Badger Trust Tackling Bovine TB Together

Towards Sustainable, Scientific and Effective bTB Solutions

Full Report January 2024

Badger Trust would like to thank the various reviewers of this report for their comments and support, and all supporting public and private organisations and individuals. In particular, we want to acknowledge the individual farmers who participated in the farmer's survey and were willing to honestly share their, at times, traumatic experiences.

We are grateful for the opportunity to work together with stakeholders from all sides of the bTB conversation.

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Foreword

This report is a significant attempt to get a collaborative way forward in dealing with the damaging disease of bovine TB in the most effective way possible. The approach is rooted in looking at the evidence to get a policy framework and measures that reduce the impact of bovine TB on cattle and other animals throughout Great Britain. It contains clear and evidence-based recommendations for the best way forward in tackling the disease and protecting our natural world.

But why is Badger Trust presenting this report?

Badgers have never been a primary spreader of bTB – as this report demonstrates, bTB is accepted to be a largely cattle-spread disease. In Wales and Scotland, badgers are not culled in their attempts to reduce bTB and stop bTB from entering the country. However, over 210,000 badgers have been culled in England since the current cull policy began in 2013, with a further 50,000 marked for culling in 2023. This intensive culling of a protected native species could amount to around half of Britain's badger population.

The badger cull is an assault on a native species unmatched in British history. Reports of local extinction events are coming in from South West England, and the government continues to be monitored by the Bern Convention on the cull's impact on the badger population. Badger Trust exists to protect badgers, their setts and their habitats, so it has to look at a policy that has been devastating to badgers and the local ecology.

Badgers are wild animals, and cattle are farmed, but the policy framework impacts both animals and the plethora of other animals exposed to bTB. This report shows that since 2012, policies in England have been heavily biased against badgers, which has proved a distraction from the measures needed to reduce bTB, such as better cattle testing, cattle vaccination, and reduced cattle movements.   The policy has also been destructive to Britain's largest remaining carnivore and a critical part of our natural world – the badger.

So, Tackling Bovine TB Together: Towards Sustainable, Scientific and Effective bTB Solutions remains a clear and evidence-based piece of work, supported by Professor David Macdonald – who wrote an introductory commentary to read alongside the report – and many other independent experts. It looks at the reasons behind bTB and how we can better collaborate between farmers, vets, the government, nature defenders, and the general public.   Its conclusions show badger culling is not an effective, or indeed, ethical, way forward.

Badger Trust will continue to call for an immediate end to the badger cull and work with anyone who wants to reduce bTB so that cattle and other animals no longer suffer from its impact.

Peter Hambly
Badger Trust
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Introduction

Bovine tuberculosis (bTB) is a chronic respiratory disease caused by the bacterium *Mycobacterium bovis* (*M. bovis*) and is one of the most pressing politicised issues facing British farming today [1]. The disease has a significant financial and social impact on the farming community, as well as a considerable combined cost to the UK taxpayer and industry of around £150 million per year [2]. Bovine TB impacts cattle health and, therefore, farm businesses, farmer livelihoods, and farmers' mental health and wellbeing. Ineffective control of bTB raises further animal welfare concerns for both livestock and wildlife.

Mycobacterium bovis is a major zoonotic disease, and cattle are the main source of infection risk to humans, mainly via unpasteurised milk. Since pasteurisation in 1935, however, bTB is not currently a wide-scale human health problem [3, 4]. Bovine Tuberculosis has continued to receive global attention in attempts to eradicate the disease. The 'One Health' initiative led by the World Health Organisation (WHO), the World Organisation for Animal Health (WOAH), the Food and Agriculture Organization of the United Nations (FAO) and the International Union against Tuberculosis and Lung Disease (the Union) has been established with the aim to implement strategies for its global eradication.

Spread primarily via the breath or discharge from the nose and mouth of infected cattle [5, 6], advanced infections of *M.bovis* in cattle can result in the deterioration in condition, milk yield, and meat quality [7]. *M.bovis* can persist and be infectious for months to years in the environment including in slurry, hay, silage, soil, faeces, and water and within single-celled organisms that can survive drought and other environmental stressors [8-10]. According to the British Cattle Veterinary Association (BCVA) CHeCS programme (formerly known as Cattle Health Certification Standards), nose-nose contact between cattle is a key and underestimated pathway of transmission between cattle. The infectious dose of aerosol *M.bovis* is just 10 TB bacteria [11]. Bovine TB can take months for clinical signs to appear in an infected animal due to the long generation time of these bacteria [5, 8, 12], and can infect numerous wild and domestic species including, but not limited to, deer, rats, badgers, sheep, alpacas, goats, and cats [13].

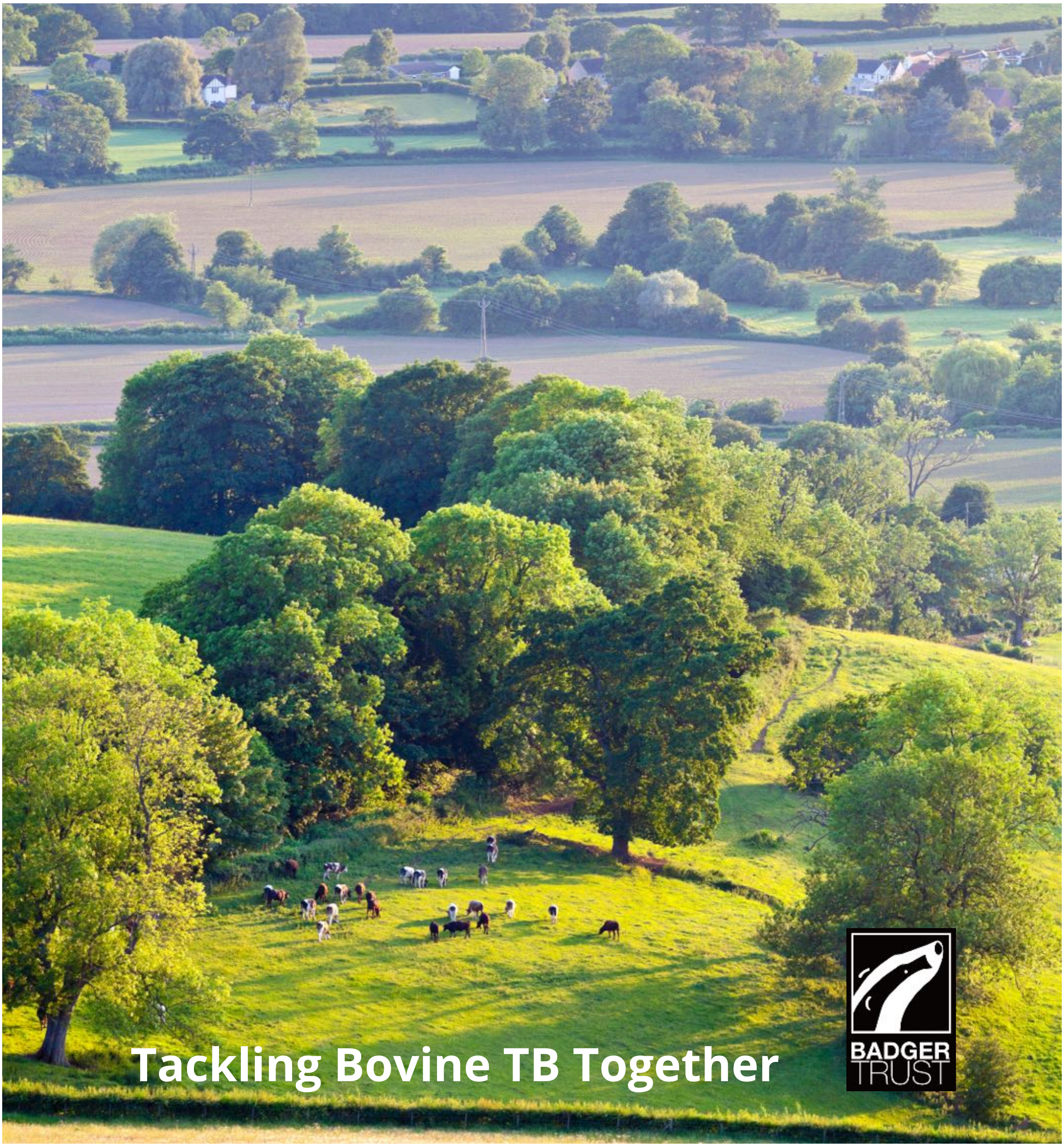
Since 2013, badger culling has been part of a series of government measures to tackle bTB eradication in cattle in England. Epidemiological and statistical evaluation of badger culling and trends in bTB transmission, however, has shown that badger culling is frequently neither scientifically supported nor an effective method of controlling bTB in cattle [14].

Government policy has now resulted in the culling of over 210,000 badgers in England – almost half the estimated badger population of England and Wales [15, 16]. The badger's role as bTB vectors to cattle has been widely debated [17-19], and according to one study over 94% of bTB transmission occurs from cattle to cattle [20]. Repeatedly, cattle-based measures have proven most effective in reducing bTB transmission (see sections 4.2.2, and 10.1.5-10.1.8).

In 2021, the government pledged to end intensive badger culling in 2025 but reportedly intends to replace it with epidemiological culling, where up to 100% of badgers in an area can be culled based on epidemiological evidence.

In this report, Badger Trust provides an evidence-based overview of the impact of badger culling on disease control in cattle, the environment, the economy and animal welfare. We bring together the voices of those impacted by ineffective disease management, recognising that bTB is about more than badgers. We recommend how the devolved governments, farmers, veterinarians, and nature-based organisations can collectively work together towards a future free from bTB where native wildlife and farming practices can co-exist sustainably.

This report aims to open a dialogue on the control of bTB between stakeholders and across disciplines and how we might best approach this disease together. By setting out a holistic review of the policy and science to date, we hope to take an important step towards depolarising what is one of the most contentious and political animal health issues Britain continues to face.



Part I The History of bTB in Britain

The Science		*The Policy*
Infected bTB cattle disperse to former British colonies.	**The 1800s**	
The tuberculin skin test is introduced, allowing routine testing of cattle.	**1920s**	
	1935	*Milk pasteurisation starts protecting people from bTB.*
	1935-1937	*The Ministry of Agriculture rolls out the Tuberculosis-Attested Herd Scheme.*
Targeted, exclusively cattle-based control measures dramatically reduce the prevalence of bTB in cattle in many countries.	**1950s**	
Bovine TB is now almost eliminated from Britain through rigorous testing of cattle herds and strict quarantine.	**1960s**	
The South West is identified as having a higher rate of bTB recurrence.	**1970s**	
BovineTB is first discovered in badgers.	**1971**	
	1973	*The Badgers Act is introduced to protect badgers against badger baiting.*
	1975-1981	*Strategic culling using gassing is employed.*
	1981	*Gassing stops as a culling method.*
	1986	*Dunnet Report: Partial trapping policy replaces clean ring policy as an interim strategy.*

	1986-1993	*Interim strategy is deployed, which involves removing and culling badgers only on farms where bTB has been confirmed. Incidences of bTB increase in South West England and spread to new areas.*
bTB outbreaks resume a year-on-year increase.	**1987**	
	1992	*The Protection of Badgers Act is introduced to counter widespread violent persecution.*
A trial study of a diagnostic test on live badgers begins but is suspended due to poor test sensitivity and methodological issues.	**1994-1996**	
The Krebs report is published, which recommends a randomised block experiment of badger culling to test effectiveness in bTB control.	**1996**	
	1997	*Ongoing culls continue, but no new culls start.*
The Randomised Badger Culling Trial begins (RBCT; see main text).	**1998**	
Tuberculin testing is suspended due to Foot and Mouth disease (FMD). Movement controls are abandoned for re-stocking.	**2001**	
Northern Ireland bTB has now been significantly reduced via cattle-based measures.	**2002**	
The RBCT's reactive culling component is terminated prematurely due to evidence that it increases bTB incidences.	**2003**	

Science	Year	Policy
Results from the RBCT proactive culls are now ready for review.	**2005**	*Pre-movement testing in England and Wales is implemented to reduce cattle-to-cattle bTB spread.*
RBCT is published and concludes that "badger culling can make no meaningful contribution to cattle TB control in Britain".	**2007**	
	2008	*Stricter cattle movement controls are introduced to try and reduce transmission to other herds.*
	2010	*Badger vaccination is first deployed, with programmes in 18 counties.*
Cattle testing is found to be highly unreliable. Strain et al. suggest "an increasing probability that the true figure of SICCT sensitivity is near 51%". Subsequent work suggests it may be half that (Watt et al., 2021).	**2011**	*Plans for a mass badger cull in West Wales are abandoned, and a badger vaccination programme is introduced.*
Scientists from the RBCT warn the planned badger cull will be ineffective.	**2012:**	

Running total: 1,966 badgers culled.

Science	Year	Policy
First Godfray review cites 49% mean herd-level sensitivity of the SICCT test.	**2013**	*A two-year pilot badger cull begins in two zones in Gloucestershire and Somerset. Cattle testing using SICCT in England is organised into three separate Risk Areas: i) Low Risk – four yearly, ii) High Risk – annual, iii) Edge – increased from two or four yearly to annual.*

Running total: 2,581 badgers culled.

Science	Year	Policy
The government-led Humaneness Monitoring report confirms controlled badger shooting is inhumane.	**2014**	*All breakdowns in the Edge Area and some in LRA to be subject to SICCT at severe interpretation. All confirmed breakdowns in the Edge and Low Risk Areas to be tested supplementarily with IFN-γ.*

Running total: 4,048 badgers culled.

Science	Year	Policy
Rates of bTB start to fall in Wales, which continues to focus on cattle biosecurity instead of culling badgers.	**2015**	*The government claims the badger culling pilot has been successful. A third zone is introduced.*

Running total: 14,934 badgers culled.

DEFRA commissions the Badger Found Dead survey in edge areas of England to trace bTB in badgers.

2016

A further seven cull zones are licensed.

Running total: 34,471 badgers culled.

2017

Another 14 cull zones are licensed. Compulsory increase in IFN-γ testing across the HRA for confirmed breakdowns which meet any of three criteria.

Running total: 67,405 badgers culled.

The Badger Found Dead report is finished but is withheld from publication. Laheurta-Marin et al. (2018) estimate median sensitivity of the SICCT test sensitivity at standard interpretation to be 40.5-57.7%, and at severe interpretation 49.0%-60.6%.

2018

A further 11 cull zones are licensed. The government commissions an independent review of its bTB control strategy (the Godfray Review).

Running total: 102,439 badgers culled.

2019

There are now 43 cull zones licensed. Wildlife charities Badger Trust, Born Free and Eurogroup for Animals motion a joint complaint under the terms of the Bern Convention.

Running total: 143,331 badgers culled.

The Godfray Review is released, concluding badger culling is not the most effective method for reducing bTB in cattle. The Badger Found Dead survey concludes badgers are unlikely to be a significant bTB wildlife reservoir.

2020

Licensed cull zones are increased to 54 areas, including low-risk bTB areas. The government responded to the Godfray Review by promising a move away from badger culling beyond 2025.

Running total: 176,928 badgers culled.

The world's first clinical field trials of the BCG vaccine and DIVA skin test for cattle begin.

2021

There are now 61 licensed cull zones in operation. Secretary of State George Eustice judges badger culling to be unacceptable.

Running total: 207,000 badgers culled.

Langton et al. (2022) confirms badger culling has not reduced bTB in cattle.

2022

Up to half of Britain's badger population is now culled on land covering ~ ⅓ of England. DEFRA dismisses the new research but later retracts its statistical rebuttal after it is found to be incorrectly calculated.

Running total: *To Be Announced* badgers culled.

Cattle vaccination testing is in the second phase; expected to be ready by 2025.

2023

Government states badger vaccination will replace culling but has no current plan for roll-out or funding. DEFRA confirms that cattle vaccination won't be mandatory when it's ready.

1.1 History of bTB Control Policy in Britain

Bovine TB has been known to be present in British cattle herds and the wider environment since being able to test for the disease in the 1800s [21]. However, the risk posed to humans was mostly alleviated by the introduction of milk pasteurisation in 1935 followed by the development of a human vaccine, the BCG, in 1953 [4].

By the 1960s, the implementation of cattle measures, including testing and restrictions on cattle movement, had almost completely eradicated bTB from Britain [21, 22]. Cattle herd sizes were smaller than today, and cattle movements were fewer, so it was easier to eradicate the disease by culling entire herds where one or more individuals tested positive for bTB. Farmers were then compensated accordingly. As will be explored later, it is now the individual cattle (rather than the herd) that is treated as the "epidemiological unit" [4]. It is no longer considered cost-effective to cull entire herds due to the larger herd sizes. However, at least 50% of herd infections are caused by diseased individuals that went undetected during previous bTB testing (see section 10.1 for more information on cattle testing) [23].

As shown in Figure 1, the timeline of bTB science and policy is long, though the speculation about the role of the badger in the spread of bTB in the UK did not begin until the 1970s. By this point it was already known that bTB was widespread in the environment, including in other animals, and it was already identified in badgers in the 1950s in Switzerland [24]. In 1971, a single badger carcass in Gloucester tested positive for the disease, which coincided with the recognition that bTB infection in cattle was rising once again and in contrast to previous outbreaks, was focused mainly within the southwest of England and west Wales [25, 26] (see Text box 1).

There are likely several reasons for this rise in bTB in cattle after all but disappearing. The inaccuracy of the Single Intradermal Comparative Cervical Tuberculin Test (SICCT test) was probably largely to blame as it resulted in many false negatives (as we will see in sections 4.2.1 and 10.1), while simultaneously a strike of Irish vets between November 1974 and June 1976 also meant screening did not take place for cattle imported from Ireland to England. Other reports also suggest the switching of ear tags and identity cards was not uncommon and allowed bTB-positive animals to be imported to England [24]. At the same time, the intensive testing under the TB Area Eradication Plan that had helped all but eliminate bTB in cattle had increased testing intervals to 4 years, meaning longer time frames for infected cattle to go unnoticed. The increase in herd sizes had also made it economically and ethically difficult to treat the herd as an epidemiological unit and slaughter whole herds as previously.

Large-scale badger sampling commenced, but testing did not extend to any other wildlife, despite many wild and domestic species also being known sources of bTB [27]. As a badger's diet is primarily made up of earthworms, invertebrates, and fruit they thrive in mixed pasture and woodland - areas with this habitat in abundance coincide with areas where most cattle farming occurs today [4]. More recent studies have failed to show a relationship between badger densities and bTB in cattle, [28-30], but this location-based relationship was enough at the time to propose the badger hypothesis.

Text box 1: Why are badgers associated with bTB incidence? A case of correlation and not causation.

Badgers have been widely implicated in bTB outbreaks, and this association has primarily come from high bTB breakdown incidence being spatially correlated with high badger densities.

However, this association is not necessarily indicative of a causal link. The higher incidence of bTB in the South West of England and Wales is likely to be, at least in part, related to the history of bTB management programmes.

After WWII, a cattle bTB test-and-slaughter eradication programme was rolled out across the UK, becoming compulsory in 1950. Prior to this, the highest incidence of bTB outbreaks was in the north west and north midlands of England. This programme was relatively successful, reducing the reactor rate to as low as 0.01% [24, 31]. However, the way the programme was spatially rolled out, starting in Scotland and heading south, essentially 'swept' infected cattle into the South West, where the reactor rate did not fall as low [24, 31]. If badgers were responsible for cattle infection, the level of badger infection in hotspot areas would have been unaffected by the 1950s cattle test-and-slaughter programme, which was not the case [22].

Bovine tuberculosis is also more prevalent in dairy cattle, which are more commonly farmed in the South West, due to the nature of how these cattle live together, in large numbers, often under one roof, and with shared feeding and water sources [32].

Furthermore, the density of badgers has been shown to be related to habitat suitability for sett construction, topography and altitude, along with hedgerow and woodland availability [33], driving greater densities in the south and south west of England.

From 1975 to 1993, badger culling was trialled by several means, from the gassing of entire setts to the culling of whole clans where infected individuals were confirmed [34]. It should be noted here that the government had moved away from culling whole herds of cattle, and only culling individuals that have tested positive for bTB, known as 'reactor' animals. The gassing of badgers was later shown to be inhumane when it was realised that badgers were resistant to cyanide poisoning and needed a significantly higher dose than had been used [4, 24].

In 1996, Professor, now Lord, Krebbs proposed the need to evaluate the effectiveness of badger culling methods for reducing bTB herd breakdowns [35]. A trial study, titled the Randomised Badger Control Trial (RBCT), was implemented from 1998 to 2005 at a cost of £50 million [24], which tested two badger control conditions, reactive culling and proactive culling, against no culling (see Text box 2).

Text box 2: Randomised Badger Control Trials (RBCT)

The Randomised Badger Control Trial (RBCT) was implemented from 1998 until 2005 to test the efficacy of culling badgers for managing bTB in cattle. In this study, badgers were controlled in ten areas in the West of England with high rates of bTB in cattle. In each area, three 100 km^2 zones were selected, and each area was subjected to one of three forms of culling (see Table 1).

Table B1. The three approaches trialled in the Randomised Badger Control Trials 1998-2005*

Type	Approach	Outcome
Reactive culling	Badgers were culled on and around farms with outbreaks of bTB.	Reactive culling was suspended prematurely (in 2003) due to a 27% increase in bTB within reactive culling areas.
Proactive culling	As many badgers as possible were culled across the entire area irrespective of bTB outbreak status.	Bovine TB decreased in proactive cull zones by 27%, but bTB increased in surrounding areas by 25%.
Survey	No badgers were culled. Badger activity was monitored via surveys.	Acted as a comparison data set to reactive and proactive culling approaches.

**Adapted from Giesler and Ares (2018, p.6).*

In 2001, the Foot and Mouth Disease (FMD) epidemic devastated British farming. During this time, the government was pressured to re-stock farms where entire herds had been lost to FMD. Bovine TB cattle testing and restrictions on cattle movement were subsequently suspended. However, the movement of cattle without biosecurity measures directly resulted in increased bTB transmission [36].

By 2007, the report of the RBCT was published, which found that badger culling offered "**no meaningful contribution to reducing bTB in cattle**" warning instead that badger culling could cause an increase in cattle infection via social perturbation [37, 38] (see Text box 3).

"Weaknesses in cattle testing regimes mean that cattle themselves contribute significantly to the persistence and spread of disease in all areas where TB occurs" [39]

Based on the evidence from the RBCT, Professor John Bourne and the Independent Scientific Group who ran the trial confirmed two primary conclusions:

1. **"badger culling is unlikely to contribute positively, or cost effectively, to the control of cattle TB in Britain."**
2. **"there is substantial scope for improvement of control of the disease through the application of heightened control measures directly targeting cattle... priority should be given to developing policies based on more rigorous application of control measures to cattle, in the absence of badger culling."**

Initially, policymakers accepted the scientific findings of the RBCT and removed badger culling as a form of bTB management in cattle. However, as bTB infection in cattle persisted, badgers became focal in the bTB debate in the popular press. Many conflicting viewpoints were expressed by politicians, scientists, policymakers, farmers, and the public [25, 40]. Generally, the farming community were in favour of culling badgers, as they were perceived as the main vector of bTB spread. Much of the public saw badger culling as extreme and barbaric, and it was generally agreed by epidemiologists and ecologists that badgers represented minimal bTB risk to cattle compared to cattle-to-cattle transmission. Despite this, policymakers continued to focus their efforts on controlling the badger population. Thus, the bTB issue quickly became a debate about the protection or lethal control of badgers.

Whilst there was minimal evidence of a significant bTB reservoir present in badger populations (see section 1.2), there was considerable concern about the possibility of badgers being a major contributor to the spread of the disease. By 2008, there had been an annual increase of 24% in reactor cattle, which was around 40,000 bTB positive head of cattle per year [4]. This, combined with a desire to protect both badgers and cattle, led to badger vaccination being deployed across 18 counties in 2010 [41].

Badger vaccination involves the trapping of badgers in baited cages, where they are then injected with a live BCG vaccine. The programme was delivered under The Veterinary Surgery (Vaccination of Badgers Against Tuberculosis) Order 2010, which required volunteers to apply for a licence to conduct the caging and vaccination of badgers [41]. Between government agencies, voluntary and community organisations, and commercial operators, a total of 6,788 doses of badger vaccination were given in England and Wales between 2010-2013 [42].

In the General Election of 2010, one party included the culling of badgers in its party manifesto and went on to form the next Government in coalition. At the same time Government investment in badger vaccination by Department for Environment, Food and Rural Affairs (DEFRA) was ended.

The final decision to cull badgers was not taken solely by DEFRA; so serious was the issue that the decision was taken by the Prime Minister and other senior members of the Government. The decision to cull was made and plans were drawn up to start the badger cull pilot.

The aspect being piloted was not the culling of badgers – that had been undertaken several times before – it was the method of controlled shooting that was piloted for efficacy, safety, and humaneness.

By 2013, against the RBCT recommendations, badger culling was pursued by the government as part of a series of bTB control measures. The independent scientific group that designed, oversaw, and analysed the RBCT responded by highlighting that their results had been severely misinterpreted, and the controlled conditions of the RBCT could not be replicated by cull contractors [43]. Furthermore, the group expressed serious concern that badger culling would do little to address the government's long-term policy of eradicating bTB, and may actually increase bTB [43].

Intensive culling first began in two trial areas in Gloucester and Somerset, at the same time that cattle testing in England was organised into three separate Risk Areas: i) Low Risk Areas (LRA), where cattle were tested every four years, ii) High Risk Areas (HRA) where cattle were tested annually, and iii) Edge Areas, where cattle testing increased from every two or four years to every 6-12 months (see section 4.1) [44].

Routine testing intervals have since been amended to every six months within High Risk areas and every 6-12 months within Edge areas, depending on the location and infection history of the herd. In the Low Risk areas, herds still undergo routine testing every four years, with exceptions within some areas and when herds are in the vicinity of a breakdown.

By 2023, badger culling had expanded exponentially to include 72 designated cull areas, 58 of which are still active, covering approximately ⅓ of land in England [15]. And yet, scientific, effective, and humane alternatives for bTB eradication are available.

Neither Wales – with a lengthy border along the HRA of England – nor Scotland have implemented mass badger culling. Instead, both nations have managed bTB effectively by applying robust cattle-based biosecurity measures and enhanced wildlife surveillance (see sections 4.1-5.1).

Text box 3: The Perturbation Effect

One of the key findings of the RBCT report was the hypothesis that culling badgers was likely to result in social and disease perturbation.

The perturbation hypothesis postulates that killing individuals may affect the survivors in ways (behavioural, physiological, immunological) that cause a disproportionate, and perhaps counter-productive, effect [45]

In terms of bTB, this impact could be that badgers that survive culling, or neighbouring clans, roam beyond their usual ranges as previously occupied territories become available [38, 46-50] and thus spread bTB over greater distances. Research has shown that the social dynamics of badgers can remain disturbed for up to eight years after culling occurs [37].

1.2 Badgers and bTB

It is very difficult to understand the scale of the bTB reservoir in badgers because badgers are not routinely tested for bTB, either before or after culling [51]. Most badgers tested for bTB come via roadkill, or testing at the point of vaccination. Furthermore, it is difficult to determine the prevalence of the disease in post-mortems of badgers due to uncertain culture sensitivity. In 2022, researchers attempted to describe the badger bTB reservoir in the Edge Area of England (area between HRA and LRA), but evidence of badger infection was so "sparse", that it was not possible to conclude whether local badgers and cows shared the same strain of bTB infection [52].

The badger's role in the transmission of bTB to livestock (i.e. the "risk pathway" between badgers and cattle) has also been long debated [17-19]. Direct badger-to-cattle transmission is generally considered a rare event [53, 54] as badgers avoid close proximity with grazing cattle [55]. Although research has shown that bTB can spread in badger urine and faeces [54], cattle tend to avoid badgers and badger faeces when grazing [56]. Whilst badgers may opportunistically enter farm buildings and feed stores when foraging [57], biosecurity measures have been shown to be highly effective at preventing wildlife from coming into proximity of livestock or feed stores, effectively negating this risk [58].

Traditional attempts to differentiate spoligotypes or strains of *M. bovis* are useful for identifying the spatial patterns of bTB infection, but are not a useful tool for identifying transmission rates or direction between species, and thereby are a limited tool in managing disease outbreaks. As scientific technology has advanced, a greater understanding of risk pathways has been possible. Whole Genome Sequencing, for example, is a scientific method that allows **genetic tracing of disease to the source of infection, the use of which has revealed that cattle movement is most impactful for the spread of bTB** [59]. For example, researchers in Cumbria found that the bTB strain responsible for a recent outbreak came from infected cattle imported from Ireland. These cattle were imported six years prior to the same strain appearing in badgers [59]. Thus, it was highly likely that cattle initially transmitted bTB to the surrounding wildlife.

The routine TB test and slaughter programme was nationally suspended for almost ten months during the outbreak of foot and mouth disease in 2001 [60]. As a result, there was an increase in the prevalence of *M. bovis* infection in badgers, further suggesting increased transmission from cattle to badgers [61]. Much of the risk posed by wildlife could be reduced via farm biosecurity measures that prevent cattle-wildlife cross-contamination (see section 10.1.6).

Text box 4: Transmission of bTB is 800 times more likely to occur from cattle to badgers than the other way around

A five-year-long study in Northern Ireland used bacterial genome data to show that **transmission of bTB was 800 times more likely to occur from cattle to badgers than from badgers to cattle**. The study, funded by the Agri-Food and Biosciences Institute, also found that transmission rates from badger-cattle were negligible, and no badger-badger transmission was found [62].

The authors of the Northern Ireland study (Text box 4) found that just 5.8% of badgers tested positive for *M.bovis* [62]. This does not, however, mean that test-positive badgers were infectious or could pass the disease on to cattle. The paper also confirmed that only around half of *M. bovis* infections are detected within a year of first becoming infected [62]. This in-depth epidemiological study shows that the transmission dynamics of this disease are mainly driven by cattle, even in an area of high average badger density (3.88 badgers per km^2).

A similar study in Gloucestershire supported the idea that transmission was much more likely between individuals of the same species than between different species. At this site, badgers were more likely to spread bTB to cattle than the other way around [63]. The environmental context of the site was unusual, however, with exceptionally high badger densities (30-40 badgers per km^2) reported, and significant bias was reported due to poor sensitivity of the testing methods. Additionally, samples were taken over a longer period of time, and over a wider spatial area for cattle than badgers making transmission pathways over time unclear. The authors also reported analytical limitations of the modelling approach used, and when more complex population structures were accounted for in models, results indicated that transmission rates between badgers and cattle were almost equal.

