has been classified as OTF-W or OTF-S in the previous three years, movement restrictions remain in place until the inconclusive reactor is re-tested. If the herd has not been classified as OTF-W or OTF-S in the previous three years, movement restrictions are lifted and only the inconclusive reactor needs to be isolated and remain on farm.

could not sell any animals. Richard increased the mobility of his business to protect himself from the potential ramifications of a breakdown. Once again, he was trading animals not to reduce his risk of having bTB on his farm, but rather to reduce the risk of *M. bovis* being detected on his farm and to reduce the ramifications of a breakdown. He had blended his conceptualisation of risk-based trading into his business plans and made his business less vulnerable to the detection of infection; risk-based trading was aligned with his farming practices.

This then raises the question: does risk-based trading reduce the risk of bTB being *transmitted* onto a farm or reduce the risk of bTB being *detected* on a farm? The first installs protective walls around a farm to regulate disease mobility, whilst the second increases cattle mobility to increase a farm's resilience to disease being detected. Richard's practices used breaches in the testing borderline to reduce the impact of a breakdown, for example by undertaking pre-movement tests in order to sell calves prior to his entire herd being tested. This is counter to the conceptualisation of the pre-movement testing borderlines as reducing the risk of *M. bovis* transmission. Agents do not cohere to biosecurity barriers (Hinchliffe, 2007), but rather reshape barriers to fit their local context. Borderlines are conceptualised differently in different spaces according to the local geographies of disease (Whatmore, 2002) and the "uncertain webs of human-nonhuman interaction" (Ginn et al., 2014: 120). The relations between Richard, cattle and the infected pasture, illustrate how the use of fixed borderlines to keep disease out of a farm is an impossible ideal because bTB is in his farm already. The current testing borderlines attempt to reduce the risk of *M. bovis* transmission, but work in conflict with local practices that attempt to reduce the risk of disease detection.

Richard's practices present disease risk as "a pattern, a web, of partially connected and different flows with criss-crossing barriers" (Law, 2006: 236) between skin testing, cattle trading, previous disease outbreaks and changes in the type of business he runs. The web of flows, herein analysed, are between practices on different scales. Local practices connect with national policies of testing borderlines; for example, the duration of time cattle are put out to infected pasture, to reduce the risk of a breakdown. Linking local and national practices presents a manner of formulating risk-based trading, alternative to national skin testing borderlines. Enticott (2008b) suggests that risk-based trading can be a strategic compromise, creating a national system to manage bTB whilst accounting for local contingencies. In their work on biosecurity, Enticott et al. (2012b) recognise the need to join national systems with local contexts and local expertise. In the next section, I present a proposal from Paul, a dairy farmer in the Edge Area, for a risk-based trading scheme that links risk with compensation, *M. bovis* transmission with disease detection, and national, centralised practices with local practices. I consider it as a potential approach to shift enactments of risk away from biosecurity borderlines, rooted in geographical territory, and towards biosecurity borderlands, which reflect the relational networks between disease and disease environments.

4.4. Borderlands: linking *M. bovis* transmission and disease detection

I interviewed Paul in the Edge Area.[69] Whilst drinking tea in his kitchen and watching the rain fall, Paul and I discussed the need for, and implementation of, a statutory risk-based trading scheme. Paul proposed an approach to encourage risk-based trading by linking risk scores produced by APHA, cattle trading, compensation, disease detection and *M. bovis* transmission.

In brief, Paul proposed that it be made mandatory for farmers to share their bTB risk information and introduce financial penalties for farmers undertaking risky trading

[69] IN Farmer Edge 2, 17.08.17

practices. He said that farm level bTB risk information could be shared in the format of APHA risk scores. In 2016, APHA published details of a risk score system through which every farm in England and Wales was assessed as a score on a scale of 1–5 based on the risk of future *M. bovis* infection of on-farm cattle (Defra, 2016a). The 1–5 risk score is calculated using the following criteria (Figure 15):

- years TB Free/since last breakdown (0–2, 3–5, 6–10, 10+)
- movements from a high-risk area in the last 5 years (>0)

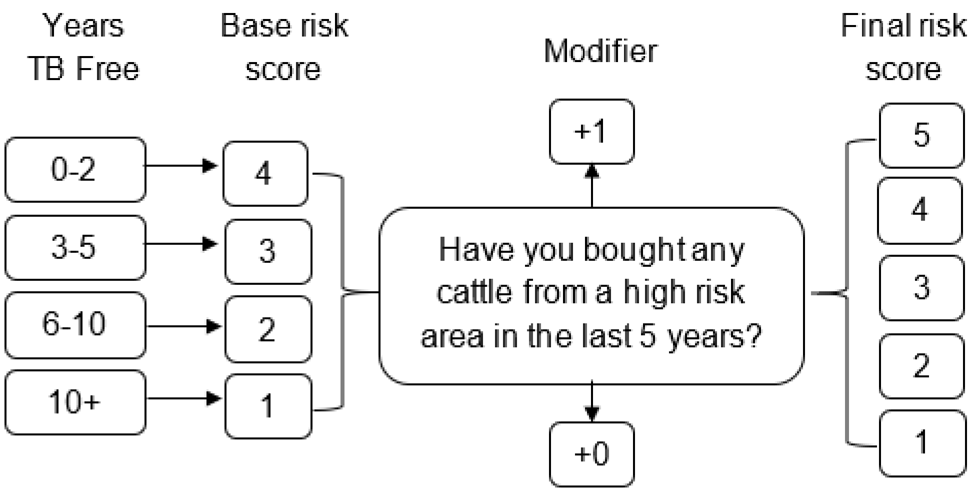


Figure 15: Risk score calculation method. The higher the risk score, the higher the risk of cattle on that farm being infected with *M. bovis* in the future. Diagram created using information from AHVLA (2013).

The State's focus on risk-based trading has been on empowering farmers to manage bTB risk voluntarily (The Bovine TB Risk Based Trading Group, 2013). Down-scaling of bTB risk from 'risk area' (detailed in Section 4.2) to 'farm' renders disease control as farmer's responsibility. Therefore, rescaling is a strategic resource to suit particular politics (Keil and Debbané, 2005), in this case by engendering possibilities of neoliberal disease control practices. However, Paul told me that making risk scores available and expecting farmers to voluntarily share the information would have little impact on cattle trading as *"no one at risk would take it up"*. His comment corresponds with research by Adkin et al. (2016) on the potential uptake of risk scores as part of a voluntary risk-based trading scheme. Interested stakeholders (farmers, cattle valuers, and representatives from non-government organisations) generally preferred a voluntary provision of the risk score to a statutory provision, but:

> concerns were frequently raised that without a statutory scheme the system may not be effectively carried out (Adkin et al., 2016: 2).

This observation reflects the finding reported by ADAS UK Ltd (2012) in reference to a telephone survey with approximately 200 cattle farmers in England to assess if they would prefer compulsory/statutory or voluntary approaches to risk-based trading. There was generally more farmer support for compulsory/statutory over voluntary approaches because of the likelihood of poor uptake of voluntary schemes. The likelihood of a poor uptake was estimated to be higher amongst farmers in the Edge Area and High Risk Area who appeared to have little desire for a scheme and therefore would not voluntarily share their risk information to potential buyers. This is probably because it would negatively impact their ability to sell cattle (ADAS UK Ltd, 2012; Adkin et al., 2016).[70]

The proposal of such a voluntary, risk-based trading scheme and the lack of appeal of sharing risk scores also disrupts the assumption that farmers need more information about bTB risk to undertake risk-based trading. Little et al. (2017), drawing on the same research as ADAS UK Ltd (2012), showed than 75% of farmers surveyed said they had sufficient information to make informed purchasing decisions — without including risk scores. Thus, instead of presenting risk scores solely as information to encourage changes in trading practices, Paul suggested that they would be more

[70] Modelling of cattle movements (based on cattle movement data in England and Wales from 2010 to 2011) suggested that 21% of animals purchased from farms in the High Risk Area would be affected by the implementation of a voluntary scheme (Adkin et al., 2016), likely a result of the buyer's risk score increasing with the purchase (see modifier in Figure 15).

effective if used as part of scheme to implement financial penalties of trading ‘up in risk’:

> *He said there should be consequences for trading up in risk as it not only increases the farm's risk status, but also their neighbour’s. Thus, if you trade up in risk, you get less compensation if you have a breakdown.*

Cattle farmers in England are compensated by Defra for cattle slaughtered under a mandate for disease control purposes (TB hub, 2015f). The level of compensation is determined by animal type and paid at an average market price. Defra has suggested that it will “consider the merits of varying bTB compensation rates to incentivise good biosecurity” and “consider how compensation might also be used to incentivise responsible cattle movements” (Defra, 2020a: 63). This position reflects Enticott’s observation that the use of compensation as a market instrument can “establish and reward appropriate farming practices” (Enticott, 2016: 312), and is therefore a tool that Defra could use to encourage risk-based trading. If used appropriately, compensation could link multiple aspects of how the disease is managed (for example skin testing, compensation, breakdowns and trading) and de-spatialise *M. bovis* according to risk area.

Paul suggested the definition of risk should not be spatialised according to geographical area, but rather according to individual farms. In other words, the modifier from the risk score calculation would be removed and farmers who purchase cattle from a farm of a higher risk score would receive lower compensation if they experience a breakdown. For example, a farmer with a herd of risk score 1 (lowest risk score) who purchases animals from a risk score 4 farm and has a breakdown receives less compensation because they bought animals from a farm of a higher risk score than their own. I suggest that the cause of the breakdown does not need to be linked only to the purchase of animals from high risk farm(s); compensation reduction could apply to anyone who was undertaking risky purchases and has *M. bovis* detected in their herd. The proposed scheme provides an incentive to change practices, in the form of a statutory financial penalty, to encourage more farmers to consider bTB risk-based trading.

A similar recommendation was described in the Farmers Guardian (based on risk for areas rather than for farms), including comments by a dairy farmer. The article states:

> Tweaking the compensation regime could help stop so-called 'risky trading'. He [dairy farmer] said: "Surely we should have a system where for every risk you go up, the equivalent percentages comes down. For example, if you are in a Low Risk Area and buy cattle from a High Risk Area you do not get any compensation, because you should not do that. […] You are not saying people cannot trade, but if there is a market disadvantage for trading riskily then people will become risk averse (Midgley, 2018).

Under the proposed scheme, farmers would be incentivised to participate in risk-based trading, since compensation is negatively correlated with the risk of buying cattle. It is important to note that this trading scheme encourages farmers to change their trading practices, as opposed to forcing them to change them. Whereas pre- and post-movement testing barriers force change in practices, the proposed scheme recognises and allows for the "fraught empirical practicalities" (Hinchliffe and Bingham, 2008: 1534) of cattle trading. For example, a risk score 1 farmer can continue to buy cattle from a risk score 5 farmer if they so desire, highlighting that the scheme accounts for the need for ongoing trading practices in the current farming system.

This interweaving of compensation and risk scores creates negotiated borderlands of farm risk, in which there is movement of risk in cattle trading. Borderlines attempt to spatially limit *M. bovis* transmission risk in the trading of cattle, whilst borderlands broaden risk to include relational networks of bTB as a disease. Rather like Enticott's and Hinchliffe's concepts of borderlands, Paul's proposed risk-based trading scheme focuses on the assemblage of disease and removes the enactment of disease risk as fixed in geographical space. Paul suggests that risk changes in accordance with cattle buying practices, is based at farm level, and is made visible through the detection/creation of the disease in skin testing (as described in Chapter 3). Moreover the scheme somewhat accounts for the known false positives and false negatives that can occur in skin testing by matching the level of compensation to trading risk, instead of the root cause of a breakdown.

This compensation–based approach is a financial intervention to distort the market in its current form and to nudge farmer behaviour. Interventions in the market purposefully lead to distortion, and therefore are sure to engender adverse collateral effects and unintended consequences (Merton, 1936), for example the creation of externalities or gaming. As noted by HM Treasury (2018) in its guidance on evaluation and appraisal, unintended effects need to be considered when designing a market intervention to attempt to foresee and account for them. No matter if the unintended effects can be foreseen, the scheme is bound to produce new bTB and cattle trading realities, just as the borderlines policy does.

Enticott (2016) and Enticott et al. (2012b) argue that a successful risk-based trading scheme is predicated on alignment of national and local practices. The proposed scheme would achieve this by associating risk scores (national enactments of the risk of *M. bovis* transmission) with on-farm breakdowns (farmers' place-based ways of enacting the risk of disease detection). However, the previous pattern of disparate localised practicing of national conceptualisations of disease control and risk management serve as an example of how a new national scheme — such as the one proposed — might not work across all livestock business models. For example, risk management requirements differ between Approved Finishing Units and Licensed

Finishing Units.[71] Furthermore, this scheme may have unintended consequences on cattle trading routes. During interviews, farmers communicated their concern to me that risk-based trading does not remove risky cattle from the market, but may change the routes by which they travel.[72] If widely adopted, the scheme could increase the demand for low risk cattle and inflate the market price they trade at. In the same manner, the price of so called high-risk cattle would decline. High risk cattle may therefore become more attractive and be deliberately purchased by high risk buyers (Defra, 2018a), generating the need for place-based measures to manage bTB risk on those farms. Paul also made it clear that the scheme would *"only work in conjunction with culling as otherwise the High Risk Areas would feel like they are being unduly punished for something they cannot control"*.[73]

Careful consideration would be required prior to implementing such a scheme in relation to the potential issues and consequences of encouraging farmers to take 'ownership' of the disease (Enticott, 2008a), the relationship between local and national practices, the changes to trading routes and market prices, and the possibility that farmers in the High Risk Area might feel punished for something out of their control. Building on Paul's proposal, and addressing each of the potential consequences above, I argue that any risk-based trading scheme needs to be flexible to adapt to local contexts. To develop an appropriate scheme and investigate these potential consequences, the scheme should be co-designed with key stakeholders to account for trading practices and associated conceptualisations of bTB.

[71] As detailed in footnote 33, by default, no testing of cattle is carried out on Approved Finishing Units and Licensed Finishing Units (TB hub, 2015b). So, under the proposed scheme, the risk of these units cannot be calculated. Therefore, these units may accrue unfair advantage if the scheme affects deadweight cattle prices.

[72] IN Farmer HRA 1, 11.10.16; IN Farmer HRA 2, 05.10.16; IN Farmer LRA, 26.05.16

[73] IN Farmer Edge 2, 17.08.17

4.5. Conclusions

This chapter has further explored the official narrative of control associated with bTB and how this has been implemented in borderlines between risk areas and risk-based trading practices. In sum, testing borderlines are underpinned by a narrative that bTB is detectable, fixed and controllable, whilst disease borderlands are underpinned by disease as relational flows. I have argued that risk-based trading borderlands may be more effective than testing borderlines because they bring together versions of bTB (specifically related to *M. bovis* transmission and disease detection) rather than occluding variability in practices. A national 'one size fits all' risk-based trading scheme is unlikely to 'fit all' due to different ways of practising bTB and cattle trading. To be effective, a national risk-based trading scheme needs to combine both the risk of *M. bovis* transmission and disease detection. Adopting the words of STS scholars Mol and Law (1994) in their study of the way in which tropical doctors handle anaemia, a risk-based trading scheme needs to provide fluidity between variations of the disease. I recommend that the risk of purchasing undetected infected cattle needs to be situated on farm alongside other risks and factors that a cattle keeper accounts for when purchasing cattle, such as historical and routine cattle trading patterns. In the next chapter I continue to explore bTB-in-the-making, specifically in relation to badger culling policy.

4.6. Post note

Defra (2020a) notes that it will consult on extending compulsory post-movement testing to parts of the Edge Area with annual surveillance testing. My findings suggest that spatial barriers such as pre- and post-movement testing do not necessarily encourage risk-based trading or reduce disease risk. I recommend that quantitative research is undertaken to assess the extent to which reduced bTB risk is correlated with reduced movements of high risk *cattle* (that is cattle from high risk *farms*, not cattle from a generalised High Risk Area) into the Low Risk Area.

During my internship with the Defra TB Programme in 2016, I used the research presented in this chapter to write policy notes detailing the need for a re-conceptualisation of risk-based trading and investigating how compensation can be used to incentivise risk-based trading. I found that some of my policy proposals were then reflected in 'Next steps for the strategy for achieving bovine tuberculosis free status for England' (Defra, 2020a) in which plans were announced to work with industry representative groups to develop proposals for how compensation can be used to incentivise responsible cattle movements. Can negotiated borderlands of farm risk, which account for both the risk of *M. bovis* transmission and the risk of disease detection, be created?

Chapter 5. The changing calculus of badger cull effectiveness

> The scientific evidence is clear: we know from the Randomised Badger Culling Trial that culling badgers can reduce the incidence of TB in cattle. However we also know that if not done properly culling can make matters worse. […] We therefore remain strongly minded to introducing a carefully managed and science-led policy of badger control (Defra 2011d: 9 and 42).

Should badgers be culled to control the spread of *M. bovis* in cattle in England? First asked in the 1970s, the ensuing debate has resulted in badger culling being authorised in 2011 and instigated in the High Risk Area and Edge Area from 2013. The practice of killing badgers is occurring in the face of strong opposition and has exacerbated the bTB public knowledge controversy. Badgers are a protected species and therefore require a licence from Natural England, the cull licencing authority, to be killed. In one supposedly unified operation, the operational costs of culling are met by farmers, the culling programme is enacted by private companies, and the monitoring and policing costs are met by government. To explore the badger culling policy, this chapter and Chapter 6 consider badger culling policy-as-practice in government offices and in the fields respectively.

In the previous two chapters, I have explored skin testing and risk-based trading. Both of these practices are influenced by policy, but I analysed them as practices on farms and not as a policy. In this chapter, I present a sociotechnical history of the badger culling policy in government offices and in documents. To distinguish between policy as a thing and policy as practice, in this chapter I refer to policy in reference to the entire policy loop (Figure 2) and I refer to badger culling policy 'as-practice' to denote my study of policy in composite practices performed in different sites. I explore policy documents and government reports to address RQ3: ‘How is badger culling policy made?’.

The chapter begins by outlining the history of badger culling from the 1970s to the current policy. This history sets the frame within which I build an argument about the role and impact of calculations in the current badger culling policy. Next, I detail the recent background to the current badger culling policy. More specifically, I explore the shifting calculus of badger cull ‘effectiveness’ underpinning the formulation of the policy. The main part of this chapter presents my ethnographic exploration of the policy. It unfurls methodologies, traces connections and explicates nuances between the numerical calculations of badger populations, the creation of cull targets and evaluations of effectiveness. Subsequently, I draw from the work of STS scholars Lippert and Verran to understand these calculations, and to “analyse the actual material and epistemic practices that shape numbers and stories of numbers” (Lippert and Verran, 2018: 9). I consider the calculus of ‘effectiveness’ (which includes a bundle of calculations and numbers) to be a ‘participant’ (Verran, 2012a) in the badger cull policy and I analyse this calculus as a ‘social entity’ in its own right (Lippert and Verran, 2018). I detail the relations that underpin the calculus and analyse what these achieve for the policy. I link Lippert’s and Verran’s work to my conceptualisation of the ‘policy loop’ (introduced in Section 1.4.1) [redacted]

This chapter is complemented by Chapter 6 which draws on findings from fieldwork in the Gloucestershire and Cotswolds badger cull areas and develops the policy loop by focusing on the role of affect in policy-as-practice in the field with shooters/licenced contractors, cull companies, vets, farmers and anti-cull badger protectors.

5.1. A selective history of badger culling

The connection between bTB, badgers and cattle was first suspected in 1971 when a dead badger in Gloucestershire was found to be severely infected with *M. bovis*. The badger was found in an area with high prevalence of cattle bTB breakdowns and investigations began to measure disease prevalence in badgers. Two years later, the Government introduced The Badgers Act (1973), making it illegal to kill, injure or take a badger (or attempt to do so). A further two years later, the Ministry of Agriculture, Fisheries and Food (MAFF — the predecessor to Defra) provided licences to landowners under The Badgers Act (1973) for the killing of badgers to prevent disease spread (Independent Scientific Group, 2007: 27). Historian of bTB Cassidy (2019: 75) writes that:

> By 1975, the existence of tuberculous badgers—and the idea that they could be responsible for the persistence of TB in British cattle herds—had solidified from a relatively obscure idea of some farmers and veterinarians into a still uncertain but rapidly cohering fact.

Despite the hardening of this ‘fact’, the killing of wild badgers in the English countryside caused “considerable public disquiet” (Independent Scientific Group, 2007: 28). In an attempt to manage the developing public knowledge controversy, from 1975 MAFF took responsibility for badger culling by killing badgers in their setts using cyanide gas. The Thornbury, Hartland and Steeple Leaze clearance trials were such operations. The Thornbury clearance trial involved farmers and residents of Thornbury parish in Gloucestershire, under MAFF supervision and licence, pumping cyanide gas into badger setts as part of intensive culling operations over an area approximately 100 km^2. The trial revealed that widespread badger culling could lead to a widespread reduction in bTB incidents (Gallagher and Clifton-Hadley, 2000).

However due to “continuing public concern over gassing” (Independent Scientific Group, 2007: 28), Lord Zuckerman was commissioned to review this gassing policy, during which time the clearance trials were suspended. In his review, Zuckerman (1980: 47) concluded that “badgers now constitute a significant reservoir of the bovine strain of the tubercle bacillus” and “badgers can contract TB and transmit it both among themselves and to cattle” (Zuckerman, 1980: 14). Henceforth the badger has been widely framed as a wildlife reservoir of bTB. Zuckerman recommended that gassing be resumed, subject to enquiries about “the speed with which cyanide gas kills at different concentrations” (Zuckerman, 1980: 34). The enquiries raised doubts about the humaneness of gassing badgers and led Peter Walker, the Minister of the day, to announce that cyanide gas should not be used. Under The Wildlife and Countryside Act (1981) it became illegal for citizens to use gas to kill badgers without a licence.

From 1982–1985 the ‘clean ring strategy’ was introduced based on the “hypothesis that *M. bovis* infection among badgers occurred in ‘pockets’ of infected social groups” (Independent Scientific Group, 2007: 27–28). On (what is now referred to as) OTF-W breakdown farms, badger territories were mapped out and a number of badgers from the social groups on this land were cage trapped, shot, subject to post-mortem examination and their samples were cultured for *M. bovis*. If one or more of the badgers was deemed to be infected by MAFF, all the social groups were killed. Subsequently, this strategy of killing, sampling and testing was undertaken on all contiguous social groups until a clean ring was encountered in which no infection could be identified. Dunnet et al. (1986) reviewed the clean ring policy and concluded that “there is insufficient evidence to justify the continuation of the current strategy” (Dunnet et al. 1986: 27) due to the high cost of the strategy and the lack of evidence of the impact on cattle bTB breakdowns. Dunnet et al. recommended an interim strategy of Ministry-led badger culling on farms where the Ministry considered badgers to be the most likely source of bTB in cattle, restricted to the land occupied by the breakdown herd. This interim strategy was implemented whilst MAFF researched a live diagnostic test for *M. bovis* in badgers to allow for a long-term strategy of selective removal of infected badgers.

The interim strategy was expected to last for five years, but continued for 10 years (1986–1996) due to the low sensitivity (approximately 40%) of live diagnostic tests for badgers (Woodroffe et al., 1999). In the meantime, skin test results showed that bTB incidence in cattle was increasing, therefore raising concerns from the farming and veterinary communities about management of the disease. Meanwhile in 1998, the Government commissioned Lord Krebs to lead an expert review of evidence regarding badger culling. His report highlighted the uncertainties and the circumstantial nature of the evidence regarding studies of badgers and bTB (Krebs et al., 1997). Consequently, Krebs designed the RBCT as a definitive experiment to assess the effectiveness of culling badgers in areas with high rates of bTB. The Independent Scientific Group (ISG) was established to undertake the culling trial, to analyse the results and to complete an economic assessment of the culling methods. Its findings were written into a final report delivered to David Miliband, the Secretary of State for Environment, Food and Rural Affairs, in 2007 (Independent Scientific Group, 2007).

The RBCT had ten zones, each with three areas; one area was subject to annual culling (proactive culling), another area was subject to reactive culling “locally on and near farmland where recent outbreaks of TB had occurred in cattle”, and the final area was subject to no culling (Independent Scientific Group, 2007: 19). The RBCT ran from 1998 to 2005, culling approximately 8,900 badgers by cage trapping and shooting across 3,000 km^2 of land at a cost of £50 million.[74] However, reactive culling was suspended in 2003 as it was associated with a 20% increase in cattle bTB incidence. The ISG reported a 23% reduction in the number of OTF-W cattle bTB breakdowns in proactive cull areas, but a 25% increase in breakdowns in a 2 km wide zone surrounding the edge of the cull area thought to be due to perturbation (Independent Scientific Group, 2007). Perturbation is defined as increased ranging and mixing between social groups caused by human-made disturbance of badgers (Carter et al., 2007).

In its final report, the ISG (2007: 5) concluded that "badger culling can make no meaningful contribution to cattle TB control […] some policies […] are likely to make matters worse rather than better". Controversially, the chief scientific advisor Sir David King discounted the ISG's economic assessment of badger culling and reinterpreted the data in a report released one month later. King suggested that the "removal of badgers should take place alongside the continued application of controls on cattle" (King, 2007: 4). Nature published an editorial on the issue, which was critical of King's and the Government's actions. It states that:

> it is likely that political factors will ultimately overrule scientific ones when a government takes a decision in a contentious field (In for the cull, 2007: 2).

The Nature editorial argued that a government which asks for independent scientific advice should take note of the advice. The different conclusions drawn from data arising from the same trial led people to lose confidence in the findings, in government and in scientists.

A point of contention that underpins much of the research narrative detailed above is the role of badgers in the maintenance of *M. bovis*. Scientists disagree over

[74] Culling extended over a longer period than had been anticipated, and was hampered by resource and logistic problems – not least the interruption due to the foot-and-mouth disease epidemic in 2001 (Independent Scientific Group, 2007).

whether badgers are spillover reservoirs (the disease cannot sustain in badgers thereby cattle-to-cattle transmission is the main issue) or self-sustaining reservoirs (the disease can sustain in badgers making badger-to-cattle transmission a problem) of disease (Godfray et al., 2018). Controversy also exists because it is estimated that at least 70% of the badger population needs to be killed to have an influence on cattle disease incidence, but this varies dependent on the ability of badgers to move into and out of a cull zone — because perturbation may lead to infected badgers moving into the area. The geographic and ecological variability in the effectiveness of badger culling has in part contributed to the public knowledge controversy of bTB, particularly when findings are amplified into national policy.

Cassidy (2015: 306) notes that arguments over badger culling have become increasingly polarised as:

> the findings and conclusions of the RBCT trial have been cited, presented, interpreted, contested, analysed, re-analysed and re-interpreted by multiple scientific, veterinary, political, policy, public and campaigning actors.

Widespread contradiction between research studies provides evidence for the justification of different knowledge claims (Wilkinson, 2007) and inconsistency introduces inherent and unavoidable selection of claims. The longstanding remaking and reanalysis of data from badger culling trials and policy has contributed to the making of the public knowledge controversy regarding bTB and the related 'hot spot' controversy surrounding badger culling. This controversy has been amplified in recent years due to the implementation of a badger culling policy in 2012.

5.2. Current badger culling policy

Under the culling policy enacted in 2012, badger culling is defined as a strategy of disease control to reduce bTB incidence in high incidence areas, loosely classified as the High Risk Area and the Edge Area (Defra, 2014a). Badgers are presented as a significant wildlife reservoir for bTB and badger culling as a measure to manage the likelihood of badger-to-cattle infection (Defra, 2011e, 2014a).

The Coalition (2010–2014) and Conservative (2015–present) Governments drew on evidence from the RBCT to suggest that badger culling is an effective method of reducing bTB incidence in cattle. The coalition Government considered that the ISG deemed culling to be ineffective due to economic considerations. To have a cost-effective badger culling policy, the Government created a policy whereby farmers and landowners would pay for the operational costs of culling. In what may be deemed a somewhat radical approach to disease control, the public body Natural England (2014) announced that the operational costs of culling (for example bullets, badger carcass disposal equipment and human-power to deliver the cull) would be met by farmer-led private cull companies. Private companies would enact the control programme, while the monitoring and policing costs would be covered by central Government. In 2010 the then Minister of State for Agriculture and Food Jim Paice stated that industry-led badger culling was proposed in part to meet the Coalition Government's stated aim to reduce Government expenditure, and in part to give responsibility to farmers for reducing the disease risk in badgers (Defra, 2010). Thus, badger culling was a political practice from its inception.

Since 2012, Natural England has granted licences to private companies to kill at least 70% of an estimated badger population within a particular area, over a six week period as part of a four year cull. Licences are only provided to applicants if they meet a range of criteria, including only if they are located in the High Risk Area or Edge Area, cover an area of at least 100 km^2 and that approximately 90% of the land within the application area is accessible to licensed contractors or within 200 m of accessible land (Defra, 2018b).[75]

Badger culling is executed using two methods: controlled shooting, and cage trapping and shooting. Controlled shooting involves a licensed contractor using a spotlight, night vision or thermal imaging at a maximum distance of 70 m to locate, and then kill a badger (Defra, 2018c). Cage trapping and shooting involves baiting a cage with peanuts to trap a badger and shooting it through the brainstem with a shotgun; I present more information about the practices of killing badgers in Chapter 6.

Prior to this policy, the controlled shooting of badgers had not been used as a method to systematically cull badgers. Thus, badger culling, from its implementation in 2013 and onwards, was monitored to test the safety, humanness and effectiveness of free shooting.[76] Effectiveness is defined as:

> Test[ing] the assumption that controlled shooting is an effective method of badger removal, in terms of being able to remove at least 70% of the starting population in the area, over the course of a six week cull (Independent Expert Panel, 2014: 8).

The policy is underpinned by pre-cull badger population counts from which the number of badgers to be killed is determined (these calculations are discussed in Section 5.3). The effectiveness of the shooting procedures outlined in the policy are judged against the target of culling 70% of the estimated pre-cull population. This 70% cull target stems from the RBCT and is considered to be the minimum number of badgers that are required to be culled to achieve the desired aims in the reduction in cattle bTB incidence. In addition to this 70% minimum cull target, Defra defines a maximum target number because badgers are a protected species. The culling policy must "not be detrimental to

[75] These criteria were altered in 2016 in response to insight gained from policy practices in the field.

[76] This chapter does not focus on the humaneness and safety of the badger culling policy.

the survival of the population concerned" (Defra, 2015a: 4) according to the Council of Europe (1979) Bern Convention; the policy cannot cause local extinction of the species.[77] Estimates of the pre-cull badger population were deemed important to determine the number of badgers to be killed and to calculate the effectiveness of the policy against the 70% target kill rate. However, despite the seemingly obvious challenge of counting this species — given that badgers live underground, are nocturnal and rarely interact with humans — the policy was based on absolute badger population counts and associated percentage cull targets.