1.3 Badger Cull

The premise of badger culling centres around the notion that there will be a net reduction in the level of bTB in cattle herds within and around control areas as a result of the policy. Badgers are capable of carrying bTB, and have an unusual ability to carry a mycobacteria load (in this case the bTB mycobacteria strain) without it impacting their population-level health [4]. Badgers' increased exposure to higher than normal bTB, beyond the mycobacteria that are always present in the environment, stems from cattle [4].

Repeatedly, independent analyses of government data have shown that mass badger culling has not been effective at eradicating bTB in cattle. In a study by APHA scientists, Downs et al., (2019) identified a statistically significant decrease in bTB incidence in Gloucestershire and Somerset after four years of badger culling between 2013 and 2017 [64]. Although this study is often cited to support badger culling, the authors highlighted that the specific causes of the decline were unclear, and could have been attributed to improved farm biosecurity and veterinary advice. Furthermore, when expanding the APHA data to include up until September 2018, McGill & Jones (2019) found a 130% increase in bTB herd incidence in Gloucestershire [20]. Drawing a definitive conclusion, therefore, that culling badgers alone has any beneficial effect on disease reduction in cattle from any of the available data is currently made impossible, given the complexity of factors involved.

Improvements in bTB rates in HRAs are also likely to be in part as a result of increased testing using Interferon-Gamma (IFN-γ) blood testing, which is more accurate than the skin testing used in routine testing. IFN-γ testing has increased since 2017 [65], which is likely to have improved bTB detection rates and contributed to the decline in herd breakdowns.

Another scientific paper published in 2022 rigorously analysed government bTB surveillance data between 2009 and 2020. This study concluded that the reduction in bTB incidences was likely due to cattle-based biosecurity measures implemented either before culling began, or during the cull period [14]. The analysis of eleven years of data, from both within and outside cull zones, showed no correlation between badger culling and a decline in bTB in cattle. Further analysis of ten high risk counties showed that bTB incidences in cattle had already begun to fall before the intensive badger culls were implemented.

1.4 Epidemiological Culling of Badgers

Epidemiological culling of badgers has been defined as a process to cull 100% of badgers in newly diseased areas, defined as a Minimum Infected Area where TB free status has been withdrawn as a result of clusters of herd incidences [66]. Badger numbers will also be heavily reduced in an outer area, followed by vaccination in a third year [2]. According to the government's Next Steps document from 2020, culling will be replaced by cattle and badger vaccination, and epidemiological culling in 'exceptional circumstances'. This will replace the 4-year intensive licences followed by supplementary licences that have been used to cull badgers since 2013 [2, 66]. Under this proposal, reactive culling will continue for an unspecified amount of time into the future.

A public consultation on epidemiological culling is expected before the end of 2023 [67], and, in June 2023, a Secretary of State for DEFRA publicly said, "I'm not keeping to an artificial deadline", and there is "no fixed deadline" to end badger culling [68, 69]. This is despite an independent analysis of government data showing that badger culling has had no measurable reduction in bTB in the HRAs [14].

A four-year-long trial of epidemiological badger culling conducted in Cumbria showed removing badgers had no significant contribution to controlling bTB in cattle [66]. Even if all the badgers are culled in an area, the Cumbria trial shows the inability to completely remove bTB from the herds using current testing mechanisms. This means that cattle will continue to re-infect the repopulating badgers and other wildlife [66].

Since 2013, the government has set cull targets of >70% of badgers in cull areas with this figure increasing to 100% cull rates in areas of epidemiological culling [70].

Badger culling aimed at reducing bTB in cattle hasn't proven effective, and no clear link has been found in independent analyses of government data. Improved biosecurity, better testing methods, and cattle-based measures appear to be the main contributors to the decline in bTB in cattle, rather than badger culling.

Part I Summary

- bTB is most commonly transmitted cattle-to-cattle, and not from badgers-cattle.

- bTB was first identified in the United Kingdom in the 1800s; since then cattle-based measures have been the most effective mechanism for disease reduction in cattle.

- By the 1960s, the implementation of cattle measures, including testing and restrictions on cattle movement, had almost completely eradicated bTB from Britain. Cattle herd sizes were smaller than today, and cattle movements were fewer, so it was easier to eradicate the disease by culling entire herds.

- It is no longer considered cost-effective or ethical to cull entire herds due to the larger herd sizes. However, at least 50% of herd infections are caused by diseased individuals that went undetected during previous bTB testing.

- Badger culling was originally opposed by government-appointed scientific advisors because it was unlikely to be effective in protecting cattle and could potentially make bTB prevalence worse.

- Intensive badger culling began in England in 2013. By 2023, over 210,000 badgers had been killed, up to half the estimated population across England and Wales. This included 58 active cull areas, covering approximately ⅓ of land in England. And yet, scientific, effective, and humane alternatives for bTB eradication are available.

- Badgers are not routinely tested for bTB before or after culling.

- Scientific advances have shown that bTB is infrequent in the badger population.

- Drawing a definitive conclusion that culling badgers alone has any beneficial effect on disease reduction in cattle from any of the available data is currently made impossible, given the complexity of the factors involved.

Part II Ethics of Badger Culling as a Form of bTB Control

2.1 Badgers

Badgers have lived in Britain for an estimated 250,000 years [71], and their presence is part of the natural landscape. Badgers are well recognised by their distinctive black and white stripes and for their depictions in much-loved children's tales. The badger's native residency has also been commemorated in place names across England and Wales from Badger Wood in Radnorshire to Brockwell Park in London.

Thus, badgers are an important flagship species for British natural heritage.

Although the European badger is listed as "least concern" by the International Union for Conservation of Nature (IUCN) [72], the IUCN assessment of *Meles meles* covers the whole range of the Eurasian badger. Yet in the UK, there are significant threats to badger populations, including wildlife-vehicle collisions, badger baiting, housing and development, and culling [73]. In a changing climate, both flooding and drought will further add to the risks faced by badgers, alongside our other native species. Hence, the current population health of badgers in Britain is unknown.

The most recent population estimates of badger numbers in England and Wales were recorded pre-cull and thought to be around 485,000 badgers (ranging from 391,000–581,000) [15]. Thus, culling over 210,000 badgers in the past decade could have had a significant impact on the population health and resilience of Britain's badger populations.

2.2 Badger Ecology

Badgers live in social groups called a clan that average four to eight members but can exceed 20 individuals.

Their sociality, however, can vary across their range and Britain's badgers are considered more sociable than their European mainland counterparts [74, 75]. Badgers live in setts – a mixture of underground tunnels and chambers – and can pass them down for generations, some are over 100 years old [76]. These are family homes used and maintained by generations of the same family group. Clan territories often include multiple setts; a main sett, and ones that are visited less frequently, known as an outlier. A member of the mustelid (weasel) family, badgers typically only live three to five years but, rarely, can live up to 14 years.

2.3 Badgers and Biodiversity

Though omnivores, badgers are Britain's largest native terrestrial carnivore and a keystone species for maintaining ecosystem health, serving as 'ecosystem engineers' [77, 78]. By creating opportunities for a wide range of pollinating insects, birds, and mammals, badgers support biodiversity and ecosystem health across their native range [78]. Badger burrowing and digging behaviour changes the chemical and physical properties of topsoil and promotes soil enrichment [79, 80], providing opportunities for the growth and species richness of lower plants [81, 82]. Their ranging activity makes badgers effective seed dispersers [83] and badger setts also offer refuge and breeding sites to numerous other terrestrial species [84, 85].

> ***"biodiversity, encompassing variation from within-species to across landscapes, may be crucial for the longer-term resilience of ecosystem functions and the services that they underpin" [86]***

Biodiversity is essential to all processes that support life on earth [87], and badgers have a functional role shaping and supporting species diversity. Badgers are an integral part of this system providing valuable services as a mesocarnivore (carnivore occupying an intermediate level of a trophic system) that can have knock-on effects across the entire ecosystem. With an absence of large carnivores in Britain and few mesocarnivores, badgers, together with foxes, are one of the few remaining species that can drive community structure and function at this level [88]. The loss of badgers can restructure the behaviour and abundance of other species to the detriment of the overall ecosystem, as well as having cascading effects on the functioning of processes that we depend on.

For example, culling badgers has resulted in an increase in red foxes (*Vulpes vulpes*) of 1.6 - 2.3 foxes / km^2 in those areas [89]. This increase in fox density has potentially wide-ranging economic and ecological impacts [89].

There is a common misconception that badgers play a significant role in the decline of vulnerable species such as European hedgehogs (*Erinaceus europaeus*) and ground-nesting birds. However, evidence to support unsustainable levels of species predation by badgers is lacking [90, 91]. In fact, one study has shown that badgers and hedgehogs in urban spaces can co-exist quite peacefully, with very few interactions classed as predatory [92]. Although classed as a carnivore, badgers are actually omnivores, and their diet consists primarily of earthworms (65-70%) as well as insects, fruits, cereals and occasionally small mammals with just a small portion as bird remains (6%), the latter of which is most likely eaten as carrion [93, 94].

Hedgehog numbers have declined all over the UK [95], including in regions with fewer badgers than those estimated in cull areas [96]. Badgers and hedgehogs have coexisted for thousands of years without human interference. When it comes to taking action for hedgehogs, we need to look closer to home and provide good habitat cover and wild areas with good connectivity between gardens.

Most environmental organisations do not support the removal of badgers as a form of native wildlife conservation (see Text box 5). For example, the Hedgehog Preservation Society and the People's Trust for Endangered Species identified the intensification of agriculture, fewer hedgerows, tidier gardens, and road fatalities as the main drivers towards declining hedgehog numbers [96].

Text box 5: Culling badgers won't save hedgehog populations

"Identifying badgers as the primary reason for the fall in hedgehog numbers isn't backed by science. While badgers may play a role locally, hedgehogs are absent in many areas where there are no badgers and, in areas where nesting and feeding sites are plentiful, the two species coexist. Culling badgers to control the spread of bTB isn't supported by scientific evidence. Culling badgers is unlikely to save hedgehogs."

The British Hedgehog Preservation Society and People's Trust for Endangered Species, 2020 [97].

Badgers are also often blamed for contributing to the decline of ground-nesting birds, with up to 75% of people in one survey, conducted by Game and Wildlife Conservation Trust, believing this is true [98]. However, a recent peer-reviewed study looking at bird populations inside and outside badger cull areas in South-West England found no evidence that the removal of badgers made any difference to ground-nesting bird numbers [91].

A study by DEFRA [99] on the ecological effects of badger removal during the RBCT found that "During the initial stages of the experiment to investigate the effect of badger removal on nests of ground-nesting birds it became apparent that direct damage by livestock was a source of considerable nest loss." Agricultural intensification is often cited as a significant contributor to the decline in ground-nesting bird numbers and some studies have shown that the impact of trampling and consumption of eggs and chicks from cattle and sheep on ground-nesting birds is significant [100, 101].

The British Trust for Ornithology provides information on skylark population trends and in reviewing research, states "that the most likely cause of declines in skylark is agricultural intensification, specifically the change from spring to autumn sowing of cereals, which reduces the number of breeding attempts possible and may also reduce overwinter survival due to loss of winter stubbles." [102]

Stocking densities have increased dramatically over the last 50 years, and one study found a correlation between livestock (sheep and cattle) and populations of ground-nesting birds at a national scale, combining 10,531 Breeding Bird Survey squares surveyed in England (by the British Trust for Ornithology) between 1994 and 2003 [103]. Mapping the results of the surveys of two species (meadow pipit and skylark) nesting in grazed land (with or without livestock present – data from DEFRA census) compared to non-grazed land (i.e. arable, silage, and set-aside) showed that it was possible to predict their abundance by the land use. There was a significant negative association between livestock and the abundance of meadow pipits and skylarks.

2.4 Nature Conservation and Sustainability

Britain has one of the most nature-depleted landscapes in the world. According to the Biodiversity Intactness Survey, Britain ranks last of the G7 and is in the bottom 10% globally for biodiversity [104]. The culling of a native mammal in already struggling ecosystems undermines Britain's commitments to global biodiversity, including the Bern Convention, the United Nations Sustainability Goals, and the Convention of Parties (COP15) Kunming-Montreal Biodiversity Framework for nature recovery by 2030.

The British government has been consistently criticised for its lack of leadership in relation to environmental regulation and compliance (see Text box 6). The Wildlife and Countryside Link, the largest environment and wildlife coalition in England comprising 70 organisations, highlighted these same leadership shortcomings for policy related to farming and land management [105]. Whilst the UK government's response to the climate crisis has been to add more targets under the Environment Act and the Climate Change Act, Wildlife and Countryside Link explains that none can be sufficiently addressed without mandatory compliance from the agricultural sector.

Text box 6: Top-level political leadership as a priority
"The commitment of engaged stakeholders is not enough without an enabling policy environment and the partnership of Government. The Government must demonstrate top-level political leadership on this Agenda. Without it, the Sustainable Development Goals will fast become a missed opportunity for the UK."

From the Executive Summary of Measuring Up 2.0 [106]

2.4.1 Badgers and The Bern Convention

The UK has been a signatory to the Bern Convention since 1982. The Bern Convention aims to ensure the conservation and protection of Europe's wildlife, within which it regulates the exploitation of species listed in Appendix III, including badgers [107]. The UK is an important badger region, holding approximately 25% of Europe's *Meles meles* population [15], and badger populations are protected from unsustainable and unmonitored lethal management under the Bern Convention.

Under Article 7, Parties to the Convention are committed to taking appropriate and necessary legislative and administrative measures to ensure the protection of listed species, and to regulate any exploitation to keep these populations out of danger.

Article 9 permits contracting parties to make exceptions to the requirements in Article 7 to "prevent serious damage to livestock", albeit only when there is no other satisfactory solution and where the action will not be detrimental to the survival likelihood of the population (see section 3.1.3 for further information on how badger culling in England fails to meet the International Consensus for Ethical Wildlife Controls).

The UK government has relied on this exception in Article 9 to justify its policy of badger culling. However, the UK government has failed to:

- conduct accurate assessments of badger populations in cull zones in order to ensure the survival likelihood of populations within those zones.
- conduct adequate ecological risk assessments to ascertain the potential impacts of the removal of badgers on other protected species.
- account for the cumulative risk to local badger populations from the various threats they face.
- implement other satisfactory solutions that would avoid a cull such as biosecurity measures or vaccination.

For these reasons, the badger cull policy in England could be found to be in direct contravention of articles 7-9 of the Convention. This is further true for the concept of epidemiological culling as by their very remit they are designed to cause local extinctions.

In 2020, Badger Trust, Eurogroup for Animals and Born Free Foundation submitted a formal complaint to the Council of Europe. The complaint, which is currently ongoing, includes eight breaches of the Bern Convention under articles 7-9 (summarised in Text box 7).

Text box 7: Badger culling: An alleged breach of the UK's Commitment to the European Convention on the Conservation of European Wildlife and Natural Habitats [108]

Breach of Article 7:

1. Badger culling jeopardises the population concerned.
2. The exploitation of badgers is not monitored sufficiently by the Government.
3. The exploitation of badgers has a negative impact on other species that are protected by the Convention.

Breach of Article 8:

4. The exploitation of badgers is indiscriminate, and capable of causing local disappearance of the population.

Breach of Article 9

5. The Government has failed to choose the most appropriate alternative, amongst possible alternatives, and has failed to be objective and verifiable in its reasoning for this decision.
6. The Government has failed to base the policy on accurate current data on the state of the population, including its size, distribution, state of habitat and future prospects.
7. The Government has failed to demonstrate that the measures undertaken by the Government involving the exploitation of badgers can prevent serious damage to livestock.
8. The Government has failed to submit biennial reports to the Secretariat in connection with the exceptions.

In a Freedom of Information (FOI) request that Badger Trust conducted with APHA in September 2023, they confirmed that:

- Baseline disease levels in badgers are not monitored.
- APHA is not assessing disease transmission risk from badgers to cattle.
- APHA is not looking at specificity of active bTB infections in badgers.
- APHA is only looking at bTB in badgers - not other animals such as non-badger wildlife and soil inverts.

This lack of scientific robustness when implementing these measures is a repeat of historical practices from earlier nationwide culls conducted in the 1970s (see above in Part I) when there was an over-focus on badgers against other sources or mechanisms of disease.

Importantly, the FOI response confirmed that badger population numbers are surveyed, estimated, and monitored by cull contractors, not scientists. Furthermore, APHA and Natural England do not hold data on badger population sizes or disease levels in cull zones.

This means that badger population numbers are surveyed, estimated, and monitored by cull contractors, not scientists. This was confirmed in the FOI response Badger Trust received: APHA and Natural England do not hold records for badger population sizes or disease levels in cull zones.

2.4.2 Badger Culling at odds with the Kunming-Montreal Global Biodiversity Framework

In 2022, the United Nations Biodiversity Conference (COP15) was held under the United Nations Convention on Biological Diversity (CBD). Attended by global leaders, COP15 resulted in the adoption of the Kunming-Montreal Global Biodiversity Framework, a set of global goals to address biodiversity loss by 2030.

Within the 23 nature targets set out in the Kunming-Montreal Global Biodiversity Framework, several are at odds with the badger culling policy in England (see Table 1)

Table 1. The Kunming-Montreal Global Biodiversity Framework targets that are contradicted by the badger culling policy in England

Target	Description	How Badger Culling Fails the Target
5	Ensure that the use, harvesting and trade of wild species is sustainable, safe and legal, preventing overexploitation, minimising impacts on non-target species and ecosystems, and reducing the risk of pathogen spill-over, applying the ecosystem approach, while respecting and protecting customary sustainable use by indigenous peoples and local communities.	Badger culling in England is indiscriminate and risks localised badger extinctions. The government has failed to provide evidence that the culling of badgers is sustainable, and given the accused breaches of the Bern Convention (see section 2.4.1), the cull may be found to be in breach of international regulations. Exploitation levels are not monitored effectively (see section 2.4.1) ,nor are the impacts on non-target species and ecosystems. Disease spillover is encouraged by the indiscriminate culling of badgers and the subsequent perturbation effect (see Text box 3).
7	Reduce pollution risks and the negative impact of pollution from all sources, by 2030, to levels that are not harmful to biodiversity and ecosystem functions and services, considering cumulative effects, including: reducing excess nutrients lost to the environment by at least half including through more...	The current bTB policy in England does not include mandatory farm biosecurity including safe and hygienic slurry management, livestock grazing, and livestock-wildlife interaction mitigations. Furthermore, historic and some current controls for cattle testing and movement have resulted in the spread of cattle ...

7...	... efficient nutrient cycling and use; reducing the overall risk from pesticides and highly hazardous chemicals by at least half including through integrated pest management, based on science, taking into account food security and livelihoods; and also preventing, reducing, and working towards eliminating plastic pollution.	...infection. The current policy does not, therefore, actively prevent *M. bovis* from entering into the environment from cattle.
10	Ensure that areas under agriculture, aquaculture, fisheries and forestry are managed sustainably, in particular through the sustainable use of biodiversity, including through a substantial increase of the application of biodiversity friendly practices, such as sustainable intensification, agroecological and other innovative approaches contributing to the resilience and long-term efficiency and productivity of these production systems and to food security, conserving and restoring biodiversity and maintaining nature's contributions to people, including ecosystem functions and services.	The UK government has designed Environmental Land Management (ELM) schemes to pay farmers and land managers for undertaking environmentally beneficial activities on their land. However, epidemiological badger culling is expected to continue as part of England's bovine tuberculosis eradication strategy, despite the importance of badgers for biodiversity and ecosystem health. It is therefore contradictory that landowners remain eligible for ELMs while culling badgers, given the lack of environmental benefit and absence of monitoring sustainability or impacts of the cull on ecosystem function and services.
18	Identify by 2025, and eliminate, phase out or reform incentives, including subsidies harmful for biodiversity, in a proportionate, just, fair, effective and equitable way, while substantially and progressively reducing them by at least 500 billion United States dollars per year by 2030, starting with the most harmful incentives, and scale up positive incentives for the conservation and sustainable use of biodiversity.	Epidemiological badger culling will continue where deemed necessary beyond 2025. No further information on the logistics or evidence for epidemiological culling has been provided at the time of print.

3.1 Animal Welfare and Badger Culling

3.1.1 Badger Legal Protections

Badgers have endured a long history of persecution in the UK. The act of badger baiting (where dogs are set upon badgers to fight to the death) was documented as early as the 1600s in England [109]. Although prohibited in 1835 under the Cruelty to Animals Act, badger baiting continued, which led to the introduction of the Protection of Badgers Act in 1992. The act gave badgers across the UK unrivalled species-specific protection making it illegal to harm or interfere with a badger or their sett without a licence, whether with intent or by negligence [110].

Additional legal protections are sometimes provided to badgers by the Wildlife and Countryside Act 1981, the Animal Welfare Act 2006, and the Hunting Act 2004 [111-113]. Badgers are also listed in Appendix III of the Convention on the Conservation of European Wildlife and Natural Habitats. Despite these measures, illegal badger persecution is a large and ongoing issue in parts of the UK.

Badger persecution is currently listed as a National Wildlife Crime Priority by The National Wildlife Crime Unit in recognition of its prevalence and links to other types of crime [114]. Badger baiting and digging have been linked to violent crime (including domestic violence), drugs, and firearm offences [115, 116]. Research has shown that 70% of people found guilty of animal abuse have committed other crimes [117].

Given the link between crimes against animals and crimes against humans [118], the Protection of Badgers Act 1992 acts as an important legislation for law enforcement, one that must be strengthened rather than questioned [116, 119].

Badger persecutors in England have been known to claim that the illegal killing of badgers is a form of public service due to the widespread perceived association between bTB and badgers. Thus, badger culling can set a precedent amongst some groups for killing protected species (see Text box 8). Similar findings have been reported elsewhere when carnivores are subject to culling. Analysis of the liberalisation of wolf (*Canis lupus*) culling in Massachusetts in the USA, for example, concluded that culling was “substantially more likely to increase poaching than reduce it” [120].

Text box 8: Protecting badgers also protects people

“Since the badger cull we have seen people's attitudes towards badgers change. The cull is a polarised area where to some, badgers are seen as vermin, and the cull is an excuse to cause them harm by any means.

The Protection of Badgers Act is a key piece of legislation in the fight against wildlife crime. We continually see that those who commit the worst wildlife crime are also linked to more serious and organised crimes and domestic violence.

Our message is clear. Protect our badgers at all costs.”

Chief Inspector Kevin Kelly,
Head of The National Wildlife Crime Unit

3.1.2 Animal Welfare

Animal welfare is a priority concern of the British public when it comes to policies that impact commercial animals [121, 122]. Badgers are generally considered one of the most 'liked' mammals in the UK, and badger culling has always been controversial concerning its impact on badger welfare. A YouGov survey showed that only between 7-15% of the public support the cull [123] and therefore banning the cull is likely to be widely supported by the general public who want to see greater environmental and animal welfare protections and more cost-effective disease strategies amidst the cost-of-living crisis.

As shown in Figure 1, the government commissioned a Humaneness Monitoring Investigation from 2013-2014 [124] to determine the humaneness of "controlled shooting" (the shooting of free-running badgers). Overall, the study found that badgers were often non-fatally shot, and up to 22.8% of badgers took more than five minutes to die, thereby failing the humaneness test. This humanness measure is now no longer reported. In 2022, a further 6.6% were shot but not recovered [125].

The report raised serious concerns about the likely suffering endured by badgers killed by controlled shooting (see Text box 9). On this basis, the panel recommended that only shooters who have demonstrated a high standard of marksmanship in the field, and who have a good knowledge of badger behaviour, be licensed [126].

Text box 9: Conclusion of the Humaneness Monitoring Investigation

"It is extremely likely that between 7.4% and 22.8% of badgers that were shot at were still alive after 5 min, and therefore at risk of experiencing marked pain. We are concerned at the potential for suffering that these figures imply." [124]

Independent Expert Panel.

DEFRA responded to the Independent Expert Panel's report by agreeing to enhance cull contractor training and to monitor the effectiveness of marksmen so that badger suffering would be reduced [127].

Between 2017-2022 only 10% of contractors were monitored for humaneness compliance, with 25% monitored in 2022 [128]. Controlled shooting is now the most common way badgers are culled in England [129], having increased incrementally each year since 2013. By 2022, most badgers (87.7%) were killed by controlled shooting (see Table 2).

The BVA has also called on the English government to "reduce pain and distress experienced by badgers" with controlled shooting, by focusing on the more humane option of cage trapping and shooting [7].

Badgers are sentient beings capable of making decisions that show capacity for conscious thought [130]. UK law recognises all vertebrate animals as sentient beings [131] and with this legislation comes the responsibility that relevant government policies must take into account animal sentience. This is important because conscious thought and having sensory and emotional experiences have been related to the extent a being responds to pain and suffering [132]. Culls in this capacity, can therefore not be humane.

Badgers are highly social mammals, and it is not known how the stress of culling impacts the welfare of surviving social group members. Nor is it known how the removal of an ecosystem engineer impacts the well-being of other native species (see section 2.3). Thus, lethal control of badgers has not been adequately monitored concerning all animal welfare implications.

Table 2. Number and percentage of badgers killed by controlled shooting compared by caged trapping per year (2013-2021)

Year of cull licence	Controlled shooting	%	Cage trapping	%	Total
2013	903	57.96	655	42.04	1558
2014	313	50.89	302	49.11	615
2015	743	50.65	724	49.35	1467
2016	5667	52.06	5219	47.94	10886
2017	11834	60.57	7703	39.43	19537
2018	20905	63.48	12029	36.52	32934
2019	24645	70.35	10389	29.65	35034
2020	31838	77.86	9054	22.14	40892
2021	29544	87.70	4143	12.30	33687
2022	29574	87.95	4053	12.05	33,627
TOTAL	**155,966**		**54,271**		**210,237**

3.1.3 The International Consensus for Ethical Wildlife Control

According to international standards, any lethal control method employed to mitigate human-wildlife conflict should abide by the principles outlined by the International Consensus for Ethical Wildlife Controls [133]. However, as can be seen in Table 3, badger culling in England fails in all seven of these internationally accepted principles.

Table 3. International consensus principles for ethical wildlife control*

	Principle	Approach	Does badger culling abide by this principle?
1	Modifying human practices	The decision must consider if human behaviour has affected the ecosystem to address the root causes of the human-wildlife conflict.	**No.** Bovine tuberculosis is a disease primarily transmitted between cattle [63]. Under current policy, farm biosecurity is not mandatory and robust restrictions on cattle movement are absent.
2	Justification for the control of the population	Control must be based on a balance of harm and benefit with evidence that the species causes significant harm.	**No.** Research has shown that badgers are unlikely to be a significant vector of disease to cattle [18, 19, 20, 21] and there is no evidence that the culling of badgers will significantly reduce bTB incidence or prevalence in cattle [14].

3	Clear and achievable outcome-based objectives	The objectives should be specific, measurable, based on harm reduction, and monitored through clear indicators.	**No.** Badger culling targets >70% of badger populations [70], yet population estimates are outdated [15]. It is, therefore, unknown how many badgers reside in England and what the impact of long-term culling will be. DEFRA has yet to supply evidence on the regular monitoring of the effect of culling for disease control [134].
4	Minimise animal welfare harms	Control methods should predictably and effectively cause the least animal welfare harm to the least number of animals.	**No.** In 2021, nearly 9 out of 10 badgers were killed by controlled-shooting (87.7%) [129], a method verified as presenting a significant risk to animal welfare (see Text box 9).
5	Social acceptability	Decision-making on wildlife management must involve all stakeholders and benefit from the support of local actors.	**No.** In 2022, a YouGov poll found that badger culling was only supported by 15.4% of English adults [123].
6	Systematic planning	Control must be part of a long-term systematic framework including preventative measures.	**No.** The most effective preventative measures for bTB are cattle biosecurity and an effective cattle vaccine and DIVA test. Under the current government strategy, cattle biosecurity is not mandatory in England (see section 4.1), despite being a highly effective disease prevention strategy.
7	Decision - making by specifics rather than labels	Decisions to control wildlife should be based on local and specific circumstances and not negative labels applied to species.	**No.** Badger culling now takes place in low-risk areas, and kill targets are not based on epidemiological evidence of bTB within badger populations (see section 2.4.1 and 4.2.4 and Text box 10). Badgers are one of the most persecuted native species of British wildlife, with a history of persecution spanning hundreds of years (see section 3.1.1)

**Adapted from Dubois et al. (2017) [133].*

Text box 10: Subjective data and the badger cull
Badgers are culled due to their perceived conflict with people, in this instance disease transmission to farm animals. Without objective data to verify that badgers from specific geographic locations are the real source of transmission of bTB to cattle, this raises strong doubt and ethical concerns over the subjective nature of being allowed to freely implement a cull to control these animals.

Part II Summary

- Badgers are integral to British ecosystems and cultural heritage, having resided in the UK for at least 250,000 years.

- Badgers serve as 'ecosystem engineers' by creating opportunities for a wide range of pollinating insects, birds, and mammals, supporting biodiversity and ecosystem health across their native range.

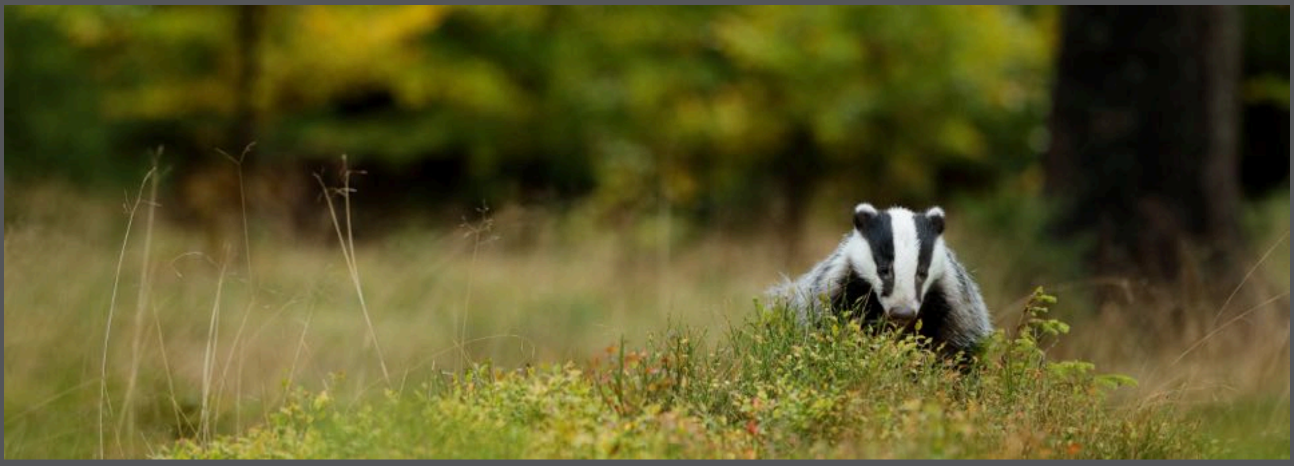
- It is a common misconception that badgers play a significant role in the decline of vulnerable species such as European hedgehogs (*Erinaceus europaeus*) and ground-nesting birds. Most sources agree that human-induced changing landscapes and a lack of suitable habitat and resources are the main reasons for these declines in native species.

- In the UK, there are significant threats to badger populations, including wildlife-vehicle collisions, badger baiting, housing and development, and culling. In a changing climate, both flooding and drought will further add to the risks faced by badgers, alongside our other native species.

- Badgers are protected under the Protection of Badgers Act 1992 making it illegal to harm or interfere with a badger or their sett without a licence, whether with intent or by negligence. Additional legal protections are sometimes provided to badgers by the Wildlife and Countryside Act 1981, the Animal Welfare Act 2006, and the Hunting Act 2004. Badgers are also listed in Appendix III of the Convention on the Conservation of European Wildlife and Natural Habitats. Despite these measures, illegal badger persecution is a large and ongoing issue in parts of the UK.

- The most recent population estimates of badger numbers in England and Wales were recorded pre-cull and thought to be around 485,000 badgers (ranging from 391,000–581,000). Thus, culling over 210,000 badgers in the past decade could have had a significant impact on the population health and resilience of Britain's badger populations.

- The culling of a native mammal in already struggling ecosystems undermines several international agreements concerning animal welfare, the environment, and sustainable development including the Bern Convention, the United Nations Sustainability Goals, and the Convention of Parties (COP15) Kunming-Montreal Biodiversity Framework for nature recovery by 2030.
- Badger welfare is significantly compromised from culling, which has not been adequately addressed by bTB policy.
- Controlled shooting is now the most common way badgers are culled in England having increased incrementally each year since 2013. By 2022, most badgers (87.7%) were killed by controlled shooting.
- UK law recognises vertebrate animals as sentient beings and with this legislation comes the responsibility that relevant government policies must take into account animal sentience. Culls in this capacity, can therefore not be humane.
- Badgers are highly social mammals, and it is not known how the stress of culling impacts the welfare of surviving social group members. Nor is it known how the removal of an ecosystem engineer impacts the well-being of other native species. Thus, lethal control of badgers has not been adequately monitored concerning all animal welfare implications.
- A YouGov survey showed that only 15% of the public supports the cull and therefore banning the cull (including epidemiological culling) is likely to be widely supported by the general public who want to see greater environmental and animal welfare protections and more cost-effective disease reduction strategies amidst the cost-of-living crisis.



Part III Attitudes to bTB Control

4.1 Case Study 1: A Wales and England bTB Eradication Strategy Comparison

In mainland Britain, only England culls badgers as part of a Bovine tuberculosis eradication strategy. Yet, England maintains higher incidence rates of bTB in cattle than either bordering Scotland or Wales [135] (see Figure 4).

Scotland is already listed as 'Officially TB Free' under the EU Council Directive 64/432/EEC, meaning that rates of bTB are low enough to be at maintainable levels [136]. England and Wales have both implemented strategies towards achieving TB Free status, by 2038 and 2041 respectively [2, 137, 138].

England and Wales have different approaches to managing bTB in cattle (Table 4), and so a comparison between the two nations' strategies provides a case study to assess the effectiveness of different disease control approaches.

Table 4. Comparison of Bovine TB Eradication Strategies Employed by Wales and England

Wales	England
All herds are tested annually, and herds in the Intensive Action Area (IAA) are tested every 6 months Homebred cattle from CHeCS TB Herd Accredited score 10 can forgo statutory post-movement TB testing [11]. From February 2024, pre-movement testing will be reintroduced into the Low TB Area of Wales. Also, cattle moving into the Intermediate TB Area from the High TB area of Wales, the High Risk Area of England and from Northern Ireland will need a post-movement test [139].	Routine cattle testing interval depends on location [2, 140]. Routine testing occurs every six or 12 months in HRAs (6 months if herds qualify under the CHeCS scheme). Herds in edge areas are tested every 6-12 months depending on location, infection history and biosecurity measures in place. In August 2023 mandatory post-movement skin testing of cattle was introduced in the 12-monthly part of the Edge area of England. Herds in LRAs are tested every four years as standard, and annually for certain industries or in the vicinity of a herd breakdown.
Cattle have been routinely tested using a combination of the SICCT test, the interferon-gamma blood test and the IDEXX antibody test since 2018 [137]. The interferon-gamma blood test is compulsory for certain inconclusive reactors that give an inconclusive result upon SICCT re-testing.	Cattle are routinely tested using the SICCT test only. The IFN-γ is only available privately, or is mandatory in HRA and six-month testing edge areas when there is a recurrent (within 18 months) breakdown with lesion and/or culture-positive animals, and for all new breakdowns within LRA and annual testing edge areas [65].

Non-validated tests are allowed under exceptional circumstances under strict conditions, and should aim to assist in test validation. The Enferplex (bovine serum) test is permitted where authorised for private use, only in exceptional circumstances. The use of this test is currently being piloted [141]. If test positive animals remain after a specified period, they must undergo a high sensitivity testing regime and if positive, they will be removed with compensation [141].	Private use of non-validated tests such as Enferplex or IDEXX ELISA is restricted, but applications for use can be made in order to supplement (not replace) the current statutory TB testing regime. APHA is under no obligation to remove test-positive animals using unofficial tests, and therefore no compensation will be given, unless an animal tests positive to an approved testing method [142].
Cattle moving within High and Intermediate Risk areas must be skin tested with negative results within 60 days prior to the movement. Inconclusive pre-movement test results in restricted movement on the entire herd. Cattle moving into low TB areas must comply with post-movement testing requirements when cattle originate from higher risk areas in Wales, high or edge areas in England, or from Northern Ireland [137]	Cattle moving from all herds must be skin tested with negative results within 60 days prior to the movement, except in LRAs where cattle are tested less often than annually [143]. Inconclusive pre-movement tests result in restricted movement on individual animals, or the herd only if there is a history of bTB. Cattle moving into LRAs must comply with post-movement testing if they come from HRA or Edge areas, or from Wales.
Farm biosecurity and cattle movement restrictions are mandatory and applied across the country. Exemptions for post-movement testing for CHeCs accredited (level 10) herds when moving cattle into Low TB Areas from the Intermediate or High TB Areas [144]	Farm biosecurity is optional. Cattle movement restrictions are location-dependent, and some movements are exempt from the policy (see section 4.2.1) Herds in the HRA and Edge Areas of England on six-monthly testing can remain on annual testing if they meet Cattle Health Certification Standards (CHeCS) [11].

Farmers are provided free veterinary support to protect cattle from bTB and comply with policy-mandated cattle control measures [137].	Optional veterinary advice and support to protect cattle from bTB has been available since 2017. Biosecurity measures are expected in the case of persistent and recurrent herd breakdowns but no penalty for non-compliance. bTB biosecurity advice is available online, and free advisory phone calls and farm visits are available from the TB Advisory Service. However, support is optional, and no funding is available to implement suggestions [145]. Service includes free badger sett surveys and advice where deemed necessary.
Compensation can be reduced if there are violations of rules of the 'TB Order' [146], including where precautions against spread of infection are not taken [147].	Compensation is not directly linked with biosecurity best practices. Compensation can only be reduced if routine bTB cattle testing is overdue, or if cattle test positive after having moved into a TB breakdown herd, but exemptions apply [11]
Badger bTB surveillance is country-wide [137]	Badger bTB surveillance is conducted in limited regions only.
Mass badger culling is prohibited. Between 2017-2023 Trap and Test was carried out on farms with persistent bTB breakdowns. Positive test badgers were humanely euthanised, and negative test badgers were microchipped, vaccinated and released. The project was due to end in 2023 [148].	Badger culling is routinely conducted in licensed areas.
Badger vaccination is deployed to populations where epidemiological evidence supports it, partially funded by the government [137].	Badger vaccination is enrolled where farmers/landowners choose, irrespective of epidemiological evidence for it. Government grants for badger vaccination closed in February 2023 [149]. No further funding awards have been confirmed.

4.1.1 bTB rates in England and Wales

As shown in Figures 2 and 3, there are no substantial differences between bTB rates in England compared to Wales in the previous 10 years (Tables 1 and 2, Appendix 1). In 2022, 94.7% of Welsh cattle herds were free from bTB [138] and 95.6% of English cattle herds. This is despite Wales using a stricter testing regime, having mandated controls in place, and not culling badgers. As we will see throughout this document, the low accuracy of the SICCT test, and the infrequency of testing outside of the HRA, also means that the figures in England are probably inaccurate, and the number of infected cattle may be as much as 50% higher than recorded. In Wales, the use of the interferon-gamma blood test to detect bTB in cattle is also likely to make their results closer to the true number of infected cattle.

Figure 2. Bovine TB incidence by herd and cattle level in England

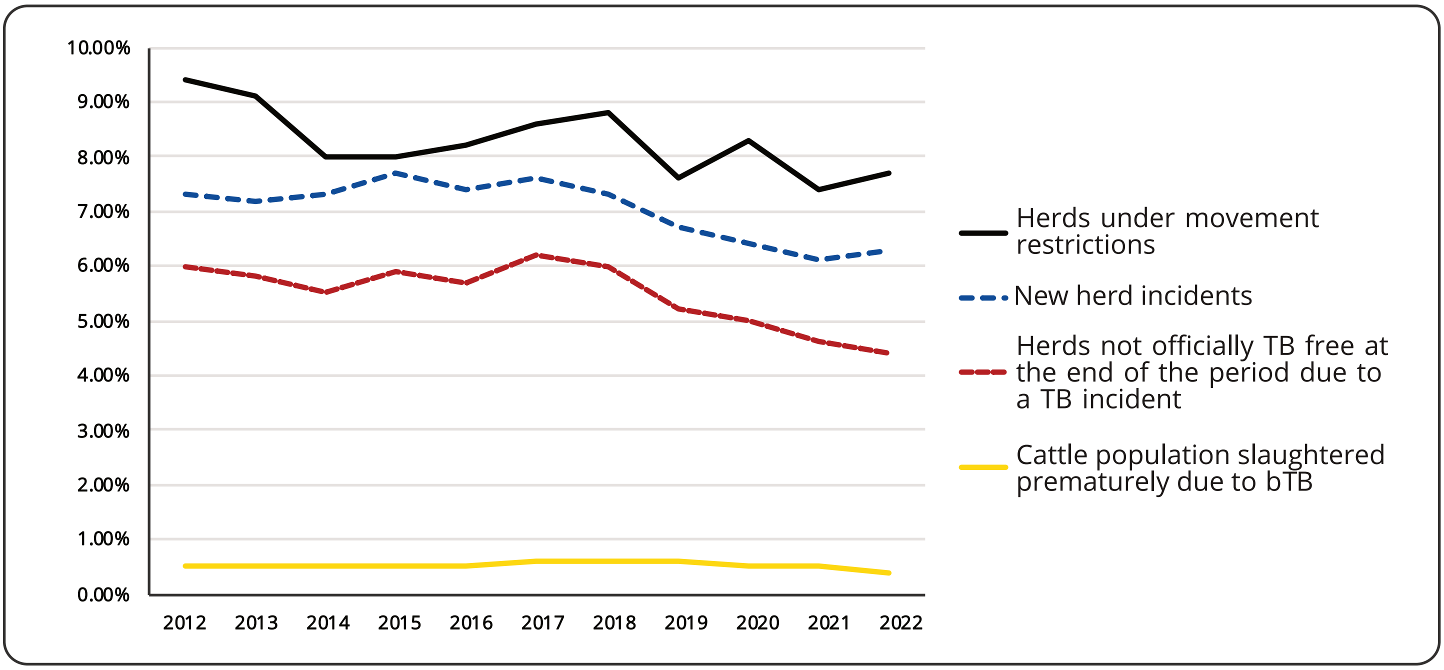
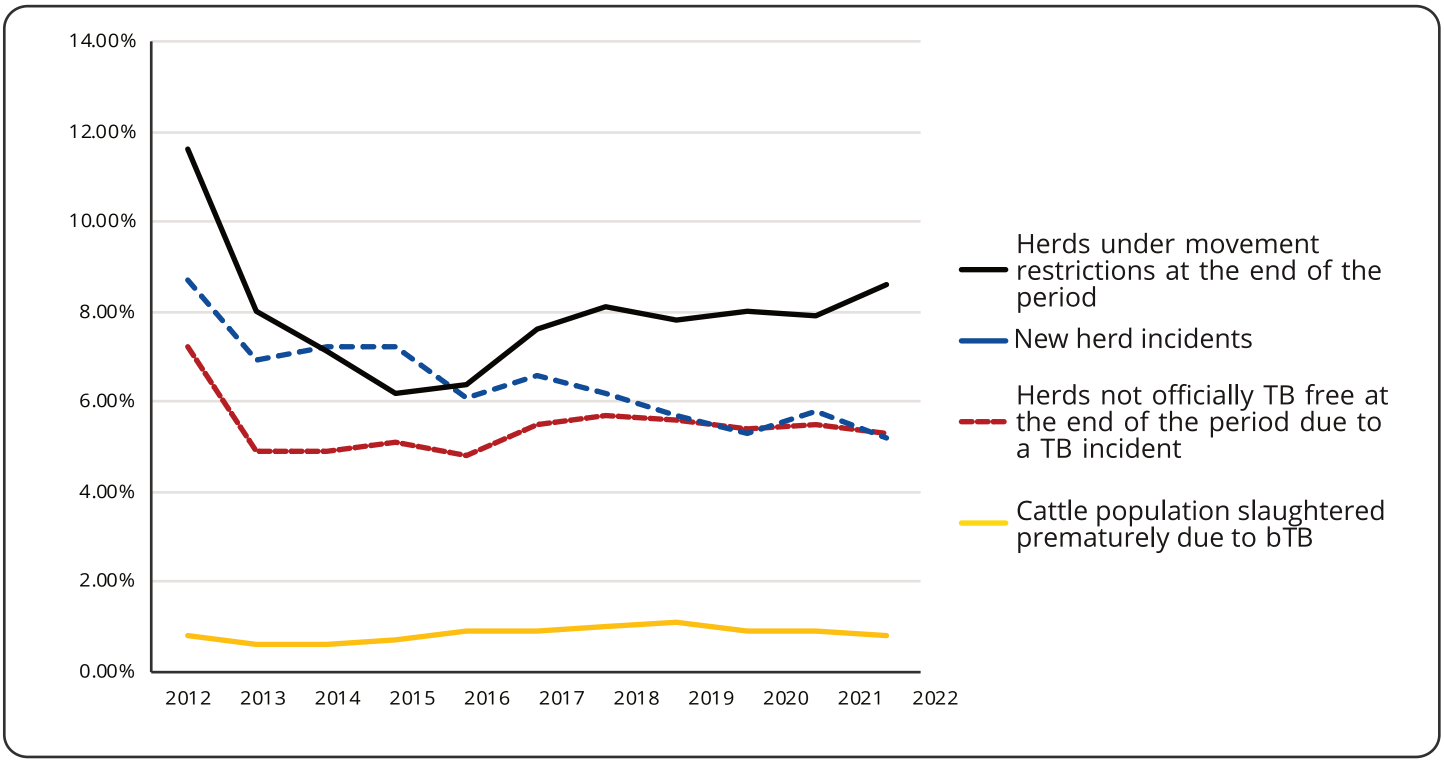


Figure 3. Bovine TB incidence by herd and cattle level in Wales

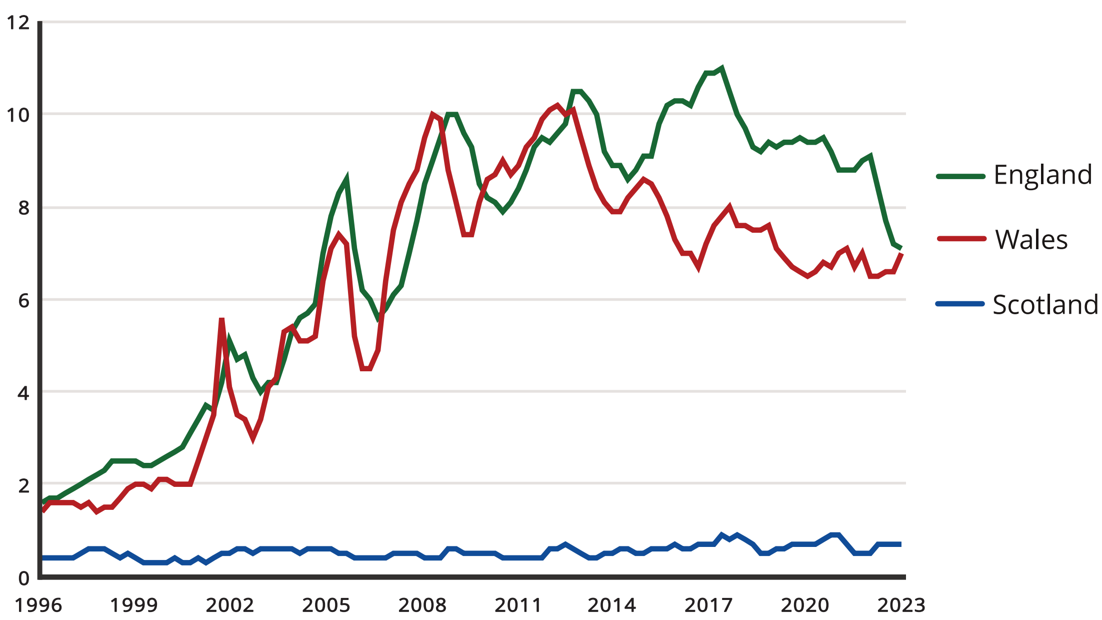


There has been a decline in the number of cattle herds in England (around 13%) since 2012 [151]. Whilst there has been a slight decline in the number of individual cattle, this has only been around 5%. In Wales, there has also been a decline in the number of cattle herds (around 10%), but the number of actual cattle has increased by just over 1% since 2012 [151]. This indicates that cattle herd sizes have increased in both countries, but more so in Wales, and therefore so has the opportunity for increased transmission of bTB

The percentage of herds that are not officially TB free is not significantly lower in England with badger culling than in Wales without badger culling. Both countries have reduced the number of herds not succumbing to a bTB-positive test by just under 2% in the last ten years (England -1.6%, Wales -1.9%)

Wales has managed to reduce both their new herd incident rate (Wales -3.5%, England -1%) and the number of herds under movement restrictions more than England (Wales -3%, England -1.7%). The percentage of the cattle population slaughtered prematurely due to bTB for both countries has hovered around the same rate (average for England 0.52%, Wales, 0.84%).

Figure 4. Longterm view of new herd incidents per 100 herd years at risk of infection during the year – GB



4.1.2 HRA, LRA, and Edge Areas of England

In England, counties are assigned to the High Risk Area (HRA), Low Risk Area (LRA), or Edge Areas in relation to the risk of bTB outbreaks. When considering the HRA of England only, we see a similar trend as to the overall picture shown above (Figure 2, Figure 3) with a decline in the overall number of herds in the HRA since 2012 (Table 5) (see also Table 3: Appendix 2). As a percentage of the overall cattle herds in England, however, the percentage of herds in the HRA has remained relatively consistent.

Table 5. Percentage of English cattle herds in each bTB risk sector by area

Year	% of national herds in HRA area	% of national herds in LRA area	% of national herds in Edge areas
2012	42.01%	30.29%	18.70%
2013	41.35%	39.66%	18.98%
2014	40.85%	40.42%	18.73%
2015	40.73%	40.85%	18.42%
2016	40.67%	41.00%	18.32%
2017	40.86%	41.01%	18.13%
2018	50.37%	50.04%	21.95%
2019	41.07%	40.97%	17.96%
2020	41.08%	41.13%	17.79%
2021	41.02%	41.28%	17.70%
2022	40.76%	41.55%	17.69%

There has been a general downward trend in the number of herds not officially bTB free, new herd incidents, and herds under movement restrictions in the HRA since 2012 (notably, since before intensive badger culling was introduced: Figure 5). In terms of the percentage of the national cattle population slaughtered prematurely due to bTB infection, the majority (up to 90%) are bTB-positive reactor cattle from the HRA. Over 40% of cattle herds nationally are in HRAs (Table 6).

Figure 5. Bovine TB incidence within herds in HRAs of England (as a percentage of all herds in the HRA)

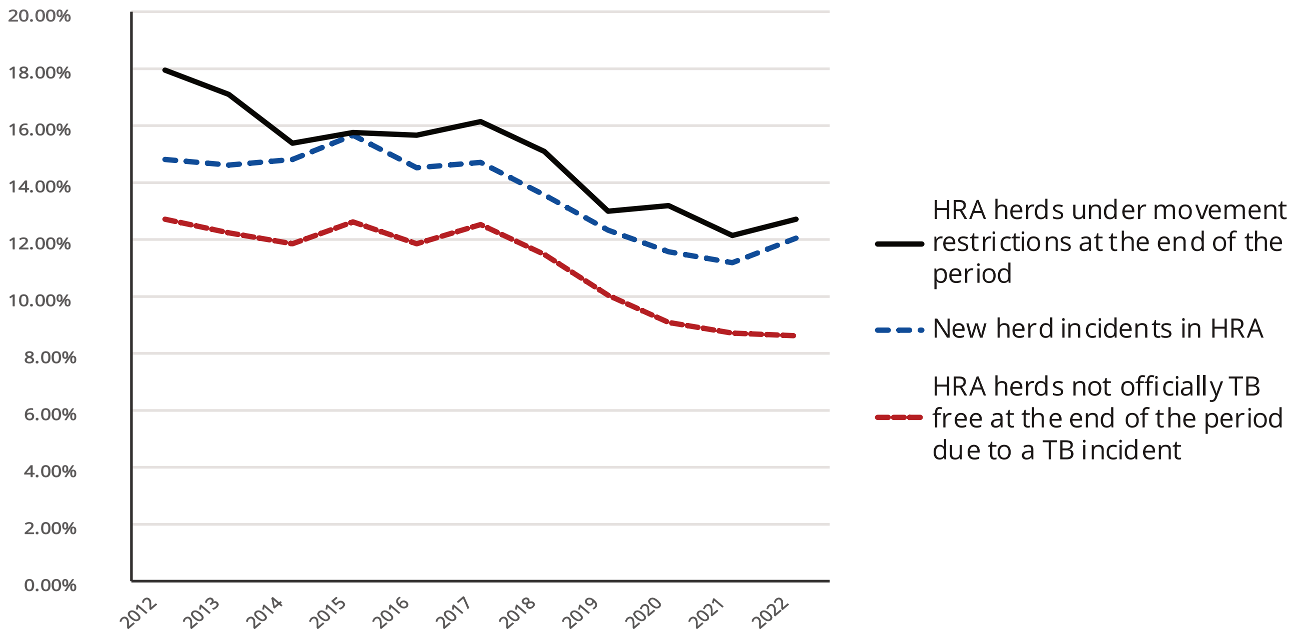


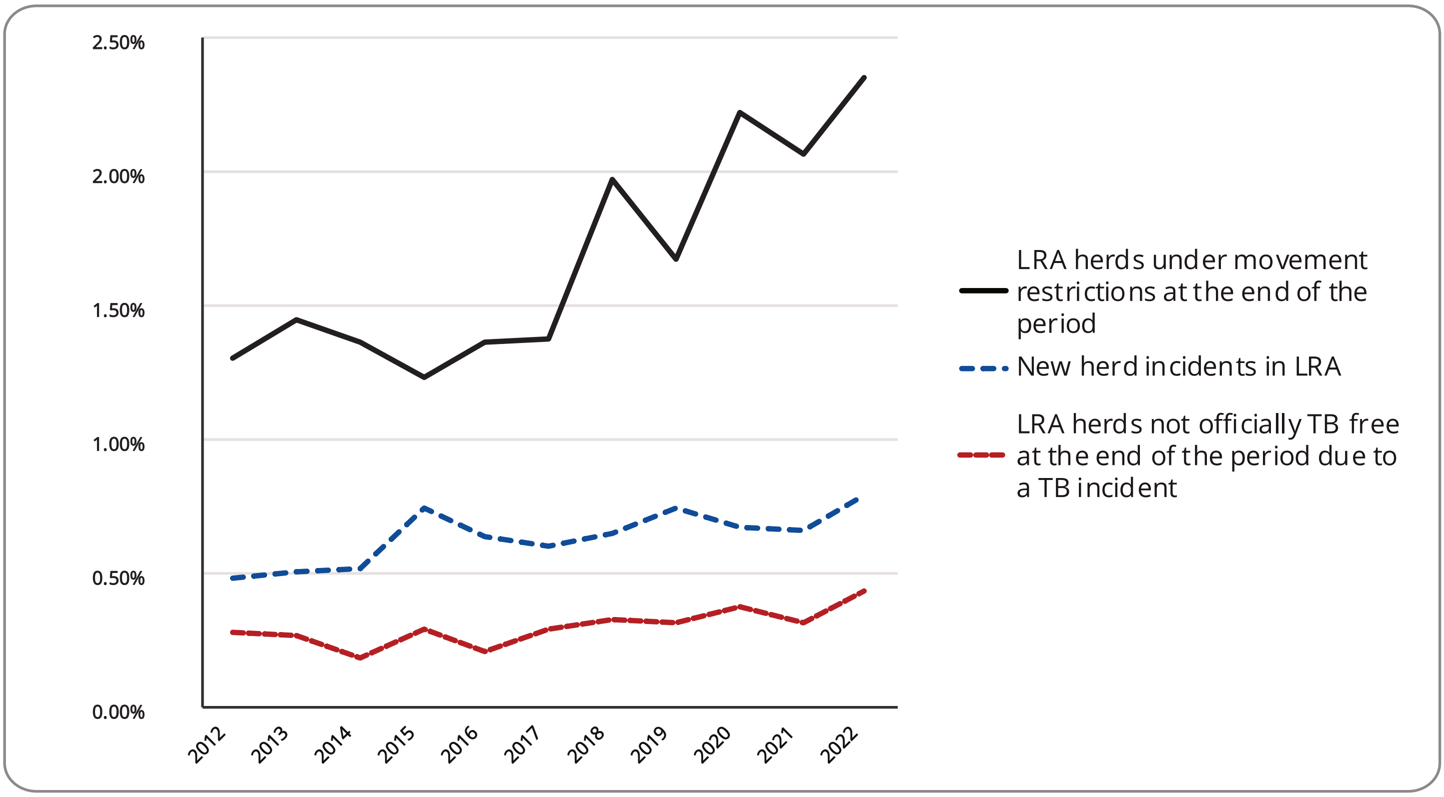
Table 6. Percentage of national cattle population slaughtered early to bTB by area England

Year	% of bTB positive cattle slaughtered nationally from an HRA herd	% of bTB positive cattle slaughtered nationally from an Edge area herd	% of bTB positive cattle slaughtered nationally from an LRA herd
2012	90.58%	8.67	0.75%
2013	87.10%	11.17	1.73%
2014	82.48%	14.93	2.59%
2015	84.55%	13.27	2.18%
2016	82.46%	15.48	2.06%
2017	79.47%	17.76	2.77%
2018	74.72%	23.09	2.19%
2019	74.24%	23.36	2.40%
2020	79.07%	19.68	1.25%
2021	79.21%	18.83	1.95%
2022	81.27%	16.79	1.94%

Within the LRAs, the pattern is somewhat different. Since 2012 there has been an increase in herds not officially bTB free, new herd incidents, and herds under movement restrictions (Figure 6: see also Table 4 Appendix 2). It should be noted here that the biosecurity measures, funding opportunities, and testing mechanisms and regularity are all much reduced in the LRAs compared to the HRAs. Similar to the HRAs, the LRAs account for around 41% of the cattle herds in England (Table 5). With almost an equal number of herds in both the HRA and LRA areas, bTB and its management have become a divisive issue.

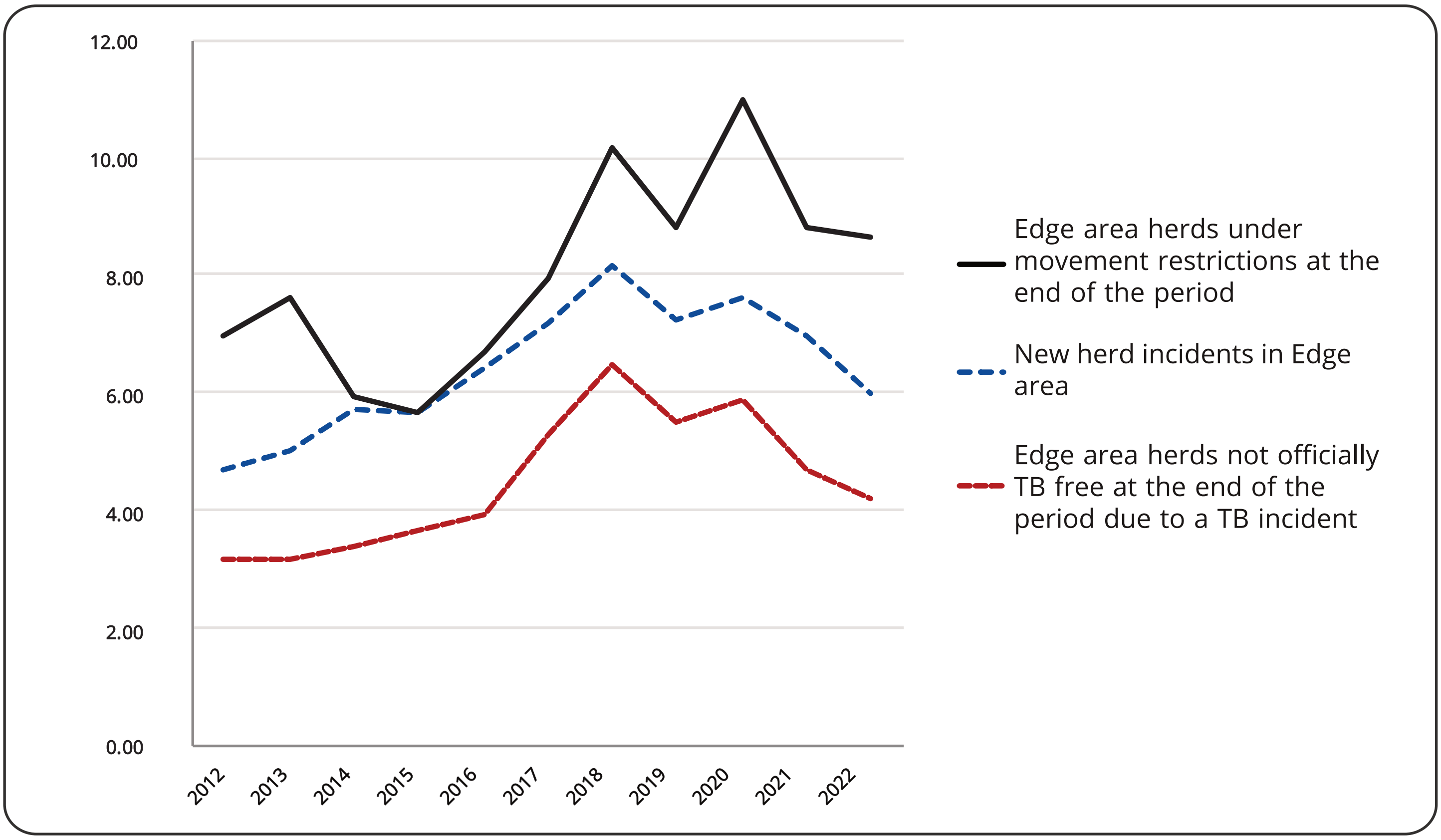
It should also be noted that the numbers in the LRA are likely to be higher than reported, as many animals (up to 80%) may go untested during their lifetime (see section 10.1.1), and some animals are not routinely tested [140, 152].