At the time of writing, badger culling has been occurring in England for six years. Whilst writing this thesis, Defra announced:

> The Government envisages that the current intensive culling policy would begin to be phased out in the next few years, gradually replaced by Government-supported badger vaccination and surveillance. Culling would remain an option where epidemiological assessment indicates that it is needed (Defra, 2020a: 29).

Whilst badger culling is envisaged to "wind down by the mid to late 2020s" (Defra, 2020a: 7), it will continue in the near future and will remain, in the Government's words, a "tool in the toolbox" (Defra, 2013a: 2) for future bTB management. Studies suggest that, like intensive culling, 70% of a badger population needs to be vaccinated to decrease the risk of transmission to cattle. Therefore like culling, badger vaccination will likely rely upon counting populations and deciding upon vaccination targets. The findings presented in this chapter are relevant to counting badgers, and consequently, are relevant for both the current badger culling policy and

[77] The Bern Convention was enshrined in the European Commission (1992) Habitats Directive and in the UK's The Wildlife and Countryside Act (1981). The European badger is listed in Appendix III as a species requiring protection. Activities capable of causing local disappearance of, or serious disturbance to, populations of badgers are prohibited (Jones, 2019).

future badger vaccination and culling policies. I reflect upon this policy change in Section 5.8.

I now explore how badger cull effectiveness was calculated from 2012 to 2016.[78]

5.3. Calculating pre-cull badger populations and badger cull effectiveness

In 2012, the NFU presented two areas in West Gloucestershire and West Somerset as suitable for badger culling. In October 2012, the pre-cull badger population was estimated in West Somerset and West Gloucestershire using sett surveys (AHVLA, 2014). This information was combined with an assumed "average number of badgers per active sett of 5.4, which was calculated from two other studies conducted over several years in the Gloucester region" (Anon, 2013: 7). The culls were planned to commence in summer 2012, but were delayed until 2013 at the request of the NFU, acting as a representative of the companies organising the culls (Defra and Paterson, 2012). The Secretary of State Owen Paterson (2012) reported that this was due to bad weather, lack of policing (because the police were working on the Olympics and Paralympics), and higher than expected badger densities. In interview, a cull company director said it was because the target cull numbers had been recalculated so appeared far higher than the number of badgers on the ground and were deemed unachievable:

> *before we actually started the cull, because we had a false start, we were going to start in 2012 and then well the numbers have changed at the last minute, it all just went wrong, so we had to postpone.*[79]

[78] I have chosen to explore the badger culling calculus from 2012 because it was from this year that a formal disease control strategy was put in place by the Government to cull badgers. I present the changing calculus until 2016 because the calculation changes thereafter replicate those taking place between 2012 and 2016.

[79] IN Cull Organiser HRA 4, 09.09.16

In 2013, badger culling was licenced in West Gloucestershire and West Somerset, granted on the basis of disease control for the purpose of eradication (Defra, 2011e). The first two years (2013 and 2014) of these culls were framed as *badger culling pilots* to test the policy's underlying assumptions about the effectiveness, humaneness and safety of killing badgers using controlled shooting.

In 2013, Defra undertook 'hair trapping' in both cull areas to estimate the size of the badger population per sett and therefore to reduce the uncertainty of the pre-cull badger populations calculated in 2012:

> Hair traps consist of short lengths of barbed wire which catch the fur of passing badgers, either close to sett entrances or on established badger runs. The DNA profile of each badger can then be determined (Defra, 2014b: 7).

The badger population size in Gloucestershire was revised in spring 2013 on the basis of the hair trapping evidence. Just before the culls began in autumn 2013, the pre-cull badger population was once again revised (AHVLA, 2014) due to new badger hair trapping evidence showing the total population of badgers was vastly smaller than original estimates (Defra, 2013b); some anti-cull activists claim this is because they removed hair from the traps in order to sabotage the cull (Stop the Cull, 2013).

The revisions in badger population counts and/or cull targets from summer 2012 to autumn 2013 reduced the estimated average badger population in Gloucestershire cull zone from 3,664 to 2,350 badgers (-30%) in less than a year. Multiple reasons were given for this reduction. The Telegraph newspaper reported:

> Defra sources claimed the initial figures were based on estimates of badger population size from 2012, and that a new analysis suggests numbers declined significantly during the harsh winter meaning fewer needed to be shot (Collins, 2013).

The BBC News reported:

> Government officials have blamed the cold winter, disease or lack of food for the dwindling numbers. […] "These badger populations go up and down," the environment secretary Owen Paterson said last week. "We're dealing with a wild animal, whose numbers will go up and down depending on weather, disease and other conditions." However, wildlife charities are concerned that illegal killing of badgers may be behind the fall in numbers (Briggs, 2013).

The parliamentary 'Environment, Food and Rural Affairs' (EFRA) Committee also commented on the revisions of badger population estimates. In its review of Defra in 2012/13, the EFRA Committee (2014: paragraph 41) noted:

> Accurate estimates of the local badger population are crucial if the success of a cull is to be accurately judged. Repeated revision of those estimates undermines confidence in the process.

Defra (2014c: paragraph 9) responded:

> Estimating badger populations accurately is difficult. Throughout the process, we have used the best available data from fieldwork carried out in the pilot areas, including those obtained just prior to culling commencing.

The BBC and the Telegraph articles were critical of Defra's stance, exposing the absurdity of the suggestion that badgers themselves created this change in their population estimates. In its response to EFRA Committee, Defra recognised the difficulty in calculating badger populations whilst at the same time reinforcing the requirement for the calculation of badger populations and its method as the best possible available. Defra did not open-up the possibility of contingencies resulting from population estimations — whereby different methodologies could produce different badger population estimates. Consequently, the uncertainty and unreliability of these seldom used population calculation methods (based on hair trapping, modelling and sett density) were backgrounded: the methods remained unquestioned and were presented as reliable.

In addition to estimating the pre-cull badger population and monitoring effectiveness itself, Defra appointed an Independent Expert Panel (IEP) to monitor the effectiveness of controlled shooting during the 2013 pilot culls. Defra (2013a) stated that:

> The [IEP] members were appointed for their expertise in animal welfare, veterinary pathology, badger ecology, wildlife population biology, statistics, marksmanship and the management of wild animal populations.[80]

The IEP monitored effectiveness by collecting shot badger carcasses and recording the total number of badgers killed, and comparing this to the estimated pre-cull badger population. The IEP combined hair trapping and sett survey evidence in two methods to estimate the pre-cull badger population and the cull rate:

> Capture Mark Recapture; the pre-cull badger population was estimated based on the number of setts in the area and the average number of badgers per sett based on the frequencies with which badgers were repeatedly hair-trapped. Then, the number of badgers culled was compared against this estimate of pre-cull population size, in order to provide an estimate of the proportion of badgers removed
>
> Cull-sample matching; the proportion of individuals that were hairtrapped pre-cull which were subsequently culled was used to estimate the proportion of the population that had been removed (Defra, 2014b: 7).

The IEP noted that point estimates of populations, which were used to enumerate cull targets using data from sett surveys and hair trapping (Anon, 2013), are inherently uncertain and variable. The IEP report contained information on six methods of calculating pre-cull badger population size and population estimates, ranging from sett surveying and hair trapping, to line transect distance sampling (Table 8). Using these methods, proposed cull targets ranged from 1,339 to 5,423 for Gloucestershire; a difference factor of four.

[80] Professor Ranald Munroe, former Head of Pathology at the Veterinary Laboratories Agency, and former president of the World Society for Protection of Animals, chaired the panel.

Table 8: ‘‘Estimates of population size in each of the two pilot areas. A range for population size represents the 95% Confidence Interval. “* RBCT: Randomised Badger Culling Trial. ** 5.4 was taken as the average number of badgers per social group, based on trapping data obtained in the RBCT (Independent Scientific Group on Cattle TB, 2007). *** CMR: capture mark recapture” (Independent Expert Panel, 2014: 13).

Est. #	Date	Source	Method	Population size	
				Somerset	Gloucs
1	2011	Defra	Based on numbers of badgers removed in initial culls during the RBCT*	1098	1339
2	2012	Farming industry	Survey work to determine number of main setts, which was then multiplied by 5.4**	2553	2492
3	2012	Farming industry	Same as above but based on additional field work	1787	1557
4	2012-2013	Defra	Survey work to determine number of active setts (2012), plus CMR*** analysis of hair-trapping data to determine average number of badgers per active sett (2013)	1501-3905	1999-5423
5	2013	Defra	CMR analysis of pre-cull hair-trapping data to determine average number of badgers per active sett. Number of active setts was taken from the 2012 survey.	850-1905	1394-3242
6	2013	Defra	Cull sample matching	1802-2512	1811-2575

The large differences in these calculations show the lack of synchronicity in evidence making regarding badger populations and the inability to accurately numerically estimate the pre-cull badger population. I argue that the representation of badger populations in numbers articulates badgers as “something that can be calculated, modelled and forecast” (Enticott, 2001: 154) and therefore precisely culled. Despite the numbers being unreliable, the practice of measuring the proportion of the badger population that has been culled (using one or another population estimate) gives the appearance of a definitive evaluation of the culling operations as effective or ineffective. [redacted]

The pre-cull badger population in Gloucestershire was based on hair trapping, sett survey work by Defra and farmers, and modelling. In other words, it was an amalgam of methods 2, 3 and 4 shown in Table 8. In the 2013 six week cull period, 30% (708 badgers) of the estimated pre-cull badger population was culled in Gloucestershire (Defra et al., 2013a). Due to this failure to meet the cull target of 70% of the pre-cull badger population, Natural England granted a licence to extend the culling period by eight weeks in Gloucestershire and revised the cull target from 70% to 58% (Defra et al., 2013a). According to the definition of effectiveness as the ability to kill 70% of the pre-cull badger population in a 6 week period, the extension of the culling period and the reduction in the target cull population implied that controlled shooting was ineffective.

At the end of the pilot cull, Owen Paterson (2013) claimed the Gloucestershire cull had been a *success* despite only killing between 43% and 56% of estimated badger population (924 badgers) according to the cull sample matching method (Table 8).[81] This cull rate was lower than the final revised target of 58% and only 25% of the original population count in October 2012. When asked in an interview if he had moved the goalposts regarding badger numbers, Paterson replied “The badgers moved the goalposts” (BBC News, 2013). The national press mocked Paterson for his suggestion that badgers were responsible for the change in population counts rather than to the (lack of) accuracy of the calculation methods (Bell, 2013).

The IEP (2014) noted the lack of accuracy in the calculation methods and concluded that if controlled shooting were to continue, multiple changes needed to be made. It recommended that hair trapping and genotyping efforts should be sustained to

[81] The extended cull period for Gloucestershire was terminated 2.5 weeks early by Natural England because not enough badgers were expected to be culled to meet cull targets (Defra et al., 2013b).

at least the same extent in the pilot areas for future years and for any future areas. This was recommended to reduce the uncertainty of population and effectiveness estimates (IEP, 2014: 51). In response Defra (2014d) 'noted' this recommendation. It did not accept it, giving the reasons as due to expense, and the method effectiveness being potentially affected by anti-badger cull protestors interference with hair-traps (Defra, 2014e).

5.4. Sett surveys and equations in two pilot badger culls

Problems remained in the estimation of badger populations, without which effectiveness and cull targets could not be measured. Defra (2014b) noted that estimating wildlife populations is subject to high uncertainty (of order of magnitude 100), and yet policymakers estimated the badger population at the start of the second year of the cull and used this to set a minimum cull target number for Year Two. In Somerset this was done using the number of active setts (from June to July 2014) and estimates of the number of badgers per active sett from 2013 (based on hair trapping and sett surveys). In Gloucestershire this was done differently: choosing the lowest 'mid-point' number from a range of estimates arising from five methodologies. Defra (2014b: 12) advised Natural England to use this approach to estimate the minimum cull number because it "assumes that there is no rational way of distinguishing between these methods". The chosen number was created from a methodology that used a step-by-step series of assumptions about badger reproduction, mortality and badger incursions from outside the cull area. Defra wrote that the method chosen for Somerset was probably most reliable, but chose a different method for Gloucestershire because all methods produced relatively consistent results. The use of different methods in each cull zone made the methods and numbers incommensurable.

At this point officials made the contentious decision to start revising cull targets midway through the cull. Revisions were made if evidence suggested that the number of badgers in the cull zones was lower or higher than estimated. Defra revised targets dependent on the effort deployed by contractors in each unit of land within the cull area and the number of badgers 'removed' (Defra, 2014b). To enable these revisions to occur, cull companies were obliged to provide data regarding:

> levels of culling effort applied (e.g. contractors deployed, hours spent shooting, number of traps set) and the number of badgers removed as well as the location where such effort was deployed (Defra, 2014b: 15).

In an interview about the methods employed in the badger culls badger ecologist Rosie Woodroffe, who worked on the RBCT, said "the Government risked losing trust on how it used evidence" (Ghosh, 2017). The revision of badger population estimates mid-cull made the calculations of effectiveness dependent on contractors killing badgers. As noted by Woodroffe, this made the calculations difficult to evaluate as effective or ineffective. Ghosh reports:

> according to Prof Woodroffe, if the Government can revise its targets then by definition the culls will always be successful
>
> "Where few badgers were being killed, they lowered the targets; where a lot were killed, they raised them. This means that there is really no way to tell what reduction in badger numbers was achieved by these culls. Culling that was consistently ineffective would look like a low badger density and prompt a reduced target" (Ghosh, 2017).

Woodroffe notes that lower population counts increased the likelihood of the cull company killing 70% of the pre-cull population and therefore the likelihood of the policy being deemed 'effective'. This is a policy loop: cull targets are constructed in government offices, represented in documents which influence practices in the field, and re-constructed based on data from the field. In other words, the enactment of policy in the field is dependent upon and influences the enactment of the policy in government offices. Through this loop, all culling practices can be argued to be effective (see Section 5.6).

Defra decided that the culls would not be independently monitored in 2014, as undertaken and recommended by the IEP. Instead, Natural England conducted effectiveness monitoring in 2014 and Nigel Gibbens (Defra's Chief Veterinary Officer) reviewed the culls on a yearly basis. This did not open up the methods for independent analysis. West Gloucestershire culled 274 badgers (target 615–1091) and West Somerset culled 341 badgers (target 316–785) (Defra, 2014f). [redacted] West Gloucestershire zone missed its minimum cull target by 341 badgers, [redacted]

Defra (2014e: 7) recognised the "considerable uncertainty" of "pre-cull numerical targets based on population estimates", but continued to simplify the complexity of badger populations into a single number and to use this number to derive targets from which to determine whether the culls were effective. Three out of four operations in the two pilot cull zones in 2013 and 2014 did not achieve the pre-cull minimum cull targets, but all culls were licenced to continue [redacted]. This was determined on the ground that "The chief veterinary officer (CVO) has advised that the 60% reduction this year [2013] will deliver clear disease benefits as part of a four-year cull" (Paterson, 2013) and that in 2014 Somerset did indeed cull the target number of badgers (Defra, 2014f; Gibbens, 2014).

[redacted] Similar pronounced patterns of uncertainty and certainty in science-policy interfaces have been analysed in relation to climate change (Mehta and

Srivastava, 2020) and monetary policy (Walter and Wansleben, 2020). In both cases, both sets of authors argue the uncertainty in evidence is recognised and considered, and yet policy-making is often dominated by efforts to minimise and control uncertainty. [redacted] Government rolled out the cull to Dorset in 2015 and to seven new areas in 2016. I now turn to the modelling techniques employed by the State for these new cull areas.

5.5. Modelling of badger populations in 10 badger cull areas

In 2014, Defra concluded that the sett survey method was more reliable than modelling methods in estimating the pre-cull badger population count. However in 2015 and 2016, [redacted] Defra used modelling methods to enumerate cull targets in new areas. The starting badger population for the seven new cull areas in 2016 was estimated in a wholly new way: through a National [badger] Sett Survey (Judge et al., 2014) and a badger Social Group Size study (Defra, 2016b; Judge et al., 2017). These studies produced estimates for the average number of badger social groups and average number of badgers per social group in relation to seven broad Land Class Groups.[82] Ambiguity in this method was reported by the science correspondent for BBC News:

> The new method predicts a higher and lower number for the total number of badgers in any given cull area. This reflects the scientific uncertainty. In its advice to Natural England, who issue licences for the trials, Defra has suggested the agency require culling companies to kill the lower number. The document also states that if it becomes apparent during

[82] The Land Classification System was devised by the Centre for Ecology and Hydrology and it assigned each 1 km square in the UK to one of seven broad landscape types, known as Land Class Groups (Judge et al, 2014).

> the cull itself that there are more or less numbers than predicted the targets should be revised accordingly (Ghosh, 2017).

The minimum and maximum numbers of badgers to be removed in the first year of the culls were calculated from the lower end of the population size range rather than the average population size (Defra, 2015c). Defra states that this is “a precautionary approach” to reduce the risk of local extinction (Defra, 2016b) according to the Bern Convention (Council of Europe, 1979). However, this approach was controversial. Calculating targets from the lower end of the population size range rather than the average population size meant fewer badgers needed to be culled for the culls to be defined as effective, hence effectiveness became more achievable (Ghosh, 2017). A scientist who calculates wildlife populations informed me that no respected academic scientist would base the population size on the lower end of the estimated badger population because it is *“twisting the statistics to meet your needs”*.[83]

In 2016, all seven areas had their minimum and maximum cull targets updated mid-cull based on contractor effort and badgers killed. Table 9 displays the difference between the starting and the revised minimum and maximum cull targets.

[83] IN Biologist, 15.11.18

Table 9: Changes to badger cull target in 2016. Data for starting (Defra, 2016b: 16) and updated (Defra, 2016c: 2) minimum and maximum numbers in Areas 4 to 10, and the percentage difference.

Area	**Minimum and maximum numbers based on lower level of the population estimate**		**Updated minimum and maximum numbers based on contractor effort and badgers killed**		**Percentage change between the original and the updated minimum and maximum numbers (%)**	**Number of badgers killed in 2016**
	Minimum	**Maximum**	**Minimum**	**Maximum**		
Area 4- Cornwall	1299	1763	588	798	-54.7	711
Area 5- Cornwall	874	1187	730	991	-16.5	851
Area 6- Devon	1922	2609	1502	2039	-21.9	2038
Area 7- Devon	1436	1949	717	973	-50.1	833
Area 8- Dorset	1282	1740	2571	3489	+100.6	3000
Area 9-Gloucestershire	1463	1986	1844	2503	+71.1	1853
Area 10-Herefordshire	872	1183	568	750	-34.9	624

The variations in the updated numbers and the number of badgers culled in Table 9 shows that target numbers were reduced in five areas, in two areas by more than 50%, whilst one area more than doubled its target number. All seven new areas met their updated minimum number and did not exceed their maximum number; Area 6 Devon was only 1 badger short of its maximum number. Four of these areas killed less badgers than the original minimum target number and one area killed 1,260 badgers more than its original maximum number (Area 8 Dorset). If there was a consistent error in the calculation methodology (and contractor effort was stable across all cull areas, as reported), it is likely that the minimum/maximum numbers would be consistently above or consistently below the number of badgers killed. [redacted] I now turn to analyse how these changes in the calculus of effectiveness enacted the policy and the contention that this then caused.

5.6. Unpacking the policy loop

I look to make sense of the changing calculus of badger cull effectiveness by considering the pre-cull badger population counts and badger cull targets as 'social entities' (Lippert and Verran, 2018). Verran (2012b: 112) considers that "the workings of numbers are deeply embedded in and constitutive of the real". This way of thinking about numbers takes them as relational, as devices and as inseparable from how they are made and what they make. This work shapes my argument in two ways. First, I consider the calculus not only in the evaluation of the effectiveness of the policy, but also the enactment of the policy itself. I show how [redacted] numerical format enables them to be brought together and compared. Second, I undertake relational analysis of the effectiveness calculus so that I can develop my concept of the badger culling policy loop. [redacted]

As detailed earlier in this chapter, officials recognised the difficulties of creating numbers and the uncertainties in the methods of calculating badger populations and target cull rates [redacted] (see Chapter 6). The control over policy-as-practice made by the use of numbers can be seen in the focus on badger cull effectiveness in the first place. It is important to remember that the stated aim of the pilot badger culls was [redacted] to test the effectiveness of free shooting; Defra (2011d) claimed that the RBCT provided substantial epidemiological evidence to prove the impact of badger culling on reducing bTB incidence. Thus, the aim of these pilot culls diverged from the central policy target of disease control. Law and Singleton's (2005) concept of managerial methods is useful to explain this slippage from providing cull licences for the purpose of bTB control, to pilot culls aimed at measuring the effectiveness of controlled shooting in removing a percentage of the badger population. In their research exploring the management of alcoholic liver disease, Law and Singleton found it was difficult to keep the condition in focus, in part because it was messy: it was difficult to order, to clarify and to know. They write that to make the condition comprehensible, its messiness was subject to managerial interventions:

> Nice and regular, it makes clear trajectories, and objects that may be known because they don't slip and slide imperceptibly into other and different objects (Law and Singleton, 2005: 2–3).

Badger culling policy slipped into nice and regular measurements of effectiveness. In part, it was reasonable that a new method of killing badgers (controlled shooting) needed to be tested to examine if it was effective. It was reasonable to simplify a complex policy of bTB control into sections that can be evaluated and managed. [redacted] Latour (1993) states that the practices of calculating and defining as part of scientific enquiry simplifies research outputs from the complex network on which they rely. The process of calculation relies upon, and renders, the work of networks “invisible, unthinkable, unrepresentable” (Latour, 1993: 34). The invisible, unthinkable and unrepresentable network for the badger cull includes badgers moving into and out of the cull area, badgers reproducing, contractors not killing enough badgers, cull areas not having ‘hard’ boundaries to reduce the likelihood of badger movements, not having reliable methods of estimating badger populations, change in cattle density, change in badger density, topography, anti-cull activism and cattle interacting with badgers. To define and measure these aspects of the network, in order to measure the change in cattle incidence due to badger culling, poses a significant challenge. Badger culling, however, bypassed this complexity: it was implemented as a policy and not as a trial from which variables and outputs could be measured (Section 6.2.1 details how this challenge has been managed). [redacted]

Drawing on Enticott’s (2001) work on bTB statistics and maps, this slippage into numerical calculations of effectiveness ordered, legitimised and enabled governance of the badger cull policy. The making of badger culling through numbers articulates proof of the effectiveness of the policy and imposes a regime onto the field from afar. The changing of targets mid-cull creates a looping calculus to calculate badger populations and cull targets: the policy makes it lawful for accredited contractors to kill badgers, officials to estimate badger populations, contractors to put effort in to kill badgers, and officials to recalculate badger populations mid-cull based on contractor effort and kill rates. [redacted] Needless to say, culling cannot happen without the policy, and the calculus of cull effectiveness underpins the policy. This badger cull policy loop related to effectiveness is displayed in Figure 16. The policy loop in Figure 2 (page 21) is high level, whilst the policy loop in Figure 16 zooms in on effectiveness.

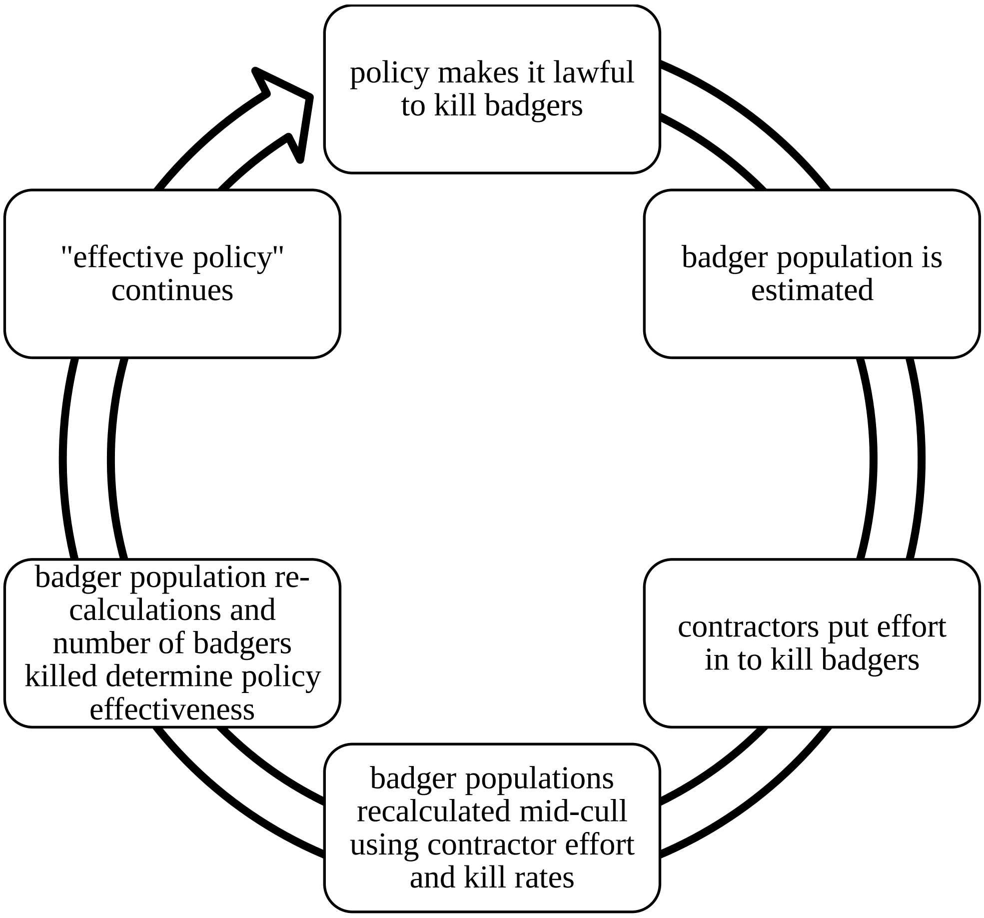


Figure 16: Loop for badger cull policy related to effectiveness (Author)

I consider this policy loop to be a device. The numbers estimated and recorded within it have a ‘social-functioning’ (Verran, 2012b) of measuring and defining effectiveness and perpetuating the cull. As shown, the numbers used in the calculation of badger cull effectiveness were not fixed and defined, but rather made to be coherent, editable and comparable units. In his analysis of calculation devices, Lippert (2018: 64) writes how “cohering elements contribute to amassing certainty, despite mathematical inconsistency”. Although the badger populations and cull targets numbers were created using different methods, each absolute number appears compatible, and thereby combinable in the numerical system. Hence, a coherence was created amongst the “mathematically non-cohering processes” (Lippert and Verran, 2018: 4). In other words, the calculus of badger cull effectiveness is a device that achieves certainty and coherence despite ever-changing inconsistencies. [redacted]

The numbers have a social functioning in how they “come to life and to stay live” (Verran, 2012b: 121) based on population surveys, modelling and percentage calculations, and through the killing of badgers and the counting of their carcasses. But, the multiple calculations of effectiveness described reveal the creation of incoherence, inconsistence and chaos. Varying ways of counting badgers generated different populations which lacked synchronicity and brought large differences in cull targets into being. The incoherence in these methods loops back into the badger culling network to impact on the badger culling policy, both in government offices and in the field. Veterinarian Trevor Jones (2018: 117) notes how Defra prides itself on making ‘evidence based policy’, but has been accused of “plunging into a badger culling exercise and obtaining evidence retrospectively”. [redacted]

Interestingly, Defra recognised and criticised a similar looping calculus [redacted]. In a document advising Natural England on ‘Setting the minimum and maximum numbers for Year 2 of the badger culls’, Defra (2014b: 10) placed low confidence in a new method proposed by Defra using RBCT data to estimate pre-cull badger population counts because:

> the initial starting populations [redacted] were only calculated after the culls and were themselves not independent of the data emerging from the culls. This raises a question as to whether this [proposed new] method is valid, because there was no independent estimate of the number of badgers. In addition, the assumption that the badger populations in the Gloucestershire and Somerset cull areas will have responded to culling in the same way as in the smaller RBCT areas is weak.

[redacted] Lippert (2018) suggests that oscillations such as this strengthen the power of numbers as they evoke both doubt and confident action. [redacted]

[redacted]

However, the loop caused confusion. [redacted] Defra used the results of the RBCT to claim that the implemented badger cull would reduce bTB incidence in cattle (APHA, 2018d), whilst changing the methods by which badgers were to be killed (from cage trapping and shooting, to controlled shooting and cage trapping and shooting). In addition, the purported significance of badger culling on reducing bTB incidence was already contentious and the badger culling policy had been disputed by a raft of experts. Before the culls began, 31 eminent animal disease experts signed a letter to The Observer in 2012 describing the cull as a “costly distraction” that risks making the problem of bTB worse (Carrington and Doward, 2012). In the letter Lord Krebs, architect of the RBCT, wrote “this cull is not the answer to TB in cattle. The Government is cherry-picking bits of data to support its case”.

In a blog for the Zoological Society of London Woodroffe (2018) noted:

> The science of bovine TB control is like a cherry orchard: it offers an abundance of evidence that you can pick through, selecting fragments that seem, on their own, to support almost any position on TB management.

[redacted] I argue that this gap was amplified by the calculus loop’s two roles: first to estimate badger populations and second to judge whether the culls were effective. The first role allowed for the recognition of uncertainty in policy-as-representation-as-practice in reports, whilst the second role eliminated uncertainty in policy-as-practice as the numbers were continually used to define effectiveness.

Professor Tim Coulson, a wildlife population biologist and member of the IEP, articulated these two roles of the calculations of numbers for the badger cull in an interview with the Guardian newspaper. Coulson criticised Defra's recalculations of cull targets mid-cull:

> "The targets are being based on poor estimates of [badger] population size and are deliberately being biased downwards" to construct cull targets which are easier for the cull companies to achieve, and therefore for policy to deem the badger culls as effective [at killing 70% of the pre cull the badger population] (Carrington, 2017).

Coulson suggests that badger populations and cull targets were used to both estimate badger populations and to judge whether the culls were effective. This dual use of numbers recalls Verran's work on the importance of opening up the practice of making numerics so as to explore how numerics are used. In her exploration of the practice of numbering, Verran (2012b: 112) suggests that calculation involves:

> a seamless elision of the dual moments of articulating an order so as to create value, and valuing the categories created in the order, to stabilize the order.

The switch between ordering and valuing can shift from a number that produces order to a number that makes an epistemic claim. Coulson's critique suggests that badger population calculations were created to count the number of badgers. But, this was not just a count. It was a count compared against the value judgement of effectiveness (70% cull rate). Hence, Coulson criticised how the population counts and cull targets comprised value judgements "for policy to deem the badger culls as effective" (Carrington, 2017).

Contention about the looping calculus and the changing targets mid-cull played out in 2018 when conservation ecologist Tom Langton commenced legal action against Defra for the policy change allowing badger culling in the Low Risk Area. On his 'crowdjustice' website, Langton (2018) writes:

> we have commenced legal action against those actions that fly in the face of accepted science. Levels of ambiguity in the methods seem to move the badger killing process further towards a 'make it up as you go along' endpoint.