Figure 6. Bovine TB incidence by herd level in LRAs of England



For the edge areas of England, since 2012 there has been an increase in bTB in herds not officially bTB free, new herd incidents, and herds under movement restrictions (Fig. 7: Table 5 Appendix 2).

Figure 7. Bovine TB incidence by herd level in Edge Areas of England



4.1.3 High Risk and Intermediate Areas Wales

The High Risk Area East in Wales shows an improving situation with a decline in new herd incidents and herds under movement restrictions, with an increase in the number of herds designated officially TB free (Fig. 8). This also corresponds with a decline in the number of herds, with a 1.29% reduction in herd numbers in the HRA East between 2012 and 2022 (Table 7).

Figure 8. Bovine TB incidence by herd level in High Risk Area East, Wales

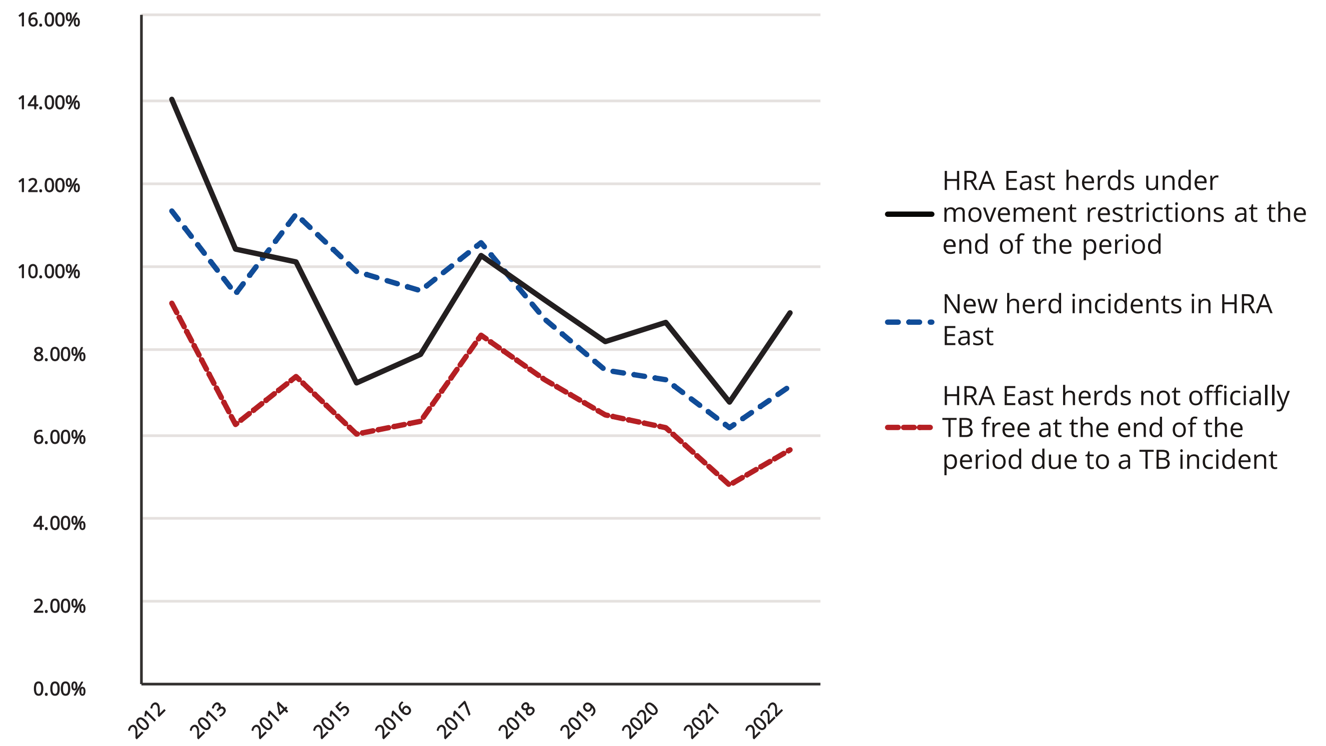


Table 7. Percentage of Welsh cattle herds in High Risk Areas (HRAs) and Intermediate Risk Area

Year	% of national herds in HRA East area	% of national herds in HRA West area	% of national herds in Intermediate area
2012	25.14%	27.68%	17.02%
2013	25.05%	27.70%	17.05%
2014	24.45%	27.83%	17.07%
2015	24.02%	27.78%	17.05%
2016	23.81%	27.78%	17.06%
2017	23.61%	27.75%	17.02%
2018	23.98%	27.21%	17.11%
2019	23.87%	27.05%	17.28%
2020	23.80%	27.00%	17.31%
2021	23.89%	26.85%	17.38%
2022	23.85%	26.73%	17.41%

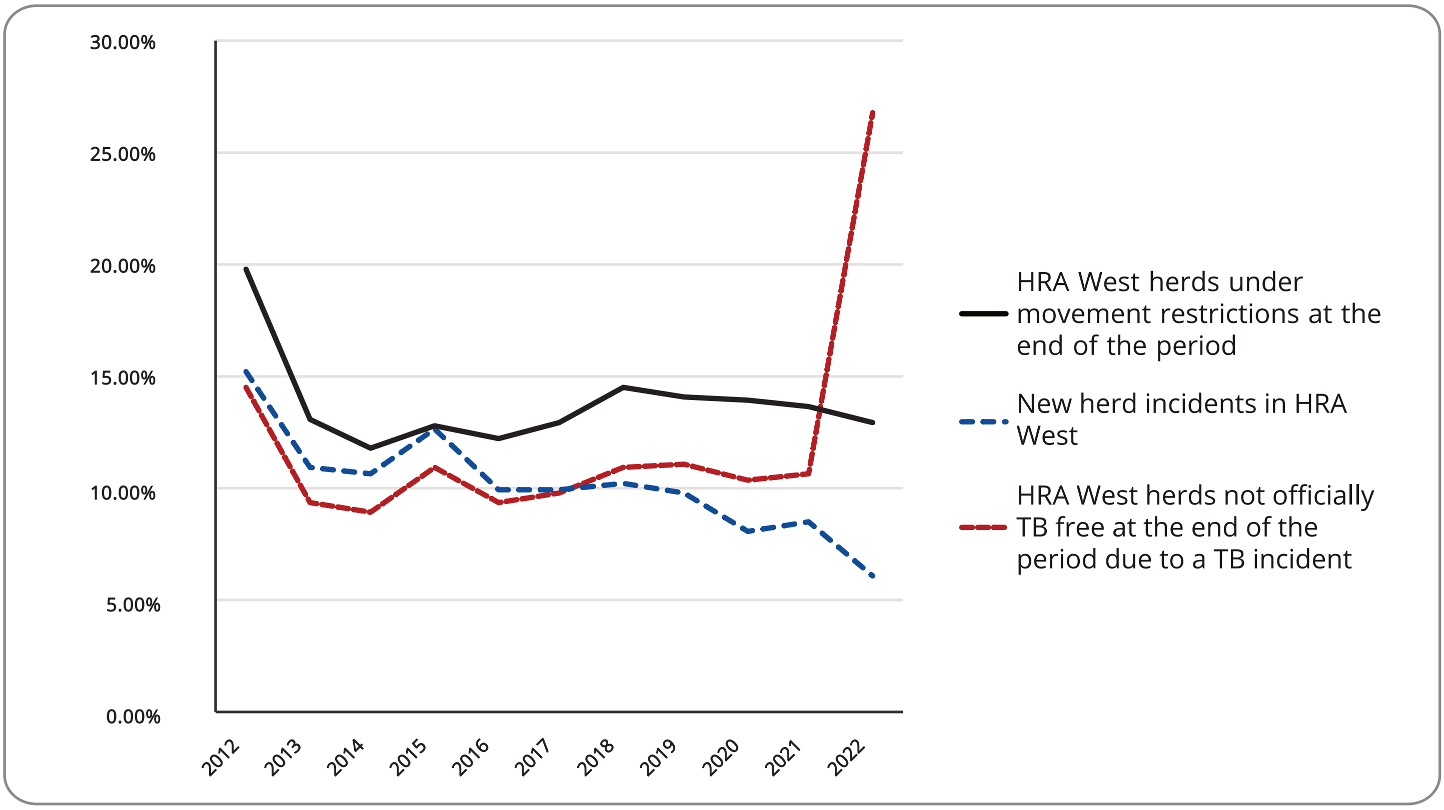
There has been a decline of almost 12% of the number of cattle slaughtered prematurely due to bTB in the High Risk area East since 2012 (see Table 6: Appendix 3), and a decline of 2% in the High Risk area West (Table 8). It is unclear from this data why the decline is more in the East area, rather than the West. The decline in the number of cattle slaughtered prematurely due to bTB in the High Risk areas could be attributed to combined effects of declining herd numbers, a decline in bTB incidences, or a change in testing regime.

Table 8. Percentage of national cattle population slaughtered early due to bTB by area in Wales

Year	% of bTB positive cattle slaughtered nationally from an HRA East herd	% of bTB positive cattle slaughtered nationally from an HRA West herd	% of bTB positive cattle slaughtered nationally from an Intermediate area herd
2012	28.11%	61.46%	4.18%
2013	27.12%	60.66%	4.68%
2014	34.52%	48.89%	5.20%
2015	25.24%	62.34%	5.03%
2016	19.46%	65.36%	7.35%
2017	23.67%	64.11%	4.22%
2018	19.63%	66.92%	5.23%
2019	16.35%	67.46%	5.09%
2020	20.46%	60.20%	5.24%
2021	15.54%	58.92%	7.09%
2022	16.18%	58.77%	4.21%

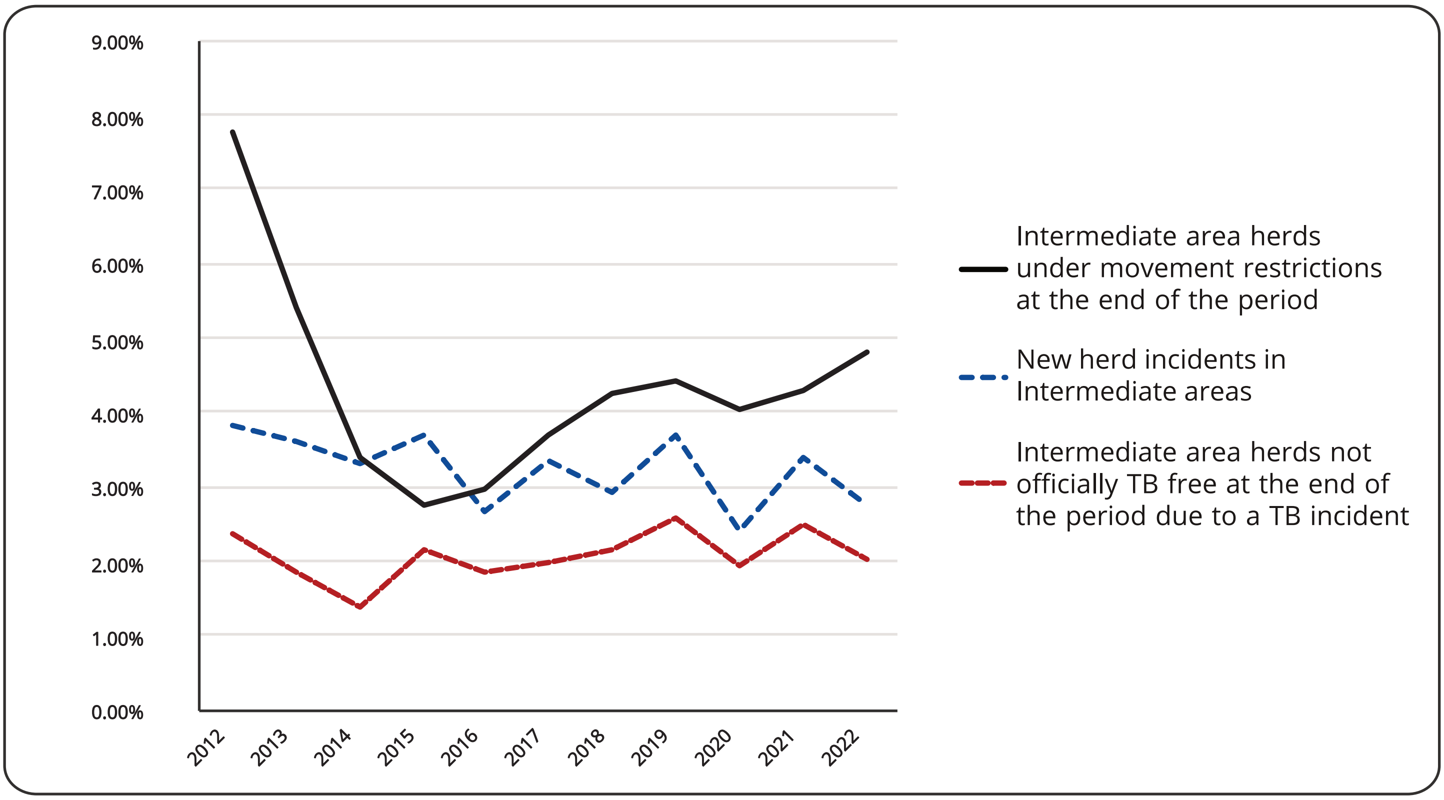
Within the High risk area West, bTB has historically been higher than in the East. Almost 50% or higher (49-67%) of the cattle population slaughtered prematurely due to bTB are from within the High Risk area West (Table 8; see also Table 7 Appendix 3). There was also a sharp spike in bTB incidences between 2021 and 2022 due to incidences in hotspot areas, with infection spreading from missed infected cattle imported from low risk areas (Fig. 9). The percentage of the national herd numbers in the HRA West has reduced 0.95% between 2012 and 2022.

Figure 9. Bovine TB incidence by herd level in High Risk Area West, Wales



For the Intermediate areas, the number of herds within these areas has reduced, but this has accounted for roughly the same percentage of herds nationally over the 10-year period (average 17.16%: see Figure 9). Overall there has been less of a decline in bTB in this area compared to the High Risk areas. On average, 5% of cattle slaughtered prematurely due to bTB nationally come from an Intermediate area.

Figure 10. Bovine TB incidence by herd level in Intermediate areas, Wales



4.2 Key Differences between England and Wales bTB Policy

The most notable difference in approach between England and Wales is that Wales applies stricter controls to cattle via country-wide annual testing, restrictions to cattle movement, and mandated farm biosecurity. By paying greater epidemiological attention to cattle, the Welsh bTB strategy is amongst the most progressive and effective bTB control programmes employed in Great Britain to date.

4.2.1 Cattle Testing and Movement

The current herd-based testing policy may leave up to 80% of cattle in England untested for bTB in their lifetime [153]. This is because cattle testing in England can be as infrequent as every four years in low risk areas. Movement between herds may result in animals either avoiding tests or cattle being slaughtered before the next testing regime. Cattle in England are also exempt from routine bTB testing under various conditions, including moving to exempt agricultural shows or from low-risk areas of England into low-risk areas of Wales, as well as cattle housed in artificial insemination facilities, and when travelling for veterinary treatment [154].

Weak testing controls in England have led to some regions of the country developing greater farm connectivity, contributing to a more prevalent spread of the disease. For example, where there is a lack of pre-movement testing in the LRA and parts of the Edge area, cattle are easily moved between sites [155]. As a result, new bTB incidence from the movement of undetected infected animals is the main bTB risk factor for cattle herds in Cumbria, Yorkshire and Humberside, Hampshire, and the North East of England [156].

In Wales, all cattle have been tested annually since 2008, unless in the highest-risk ("Intensive Action") area where cattle are tested every six months. The testing procedure itself is also more stringent. Recognising that the low TB areas could be harbouring more bTB infections than realised, the Welsh government are implementing pre-movement testing in the low TB areas from February 2024. These pre-movement tests will be compulsory and funded privately by the farmer.

The bovine skin test (SICCT) is the most widely used in Europe, but it is less reliable than the interferon-gamma blood test (IFN-γ) and the IDEXX antibody test. The percentage of positive individuals identified by the SICCT test can be as low as 49% at standard test interpretation [157, 158], meaning one in two to one in five (50% - 20%) infected animals could be missed each time a herd is tested. These issues of diagnostic sensitivity with the SICCT test mean that a substantial portion of bTB-infected cattle are misdiagnosed with false negatives and continue to be treated as bTB free cattle when they are not.

Cattle in Wales are tested with the interferon-gamma blood test and the IDEXX antibody test in conjunction with the SICCT test, particularly for herds with long durations of bTB breakdowns [159]. Only the SICCT test is routinely applied to test cattle in England.

For a herd in England to be eligible for the interferon-gamma blood test, a vet must advise its application on the basis that the herd has suffered a severe breakdown, has experienced persistent or recurrent bTB problems, or where the bTB breakdown is experienced in a herd located in a low bTB incidence area. Should a farmer wish to use the IDEXX antibody test, the farmer would need to do so privately and only where permission has been obtained from APHA [140]. IDEXX, and other non-validated tests such as Enferplex, can only be used to supplement standardised testing, not as an alternative [141, 142].

Despite the low levels of reliable testing, cattle in England are not required by law to be isolated from established herds on arrival. According to the DEFRA 2019 Farming Practices

Survey, only half of the purchasing farmers isolate bought cattle, and 17% never isolate them from the herd on arrival. The same survey showed that of those that had bought cattle in the last 12 months:

- 18% of purchasing farms in England did not find out the date of the pre-movement test
- 26% of purchasing farms in England did not find out the date of the source farm's last routine test
- 33% of purchasing farms in England did not find out the source farm's TB risk area
- 23% of purchasing farms in England did not find out the testing frequency of the source farm

More understanding is needed from the farmer's perspective as to why these decisions not to isolate or follow other measures are made. This runs concurrently to the current policy which does not make it easy for farmers in England to measure the risk of infection when making cattle purchasing decisions (see section 10.1.4).

All cattle purchases are at risk for many different infectious diseases, and bTB is one of these [11].

4.2.2 Farm Biosecurity

Farm biosecurity is not mandated as part of the bTB eradication strategy in England. Since 2017, DEFRA offers farmers optional advice on protecting their cattle from bTB infection [see 145]. However, compliance with this advice is not linked to bTB compensation eligibility, and there is an over-emphasis on badgers, which are less likely to transmit bTB to cattle than other cattle.

Practices such as unhygienic slurry spreading, shared livestock grazing (between cattle and non-bovine stock which are susceptible to bTB), contamination of waterways, and lack of adequate disinfection of visiting vehicles and shared equipment are all potential disease pathways that are not currently managed as part of a mandated national approach to bTB eradication in England [160, 161]. It should be remembered here that *M.bovis* can survive in a range of environmental protozoa, for example, cysts that can survive for months in mud, including those that stick to the tread of a vehicle tyre [162, 163].

By mandating basic farm biosecurity measures, the economic and social disruption caused by bTB outbreaks can be limited, in addition to reducing outbreaks of other diseases that affect the health, welfare and productivity of livestock, including foot and mouth disease, Bovine Spongiform Encephalopathy, bovine viral diarrhoea, leptospirosis, mastitis and infectious bovine rhinotracheitis [164].

According to the DEFRA 2019 Farming Practices Survey:

- Only 24% of farms in England have installed sheeted gates (to prevent wildlife from accessing buildings)
- 52% of farms in England have raised feed troughs and mineral licks (to prevent badgers from using them)
- 29% of farms in England spread slurry on grazing land, a small percentage of which is from other farms
- Only 33% of farms in England that spread slurry wait six months before spreading
- Only 36% of farms in England double fence between livestock and other herds
- Only 37% of farms in England carry out disinfectant regimes (footbaths, wheel sprays, etc.)
- Only 15% of farms in England fence off badger setts and latrines (despite the culling of hundreds of thousands of badgers)
- Only 17% of farms in England 'badger proof' buildings to prevent their entry.
- Of these measures, between 1/5th and 1/3rd of farmers have stated that they would never implement them.

4.2.3 Consistency vs Inconsistency

A running theme throughout the England/ Wales bTB policy comparison is the varying degrees of policy consistency employed across each nation.

In Wales, bTB policy is consistently applied across the country. Farmers in Wales all operate under the same rules, making regulations easier to follow. Compliance with bTB policy (including farm biosecurity) is also linked to compensation, which incentivises disease control best practices from all farms within the farm network. In England, compensation is only linked to biosecurity when signed up to the CheCS TB Herd Accreditation Scheme (see section 10.1.5).

As shown in Figure 11, a patchwork of policies has been rolled out in England since 2010 which means farmers have been faced with confusion surrounding new regulations enforced in new areas across the country on an ad-hoc basis.

Figure 11. Timeline of bTB Control Strategies in England and Wales

England	Year	Wales
	2008	Cattle control measures introduced
High Risk Area (annual cattle testing) is established in the South West and West Midlands. Buffer Area (biennial cattle testing) is established surrounding the High Risk Area. Cattle testing remains once per four years for all cattle outside these areas.	2010	Annual TB testing is introduced for every cattle herd in the country.
High-Risk Area is expanded, within which cattle movements are restricted. Compensation payments for bTB positive herds are reduced where bTB tests are overdue.	2011	
	2012	The Intensive Action Area is established in the South West, within which enhanced cattle control measures and six-monthly herd testing is established. A five-year badger vaccination programme is introduced.
England is split into annual and four-yearly cattle testing counties. Annual testing is applied to all counties at the edge of the High-Risk area. A two-year badger cull pilot begins in Gloucestershire and Somerset.	2013	Cymorth TB is introduced, a free vet support service provided to farmers with new TB herd breakdowns
Loopholes in the High-Risk Area pre-movement testing rules are closed.*	2014	The Badger Found Dead survey is launched to monitor bTB infection in badgers.
Herds in the edge area of Cheshire are put on six-monthly testing. Badger culling is expanded into Dorset Central.	2015	

Mandatory post-movement skin tests are introduced in Low-Risk areas. The two-year Edge Area bTB Surveillance study begins in which found dead badgers are tested for bTB in Edge Area counties. Badger culling is rolled out to seven more areas.	**2016**	
Cattle movement controls are strengthened in High-Risk Areas. Badger culling is expanded to fourteen more areas. The TB Advisory Service is established, a free veterinary advisory service, is introduced for cattle farmers in High Risk and Edge Areas.	**2017**	A refreshed TB Eradication Programme and Delivery Plan is published that identified four phases: Keep it Out, Find it Fast, Stop it Spreading, and Stamp it Out.
Six-monthly testing is implemented for herds within higher incidence regions of the expanded Edge Area. Annual herd testing is introduced with targeted "radial" testing of herds located in 3km of newly "officially TB free withdrawn" incidents within the rest of the Edge Area. Badger found dead survey is introduced in the Edge Areas. Badger culling is expanded to eleven more areas.	**2018**	Cymorth TB is expanded to offer free support services for other categories of herds.
Cattle herds in six-monthly testing areas that meet certain criteria eligible to return to annual testing. Badger Edge Vaccination Scheme (BEVs) launched.	**2019**	Wales offers Badger Vaccination Grant to support farmers, landowners and other organisations to vaccinate badgers.
More frequent testing in HRA introduced. Sales of TB restricted cattle (orange markets) not allowed in the LRA The TB Advisory Service is extended across England. Farmers and keepers of cattle, deer, goats, camelids, pigs, or sheep are now eligible to apply. The world's first clinical field trials of BCG vaccine and DIVA skin test for cattle begin.	**2021**	Sales of TB restricted cattle (orange markets) approved in High TB areas.
Pre-movement testing no longer required for cattle moving between approved finishing units or via an orange market PCR detection of *M. Bovis* in post-mortem tissue samples introduced	**2022**	Pre-movement testing no longer required for cattle moving between approved finishing units or via an orange market
Mandatory post-movement skin testing introduced in parts of the Edge area. Cattle vaccination testing trial enters Phase 2. BEVs ended, no further funding announced. Badger culling expanded to include 72 cull areas covering ⅓ of England.	**2023**	'Trap and test' project to test badgers and vaccinate or euthanise infected individuals ends.
Cattle vaccination trial is expected to be completed by 2025	**Future**	Pre-movement testing will be reintroduced in Low TB risk areas in 2024.

*****High-Risk Area pre-movement testing rules are changed to prevent exemptions that allowed cattle movements between sole occupancy holdings and to and from common land.*

Figure 11 also shows how England's bTB policy has undergone several revisions. The revisions, made to strengthen the pre-existing and fragmented rules, indicate that the measures were not strong enough to begin with to prevent the disease from spreading. Furthermore, other than cattle testing and some restrictions to cattle movement, all other bTB control measures (including farm biosecurity) are optional in England.

The lack of a relationship between biosecurity compliance and compensation in England provides no incentive for farmers to uptake best practice cattle biosecurity measures. Therefore, even the most diligent farmer could be at risk from interactions with other farms in the farm network that have not implemented optional best practices. High-risk activities include shared grazing, cattle purchases, movements to shows or other test-exempt facilities, and farm visits to less biosecure farms [154].

Overall, fragmented regulations and low uptake of best-practice guidelines do not protect the entire farm network in England, and as a consequence do not adequately protect individual farms or farmers.

4.2.4 Wildlife Surveillance

Another focal difference between the Welsh and English approaches to bTB eradication is the link between epidemiological evidence and wildlife control. For example, Wales routinely tests badgers for bTB across the country (see section 5.1.4.1), which informs the measures taken to control disease in wildlife.

In England, badger testing has been conducted in a select few locations and time periods, the results of which have not been used to guide wildlife control. Instead, badgers are culled across High Risk, Low Risk, and Edge Areas without evidence that culled badgers carry the disease.

Unexplained infections in cattle are routinely presumed to have come from badgers, without any evidence. Effectively ignoring the limitations of the SICCT and IFN-γ cattle tests and calling it 'unexplained'.

4.2.4.1 Badger Surveillance and Management in Wales

In Wales, badgers found dead (i.e. road fatalities), have been routinely tested for bTB since 2014. The Welsh 'All Wales Badger Found Dead Survey' encompasses the entire country, generating results nationally and locally. Since the study began, overall 92.1% of badgers found dead in Wales have been free from bTB [165]. Of those identified as having bTB-like lesions, it is unclear how many were infectious. It should be noted at this point that the cause of death was not established or reported on by the study.

A recent survey of Badgers Found Dead in Holy Island has shown that no badgers tested positive for bTB [166]. An increase in herd breakdowns in Anglesey led to a review of bTB in local cattle populations, and all carcasses tested negative. The increase of bTB in cattle was through to come from a source of infection related to cattle movements from bTB hotspot areas

Following the Animal Health and Welfare Framework Implementation Plan 2022-2024 for Wales, **badgers are not considered a zoonotic risk to other animals or humans due to the low levels of bTB in the badger population**. (Of note, the position in England is unlikely to be materially different).

On this basis, badgers have not been culled in Wales. Instead, where there is evidence that rates of bTB are increasing in the badger population, these specific badger populations are targeted with vaccination, a non-lethal approach to wildlife disease control.

For example, the worst affected parts of Wales occur in the Intermediate TB Area North, a cluster near the border of England. By the end of 2021, this cluster accounted for 59% of new breakdowns according to the 2022 Welsh government bTB eradication strategy consultation [165]. Yet testing of found dead badgers from 2014 to 2021 found only 8 badgers (4.3%) tested positive for bTB infection.

Further epidemiological analysis of the herd breakdowns confirmed that cattle movements caused the outbreaks in Wales, namely the movement of cattle from Edge Areas in England (where cattle measures are weaker). Increased rates of bTB in local wildlife populations in the Intermediate TB Area North were also traced to cattle. Thus, badger vaccination programmes were deployed to these specific populations, supported by the government's badger vaccination grant scheme [137].

Between 2017-2023 Trap, Test and Remove was carried out on nine farms with persistent bTB breakdowns. Positive test badgers were humanely euthanised, and negative test badgers were microchipped, vaccinated and released. The project was due to end in 2023.

4.2.4.2 Badger Surveillance and Management in England

In England, badgers found dead are not routinely tested for bTB infection. Rather, several projects to measure bTB in found dead badgers have occurred in specific locations and over a much shorter time period than in Wales.

In 2016 and 2017, two badger-found-dead surveys were conducted in England, one in the southern countries of the Edge Area and one in the northern counties of the Edge Area (see Table 9). A third study began in 2018 in bTB hotspots within the Low-Risk Area of England.

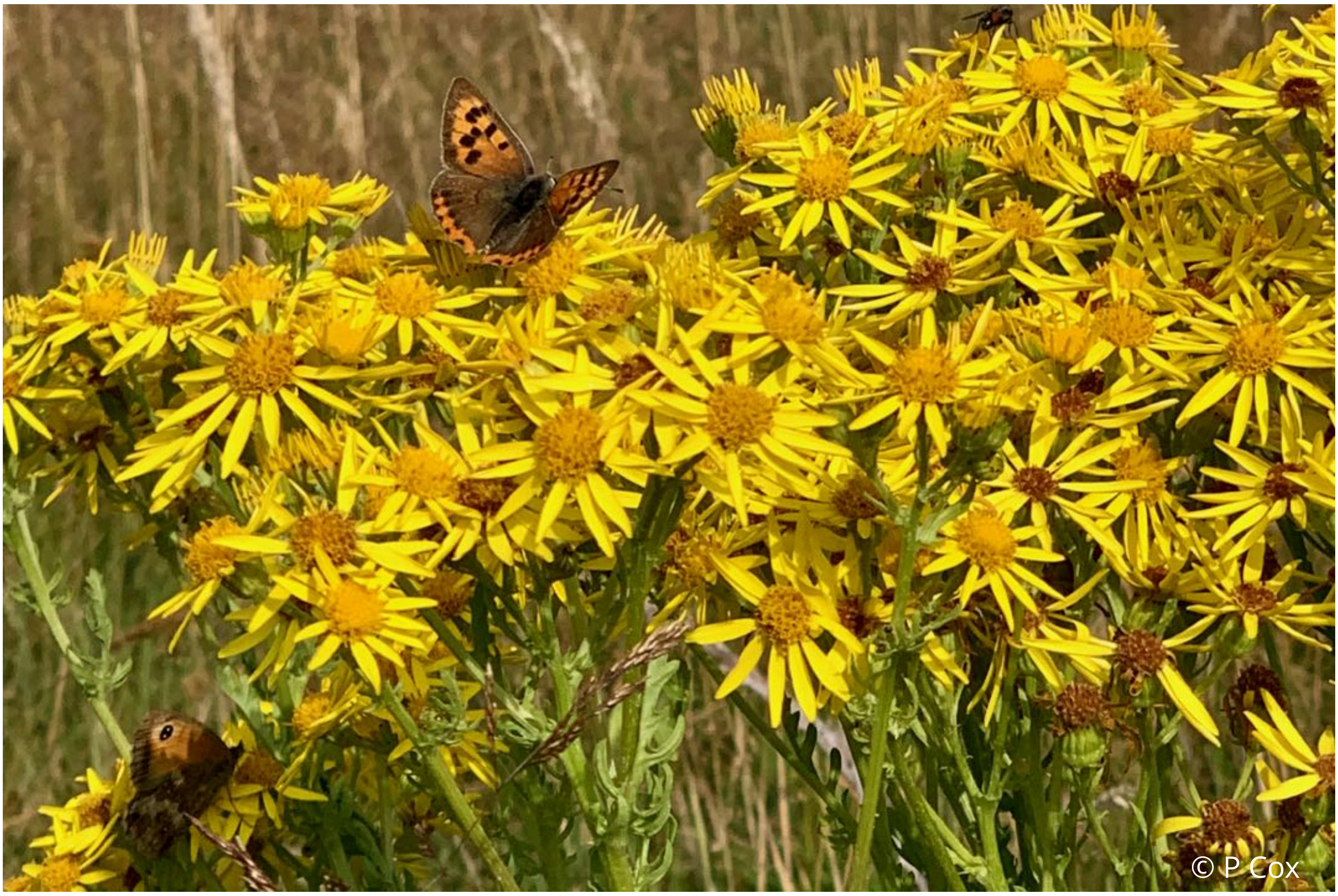


Table 9. Bovine TB prevalence in badgers found dead in the Southern and Northern Edge Counties of England in 2016-2017*

Southern Edge County	No. tested badger found dead carcasses	% bTB positive
Hampshire	65	0 (0.0%)
Oxfordshire	99	3 (3.8%)
Berkshire	16	0 (0.0%)
Buckinghamshire	86	0 (0.0%)
East Sussex	102	0 (0.0%)
Location unidentified	4	0 (0.0%)
TOTAL	**372**	**3 (0.8%)**
Northern Edge County	**No. tested badger found dead carcasses**	**% bTB positive**
Cheshire	104	15 (14.4%)
Derbyshire	100	4 (4.0%)
Nottinghamshire	101	5 (4.9%)
Leicestershire	105	13 (12.4%)
Warwickshire	102	10 (9.8%)
Northamptonshire	98	4 (4.1%)
TOTAL	**610**	**51 (8.36%)**

**Adapted from* [167, 168]

It should be noted at this point that cause of death was not established or reported on by these studies. Badger groups have previously been called out to recover badgers thought to be victims of road traffic collisions and found some were in fact victims of badger baiting, dog attack and shooting, but the carcasses were dumped at the roadside to mimic roadkill.

As shown in Table 9, less than 1% of badger carcasses tested positive for bTB throughout the Southern Edge counties of England throughout 2016 and 2017. **These results confirmed an absence of epidemiological evidence in support of culling badgers to prevent bTB in cattle in these regions**. Yet from 2018 to 2022, 3,880 badgers were culled in Hampshire, Oxfordshire, and Berkshire [125].

Within the Northern Edge countries, a total of 8.36% of badger carcasses tested positive for bTB between 2016 and 2017. Most badgers that had a positive test for infection, showed no clear signs of tuberculosis lesions on gross post-mortem examination [167]. Results again confirmed low rates of disease in the badger population. Cheshire, Leicestershire and Warwickshire had higher headline infection rates (10-15%). In Cheshire, Derbyshire and Nottinghamshire this was linked to co-localisation of cattle breakdowns, but there was a less clear pattern in the other areas. It was theorised that this could be due to historic infection pathways. Despite this, from 2018-2022, 17,313 badgers were culled across Cheshire, Derbyshire, Leicestershire, and Warwickshire [125].

Since 2018, culled badgers in bTB hotspots of the Low-Risk Area of England have been tested for bTB. As demonstrated in Table 10, a total of 94.7% of badgers killed in these areas were free from bTB infection. No 'found dead' badgers were tested for bTB prior to the implementation of badger culling in these regions.

Overall, the scale of badger culling in England does not correspond with the disease risk presented by the badger population. Thus, **epidemiological evidence has not informed the badger culling policy in England**, despite the badger-found-dead surveys in the Edge Area of England costing the taxpayer a total of £497,129.00 [167,168].

Table 10. Results from the bTB surveillance in TB control intervention areas since their implementation in 2018-2021*

Year	Area	No. tested culled badger carcasses	% bTB positive	Active vaccination sites? (yes/no)
2018	32. Cumbria	369	41 (11.1%)	No
2019	32. Cumbria	313	0 (0.0%)	No
2020	32. Cumbria	134	0 (0.0%)	Yes
2021	32. Cumbria	62	0 (0.0%)	Yes
	54. Lincolnshire	156	14 (9.0%)	No
TOTAL		**1,034**	**55 (5.3%)**	

** Adapted from DEFRA and APHA, 2019 [169]*

4.2.4.3 Badger Vaccination

Despite the low incidence of bTB in the badger population, vaccination has been proposed as an alternative method to culling that will reduce wildlife-cattle transmission of bTB. Programmes to vaccinate badgers have been established across the country, primarily undertaken by charitable bodies or private individuals [170].

Significant investment has been put into research and development of the injectable bTB vaccination for badgers, known as BadgerBCG, which has been shown to reduce the severity and progression of the disease in wild and captive badgers [171, 172]. Vaccination also indirectly reduces transmission between individuals of the same species; a 79% reduction in positive bTB incidence was reported in unvaccinated cubs from a clan where at least one-third of the social group had been vaccinated [173].

The method and expense of vaccination, however, may deter widespread implementation by farmers whose views were sampled in this report (see 6.1.5), as at present badgers need to be cage trapped under licence [174, 175]. An oral wildlife vaccine may reduce some of the expense of injectable vaccination [176, 177], but it is not yet licensed for use. The reasons for this are thought to be varied but include the difficulties of the deployment method for an oral vaccine and ensuring the vaccine reaches enough individuals. Furthermore, research has shown that removing expense as a factor does not encourage the uptake of vaccination by farmers due to the farmers' perceived ineffectiveness of badger vaccination at reducing bTB incidence in cattle [174, 175]. Many farmers also see vaccination as a temporary measure to control bTB until culling can commence in their area [174]. To add complication, recruiting volunteers to raise money and conduct badger vaccination is made harder when they know that the badgers they have tended to and vaccinated are likely to be subject to culling when licences are issued in the area, and farmers defer to this instead of continuing vaccination as an option.

As badgers only account for, at most, a very small proportion of bTB transmission to cattle [62], efforts to reduce bTB through vaccinating badgers alone are unlikely to be effective without an equal or greater focus on improving farm biosecurity and reducing cattle-cattle transmission rates.

In 2021, licence holders in England vaccinated 1,575 badgers across England over an area totalling 425.56 km^2 [178]. In 2022, licensed individuals vaccinated 2,434 across England, but the area size was unpublished in DEFRA's report [125].

Vaccination policies vary across England depending on the bTB risk status of the area. In 2019, the Badger Edge Vaccination Scheme (BEVS 2) allowed vaccinators to apply for funding towards the cost of vaccinating badgers in land areas of at least 15 km^2. The scheme also needed a commitment to vaccinate for four years, and match funding was required to cover the entire duration. However, this scheme ended in February 2023 and is no longer available [149].

In Wales, Badger Vaccination Grants are available to landowners, farmers and organisations that wish to vaccinate badgers privately. Successful applicants can receive up to 50% of total vaccination costs [178], and they also need to show a commitment to continue vaccination for at least four years. The scheme continues to support landowners with badger vaccination costs, and new grant awards have helped vaccinate badgers on 42 farms over 46 km^2 [137]. In 2023, 204 badgers were vaccinated (up until November 2023) [179]. This scheme was well-received by landowners and was oversubscribed, meaning all grant money was used.

As we have seen in this section, the role that the badger cull has played in relation to reducing bTB in cattle is far from scientifically proven as it hasn't been possible to disentangle effects from biosecurity measures. England and Wales have both reduced bTB in cattle by similar rates, yet by using very different methods.

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5.1 Case Study II: Scotland

Scotland achieved Officially Tuberculosis Free Status (OTF) in September 2009. OTF status does not mean that Scotland has no cases of bTB, but is rather a recognition of the relatively low and stable incidence of bTB in Scottish herds (see Table 11) [180]. It has been proposed that Scotland has the advantage of having farms spaced further apart and with less intensive farming practices, which may have helped to keep the rates of bTB low [32].

Table 11. Scotland TB statistics 2015 – 2020

	2015	2016	2017	2018	2019	2020
Total cattle tested	265,800	244,188	209,951	262,494	248,090	244,125
Total cattle slaughtered	128	150	273	496	199	261
New TB herd incidents	15	11	13	12	14	14

Scotland has a risk-based bTB testing policy. The default testing interval is four years, however, this can be more frequent for herds identified as needing more regular testing, and herds identified as low risk can be given exemption from the four year testing. All herds are reassessed annually [180].

In order to be defined as 'low risk' a herd must comply with one of the following criteria:

- herds with fewer than 50 cattle (total stock on farm at 1st January in the year the herd is assessed) which have had no more than one consignment of cattle moved on from high incidence TB areas (including Northern Ireland and the Republic of Ireland) in the previous four years
- herds that slaughter* more than 25% of their stock annually in each of the previous four years and have had no more than one consignment of cattle moved on from high incidence TB areas (including Northern Ireland and the Republic of Ireland) in the previous four years
- herds that slaughter* more than 40% of their stock annually in each of the previous four years

** Slaughtered animals refers to animals that have been on the holding for at least 60 days that move either direct from farm to slaughterhouse, or direct from farm to market and then direct to slaughterhouse.*

Animals moving onto another holding temporarily between market and slaughterhouse are not included. The annual slaughter rate is calculated on the total number of cattle slaughtered in that calendar year divided by the herd size on 1st January of that year.

Taken from Scottish Government Bovine TB page, accessed 02.11.23 [180]

For animals going to slaughter via market, the usual standstill rules apply which for cattle is 13 days.

Scotland has a zero tolerance policy on testing being overdue, meaning that if tests are overdue restrictions will be placed on the herd [180]. Compensation payments will also be reduced if testing goes more than 60 days overdue.

From May 2023, tighter controls were implemented including linking compensation to the use of proper isolation facilities, and reducing compensation for any unclean cattle found at slaughter.

There are pre (within 30 days) and post (between 60-120 days) movement testing for animals moving into a Scottish herd from England and Wales.

For cattle imported from Northern Ireland or other non-OTF status countries, post-movement testing is required.

Cattle moving to and from shows must be individually identified in accordance with current Scottish Government Regulations and have their movements notified to ScotMoves+ within three days. Herd records and passports must be completed to show the movement took place.

The SICCT test is the primary bTB test used, with the gamma interferon bTB blood test used alongside this in certain circumstances. The IDEXX Antibody blood test is sometimes used in severe cases, but this is rarely used in Scotland.

Text box 11: Post-Brexit Britain

Maintaining animal health and welfare in a post-Brexit era remains a key priority. The EU continues to be one of the biggest trading partners for the UK, and so policies need to align internationally, and within Britain. The UK governments across the devolved nations need to establish structures to ensure ongoing collaboration and shared approaches that reward high-animal welfare in their policy decisions around bTB so that we can continue to be a world-leading provider of high-welfare food in a competitive way.

6.1 Attitudes from the Farming Industry and Policy Opportunities

The emotional and financial toll of a bTB outbreak on farmers can be soul-destroying. A 2009 study conducted by the Farming Community Network (FCN) found that bTB negatively impacts the economic and mental health of farmers and their families. Twenty percent of interviewed farmers claimed they experienced "panic" and "devastation" at the news of a herd breakdown, alongside "psychological distress" and "upset" at the killing of young cows.

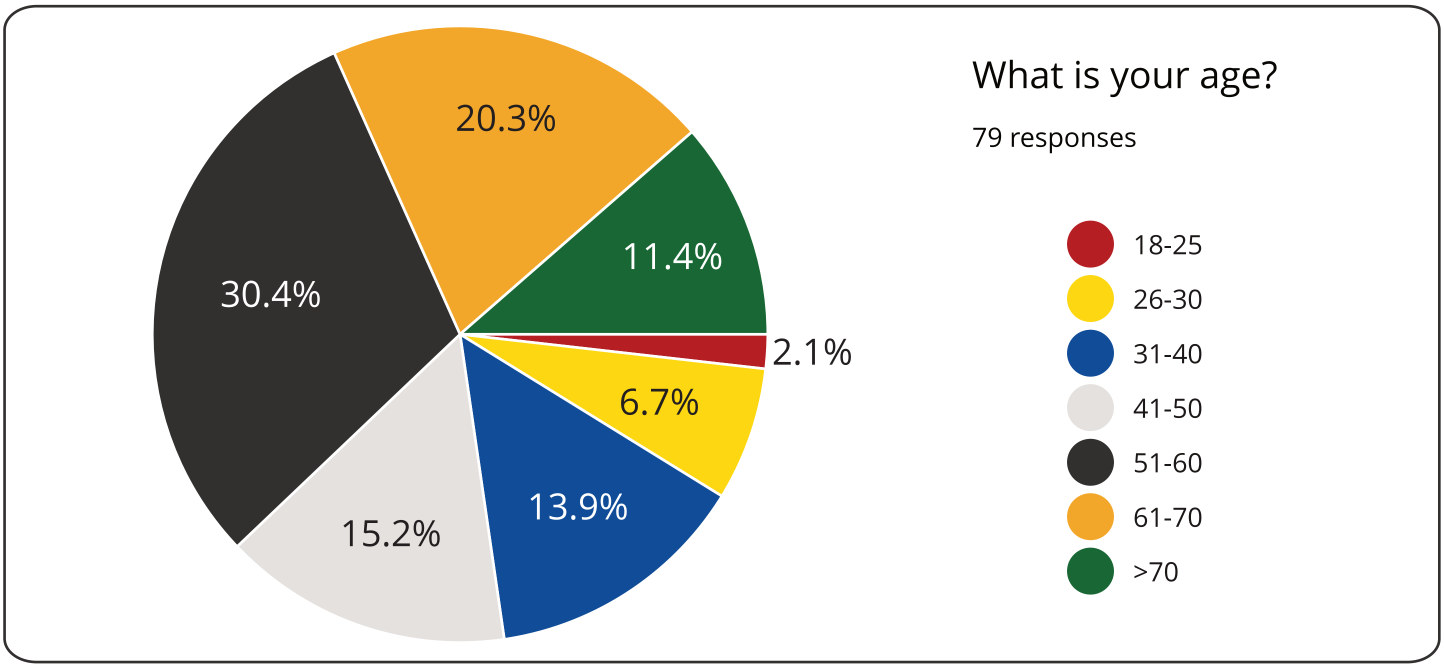
Only 26-30% of farmers considered compensation sufficient to cover the cost of replacing culled cattle [181], and generally, there was a significant issue of distrust in government approaches to bTB eradication which varies between the devolved nations. Another frequently mentioned issue expressed by interviewed farmers was that of wildlife, with farmers feeling victimised over the lack of badger culling in non-cull areas.

Another survey, conducted in 2019 by a veterinary service company and funded by DEFRA, was used to look at farmer attitudes towards bTB after low take-up on biosecurity training workshops [182]. Expressions of blame, loss, confusion, ignorance, resignation and fear were identified as reasons some farmers have become disengaged from efforts to tackle bTB. These feelings of negativity are set against the backdrop of 'concern fatigue', whereby the longitudinal nature of addressing bTB and the complex nature of measures required has left farmers with an encultured narrative of helplessness [182].

In 2023, Badger Trust conducted an online survey asking for views from the farming industry around bTB, which was advertised via FarmingUK [183]. In total, 79 respondents from the farm sector completed the survey, 87.3% (n = 69) of whom farmed cattle. In all, 58.2% (n = 46) reported having experienced a bTB breakdown on a farm they either owned or worked.

Almost one third of respondents (30.4%) were aged between 51-60 years old (see Figure 12), and one-fifth (20.3%) were between the ages of 18-25 years old. Of the 53 respondents who gave us county location data, 54.7% (n=29) were in cull counties.

Figure 12. Age demographics from survey respondents



Questions ranged from farmer knowledge of bTB disease transmission pathways to personal application of biosecurity, perspectives of government bTB eradication policies, and what future policy options they might support or reject. This survey therefore adds to the pre-existing literature on farmer experiences and perspectives of bTB in England and Wales. Survey responses were based on a sliding scale ranging from 1 = very low to 5 = very high unless presented as an open-ended question.

This farmers survey does not represent all farmers but is reflective of those who responded to our request for views. We recognise that there are many innovative, entrepreneurial, forward-thinking farmers practising great animal welfare and biosecurity measures and want to acknowledge their commitment and hard work.

This survey has been sculpted by the voices of those with lived experiences of bTB and farming cattle. Badger Trust doesn't assume to know what steps individual farmers need to take in order to become farms free from the fear of bTB. Instead, we want to be part of an open dialogue where farmers and vets feel empowered with the knowledge necessary to make informed, confident decisions and to have control of their own units over and above statutory requirements.

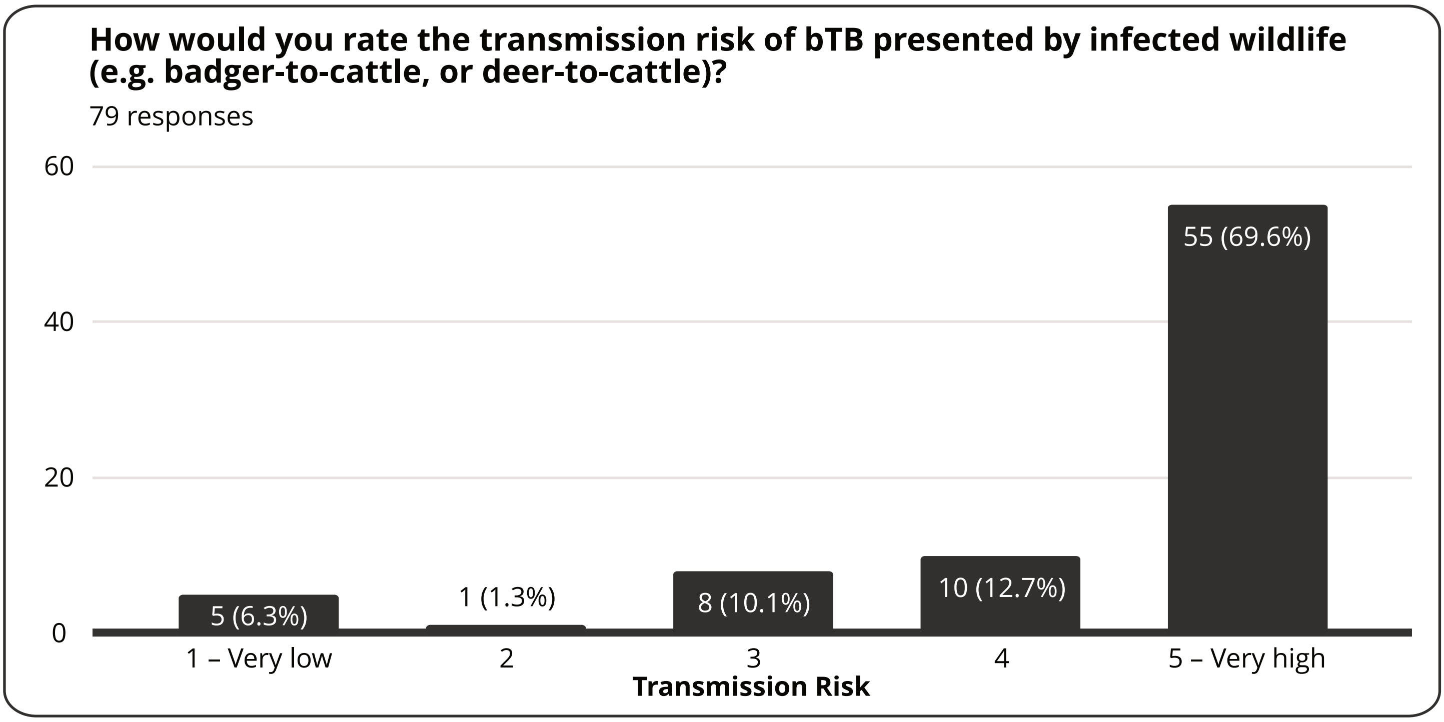
Our recommendations are based on a combination of the results from this survey, but importantly, existing research, literature and recommendations already made by others that we support.

6.1.1 Attitudes towards disease transmission

Overall, our survey results indicated that farmer perceptions of bTB transmission pathways were not consistent with scientific research that places the most common disease pathway for *M. bovis* to be between cattle. Instead, our survey participants ranked wildlife as the highest risk pathway for bTB spread.

When asked to rank the bTB disease risk from low risk to severe risk for a variety of scenarios (wildlife transmission, cattle movements, shared grazing), wildlife was considered the greatest risk with 82.3% of participants (n= 65) claiming wildlife transmission was high to very high (ranked 4-5 in Fig. 13 below).

Figure 13. Respondent ratings of transmission risk of bTB by infected wildlife



Cattle movement on the other hand was considered by farmers to be the lowest risk factor for the spread of bTB among cattle, with 70.9% of survey participants (n = 56) describing cattle movement to be low to very low disease transmission risk (numbers 1 and 2 in Figure 14 below). These findings indicate far greater efforts are needed in tackling an underlying misconception amongst farmers that cattle movements are low disease-risk events. There also appeared to be confusion regarding the risk to livestock presented by shared grazing (Fig. 15).

Text box 12: Cattle Movement Risk Factor

Cattle movement was considered to be the lowest risk factor for the spread of bTB amongst farmers, despite a recent report from DEFRA highlighting:

"The movement of cattle with undetected TB infection is believed to be one of the most common ways in which this disease spreads to new areas." [143]

Figure 14. Respondents' ratings for bTB transmission risk from cattle movements

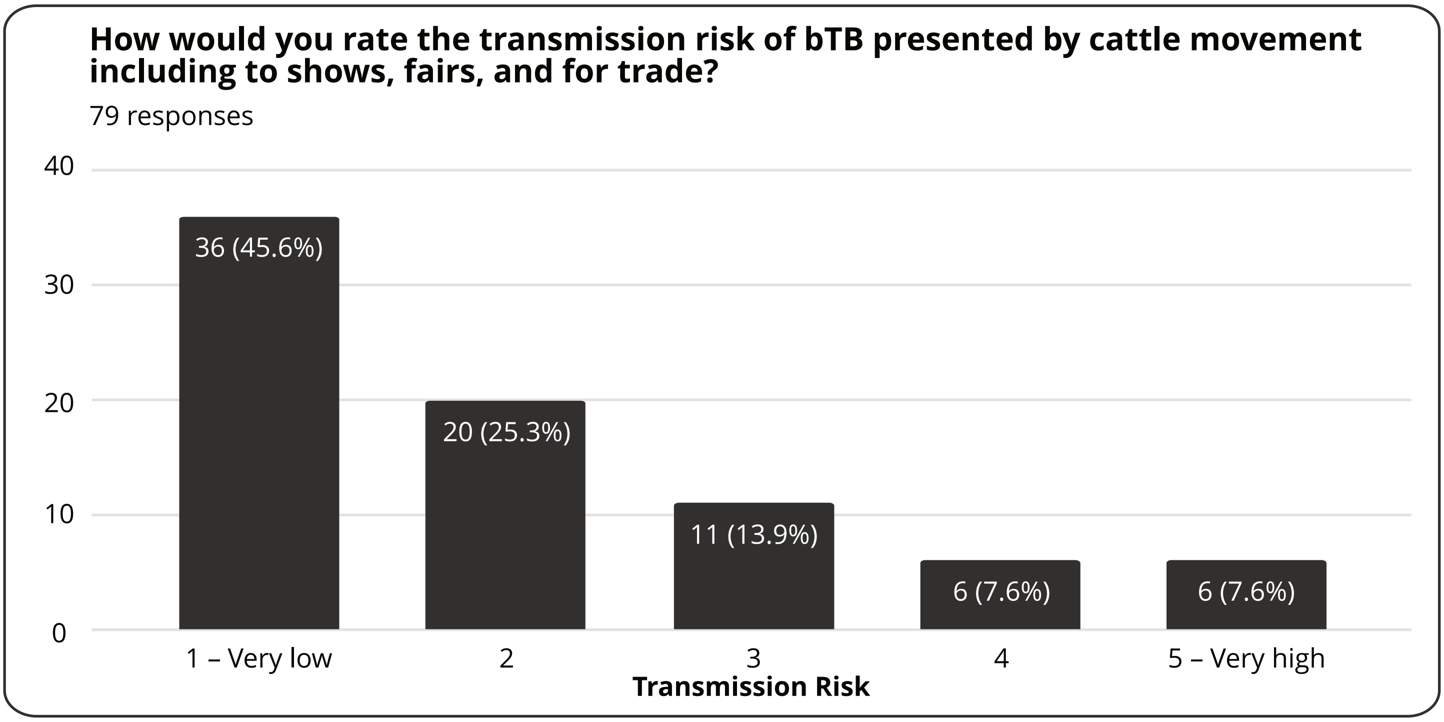
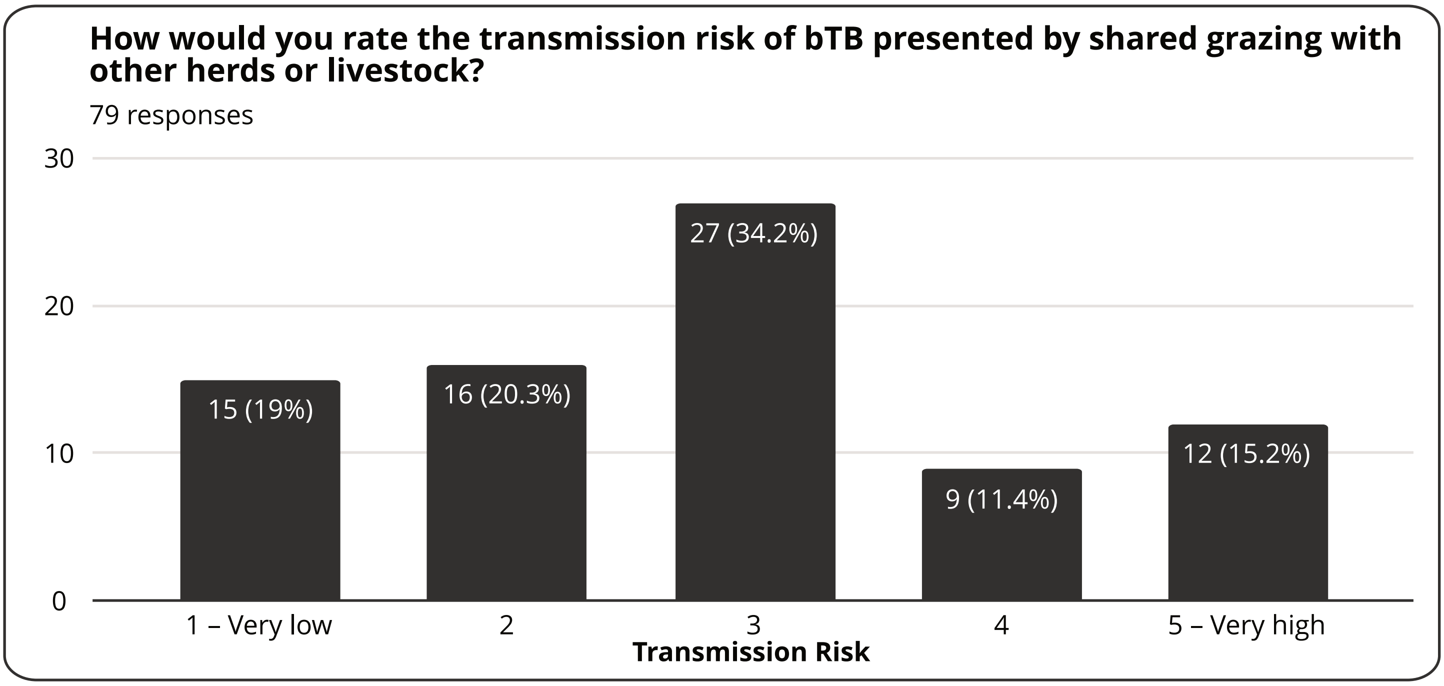


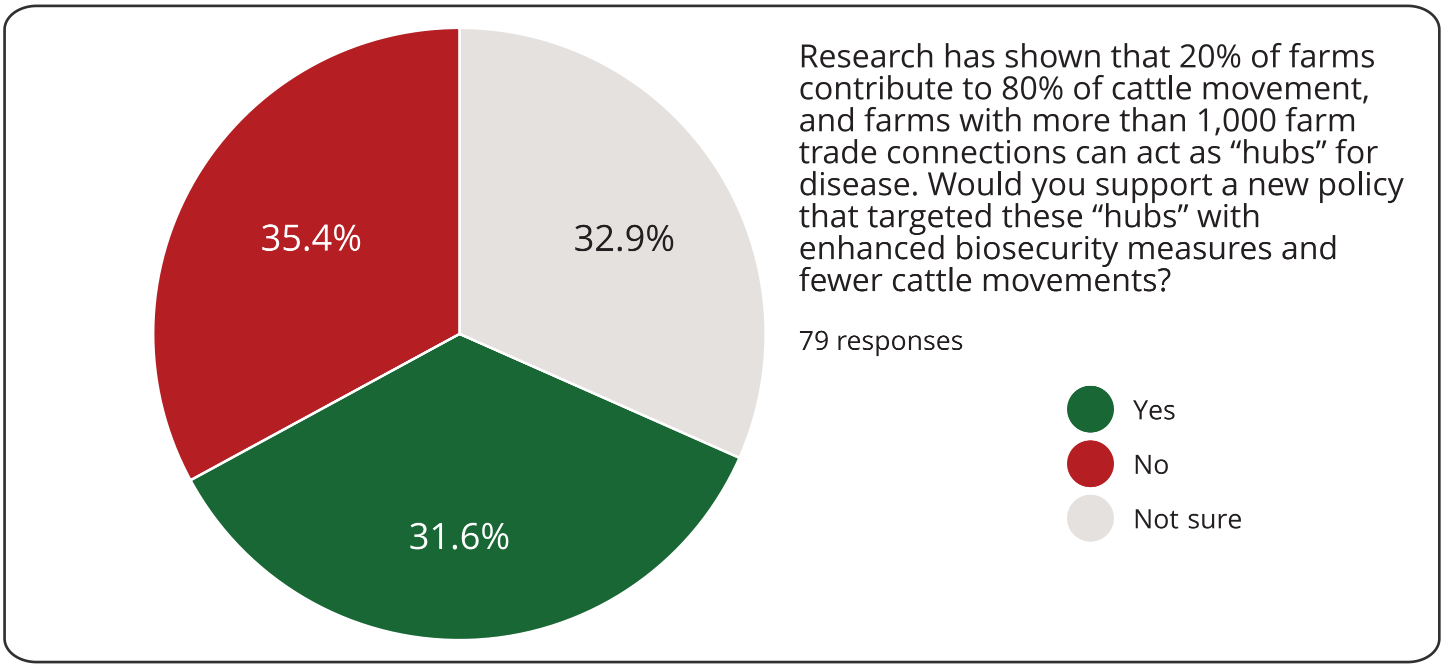
Figure 15. Respondents' ratings of bTB transmission risk from shared grazing



There appeared to be a lack of consensus regarding the disease risk posed by shared grazing, which suggests shared grazing may not be a prime concern for farmers with respect to bTB transmission (Figure 15). Again, greater efforts are needed from the government to address these underlying misconceptions regarding cattle-cattle and cattle-non bovine livestock transmission which will otherwise continue to hamper progress towards reduction in cattle disease.