Langton critiqued Defra for employing ambigious methods. [redacted] (Lippert and Verran, 2018: 4). The changing methods of calculus means that the cull targets are incoherent across years, but the ability to combine numerical outputs has enabled policy "to mix up and integrate things that are quite incommensurable" (Verran, 2012b: 120). For example, for 2018 Defra estimated badger populations based on "the average number of badgers culled per km^2 in previous first year culls" (3.18 badgers per km^2) (Defra, 2018d). No sett-survey information was included from the new cull areas and local variation was discounted from the population estimates as Defra attempted to standardise its methods.[84] This standardisation occurred despite the previous first year culls' badger populations and cull targets being calculated using different methods. In interview, an anti-badger cull protestor said *"the badger cull is a perfect example of Government policy endorsing a brand of populism rooted in ignorance"*.[85] A similar viewpoint was expressed by Gudrun Ravetz, the president of the British Veterinary Association (the national representative body for the veterinary profession in the UK), albeit in different terminology. Commenting on the cull areas in 2017, Ravetz implied that officials were not using an "evidence-based methodology" to estimate badger populations. She said:

> In terms of numbers, it is clear that badger population estimates have previously demonstrated considerable uncertainty and imprecision. It is critical that as accurate as possible population estimates, using an evidence-based methodology, are obtained and made openly available. We

[84] This standard implied that the National [badger] Sett Survey (Judge et al., 2014) was incorrect in its reporting of badger population variation in LCGs, as Defra assumed badger populations were the same across all cull areas.

[85] IN Badger Protector HRA 1, 29.09.16

> would urge clarity over cull timeframes, numbers and mid-cull review methodology (British Veterinary Association, 2017).

The inconsistencies between government and national organisations' viewpoints about the conclusions drawn from the cull effectiveness calculus [redacted]. In summary, the looping method of calculating badger culling effectiveness (including how many badgers should be killed) is controversial in and of itself, in addition to the act of killing badgers.

5.7. Conclusions

This chapter has described the [redacted] history of the badger culling policy from 2012 to the present [redacted]. Government has made multiple declarations that the policy is "carefully-managed and science-led" (Defra, 2011a: 1) and based on "robust evidence" (Defra, 2018d). [redacted] a scientist who calculates wildlife populations told me in interview, *"Defra has picked and chosen from a tombola of ambiguous, controversial and uncertain methods"*.[86] [redacted]

[redacted] This has generated difficulty between actors, amplified by the contested history of badger culling. [redacted]

[86] IN Biologist, 15.11.18

[redacted]

Thus far, I have primarily examined how badger culling was made using calculations in policy documents and official records, specifically in relation to the estimation of badger population and cull targets. [redacted] However, government's framing of the badger cull policy process is only one form of understanding. I saw badger culling in another format — I experienced it 'otherwise'. I followed the distinctive badger culling policy-as-practice into the field and witnessed, and became part of, the policy in areas of South West England. To more fully understand the establishment and implementation of this policy, I turn to present stories [redacted] of the badger cull and [redacted] the badger cull policy network. I show the unexpected practices and affects of policy in the field. I now move into the field to present another part of how badger culling policy-as-practice is done.

5.8. Post note

As detailed in Section 5.2, in 2020 government announced that it would "begin an exit strategy from the intensive culling of badgers […] by deploying vaccination to the remaining badger population" (Defra, 2020a: 7). This announcement was somewhat expected as it was stated as a policy option in 'The Government's Policy on Bovine TB and badger control in England' (Defra, 2011e). A licensed injectable vaccine (BadgerBCG©) has been shown to reduce the severity and progression of disease in both captive (Chambers et al., 2011; Lesellier et al., 2011) and wild badgers (Chambers et al., 2011). Vaccination can contribute to disease control by reducing the numbers of either susceptible and/or infectious individuals in a population and thereby reducing the number of new infections (Carter et al., 2012). Intuitively, if badgers are an important source of infection to cattle, then reduction in disease incidence in badgers should result in fewer new infections in livestock. However, at present there is no evidence to assess the effectiveness of badger vaccination on cattle bTB incidence. Government proposes that vaccination areas could help to collect this evidence (Defra, 2020a).

Officials creating new badger vaccination policies can learn lessons from the progress, operational effectiveness and participant motivations of badger vaccination undertaken in England by non-government groups from 2010 (Benton et al., 2020). Furthermore, lessons can be learned from the calculus of effectiveness in badger culling. The findings presented in this chapter are as relevant to badger vaccination practices as badger culling practices because the two policies rely upon similar calculations; the badger population needs to be counted and the proportion of badgers that are vaccinated needs to be assessed.

Chapter 6. From effect to affect: badger culling practices in the field

> *Steve* [buddy] *spots a badger on thermal imagery and lights it up with a red torch. It is head on to us so Justin* [shooter] *cannot shoot it. Steve begs the badger to turn around slightly under his breath. It does. Justin shoots. The bang echoes like a cannonball. "I bet every anti* [anti cull activist] *in a five-mile radius heard that!" says Steve.*
>
> *Immediately after the shot, we hear two car horns beep loudly on a nearby track. We quickly march to get the badger. Steve dons gloves, picks up the carcass and places it in a dyke to hide it from view. We walk over a footbridge into another parcel of land with two gates at either end that are tied shut. I am getting nervous.*
>
> *Steve tells us to be quiet as there is someone in the adjacent coppice with a flashlight, approximately 150 metres from us. My heart beats fast. Steve and Justin decide to return to pick up the badger from the dyke and head back to the truck. After collecting the badger, Steve uses the thermal imagery to search for both anti cull activists and badgers simultaneously.*[87]

The previous chapter explored the calculus of badger culling effectiveness in government offices. It showed that, since its first use in the 1970s, systematic badger culling has been closely associated with a narrative of disease control. More explicitly, under the culling policy enacted in 2012, badger culling is defined as a strategy of disease control to reduce bTB incidence in high incidence areas, loosely classified as the High Risk Area and the Edge Area (Defra, 2014a). Chapter 5 demonstrated how this narrative of control is present and visible in government offices, in part through the calculation of effectiveness. Due to the importance of disease control to the establishement and implementation of badger culling policy in government offices, I expected disease control to be visible in the field.

I spent three months in badger cull zones in autumn and winter 2016 undertaking an ethnographic study of badger culling practices in the field. I entered the field open to possibility and open to following the themes that might arise. To keep track of how

[87] FN controlled shooting HRA 3, 06.10.16

my thoughts developed, I wrote detailed fieldnotes that were often questioning and self-reflexive. A key theme that arose from my fieldnotes was the extensiveness and significance of emotions and feelings in the field. Consequently, my fieldnotes and interview transcripts led me down the path of affect. Curiously, mentions of bTB were mostly absent from my fieldnotes detailing nights spent shooting badgers or undertaking actions against the badger cull.

This chapter begins by introducing the literature on affect that I draw on as an analytical lens for making sense of the practices I observed as part of badger culling. Following this, I present findings from participant-observation and interviews to detail how, somewhat unexpectedly, badger culling has weak associations with bTB and much clearer ties to highly affective dimensions — such as relationships with badgers, interweavings with fox hunting, rurality, fear, thrill, morality, intimidation, communities and friendship. The badger culling policy supports these affective relations; these relations, in turn, were vital to the realisation of badger culling policy in the field.

Through five vignettes, I present the affective generativity of the following practices associated with either killing or protecting badgers: controlling disease and controlling badgers; controlled shooting; cage trapping and shooting; undertaking intimidation and direct action against the cull; and, sabotaging the badger cull and the fox hunt. The findings are descriptive and written in the present tense to provide an immediacy to the situations so that the reader can more closely relate to what the policy engenders (Gregg and Seigworth, 2010). First I outline the relationship between badger culling and disease control. The official narrative of control is expressed as a numerical reduction in bTB incidence. Yet to some farmers and landowners, control resonates affectively as the hope of killing a previously uncontrollable vector of the disease and as an opportunity to kill a nuisance species. I argue that this sense of control is emotionally charged; it is affective. It is generated by, and, crucially, contributes to the continuation of the badger cull. Furthermore, farmers detailed how this sense of control gave rise to other disease management practices, such as the implementation of biosecurity on-farm to further reduce disease risk. Hence I propose that the affective dimension of disease control means that other practices will be enacted.

Next, I show how enjoyment and financial incentives underpin the motivations for shooting badgers by those contracted to do so. I also show how intimidation practices by some anti-cull activists aroused affective responses such as fear, determination and community support among those involved in the cull. Additionally my ethnography illuminates affective leakages from legal badger culling into illegal badger persecution and fox hunting. Affect is bound strongly as part and parcel of the cull, even though weakly and indirectly related to bTB.

These vignettes present the affective dimensions of badger culling policy-as-practice in the field. They show how these dimensions also have generative potential; I use the term generativity to refer to the constant making and production of things and realities through practices (Law and Lien, 2012). Through my vignettes, we will see how it is not only that the badger cull generates affect, but that affect reciprocally generates the cull. Thus I reconceptualise the policy loop that I introduced in Chapter 1 as an affective policy loop. Weaving theoretical insights from emotional geography and policy studies with my own ethnographic descriptions, I argue that 'affect' is an overlooked catalyst for the looping mechanism across multiple practices and sites.

No other research on bTB has directly applied the theoretical repertoire of affect, and no other qualitative research has directly explored practices of controlled shooting and cage-trapping badgers. Therefore this chapter develops understanding of how affect patterns into the ways that bTB is made and presents a unique insight into badger culling practices in the field.

6.1. Affect

There is an established and growing literature on 'affect' across multiple disciplines. Originating from the works of philosophers Bergson (1896), Deleuze (1988) and Spinoza (1996), it is now being used in and developed through disciplines such as geography, sociology and cultural studies, with particular interest from social psychologists and emotional geographers over the past two decades (Clough and Halley, 2007; Harrison, 2007; Massumi, 2002; McCormack, 2003; Thrift, 2004, 2009). In her review of the term, cultural and political geographer O'Grady (2018) argues that affect has become important due to its conceptualisation of the world beyond representation. Representation became a prominent theoretical and methodological element of geography through the examination of the world via mediatory forces such as texts, maps and statistics. Emotional geographers argued that the focus on representation limits understandings of how agents "experience life in space" (O'Grady, 2018) because representation considers spatial experience to be a second order phenomenon. Non-representational theory was therefore developed to help understand our immediate experiences of the world in different spaces and in everyday life by focusing on relations between agents (Cadman, 2009). As part of non-representational theory, affect came to the fore in emotional geography to focus on:

> the set of ever-changing processes human and non-human bodies undergo as they experience, encounter, and perform life among other bodies within material space (O'Grady, 2018).

Affect as a concept — and specific types of affect such as fear, enjoyment and control — is complex, delicate and visceral. The term is variously defined as: being forces other than conscious knowing (Gregg and Seigworth, 2010), perspectives of embodied bodies

(Massumi, 2002), relational and in shared spaces (Anderson and Harrison, 2006; McCormack, 2006), and embodied practices (Thrift, 2004). I use the term 'affects' to account for relational forces arising from practices and embodied in agents, human and more-than-human alike, that catalyse capacity for action (Brennan, 2004; Gregg and Seigworth, 2010; Hynes and Sharpe, 2009; J. Lorimer, 2008; Pile, 2010). These affects "last as long or as short as the set of relations which hold them together are present" (O'Grady, 2018). Therefore, I investigate affects by focusing on experiences and relations in my ethnography.

There is ongoing debate and disagreement about whether emotion and affect should be categorically separate (Jacobs and Nash, 2003; Lipman, 2006; H. Lorimer, 2008; Pile, 2010; Thien, 2005). This debate is beyond the realm of the chapter, but for the purpose of this work, I follow the work of McCormack (2006) and consider emotion to be the projection or display of a feeling which is personal and internal, whilst affect "can be expressed spatially as existing across and among people and things, not within them" (O'Grady, 2018). I use the terms affective, affect and emotion in this chapter dependent on whether feelings are predominately relational or individual. For example, I consider my nervousness, expressed in the fieldnote at the beginning of this chapter, to be affective as it was generated in relation to the car horns and the flashlight in the adjacent coppice. I embodied the nervousness in my fast heartbeat and Steve embodied the nervousness in his use of the thermal imagery to search for anti-cull activists. We expressed affect differently, but it linked us both together into nervousness at what could happen and caused changes in our actions as we attempted to avoid a face-to-face encounter with anti-cull activists.

The theoretical repertoire of affect has not been applied in research on bTB, but that is not to say that affect cannot be recognised in some of this research. For example, multiple studies have reported that trust and confidence in the State with regard to bTB control is low, with farmers unlikely to act on official advice concerning biosecurity practices (Fisher, 2013; Naylor and Courtney, 2014; Robinson, 2017a). These low levels, and erosion, of trust relate to farmers' lack of confidence in how epidemiolocal and ecological trials funded by government were undertaken (in particular the RBCT), dismissal of farmers' own biosecurity knowledges by official sources, and the impracticality of official recommendations on biosecurity (Enticott, 2008a, 2008b).

Affect resonates in these studies exploring biosecurity practices, but has not been explicitly explored. The limited attention on affect in a limited range of bTB practices presents a gap in understanding how affect patterns into the ways that bTB is made. I argue that affect is especially salient for badger culling due to its surrounding public knowledge controversy. This chapter contributes to this research gap by exploring the role of affect in badger culling practices. In doing so, this chapter addresses RQ3: 'How is badger culling policy made?'.

There is widespread recognition of the importance of practices in the development of the badger culling controversy. Practices related to epidemiology, farming, veterinary science, conservation and ecology are employed by different groups in the support of and opposition to badger culling (Cassidy, 2015; Enticott, 2001; Grant, 2009; Lodge and Matus, 2014; Wilkinson, 2007). In spite of this, social research related to badger culling is limited, for example investigations of culling as a hypothetical policy option with farmers (Maye et al., 2014; Robinson, 2014), and through journalistic and campaign-based research in opposition to culling (Barkham, 2013; Dyer, 2016). Only one study explores the actual *practices* of badger culling in the field (Price, 2017). In his book 'Thinking Through Badgers: Researching the controversy over bovine tuberculosis and the culling of badgers', Price details findings from 23 interviews with farmers, vets, police and badger protectors in and around the Gloucestershire and Somerset cull zones. Through interviews and participant observation, he sought to explore their involvement with bTB and badger culling. Price (2017), like Cassidy (2019), is concerned to understand how the articulation and enactment of evidence by different groups has contributed to the public knowledge controversy, and to explore the extent to which it is possible to bring together a range of knowledges to provide avenues for progress for this controversy.[88]

Missing from all these studies are insights from any direct participant-observation of culling with badger shooters (also described as contractors). The empirical oversight of the way that the cull policy is enacted on the ground — badger culling policy-as-practice in the field — has implications for what bTB is. Notably, a direct connection between badger culling and control of bTB (outlined in Section 5.1) remains widely accepted and unquestioned. Consistent with Ward et al.'s (2004) findings on the confined framing of Foot and Mouth Disease in regard to agricultural interests, the narrow framing of badger culling relating to bTB has the effect of silencing other aspects of badger culling.[89] This silencing makes the practices of culling in the field less visible and overlooks their affective generativity, meaning the influence of affect in the enactment of the policy is obscured.

There is a need for researchers to pay attention to badger culling *practices* in the field because 'the field' is a site, in addition to the office, where the policy is done. It is necessary to theorise, consider and evaluate the generation of affect in the badger

[88] Cassidy (2019: 15) argues that the "badger/bTB public knowledge controversy involves multiple, overlapping and distinctly fuzzy groupings, which change over time" and lead to disagreements in science. In particular, Cassidy follows three communities of scientists: animal health, disease ecology and badger protection. I outline this work in Chapter 1 and 2.

[89] Notable exceptions being the work of veterinary specialist Steve McCulloch and researcher of science education Michael Reiss on the ethics of badger culling (2017a, 2017b, 2017c, 2017d, 2017e).

culling policy loop to better understand what engenders the cull and what the cull engenders. I bring to the fore the role of affect in the practising of badger culling in the field. Recognition of affect will improve understanding of the "seemingly entrenched conflict" (Price et al., 2017: 1) between those who support and those who oppose the practice, and improve evaluation of the causes of changes in bTB disease incidence related to badger culling. I now provide five vignettes from my ethnography in the badger cull zones to uncover the role of affect.

6.2. Badger cull affective generativity

In the following sections, I refer to people who are undertaking licenced shooting of badgers as contractors. Contractors are part of cull companies, private businesses established with the purpose of conducting the cull. Contractors are composed of two groups: controlled shooters and cage trappers. Best Practice Guidance for controlled shooting suggests that a minimum of two people (shooter and buddy) should be involved in controlled shooting:

> Two people are required for humaneness and health and safety reasons, and so that one person [the buddy] can operate the spotlight/image intensifier leaving the other free to concentrate on shooting and the safe handling of the firearm (Defra, 2018c: 4).

I use different terms throughout this section to refer to those people whose actions oppose the badger cull, in accordance with original fieldnotes and interviews. I refer to each group individually where appropriate and use the terms 'badger protectors' to refer to all people taking action against the cull.[90] When drawing on fieldnotes or interviews with people involved in the cull company, I use cull company's terms: 'antis' or anti-cull activists.

[90] The term 'badger protectors' was suggested as appropriate by both a saboteur and 'Gloucestershire Against Badger Shooting' member.

Activities to disrupt the badger cull arose when badger culling was first announced in 2011. Multiple groups were established, and have since expanded, to provide logistical and practical information to help stop the badger cull, to patrol the cull zone, to undertake direct action against, and to sabotage the badger cull. These groups have different roles in the cull, but all share the same aim to protect badgers. Price (2017) conducted research with anti-badger cull groups such as the Wounded Badger Patrol and Camp Badger. These groups patrol the badger cull zone at night to stop controlled shooting, but (in the main) do not undertake ‘direct action’ in the sense of intimidating farmers, trespassing and destroying cages. I undertook research with both the Wounded Badger Patrol and Camp Badger, in addition to groups undertaking direct action against the cull. In response to the lack of research that has been undertaken in the cull zone and my limited word count, I do not detail findings from my research with the Wounded Badger Patrol and Camp Badger. Instead, I focus on those groups undertaking direct action against the cull. I recommend reading Price’s (2017) work for detail about Wounded Badger Patrol and Camp Badger.

The following sections draw on photographs, fieldnotes and interview excerpts to address the evidence gap of badger culling practices in the field. I detail five vignettes, specifically focusing on the affective generativity of different elements of the badger culling policy-as-practice in the field:

- Controlling badgers and controlling disease
- Controlled shooting of badgers
- Cage trapping and shooting of badgers
- Undertaking intimidation and direct action against the cull
- Sabotaging the badger cull and the fox hunt

6.2.1. Controlling badgers and controlling disease

Many farmers in the badger cull zone distinguished between badgers as clean and dirty based on a spatialised understanding of disease risk. Clean badgers are generally considered to be those that do not have *M. bovis* and dirty badgers are those that have contributed to a bTB breakdown. As a territorial species, badgers are prone to remain in the same area, and defend their territory from other badgers. Therefore, clean badgers can be a cattle farmer's "best friend" (Hill, 2016a: 17) as they reduce the chance of dirty badgers from entering their farm and potentially causing a breakdown in their herd. In a similar vein, dirty badgers can be a cattle farmer's "worst enemy" (Hill, 2016a: 17) as they can introduce and keep bTB in a herd, potentially causing successive breakdowns. This spatialised understanding of clean and dirty badgers is reported in interviews with farmers who were considering taking part in the badger cull (Maye et al., 2014). However, the practice of badger culling has created tensions within this clean and dirty classification:

> *if you've got a clean set on your farm they don't do you any harm at all do they, but you get rid of that clean set and that leaves it open then for a dirty colony of badgers to come in and bring TB onto your holding. Now we are indiscriminately killing clean and dirty setts, but I don't know. I'm just happy for the badger numbers to be kept down really low, as we all know they've all got out of hand because they've been given free run, but yeah, it's not going to do any harm at all to keep culling them.*[91]

This extract presents tension between farmers' understanding of badgers as clean or dirty and the indiscriminate culling of badgers in the cull zone. The policy frames all badgers as potentially dirty in the cull zone. The policy, unlike farmers' understandings, cannot discern between non-infected or infected (clean or dirty) badgers: all badgers are subject to be shot as all may be disease carriers. This population approach (Section 4.1) has consequences for farmers relations with badgers:

[91] IN Cull Organiser HRA 3, 28.09.16

> *I did think it was better to protect my clean ones* [badgers on his farm] *as they keep the dirty ones out of this area…but I don't have the choice. The shooters will kill every single one they can so mine are up for grabs. I've got to do it as a badger is a badger. They could all be carriers. But who knows if dirty ones will move in?*[92]

This farmer is renegotiating his positioning on clean and dirty badgers from the level of the farm, to the level of the cull zone. Furthermore, the farmer is renegotiating his affective relationship with badgers from distinguishing between clean and dirty animals, to considering all badgers as potential carriers of *M. bovis*. What this implies is that all badgers may become enemies to farmers that are undertaking badger culling. This enmity is almost necessary if badger culling policy-as-practice is to be carried out on farmers' land.

Affective links between controlling badgers and controlling disease were also identified in farmers'/landowners' reasons for signing up to the cull. A licence to shoot badgers would only be granted to a cull company if 70% of land in the entire cull area (at least 150 km^2) was signed up for the cull. Thus, in 2011 and 2012 the cull company for the West Gloucestershire cull zone had to recruit landowners to take part. Cattle farmers are generally reported to be in favour of badger culling (Bennett and Cooke, 2005; Warren et al., 2013), but to my knowledge no research has investigated other farmers'/landowners' views on badger culling. In an interview Harry, a cull company director, described a variety of reasons as to why landowners took part in the badger cull.

> Harry: *It did take a fair bit of persuasion and a bit of peer pressure to pull some people in, quite a lot of chasing.*
>
> JP: *And so the non-cattle farmers, what are their reasons for taking part?*
>
> Harry: *So the non-cattle farmers, some* [got involved] *because they found badgers were a nuisance 'cos they're having to plough around them,*

[92] IN Farmer HRA 1, 11.10.16

> *some of them were golf courses who really dislike badgers as they dig and scrat up the course.*[93]

Harry suggests that some arable farmers took part in the cull to control a *"nuisance"* species. In interview, an arable farmer told me his reasoning for culling on his land:

> *Well number one they genuinely do play absolute havoc with the maize crops*, […] *the sett up there* [points to field]*, the one they've caught the most badgers out of, that's maize every year, and they don't half flatten it* (Figure 17)*, it's quite unbelievable and 'cos what they do, they reach up to get the cob don't they, down they go like a domino effect, and you would be amazed how much they would take out. Since the cull I mean that's virtually been eliminated now, we don't get much maize flattened at all* […] *We had a very active sett at the top end of the farm there which had oh golly you could lose a tractor back wheel down it, they've taken about a dozen badgers out of that one, and there is still activity there, but it's very low activity.*[94]

Figure 17: Flattening of maize attributed to badgers (Author, 2016)

The badgers' digging, scratting and damaging of crops and machinery created a haptic understanding between the landowners and the badgers that motivated the former to take part in the cull. Farmers and contractors sign up to the badger cull for multiple

[93] IN Cull Organiser HRA 1, 19.09.16
[94] IN Farmer HRA 4, 16.09.16

affective reasons weakly associated with bTB, such as getting rid of a nuisance species. As a result, landowners create capacity for the practicing of badger culling by helping to meet the licence criteria for land coverage (Defra, 2018b). These affective reasons therefore enable culling to take place, based in official terms on 'disease control'.

Badger control is considered by some to be the most important mechanism to overcome farmers' fatalism towards disease control (see Section 4.1). In Northern Ireland (where badger culling is not legal) Robinson has shown that farmers and vets conceive badger culling to be "the great hope for change, renewed interest and engagement" in bTB (Robinson, 2014: 246). Badger culling does not ensure bTB will be eradicated from every farm (see Section 6.2.1)[95] however, many livestock farmers are in favour of badger culling (Bennett and Cooke, 2005) and consider it to be *"the one thing I can do to control this insidious disease"*.[96] Graham, a cull company director, reveals the control gained over bTB due to badger culling in the following interview extract. Prior to this, we discussed the activism that some of the farmers in the cull area had been subjected to (detailed in Section 6.2.4).

> JP: *If you knew all this in 2011, would you have set up* [the cull company]*?*
>
> Graham: *I wouldn't have done it, I'm finishing after this year, it's taken us six years, one year recruiting, then we nearly went and didn't go* [in 2012]*, and then we did go.*
>
> JP: *In 2013?*
>
> Graham: *Yeah so six years doing this. And you ask the favours of people all the time* […] *and it's always the same people you're asking, and you run out of credibility. I run out of credibility when things don't go quite so well and you get absolutely lashed in the press, not me personally but the whole "*[the cull company] *failed again", and you take it personally and then when your neighbours go down with TB having put up with lots of crap and they ring us we've bloody gone down with TB now. And you think I'm really sorry, you take it personally, you can't not. We finally got to grips with the root of the disease and then we lost control of the part that we finally had control over. Like well you know* [Steve and Pauline] *and they*

[95] The RBCT suggests that badger culling can increase the risk of a farm experiencing a breakdown on the edge of the cull zone. Evidence from the current culls is not conclusive.

[96] IN Cull Organiser HRA 2, 27.09.16

> *went down with TB and they were very upset about it and when she told me, oh God, and they'd had a fair bit of stuff going on with Stop the Cull and* [Pauline] *had being a sector lead it's quite a lot of effort and you think oh flipping heck, that's not quite how it was supposed to be.*[97]

Graham talks about the control gained through badger culling in contrast to a lack of control over the disease overall. In contrast to research showing farmers' fatalism towards bTB control clashing with official narrative of disease control (Enticott, 2008a; Enticott and Vanclay, 2011; Enticott and Wilkinson, 2013; Naylor and Courtney, 2014), here Graham's narrative matches the official narrative of undertaking badger culling to control and 'make a difference' to bTB. However, for Graham, disease control emerged as an affective hope to counter some of the fatalism associated with bTB, whilst the State presents control in epidemiological terms of reducing disease incidence in cattle.

The licencing of culling prompted some farmers to implement other disease management practices, such as biosecurity measures. For example, in a focus group one farmer said that due to culling he felt further encouraged to raise his water troughs to prevent badgers accessing the water:

> *Now that I've finally been allowed to do the most important thing of culling, I've lifted my water troughs to keep the remaining badgers out. I don't want to risk all that we've gained from culling because I haven't bothered to do a basic thing like lift my water troughs.*[98]

Another farmer in the same focus group said that since culling began, he had stopped buying cattle at the market where he had *"no idea of their bTB risk and now I'm only buying cattle direct from other farmers and I ask about his* [the farmer's] *bTB history"*. These practices stemmed from feelings of disease control gained from badger culling and further engendered feelings of control by assessing the risk of other practices in bringing bTB onto a farm. This contrasts with other research which indicates how biosecurity is associated with farmer fatalism when not in a badger cull zone (Enticott

[97] IN Cull Organiser HRA 6, 16.11.16
[98] FG farmers and vets HRA, 21.09.16

et al., 2012b) and that farmers' sense of impotence encourages more risky practices (Enticott et al., 2020).

Farmers' sense of control was a by-product of enacting the policy and gave rise to forms of biosecurity. The affect 'leaked' out of the contained badger culling policy into other bTB management practices. In other words, there was a positive 'spillover effect' (Thøgersen, 1999, 2004) from disease control flowing from badger culling to other disease management practices; fatalism was somewhat overcome and other disease practices were brought to life.

Affective relations around biosecurity and control therefore proliferated. It is possible that these practices contributed to the reported reduced bTB incidence in cattle in the cull zones (Downs et al., 2019). Despite the cullls not having been introduced to assess the impact of badger culling on bTB incidence, research has been undertaken investigating the cull's effectiveness in reducing the incidence of bTB in cattle (Brunton et al., 2017; Downs et al., 2019). Downs et al. (2019) analysed OTF-W bTB incidence in cattle over four years of culling in three badger cull zones, 2013–2017, and attempted to control for variables other than badger culling. The analysis found that bTB incidence in cattle had either reduced or not changed in each of the three badger cull zones and the surrounding 2 km buffers. Brunton et al. (2017) and Downs et al.'s (2019) analyses do not account for how much of the change in bTB incidence is directly due to badger culling and how much is due to indirect factors, such as farmers' instigation of other disease management practices due to the sense of control generated by badger culling. The inability to separate the direct and indirect impact of the badger culling policy on bTB incidence in cattle means that the policy continues to directly tie disease incidence to badger culling, further instilling realities of control amongst farmers.

Importantly, with control comes the possibility of losing control. The interview excerpt above shows how Steve and Pauline's breakdown made Graham feel as though he had lost control.[99] The breakdown is seen as an exception to the success of the badger culling in reducing bTB incidence on farms: drawing on Enticott (2008a), and as detailed in Section 4.1, farmers that are exceptions to the standard rules become 'candidates', and therefore show that the system is fallible and that breakdowns are somewhat dependent on luck (Enticott and Vanclay, 2011; Enticott et al., 2015). In this case, the standard rule is that farms which undertook badger culling should not have breakdowns, and therefore Steve became the candidate because he had a breakdown. Enticott (2008a: 436) suggests that candidacy predicts breakdowns and assesses risks of breakdowns, alongside "explaining the role of bad luck, chance and randomness of sudden events". In his words about Steve, Graham exemplified candidacy to explain the bad luck, randomness and unfairness of Steve's breakdown; the breakdown is portrayed as an exception to the norm. The presentation of breakdowns on farms that are culling badgers as exceptions to the norm reinforces the narrative that badger culling enables disease control. Against the backdrop of fatalism due to a lack of disease control, it takes effort and vigilance to keep this narrative of control intact, achieved partly through affects of badger culling.

6.2.2. Controlled shooting of badgers

> *It is 20:30 on a cold, dark and misty autumnal night. I'm with James, a licenced badger shooter* [otherwise known as a contractor], *and Bill, a shooting buddy. James is one of 32 licenced contractors undertaking controlled shooting in the West Gloucestershire cull zone in 2016. We pull up in a farmyard with a .22 long rifle in the back of the truck. James switches off the engine and turns to face me in the back seat. "Ready?" he asks, "I'm not leaving 'til I've shot a badger". James and Bill are paid approximately £100 for every badger they shoot and receive a bonus for every 10 badgers shot. So far this year they have shot 19 badgers so are keen to get another.*

[99] IN Cull Organiser HRA 6, 16.11.16

> *James winks at me and jokes "the money is a real benefit". Laughing, Bill adds, "and the fun of killing new quarry!".*[100]

James' and Bill's comments are indicative of how the cull licence from Natural England (Section 5.2) incentivises the killing of badgers for personal enjoyment, for thrilling achievement and for financial reward, in addition to control bTB.[101] Policy itself has provided the opportunity to those incentivised by money or death to satisfy their motivations.[102]

I consider these incentives to be affects of the cull as they are manifest in interactions and occur in shared spaces such as the car and fields. These affects were built on relations between agents in the culling network — including money, guns, badgers and licences — and transformed into the embodied practice of shooting. Incentives and motivations such as these ensured enough land was signed up to the cull and enough contractors were enrolled to shoot the minimum target cull number and therefore meet the licence conditions (described in Chapter 5) (Defra, 2018b). In other words, the policy afforded a space for these motivations and these were vital to the realisation of badger culling in the field. Interestingly, bTB control provided momentum from government offices for the culling of badgers, and yet the disease is backgrounded in the field. Instead, enjoyment and money take centre stage. These affects arise from the badger culling policy and are observable in the practice of shooting.

[100] FN controlled shooting HRA 1, 03.10.16

[101] Swan et al. (2020) also found personal enjoyment as a motivation for killing foxes and magpies.

[102] I consider these to be motivations rather than neutralisation or rationalisation strategies developed to defend the legality of the practices as part of defensive ruralism (Enticott, 2003; Winter, 2003). I consider that participants did not feel they needed to defend their practices to me because I did not question the legality of the practices, I was open to all possibilities and we developed strong relationships. Furthermore, undertaking participant-observation with the participants in their setting likely reduced any defensiveness than might have otherwise been likely in other interviews.

bTB was not mentioned in the entire night spent shooting badgers with James and Bill, but my fieldnotes contained multiple traces of affect:

> *James gets his tripod stand and gun out the truck, loads it with ammunition and puts on the safety lock. We go through a gate and step into the field. James and Bill have shot six badgers on this land in the last two weeks, so it is a key place to come back to every night to "pick one* [a badger] *off the shelf".*

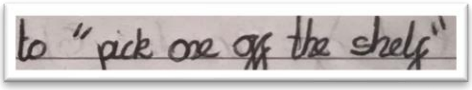


Figure 18: Jotting to "pick one off the shelf" (Author, 2016)

> *As we walk through the field, Bill uses the thermal imagery (other buddies use a spotlight or night vision camera) to check for any animals; thermal imagery provides an outline of any living animals based on heat, and night vision converts low-light images into visible light. He stops. He sees a badger directly in front of us. Bill beckons us to go around the side of the badger so that we are out of the wind and the badger cannot smell us. Bill checks to see if is safe to shoot, i.e. to check there are no humans nearby and to ensure that the licence requirements are met* (Defra, 2018c). *James sets up his gun on the tripod stand. Bill points at the badger to show James the angle to aim for. James looks through the thermal imagery to gauge the location of the badger. Unexpectedly, I scarily feel excited. I feel the adrenaline rush through my body. Taking his torch from his backpack, Bill uses a red light to illuminate the badger. In a hushed voice Bill counts "3,2,1": he lights the badger up with the torch and James takes a shot. Bang, dead. Immediately Bill turns off the torch light to reduce our visibility to any activists that are in the area and uses the thermal imagery camera to check if the badger is dead. It is a clean shot in the heart-lung target area.*[103]

I felt an adrenalin rush at witnessing the badger being shot. The fear and exhilaration shocked and disgusted me as I did not expect, or want, to feel pleasure at death. The fear and exhilaration were both personal and internal to me, and transpersonal between the badger, Bill, James and I, connecting us in the act of killing. Akin to feminist philosopher Teresa Brennan's (2004) understanding of affect, fear was embodied, shaped our actions and instigated our relationship. My exhilaration at the badger's death

[103] FN controlled shooting HRA 1, 03.10.16. Bill had used a white light on badgers on this land in the previous week and the badger ran. James told me this was because the badger must have been exposed to white light before from activists and so had associated the light with danger. They had changed to use a red light as the badgers were not used to red light and could be shot.

is comparable to Bill's enjoyment at killing a new quarry: the killing of the badger was one outcome of the policy that linked us together.

Affects were also displayed in the actions following the shooting of the badger.

> *We run over to collect the badger. I carry the small badger (roughly 10kg) over my shoulder and we walk 1 mile back to the truck. I can feel its body heat on my back. We get into the truck and drive to a farm which has a carcass bin locked in a container unit, managed by a volunteer involved in the cull. James has a key. Bill cuts open the bag so that I examine the badger. It stinks! Bill said that it probably "shat itself out of fear — kinda like Jess when she was with Steve and Justin the other night and that car drove past". He nudges me and we laugh, remembering the whirlwind of emotions that we experienced this night.*[104]

Figure 19: Shot badger in a double bag ready for disposal (Author, 2016)

Shooters regularly exchanged updates on where they were shooting badgers and location of activist activity (see Section 2.3.3 for a description of the tight knit community involved in and supportive of badger culling). Steve had spoken to Bill

[104] FN controlled shooting HRA 1, 03.10.16

about my fear of the activism we experienced — described in the extract at the beginning of this chapter — and Bill drew upon this information in his comparison of me and the badger shot dead. This extract highlights the affects generated by the badger cull between humans and badgers — in this case the affect being fear. Fear was expressed in my body through an increased heart rate, and Steve told me it was sometimes expressed in badgers through loss of control of its bowels or by scent-marking from its subcaudal gland.[105] Building on the work of O'Grady (2018), I consider that this embodied and trans-species expression of affect interlinked our capacities to affect and be affected by each other.

Bill articulated this affective relation by comparing me with the badger to help us share in the triumph of shooting badgers and to build a relationship. I looked forward to spending a night with Bill and James because of the intimacy we developed through them sharing their skills and helping me to learn about shooting. Bill and James had built a friendship through badger culling and used the time spent shooting badgers to support one another. For example, on arrival at Bill's home after a night spent shooting, Bill turned to James and said *"thanks for a good night and good chat — same again tomorrow?"*.

Shown above, the policy set out conditions of possibility, in which affect was a conduit. I consider fear, exhilaration, friendship and pleasure to be affects as, using Gregg and Seigworth's (2010) definition, they are forces other than conscious knowing. They connected agents together in relational 'thread-lines' (Ingold, 2010) centring on

[105] I witnessed scent-marking three times whilst with people undertaking controlled shooting. One night, I was with a contractor and buddy tracking badgers. We were downwind of a badger and the contractor was setting up his gun ready to shoot. The buddy sneezed. Almost immediately, the badger ran and I smelt a pungent, and frankly disgusting, odour. The contractor told me that the badger had scent-marked out of fear (FN controlled shooting HRA 5, 20.09.16).

the badger cull policy and motivating shooters to enact the policy. Thus, these affects helped to ensure enough badgers are shot to fulfil the policy effectiveness requirements.

In addition to controlled shooting of badgers, affects were also important in the establishment of the policy-as-practice in the field regarding cage trapping and shooting, as I go on to show in the next section.

6.2.3. Cage trapping and shooting of badgers

As well as being shot in the open fields, badgers are also trapped and shot in cages. After five weeks in the cull zone, I had established a relationship with a volunteer who led culling in a sub-section of the West Gloucestershire cull area. I asked if she could put me in touch with a badger trapper and she agreed. The following fieldnote describes a morning spent checking cages for badgers and the affects engendered between Rob, a cage trapper, and a badger.

> *I arrive at a farm for 05:30 and spend two hours with Rob, a cage trapper. I climb onto the back of his quadbike and he puts a bag of peanuts on my lap. We travel around six farms checking cages, laying peanuts (bait) and killing trapped badgers. Whilst clinging on to his waist for dear life, Rob tells me of his routine to trap badgers.*
>
> *Four weeks before the cull begins, he surveys the land to identify badger runs, setts and other signs of badger activity. He then lays wire cages in the runs. He lays the cages in hedgerows or field edges so they are not obvious to antis and are therefore less likely to be destroyed* (Figure 20). *Rob digs the cage into the soil and lays peanuts in the back of the cage to tempt badgers into it. He pre-baits the cages 1–2 weeks before the start of the cull period to help the badgers get used to the cages. At the start of the cull period, he ties twine to the pin on the trap door, through the side of the cage and in a triangle shape behind which he lays over the peanuts* (Figure 21). *Rob visits the cages every morning to check if any badgers are trapped that need to be killed and to check the general state of the cages; some may need to be re-tied or re-baited, and some may have been destroyed by activists.*
>
> *He tells me that a week previously he laid a trap near a fence in a badger run. One badger dug under the fence and under the trap to access the peanuts. This frustrated Rob and made him even more determined to get the badger. He dug the cage deeper and put the entrance next to the fence so that the badger had no choice but to enter it if it was using the same run. The next day Rob caught a "bloody big badger" which he said was*

responsible for the previous diggings. He says "I've trapped over 30 badgers this year already on six farms…I'm the best trapper in the area".[106]

Figure 20: Badger trap laid in a hedgerow and camouflaged so that anti badger cull activists do not destroy it (Author, 2016)

[106] FN checking cages HRA 2, 25.09.16

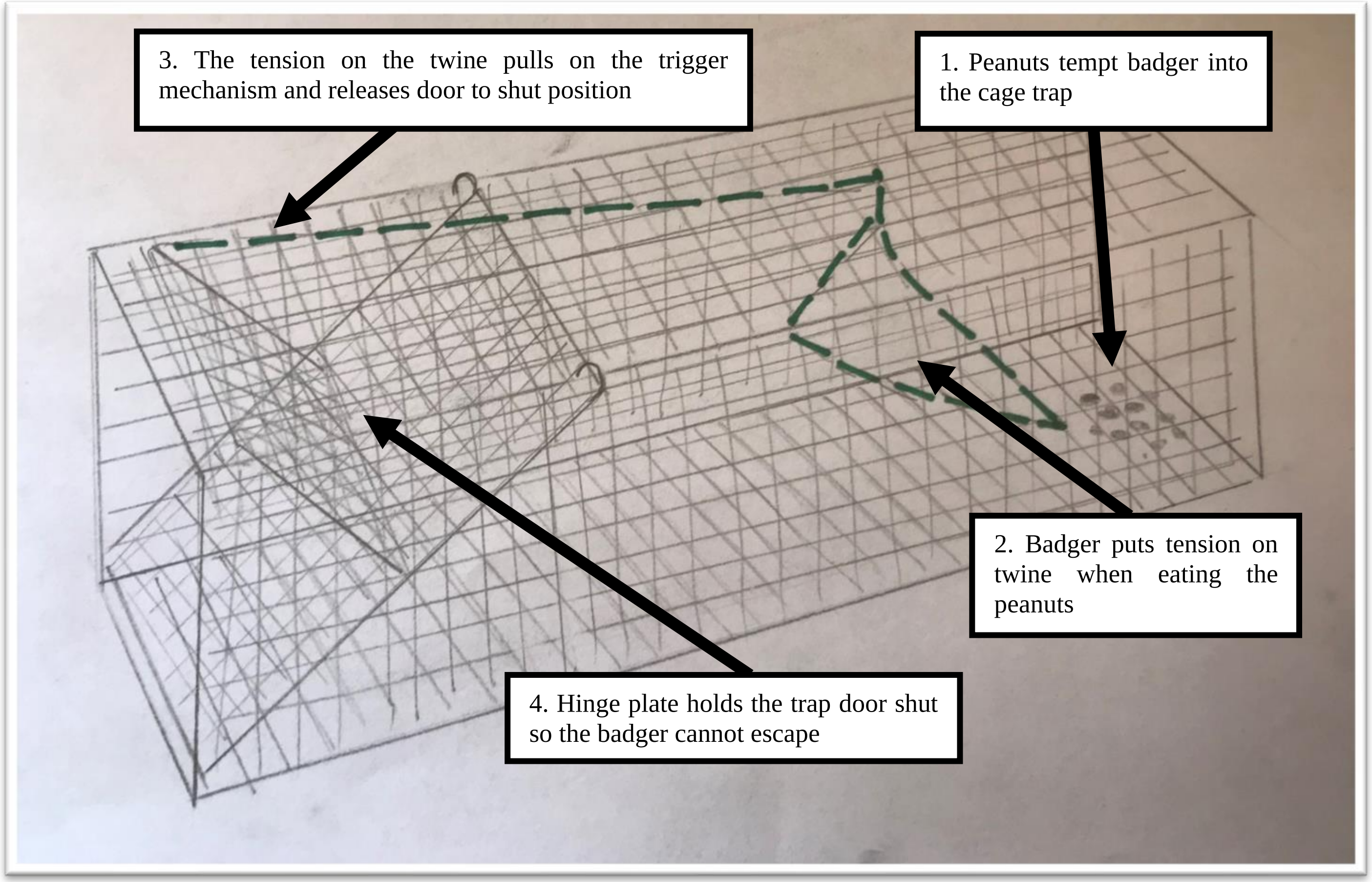


Figure 21: Labelled diagram of a shut cage trap. The green line marks the line of twine from the hinge plate (which is vertical when set) towards the rear of the trap. Cage traps can also be set by tying twine to a brick/stone which is put over the peanuts. If the badger moves the brick/stone to access the peanuts, the twine pulls on the hinge plate and the trap door is locked shut (Author, 2020).

Rob foregrounds expertise in killing and trapping, and thrill and competition in the badger cull. For Rob, killing the badger that dug under the fence was a challenge that he took pride in. As part of this challenge, he enacted his ecological knowledge and experience to limit the badger's agency so it was forced to enter a cage and be shot. His intimate sense of place, local knowledge of sett locations and tacit skills of detecting species were developed through his upbringing with family members that shot various quarry (pheasants, foxes and rabbits being the most common) and his extensive observation of land and animals. Rob decided where to lay the cages dependent on factors such as the cropping cycle, sett locations and the locations of antis. If he trapped a badger, he then shot it.

> *Once trapped, the badger is settled before being shot with frangible ammunition. The muzzle of the 12-bore shotgun is placed inside the cage, but not in contact with the animal. The shot should be placed in the* "front of the forehead with the shot angled through the brain towards the brainstem" (Defra, 2018e: 15), *resulting in rapid unconsciousness and death*.[107]

The affective confluence of knowledges, tacit skills and relations (such as competitiveness, determination and ruthlessness) made Rob a talented cage trapper. Contractors' local knowledge and experience was somewhat privileged in the policy to shoot badgers because they *delivered* the policy. This contrasts with many policies-as-practice related to bTB, like agriculture and environmental change where local knowledge has sometimes been ignored (Barker et al., 2010; Enticott, 2014; Enticott and Wilkinson, 2013; Wynne, 1982, 1992, 2002). The source of vitality for this particular confluence was the badger cull policy. And, this confluence provided potential for the further making and transformation of the policy. Rob's knowledge and skills, for example, were enacted by, and important for the success of, the badger cull:

[107] FN checking cages HRA 2, 25.09.16

the licence criteria of shooting 70% of the badger population (Section 5.2) could not be met if the shooters did not have local knowledge and shooting skills. This affective confluence is therefore integral to the policy.

6.2.4. Undertaking intimidation and direct action against the cull

As well as affording affects between contractors and badgers, the badger culling policy also afforded affects ‘on the ground’ between those supporting and those opposing the cull. The excerpt below details the affects between contractors and ‘antis’ or anti-cull activists — as named by contractors and farmers —, made possible by the badger culling policy.

> *As we head back to the truck, a car drives slowly past on the nearby road. Peter and Sam* [contractor and buddy] *run to the hedge to hide in case the car belongs to antis* [anti-badger cull activists]. *Sam mutters “don't stop at the gate, don't stop at the gate”. The car drives past and does not see us. Phew. Peter says that his reaction might be over the top, but he does not want activists to spot them. Why? Well if activists become aware of this shooting ground then they would continuously monitor it, meaning Peter could not shoot here anymore. Covert operations are needed.*
>
> *When we drive out the farmyard, a car is parked at a nearby church and two people are flashing torchlights across a field. Sam speeds up, these could be anti-cull activists. Silence and tension fill the truck. Sam pulls onto a major road where there is another car in a layby. It pulls out and follows us. Sam speeds up and tells me to hide the badger carcass. He turns round a corner and suddenly turns off the major road into a minor road; making the turn using just his clutch so that the brake lights aren't visible to the activists as that would give away our location. He turns his lights off entirely when we are 20 metres down the minor road to make us less visible. The car speeds past on the main road. Sam has lost them.*[108]

Sam swerved off the main road and turned off his truck lights because he did not want antis to know his shooting locations, number plate or carcass location, as this would enable them to limit and disturb his future shooting. The badger culling policy provides unexpected possibilities (Ingold, 2012) such as the perplexing and unlawful act of swerving off roads. These possibilities are charged by affect, and bound up with the relation between those supporting and those opposing the cull.

[108] FN controlled shooting HRA 2, 04.10.16

In interviews and informal conversations when skin testing, many farmers suggested they felt intimidated by anti-cull activists.[109] A volunteer helping to organise the cull told me about the activism they had experienced on their farm:

> [it makes me feel] *on edge, very very, because they used to come down,* […] *they* [Stop the Cull] *had rape alarms and that they were throwing into the paddock at three o'clock in the morning which were sort of a squealing noise, they would be at the bottom of the drive banging drums and buckets, blowing horns, this is all early hours of the morning. And then one of them, a well-known tactic, and it was quite convincing, they could do a call of an owl, and it sounded just like there was an owl outside of your blooming bedroom window and it was these antis doing that, but it was really convincing.*[110]

Stop the Cull encourages and undertakes telephone and field activism, including publicising farmers' details online and undertaking secret filming on farms participating in the cull (Stop the Cull, 2013). It targets its effort on large farms and estates to try to get them to remove their land from the cull zone so that the cull zone does not meet the licence criteria (Defra, 2018b) and it 'stops the cull'. It therefore instils emotions in landowners such as fear and feelings of lack of safety to limit the future possibility of culling badgers. A farmer and cull company director, Graham, tells me about his experiences of activism by Stop the Cull:

> Graham: *the first few days of the first cull* [in 2013], *the cows were going berserk with these people shining torches everywhere and all these voices, and the cows pricked up their ears and went charging up and down, so I was getting pretty uptight, "you're not coming in here, it's not a legal footpath", and then we had the police here, we had police here every night of the cull, every single night.*
>
> JP: *It sounds difficult.*
>
> Graham: [founder of Stop the Cull] *was here on that drive and told me what he was going to do to my kids, and I had the policeman right behind me, five yards behind me, and I turned to* […] *the policeman and I said, 'when the fuck does this become aggravated trespass?'. I was being hunted.*
>
> JP: *I'm sorry.*
>
> Graham: *They identified some farmers, landowners, contractors or whatever, and they were sat outside the school gate giving the wives abuse*

[109] FN skin test short interval HRA 2, 30.09.16; IN Farmer HRA 3, 29.09.16; FN skin test routine HRA 1, 10.10.16

[110] IN Farmer HRA 2, 05.10.16

> *to try and get the guys to have so much pressure at home, saying we're not doing this, we're not culling.*[111]

Many of Graham's practices merged into the defence of his family, cattle and farm from anti-cull activists. These practices present saboteurs as a threat to badger culling, his business and his family. To my surprise, the large majority of farmers I spoke to who had experienced activism such as this told me that it was unpleasant, but made them more determined to continue with the cull.[112] One farmer told me that activism had, *"made us more determined than ever and nobody, nobody has left"*.[113] By *"nobody has left"*, he meant that no landowner had withdrawn their land from the cull zone due to intimidation or any other kind of activity undertaken by those opposing the badger cull. Furthermore, the anti-cull graffiti in the local villages (Figure 22–26) was referred to as *"something that brought us locals together to fight against"*.[114]

[111] IN Cull Organiser HRA 6, 16.11.16

[112] IN Farmer HRA 2, 05.10.16; FN skin test short interval HRA 2, 30.09.16; IN Cull Organiser HRA 5, 22.09.16; IN Cull Organiser HRA 7, 15.09.16

[113] IN Cull Organiser HRA 7, 15.09.16

[114] IN Cull Organiser HRA 5, 22.09.16

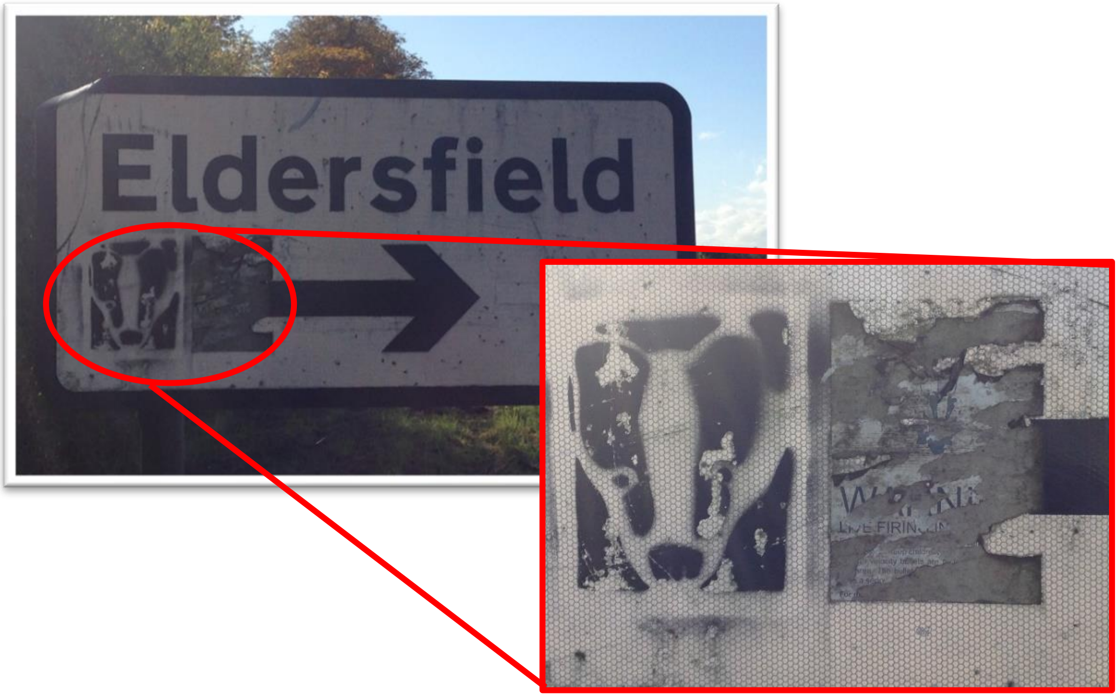


Figure 22: Face of a badger and ‘live firing warning’ sign on direction sign to Eldersfield, Gloucestershire (Author, 2016)

Figure 23: ‘Stop the Cull’ sticker on Worcestershire county sign at Corse Lawn, Gloucestershire (Author, 2016)

Figure 24: ‘Save the badgers’ graffiti on roadside near Naunton, Gloucestershire (Author, 2016)

Figure 25: ‘Stop the cull!’ graffiti on a green cabinet near Tibberton, Gloucestershire (Author, 2016)

Figure 26: Face of a badger sticker on a road sign near Highnam, Gloucestershire (Author, 2016)

Stop the Cull undertakes intimation practices in an attempt to make farmers pull out of the cull and therefore prevent culling being sanctioned. However, Stop the Cull's intimidation activities generated affects such as community spirit and determination amongst farmers, and many farmers became more determined to remain in the cull as a result. What kind of badger culling was being done here? It was unpredictable, based on situational judgement and intuition. It involved fun, exhilaration, exhaustion, fear, risk, tension, adrenaline, danger, conflict and death.

The strong oppositional relationship between badger protectors and farmers centred around badger culling practice, and did not centre around bTB. As previously stated, bTB is strongly and directly tied to badger culling in government offices, but my research suggests it is less directly tied to badger culling in the field. This disconnect between practices and narratives in government offices and in the field is sharply highlighted through the differing relations generated in each by activism. For example, in its annual report summarising monitoring of the badger culling policy in 2014, Defra recognised the impact of activism only in relation to the number of badgers that were shot, and not in any wider network:

> In some cases, the level of effort deployed and the removal of badgers may have been affected by the presence of anti-cull activists where culling took place. Contractors gave public safety priority and stopped or paused activities until it was safe to continue operations (Defra, 2014f: 2).

Here, activism is considered in relation to the safety of the cull effort. The affect tied to activism is largely unseen — not due to invisibility, as I have shown, but rather due to lack of attention. It is therefore unaccounted for in policy discussions. bTB constituted capacity for action in government offices, whilst intimidation and activism constituted capacity for antagonistic action in the field. These oppositional practices are generated and sustained by the badger cull policy.[115] Furthermore, through their disruption, saboteurs' actions significantly change the practices of contractors — for example, leading to unlawful driving. Thus, badger saboteurs *co-create* the badger cull in the field alongside (to name a few agents) contractors, farmers, badgers and cattle.

Hence, I argue that affect is a vital element in the realisation of policy: bTB is presented as the reason for initiating the policy in government offices; the policy generated opposition between badger protectors and the cull company; this affect establishes practices of intimidation and activism by badger protectors; badger protectors practices make many farmers determined to remain in the cull; farmers determined to remain in the cull ensure the policy can be enacted on the ground; and, the cull is assessed according to its impact on bTB. The evident importance of affect in the practising of policy is not widely recognised. Principally, the connections between the number of badgers shot and the epidemiological impact of the cull on bTB incidence in cattle are published in official documents. Drawing on Enticott's (2001) research on the role of numbers in rural governance, the governance of the badger cull is founded in bTB statistics. Calculating bTB through numbers knows the badger cull as singular and uniform (Enticott, 2001). Affect complicates this way of knowing as it shows how bTB and badger culling is practised in multiple and differing relations. I suggest that in the foregrounding of numbers, affect is backgrounded. I witnessed these affective relations in the field.

6.2.5. Sabotaging the badger cull and the fox hunt

Many people who identify as badger cull saboteurs also identify as fox hunt saboteurs for the Three Counties Hunt Saboteurs. The Hunting Act (2004) means fox

[115] This polarisation only appeared to exist in practice. In interviews, most badger protectors and farmers/landowners/contractors demonstrated respect for one another's differing beliefs about the cull. However in the field, they were opposed to each other's practices.

hunts cannot intentionally hunt live foxes and the Protection of Badgers Act (1992) means it is an offence to damage, destroy, obstruct or disturb a badger sett, except under licence. I observed practices that linked the legal act of badger culling and the illegal act of fox hunting. In general, badger cull saboteurs have undertaken direct action to disrupt the badger cull by causing material damage to agents involved in the cull. I define this broadly to include intimidating farmers, trespassing and destroying cages (Figure 27).

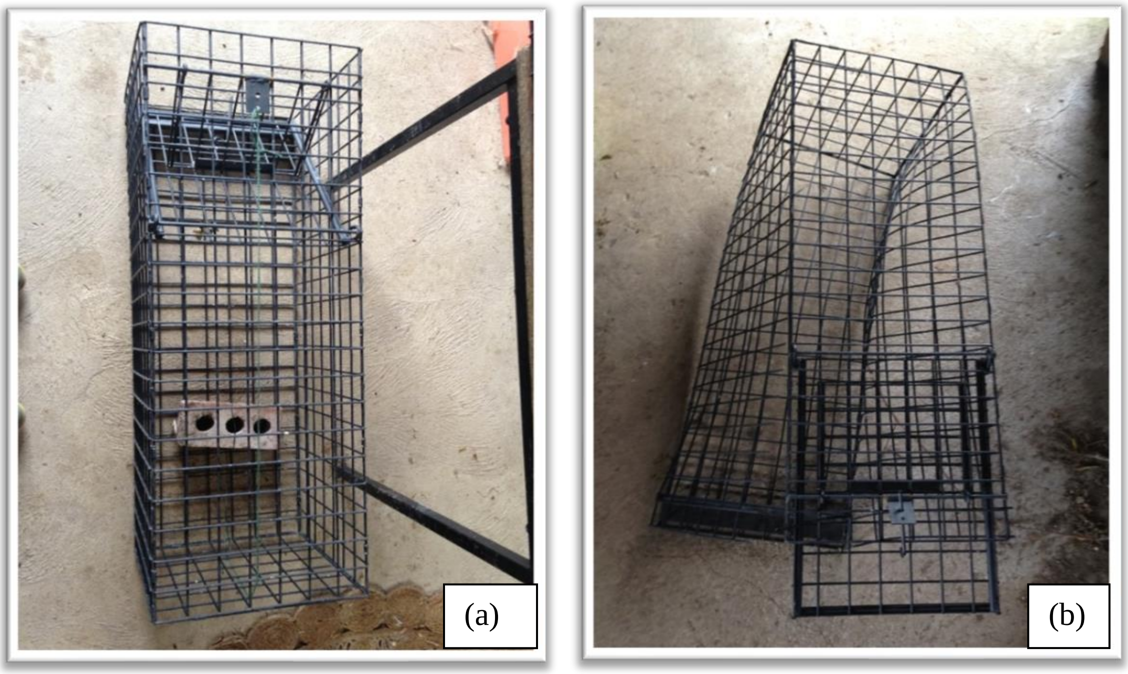


Figure 27: Cage traps. (a) cage trap with brick. (b) Trampled cage trap. Cage traps were also destroyed using bolt croppers (Author, 2016).

I spent two nights and one afternoon with badger cull saboteurs and interviewed three saboteurs. In an interview over coffee, a badger cull saboteur and Three Counties fox hunt saboteur, Pete, talked about the links between 'sabbing' fox hunting, badger persecution and the badger cull:

> Pete: *A lot of the* [anti badger cull] *campaign began with hunt saboteur groups getting involved, so people are like "did you know there's a cull going to happen?", and obviously it was on the news and everything* […] *A lot of hunt sabs became hunt sabs after they met others during the Krebs trials, that ten year trialling period, so a lot of them are like "oh it's started again". So they're getting back into it again now that these culls*

have started, but for others it's like they've either joined sab groups since the culls began, 'cos they've met more sabs, or they've been part of a sab group, they've met people who've done the culls before and then that's how they've got involved. So it is quite a big campaign for the hunt sab coming into it as well, but obviously we've got lots of people who are just locals who've heard about it who are wildlife enthusiasts from around the country, so there's a really good mix of people.

JP: *What are the links between fox hunting and badger culling or badger persecution?*

Pete: *As the local sab group anyway we have quite a lot of problems with the local* [fox] *hunt, they're prolific set blockers. So they go into an area, they block setts because it stops foxes escaping underground during the hunt, and of course what they want is a long chase across lots of fields. They don't want a fox to quickly go into a complex of earth of a complex badger sett which has got miles of tunnel underground and then it's difficult to get the fox back out of. So they block them. And if a fox does go underground, they often try and dig them out, even through badger sets. So we do need to know a lot about the badger setts in the area anyway for hunting purposes.*[116]

The Hunting Act (2004) means there should be no need for hunters to prevent foxes going to ground. Thus, Pete considered sett blocking to imply illegal live fox hunting and illegal disturbance of a badger setts under the Protection of Badgers Act (1992). This lacing together of illegal fox hunting and illegal badger persecution also entwined with legal badger culling. A few days after the interview with Pete, another badger cull saboteur and Three Counties fox hunt saboteur, Jane, and I went on a daytime 'sett check' in Gloucestershire. We checked for signs of legal badger culling and illegal sett blocking.