When presented with the statement and question: "*Research has shown that 20% of farms contribute to 80% of cattle movement, and farms with more than 1,000 farm trade connections can act as "hubs" for disease. Would you support a new policy that targeted these "hubs" with enhanced biosecurity measures and fewer cattle movements?*", survey respondents were fairly evenly split in their opinions. In all, 35.4% of respondents (n = 28) said they would not support this idea, 32.9% (n =26) said they were unsure, and 31.6% (n = 25) said they would agree with this approach (Fig. 16).

Figure 16. Enhanced biosecurity measures for transmission "hubs"



Given the even distribution of responses to this question and the low ranking for cattle movement risk, our results suggest that farmers are not adequately aware of the significant role that cattle movement plays in the transmission of bTB between cattle (see section 10.1.4). Interestingly, these findings were inconsistent with farmer comments regarding the effectiveness of cattle testing, which survey participants routinely described as unreliable for identifying infected cattle. Farmers recognised that cattle testing was insufficient to prevent infected animals entering their herds, but did not consider the movement of cattle to be a substantial disease risk.

Text box 13: Recommendation 1. Educational Outreach and Transparent Communication

Our results indicate an underlying misconception amongst farmers regarding the transmission risks for bovine tuberculosis. Notably, farmers consistently ranked wildlife as the most likely route of transmission for bTB, yet failed to identify cattle movement or shared grazing as disease transmission risks, both of which are more likely to spread bTB amongst herds than wildlife (see section 10.1 "Disease reduction benefits to cattle measures.").

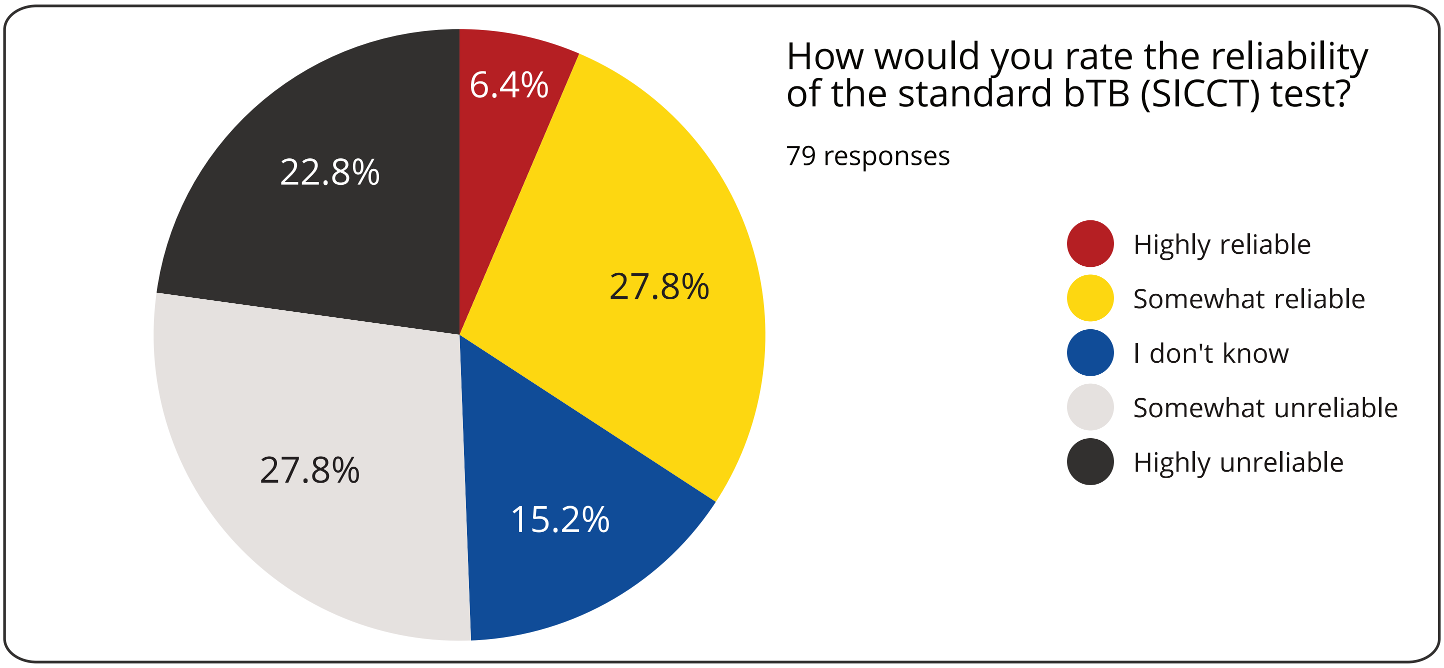
Policymakers must urgently invest in educational outreach efforts to better equip farmers with the knowledge of bTB epidemiology so that farmers are aware of the significance of cattle-cattle transmission.

Policymakers must also commit to greater transparency and honesty in public communication of the nature and significance of the sources of disease risk to cattle.

6.1.2 Attitudes towards cattle testing

Overall, our survey results confirmed that farmers were both aware and frustrated with the insufficient reliability of cattle testing in England. When asked to rate the reliability of routine cattle testing in England, over half of the respondents described cattle testing as either somewhat or highly unreliable (50.6%, n= 40). Approximately one-third (34.6%, n=27) of participants, on the other hand, reported cattle testing as either somewhat or highly reliable (Fig. 17).

Figure 17. Rating reliability of the SICCT test



Testing was also a topic of discussion in the open questions, such as "*What are the biggest difficulties you face in protecting your cattle from bTB?*" Whereas one participant explained the biggest threat to their cattle was "the government's overreliance on the standard test," another explained, "you never truly know which animals may be infected."

Similar sentiments were expressed by farmers when explaining their own experience with bTB herd breakdowns, many of whom expressed their frustrations at bringing in cattle to their herds who tested positive on arrival despite being cleared by pre-movement testing.

One notable observation was that the stress of testing day was a significant cause of concern for participants of our survey, even if all cattle tested negative for disease. Such sentiment was summarised by one respondent who commented:

"TB testing (not tb itself) is the most stressful part of my whole farming life and I'm sure most cattle farmers would agree. It prevents any effective planning, severely impacts animal welfare and costs the taxpayer a fortune with no discernible benefit".

Interestingly, these frustrations led to spontaneous blame being directed towards badgers and those who wish to protect them. As an example, one respondent wrote:

"I've not had to deal with a breakdown in my cattle, but I've had inconclusive cases, and I've had neighbours who breakdown, so we end up with six monthly testing which is stressful and dangerous for farmers handling cattle which can be unpredictable with repeated testing. The dangers to farmers are ignored by those who are totally focussed on protecting badgers, and nor do they care about the consequences for wildlife that the badgers predate."

Similar sentiments were expressed by another participant, who wrote:

"The present tb test of cattle is awful for both cow & farmer. Dangerous, stressful. I injured my arm in our last test. A friend was knocked out & almost died. The physical work involved, but mostly mental stress is dreadful, these are more than just animals to us. Generations of breeding & lifetimes work can be lost. Farmers are going out of business & giving up keeping cattle because of the threat of badgers bringing in tb & all the grief associated with it. This country spent decades trying to eradicate tb from the human population. Listen to the true country people- gamekeepers, farmers, old country men & value their opinions, & do it soon before hedgehogs are totally wiped out".

These statements from farmers highlight the detrimental impact of the current testing regime on farmers and the enormous amounts of mental and physical stress they are put under as a result. The anti-badger rhetoric, both in regards to them being the key driver in the spread of bTB and their predatory risk to other native species, highlights **an important knowledge gap between science and the farming community**. It also shows how helpless the farmers feel in tackling this disease, as the badger has been used as a scapegoat for all their problems with bTB.

According to these views, if it weren't for badgers, then the testing regimes would not be necessary. Farmers in our survey appeared to be unaware of the epidemiology of bTB as a disease that primarily spreads from cattle-cattle. As has been demonstrated throughout this report, biosecurity, including farm measures, restrictions to cattle movement and enhanced testing, is the best ways to prevent bTB herd breakdowns in the absence of a cattle vaccine. Yet farmers find the testing process highly stressful, dangerous, and inadequate at detecting infected animals. These processes are exceptionally problematic for farmers and need to be addressed by policymakers.

Policymakers are, therefore, continually failing farmers by not being transparent with the disease risk pathways, the effective ways of tackling bTB, and providing adequate compensation.

Text box 14: Recommendation 2. Enhance testing and provide greater assistance to farmers

We recommend the adoption of enhanced testing and combination tests (see section 10.1.2). Policymakers must also support the psychological health of farmers during and beyond the transition to more rigorous cattle testing. **Mental health support and financial assistance** to aid with the labour requirements of testing are vital.

In the event that combination testing was to be implemented (as we recommend), it is highly likely there would be an initial rise in bTB cases as more infected cattle are positively identified. Thus, **policymakers should prepare farmers for this likely outcome and implement measures to assist farmers** with the psychological impact of the testing and cattle removal process.

6.1.3 Attitudes towards Biosecurity

Biosecurity is a fundamental strategy for preventing bTB transmission. However, our survey results show that, whilst farmers claim to understand the importance of biosecurity, in practice biosecurity is little implemented. In an open question, we asked farmers *"What biosecurity measures do you currently use on your farm?"* Of these, ten measures emerged, as follows:

- **11.21%** of farmers claimed to have a **closed herd**.
- **3.73%** of farmers claimed to have a **semi-closed herd** (i.e. only specified individuals were permitted to move to and from the farm)
- **17.75%** of farmers said they employed **fencing** in high risk areas (such as around field perimeters)
- **12.14%** of farmers said they used **footdips and/or washed their vehicles** with disinfectant
- **21.49%** of farmers said they had installed at least one **raised food trough**
- **11.21%** of farmers claimed they had **secure cattle feed stores**
- **0.93%** of farmers said they had constructed **wildlife corridors** to allow wildlife passage through areas of the farm inaccessible to cattle
- **0.93%** of farmers said they **isolated new cattle** on arrival
- **0.93%** of farmers claimed to **avoid the spread of slurry on grazing land**
- **3.73%** of farmers claimed to employ **selective cattle purchasing** insofar as they only purchased cattle from trusted sources

In addition to the ten measures outlined above, **4.67%** of farmers stated they applied no biosecurity measures on their farm. A further **11.21%** of farmers declined to specify their biosecurity measures by providing statements such as "as DEFRA advises," "no comment," and "you can't protect them."

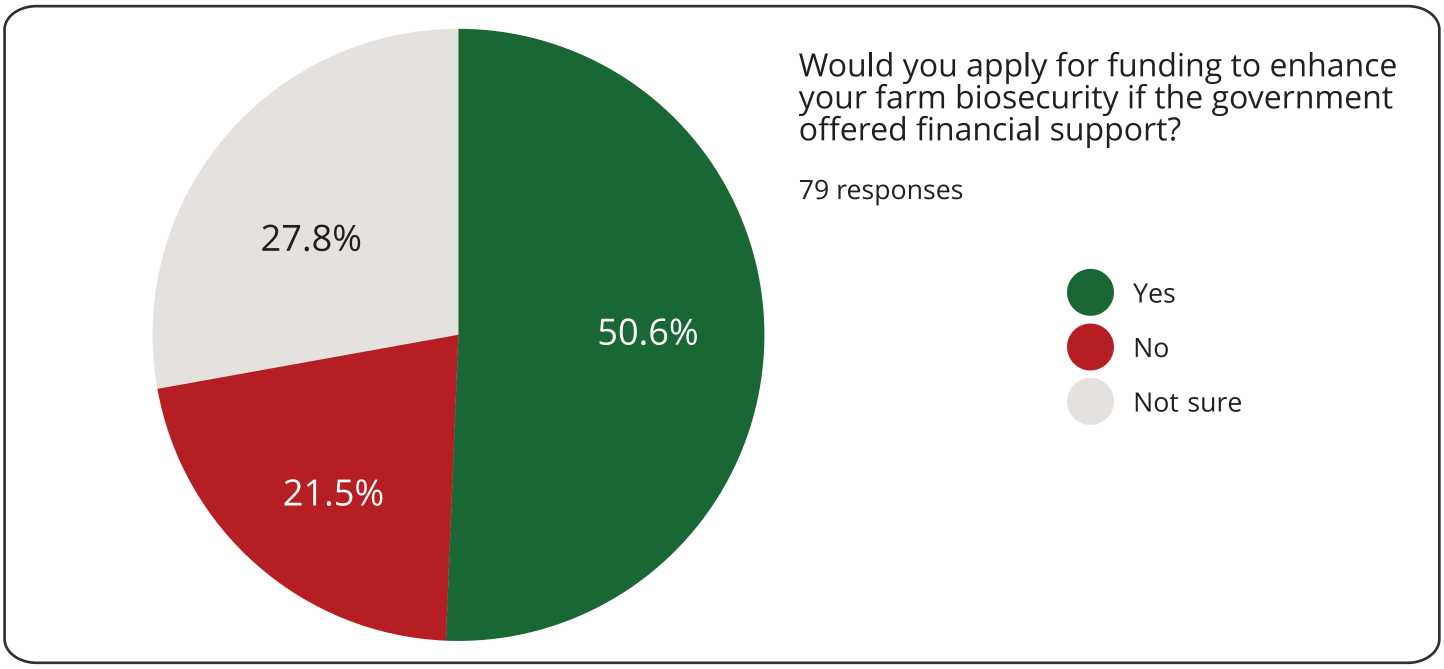
Our results show that **farm biosecurity was not widely employed by survey respondents**. In fact, on average, just one out of the ten measures mentioned was used by the farmers in our survey. The most common measure applied was raised food troughs which, whilst recommended practice, is not enough alone to prevent bTB from spreading. These are similar findings to the DEFRA 2019 Farming Practices survey highlighted in section 4.2.1.

Yet, these results are not surprising, as our survey also revealed that a common perception amongst farmers was that biosecurity was not overly effective because "you can't keep wildlife out". Indeed, when asked what the limitations farmers faced in implementing biosecurity on their farm, answers along the theme of "you can't keep wildlife out" were the most popular, presented in 36.7% of responses (n = 29), followed by 20.25% (n = 16) of respondents who claimed that "wildlife protection laws" were the primary limiting factor in biosecurity implementation. Thus, both the most common perceptions held by farmers concerning the limitations of biosecurity were about their perceptions of wildlife as a vector of disease and the difficulties of eliminating this risk, despite bTB being transmitted primarily from cattle-cattle.

In all, 12.65% of farmers (n = 10) who responded to our survey claimed that financial costs were a significant factor in biosecurity implementation, whereas 11.39% (n = 9) of respondents said there were no limiting factors in biosecurity application at all. A further 10.12% (n = 8) declined to answer the question.

Although only 12.65% of respondents claimed that financial costs were a significant limiting factor in biosecurity implementation, there was significant agreement among respondents that they would apply for funding to enhance their biosecurity if the government offered financial support (Fig. 18). Over 50% of respondents said they would apply for funding, whereas 27.8% (n = 22) were unsure.

Figure 18. Funding and farm biosecurity



Overall, whilst there is a common perception amongst farmers that it is very difficult to protect cattle from the disease risk posed by wildlife, most farmers would either apply or consider applying for funding if financial support was available to them. This presents policymakers with a unique opportunity to enhance the biosecurity of the farm network.

Text box 15: Recommendation 3. Improve biosecurity measures
Our results show that there is ample opportunity for policymakers to **improve the biosecurity measures implemented across the farm network by way of improving the funding support available to farmers** to do so.

Policymakers **urgently need to address the misconceptions regarding the significance of the wildlife disease risk**, to ensure that cattle-based biosecurity measures are routinely adopted.

Mandatory cattle isolation and funding to support the installation of isolation units for newly purchased cattle would be advantageous, as would a review of the current biosecurity recommendations to ensure that cattle are not overlooked as vectors compared to the focus given to wildlife vectors.

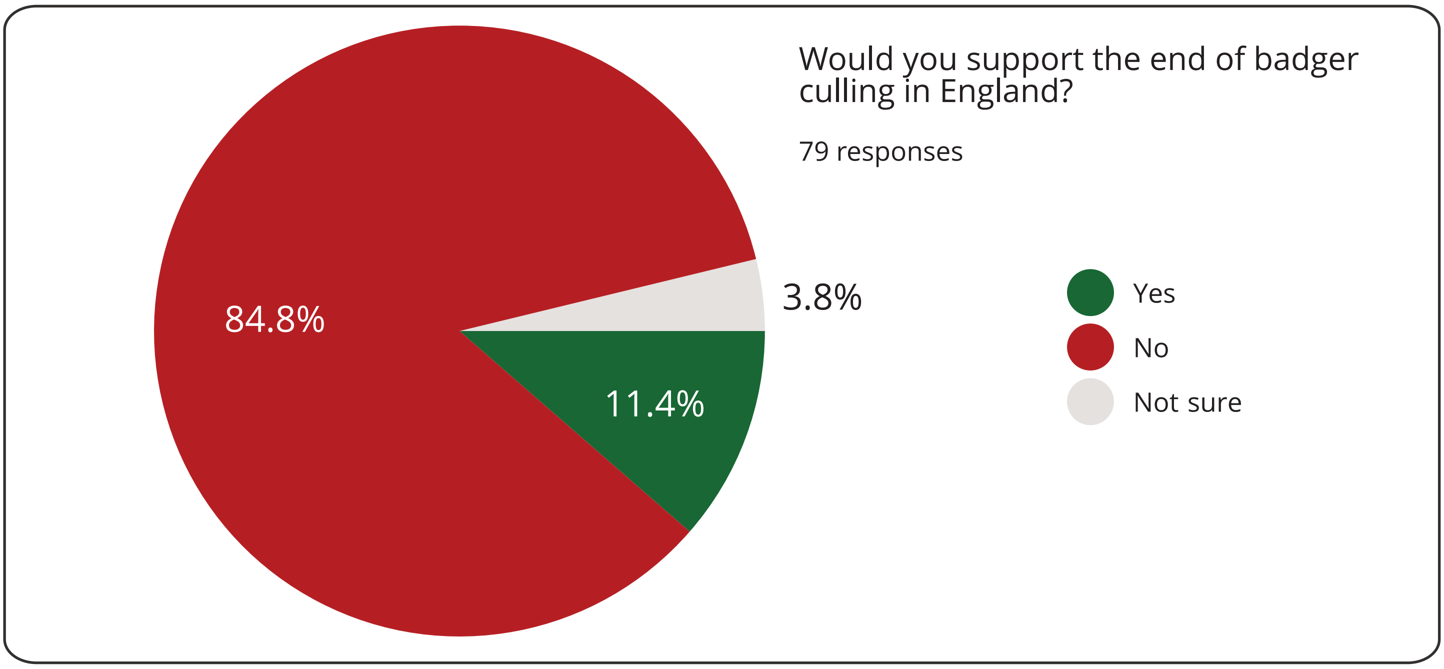
6.1.4 Attitudes towards badgers

Within the 2009 FCN survey, 81% of respondents spontaneously blamed badgers for bTB, leading the FCN report authors to conclude that:

"The comments are so dominated by the need to tackle TB in badgers and other wildlife that it seems likely that other advice was considered to be ineffectual or impractical and so was ignored."

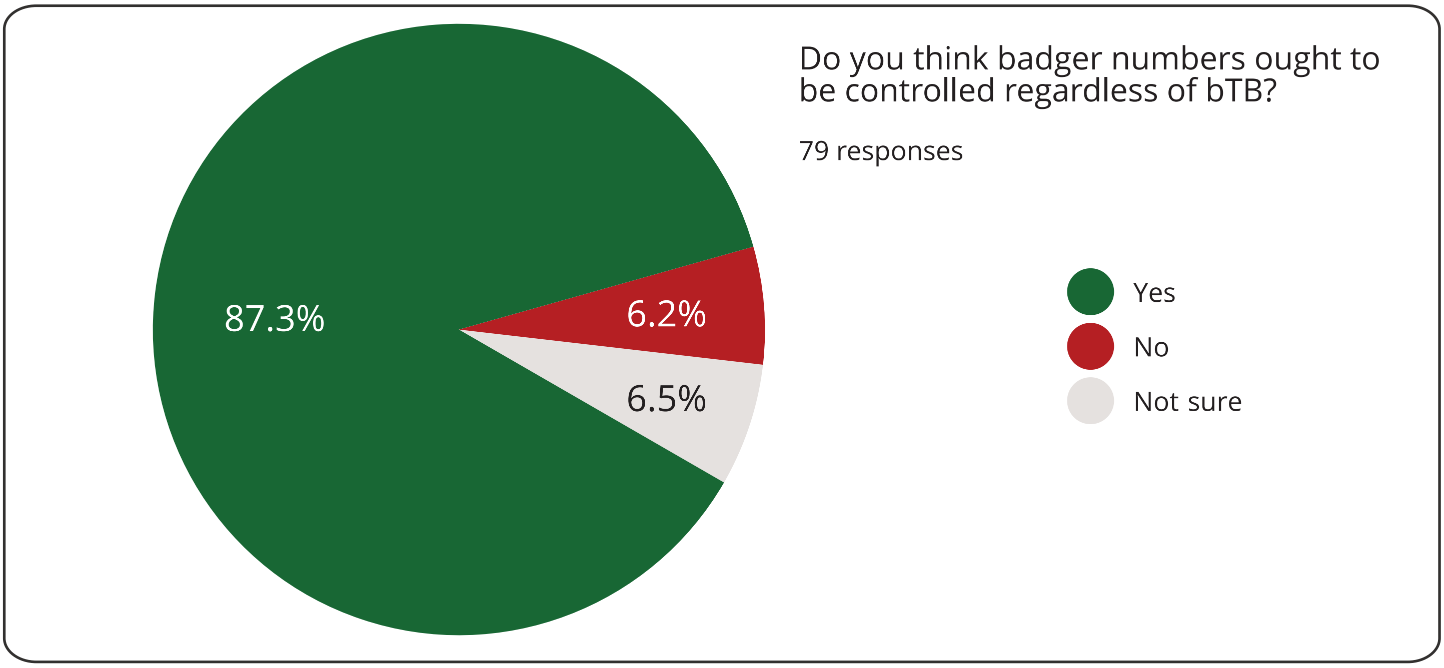
Our 2023 survey corroborated the findings of the 2009 FCN survey. The "problem" of badgers and their legal protections were commonly cited by our survey participants, regardless of the topic of the question. Only 11.4% (n = 9) of participants supported the end of badger culling in England, compared to 84.8% of participants (n = 67) who said they would not support the end of badger culling (Fig. 18). Three individuals (3.8%) did not know.

Figure 18. Respondents' support for the end of the badger cull



Like the FCN survey, our results also showed that badgers have become such a contentious and political species within the farming community that alternatives to their lethal control are likely to go unsupported by most farmers. In fact, most survey respondents supported the management of badger populations regardless of their limited role as vectors of disease (Figure 19).

Figure 19. Should badger numbers be controlled?



In all, 87.3% of respondents (n = 69) advocated badger population management regardless of disease transmission. Thus, badgers were consistently viewed as a pest species by most farmers, and alternatives to lethal management were largely unsupported. It is unclear from this survey why badgers are strongly viewed as pest species irrespective of disease transmission, but it is postulated that it could be due to beliefs around crop or land damage, damage to game bird chicks, concern for hedgehogs, or residual concern for poultry and lambs.

Text box 16: Recommendation 4. Coalition Group of Stakeholders

Given the highly politicised and polarising nature of badgers, we recommend **an integrated approach to depoliticisation of the badger via a coalition group of stakeholders** (policymakers, farmers, land owners, veterinarians, and environmental and animal welfare charities). The purpose of this would be the **opening of dialogue between stakeholders to support a shift in the anti-badger rhetoric towards a rhetoric of sustainable coexistence**.

The coalition group would be tasked with creating resources that can support farmers and landowners to protect the health and welfare of both badgers and livestock and to assist in conflict management between traditionally opposing groups such as farmers and animal welfare activists.

The coalition should be built upon the UN Sustainability Goals and the targets set out in the Kunming-Montreal Global Biodiversity Framework, and the meetings ought to be chaired by a neutral party so as to mitigate and diffuse potential inter-group conflicts.

6.1.5 Attitudes towards badger vaccination

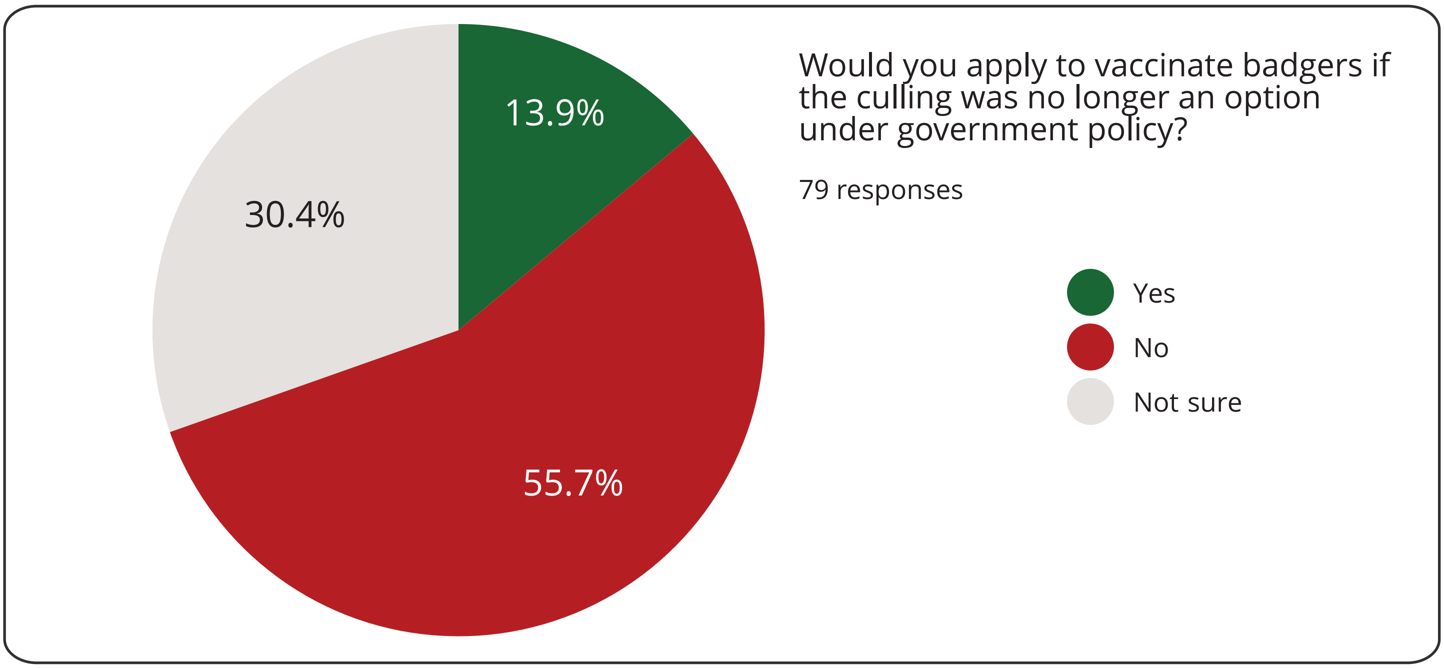
In 2009, the FCN survey found that most farmers (up to 90.7%) were not willing to vaccinate badgers whether badger vaccination was science-led, government-led, or farmer-led. General consensus was that badger trapping was time-consuming, labour-intensive, economically costly, and (in some cases) opened up farmland to biosecurity risk due to the presence of trappers and vaccinators.

The 2009 FCN survey also revealed that farmers were concerned that, if voluntary, badger vaccination would not likely be employed by non-livestock farmers and there would be gaps in protection across the farm network [175]. Thus, the survey confirmed that farmers distrusted the government's ability to protect the entire farm network due to a lack of government leadership in disease eradication policy.

Our survey revealed similarly low levels of willingness to conduct badger vaccination amongst farmers. **Only 13.9% (n = 11) of respondents said they would apply to vaccinate badgers if culling was no longer an option under government policy**.

However, 30.4% (n = 34) of respondents were “not sure” whether they would apply to vaccinate badgers if badger culling was no longer available (see Fig. 20). Thus, unlike the 2009 FCN survey, there appears to now be considerable uncertainty regarding the willingness to vaccinate badgers under government policy. Our results therefore highlight the shifting perceptions of badger vaccination as an alternative policy to lethal badger control.