Jane checks a sett for illegal backfilling and for signs of legal baiting for the badger cull. She points out three different types of bait points:

- *a spade cut into the ground where a flap of soil is lifted up and peanuts placed underneath* (Figure 28)
- *strange stones or bricks in odd places with peanuts underneath*
- *a pencil-like dibber put in the ground with peanuts placed into the hole. Saboteurs struggle to remove the peanuts from this type of bait point as it is so deep*

We go to a copse on a hill which contains an old, and well established, sett. There are obvious spade marks around some of the sett entrances and Jane says that they had been 'dug in' (aka collapsed) by the

[116] IN Badger Protector HRA 2, 13.09.16

hunt to prevent foxes from 'going to ground' (aka taking shelter) in the sett when being hunted.[117]

Figure 28: A bait point used to attract badgers to a particular point in a field where they are then shot (Author, 2016)

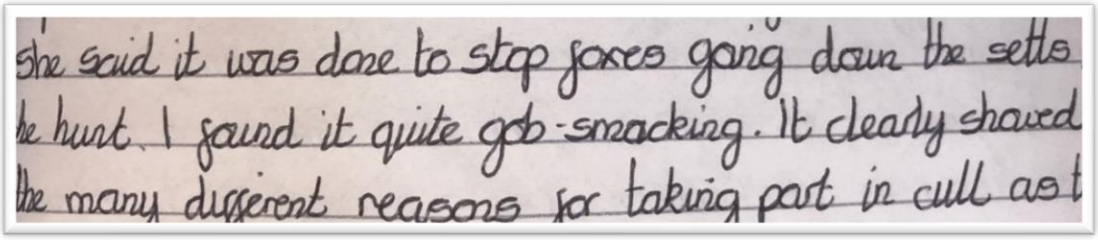
Jane tells me that some pro-fox hunt farmers are taking part in the badger cull to kill badgers on their land so that the badger setts become empty. Once empty the sett is no longer classified as a sett, but is rather holes in the ground and therefore can be legally filled to limit the opportunities for foxes to go to ground in the illegal practice of fox hunting. The following extract is taken from a fieldnote when with a farmer, Phil, undertaking a skin test:

Phil said that the Ministry told him a sett is only a sett if there are animals in it, otherwise it is just 'holes in the ground'. He only has one lot of 'holes in the ground' on his land which he has collapsed and filled with

[117] FN sett surveying HRA, 14.09.16

> *concrete. He said that culling has encouraged farmers to take the law back into their own hands.*[118]

The relation between badgers and setts is generative and fragile. If badgers move back into these 'holes in the ground' it becomes a sett again and it is legally protected. Consequently, it requires continuous effort to keep badgers out of a sett and continuous effort to protect badgers from this practice.



She said it was done to stop foxes going down the setts
he hunt. I found it quite gob-smacking. It clearly showed
the many different reasons for taking part in cull as t

Figure 29: Fieldnote detailing links between fox hunting and the badger cull. "It"= taking part in badger culling (Author, 2016).

In interview, some saboteurs and a wildlife charity suggested that illegal persecution of badgers has increased due to the authorisation of the badger cull. One saboteur suggested that farmers were taking advantage of the police's confusion over the legality of culling to undertake illegal persecution (for example gassing setts, filling in setts, poisoning setts, laying snares and shooting badgers out of the cull period) and claim it is legal. [119] In addition, a protestor said that some farmers are confused about what is legal and what is illegal because the licencing of badger culling has suddenly changed the applicability of the Protection of Badgers Act (1992). For example, in 2012 it was illegal to kill badgers and in 2013 it was legal to kill badgers for six weeks of the year under licence. Badger Trust Chief Executive Officer Dominic Dyer (2016) also claims that illegal badger persecution has increased since badger culling has been licenced.

[118] FN skin test routine HRA 1, 10.10.16
[119] FN sabotaging the cull HRA 2, 05.10.16

In 2019 a licenced contractor in Cornwall was found guilty of shooting 28 badgers outside of the licenced cull period. He stored 37 badgers in his freezer with the intention of submitting them for payment during the licenced cull period (BBC News, 2019a). Here, affect moves beyond the badger cull and into other networks. It crosses boundaries from legal badger culling to illegal badger persecution, badger killing and fox hunting. The legal badger cull policy-as-practice was in affective relation with the illegal practice of killing badgers outside of the cull period and storing them in a freezer. This may be linked to securing financial reward from the badger carcasses, using the opportunity to get rid of a nuisance species (Section 6.2.1), or increasing the likelihood of the cull being ‘effective’ and therefore being considered a success. Whatever the reason, these illegal actions are imbued with ‘affect’, and are made manifest by the cull.

6.3. An affective policy loop

The vignettes above have outlined how affect is both generated by, and, generates the badger culling policy. This generativity of the policy can be usefully related back to the conceptualisation of the policy loop introduced in Section 1.4.1. The policy loop illustrates how policy is not a linear unidirectional process that rationalises complexity, but is rather a cyclical process continuously generated in multiple practices and multiple sites as per Figure 2 (page 21). Using the findings presented in this chapter, I argue that affect is an overlooked catalyst of this loop.

The idea of an affective loop builds on Thrift’s (2004) research on the spatial politics of affect. Thrift, an emotional geographer, suggests that affect has become part of a reflexive loop which allows more and more sophisticated political technologies and military practices to take place. Building on Thrift’s reflexive loop, I argue that affect is a vital element of the policy loop (Figure 30).

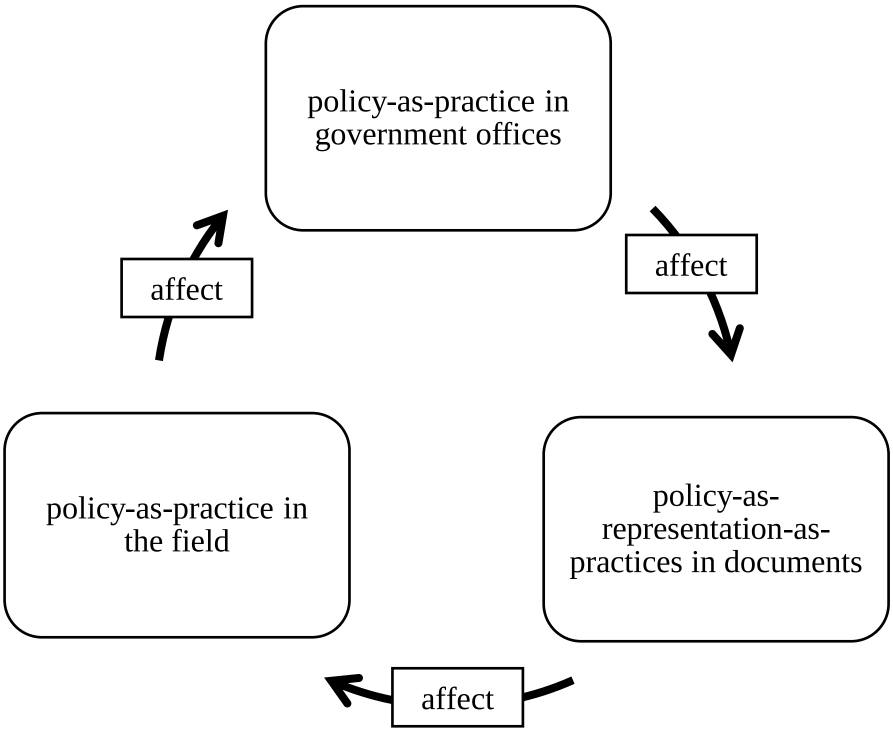


Figure 30: Loop between policy practices, catalysed with an understanding of 'affect' (Author)

I have shown that the badger cull not only engenders affect, but that this affect engenders the cull in a loop. Thinking of affect as the catalyst for the loop helps to keep a relational and material focus on the object of study (Dawney, 2011), in this case on badger culling policy. The immersion of agents — such as badgers, guns, cages, twine, shooters, flashlights, alarms etc. — in relational circulation keeps the policy in place. This circulation occurs as a loop. I argue that the generative capacity of affects between agents in the policy loop enlivens the policy and holds it in place.

Affect is beginning to be used in policy studies as conceptualisations of policy have developed. Building on Section 1.4.1, conceptualising policy as a rationalisation tool has been found to tacitly belittle emotion (Cass and Walker, 2009), perhaps due to the concept's focus on representation. However, conceptualising policy as being composed in practice and being generative focuses on lived experiences, including emotions. Affect is being used in this latter conception to display the intentional and unintentional generativity of policy (Eleveld, 2012; Leyton, 2018; Newman, 2012; Verhoeven and Duyvendak, 2016), such as the creation or undermining of trust, hope, care and control. Moreover, affect is being used in policy studies as part of the posthuman turn (Zolkos, 2018). These authors demonstrate how affect is being used to analyse policy, but their work does not seem to challenge the theorisation of policy. In this chapter I have used affect to challenge existing representations of policy and theorise how affect catalyses policy-as-practice in a loop.

Each vignette in this chapter has made different facets of this affective policy loop visible. Through them I have shown that bTB is largely absent from policy-as-practice in the field. I detailed multiple reasons that farmers and contractors signed up to the badger culling policy, many of which were weakly associated with bTB and more strongly related to getting rid of a nuisance species. These relations pre-existed the badger culling policy, but the policy has shifted them and enabled them to be put into practice. As a result of these relations, landowners helped to meet the licence criteria in regard to land coverage and therefore facilitated the enactment of the policy. I have also shown how the badger cull has renegotiated farmers' relationships with badgers, from distinguishing between clean and dirty animals to considering all badgers to be potential carriers of *M. bovis*.

The bundling together of affect and practices in the badger cull policy has made conditions of possibility for what generates and what is generated by the policy. By following the affect of disease control *forward*, I showed how it gave rise to other disease management practices. As detailed in Section 6.2.1, this affect is backgrounded in the evaluation of the badger cull, meaning that the direct and indirect effects of the badger cull policy on OTF-W bTB incidence cannot be accurately measured. This backgrounding of affect potentially creates false attribution of reductions in disease incidence to the practice of shooting badgers rather than other disease management practices (prompted by the drive for control). This reifies the official frame of badger culling tied to disease control and contributes to the backgrounding of other practices. This means that the policy cannot be effectively evaluated and affects go unrecognised. These affects need to be accounted for and recognised in the generation and entanglements of the policy, alongside bTB. I suggest the evaluation of culling would benefit from a shift in focus. Rather than only focusing on effectiveness, it may be useful to also consider affectiveness of the policy.

6.4. Conclusions

Taken together, Chapter 5 and Chapter 6 contribute to the primary research question and specifically addresses RQ3: 'How is badger culling policy made?'. Chapter 5 analysed the official enactment of badger culling as strongly and closely tied to bTB. This chapter has detailed how bTB underpins key affects in the badger culling policy as it is the reason for providing licences to undertake badger culling. It also shows how bTB is backgrounded in the practices of killing and opposing killing. Contrary to the official presentation of policy, in this chapter I have foregrounded the policy's affective dimensions. Through five vignettes I have exemplified that affects are generated by the policy and generate the policy in a looping mechanism. This is the affective policy loop.

This chapter has highlighted the importance of affect in badger culling policy-as-practice in the field. In the doing of policy, questions need to be considered about affect such as: Should a policy engender affects such as fun and adrenalin rush at the killing of animals? Should the success of a policy depend on this affect? How does badger culling policy align with existing relations of disease and badgers? And, how can policy be interpreted differently in a way that accounts for its affect? The explicit consideration of affect could help to improve the making of policy, improve understandings of the practices of the badger culling policy and improve evaluation of the causes of changes in bTB disease incidence related to badger culling. In addition, the theoretical repertoire of affect could be usefully applied to other bTB disease management practices. This could further understanding of how policies are done in the field, and shed light on why management practices are taken up, and not taken up, by farmers.

The following chapter details two alternative methods of badger culling that are currently being undertaken in Northern Ireland and Wales, and by farmers illegally in England. I present these methods of culling to show that badger culling can be done differently, in ways that are more aligned to both badger protectors' and farmers' relations with disease and badgers.

6.5. Post note

As detailed in Section 5.2, in 2020 the Government announced that it will "begin an exit strategy from the intensive culling of badgers […] by deploying vaccination to the remaining badger population" (Defra, 2020a: 7). This chapter has shown how affect is driven by and drives the badger culling policy as practice on the ground, and it is likely to be similar for badger vaccination. I suggest that the argument put forward in this chapter about the need to account for affect in policymaking may be as relevant to badger culling as it is to badger vaccination. Both practices use similar objects and have similar relations, for example, both use cage traps; are contentious; are undertaken in the field; require landowners to sign up to the policy; and, require 'volunteers' to shoot and to vaccinate badgers.[120] These similarities between the practices, in particular the enactment of the policy in the field, mean that my work on the affective badger culling policy loop may have resonance for the badger vaccination policy.

[120] Badger protectors destroyed so many cages in the 2014 and 2015 badger culls that Defra took back cages loaned to badger vaccination projects and gave them to the cull companies. Thus, the same cages have been used for vaccination and culling.

Chapter 7. How else can badger culling be done? Alternative methods of making badger culling, badgers and bTB

In Chapters 5 and 6 I explored the current badger culling policy-as-practice in government offices and in the field. In this chapter, I detail two alternative culling practices that I encountered in my fieldwork. I present the methods and philosophies underpinning these to show that the relations underpinning badger culling can be woven in different ways to make different, and perhaps better, practices. This chapter addresses RQ4: 'How can badger culling be made differently?'.

First, I recap on the 'population approach' (focusing on a sick population) and introduce the 'high-risk approach' (focusing on sick animals) to disease management (Enticott, 2012a; Rose, 1985). Subsequently, I describe two high-risk approaches to badger culling: the 'test, vaccinate or remove' (TVR) approach and the gassing of setts that are deemed to be infected. These approaches are currently in use in the UK, legally and illegally, instigated by governments and individual farmers respectively. I explore these approaches to show alternative high-risk approaches of badger control.

7.1. Population approach and high-risk approach

Defra is dependent on farmers to implement disease management strategies on farm, including: skin testing, risk-based trading, biosecurity, badger vaccination and badger culling (where applicable). However, research suggests there is longstanding mistrust in government which influences if and how people practice these strategies (Enticott, 2011a; Enticott et al., 2012a; Enticott et al., 2014; Fisher, 2013). In Section 6.2.1 I argued that some of this mistrust arises because the current badger culling policy is based on a population approach of disease control (Enticott, 2008a) that frames all badgers as potential carriers of *M. bovis* and therefore they become enemies to farmers. In brief, a population approach revolves around setting universal rules and providing generalised advice for the farming population. The approach presents and relies on people acting and knowing one version of the disease. However, this one version of the disease may not accord with farmers' own situations. This approach, Enticott (2008a) argues, often requires individuals to change their practices contrary to social norms. It therefore may create a sense of fatalism rather than changes in practices (Section 4.1).

Alternatively, a high-risk approach can be used for disease management which is more fluid, open to disease multiplicity and works with social norms (Enticott et al., 2012b). A high-risk approach centres on interventions relevant to individuals who have been identified as 'at risk'. The approach accounts for individual situations, and personal and effective plans of control and communication are created with each farm, specifically for high risk animals. Drawing on ideas from Lane et al. (2011) in regard to the involvement of publics in the creation of knowledge, I suggest that the approach recognises and captures the capacity of publics to be involved in all elements of knowledge production and disease management. Enticott et al. (2012b) suggest that trust could be improved and hope of managing the disease may be reinstated by shifting from a population approach, focusing on a sick population, to a high-risk approach focusing on sick animals. 'Test, vaccinate or remove' is one such high-risk approach for badger culling, explored below.

7.2. Test, Vaccinate or Remove (TVR)

TVR strategies have been undertaken in different forms in Wales and Northern Ireland from 2014. From 2014 to 2018 in Northern Ireland live badgers were captured and tested for an antibody response to *M. bovis*; they were vaccinated and released if they tested negative, or killed if they tested positive:

> This balanced approach removes diseased badgers and protects the uninfected ones, which could in time lead to a reduction in transmission of TB from badgers to cattle (Department for Agriculture Environment and Rural Affairs, 2018a).

Badgers were tested for bTB using the Dual Path Platform (DPP) VetTB test which is 55.3% sensitive and 97.5% specific to *M. bovis* (Mullineaux et al., 2019). The test measures for *M. bovis*-specific antigens in the blood. The test is likely to detect badgers as positive with high levels of antibodies and therefore at advanced stages of disease. It is also likely to determine badgers with low levels of infection as false negative reactions because it is undetectable (explained in Section 3.2). Northern Ireland's Department of Agriculture, Environment and Rural Affairs (DAERA) notes that false negative badgers will be:

> vaccinated before release, which should restrict the progression of the disease. Should its infection develop further we can expect that badger to give a positive response to a subsequent test (Department for Agriculture Environment and Rural Affairs, 2018a).

DAERA undertook research using the TVR approach to find evidence about the effects of culling and vaccination. Captured badgers were fitted with GPS trackers and microchipped to gather evidence about perturbation (Section 5.1). The strategy also had a control area, or non-intervention area, so that bTB prevalence in cattle in the intervention area could be compared against the control area throughout the life of the project (Department for Agriculture Environment and Rural Affairs, 2018b). When writing this thesis, the research findings had not been published and so the impact of the strategy on bTB prevalence and incidence is unknown. Despite the lack of results, I consider that there is value in undertaking the research in and of itself. DAERA has brought this alternative culling approach to the fore and demonstrated commitment by conducting a trial. This commitment likely inspired the Welsh Government to introduce TVR.

In 2017, Wales introduced a TVR policy on farms which had chronic breakdowns:

> where the Welsh Government views that badgers are contributing to the persistence of disease in chronic herd breakdowns, badgers will be trapped and tested on the breakdown farm and test positive badgers will be humanely killed. Persistent herd breakdowns will be focussed on initially (Welsh Government, 2017: 7).

The TVR policy was instigated in 2017 on three farms with persistent, or long-lasting breakdowns where biosecurity had been implemented. As in Northern Ireland, badgers were trapped, tested using the DPP test, and positive-testing badgers were killed whilst negative-testing badgers were vaccinated and released (APHA, 2019b; Welsh Government, 2018). The selective culling of 'infected' badgers in the TVR being undertaken in Northern Ireland and the TVR policy implemented in Wales are high-risk approaches to disease control as differences are being accounted for in badgers and in farms.

The TVR policy more closely aligns with badger protectors' practices of protecting badgers than the English culling policy. In 2017 I met a badger protector from Wales in the Gloucestershire cull zone. I asked her why she was undertaking direct action in Gloucestershire against the English badger cull rather than in Wales against the TVR policy. She said:

> *The selective approach seems fairer to me as at it's not widespread murder. I don't have time to protect badgers everywhere. I'm going to save more badgers in England than I am in Wales.*[121]

In the extract above, she refers to the TVR policy implemented in Wales as the 'selective approach'. She is undertaking direct action in England rather than Wales because of the comparative fairness of the two policies. Her application of fairness here relates to two

[121] IN Badger Protector HRA 4, 08.10.16

factors.[122] First, the number of badgers culled and second, whether it is discriminate or indiscriminate culling. Using these two factors, she judged the English cull policy to be less fair than the TVR policy and therefore chose to undertake direct action in England rather than Wales. I met other people in the Gloucestershire cull zone who told me that far fewer people have been undertaking direct action on farms in Wales that are subject to culling compared to the English cull zones. This is in spite of the accidental release by the Welsh Government of the names and locations of the three farms that are undertaking TVR following a freedom of information request to APHA by an animal rights group (Messenger, 2019). Direct comparisons of the degree of direct action in the two countries should be carried out with care; differences in levels of activism may be due to differences in the size of the zones, in the strength of views towards the different policies or the number of activists.

When asked about their views on different culling strategies, some badger protectors in badger cull zones and badger vaccination areas told me they were less opposed to, but would not support, the selective culling of infected badgers rather than the current indiscriminate badger culling policy, particularly if there was a more reliable test to differentiate between infected and infectious badgers.[123] At present it is difficult to differentiate between an infected and an infectious badger because exact routes of transmission are unknown, for example through faeces, urine and/or aerosol transmission. Some field tests can suggest which badgers are at greater risk of transmitting the disease, but these are of low sensitivity and have not been used to suggest which badgers are infectious. For example, badger faeces and sputum can be subject to culturing of *M. bovis* (using methods described in Appendix 2), but the

[122] For further information on fairness and geographies of environmental justice, see Walker and Bulkeley (2006) and Lucas et al. (2004).

[123] FN cull protest HRA 2, 28.09.16; IN Badger Protector HRA 5, 23.11.16

method has a low sensitivity of 8% (Drewe et al., 2010) due to contamination from a wide range of other bacteria in the samples and low numbers of *M. bovis* cells (Wellington and Courtenay, 2014). More research is required to trial and model the epidemiological impact of selective culling using field tests of different sensitivities and specificities. In addition, the field tests need to be able to differentiate between infected and infectious animals. Until this research is conducted, it will be difficult to undertake an effective high-risk approach of culling infectious badgers. Defra (2014a: 65) notes that it will "continue to review evidence emerging from badger control strategies and research in place elsewhere", but TVR is likely not being considered as a policy option in England due to these research gaps.

As well as more closely aligning with badger protectors' understandings of risk from badgers, TVR somewhat complements farmers' spatialised understandings of badgers being 'clean and dirty' (Maye et al., 2014) since badgers are tested for the disease, and in Wales the policy is only being undertaken on farms with persistent breakdowns. However, TVR does not fully align with farmers' spatialisation of badgers. The discrepancy was detailed by a farmer in the Gloucestershire cull zone in response to a question about selective culling. He said:

> *I know which ones are infected. That one is and that one is* [pointing to fields]. *The badgers from that dirty sett* [points to sett] *go in there. If they told me that one badger was infected and two badgers weren't from there then I wouldn't believe them.*[124]

This farmer paints bTB infection across the landscape according to clean and dirty fields and setts (see Section 6.2.1). In contrast he conceives 'they', in reference to people working on selective culling, know bTB infection according to badger. TVR spatialises infection by badger, whereas this farmer spatialises infection by field and sett. These

[124] FN farm visit HRA 1, 09.09.16

different approaches to the spatialisation of infection can be considered as respective differences between veterinary science, which focuses on individual animals, and epidemiology which focuses on how disease occurs in groups. Enticott (2012) reports similar differences in disease realities between vets and veterinary guidance in regard to skin testing, whereby the skin test is conceived on the scale of individual animals and the herd as a whole respectively. Returning to badgers, this farmer demonstrates how these different realities do not align in selective culling practices. This mirrors Section 6.2.1 which showed how disease realities also do not align in *un*selective culling practices. Despite this, however, I consider TVR to be more aligned to farmers' disease realities than unselective culling through their sharing of constructions such as clean and dirty or uninfected and infected badgers. There is nevertheless a need to further consider how these ways of understanding and practising disease can align.

An alternative high-risk approach — that not only mirrors the differentiation between clean and dirty, and uninfected and infected badgers, but also considers the setts themselves — is to identify infectious setts and cull all badgers in these setts. I met a farmer in Devon who was undertaking this approach.

7.3. Identifying, mapping and gassing infected badger setts

In the winter of 2016 I worked in a badger cull zone in Gloucestershire. I met with a farmer who invited me to meet another farmer, Bryan Hill, in Devon who manages bTB in an innovative way in his parish.[125] Bryan undertakes surveys of breakdown farms for signs of badger infection. He transfers these survey results onto maps and uses these maps to recommend badger control methods. In this section I

[125] As detailed in Section 2.5, with his permission I have not anonymised Bryan Hill, because I draw on a book that he authored as a source of material in this section. The book is in the public domain and so his name is already public. This section highlights different elements of his work compared to his book, but does not provide any additional information on any unlawful practices that he has been involved in.

analyse Bryan's approach. I begin by describing his motivations and strategy for gassing badgers. Second, I examine his methods in light of disseminating knowledge locally — including feedback from farmers in a focus group who worked with Bryan to gas badgers on their land. I then consider his working *alongside* badgers in terms of the work of multispecies scholars Haraway and Grandin. Finally, I analyse his understanding of epidemiological research, and briefly explore how his work and Government policy lie at odds with one another. In sum, I explore how badger culling can be done differently.

Bryan is widely known by cattle farmers due to his role in the Badger Welfare Association, which supports the unlawful gassing of infected badger setts. Two months after we met, he published a book about bTB and badgers entitled 'The Badger Killer? It's not all black and white' (Hill, 2016a). He opens the book with:

> My name is Bryan Hill I'm a countryman and cattle farmer from Devon. I've followed this TB rollercoaster for most of my life, and this is some of my story of this highly controversial multi billion pound avoidable travesty that has blighted our countryside. (Hill, 2016a: 1)

On my visit, Bryan took me around his land on a quad bike and showed me various signs that he considers to indicate *M. bovis* infection in badgers. Whilst driving the quadbike and shouting back to me over his shoulder, Bryan told me about his history with bTB:

> *In 1999, Bryan had a breakdown. He had 1/6 of his herd in a field 0.75 miles away from the other stock and those animals were the only ones that reacted to the test. Two other farms that had cows in a field close to his 'reactor field' also had reactors. These farms had been clear of bTB for 50 years. Prior to the test, Bryan found a dead badger in his field with an in-calf heifer (Alice) and concluded that a sett was infected. There was a road in between the fields and thick hedges so the cattle had not interacted. He used his tractor exhaust to gas that sett and they did not break down again for a long while.*[126]

[126] FN farm visit HRA 2, 08.11.16

To assess if his understanding of the link between badger activity and *M. bovis* infection was applicable to farms outside of his parish, Bryan contacted other farmers who were having bTB breakdowns in the West Country. He surveyed their land for badger activity and offered advice about the source of infection. After a while, farmers began to call Bryan for advice as word had spread round the farming community that Bryan was providing useful information about how to deal with bTB. Bryan refers to his work as a *"population disease control management strategy"*.[127]

Bryan had a particular method for his management strategy. He claims to have surveyed and assessed over 3,000 farms in 12 counties (Hill, 2016b) for signs of badger activity and signs of infection in badgers. He told me that his knowledge of badger ecology means he notices signs of badger activity that others do not see. Whilst surveying, he often finds that it is not the main badger sett that is infected, but an outlier or hospital sett associated with a badger nest (Figure 31). These setts are smaller and, Bryan claims, where sick badgers go when they are evicted from the main sett:

> *Bryan told me that healthy badgers kick sick badgers out into new areas and new setts. Sick badgers live in smaller setts (1 hole) or nests. Sick badgers live in nests as they are above ground so they find it easier to breathe. A nest always indicates infection. But, it is difficult to identify small setts and nests as sick badgers are less likely to leave the nest/sett as they do not have the energy to feed as often.*[128]

[127] FN farm visit HRA 2, 08.11.16

[128] FN farm visit HRA 2, 08.11.16

Figure 31: Badger nests. “A selection of badger nests, necessary when TB affects a badgers lungs. I’ve found hundreds of these well-hidden nests over the years, it always spells bad news for TB in cattle” (Hill, 2016a: 89).

Bryan undertakes investigative work on farms and in fields to identify, map and eliminate sources of infection to reduce the length of a current breakdown and reduce the chance of future breakdowns. Bryan also examines the land for 'territory boundaries' to identify the spatial extent of an infected clan of badgers and their transmission of *M. bovis* (Figure 32).

Figure 32: A well-worn badger path defining a territorial boundary. "A line defining badger territory through the middle of a corn field, on the right hand side of this line, there is a TB problem, on the left hand side there is not. Badgers occupy their own defined territories" (Hill, 2016a: 39).

Bryan translates the referent information — nests, runs, setts, field margins, cattle locations, territories — he gathers in the field and on the farm into maps, which he uses to inform the farmer about infected and non-infected badger setts. Bryan translates the things that he sees on his surveys into to a drawing, a marking on a map and a verbal description accompanying the map. Each stage aligns with the one that precedes and follows it “so that, beginning with the last stage, one will be able to return to the first” (Latour, 1999: 64). This process of translation enables Bryan to communicate his findings with the farmer whose land he is surveying. During this discussion Bryan simulates the current badger activity on their land and enhances their ability to understand the badger activity in the future. He does this by placing the map on the table as a focus of the discussion, sharing the descriptions of badger activity on the ground, linking the two, examining it in relation to bTB in cattle and advising methods of control. These actions help to disseminate his expertise through the farming community, thereby enabling farmers to take control of their local bTB situation.

Once an infectious and/or infected sett has been identified, Bryan recommends (unlawfully) gassing these ‘culprit setts’ because:

> *“gassing is the best way to control a sett as the oils in the tractor fumes contaminate the sett so it is unattractive for foxes and badgers to colonise”. He tells me that only sick badgers will re-colonise it as they’re desperate and don’t have the energy to dig a new sett. The sett shouldn’t be destroyed as it’s important for the farmer to know where the infection resides. The farmer is responsible for sett upkeep and to clear the sett if it becomes active again. If the sett s on a neighbour's land that does not want to be involved, snares are used on the run. Snares are set together to kill as many badgers are possible from the culprit sett in the same night in order to prevent perturbation.*[129]

Results from the RBCT suggested that reactive culling can increase cattle bTB incidence, potentially due to increased perturbation; perturbation is defined as increased ranging and mixing between social groups caused by human-made disturbance of badgers (Carter et al., 2007). The ISG that ran the RBCT suggested that culling can increase bTB as badgers roam more widely and come into more contact with other badgers and cattle (Independent Scientific Group, 2007). To prevent perturbation, Bryan recommends gassing entire setts. This eradication often takes place by attempting

[129] FN farm visit HRA 2, 08.11.16

to block all the sett holes excluding one. A fumigator/gas engine/tractor exhaust pipe is put into the hole and the sett is filled with carbon monoxide. Bryan claims that the gas sends the badgers to sleep before painlessly suffocating them. Bryan is passionate about *"responsibly dealing with infectious setts"*, followed by infected setts and leaving healthy setts to repopulate an area and prevent perturbation of other infected badgers into the area.[130] As described in Section 6.2.1, Bryan distinguishes between clean and dirty badgers as best friends and worst enemies:

> as a cattle farmer badgers could be your best friend or your worst enemy (Hill, 2016a: 17).

Bryan shows farmers the setts where dirty badgers live both on their farm and on the map. He advises farmers to keep an eye on hospital setts and nests, and to eliminate them if they see any signs of badger activity. He advises farmers to continuously gas these setts because the purpose of a sett remains the same over time and bTB will be in the soil of the sett so any new occupants will succumb to the disease.

My research in Gloucestershire illuminated how Bryan disseminates this knowledge to other farmers and thereby enables them to gas badgers on their land. I carried out a focus group with four farmers and two vets in the Gloucestershire cull zone, who were supportive of Bryan's work. One of these farmers had previously gassed infected setts, but was now partaking in the badger cull policy. They said:

> *what we may want and what are achievable are two different things, and so you have to be realistic. I would agree with you* [vet] *I think that it* [gassing] *is the way to go because it is quick, cheap and effective. Currently what we have is complicated, quite expensive, and slow, so there aren't really, it's not ideal but it's better than nothing, it is getting things started. I would absolutely agree with you, gassing is the obvious way to go, I would hope that will progress in time.*[131]

[130] IN Farmer HRA 5, 21.09.16
[131] FG farmers and vets HRA, 21.09.16

Some farmers were taking part in the badger culling policy as it was the only option available, but would prefer a targeted cull (usually by gassing) of dirty setts:

> *It'd be nice in a way if there was a way of testing the setts before they're culled, and if they're clean you would sort of say well that's clean, we'll leave it, but that one's dirty, gas that and so you end up with a clean area.*[132]

Gassing was preferred to controlled shooting and cage trapping and shooting because it *"would exterminate the entire sett rather than just popping off the random ones* [badgers] *we can get hold off, which is what we're doing at the moment"*. [133] Similar preferences for a targeted badger cull using gas are reported by Maye et al. (2014).

In this method, Bryan can be considered to be working *alongside* badgers. For example, Bovine TB Blog (2007) writes that Bryan "lets the badgers decide who is sick". When a badger is ousted from a social group because of debilitating bTB, he puts "this disperser out of its misery before it can infect anything else". Bryan accounted for badgers' agency in their geographical location and therefore worked *with* badgers; he did not bar badgers from physical participation in his work (Woods, 2000).[134] Bryan limits the representation of the badger as a wildlife reservoir by accounting for differences within the species, shown by the badgers' own ways of living. For example, he primarily recognised badger nests to be signs of bTB. He did not want to destroy the nest because badgers would use it for the same purpose year on year. Thus, he would always know if infection in the badgers had returned due to the manifestation of badger

[132] IN Farmer HRA 1, 11.10.16
[133] IN Farmer HRA 4, 16.09.16
[134] A badger protector told me that Bryan was inaccurately transforming the badger's living conditions into signs of bTB, but whether his approach is accurate or not is beyond the scope of this research.

activity in the nest. In addition, he advised farmers to protect their clean setts as these would protect their cattle herd from the incursion of dirty badgers.[135]

Bryan's work can be understood by what Singleton and Mee (2017) describe as an 'ethics of flourishing' whereby he aims to produce more liveable worlds, rather than just relieve suffering. Human geographers Ginn et al. (2014: 121) describe feminist technoscience scholar Haraway's understanding of 'multispecies flourishing' as one that does not exclude the possibility of death:

> vulnerability, violence, and death are part of on-going, generative engagements with nonhuman others […] We suggest that the environmental humanities are ideally equipped to show the poignant complexities of multispecies flourishing, a flourishing that is never innocent, nor good for all involved, but rather an awkward, fumbling process.

Life and death are part of the 'fumbling process' of learning, unlearning, exposing oneself and admitting failure in the journey of *becoming with* other species (Beisel, 2010). From Bryan's perspective, his situated compassion for cattle and for sick badgers informs practices that cause pain for some badgers, but also create betterment for animals entwined in bTB. Bryan claims he is helping by gassing badgers as it is as an act of mercy to relieve badgers of the pains of bTB. Interestingly, The Protection of Badgers Act (1992) allows seriously injured or sickly badgers to be killed as an act of mercy. Thus, Bryan considers his practices to be legal.

Bryan shows regard for badgers by tracing their movements through the landscape and mapping these movements as a basis for decisions about gassing some setts and protecting others. Reflective of the work of animal scientist Grandin (1997) who *becomes with* livestock to understand their perceptions and reduce the stress

[135] Bryan is actively against the culling of all badgers because *"the current culls are taking out healthy badgers as they are the easiest to kill. They go out of their sett more often and scavenge more for food. The current culls are also causing perturbation as not all badgers in one sett are killed" (*IN Farmer HRA 5, 21.09.16). He told me that the *"NFU logic of 'a good badger is a dead badger' is stupid logic"*. He thinks a good badger is a live healthy badger and a dead infected badger.

invoked for animals in transport and slaughter, Bryan *becomes with* badgers to understand which are clean and dirty. His approach relies on clean badgers flourishing in the territory freed from the culled badgers. Bryan's ethics of flourishing is shared with the farmer on whose land he is working and continues as the farmer keeps looking at the dirty setts for signs of habitation. There is a continual exchange of signals between the human and the badger and continual building of relations based on a commitment to multispecies co-flourishing.

Yet despite this commitment, Bryan's work lies at odds with government policy on badger culling, and the evidence he has amassed is not considered 'scientific'. Whilst travelling around his farm on a quadbike to look for signs of badgers, he told me about his local 'trial' of sett gassing. After his first breakdown in 1999, Bryan joined with 11 neighbouring farms and 'dealt with' the badger population in an area of land 3.5 miles by 2 miles.[136] He has calculated this has saved the Government £2 million in 10 years by substantially reducing breakdowns in the area, therefore preventing the increased frequency of testing due to breakdowns and reducing compensation costs. His method is dependent on all farmers and villagers working together. He informed his neighbours that they should only gas infected setts and not healthy setts. If one farmer decides to poison a healthy sett, this can ruin the entire strategy as infected badgers can move around in others' territories.

Bryan showed me maps from his trials, based on Ordinance Survey maps with penned markings of badger setts and runs.[137] A red 'X' was put over every sett that had been gassed, along with the date of the gassing(s). In addition, Bryan showed me bTB breakdown information in tables related to the farms he had worked with in the trial.

[136] FN farm visit HRA 2, 08.11.16

[137] For confidentiality reasons, I cannot insert photographs of the maps as they show the locations of farms that undertook unlawful badger culling.

Since 1999, Bryan considers the work in his local parish to be the equivalent of a scientific trial:

> *He told me he has done a scientific trial and it is not being accepted as people are reliant on bTB for their jobs and they do not want to eradicate it. He knows it is not science in the traditional sense of the word, but it is evidence that his strategy works. Why is it not being listened to? Owen Paterson did listen to it a bit and instigated trials for sett tests.*[138]

Bryan told me that Defra offered him the opportunity to trial his method alongside a PCR test (detailed in Appendix 2) developed by Liz Wellington at Warwick University; a non-invasive method of identifying diseased badger groups by identifying *M. bovis* in badger faecal samples (Travis et al., 2014). His method of identifying infected setts would be analysed alongside the PCR test which is the ‘gold standard’. However, Bryan rejected this offer on the grounds that his method was more sensitive than the PCR test, and therefore the use of PCR as ‘gold standard’ would underestimate the sensitivity of his method. Since then, APHA has trialled the sensitivity and specificity of the PCR test and rejected it on the grounds of poor sensitivity.

In this case, the coming together of things and knowledges at a local level means the breaking apart of things and knowledges at a national level. Bryan’s embodied methods of detecting, mapping and dealing with bTB are not operationally consistent with official methods, therefore creating a challenge to the adopted vision. A disjuncture is created between the Government population disease approach and Bryan’s high-risk approach. Bryan takes a high-risk approach by only dealing with breakdown farms and personalising advice to the local environment. Building on Lane’s et al. (2011) argument in relation to practices and knowledges about flooding, it is easier to silence the challenge of alternative practices of badger culling by making them appear unprofessional and uncertain rather than to take the challenge on and try to incorporate

[138] FN farm visit HRA 2, 08.11.16

these into official systems. However, ignoring or undermining the value of local knowledge in disease management contributes to a loss of farmers' trust in government (Enticott, 2008a, 2008d; Mort et al., 2005), thereby creating a likely barrier to engagement in the bTB strategy (Defra, 2020a).

7.4. Conclusions

I have written this short chapter with an orientation towards the future in which change is my primary goal. I do not just wish this chapter to have illuminated 'what is', but to help make 'what is to become'. Thus, in this final section I summarise my findings and look forward to what this may mean for future policies around bTB and badgers.

The high-risk approaches of TVR and gassing pose multiple issues such as the sensitivity of the detection test, the unlawfulness of gassing, public contestation about gassing (Section 5.1) and the epidemiological impact on bTB in cattle. However, these high-risk approaches allow the multiplicity of bTB to be recognised and likely ease tension between people with different views on badger culling. Challenging and questioning policy is likely to open up alternative ways and visions of 'what may otherwise be' for badger culling. Contrary to badger culling in Chapters 5 and 6, where bTB was barely visible, this chapter shows that the visibility and tracing of bTB may be highly important to an alternative mode of badger culling. Visibility can be achieved through genetic tests such as the DPP test or through the kind of ecological embodied knowledge held by Bryan Hill.

If badger culling was woven as the selective culling of setts on farms that have chronic bTB infection due to badgers, it would likely be more accepted and would match farmers' ways of knowing badgers as clean and dirty. This, in turn, prompts ethical questioning, for example: How can policy institutions become more sensitive to the shared cultural and emotive issues engendered by policy? How does badger culling policy align with existing disease realties? And, how can policy be woven to encourage multispecies flourishing? These collective conversations about how badger culling can be done differently may help to recognise complexity, situate culling approaches in the wider landscape of farming and badger protection, and increase the likelihood of sustained collaboration around disease management. In the next chapter I investigate how collaboration can also be made through citizen science.

Chapter 8. Measuring *M. bovis* prevalence in badgers: how can citizen science realise collaboration between divergent groups?

> *if you can't measure it, you can't manage it. And unfortunately for poor old badger, if the badger is involved then we specifically need to target the badger and if there's so much resistance to doing anything to the badgers, if we have concrete evidence that they are involved, then you know science would dictate that we have a case to act on it.*[139]

This chapter presents ethnographic findings from three months working in the veterinary school at the University of Nottingham on a Defra-funded, participatory 'Badger Found Dead Study'; hereafter referred to as 'the BFD Study'. The BFD Study was undertaken as a form of citizen science to determine the prevalence of *M. bovis* in badgers in the Edge Area, i.e. the proportion of infected badgers in counties on the politically defined geographical edge of the cattle bTB epidemic (Figure 1). I analyse how citizen science may be used in bTB, particularly in regard to disease surveillance, and the benefits and challenges of doing so. Using the BFD Study as a case study, in this chapter I address RQ5: 'How can citizen science realise collaboration between divergent groups?'. I do this by showing how veterinary epidemiology can be practised differently in relation to bTB, in contrast to the expert-centric norm, in a way that involves multiple groups with a stake in the controversy. I detail how communities were brought together through science-in-the-making, specifically by sharing goals and uncertainties. I argue that participatory veterinary epidemiology, as a form of citizen science, can enable groups with different worldviews of bTB to work together towards a common goal. It can develop better, more meaningful knowledge for communities, help to dismantle the certainty made by 'The Science' in the controversy, and make space for collaboration between oppositional communities. On the one hand, this

[139] IN Farming Representative Edge 2, 06.02.17

collaboration is somewhat extraordinary against the background of longstanding and recalcitrant polarisation. On the other, I show that this collaboration was fragile and broke apart when the BFD Study findings were released because communities used them to reinforce their longstanding worldviews about the controversy. In the current controversy, practicing citizen science alone cannot overcome the deep-rooted antagonisms that are present around the controversial issue of badger culling and bTB (detailed in Chapter 5 and Chapter 6). However, this chapter opens new ways of thinking about and doing citizen science to both improve knowledge and create space for actors with divergent worldviews to engage.

8.1. Collaborative knowledge generation and participatory veterinary epidemiology

Polarised worldviews around bTB and badger culling are difficult to reconcile, in part due to the different realities of bTB that they present (for more detail, see Section 1.4.3). The divisions, sustained in part by 'The Science' around badger culling, seem unresolvable as they are based on longstanding framings of the issue which interfere with one another (see Chapter 6 for examples of divisions in the badger culling fields). However, these framings create points of intersection between identities and communities, thereby providing opportunities to connect and value multiple knowledges. Connections between so-called polarised communities, for example, have been found in 'online issue publics' related to the badger cull in England. Sandover et al. (2018) found lengthy debates on Twitter between pro- and anti- cull users about the relative merits of wildlife and ecological research about badger culling. The authors report that for a short period of time, the conversation about wildlife and ecological research provided an opportunity to move beyond the intractable conflict. They suggest that the "heterogeneity and contextual specificity"

(Sandover et al., 2018: 110) of communities poses opportunities for building connections between them.

One way of building such connections between polarised communities is through the practice of collective knowledge generation about the issue of concern, for example using citizen science. I use the following definition of 'citizen science' as the methodological basis for my findings on the BFD Study:

> scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions (Oxford English Dictionary, 2014).

Citizen science is an approach that democratises science-in-the-making (Irwin, 2015; Ottinger et al., 2017) and, if undertaken as 'upstream engagement', can bring publics together in dialogue about emerging research to frame research trajectories (Wilsdon and Willis, 2004). Empirical studies show that it may help to: develop participants' skills (Pritchard et al., 2018); restore public trust in and care for knowledge (Gabrys, 2017; Pritchard and Gabrys, 2016); re-orientate knowledge toward coping with the complexity of environmental problems (Calvillo, 2018); install democratic governance of knowledge (Eitzel et al., 2017); and, enable publics with differing views to work together to "negotiate a new and collective sense of knowledge" (Lane et al., 2011: 32).[140] In the midst of a controversy, citizen science also provides an opportunity to foster alternative awareness of the issue at stake, redistribute expertise and potentially develop better futures (Landström et al., 2011; Whatmore and Landström, 2011). In line with Lane et al.'s (2011) and Callon's (1999) arguments regarding publics participation in the process of knowledge generation (detailed in Section 1.4.3), citizen science could help to recognise multiple forms of knowledge and

[140] Many analyses of and guidance for citizen science have centred around projects related to conservation and ecology (Pocock et al., 2014; Silvertown, 2009; Tweddle et al., 2012).

lessen the authority of 'The Science' by making knowledge generation something that is done by all. In this chapter, I argue that citizen science can "reveal a diplomatic space for doing TB differently" (Price, 2017: 1) by identifying where there is potential for common ground. I suggest there is an opportunity to use the approach of citizen science to bring partisan groups together by encouraging conversations to be had, learnings to be shared and further connections to be established between antagonistic communities.

In veterinary science, 'citizen science'-like studies are most often undertaken in the sub-discipline of epidemiology surveillance, referred to as 'participatory veterinary epidemiology' (Thrusfield, 2007). Building on Catley et al.'s (2012) review in The Veterinary Record, Enticott (2017) argues that participatory veterinary epidemiology can be used as a form of collective knowledge generation. In this chapter, I use epidemiologists and veterinarians Catley et al.'s (2012: 151) conceptual definition of participatory veterinary epidemiology as:

> the essential involvement of communities in defining and prioritizing veterinary-related problems, and in the development of solutions to service delivery, disease control or surveillance.

Catley et al. (2012) detail how combinations of participatory and conventional veterinary methods can be used for disease surveillance, such as drawing on livestock keepers' observations to inform the positive predictive value of Foot and Mouth Disease in Tanzania (Catley et al., 2004). In his book about participatory livestock research, Conroy (2005) details a framework for participatory situation analysis and participatory technology development. In the main, Conroy's work focuses on downstream engagement with interested parties such as vets and farmers, for example by setting research questions and methodologies, and then requesting farmers' engagement to address these questions.

I found that 'citizen science'-like participatory veterinary epidemiology studies on bTB have been taking place in England since the 1970s. Since the beginning of Muirhead's investigations of bTB in badgers in Gloucestershire in the early 1970s (Section 5.1), people have been bringing dead badgers to MAFF officers. In 1972, MAFF formalised these contributions — in what would now be described as 'citizen science' — in a 'Badger Survey'. MAFF requested that any carcasses found by members of the public were brought to the nearest Ministry office and veterinary officers dissected and cultured carcass samples for *M. bovis* (Atkins and Robinson, 2013b). This project continued until 1990. Since then citizens have been involved in badger road traffic accident surveys in England between 2000 and 2001, between 2002 and 2005 (Defra, 2016d), and in the present day.[141] However, to my knowledge, there is no social scientific research investigating how these surveys were undertaken and how they affected the bTB controversy.

Veterinarians Toribio and Rushton (2012) criticise some pioneers of participatory epidemiology for being so passionate about the sub-discipline that they do not assess the weaknesses of the approach or draw on the experiences and application of participatory methods across multiple fields. From my perspective, a substantial weakness exists in current participatory veterinary epidemiological approaches. In its current form, many participatory veterinary epidemiology studies do not sufficiently consider, or realise, the benefits that can be achieved through citizen science with, and for, diverse publics (outlined earlier in this section). Instead, studies focus on furthering epidemiological knowledge (Lawson et al., 2015). For example, like Catley et al. (2012), Conroy's work does not cover more upstream citizen science approaches with

[141] In addition, Enticott et al. (2018) developed an internet-based map of farm disease status and undertook usability trials with farmers and veterinarians. Whilst this work is not described as citizen science, it demonstrates how citizens may be involved in the development of epidemiological maps.

diverse 'publics' and therefore does not help to form connections between such groups or encourage questioning of the authority of 'The Science'. Consequently, studies such as this could be argued to reinforce deference to 'The Science' (Yearley, 2000). I argue that the more extensive use of upstream citizen science approaches — such as citizens being definers of problems, and observers, collectors and contributors to data files — could help to develop participatory veterinary epidemiology to further knowledge of disease surveillance, *and* to build a network of people with divergent worldviews about a public knowledge controversy.

In the UK, there is a developing body of citizen science work on environmental public knowledge controversies. There is a recent body of citizen science work on air quality and chemical toxicity, for example, which highlights citizen disagreement with how industries and governments are managing air quality (Calvillo, 2018; Pritchard and Gabrys, 2016; Tironi, 2018). However, there remains an evidence gap about how participatory veterinary epidemiology can be undertaken in the field of controversies, and the benefits and challenges of doing so from the perspectives of both participants and scientists. This chapter addresses this gap.

Social scientific researchers are increasingly critiquing citizen science, specifically in relation to: the public–expert relationship (Cornwell and Campbell, 2012; Irwin, 1995, 2015), the experience and motivations of participants (Bruyere and Rappe, 2007; Geoghegan et al., 2016; Hobbs and White, 2012; Raddick et al., 2013), or, the learning outcome of participants (Crall et al., 2013; Cronje et al., 2011; Jordan et al., 2011; Trumbull et al., 2000). Riesch and Potter (2014) note that these critiques are often presented from the perspective of the participants and there is limited social scientific research analysing concerns, lessons learned and reflections from scientists. Through my role as a co-creator of the BFD Study, my analysis throughout this chapter contributes a critique of participatory veterinary epidemiology, as a form of citizen science, from the position of a 'scientist'.

I now turn to introduce and analyse the BFD Study. In the remainder of this chapter I use the term 'participants' to refer to people collecting badgers, and 'scientists' to refer to those undertaking work in laboratories. This distinction is not accurate as all people involved in the BFD Study were involved in science-in-the-making, but I distinguish between the two groups for the purpose of clarity.

8.2. Calculating *M. bovis* prevalence in badgers in the Edge Area

In 2016, Professor Malcolm Bennett (Zoonotic and Emerging Disease at University of Nottingham) invited me to work on the BFD Study. The Study followed on from the 'Cheshire Badger Tuberculosis Survey' undertaken in 2014/15, which was instigated by the Cheshire TB Eradication Group, composed of multiple actors with divergent worldviews on bTB management strategies. These included the Cheshire and Wirral badger group, Cheshire Wildlife Trust, APHA employees, local vet practices and farmers. The Cheshire TB Eradication Group and Professor Bennett co-defined the salient issues and questions to be answered in an upstream model of citizen science (Wilsdon and Willis, 2004). The study aimed to:

> provide some idea of presence/absence, geographic distribution and genotype of the bacteria that can then be used both as pilot data for larger scale studies and as preliminary evidence to discuss various TB control measures (University of Liverpool, 2014).

Badger carcasses (predominately roadkill) collected by the Cheshire TB Eradication Group were submitted to the University of Liverpool for microbiological analysis. They underwent post-mortem examination and were subject to genetic testing with the aim of developing information about bTB disease prevalence in Cheshire. Upon analysis, 20% of 96 badger carcasses collected in the Cheshire study proved to have *M. bovis* infection (Sandoval Barron et al., 2018). Following this, funding was secured from

Defra to undertake citizen science to collect at least 100 fresh dead badgers in all 11 Edge Area counties (Figure 1) from August 2016 to August 2017. The aim was "to assess the prevalence and geographic distribution of tuberculosis in badgers in the Edge Area of England" (Defra and Bennett, 2016: 53).

Figure 33 shows a diagrammatic overview of the method. Detailed notes of the practices for each of these stages (excluding 'culture', 'growth of mycobacteria-possible positive' and 'contamination' which are presented in this chapter) are presented in Appendix 2.

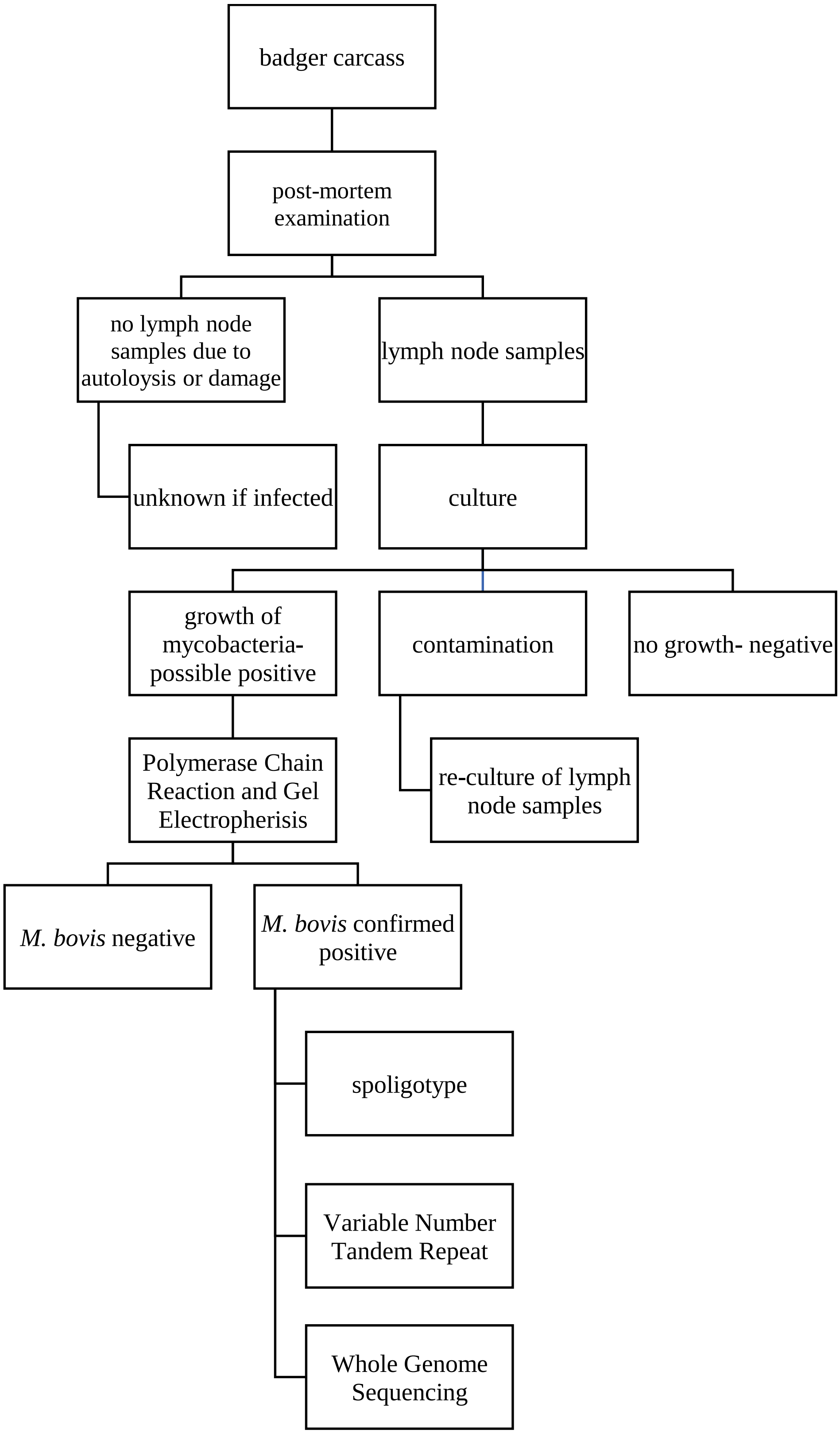


Figure 33: Overview of the BFD Study methodology (Author, 2018)

In contrast to the earlier MAFF studies mentioned where citizen involvement was limited to the collection of badger carcases, the BFD Study included citizens as collaborators through the entire project cycle. In addition, the MAFF studies were government led and predominantly involved farmers and veterinarians. The BFD Study, on the other hand, was led by an academic institution and specifically invited a wider range of stakeholders to be involved. However, stakeholder involvement was externally delimited: the BFD Study was designed by Professor Bennett himself, not in collaboration with interested parties. Some social researchers may suggest the BFD Study was the deficit model of knowledge production in a new guise (Wilsdon and Willis, 2004; Wilsdon et al., 2005) as participants were engaged to answer pre-defined questions. While this design does not match the ideals of upstream citizen science (Wilsdon and Willis, 2004), the questions were relevant to participants as they were extensions of those used in the predecessor study undertaken in Cheshire; which were co-designed by the Cheshire TB Eradication Group and Professor Bennett.

I predominately worked on the studies undertaken in: Cheshire, Derbyshire, Nottinghamshire, Leicestershire, Northamptonshire and Warwickshire. This chapter largely focuses on Derbyshire because there was a wider variety of actors involved in the BFD Study, and the research had much at stake due to the local political possibilities it could engender. Prior to and during the BFD Study, Defra funded badger vaccination in the county was occurring on private estates, a handful of farms, National Trust land and Wildlife Trust land. In addition, Derbyshire farmers had applied for a cull licence and been rejected. The tensions between these possibilities of badger management meant the controversy was intensely playing out in Derbyshire and therefore the study was important in proving prevalence of infection. Consequently, I undertook extensive negotiations to involve polarised communities in the BFD Study.

I had multiple roles in the BFD Study: I recruited participants to collect carcasses for the BFD Study, helped conduct post-mortem examinations of badgers, gave presentations about the BFD Study to participants and analysed the Study for my own research. I was therefore part of the research team at the University of Nottingham and an ethnographic researcher observing the study. My dual role as part of the research team and ethnographic researcher provided me with a detailed understanding of how the research looks from the inside out, rather than the outside in. My positioning as a co-creator of the BFD Study enabled me to actively place myself in the work (Star, 2015) and make informed recommendations for how bTB science might be done differently in the future.

8.3. Making of collaboration

In this section I argue that collaborative relations were made through the BFD Study by sharing goals and uncertainties, and developing personal relations.

8.3.1. Sharing goals

In the BFD Study's predecessor, the 2014/15 'Cheshire Badger Tuberculosis Survey', the majority of participants were farmers and those with the strongest interest had experienced bTB breakdowns. As a result, many of the badgers were collected from areas of high bTB prevalence in cattle, and the findings were not geographically representative of the badger populations. The scientists recognised the importance of bringing together a variety of actors in the BFD Study to collect enough badgers to calculate a prevalence rate of infection in badgers that was geographically representative and statistically significant. The scientists primarily wanted to recruit participants who had an interest in bTB and badgers to ensure their 'buy-in' to the study. Consequently, the scientists attempted to recruit actors with varied positions in relation to the bTB controversy to encourage badger collections from all over the counties and guarantee that enough badgers were collected (approximately 1,100 badger carcasses were required).

It was crucial to know what motivated participation in the BFD Study, and equally to meet these motivations to encourage sustained engagement (Measham and Barnett, 2007; West and Pateman, 2016). Like other citizen science studies, there were multiple motivations for taking part (Geoghegan et al., 2016). In the interest of focusing on the BFD Study as participatory veterinary epidemiology in the midst of a public knowledge controversy, I focus on one motivation in particular which was shared by the majority of participants, namely, to know more about *M. bovis* prevalence in badgers.

Many vets, farmers, farming representatives, badger groups and badger cull companies wanted to collect badgers to calculate the prevalence of *M. bovis* in badgers in their local area and drive action on bTB management in wildlife. In interview, one farmer said *"we need to know the facts about infection in wildlife before a management strategy can be put in place"*.[142] A NFU county advisor considered that the BFD Study would drive more specific and localised targeted action on bTB. He said that if the study found that only a few badgers were infected across the whole of a county, but a particular area had many infected badgers, this would suggest that a geographically specific strategy of badger vaccination or badger culling may need to be undertaken.[143] In interview, another NFU county advisor in the Edge Area said that an APHA vet had

[142] IN Farmer Edge 1, 03.02.17
[143] IN Farming Representative Edge 2, 06.02.17

told him that *"the roadkill survey was of 'strategic importance' for the roll out of culling"*.[144]

These farmers and farming representatives were motivated to be involved in the BFD Study (by collecting and submitting badger carcasses) because of the perceived opportunity that the Study presented to prove that a significant proportion of the badger population was infected with *M. bovis*. Their confidence in the likelihood of finding high levels of infection stemmed from their experience of living with the disease and believing that badgers were a source of infection on their farm (for example, see the description of Richard in Section 4.3). According to one farmer, "*we know that many of the badgers round here are infected, we just got to prove it"*.[145] This confidence that the BFD Study could prove that badgers were infected developed into confidence that the findings could help local areas to secure a cull licence. The link between the BFD Study and badger culling was amplified because a badger cull was licenced in Cheshire one year after the 'Cheshire Badger Tuberculosis Survey' had been completed. A vet involved in the Cheshire cull told me that, *"I got what I wanted from the old survey* [the Cheshire Badger Tuberculosis Study]. *It has helped get a cull in the area"*.[146] But the supposed causative relationship between the findings from the 'Cheshire Badger Tuberculosis Survey' and the licencing of the cull in Cheshire also proved to be a barrier to involvement of groups that opposed badger culling.

Some badger groups refused to collect badgers for the BFD Study due to the licencing of the cull in Cheshire: it was *"a tool for pushing for more indiscriminate*

[144] IN Farming Representative HRA 1, 14.09.16. The badger cull is licenced for "the purpose of preventing the spread of bovine TB under section 10(2)(a) of the Protection of Badgers Act 1992" (Defra, 2018b) and therefore, if the BFD Study produced evidence to prove a significant proportion of the badger population was infected, an area could be more likely to secure a licence.

[145] IN Farmer Edge 4, 21.01.17

[146] IN Vet Edge 1, 15.01.17

methods of badger culls".[147] For other badger groups the negative potential link between the 'Cheshire Badger Tuberculosis Survey' and the licencing of badger culling in Cheshire was outweighed by the opportunity that the study presented to prove that a significant proportion of the badger population was not infected with *M. bovis*. One badger vaccinator told me that she was involved in the BFD Study to understand *M. bovis* prevalence in badgers *"so that we can do something productive about the disease, aka we can vaccinate in the best place and show a cull is unnecessary"*.[148]

The BFD Study provided an opportunity for the realisation of a much-shared goal (collecting information about the prevalence of *M. bovis* in badgers in Edge counties) and therefore encouraged collaboration in the midst of a public knowledge controversy. Reflective of Sandover et al.'s (2018: 108) analysis of badger culling on Twitter, "it is not so much the pre-controversy affiliations of actors that are at issue, but the very issue through and by which they assemble". The sharing of a goal brought people with polarised viewpoints into collaboration in the practice of collecting badger carcasses for the BFD Study. As suggested in Whatmore's (2009) analysis of controversies, the multiple 'whos' were brought together through a 'what'.