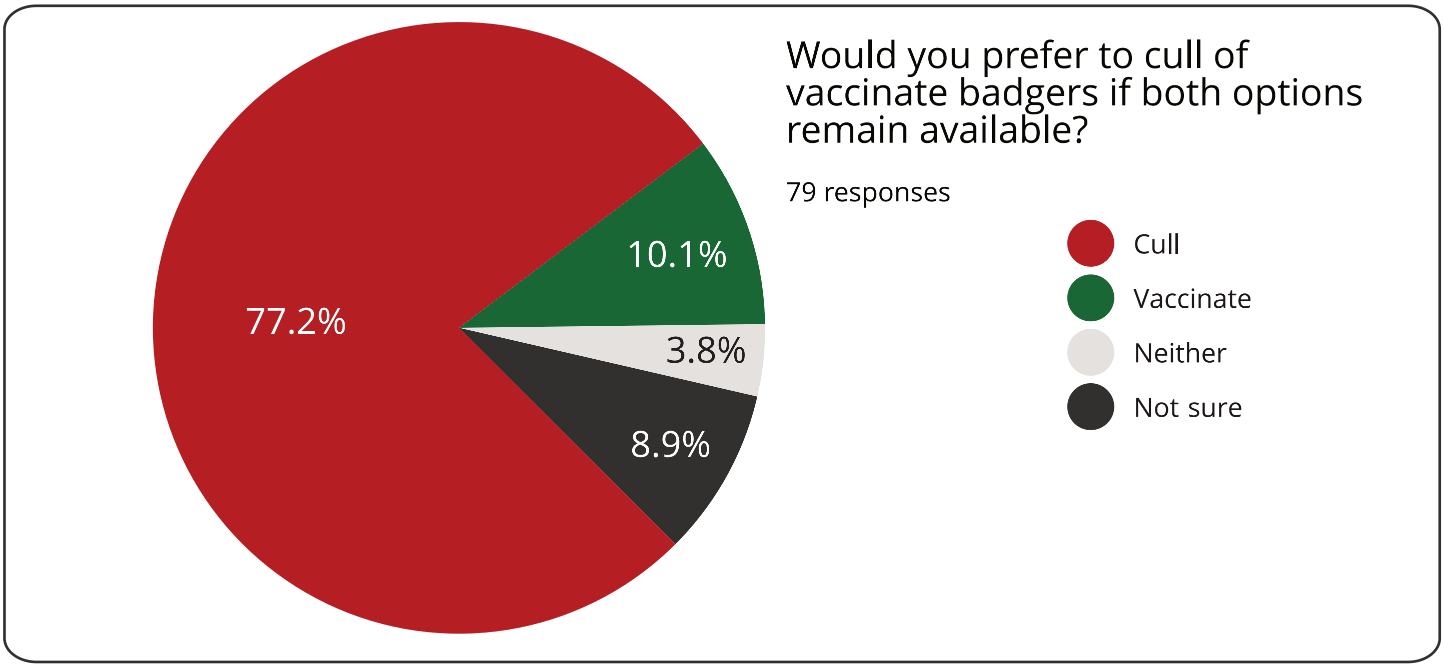
Figure 20. Badger vaccination



However, a noteworthy observation was that our survey results indicated that badger vaccination would not be successfully adopted unless culling was no longer available.

When asked which option was most preferable between culling and vaccination, only 10.1% (n = 8) of respondents said they would opt to vaccinate badgers, and 8.9% (n = 7) were unsure (see Fig. 21). In all, most farmers in our survey would opt to cull badgers rather than vaccinate them (77.2%, n = 61).

Figure 21. Cull or vaccinate preferences



Our survey shows that badger vaccination is most likely to be taken up by farmers when there is no longer a lethal control option available to them.

These results are unsurprising when compared to the common misconception amongst our farmer participants concerning the risk posed by wildlife disease transmission, and the negative perception of badgers more broadly.

Text box 17: Recommendation 5. Badger vaccination rather than culling

Whilst badger vaccination is preferable to culling on the basis of animal welfare, protection of badgers against cattle borne disease, and economic grounds (see sections 4.2.4.3 and 9.1.2), our survey results indicate a general lack of farmer interest in badger vaccination alongside a preference for lethal control.

We recommend **policymakers shift to badger vaccination in conjunction with an immediate end to badger culling, as our results also show vaccination take up will be more likely only when culling is no longer an option**.

6.1.6 Attitudes towards cattle vaccination

Research conducted in 2022 by the University of Gloucestershire, funded by DEFRA, confirmed that farmers are overall supportive of a cattle vaccination programme, yet they also hold reservations about its implementation [184].

Firstly, farmers noted that the development of a cattle vaccine has "always been five years away from completion". Farmers in the survey claimed to have been waiting for the development of a cattle vaccination for more than twenty years, and recalled headlines often claiming that the vaccine would be ready in five years' time. Overall, farmer trust in the promise of a cattle vaccine is very low, based upon past experiences of its non-delivery.

Secondly, most farmers are also sceptical about the deployment of a voluntary, farmer-led, vaccination programme whereby the costs of vaccination would fall to the farmer [184]. Again, lack of government leadership by way of unsupported mandated policy leaves farmers bearing the bulk of the responsibility in terms of economic, time and labour expenses and there is thus little incentive for the policy to be adopted. Unless cattle vaccination is taken up by all farms within the farm network, then bTB will continue to spread.

Our survey results generally support the findings of the University of Gloucestershire research, in that farmers were supportive of a cattle vaccine, but overall the vaccine was considered less important to our survey participants than badger control.

When asked what the government ought to be doing to protect cattle from bTB, the development of a cattle vaccine was the third most common suggestion, featuring in 12.65% (n = 10) of respondent answers.

However, badger culling and revoking the badger's legally protected status was the most common suggestion, appearing in 45.56% (n = 36) of responses. Enhanced cattle testing in comparison scored second, featuring in 18.98% (n = 15) responses.

Thus, again the emphasis was on the lethal control of badgers over cattle-based methods. However, this could in part be due to the continual failings to develop a cattle vaccine and so farmers are not convinced that a cattle vaccination programme will ever be forthcoming.

Text box 18: Recommendation 6. Cattle Vaccination and DIVA test transparency

A bTB cattle vaccine is the most effective way to protect against disease spread. Thus, the development of a cattle vaccine and corresponding DIVA test ought to be the priority for the eradication of bTB. However, development has been slow, and information pertaining to its progress has not been transparently communicated to farmers or other stakeholders.

Lack of trust in the government's ability to develop and successfully implement a cattle vaccine and DIVA test is therefore in need of urgent attention. Policymakers must be **more transparent with the details of the DIVA test development** rather than estimating its arrival as a generic 'five-year' time frame that never progresses.

Given the reservations of farmers concerning the voluntary deployment of a cattle vaccine, we highly recommend that **policymakers take a leadership role in the implementation of a cattle vaccine and make its application mandatory when the appropriate DIVA test is deployable**. Only through a complete and comprehensive vaccination programme will the entire farm network be protected from the devastating impacts of bTB in cattle.

7.1 Vets

The Veterinary profession is key to addressing bTB in cattle. They are a trusted source, especially when an Accredited bTB Advisor (see CHeCS scheme in section 10.1.5) and can offer the best advice to the local situation.

Vets can:

- play a key role in communicating the importance of good biosecurity practices;
- tailor and improve biosecurity to each individual farm/situation
- provide reassurance to farmers;
- help assess the risks of potential stock purchases;
- counter misinformation;
- explain tests and testing intervals;
- and offer bespoke advice on herd health planning.

The farmer-vet relationship is crucial to knowledge-sharing of bTB solutions, and effective implementation. Farmers see their vet as a "reliable and trustworthy" source [185] that can provide tailored advice, especially when that relationship is pre-existing and long-term.

Vets are well-equipped to make diagnoses and provide solutions to diseases, but studies have found that some private vets are frustrated by their lack of involvement in addressing bTB beyond conducting statutory tests [186, 187]. Expanding the opportunities for private vets to conduct disease investigations alongside government vets, could enable more tailored and real-time infection control and disease prevention [7].

Addressing bTB has also been shown to impact the well-being of veterinary professionals as they navigate between broad-scale policy and working closely with individual affected animals and farms. There is a fine line between statutory testing requirements and navigating the needs and impact on the farmers. Vets and farmers have a professional relationship, which often extends over many years, but can be seriously harmed when statutory testing throws up positive results. It is difficult to keep the balance between the preventative and advisory role a vet has and the national disease prevention programme that can have a major impact on a farmer's livelihood. The challenges and stresses that vets face are important aspects to understanding how the disease is managed and the ongoing provision of veterinary services. Accordingly, the stress of disease management, including from bTB, has been shown to impact veterinary migration from the profession [188].

Strong collaborative efforts between government and private vets, including efficient data sharing, have been shown to build stronger relationships and have better outcomes [7]. This prevents contradictory advice from being given to farmers or the perception that private vets do not have the necessary "epidemiological skills" [189]. Allowing private vets to take more of a leadership role could build confidence in the relationship between farmers and their private vets, private vets and government vets, and improve morale amongst the veterinary profession.

Veterinary surgeons who are in practice across all disciplines are also in a position where they "*must take steps to provide 24-hour emergency first aid and pain relief to animals according to their skills and the specific situation*". This is in accordance with Principle 1.4 of the RCVS Code of Professional Conduct [190]. This means that the same vets treating the farmed cattle can also be responsible for providing emergency care to wildlife, including badgers. This can include badgers injured but not killed, by cull contractors. This can raise complex and, at times, conflicting emotions among some vets who can feel torn between their responsibilities [191]. Reinforcing this ethical code amongst vets may help to alleviate the stress of viewing these situations as personal conundrums and reminding vets that they are a standard code of practice.

Text box 19: Recommendation 7. Collaborative working between private and government vets

Ensure strengthened collaborative working between government vets and private vets, with private vets taking more of a lead role in tackling bTB.

8.1 Nature-Based NGOs

Nature-based charities can play a crucial role in tackling bTB through conservation, research, education, and advocacy. By taking a holistic approach that balances the interests of wildlife conservation and agriculture, prioritising evidence-based solutions, and fostering collaboration among various stakeholders, nature-based charities can be a vital component in tackling bTB. Some of the ways that nature-based charities can help to tackle bTB are addressed in Table 12 below.

Table 12. How can nature-based NGOs help tackle bTB?

Habitat Preservation and Restoration	Protect and restore natural habitats for wildlife, including badgers, which can help maintain healthy populations and social structures to help reduce potential disease spread.
Monitoring and Research	Support research projects that aim to understand the behaviour, ecology, and disease dynamics in wildlife populations, such as badgers, to inform evidence-based management strategies.
Education and Awareness	Raise awareness about bTB transmission risks. Educating the public and stock farmers about best practices for biosecurity and disease management.
Invest in rural communities	Use behavioural science to address the polarisation of opinions surrounding the protection of badgers
Support policy development and advocacy	Lobby for evidence-based policies that prioritise the conservation of wildlife and the reduction of bTB transmission, while also supporting the economic interests of farmers. Advocate for the use of cattle-based measures and cattle vaccination.
Collaborate with stakeholders	Collaborate with government agencies, farmers, veterinary professionals, and other NGOs to create integrated strategies for bTB management that are science-based and sustainable.
Promote responsible and sustainable farming practices	Encourage and advise farmers on the implementation of biosecurity measures to reduce the risk of bTB transmission. Encourage sustainable farming practices that promote animal welfare and lower the risk of disease transmission, such as rotational grazing or improved cattle housing.
Research funding	Provide funding for research into bTB management strategies, testing effectiveness, vaccination development and implementation.
Public engagement and citizen science	Engage the public in wildlife monitoring and research through citizen science initiatives, fostering a sense of ownership and responsibility for bTB management.

Nature-based NGOs have a key role to play as the bridge between broader conservation and animal welfare initiatives, and how that sits within farming industry practices. Environmental protection, like bTB, is everyone's responsibility and it is important that all the voices involved have a seat at the same table. Bovine tuberculosis does not exist in isolation, and as we've seen in sections 2.4 and 3.1, must be considered in the wider environmental and animal welfare (including animal welfare of farmed animals) context.

Policies that are needed to address bTB combine values of the environment, food security, sustainability, biodiversity, and rural cultures all set against the backdrop of climate change. The role of nature-based NGOs in this conversation is to ensure that any farming policy propositions support, and maybe even enhance, our national and international environmental legislations rather than contradict them.

Many nature-based NGOs have an interest in bTB, and a large reason for this is because of the policy to cull badgers and the impact that has on this native species and the wider ecosystem. Others, however, are interested from a farmed animal welfare perspective. Badger Trust supports the notion of uniting in the shared goal to find alternative solutions to tackling bTB that do not compromise our native fauna.

Traditionally an 'us versus them' mentality has existed between nature-based NGOs and other stakeholders such as farmers, politicians and vets, and it is time that we work together as a united front to tackle the problem. We all want the same thing – to reduce the incidence and prevalence of bTB to ensure the best welfare for both animals and people. Nature-based NGOs can, therefore, offer a more inclusive environment that allows better communication between stakeholders of opposing views.

The Wildlife and Countryside LINK bTB group is an important platform for bringing together the key voices of nature-based NGOs that share a unified interest in bTB and the associated policy impacts on nature. This group could be used as a platform for other stakeholders to engage with nature-based NGOs in a non-confrontational manner.

We want to champion the voices of nature-based charities engaged in priority issues affecting our native wildlife. This includes bTB and the impact it has on badgers and the wider environment. Farming and veterinary representation are often considered in various working groups, and we would like to see the totality of the countryside included more in these conversations by including nature-based NGOs.

Text box 20: Recommendation 8. Inclusive, evidence-based narratives from nature-based NGOs

To see the totality of the countryside represented in priority setting and outreach initiatives around bTB.

For nature-based NGOs to be more inclusive with stakeholders of opposing views to address the polarisation of opinions surrounding the protection of badgers.

Part III Summary

Case Studies

- Scotland is Officially TB Free, and England and Wales have both implemented strategies towards achieving TB Free status, by 2038 and 2041 respectively.

- There are no substantial differences between bTB rates in England compared to Wales. in 2022, 94.7% of Welsh cattle herds were free from bTB and 95.6% of English cattle herds.

- Wales do not cull badgers, but Welsh herds are subject to stricter controls to cattle via country-wide annual testing, restrictions to cattle movement, and mandated farm biosecurity.

- The infrequency of testing in England outside of the HRA or Edge areas likely results in inaccurate figures. Due to inaccuracy and high false negative rate of SICCT, the true number of infected cattle in England may be as much as 50% higher than recorded.

- Cattle testing in England can be as infrequent as every four years, meaning some cattle can go untested in their lifetime, whereas testing in Wales occurs annually, unless in the highest-risk ("Intensive Action") area, where cattle are tested every six months.

- Geographically inconsistent and evolving policies in England have caused confusion for farmers surrounding regulations.

- There is an absence of incentives to adopt best practice cattle biosecurity measures in England, and therefore they are rarely implemented. By mandating basic farm biosecurity measures and linking biosecurity compliance to compensation payments, the economic and social disruption caused by bTB and other disease outbreaks can be limited.

- It is clear that epidemiological evidence has not informed badger culling in England, as wildlife surveillance in both England and Wales has failed to find a significant reservoir of bTB in badger populations to constitute a significant risk to livestock.

- Where there is evidence that rates of bTB are increasing in the badger population in Wales, these populations are targeted with vaccination.

- As badgers only account for a very small proportion of bTB transmission to cattle, efforts to reduce bTB through vaccinating badgers alone are unlikely to be effective without equal or greater focus on improving farm biosecurity and reducing cattle-cattle transmission rates.

- Scotland may have maintained low bTB incidence due to wider geographic spacing of farms and less intensive farming practices.

- Scotland has a risk-based bTB testing policy. The default testing interval is four years, but it can be more or less depending on the herd. All herds are reassessed annually.

- Maintaining animal health and welfare in a post-Brexit era remains a key priority. The EU continues to be one of the biggest trading partners for the UK, and so policies need to align internationally, and within Britain.

- The UK governments need to reward high animal welfare in their policy decisions around bTB, so that we can continue to be a world-leading provider of high-welfare food in a competitive way.

Farmer Survey

- The financial costs associated with a herd breakdown can be crippling to farmers and lead to devastating emotional strain.

- In 2023, Badger Trust conducted an online farmer survey which revealed an underlying misconception amongst farmers regarding the transmission risks for bovine tuberculosis, with wildlife thought to be the most likely route of transmission over cattle-to-cattle infection.

- Badger Trust does not assume to know what steps individual farmers need to take in order to become farms free from bTB and the devastating impacts it can have. We strive to present the best available data and research, whilst acknowledging that we have gaps in our understanding.

- Policymakers must urgently commit to greater transparency and honesty when communicating the nature and significance of the disease risks to cattle in order to reduce misunderstanding and remove barriers to effective disease control.

- Intensive educational outreach efforts are needed to better equip farmers with the knowledge of bTB epidemiology.

- Our survey results confirmed that farmers were both aware and frustrated with the insufficient reliability of cattle testing in England and “the government's overreliance on the standard test”.
- Policymakers must support the psychological health of farmers during and beyond the transition to more rigorous cattle testing. Mental health support and financial assistance for increased testing and implementation of biosecurity measures are vital.
- Alternatives to badger culling were largely unsupported by the survey respondents, and vaccination would likely only be taken up by farmers when lethal controls are no longer available.
- We recommend an integrated approach to the depoliticisation of the badger via a coalition group of stakeholders to open the dialogue between groups and shift the rhetoric towards sustainable coexistence.

Vets

- Veterinary professionals are considered a trusted source that are key to addressing bTB in cattle.
- The farmer-vet relationship is crucial for sharing knowledge of bTB solutions, and effective implementation.
- Expanding the opportunities for private vets to investigate disease pathways could enable more effective and efficient infection control and disease prevention.
- Addressing bTB impacts the well-being of veterinary professionals as they navigate between broad-scale policy and working closely with individual affected animals and farms.
- Strong collaborative efforts between government and private vets, including efficient data sharing, have been shown to build stronger relationships and have better outcomes.

Nature-based NGOs

- Using more inclusive dialogue to engage with all stakeholders, including those of opposing views can contribute towards collaborative solutions.

- Investment in rural communities for educational outreach can address the polarisation of opinions around badgers and other wildlife.

- Using evidence-based narratives and investing in multi-stakeholder research can provide more effective solutions to problems and encourage uptake of alternative methods.

Part IV The Economic Costs and Cattle Welfare of Disease Reduction

9.1 Economic costs of the current strategy

9.1.1 Badger culling

The badger cull in England is paid for by the taxpayer and farmers. Taxpayer expenditure (detailed in Table 13) covers the costs of licensing and compliance monitoring, humaneness monitoring, efficiency monitoring, advice and assessments, additional expenses such as equipment, and policing costs. **The badger cull has cost at least £58,776,156** from 2013-2022 according to official figures [192 193]. This excludes other costs not met by the taxpayer, such as payments made by cull contractors for the culling of badgers, or other staffing costs associated with the cull, such as those within DEFRA, APHA, and Natural England.

Badger culling is performed by cull contractors, and the cost to these companies includes the surveying, preparation and shooting of badgers. These costs have been estimated by the government to average £131,000 per cull area over a four-year cull period. However, cull contractors also receive payment for each badger killed and, therefore, may earn a significant profit from culling badgers [194]. This profit aspect could be in breach of the COP15 biodiversity targets. Badger Trust conducted a Freedom Of Information (FOI) request to identify the exact costs of payments to cull contractors for culling badgers, but was told that this information is not available. Thereby this cost is excluded from the table above. It has been publicly reported, however, that contractors are paid £50 for every badger that they kill [195].

This legal government-endorsed culling of badgers has also incentivised the illegal killing of badgers. For example, one licensed badger cull contractor illegally killed 28 badgers outside of the cull period and stored the bodies in a freezer in order to claim payment when the cull period reopened [196].

An estimated benefit of culling has been projected at between £420,000 and £2.85 million [4]. This broad calculation is based on the potential for reduced costs if herd breakdowns are fewer. This must be considered against an expenditure of £6 million a year spent on culling (as seen in Table 13).

9.1.2 Badger vaccination

Badger vaccination reduces: the prevalence of disease in adult badgers; the severity of the disease; the likelihood of other badgers becoming infected; and the likelihood of badger cubs testing positive [173]. Badger vaccination has been shown to reduce the risk of an uninfected badger catching the disease by around 76% [173]. Badger vaccination can be used as a tool to help badger populations remain healthy and stable.

The Badger BCG has been authorised and is available through DEFRA. The costs, however, are variable and depend on various factors such as accessibility, size and nature of the site. It has been estimated that such a service could cost between £41-56 per hectare [197] or around £2,000 per km^2 [4, 197], or that the cost of an individual dose costs between £82-380 [197, 198]. The first year of badger vaccination costs more than subsequent years due to the purchase of equipment such as live-traps (£140 each) and training. Vaccinators must have a Certificate of Competence which costs £700 per year, after successful completion of the APHA training course which costs £750. Only then will you be able to get prescriptions for the Badger BCG. The vaccination contractor will also need to take out insurance.

Importantly, vaccination does not require the expensive policing costs required of the badger cull, which as shown above, cost participating forces £3,732,000 in 2022.

Table 13. Costs incurred by the taxpayer to cull badgers in England from 2014 to 2021

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Licensing and compliance monitoring	£859,000	£1,036,000	£1,003,000	£1,284,000	£1,289,000	£1,312,000	£1,459,000	£1,541,000	£1,546,000	£1,520,000
GPS and humanness monitoring, including post mortems	£2,628,000	£1,515,000	£154,000	£392,000	£506,000	£352,000	£388,000	£282,000	£254,000	£643,000
Efficacy monitoring	£2,311,000	£17,000	£0	£0	£0	£0	£0	£0	£0	£0
Advice and assessments	£389,000	£294,000	£460,000	£646,000	£728,000	£410,000	£314,000	£313,000	£88,000	£143,000
Other costs, including equipment	£107,000	£205,000	£162,000	£53,000	£49,000	£1,000	£20,000	£16,000	£3,000	£1,000
Payment to cull contractors for badger carcasses	FOI does not reveal information									
Policing costs	£3,524,000	£1,392,000	£1,803,247	£3,029,998	£4,046,561	£3,237,350	£3,658,000	£4,071,000	£3,589,000	£3,732,000
Total (not including badger carcass costs)	**£9,818,000**	**£4,459,000**	**£3,582,247**	**£5,404,998**	**£6,618,561**	**£5,312,350**	**£5,839,000**	**£6,223,000**	**£5,480,000**	**£6,039,000**

Models suggest that if 70% of badger populations are vaccinated annually, bTB could be eradicated from their population in 20-30 years, assuming no other spillover effects from cattle, livestock, wildlife or other environmental sources [4, 199].

To achieve maximum effectiveness of badger vaccination, the government must accept a leadership role and develop industry support for the large-scale delivery of a badger vaccination programme. The development of an oral vaccine with an effective deployment method would make it easier and cheaper to achieve on a large scale [42].

Overall, badger vaccination effectively manages disease whilst adequately safeguarding animal welfare, natural behavioural ecology, and the wider environment. However, badger vaccination is more effective and economical when deployed based on epidemiological evidence of heightened bTB infection in specific badger populations. Given the poor link between badgers and bTB spread to cattle (see section 1.1 and 1.2), and the lack of farmer support for badger vaccination (see section 6.1.5), only badgers that are at high risk of being infected with bTB should be vaccinated so as to avoid the expenditure of resources on the vaccination of animals where disease risk is minimal.

It should be noted that a study from 2021 showed that only between 4-15% of badgers in England tested via post-mortem have been shown to have bTB-like organisms detected [200], and other studies have found this number to be even lower [167, 168]. Of these, it is unclear how many of these individuals were shown to be actively infectious.

The vaccination of badgers in particular hotspot regions (as deployed in Wales, see section 4.2.4.1), would be the most logical application of badger vaccination in terms of disease control and economic cost-benefit. It would therefore be advisable for badger vaccination in England to be implemented in line with national wildlife surveillance, as is the case in Wales. This would require a national approach to wildlife surveillance, rather than the ad-hoc badger-found-dead surveys currently deployed in select regions of England (see section 4.2.4.2).

Whilst badger vaccination is both more effective at reducing bTB in badgers (remember the perturbation effect theory), and significantly cheaper than culling (remember the vast policing costs), it would, of course, be simpler to focus on the leading cause of bTB infection, the cattle and their management. The production and implementation of effective cattle vaccination and testing protocols, alongside better farm biosecurity and animal welfare still remain the leading tools for reducing bTB.

9.1.3 Farmer compensation

Net expenditure on bTB-related work in England has remained at around £100 million per year since 2012 [201], inclusive of a yearly average of £30 million in compensation to farmers due to loss of cattle from bTB herd breakdowns (see Table 14). Badger culling has had no impact on reducing the amount of compensation awarded to farmers during this time. Cattle compensation was lower (£28 million) in the year 2011-2012, before badger culling began (see Table 14).

Table 14. DEFRA's net expenditure on bovine tuberculosis (bTB) eradication in England since 1998

Financial Year	Cattle compensation paid to farmers	Total Cost incurred to taxpayer
1998/1999	£200,000	
1999/2000	£4,300,000	
2000/2001	£5,200,000	
2001/2002	£5,900,000	
2002/2003	£23,200,000	
2003/2004	£25,100,000	
2004/2005	£25,200,000	
2005/2006	£30,900,000	
2006/2007	£13,200,000	
2007/2008	£16,100,000	
2008/2009	£28,400,000	
2009/2010	£28,100,000	
2010/2011	£24,300,000	
2011/2012	£23,500,000	
2012/2013	£23,900,000	£96,000,000
2013	£31,400,000	
2013/2014	£22,600,000	£101,800,000
2014	£30,500,000	
2014/2015	£20,900,000	£92,900,000
2015	£29,900,000	
2015/2016	£20,900,000	£90,400,000
2016	£27,000,000	
2016/2017	£29,500,000	£19,300,000*
2017	£37,000,000	
2017/2018	£37,300,000	£36,200,000
2018	£35,300,000	
2018/2019	£34,000,000	£37,600,000
2019	£32,200,000	
2019/2020	£31,400,000	£36,900,000
2020	£30,800,000	
2020/2021		£31,600,000
2021	£34,900,000	
2021/2022		£34,300,000

2022	£30,800,000	
2023 (Oct)	£23,900,000	
Total	**£817,800,000**	**£577,000,000**

References: [201 - cost to taxpayer] [202 - 205 - Cattle compensation costs]

**The lower figure shown here is mainly due to a difference in the handling of salvage income rather than any cut in TB control expenditure in real terms. The following years (2017-2022) omit costs incurred by the Animal and Plant Health Agencies, which brings the total to an estimated yearly average of £100 million of taxpayer money [201, 202]*

Cattle compensation is equated based upon the market value of the cattle, and cattle slaughtered due to bTB infection may still continue to be sold as meat as long as lesions are restricted to just one organ [140]. However, this compensation does not cover the profits that cattle would accumulate over time if slaughtered on schedule (such as via the production of offspring). The limitations on the movement of cattle (both into and out of the herd) also place additional stress and economic strain on farmers who are temporarily prevented from trading and moving cattle until their cattle repeatedly test negative for bTB infection. Whilst no compensation is provided for these delays and the stress incurred, the government does pay for the veterinary costs associated with testing, whereas labour costs fall to the farmer [206].

These financial costs can be crippling to farmers and lead to significant emotional strain, particularly for farm businesses carrying substantial debt. Beyond just the financial costs, the forced premature slaughter of herds built up over generations can be soul-destroying.

The average cost of a bTB herd breakdown incurred by both the farmer and the taxpayer in the HRA can be seen in Table 15. These costs obviously depend on the size of the herd involved, the nominal value of the beasts slaughtered, and the number of infected cattle.

Table 15. The estimated average cost of a confirmed new bTB breakdown in the High-Risk Area of England (2022 prices in pound sterling)

	Cost incurred by taxpayer		Cost incurred by farmers
Testing	£2,391	**Testing**	£2,730
Slaughter costs	£7,327	**Restrictions and isolations**	£2,265
Administration	£321	**Output losses**	£697
Other	£0	**Other**	£1,121
Total Taxpayer	£10,039	**Total Farmer**	£6,813
		Grand Total	**£16,852**

As reported by DEFRA [207]

As discussed in Part III, the compensation awarded to farmers in England for loss of cattle due to bTB breakdowns is not linked to compliance with biosecurity best practices. Farmers are compensated for their cattle regardless of whether the farm in question has been effectively managed to prevent bTB infection. Thus, the installation of biosecurity best practices is limited, which only furthers the risk of cattle-cattle, cattle-wildlife, and wildlife-cattle infection.

Compensation, however, frequently does not cover the full costs of a herd breakdown, and the cost to farmers varies considerably. A study in the South West of England in 2010 estimated costs of between £505 to nearly £3,184 depending on herd size, but this did not account for many additional costs or loss of earnings associated with movement restrictions, including additional labour, bedding and feed, drops in production or outbreaks of disease or illness associated with overstocking [208]. A more recent report of a study from 2018-2019, showed that the costs of a bTB breakdown had a median value of around £6,600 across all farms surveyed [209]. Median costs across England and Wales for herds of more than 300 cattle were found to be around £18,600, whilst costs for farmers with herds of up to 50 cattle were around £1,700. Even in the proceeding years since this study, costs are likely to have increased.

As explained in Part III, biosecurity is the most effective method for reducing bTB spreading in livestock and wildlife, and the most effective way to encourage compliance is for the government to take a leadership role in its implementation. Farmers should therefore be supported to increase their knowledge and application of biosecurity, and biosecurity requirements should be made mandatory via its linkage to compensation.

It ought to be noted, however, that rates of bTB will first increase in response to enhanced testing as more previously unidentified infected animals are detected. Compensation rates are therefore likely to be higher during the early stages of enhanced disease surveillance in cattle, though compensation is likely to decrease following the decline in disease spread via the identification and removal of infected individuals, as was observed in Wales (section 4.1.1).

Only by identifying and removing infected animals will disease and compensation costs fall. Given that bTB is spread mostly via cattle-cattle transmission, it makes most economic and epidemiological sense to concentrate disease control methods on cattle.

10.1 Disease reduction benefits to cattle measures

10.1.1 Enhanced testing

The control of *M.bovis* relies on the early detection and removal of infected animals.

This is made more challenging as:

> ***"The disease usually spreads within a herd before any clinical signs are noted in individual animals" [5]***

This silent transmission between cattle is what makes accurate, and regular testing so important. The incubation period for *M.bovis* is highly variable ranging from 100 days [12] to a latent infection occurring many years after initial exposure [8]. Veterinary advice for testing for bTB in cattle emphasises that an indirect test is meaningless if not combined with clinical examination, direct screening, and with another indirect assay. Combinations of tests always improve diagnosis, as long as independent tests are chosen [5].

Currently, up to 80% of cattle in England can go untested for bTB in their lifetime because of disjointed testing regimes across the country [153]. Thus, all cattle in England ought to be regularly tested (at a maximum of once per year) irrespective of their geographic location.

Table 16 shows that there still continues to be an overreliance on the SICCT test in England, despite the limitations of the test.