Catley et al. (2012) pose that sharing common understandings of goals in participatory veterinary epidemiology can help to achieve relevant and sustained outcomes. In the BFD Study, the shared goals contributed to collaboration, and therefore to the creation of geographically robust findings about the prevalence of *M. bovis* in badgers. However, approximately half of those involved expected high prevalence of *M. bovis* and half expected low prevalence of *M. bovis* to justify practices of badger culling and badger vaccination respectively. The differing reasons for wanting

[147] IN Wildlife Group Edge 2, 05.01.17
[148] IN Wildlife Group Edge 4,18.01.17

to know more about *M. bovis'* prevalence in badgers hinted at the contestation that was to be experienced when the findings were released (Section 8.4).

Not all people with this goal immediately participated in the BFD Study because it conflicted with other activities. At the time of the BFD Study, the Badger Trust was running a campaign called 'Give Badgers a Brake'. The campaign aimed to:

> increase awareness to the risks of roads and developments to badgers. We encourage you to report any badger road traffic casualties that you spot so we can pinpoint hot-spots and petition local councils for better safety measures (Badger Trust, 2017).

Some badger groups in the Edge Area were affiliated to the Badger Trust. They considered the BFD Study to be removing badgers from the roadside from which they would otherwise learn about badger road crossing points as part of the 'Give Badgers a Brake' campaign. The groups wanted to put carcass site information into the 'Give Badgers a Brake' campaign to have a more complete record of where badgers were regularly being killed on the road.[149] Some of these badger groups only agreed to take part in the BFD Study if they received information about the location from which each badger was collected. Professor Bennett agreed to share this site information, which was being collected in the 'badger carcass submission form' as part of the standardised method of collecting dead badgers (outlined in Appendix 2).

Following Professor Bennett's decision to share site information with the local badger groups at the end of the BFD Study, three local badger groups took part in the BFD Study. In two counties, local badger groups were the largest carcass collectors.[150] Local badger groups' motivations were translated into the BFD Study network and consequently translated the BFD Study resources into the 'Give Badgers a Brake' network. Without their involvement, the project would have been unlikely to have

[149] IN Wildlife Group Edge 5, 15.02.17; IN Wildlife Group Edge 6, 16.01.17
[150] IN Wildlife Group Edge 1, 27.01.17; IN Wildlife Group Edge 6, 16.01.17

collected 100 badgers in each county. Consequently, the sharing of site information provided an interface to link local badger groups in both the BFD Study network and the Badger Trust network. The site information was concurrently a method of mapping *M. bovis* prevalence per county, and a record of badger road crossing points for badger groups. Drawing on the theoretical findings of STS scholars Singleton and Michael (1993) in their research on the durability of the UK cervical screening programme, I consider that this linking of networks led to their associated durability due to their dependence upon one another for information. The information proved to be a bridging object between the Give Badgers a Brake campaign and the BFD Study.

However, one participant did not share the goal of mapping the prevalence of *M. bovis* in badgers. Instead, the BFD Study provided a way of making money; each participant was given £10–15 per badger as compensation for their time and effort.[151] The following fieldnote details my collection of badger carcasses from a knacker's yard:

> *I arrive at the knacker's yard and park outside. I walk past a scrap yard to the shed in which they cut up animals. Today there is a skinned cow hung up on a hook from the ceiling with its blood and organs all over the floor. The shed is warm from the meat and the smell of rotting flesh hung in the still air. I draw in my breath before entering. A man, cutting up what seemed to be a horse, looks up to me and asks, "are you here for the badgers?". I nod. He sticks his knife in the carcass, wipes his bloody hands on his overalls and takes me over to a walk-in fridge. Inside are two badgers in collection kits, one badger that is not in a collection kit, a dead calf and what seems to be a dead dog. He passes me the two bagged carcasses in the collection kits, which had been delivered to the site by a farmer. He tells me that the farmer had "gone and accidently run one of them over!" the previous evening. I put them in my car whilst he bags up the other badger and completes a submission form- how he knows where the badger was collected is beyond me.*[152]

[151] The total payment per carcass was £15. Collectors were paid £10/carcass and the persons who stored the carcass were paid £5. Many collectors received £15 as they stored the carcass before it was collected by the research team. Collectors were paid £10 if they had collected the carcass and delivered it to a collection centre who stored the carcass before it was collected by the research team.

[152] FN collecting badgers The BFD Study 1, 08.12.16

Some badgers were put in collection kits at the knacker's yard rather than when the carcasses were collected and I was therefore unsure if the site information was accurate. Due to the knacker's yard not sharing the goal of collecting information about *M. bovis* prevalence in badgers, concern was raised about whether it was accurately recording the location of the badgers. The following fieldnote details a conversation with Professor Bennett about the activities at the knacker's yard:

> *Professor Bennett tells me that Mr Johnston* [owner of the knacker's yard] *asked him if he was accepting badgers from Lincolnshire. Professor Bennett said no and Mr Johnston said he could just pick up a badger in Lincolnshire and swap the grid reference to a Nottingham reference, and he would get paid. Mr Johnston has thus far given 30 badgers and so is one of the largest collection centres. Professor Bennett doesn't want to get on the wrong side of him, but he doesn't want badgers from Lincolnshire. In the end it comes down to trust.*[153]

The knacker's yard was motivated to participate in the BFD Study due to the £15/carcass payment. Consequently, the carcass was a commodity and the submission form was a mechanism for the receipt of payment.

In summary, the BFD Study was part of the longstanding public knowledge controversy and therefore the intractability of divisions and polarisations between communities posed challenges to securing their involvement. Government's supposed use of findings from the 'Cheshire Badger Tuberculosis Survey' to licence a cull was widely interpreted. Some people who supported badger culling viewed this positively and it encouraged their participation in the BFD Study. Some people who opposed badger culling viewed this negatively and were discouraged to take part. The varied influence of the study on involvement in the BFD Study reflects the polarisation of debates around badger culling. Despite these differences, many people with differing views of bTB were motivated to take part in the BFD Study to gather information about

[153] IN Disease Scientist The BFD Study, 12.12.16

the prevalence of *M. bovis* in badgers. In other words, in the midst of a divisive and polarising controversy, people came together around a common aim.

8.3.2. Sharing uncertainties and developing personal relationships

When someone collected a carcass, they informed the university research team and someone from the team went to collect it. It was put in a fridge at the university and a post-mortem examination was undertaken as soon as possible. The aim of the examination was to sample lymph nodes (glands that help the body fight infection and disease and can become enlarged and/or lesioned due to bTB) from which a microbiologist attempted to culture *M. bovis*. I observed 15 post-mortem examinations whilst at the University of Nottingham. More information about the process is detailed in Appendix 2.

Once the lymph nodes had been extracted from the badger carcasses, they were subject to microbiological investigation in a CL3 laboratory.[154] I was not allowed into the laboratory because it required security clearance as *M. bovis* poses a danger to humans and the environment. Instead, I sat in a corridor outside the laboratory and observed the microbiologist, Jim, through a window. Jim and I used FaceTime on iPads to communicate (Figure 34).

[154] There are four types of laboratories: CL1 the samples pose no threat to humans or the environment; CL2 the samples pose a small human threat and good treatment is available; CL3 the samples pose an environmental danger and human danger and treatment is available; and, CL4 the samples pose a large environmental danger and human danger and no treatment is available.

Figure 34: iPad showing the cabinet where Jim created slopes for culture (Author, 2017)

The process of culturing bacteria involves encouraging the multiplication of bacteria in a controlled environment. It is not an ‘exact science’, and Jim was aware of the potential for error. Like other tests for disease (Chapter 3), the performance of culturing (a binary classification test based on the presence or absence of *M. bovis*) is determined by specificity and sensitivity.[155] Culture has high specificity if checked by PCR and spoligotyping methods (Appendix 2). It has ‘mid-range sensitivity’ due to the multiple opportunities for *M. bovis* not to be successfully cultured in this process. I now describe

[155] Specificity is the proportion of non-infected animals that will be correctly identified as negative (true negative). In epidemiological terms, specificity quantifies the avoiding of false positives. Sensitivity is the proportion of infected animals that will be correctly identified as positive (true positive). In epidemiological terms, sensitivity quantifies the avoiding of false negatives.

these uncertainties, show how they were shared with participants and analyse how this helped to form collaboration.

The culturing process began by Jim pooling the lymph node samples into four groups. The lymph nodes were put into groups to decrease resource costs, however the pooling of lymph nodes also decreases the sensitivity of the culture. For example, if one infected lymph node was pooled with seven uninfected lymph nodes it was more difficult to culture *M. bovis*. To counteract the reduced sensitivity caused by pooling, Jim cut the lymph nodes and trimmed off the fat to increase the sensitivity of the culture.[156] Taking a small sample of the lymph node meant less oxalic acid was added (see footnote 158), reducing dilution and increasing sensitivity compared to a large sample. But, conversely, taking a small sample also contributed to reducing sensitivity as there was a lower chance of sampling a part of the lymph node that has *M. bovis*. Jim tried to counter this reduced sensitivity by cutting off a sample that looked or felt like *M. bovis* may be present: looked like a lesion, was white or gritty.[157]

The samples were put into a suspension and transferred into tubes containing media to form slopes.[158] The slopes were put into an incubator for 12 weeks at 37*c. Once incubated for eight weeks, bacterial colonies became visible. Jim showed me samples which had been cultured for 10/12 weeks.[159] He considered two samples to be *M. bovis* positive which were granular and light colour (Figure 35a), and another sample to have been contaminated by another bacteria (Figure 35b). Jim told me that contamination occurred in approximately 10% of carcasses and therefore 1% of tubes (five lymph node pools per carcass and two tubes/pool). Contamination meant at least

[156] FN culture The BFD Study, 12.12.16

[157] IN Microbiologist The BFD Study, 20.02.17

[158] The sample was ground up with a pestle and mortar. Jim then added sterile sand, oxalic acid and phosphate buffer saline to destroy other bacteria and encourage growth of bacteria respectively.

[159] FN culture The BFD Study, 12.12.16

1% of tubes could have been false negatives as it was impossible to know if Mycobacteria had been cultured in contaminated tubes (Figure 35b). This error was minimised because multiple tubes and pools were taken from one carcass. It was rare that more than one tube was contaminated per carcass and therefore Mycobacteria may have been cultured from another pool if the animal was infected. Due to the possibility of contamination and the selection of a small part of the lymph node to culture from, Jim was only confident if the sample was positive. He never knew if a culture negative was a true negative or a false negative, and thus infection rates were likely to be higher than those estimated.[160]

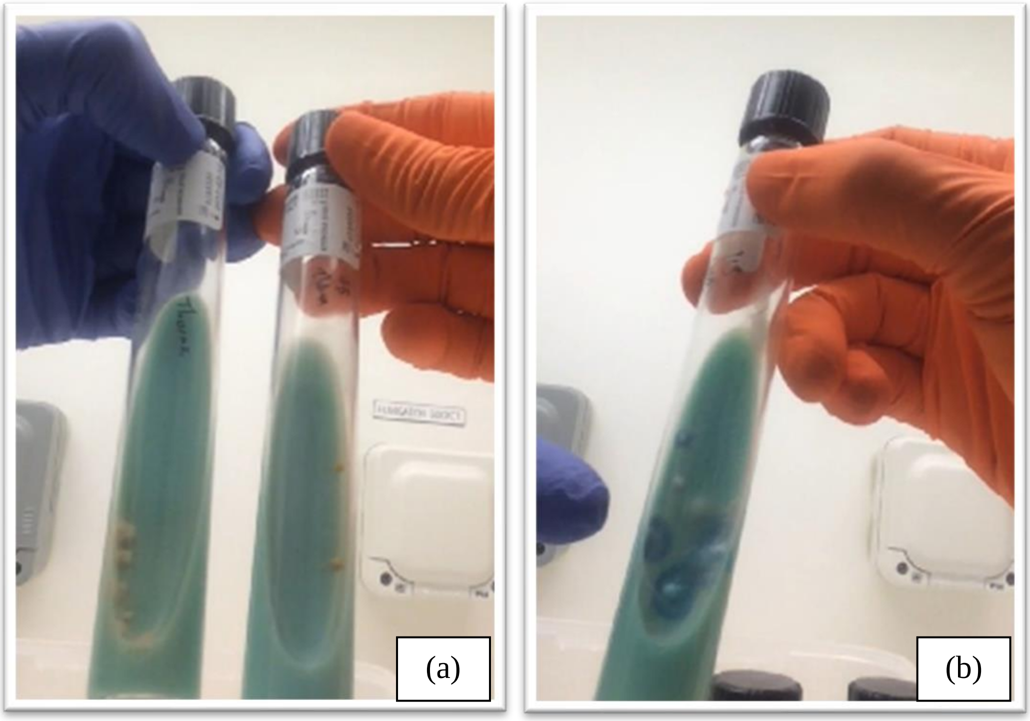


Figure 35: Cultured samples from badger carcasses. (a) Mycobacterial colonies. (b) Slope contaminated by other bacteria (Author, 2017).

[160] In this thesis, I use the epidemiolocal version of the terms true positive, false positive, true negative and false negative (see Section 3.1).

If a slope showed signs of mycobacterial growth at 8–12 weeks and the bacteria was identified as *M. bovis*, the sample was genotyped (Appendix 2). The genotype is commonly referred to as a strain of *M. bovis* (APHA, 2017).

Professor Bennett and Jim were keen for participants to understand uncertainties in the culturing process and to be aware that culture negatives are not necessarily true negatives. The following extract is taken from an email sent to participants describing the process of post-mortem examination and culture:

> [Jim] *carefully trims the tissues, grinds them up and mixes them with dilute oxalic acid. The idea behind this treatment is that the weak acid kills bacteria, but kills Mycobacteria less well than most of the bacteria that might be contaminating the tissues. After death, bacteria from the gut quickly leach into the abdomen, while any breaks in the skin allow other bacteria in (both reasons why we've asked for fresh carcasses, minimally squished). As Mycobacterium bovis takes at least 6–8 weeks to grow, and we can't say for sure all the cultures are negative until we've waited 12 weeks, it's important that we kill many as possible of bacteria that grow more quickly – but without killing the mycobacteria themselves. So this stage is quite critical* (Bennett, 2017).

Many participants told me that this email communicated complex ideas in simple ways which helped them to understand the uncertainties in science-in-the-making (see Section 1.4.2). The email details how uncertainty in the BFD Study can be reduced by only submitting 'fresh, minimally squished' badgers. Jim and Professor Bennett extended their influence outside the laboratory by standardising methods of collecting fresh, minimally squished badgers to improve the certainty of the BFD Study results. However, scientists did not want to overly-discipline participants about the types of carcasses they could collect for fear that the participants would leave the BFD Study and therefore not enough badgers would be collected to have statistically significant and representative results.

The uncertainties associated with culturing *M. bovis* were raised in an interview with a representative of farmers and landowners:

> *farmers have been telling us that Defra needs to do a roadkill survey. It's especially attractive because they can know if their local badgers are infected. Yes, I know it's not 100% certain that they will detect infection in all the infected badgers, but they can't do anything about it. It's not them making a mistake or missing something…the method is the best we got and it's not perfect.*[161]

This farming representative recognised that the method had uncertainties and knew that the scientists could not confirm if culture negatives were true negatives. The sharing of uncertainties and the development of personal connections between participants and Professor Bennett facilitated trust, confidence and certainty in the scientists, the outcomes of the BFD Study and the limitations of the findings:

> Farming representative: *I'm collecting badgers for Malcolm because it is benign, there is no contestation…well until the results are released. The survey gives a representative statistic on TB in badgers in the Edge Area. The data can stand up to scrutiny by the opposition, they cannot show it to be inaccurate.*
>
> JP: *Why can it stand up to scrutiny?*
>
> Farming representative: *The results won't be perfect, but it will show us the minimum level of infection in the badger population. Malcolm's told me of some of the problems with, what is it, false negatives?*
>
> JP: [nods]
>
> Farming representative: *Yeah so I know the problems, he emails me. Malcolm isn't trying to hide anything. It's better than hiding the problems and then it all coming out when the results are released and some people don't like what it shows.*[162]

The scientists and I had open discussions with participants about uncertainties in the BFD Study on a one-to-one basis when we: recruited people to partake, picked up badger carcasses from them, and chatted over the phone. These discussions risked weakening their engagement in the BFD Study as it may have reduced their confidence in the results. However, participants' active roles in collecting roadkill badgers and Professor Bennett's regular email contact built personal connections. As a result, the BFD Study wove personal connections between scientists and participants, increased

[161] IN Farming Representative Edge 3, 27.01.17

[162] IN Farming Representative Edge 1, 20.12.16

their knowledge of uncertainties, improved the project's rigour and enabled participants to critique the findings. In an appreciation of uncertainty and contingency, the BFD Study 'un-black-boxed' the scientific process (Tsouvalis and Waterton, 2012) by questioning it (Waterton et al., 2015); highlighting and accepting uncertainties and contingencies; and, instigating collective action to reduce the uncertainties. However, this collaboration was fragile and short-lived.

8.4. Breaking of collaboration: sharing findings

Professor Bennett and I presented the BFD Study findings to participants and interested parties in Derbyshire at three events. One event in a village hall brought together participants with divergent views. There was a calm tension at the start of the meeting as people had a cup of tea, discussed local stories of bTB and anxiously waited to hear the findings. People sat down: badger vaccinators sat next to people involved in a badger cull company, and animal rights activists sat next to farmers. Professor Bennett and I presented the aim, methodology, uncertainties, findings and possible interpretations from the BFD Study.

In the BFD Study (and similar studies, see Goodchild et al. (2012)), genotypes were largely assumed to provide certain information on the strain of *M. bovis* that was present in each badger and assess if *M. bovis* infection in badgers was linked to *M. bovis* infection in cattle. In Great Britain, *M. bovis* genotypes in cattle are frequently found to be geographically clustered. These clusters are known as 'homeranges' (Smith et al., 2006). In Derbyshire, 4% of 100 badgers (95% confidence interval 3-10%) were infected and most carried the homerange genotype (Bennett, 2018). After announcing this to the people in the village hall, I felt the room split.[163] To badger groups, these findings justified badger vaccination as they perceived there to be low levels of disease

[163] FN presentation The BFD Study 5, 26.06.17

in the badger population. To some farmers and farming representatives, this information justified a badger cull in South Derbyshire on the basis that genotype information proved that the disease epidemic in cattle was linked to disease in badgers. We opened the floor to questions and were faced with a room full of raised hands. We were asked if the findings supported a badger cull, if we supported badger culling or badger vaccination in Derbyshire, and what Defra were doing with the findings. Then a farmer who had submitted over 10 badgers to the Study spoke up. He said that the findings must be wrong. He had experienced multiple breakdowns on his farm which he knew was due to badgers and yet none of the badgers around his farm were detected positive. He drew on the uncertainties that we had shared throughout the BFD Study to forcefully tell the room that the results were meaningless at both farm and county scale as the process was not sensitive enough to detect all infected badgers and therefore we had missed lots of infected badgers. [164]

In Cheshire, 14% of 104 badgers (95% confidence interval 9–22%) were infected and most carried the homerange genotype (Bennett, 2018). A farmer in Cheshire used the findings to suggest that it was irrefutable proof of the '*least extent'* of bTB in badgers:

> *Malcolm has done his study and that has created a set of data that's irrefutable that says TB is at least 100 times worse in Cheshire badgers that it was 20 years ago. I say 'at least' as their method may have missed some of the infected badgers.*[165]

These farmers considered the information on positive badgers (although not necessarily negative badgers) as an irrefutable truth. The conception of the data as irrefutable was based on the use of genomic infection to certainly and conclusively identify any growths of *M. bovis*. Genomics was a 'narrative bottleneck' (Singleton and Michael, 1993)

[164] IN Wildlife Group Edge 3, 06.01.17; IN Wildlife Group Edge 4,18.01.17
[165] IN Farmer Edge 2, 17.08.17

through which evidence was considered reliable in the identification of truly positive badgers. This certainty in the identification of truly positive badgers reflects Jim's, the microbiologist, certainty detailed in the previous sub-section.

A person from a badger group in Cheshire commented that the BFD Study was funded by Defra so it was unsurprising that 14% of badgers were infected and all carried the homerange genotype as this justified a badger cull. This mistrust of the interpretation of the findings reflects a historical unease about how Defra and government scientists have used epidemiological findings to justify badger culling. As noted in Section 5.1, in 2007 the government Chief Scientific Advisor Sir David King published a report rebutting the ISG's interpretation of the RBCT findings and reinterpreting the findings in support of badger culling. In contrast to the ISG, King excluded economics from his analysis and did not weigh up culling against alternative approaches. Furthermore, the ISG findings were re-interpreted by Defra and APHA in the authorisation of badger culling in 2014 (Section 5.2). The selective use of evidence to support pre-existing agendas has "contributed to an atmosphere of mistrust and the politicisation of 'evidence'" (Cassidy, 2019: 283). This historical backdrop of intractable contestation and mistrust (described in Section 1.1) affected the BFD Study through the wider network in which it was woven. The BFD Study was funded by Defra and therefore its previous uses of epidemiological knowledge likely shaped how the person from the Cheshire badger group responded to the findings. Furthermore, mistrust was created in the BFD Study as many badger groups' stated that the 'Cheshire Badger Tuberculosis Survey' findings were inappropriately used by the NFU, Defra, farmers and vets to approve a cull.

Badger groups' mistrust of Defra came to the fore due to the timings between the results being published and the approval of culling in some Edge counties. The findings of the BFD Study were reported to participants (including Defra) in 2017 and badger culling was licenced in Derbyshire in 2020, after many failed applications.[166] Comparable to the quick implementation of the Cheshire cull in 2014 after the 'Cheshire Badger Tuberculosis Survey' were released, the BFD Study findings may have been used to justify a badger cull in Derbyshire; the genotype information provided information which some farmers and vets used to infer the disease in cattle and badgers was linked, although it is not known in what direction disease was transmitted and the overall prevalence of infection in badgers was low.[167] A Derbyshire badger group member said, "*we need lots more evidence before anyone can begin to justify a cull"*.[168] For them, the BFD Study findings were just one piece of evidence and far more was needed to justify a cull in Derbyshire. In addition, in our answers to questions, we suggested that the findings did not show that *M. bovis* in badgers and cattle was linked in Derbyshire, and therefore we did not perceive a cull to be epidemiologically useful (although it could be useful for other reasons as outlined in Chapter 6). This supported badger groups' worldview of wanting to stop culling and therefore they considered the findings to have been used inappropriately by others to justify a badger cull.

Multiple communities used uncertainties to undermine the results, especially when the results did not fit with what they expected to find. This changing of positions in regard to the certainty and reliability of findings is reflective of what happened when

[166] A badger cull was close to be being licenced in Derbyshire in 2019, but was not granted on the eve of the start of the badger cull in an unexpected policy change. The National Farmers Union brought a legal challenge against the Government for the policy 'U-turn'. Defra stated the decision was made was because it wanted to give further consideration to how "best to manage the coexistence of vaccination projects and badger control projects in the edge area" (BBC News, 2019b). However, the court proceedings state that "the Prime Minister took a personal interest in the matter" and "failed to give his express blessing" (Andrews, 2020). The Times newspaper reported that Prime Minister Boris Johnson intervened twice to stop the Derbyshire badger cull from going ahead after his partner Carrie Symonds, a longstanding animal welfare supporter, met the Badger Trust and took an interest in stopping the cull (Webster, 2020). The challenge was dismissed by the High Court.

[167] IN Farmer Edge 2, 17.08.17; IN Vet Edge 1, 15.01.17

[168] FN presentation The BFD Study 5, 26.06.17

the ISG published its findings from the RBCT. Cassidy (2019: 220) reports that prior to the trial, the Badger Trust had campaigned vociferously against it, but "by the time that the ISG delivered its final report they were effusive in their praise for the 'sound science' that demonstrated culling did not work". Likewise, NFU representatives welcomed the RBCT prior to the results being published, but reversed their position when the results were published, extensively criticising the ISG and its findings. Since then, it is common for actors to argue that 'The Science' supports their worldviews, "while selectively drawing on different experts or interpretations of research findings to do so" (Cassidy, 2019: 220). In the BFD Study, badger cull supporters used the results to suggest that a cull would be the most effective control strategy and badger vaccination supporters used results to suggest that badger vaccination would be the most effective control strategy. In other words, the historical selective use of knowledge to support arguments about culling positions continued in the BFD Study.

Participants tailoring of attributions of certainty and uncertainty to the findings, undertaken to suit divergent participants' interests, demonstrates the room for contestation in the findings. The uncertainty behind the evidence became the focus in these controversial findings. Against the writ large backdrop of 'The Science' in which politicians and campaigners continue to frame knowledge as exact and certain, all participants witnessed knowledge-making as uncertain and contingent and they incorporated this into their own interpretation of the results.

Whilst the *doing* of participatory veterinary epidemiology brought people together and made the uncertainties in science-in-the-making more visible, the findings meant different things to different communities and were interpreted as part of their longstanding worldviews about the controversy. In sum, citizen science brought polarised communities together, but was unable to hold them together as the findings became part of, and could not overcome, the longstanding contestation. Reflecting on the BFD Study, I wonder if there may have been an increased chance of holding people together if there was more face-to-face engagement between participants throughout the process: we did not organise any events for participants with divergent views to meet together until the end of the project. This lack of engagement throughout the process likely limited the possibilities of the BFD Study in providing a space for people to come together around a common aim, empathise with each other and hear other views. Building on the idealism of what upstream citizen science may achieve, physical meetings may have helped to hold the communities together, and new common ideas for further participatory research and action may have been developed.

8.5. Conclusions

The BFD Study has offered ideas for how epidemiological research can be undertaken in relation to a public knowledge controversy. I suggest that the participatory, collaborative approach to this BFD Study provided opportunities that benefited both bTB epidemiology and built a network of people with divergent worldviews. Reflective of the work of Lane et al. (2011) on flood risk, the coming together of different participants for a common aim can lead to challenging and questioning the way things are. These conversations about how epidemiology can be done differently may help to recognise complexity, develop ideas about how to develop epidemiology in accordance with stakeholders needs, and open up ways of 'what may otherwise be' for disease control. Thus it may be useful for bTB scientists to consider citizen science in more detail, both for the opportunities it presents to further epidemiological knowledge and to build networks about bTB.

However, I have also argued that the collaborative relations engendered by citizen science were temporary rather than enduring. Collaborative relations fractured when the BFD Study findings were shared, largely because participants used them to reinforce their longstanding worldviews about the controversy. The intractability of divisions and polarisations between participants poses challenges to both undertaking citizen science, and holding communities together. I do not suggest that citizen science is the ‘silver bullet’ to solve or put an end to the controversy. Instead, I argue that participatory veterinary epidemiology provides approaches to create meaningful knowledge and enable conversation between those with divergent views. This is more likely to be achieved if projects reflect more of an upstream model of citizen science, in which actors are threaded through the entire research and have a higher level of participation; as famously depicted by Arnstein’s (1969) ‘ladder of participation’. As an initial step, this could involve making space for actors to meet together throughout a project to share ideas. In a more advanced manner, this could involve working together to define the evidence that exists, consider unanswered questions, decide which question should be answered and how, and then undertake a study.

I suggest that citizen science projects in controversial settings need to be flexible enough to ensure communities can co-operate together without consensus. I also argue that a widespread shift in the creation, presentation and use of ‘The Science’ is required if uncertainties are not to be used to imply weakness. This should not cause a loss of hope for scientists; the more studies undertaken with citizens, the greater the opportunity for respectful conversations to occur between communities and the larger the likelihood of shifting the framing of ‘The Science’ to ‘science-in-the-making’. This chapter has provided a glimpse into how bTB epidemiology can be done differently to make potentially better futures.

8.6. Post note

In its updated bTB strategy for England, Defra (2020a) encouraged collaboration on bTB related research. However, it focuses on the collaboration of scientific resources (specifically funding and working with APHA) rather than encouraging citizen science or publics participation in research. This focus on researcher collaboration does not recognise the benefits of citizen science for the development of knowledge and the development of constructive connections between those involved in bTB. Citizen science provides a route through which bTB certainties may begin to be dissolved, relations may be built between groups, versions of bTB may be shared and knowledge may be collaboratively developed. In isolation it cannot overcome the deep-rooted antagonisms that are present around the public knowledge controversy, but similar to stakeholder dialogue on bTB (Office for Public Management and dialoguebydesign, 2014), it can contribute to moving forward from the impasse between polarised groups and polarised versions of bTB. The BFD Study was only one study around which people collaborated and collaboration could have continued by identifying the next question around which people could cohere and so on over time. The question is: how can such open, questioning groups be sustained?

Chapter 9. Conclusions

No-one can understand the pain, the stress and the daily grind of the wretched politics of this disease.[169]

In this thesis I have shown that multiple kinds of difficulties, antagonisms and pain are enmeshed in some of the ways that bTB is made at present. It is a disease that involves the suffering and slaughter of cattle, the suffering and culling of badgers, financial ruin for some farm businesses, stress for farming families and intense contestation between groups with different views on disease management practices. Through empirical ontology, I have attempted to better understand how bTB is made in practice and find points of intervention which open up ways that the disease can be made differently, and better, in the future. In this final chapter, I bring together my findings to address my primary research question: 'How is bTB made in disease management practices?'. I pose future directions for research and use my findings to suggest how the disease can be done better.

9.1. How is bTB made in disease management practices?

Through this research, I wanted to explore what bTB is and how it comes to be. My aim was to *investigate* the making of bTB in practices and *explore* how bTB could be made differently to create better futures for the disease. In doing so, I extended empirical ontology to examine bTB-in-the-making. Drawing upon insights from STS, I organised this thesis so that each chapter followed in detail how a practice is being undertaken, how the practice contributes to the making of bTB, and, in some cases, how it could be done differently to make a different kind of bTB. Each of my research questions centred around understanding bTB-in-the-making through an examination of disease management practices (Table 10).

[169] IN Farmer LRA, 26.05.16

Table 10: Research questions addressed, practice examined and analytical lens applied in each chapter

Chapter	Research Question(s) addressed	Practice examined	Analytical lens applied
Chapter 3	RQ1: What are farmers', vets' and government's ways of making bTB through the skin test?	Skin testing	Ordering and occlusion of uncertainty
Chapter 4	RQ2: How is bTB made in cattle trading?	Risk-based trading	Borderlines and borderlands
Chapter 5	RQ3: How is badger culling policy made?	Assessing the effectiveness of badger culling policy	Exploration of calculations
Chapter 6	RQ3: How is badger culling policy made?	Culling badgers and opposing the killing of badgers in the field	Affect
Chapter 7	RQ4: How can badger culling be made differently?	Culling badgers by alternative methods	Population approach and high-risk approach
Chapter 8	RQ5: How can citizen science realise collaboration between divergent groups?	Conducting citizen science related to bTB	Public knowledge controversies and citizen science

Throughout this thesis, I have detailed how bTB is widely conceptualised as a singular disease interpreted in multiple ways, potentially bestowing it with undue ontological coherence. My research challenges this coherence by investigating the heterogeneity of the disease itself and how it is made in disease management practices, some of which have not been researched before — for example culling badgers, assessing the effectiveness of badger culling policy and conducting citizen science related to bTB. Whilst these practices are clearly connected to the Government's objective of controlling bTB, they generate different versions of bTB-in-the-making. This thesis critically engages with bTB-in-the-making and, more specifically, with the generativity of disease management practices, by examining the ethnographic findings collected using multiple analytical lenses (shown in Table 10). Empirical ontology has enabled me to see that certain disease realities have been made through practices and I have been able to make visible some of the versions of bTB that are effaced or obscured through the reductionist discourse of bTB as a bacteria to be eradicated. The disease realties that have been created include: its definitive knowability through the skin test, its bounded nature in geographic space, its controllability through culling and its science-base (and not emotion- or affect-base). I suggest that interventions in practices should explicitly consider bTB as a disease-in-the-making if we are ultimately interested in shifting disease realities to improve bTB management, and moving beyond the impasse surrounding the controversy. As such, this thesis contributes to a small, but growing, body of social research on bTB which cuts across human geography, sociology, history, veterinary science, agriculture and philosophy.

Bringing together the findings and arguments presented in Chapter 3 to 8, below I unpick how three disease realities — characterised by uniformity, controllability and scalability — are made in practices and make room for alternative ways that the disease can be done.

9.1.1. Creating uniformity from heterogeneity

In policy, bTB is quantified in statistics such as disease incidence, disease prevalence and effectiveness of badger culling. These statistics and calculations remove bTB from the network in which it is made and consequently cannot present the heterogeneity of the disease. For example, official documents detailing annual epidemiological analysis of bTB data present bTB as a fixed, measurable and controllable bacteria. Its removal from the complexity of the network in which it is produced means bTB is presumed to be homogenous — disease homogeneity is produced from heterogeneity. This official conceptualisation of fixity and associated certainty is imposed onto farmers and vets through policy and technologies of governance — such as the designation of skin testing according to risk areas — through which they must manage the heterogeneous disease.

My investigation of risk-based trading in Chapter 4 demonstrates how uniformity is created from heterogeneity. For officials, the practicing of risk-based trading attempts to reduce the risk of *M. bovis* transmission by the installation of protective testing barriers or, using the terminology of Hinchliffe et al. (2013), borderlines. However, aligning with the work of Enticott (2008b), the use of fixed borderlines to keep disease out of a farm is an impossible ideal because bTB is in many farms already. This spatialised, homogeneous policy according to risk area makes the disease appear controllable, in part by not accounting for disease heterogeneity on farm. For example, some farmers used risk-based trading to reduce the risk of disease *detection* by increasing cattle mobility. This strategy of increasing mobility in cattle shows how some farmers equate bTB to a 'breakdown'. bTB as breakdowns means the mycobacteria may be present — but the disease is effectively made absent — through lack of detection and therefore lack of 'breakdowns'.

My ethnography of badger culling policy-as-practice in the field led me to investigate disease heterogeneity through an exploration of the affective relations bound to this. In Chapter 6 I detailed how much research reports on the juxtaposition between the official narrative of disease control and farmers' fatalism towards bTB control. Somewhat differently, the practicing of badger culling made some farmers feel in control of the disease, and therefore can be considered to have reduced their fatalism. However, this finding should not be separated from my broader analysis of badger culling in relation to affect. I demonstrated how affect was generated by, and vital to, the enactment of badger culling policy in the field. The shooting of badgers and the protesting against the shooting of badgers are affectively related to factors such as controlling a pest, building friendship, fox hunting, rurality, fear, thrill, morality and intimidation.

My conceptualisation of the policy loop (Figure 30) shows how these affects part-generated the badger cull and were generated by the cull. In other words, bTB is not made in isolation. It is not just a disease caused by bacteria but is also enacted through affective relations in natural and social life, across multiple sites. The policy loop advances the work of Interpretative Policy Analysis by providing a framework through which policy-as-practice can be investigated between multiple sites. The loop keeps a relational and material focus on the study of policy and links with governmentality by exposing how (disease) realities can be rationalised in order to be governed. For example, any evaluation of the badger cull linked only to bTB potentially falsely and narrowly attributes reductions in disease incidence to the badger cull, rather than the heterogeneity of other disease management practices. This falsely narrow attribution reinforces the official frame of badger culling tied to disease control, further distils what bTB is and therefore enables control of this supposedly known disease.

9.1.2. Foregrounding disease control and backgrounding uncertainty

In examining how bTB is made, I have detailed how Defra relies upon a singular, certain and knowable version of disease for the purpose of control and eradication. This version of bTB is enacted through skin testing, risk-based trading and badger culling — in part by backgrounding uncertainty. I argued that some of the uncertainties of the skin test (Chapter 3) are occluded within the official narrative of bTB control and eradication, which relies upon the skin test identifying infection and simultaneously ordering the fate of every individual animal. In other words, the skin test simultaneously enacts a version of bTB which is detectable, measurable and therefore eradicable, and a version which is deciphered and conceptualised through particular modes of sociotechnical and sensory perception. My findings corroborate other ethnographic studies exploring skin testing on farm and in veterinary surgeries which also evidence the creation and management of uncertainty (Enticott, 2012; Robinson, 2014) and advances these studies by investigating how these uncertainties are managed in line with the narrative of control.

Disease control is also foregrounded in risk-based trading, through the making of disease risk based upon transmission through the buying and selling of cattle. The official narrative of control is implemented in the creation of borderlines between risk areas, and ‘walling off’ the Low Risk Area from ‘outside’ areas at higher risk of infection. In doing so, as Chapter 4 elucidated, the practice backgrounds the ‘seeping’ of *M. bovis* at breach points of this porous testing borderline. For example, it does not recognise how pre-movement testing borderlines may give farmers confidence that they are only buying uninfected animals, and therefore increases cross-borderline trading activity. The borderlines are both barriers *against* and conduits *for* the flow of the cattle-bTB disease assemblage. This conduit is not recognised in official discourse, and instead the borderlines are only mentioned in regard to barriers, therefore enacting the narrative of disease control.

bTB is also made through the calculation of badger cull effectiveness, and the backgrounding of uncertainties in this. To evaluate effectiveness, population estimates from site specific methods — such as sett surveys and contractor effort — have been linked with national modelling of badger populations into the creation of a policy loop. [redacted]

[redacted] The assumption that achieving effectivity will reduce bTB once again makes bTB a fixed and knowable disease across time and space. The narrative of control remains, while uncertainties and incongruences associated with the badger culling policy are occluded by the constant changing of calculation methods.

9.1.3. Enacting disease on different scales

Throughout this thesis, I have detailed how bTB is enacted on multiple scales. In the main, bTB is made knowable on farm through the skin testing of individual bovines. These results are then transformed into the categorisation of a farm as officially bTB free or suffering a breakdown. Farm level results are then brought together into county level, risk area and national statistics of bTB incidence and prevalence. This increased scaling of bTB reduces the visibility of the variability of the disease. For example, a particular herd's disease risk does not always correspond to the categorisation of risk areas and hence the categorisation of risk glosses over a wide variety of disease situations. Scaling techniques productively occlude variability to create a disease which is fixed at the national level, detectable and therefore more amenable to control through current disease management practices. This scalar fix (Section 3.5) is enforced through the production and use of technologies of governance such as maps and statistics.

As well as being scaled up, bTB is also scaled down. Chapter 4 details how Defra is rescaling bTB risk from 'risk area' to 'farm' through the creation of risk scores. Defra's downscaling of bTB risk locates the problem of bTB at the farm scale and therefore suggests disease control is the farmer's responsibility. I argue that this down-scaling of risk enables possibilities of neoliberal disease control practices to be introduced on a farm scale, for example by linking the risk of cattle purchases to the amount of compensation received in a breakdown. Therefore, rescaling is a resource that engenders disease as the responsibility of different groups. Enticott and Franklin (2009) present a similar argument about rescaling, whereby the institutional rescaling of bTB policy in 2005 led to the disease being located at new spatial scales for the purposes of new governance arrangements. Here, scale is a strategic resource for the active making of different disease realities, and the subsequent control of these realities by establishing new levels of responsibility and forms of governance.

Scale was also used as a resource in the interpretation of the Badger Found Dead (BFD) Study’s finding. As detailed in Section 8.4, people disagreed about whether the BFD Study findings were representative at county level and farm level, dependent on the quantity and distribution of the submitted badgers, and the sensitivity of the culturing process on the scale of individual animals compared to a population. Here, scale either legitimised or delegitimised the BFD Study findings. The politics of scale thereby helped to create disease realities that fitted longstanding perspectives on the disease.

Scale is also a central feature of practices of badger culling. As outlined in Chapter 6, the population approach to badger culling uses the scale of the cull zone to conceptualise all badgers as potentially dirty as it does not discern between non-infected or infected (clean or dirty) badgers: all badgers are subject to be shot as all may be disease carriers. However, high risk approaches to badger culling use the scale of setts to differentiate between infection and non-infection. For example, variability in disease at the scale of the sett can be recognised by identifying, mapping and gassing badger setts as undertaken by Bryan Hill. This variability, also made in the Test, Vaccinate or Remove approach, more closely aligns with farmers’ ways of knowing badgers as clean or dirty on the scale of the sett, compared to the scale of a cull area. In this case, the scalar presentations of bTB infection in badgers correspond with particular badger culling practices.

I argue that scalability is a resource in the making of bTB. Scale is actively worked with as a way of creating different versions of bTB, which align with different practices and forms of governance. In other words, the making of bTB at different scales establishes narratives and practices of control that align with longstanding perspectives on the disease. Scaling enables multiple narratives of disease control to be created as part of the richness of disease management practices.

9.2. Future directions

I have taken a future-forming orientation in which change is my primary goal. Indeed, one of the drivers of this research was the contribution it could make to improve disease management practices. Therefore, having addressed my primary and secondary research questions, I now ask what conclusions can be drawn for disease management and how these can be taken forward. In a substantive contribution to debates around bTB and practicalities of bTB management, this thesis has shed light on how bTB can be made differently by altering the practices through which it is engendered. Versions of bTB have been presented which both further our understanding of the current bTB controversy and require being brought into conversation. This is particularly timely considering that the Bovine TB Strategy was subject to an 'independent review' in 2018 (Godfray et al., 2018) and Defra published its response to the review in 2020, including updates to its strategy (Defra, 2020a). I have presented policy recommendations for specific practices at the end of many of the empirical chapters. To enhance the influence of this research, these recommendations, and key findings, will be translated into a policy briefing note for civil servants. In this section I draw together elements of these recommendations to provide one further recommendation about disease governance more generally. I then go on to outline future directions for research.

Multiple actors are calling for changes to the ownership and management of the disease (Godfray et al., 2018; Waters, 2019). In response, Defra (2020a) states that it will create a ‘true partnership’ and ‘new governance arrangements’ to eradicate the disease.[170] I argue that the recognition and inclusion of different knowledges in decision-making and disease governance could help to create longstanding policies that are relevant to the people practising them ‘on the ground’ and that resonate with their versions of bTB. In addition, it may help to encourage a greater sense of optimism for bTB management amongst a variety of actors, identified as a key factor in successful disease management programmes internationally (Lehane, 1996; Livingstone et al. 2015). Can new governance arrangements include actors on all sides of the public knowledge controversy to enable versions of bTB to be brought together? In addition, can new governance arrangements include discussions and decision-making about whether England should continue to strive for disease eradication? The Government’s decision to leave the EU and have regulatory authority means the UK can choose to not be subject to the target of disease eradication under a European Commission (1977) directive. Might this provide an opportunity for government to alter its aim from disease eradication to disease management? I believe that the Government may have an opportunity here to communicate, explain and manage bTB in a way that better matches farmers experiences of bTB. To assist with the design of new governance arrangements,

[170] This would be a development from previous disease governance arrangements. For example, The TB Eradication Advisory Group (TBEAG) was established in 2008 and “advises on the development and implementation of the strategy for eradicating bovine TB”. It is formed of representatives from local authorities, retail, academia, Defra, the farming industry and the veterinary profession (Defra, 2014e). However, with no representation from wildlife groups or anti-badger cull activists and with no decision-making authority, TBEAG has a limited role in developing disease policies, let alone developing policies that cohere with different actors’ ways of knowing the disease and encourage co-ownership of bTB.

an exploratory study could be undertaken on different governance possibilities asking questions such as: How can governance options and methods of policy development reflect the heterogeneities of bTB?

Chapter 6 detailed affects of badger culling related to farmers' actions with bTB, for example implementing biosecurity and risk-based trading. Ethnography enabled these affects to be described, and further research could add weight by examining the extent of these changes in farms across multiple cull areas. To assess the extent of changes in practices linked to badger culling, and in line with Enticott et al. (2020), I suggest that quantitative analysis is undertaken to identify any changes in the number of animals purchased and the risk of the herd from which animals are bought. To ensure validity of any causal changes identified, this analysis could be compared to matched areas that have not undertaken culling. I recommend this quantitative analysis is undertaken alongside case studies of some of these farms to explore how and why these changes occur(ed).

My ethnography also added evidence to existing claims that the badger cull is encouraging illegal badger persecution (Dyer, 2016). Research is warranted to assess the extent of illegal badger culling and investigate to what extent it is correlated with licenced badger culling. Multiple evidence sources for badger persecution could be brought together and validated — for example from the police, badger groups, hunt saboteur groups and the Wildlife Trust — to assess the extent of the issue. It would be beneficial to supplement this analysis with interviews to understand why people undertake badger persecution and to potentially explore the unintended consequences of the badger culling policy.

This thesis has primarily explored current bTB practices, but there are several research questions that were outwith the scope of my research, that would enhance understandings of bTB management such as the potential impact of a cattle vaccine for bTB on farmer engagement with disease management. Since 1998 government has invested in research to develop a cattle vaccine and DIVA test: a test to 'Differentiate between an Infected and a Vaccinated Animal' (Defra, 2020b). In July 2020 Defra announced that vaccination trials are set to get underway in England and Wales with the aim of deploying the vaccine by 2025 (Defra, 2020a). If trialled, can ethnographic research be undertaken to comprehend the impact of the vaccine on disease management and investigate its effects on conceptualisations of bTB?

Finally, it is worthwhile to consider further what insights can be gained by looking at things in the world through 'empirical ontology'. As I have done with bTB, the approach could be usefully applied to other rural controversies (for example grouse shooting and agricultural flooding) in an attempt to explore how realities are created and open up alternative ways of doing better futures. Advancing work by Hinchliffe and Bingham (2008) in regard to biosecurity and Mather and Marshall (2011) in regard to Avian Influenza, social scientific research into other livestock and zoonotic diseases could apply empirical ontology to investigate assumptions underpinning disease realities and consider how these have shaped the knowledges that have been produced. Research such as this, for example on diseases such as Ebola, or COVID-19, may expose current disease realities and enable better disease futures to be co-created.

9.3. Concluding remarks

In this thesis I have shown that multiple kinds of difficulties, antagonisms and pain are enmeshed in some of the main ways that bTB is made at present: the difficulty of detecting the disease and defining risk; the troubling questions about whether badger culling should be undertaken and if so, how it should be done; the antagonisms between people killing badgers and people opposing the killing of badgers; and, the pain of both cattle and farmers when livestock are slaughtered for the purpose of ‘disease control’. I have shown that there is the possibility — at least — that we as a society could make alternative disease realities. I have provided glimpses into how bTB could be done in ways that strive for less antagonisms, less polarisation and less pain… better ways of doing bTB are possible.

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Appendix 1. Interview guide for farmers

Thanks for taking part in this study — hugely valuable for the research. Length of the interview — between 30 minutes and 1 hour. Any questions before we make a start?

General info questions
Please tell me the size of your herd/how you got into farming/how long you have been farming/who is involved on the farm/who you supply?
What is the TB history on the farm?
What is the impact of TB on you? Personal? Family? Emotional? Business?
Where do you find out information about TB?

TB policy and science
What does managing TB mean to you?
How do you manage TB on your farm? Biosecurity? Badger control measures? Testing?
How does Defra manage bTB on your farm?
What is the role of Defra in disease management more generally?
What is your understanding of TB policy?
How does TB policy help you in regard to disease management?

Cattle and badgers
What role do you think cattle mobility/cattle rearing/farm systems have in the spread of bTB?
What role do you think badgers play in transmission of the disease?
What do you think about the current badger culls? Expansion into Dorset? Changing measurements? Badger density? Activism?
What is your understanding of effectiveness?
What is your opinion on badger vaccination?
Is there anything we can do to the cattle industry to help manage TB transmission?

Closing questions
In an ideal world, how would you manage bTB? Vaccination? Biosecurity? Cull? Other?
What do you think is the most important point you have raised in this interview?
Is there anything else I should have asked?

Appendix 2. ‘Badger Found Dead Study’ methodology

Participants were provided with a collection kit (Figure A2.1) containing background information to the project, a submission form, collection guidelines and the equipment needed to safely and securely bag a dead badger.[171] Each badger carcass had to be accompanied by a completed ‘badger carcass submission form’ to be accepted into the BFD Study (Bennett, 2016). These forms created a standardised index of information from which all carcasses could be identified based on carcass ID number, date and time of collection, and site location.

Figure A2.1: Collecting a badger carcass. (a) Badger carcass collection kit; and, (b) a badger carcass in a collection kit (Author, 2016).

Once the submission form was complete and the badger was bagged, a member of the research team collected the badger from the collector within 1–2 days. Each participant was given £10–15 per badger as compensation for their time and effort (see footnote 151). The information collected in the submission form was required to map the spatialised prevalence of *M. bovis* in badgers.

[171] This included: disposable gloves, heavy duty polyvinyl chloride bag, ‘tiger’ striped bag, cable ties, brown tag (to label the bags), pen and submission form.

The carcass was laid inside the cabinet and the pathologist, Tim, checked the badger for any cuts, ulcers or bite wounds, and noted its age (based on teeth wear and body size). Tim systematically sampled the carcass beginning with the lymph nodes in the heads and neck (Figure A2.2) and finishing with the lymph nodes in the abdomen.[172] It was common for the badger carcass to have visible signs of trauma and a broken spine due to the impact of being hit by a moving vehicle.[173] If the abdominal cavity had ruptured as a result of the trauma, Tim did not sample the hepatic lymph nodes (between stomach and liver) because it was deemed to be impossible to culture *M. bovis* from a lymph node contaminated with stomach acid. Additionally, lymph nodes were not sampled if the carcass was severely autolytic/rotten due to the contamination of the animal with flesh eating bacteria.[174] *M. bovis* is a slow growing bacteria (Tomlinson et al., 2013) meaning it is difficult to culture if the lymph node, otherwise known as a sample, is contaminated with other bacteria.

[172] FN badger post mortem 1, 29.11.16

[173] FN badger post mortem 3, 29.11.16; FN badger post mortem 4, 06.12.16; FN badger post mortem 7, 14.12.16

[174] FN badger post mortem 3, 29.11.16

Figure A2.2: The start of a badger post-mortem examination (Author, 2016)

Using tweezers and a scalpel, the pathologist cut out the lymph nodes and placed them (one by one) on his right hand. Using the tweezers in his left hand, he visually examines the lymph nodes for *"white spots"* or "*white multi-focal areas"* (Figure A2.3). Tim did not think the white spots were related to *M. bovis* infection, but Jane, the laboratory assistant, made a note of it and Tim took a sample for histology in case the presence of white spots correlated with infection from the culturing process.[175]

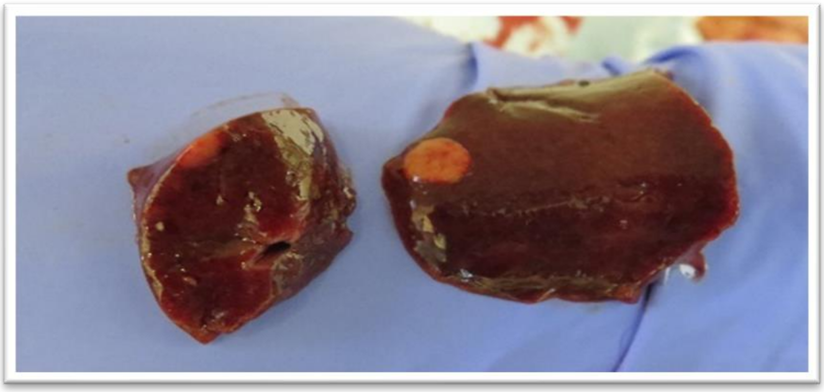

Figure A2.3: Visible lesion on a badger's enlarged lymph node (Author, 2016)

[175] FN badger post mortem 6, 14.12.16

Tim had two sets of equipment and rested one set in formalin between each sample to kill any bacteria on the equipment and reduce the chance of infection from one lymph node contaminating another. Tim said *"it* [cross contamination caused by using the same equipment] *wouldn't make a big difference as it's the same badger, but it's nice to know where the mycobacteria is concentrated"*.[176] The changing of equipment between sampling meant the microbiologist could assess in which lymph node pool the mycobacteria was located. The lymph nodes were placed into sample tubes for microbiology and organ samples were placed into formalin for histology and pathology.

Once all the samples had been taken and placed into pots, Tim assessed the badger's body condition (based on the amount of fat) and the extent of autolysis (decay). The carcass (Figure A2.4) was put into a bag and placed in a bin to be disposed of by a knacker's yard. The samples were put into a plastic box in the fridge (labelled with the carcass ID from the 'badger carcass submission form') ready for the microbiologist to collect (Figure A2.5).

Figure A2.4: A badger carcass after post-mortem examination (Author, 2016)

[176] FN badger post mortem 6, 14.12.16

Figure A2.5: Badger samples ready to be cultured (Author, 2016)

Information about the badger carcass was written into the 'badger post mortem report form' and a checklist was completed noting which tissues had been examined and which of the lymph nodes had been collected for microbiology and histology. Ideally, 20 lymph nodes were taken from each badger although this was often not the case due to autolysis or carcass damage.[177]

The purposeful recording of which lymph nodes were taken from each carcass moulded information about individual carcasses into an information repository for approximately 1,100 badger carcasses. Data from the badger carcass submission form and the badger post-mortem report form were processed into a spreadsheet that contained standardised, but carcass specific, data. The unit of analysis, otherwise known

[177] FN badger post mortem 2, 29.11.16

as the badgers, were dissected (literally and metaphorically) into modules to help with the transfer of information. Modules per badger included:

- Site of collection
- Date and time of collection
- State of autolysis
- Body condition
- Weight
- Sex
- Age
- Lymph nodes
- State of the individual lymph nodes[178]

The lymph nodes were then subject to culture (described on pages 248–251). If a slope showed signs of mycobacterial growth at 8–12 weeks and the bacteria was identified as *M. bovis*, the sample was subject to PCR. A cocktail stick tip worth of the sample was taken and heated to 100*c for 15 minutes to kill the bacteria and break open the cell walls to release the DNA. The output is called a 'template'. The template was combined with reagent and a positive and negative control was created: water and BCG with reagent. Water does not contain any DNA so if DNA was present in this sample, Jim knew there was contamination between all the samples and re-did them. The tubes were labelled with the badger identification number and the lymph node pool, and placed in the PCR machine to create an exponential increase of IS6110 DNA. PCR involves:

1. Heat sample to 95*c: denaturing. The enzyme breaks apart the DNA into two bands.

[178] FN badger post mortem 2, 29.11.16

2. Heat sample to 55–65*c: annealing. The primers attach themselves to a small part of the mycobacteria DNA called ISG6110. *M. bovis* complex has 10 copies of IS6110 in each cell and BCG has 2 copies of IS6110 in each cell. The use of a primer makes the PCR specific as only certain sections of DNA are amplified. The primers cut the DNA at 300 base pairs. The forward primer attaches to one end and the reverse primer attaches to the other end of the 300 base pairs of the ISG6110 complex. This causes the DNA to be cut between the primers.
3. Heat sample to 72*c: extension. DNA polymerase attaches to the primers and makes a copy of each template strand. Nucleotides attach to the other side of the DNA forming two pieces of DNA from the original one.
4. Repeat above steps 30x: exponential increase of DNA. It is done 30x because this is few enough times to prevent other pieces of DNA from amplifying too much whilst creating enough IS6110 DNA to create a band in the PCR. Each time the process is repeated the DNA increases exponentially.

After conducting PCR, the samples were subject to gel electrophoresis.[179] The samples were transferred into agar jelly using a micro-pipette which sat in ethidium bromide and electricity flowed through it. The electricity binds to the DNA and moves it along the agar jelly dependent on the number of base pairs. BCG has less IS6110 DNA than the templates so if a line appeared in the agar jelly for BCG, Jim knew the templates will show as positive if they contain mycobacteria.

If the bacteria were identified as *M. bovis*, the sample was put through spacer-oligonucleotide typing ('spoligotyped'). Spoligotypes are genomic typings of *M. bovis*. In the UK, *M. bovis* spoligotypes in cattle populations are highly geographically clustered, with spoligotypes and genotypes having a typical 'homerange' (Smith et al., 2006). Spoligotypes are often used in conjunction with 'Variable Number Tandem Repeat' data to identify the genotype of *M. bovis*. The genotype is commonly referred

[179] IN Pathologist The BFD Study, 02.12.16

to as a strain of *M. bovis* and has more typing categories compared to spoligotypes (APHA, 2017).

The genotypes of *M. bovis* in infected badgers were determined using a microarray of nucleotides that are complementary to the DNA in part of the *M. bovis* genome. The DNA in the sample was attached to the nucleotides on the microarray and made visible by the depth of colour from the horseradish peroxidase that was added to the sample. Each genotype had a different pattern on the microarray, identified by a computer that read the spacers in between the nucleotide attachments. The computer matched the sample to a pre-established standardised range of genotypes dependent on which parts of the microarrays had a DNA attachment and which parts did not. The computer assigned a value of 0 or 1 to each nucleotide according to the depth of colour from the horseradish peroxidase. If a nucleotide had a weak colour, the pattern on the microarray was compared to all known spoligotypes and the unknown nucleotide was assigned 0 or 1 dependent on the most similar spoligotype pattern. There was no fixed boundary as to what value was assigned to what depth of colour. The output of the categorisation of individual nucleotides to 0 or 1 according to the depth of colour from horseradish peroxidase was a spoligotype.[180]

[180] FN spoligotype The BFD Study, 10.01.17

Appendix 3. Information sheet and consent form

Information sheet

Lancaster University

Learning to manage Bovine Tuberculosis: Bringing together the understandings of vets, farmers, charities and the policy process

This research project is part of the PhD degree programme that I am currently undertaking at Lancaster University. It is funded by the UK Economic and Social Research Council which does not have any commercial interests (www.esrc.ac.uk).

Purpose of the project

This research will bring together local understandings of Bovine Tuberculosis (bTB) and government official's and scientific advisors' understandings of bTB policies. This is a qualitative social science investigation involving first-hand observations and participation (ethnography) in 'real-world' settings in order to understand local perspectives of disease management. Observations will be carried out in different areas regarding bTB: badger cull area, edge area roadkill badger survey and low risk area. It will involve observation and participation in meetings, TB testing, implementation of biosecurity and badger vaccination. Where possible, detailed fieldnotes will be made during and after observation/participation. The research will also involve interviews with people involved in these activities. The results of the research will form the basis for recommendations for future bTB policy and disease management.

What is involved in your participation?

Through interactions with people involved in bTB management, I hope to gain three types of data: observational data of meetings and activities; one-to-one interview data; and, discussion group recordings. I will seek permission to record meetings, conversations and interviews on an audio recording device. As a participant, you can ask me not to record at any time and I will make notes by hand. If you agree to be interviewed, you are free to refuse to answer any of the questions, to withdraw from the interview at any point before or during the interview, and to ask me to delete records of the interview. You can also withdraw your data from the project entirely at any time up to three months after the fieldwork is concluded. I do not foresee any risks to your participation in this project. All participation is entirely voluntary.

Protecting anonymity, privacy and confidentiality

Audio files and transcribed text files will be stored in a password protected laptop and the recording device will be stored in a locked drawer in a university office at the Department of Sociology.

All data derived from interviews, discussion groups and observation/participation will be anonymised. Anonymising means deleting or disguising all information that can render a person identifiable to an outsider. However, it is possible that participants and their data will be identifiable to people closely familiar with bTB management and the local area, and so complete guarantees cannot be provided.

I will transcribe all audio recordings personally. Your name and contact details will be held separately from any interview recording and notes in order to protect your identity. Data will be analysed thematically using data analysis software. Six months after the end of the project I will delete or destroy all records in my possession containing personal information. However, I intend to keep anonymised research records for future research purposes. No personal and private information you share with me will be shared with anyone else unless it involves unlawful activity or the safeguarding of a vulnerable person, in which case it is my legal duty to report it to the police.

End uses of the information provided

The information you provide will be analysed for the purposes of this project. The findings of the research will be written up as a PhD thesis, and a short report for policy makers and other organisations interested in this work. The findings may be published, and they may also be used for teaching and research training. The data will be stored securely for a maximum of ten years. The written work may include direct quotations from the interviews, but individuals will never be named. Please feel free to ask me any further questions you may have about the project. You can also advise me of anything else you would like me to do to protect your privacy.

Consent form

Lancaster University

Learning to manage Bovine Tuberculosis: Bringing together the understandings of vets, farmers, charities and the policy process

Researcher details

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Project supervisor details

Dr Claire Waterton, Reader, B147, Department of Sociology, Bowland North, Lancaster University, LA1 4YT (E: c.waterton@lancaster.ac.uk / T: 01524 593 322)

Prof Maggie Mort, Professor, B131, Department of Sociology, Bowland North, Lancaster University, LA1 4YT (E: m.mort@lancaster.ac.uk / T: 01524 594077)

Any questions or problems?

I don't anticipate any problems arising from the conduct of this study. If any issues arise, it will probably be easiest to resolve them by discussing them with me, the researcher, in the first instance. If you have any further questions, any cause for complaint or would like to raise any concerns about my behaviour or about the research undertaken, please contact one of my supervisors.

I, the undersigned, confirm that (please tick box as appropriate):

1) I confirm that I have read and understood the information sheet for the above study and have had the opportunity to ask questions. My questions have been answered adequately.	
2) I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without detriment.	
3) I agree to the use of any anonymised information given by me in future published reports, articles or presentations by the researcher for the purposes of the study.	
4) I consent to being audio recorded.	
5) I agree to the archiving of anonymised data for future use by the researcher or by other researchers for purposes compatible with the purposes of this study.	
6) I agree to take part in the above study.	

Name of Participant | Date | Signature

Researcher | Date | Signature

This consent form will be kept by the researcher for at least three years beyond the end of the study.