Table 16. Proportion of cattle tested each year by area and test type*

Year	TBArea	Skin	Gamma	Antibody
2012	Edge	98.13%	1.87%	0.00%
2012	HRA	99.91%	0.09%	0.00%
2012	LRA	98.50%	1.50%	0.00%
2013	Edge	98.60%	1.40%	0.00%
2013	HRA	99.90%	0.10%	0.00%
2013	LRA	97.86%	2.14%	0.00%
2014	Edge	96.49%	3.51%	0.00%
2014	HRA	99.88%	0.12%	0.00%
2014	LRA	98.87%	1.13%	0.00%
2015	Edge	95.78%	4.22%	0.00%
2015	HRA	99.92%	0.08%	0.00%
2015	LRA	98.84%	1.17%	0.00%
2016	Edge	96.00%	4.00%	0.00%
2016	HRA	99.87%	0.13%	0.00%
2016	LRA	98.62%	1.39%	0.00%
2017	Edge	95.12%	4.88%	0.00%
2017	HRA	99.63%	0.37%	0.00%

2017	LRA	97.88%	2.13%	0.00%
2018	Edge	94.96%	5.04%	0.00%
2018	HRA	98.49%	1.52%	0.00%
2018	LRA	98.62%	1.39%	0.00%
2019	Edge	93.59%	6.41%	0.00%
2019	HRA	97.60%	2.39%	0.01%
2019	LRA	98.81%	1.20%	0.00%
2020	Edge	95.39%	4.59%	0.02%
2020	HRA	97.11%	2.84%	0.05%
2020	LRA	99.47%	0.53%	0.00%
2021	Edge	96.31%	3.69%	0.00%
2021	HRA	96.86%	3.12%	0.02%
2021	LRA	98.85%	1.15%	0.00%
2022	Edge	98.17%	1.81%	0.02%
2022	HRA	98.01%	1.99%	0.00%
2022	LRA	99.10%	0.90%	0.00%
2023	Edge	98.04%	1.96%	0.00%
2023	HRA	98.20%	1.77%	0.03%
2023	LRA	98.30%	1.70%	0.00%

**data from an FOI response to APHA 20.11.23*

If the costs currently attributed to badger culling were redirected to the implementation of annual combination testing as advised in veterinary journals, then the government could better support farmers to protect their herds from the main cause of bTB transmission, cattle-cattle infection. If sufficient funds, money could include both cattle testing and subsidising farm labour for testing. Additionally, the costs involved with testing are variable, depending on the type of test used, the size of the herd and the testing frequency requirements of each area. It is estimated that the average cost of administering and reading the SICCT test is £1.36-£6.10 per animal [208], so the overall cost to farmers will depend on the herd size and additional staffing requirements from testing.

More rigorous testing of cattle in England would also reduce disease transmission across county and country borders as fewer animals would carry undetected disease. Thus, enhanced testing regimes would benefit the entire farm network.

Importantly, where appropriate testing timeframes are in place, consequences such as compensation loss for non-compliance or extended time frames before conducting the test need to be robustly implemented.

Text box 21: Policy Gap: Best combination tests as standard
Up to 80% of cattle go untested for bTB in their lifetime, and up to half of infected cattle go undetected during routine SICCT testing [153]. Unless testing frequency is increased nationally, and the best combination tests used as standard, bTB will continue to spread.

10.1.2 Testing Options

Table 17. Testing Mechanisms available for bTB in cattle and their limitations

Test	How does it work?	Accuracy	Advantages	Disadvantages
Single intradermal comparative cervical tuberculin test (SICCT) (also known as the tuberculin skin test)	Measures inflammatory immune response to side-by-side injections of both bovine and avian tuberculin (M. avium) into the neck. Animals previously exposed to bTB will show a greater reaction at the bovine tuberculin injection site than the avian tuberculin site after 72 (+/- 4) hours. Result is determined by visual inspection. Used in routine testing	Specificity between 78.8 - 100% Sensitivity between 52.0% and 100% (median values 80.0% and 93.5% for standard and severe interpretations, respectively.) 20-50% of bTB infected cattle can be missed	Relatively inexpensive High specificity Comparative test allows for better discrimination between infected animals and those exposed to M. avium or to other environmental mycobacteria [210] WOAH approved	Infected animals will not be detected for up to 6 weeks after infection with *M. Bovis*. Cattle with a compromised immune system will not be detected due to depressed immune response, including those with late-stage TB. Cross-reactivity can interfere with test interpretation (e.g. environmental mycobacteria or Johne's disease) Unable to distinguish vaccinated and infected individuals Highly subjective result interpretation [211] More time-consuming than other available skin tests. Some evidence to suggest desensitisation to Interferon-gamma (IFN-γ) if tested too regularly [212, 213], but see [214].
Caudal Fold Tuberculin test (CFT)	Measures immunity response to injections of a small amount of purified protein derivative (PPD) tuberculin is injected into the fold of skin at the base of the tail.	Specificity 89.2 - 99.0% Sensitivity 63.2 - 93.0% [215]	WOAH approved	Non-comparative - less able to discriminate between animals infected with M. Boivs or those exposed to other mycobacteria. Some evidence to suggest desensitisation to Interferon-gamma (IFN-γ) if tested too regularly [212, 213], but see [214].
Single Intradermal Cervical tuberculin test (SICT)	Single Intradermal Test (SIT) applied in the skin of the mid-cervical region. Similar process as SICCT, but in addition to visual inspection, skinfold thickness is measured with callipers before and after the injection of tuberculin [216]	Specificity 53.1 - 99.0% Sensitivity 80.2 - 100% [217] but lower under Bayesian analysis 53 - 69.4% [218]	WOAH approved More sensitive than the CFT [210]	Non-comparative - less able to discriminate between animals infected with M. Boivs or those exposed to other mycobacteria. Less specific than the CFT [210] Some evidence to suggest desensitisation to Interferon-gamma (IFN-γ) if tested too regularly [212, 213], but see [214].
Interferon-gamma (IFN-γ) blood testing	Carried out in a laboratory using fresh blood samples. Measures levels of interferon gamma (IFN-γ) immunological hormone in the...	Less likely to miss infected animals (~90% sensitivity) High specificity (96.6%) [219]	Sensitivity is similar to skin tests, and greater than SICCT. Can identify infection earlier than SICCT [220] Enables more...	More expensive than SICCT, but the added expense of laboratory analysis is offset by avoiding repeated farm visits and automation [219] Blood samples must be transported in...

	...blood, which are elevated in infected animals. Used to supplement SICCT testing in specific TB breakdown herds.	Less likely to miss infected animals (~90% sensitivity) High specificity (96.6%) [219]	...rapid repeat testing Single farm visit required Result interpretation is more objective and standardised. Reduced practical limitations of skin testing (poor facilities/ equipment, operational error etc.)	...temperature-controlled packaging systems to a laboratory within a few hours [221] Apparent lower specificity than SICCT (more false positives), although this can be overcome. Cattle with a compromised immune system will not be detected due to depressed immune response, including those with late-stage TB. Recent skin testing (<7 days) may interfere with responses, although results are inconclusive
IDEXX ELISA (IDEXX Laboratories, Maine, USA)	Uses a combination of two *M. bovis* recombinant antigens (MPB83 and MPB70). Antibody assay WOAH approved	Moderate test sensitivity of 65% and a specificity of 98% in cattle [142]. This maximum sensitivity is only achieved after a tuberculin skin test.	Can provide a test result within two hours	At the time of writing, IDEXX ELISA is not recognised under EU legislation. This test can be used by APHA in exceptional circumstances, such as in herds with persistent and recurring TB breakdowns, and when a herd fails to regain its officially TB free status after repeat skin and interferon gamma testing [140]
Enferplex (Enfer Diagnostics [222])	Serological test of bodily fluids to detect antibodies in bTB infected cattle. Antibody assay WOAH approved since May 2019. The use of this test is currently being piloted in Pembrokeshire [141].	Diagnostic specificity 98.4 - 99.7% using high sensitivity and high specificity settings of the test, respectively [222] High sensitivity 94.2% boosted by a prior intradermal injection of tuberculin, or 71.4% (non-boosted).	Tuberculin skin tests did not affect overall specificity (98.4 - 99.7%). Relative sensitivity higher than SICCT Relatively inexpensive Can be used to detect infection from bovine serum, and provisionally for milk. Can differentiate between vaccinated and infected cattle [223]. Enferplex can detect bTB infection throughout the disease process.	Not yet recognised by the EU, or approved by DEFRA, Scottish and Welsh governments for statutory testing in cattle. Limited private use is available subject to APHA approval, but costs fall to the farm business and compensation for test-positive animals is not guaranteed.
Actiphage	Blood test	95% sensitivity (95% CI; 0.84–0.99) Specificity 100% (95% CI; 0.92–1)	Can differentiate between vaccinated and infected cattle Can detect *M. bovis* bacterium within 6 hours [219]	The test is not currently validated for use and so farmers have to pay for it privately from PBD Biotech if they want to use it after acquiring permission from APHA.

Key References:

De la Rua-Domenech R, Goodchild A.T, Vordermeier H.M, Hewinson R.G, Christiansen K.H, Clifton-Hadley R.S. (2006). Ante mortem diagnosis of tuberculosis in cattle: A review of the tuberculin tests, γ-interferon assay and other ancillary diagnostic techniques. Research in Veterinary Science 8, 190–210

Live testing of bTB in cattle can be done via skin tests, culture, blood tests, urine, faeces or tracheal aspirate methods (Table 16), although no currently available live testing allows for perfect determination of *M. bovis* infection status of cattle [219]. The tests routinely chosen for cattle are based on ease of obtaining a sample, cost and time of processing the sample, and, ideally, the accuracy of the test's detection.

As demonstrated in Part III, the reliance on the SICCT test as the standalone test for routine cattle testing is not scientifically supported (Text box 22) [157, 158]. Like Wales, which has achieved bTB free status in 94% of its herds, farmers in England would benefit from ease of access to additional test methods and more regular and consistent testing intervals.

Text box 22: SICCT test limitations

The effectiveness of the SICCT test is compromised by a variety of factors, including but not limited to: other pathogens the cows may be hosting; certain genetic lines of cattle; and pregnant cattle may all reduce the accuracy of the SICCT test [224, 225].

Furthermore, **the interpretation of the results of the SICCT test is highly subjective**. A positive result is determined by evaluating the relative size of lumps caused by an inflammatory immune response to adjacent injected samples of *M. Bovis tuberculin* and *Avian tuberculin* [157, 211]. Whether a result is deemed positive depends on the severity of the testing protocol in place, which may be higher in different risk areas or if the herd has had a previous breakdown. There has been further evidence that the judgement of what constitutes a positive result is affected by the gender of the vet administering the test [211, 226].

More recently a combination of SICCT and interferon-gamma (IFN-γ) blood tests has increased the accuracy of tests slightly, but even that has major limitations and 20-50% of cattle judged to be officially TB free (OTF) could actually be infected with bTB [4].

10.1.2.1. Validated tests

A validated test for testing for bTB in cattle is one that has been approved by the World Organisation for Animal Health (WOAH/ previously OIE).

The Single Intradermal Comparative Cervical Tuberculin test (SICCT) and the supplementary interferon-gamma (IFN- γ) blood test are the only tests currently approved for live cattle as part of the statutory cattle bTB testing programme in England [142] (see Table 16). The IFN- γ, whilst good at detecting infected cattle missed by the SICCT test, requires samples to be kept in temperature-controlled conditions for laboratory analysis [227], is more costly to perform, and can produce a higher number of false positives than the SICCT, making it politically unacceptable as a primary diagnostic test [228].

Currently, IFN-γ is only used under certain conditions at the taxpayers' expense. Its voluntary use can be used at the farmers' expense. This lack of investment into other methods suggests a reluctance from the government to move away from the largely inaccurate SICCT test, perhaps due to financial reasons, or the lack of measures in place to effectively handle a larger scale of bTB infected cattle than currently accurately identified.

The IDEXX ELISA is an antibody assay but is only allowed in England for discretionary use in exceptional situations where there are chronic or persistent herd breakdowns after the SICCT and IFN-γ have been used repeatedly.

10.1.2.2. Non-Validated tests

Some tests are not yet validated by the EU or by the WOAH, meaning that they are not yet rolled out by the government for routine use. This does not mean that the tests are flawed or inaccurate, and indeed some of these tests are already used at the discretion of APHA or the Welsh government.

The benefit of using non-validated or non-DEFRA-approved tests is that it allows farmers to identify high risk animals missed by other tests and thereby manage their herd, e.g. in isolated groups until the end of lactation. In Wales, if after a specified period test positive animals remain they must undergo a high sensitivity testing regime and if positive will be removed with compensation [141]. In England, APHA is under no obligation to remove test-positive animals using unofficial tests, and therefore no compensation will be given unless an animal tests positive to an approved testing method [142]. For industry, the benefits of field trialling these unofficial tests are that they get to more rigorously test the field application of the methods.

Two tests that have the potential to dramatically improve the accuracy of detecting bTB in cattle are the Actiphage blood test and the Enferplex antibody test.

Actiphage is one such test that can be used at the discretion of APHA. This blood test can detect *M.bovis* bacterium within six hours and is thought to have a sensitivity of 95% and a specificity of 100%. Currently, farmers have to pay for it privately from PBD Biotech if they want to use it after acquiring permission from APHA.

The Enferplex antibody test, although approved by WOAH, has not yet passed EU regulations or been approved by DEFRA. The Enferplex has a diagnostic specificity of 98.4 - 99.7% using high sensitivity and high specificity settings of the test, respectively [222]. Results from this test to date appear to undermine the accuracy of both the SICCT and the combination SICCT/IFN-γ test even further (Watt et al., 2021). The Enferplex can also differentiate between vaccinated and infected cattle.

The accuracy of these tests has revealed devastating implications for the number of infected cattle going unnoticed [4]. Thousands of infected cattle may have been missed by the widely used SICCT testing regime, allowing infected cattle to freely take part in the 2.8 million cattle movements that occur annually.

All animals that test positive with tests not currently validated, however, do not have to be compulsorily slaughtered, and compensation is not given [229, 230]. Test-positive animals are either voluntarily slaughtered or restricted to the holding for life. Testing from non-validated tests does not contribute to the lifting of movement restrictions.

There is little incentive, however, for farmers to self-fund these additional tests, especially in high risk areas, as the financial cost to the farmer is potentially high and the benefits negligible without the tests being approved for use. The farmer would have to pay for:

- the voluntary non-validated or non-approved tests;
- the cost of the slaughter of test-positive animals;
- if a farmer does not slaughter a non-approved test-positive individual, they cannot regain OTF status under the mandatory APHA protocol without paying for a private IFN-gamma parallel test for these individuals;
- farmers will get no compensation for slaughtering non-approved test-positive individuals.

Of note, milk from dairy cows that have tested positive to these non-validated or non-DEFRA-approved tests (even with their high detection rates), can still enter the human food chain and go through pasteurisation.

These tests need to be urgently approved, rolled out, and financed as standard for the more accurate detection of bTB in cattle (Text box 23). More accurate testing would reduce stress and improve farmers' welfare by reducing the number of tests required to get an accurate response, enabling farmers to act quickly in the event of a breakdown or to be able to trade without reservations. This would simultaneously improve cattle welfare.

Text box 23: Recommendation 9. Validate and approve more accurate tests

Significantly increase resources into validating the more accurate Actiphage test and approving the Enferplex test as soon as possible followed by the financing, training, and rollout of these tests as **statutory bTB detection measures**. Doing so would improve animal welfare, reduce farmer stress by allowing early and accurate detection, and reduce the financial burden on farmers by allowing compensation from these tests.

10.1.3 Prioritisation of a cattle vaccine

When combined with other disease control methods such as improved biosecurity and husbandry practices, vaccination can be a key tool for tackling infectious diseases. Cattle vaccination itself is not 100% effective at preventing bTB infection, with its spectrum ranging from full protection to not protected at all [2], and its unknown impact on cattle-cattle disease transmission. This is not unusual in vaccines, and protection is maximised by ensuring wholesale takeup, hygiene measures, and related biosecurity. Therefore, vaccination should not be considered as a cure-all alone but rather to work alongside other effective methods of cattle management.

The efficacy of the vaccine is further dependent on individual or herd history such as other disease load and, perhaps, stress. Vaccination is likely, however, to reduce the severity, progression, and excretion of bTB [231], as well as transmission [232]. These factors make a cattle BCG vaccination a feasible option to help reduce the significant costs to the farmers associated with the slaughter of reactor cattle.

Despite promising results in initial testing [233, 234], the main limitation to vaccine development remains the interference of the Bacillus Calmette–Guérin (BCG) vaccine with routinely used SICCT skin tests. The BCG vaccine, as used in humans, causes approximately 80% of cattle to show false positive results using the SICCT tuberculin test [235]. Without effective testing regimes that can differentiate between infected and vaccinated cattle, the disease control benefits of vaccination are limited. A high number of false positives from vaccinated individuals could put farms under bTB restrictions repeatedly and for prolonged periods, risking business viability.

As a result, bTB vaccination for cattle is prohibited in the EU in line with international trade standards set by WOAH. This prevents the live movement of cattle and cattle products (excluding meat) without a negative test result. Since Brexit, this legislation doesn't apply directly, but the UK would not be able to trade in Europe without a clear bTB test unless there was a free trade agreement, which, at the time of publication, is not in place.

In addition to vaccine development, this highlights the need for research into alternative testing methods that are not only more effective than SICCT (section 10.1.2), but can also differentiate between vaccinated and infected cattle. The BVA has also asked the government to reconsider if the SICCT test is the right test to be used to identify and remove bTB from herds and to consider alternative tests [32].

While trials to estimate the effect of a vaccine on transmission are relatively simple, demonstrating the cost-effectiveness for farmers of a cattle BCG vaccine is significantly more difficult, and would need to involve 500 herds, with up to 75,000-100,000 cattle. [236].

In the UK, phase 1 trials towards CattleBCG vaccination commenced in 2021, which focused on the effectiveness of the Differentiate Infected and Vaccinated Animals (DIVA) skin test in unvaccinated animals [237]. Although the DIVA interferon gamma test or DIT, was effective at identifying bTB-free or vaccinated animals [238], the sensitivity for infection detection was only slightly better (56%) than that of the tuberculin SICCT [239], which is not sufficiently effective in a stand-alone routine cattle testing [157, 158], as previously discussed (section 10.1.2). Phase two trials have commenced, and are due to be completed in 2023 [237].

However, the Actiphage test, as shown in Table 16 above, has more promise. Although not currently WOAH-validated, it has high accuracy and can differentiate between infected and vaccinated cattle. This should be a priority area for financial input and other resources.

Even after securing a successful vaccination and associated testing protocol, the feasibility of deploying it in practice requires work. Mandatory deployment of the vaccination has not been confirmed, and would likely be initially deployed in the HRA targeting high risk herds [2]. It is also likely that stockholders will be required to fund vaccination, particularly outside of the HRA [235]. The cost of additional animal identification and movement tracking will also need to be covered, but this could be preempted by mandatory biosecurity and movement restrictions (section 10.1.4.1). There will also be a need for education work to be done with farmers and cattle buyers to get buy-in towards the acceptability of cattle BCG vaccination. Trade implications will be an important factor to farmer uptake as any DIVA test would need to be validated for international trade and export of live animals, meat, milk, and their products as well as the implications for OTF status for England, Scotland and Wales [2].

This should, however, be considered in the context of the present system in which cattle tested using the SICCT test with its well-documented unreliability are accepted for sale. The SICCT test is very unlikely to give a false positive reading, so cattle without disease are unlikely to test positive and cause their sale to fall through. However, the test is unreliable, so it's possible for infected cattle to give a false negative result, and be sold on to an unsuspecting owner, taking bTB with it into the new herd at home or abroad. Present trade arrangements are therefore allowing undetected reactors to be bought and sold.

Text box 24: Policy Gap: Prioritise Cattle Vaccination and DIVA test
The development of a cattle vaccination and appropriate DIVA test has not been adequately prioritised. Even when available, it has not been confirmed that cattle vaccination will be a mandatory policy.

10.1.4 Targeting "disease hubs" within the farm network

In the UK, cattle trade occurs privately via dealers or cattle markets, and each animal movement is documented on the National Cattle Tracing System (CTS). A systematic review of cattle movements documented on the CTS conducted by researchers in 2019 illustrated the scale of cattle movement and the high potential for disease spread [155]. In total, 158 million individual animal movements were recorded from 2001 (when recording became mandatory) to 2015. Of these, 26 million movements (35%) took place via markets and showgrounds, conditions well associated with the concentrated mixing and then dispersal of animals [240] Farms have been known to purchase cattle from over 60 different animal holdings in one day from one cattle market [241].

In all, the 2019 CTS analysis, which excluded the movement of cattle to slaughterhouses, revealed 9.5 million edges (links between contacts), and 70,000 nodes (contact points), to which the authors concluded:

"the British cattle network is complex, and the potential transmission pathways can be extensive" (p.12).

The analysed data also revealed that cattle farms fell into two groups; those with few contacts on their contact chain (typically fewer than 10) and those with more than 1000.

Farms with the highest degree (those that traded with the most farms) were connected with those with low degrees (those that traded with few), and vice versa, and larger farms tended to have higher strength, meaning they were responsible for trading more animals. Of the latter, dairy farms were more commonly represented. Thus, dairy farms which become infected may be "disproportionally influential for disease spread into the cattle network" (p.13). Such farms act as hubs for disease, an epidemiological role previously attributed to markets.

Approximately 20% of farm holdings contribute to 80% of livestock movement [242]. Yet there is no way for farmers to know if the farm they are trading with is a potential hub for disease, even though cattle movements are nationally documented.

Whilst cattle purchasing will likely always carry some degree of risk, the government has not made it mandatory or even possible for farmers to avoid or reduce risk by introducing robust controls on cattle movement.

For example, movements from the HRA to lower incidence areas in England, Wales, and Scotland are thought to account for between a quarter and a fifth of all new bTB herd breakdowns in the LRA each year and one in six in the Edge Area [143, 243]. Remembering here the low detection rates of the SICCT test means that a significant number of cattle will record as false negatives, meaning that this figure will in reality be much higher.

Text box 25: Evidence for drivers of bTB in cattle
The APHA Year-End bTB Epidemiological Reports for each cull county have shown that **"Movements of undetected infected cattle remained the biggest driver for new incidents"** [156].

The North East England [244] report went further to say **"Only cattle movements were identified as a key driver of the TB epidemic in the NE of England during 2022"**.

Where badgers have been listed as a 'probable' driver for an area, this is on limited datasets. For example, in Cheshire in 2021 the first listed "key driver" was "exposure to probable infected badgers" [245]. Yet the underlying Disease Report Forms (DRF) data showed that there were no "definite" badger cases in the area 0 (0%) out of the 184 cases noted on the DRF forms as badger-related. This ignores other potential vectors or transmission routes even in the absence of evidence of bTB coming from badgers.

As yet, the government has not introduced effective traceability of cattle movement on a national scale despite the high rates of cattle movement in Britain being well documented as a driver towards bTB transmission [20]. Farmers are unable to determine the risk level per farm when making purchasing decisions. Cattle are also free to graze on land shared with high-risk herds and other livestock that can contract and carry bTB but which are not routinely tested [13., 154].

Given that farm movements are already documented, the government could investigate the role of the National Cattle Tracing System (CTS) in identifying high risk farms and setting strategic control measures accordingly. Targeted measures have previously been applied to cattle markets [246].

Text box 26: Policy Gap: Cattle Movements and associated risks
Cattle movements are currently not adequately controlled on a national scale as part of the bTB eradication programme in England. Unless farmers know the risks associated with cattle purchases, they are unable to protect themselves from introducing high risk cattle into their herds.

It is unclear why the National Cattle Tracing System has not been used to identify and target farms that could act as "hubs of disease" with additional cattle measures.

10.1.4.1 Traceability
It should be noted that at the time of writing the government is holding a consultation on upgrading from the paper-based CTS to a digital Livestock Information Service (LIS) to simplify legislation and support new technologies. The new system will digitise the process using bovine electronic identification, linking everything to scannable cattle ear tags. It also proposes to include whole movement reporting, and voluntary pre-notification reporting to enable farmers to better plan their purchasing options.

It is proposed that the LIS will become a central database tracking the movement and medical records of livestock in the UK.

This would enable more collaboration and cooperation between governments, farmers, and vets as an animal's history would be readily available allowing informed decisions around testing and purchasing of livestock.

As recognised in the consultation briefing pack, "the accuracy of traceability data and the speed with which it becomes available is critical to reduce the impact of disease". This is a vital tool that focuses on cattle movement and trading measures and Badger Trust is hopeful that the consultation will lead to the necessary legislative changes to truly monitor movement and mitigate disease hubs (Text box 27). The devolved nations have already, or are in the process of, implementing a digital cattle tracing service.

Text box 27: World-leading Livestock Information Service

Improving the traceability of livestock will allow the UK to enter into new trade deals. If the LIS can become a world-leading standard in livestock traceability, it would give the UK a competitive advantage and make the UK more responsive to animal welfare and disease.

10.1.5 Farm biosecurity (including slurry)

Implementing robust biosecurity measures can significantly reduce the risk of disease transmission, as well as being beneficial to public health, environmental health and animal welfare. Outbreaks of diseases in livestock are highly likely to significantly disrupt local and national trade through their far-reaching and systemic impacts, as well as causing significant financial and social stress to farmers.

Text box 28: Tracing of disease outbreaks

Rules need to be more strictly enforced relating to the movement of livestock, ear-tagging, cattle passports, registering of livestock deaths or keeping on-farm records. **Without this, it is almost impossible to trace disease outbreaks.**

By mandating and checking basic farm biosecurity measures, the economic and social disruption caused by bTB outbreaks can be limited (Text box 28). Additionally, effective biosecurity measures can reduce outbreaks and the impact of other diseases, including foot and mouth disease, bovine viral diarrhoea, leptospirosis, mastitis and infectious bovine rhinotracheitis [164].

It is important to minimise the risk pathway from within a herd, such as where inconclusive reactors (IRs) may be present. Resolved inconclusive reactor cattle are 12 times more likely to become a conclusive reactor [11]. Having a clear farm mitigation plan, and appropriate legislation for removing IRs from a farm, allows farmers to safely mitigate disease risk from these individuals and is key to reducing the likelihood of whole herd breakdowns [11].

The recent outbreaks of Highly Pathogenic Avian Influenza (HAPI), African Swine Fever and Coronavirus (COVID-19) have highlighted the importance of biosecurity for public health [247], attracting growing public concern and scrutiny [248]. Implementing biosecurity protocols on farmland not only reduces the risk of livestock contracting diseases but also reduces the risk of exposure of farm professionals and the public to potentially zoonotic diseases.

It is possible that livestock can contract bTB and other diseases indirectly from contaminated water [249 - 251]. Using fencing, farmers can prevent cattle from drinking from potentially contaminated watercourses, protecting livestock from contracting diseases, and also preventing urination or defecation in or near water to reduce the risk of contamination of water downstream. Similarly, avoiding spreading slurry on pasture near watercourses will reduce the risk of contamination. These measures additionally result in the added environmental benefit of reducing pollution and degradation of water systems [252, 253], saving water companies and taxpayers' money on costly filtration systems [253].

Careful management of slurry and manure can also be effective biosecurity measures to prevent bTB infection. Bovine TB bacteria survive in cool, dark, damp environments with a neutral or slightly acidic pH, just like a slurry store. *M. bovis* bacteria can remain infectious for up to six months in stored slurry, and survive on pasture for up to two months in the summer, and up to six months in the winter [229]. Slurry options include ensuring that all hired slurry equipment is sanitised before entry to the farm, avoiding slurry spreading on pasture [254], increasing storage duration from two to six months for manure and slurry respectively, and ensuring that there is a minimum of 60 days between slurry spreading and grazing cattle [255].

Studies based on culture have shown *M. bovis* persistence in the faeces of infected cattle [256 - 258] More recent work has disputed this, suggesting that transmission risk from shedding of *M. bovis* in faeces of infected cattle is thought to be lower than previously thought [259]. However, it remains evident that contraction of bTB from faecal matter is possible, particularly when the infection is advanced [259]. Due to the inaccuracy of the SICCT test, we don't truly know the bTB status of any herd, making it difficult to assess the true risk from manure or slurry spreading within each herd. Therefore, it is better to adopt a cautionary approach and follow these biosecurity measures regardless of herd status, as a 'no-regrets measure'.

The CHECS scheme is a UK-wide TB entry-level membership that teaches biosecurity 'basics' to help farmers reduce the risk of bTB breakdowns in their herds [11]. Based on six biosecurity risk factors the scheme is designed to be accessible and achievable by the majority, so that farmers can get involved at their own level. It promotes that even small, low-cost changes in biosecurity measures can make a difference. These 'no-regrets measures' focus on the major risk factors of bTB for cattle herds (Text box 29). This sits alongside the TB Herd Accreditation scheme which sets more stringent standards to protect against bTB infection, but the scheme had more limited take-up. The Entry-level membership scheme is an attempt to break down some of those barriers to efficient biosecurity measures. It was also recognised that vets need to increase engagement in bTB biosecurity with their clients, so the CHECS scheme provides half-day training for vets to become BCVA Accredited TB Advisers (BATVA), to help equip vets with the tools needed to forge stronger relationships with farmers. CHECS TB Herd accredited farms in an HRA or edge area may also be eligible to stay on annual testing, rather than six-month testing, rewarding clients that are actively engaged with TB biosecurity. The CHECS scheme is a great step change, but will only realise its full potential if it becomes a mandatory part of biosecurity training.

Although the implementation of biosecurity measures inevitably comes with costs, these are compensated through the long-term health and continued productivity of livestock [260]. Good practices of biosecurity and maintenance of welfare standards are also linked to reduced antimicrobial usage and associated costs [261]. There are also various advisory groups such as the CHECS above, and different funding avenues regularly reviewed by the government. Many of the practices, however, involve time, effort, and accurate information.

Text box 29: CHeCS Scheme
"Key element will be the farmer vet conversation around (b)TB and controlling the controllable'' *BVCA endorsed CHECS scheme, 2021.*

10.1.6 Badger and other wildlife Biosecurity

Badgers are nocturnal and can go unnoticed on farms unless farmers are aware of accurate badger signs. Badger activity can be identified via sett surveying around cattle grazing paddocks, and mapping activity such as badger pathways and latrines. Farmers can also place wildlife cameras around the farm to identify areas of badger activity and interactions. Farmers can get help with identifying badger signs from their local badger group, or through hiring an ecologist to conduct a survey on the land.

Bovine TB bacteria can live up to 60 days in water [11], so raising water troughs and feed buckets or licks to more than 1m off the ground prevents badgers from sharing access to these stores and possible disease transmission pathways between species in both directions. Troughs and licks should also be positioned in ways which prevent cattle from defecating in or on them and risking direct contamination with faeces.

Badgers can get through gaps as small as 7.5cm, so ensuring that there are no gaps inside sheds or to stored feed can prevent access by badgers and other wildlife. However, it should be remembered that badgers rarely enter farm buildings in this manner.

Electric fencing has also been shown to be a successful badger deterrent when placed around the boundary of grazing fields [262]. Implementing these measures can be sufficient for minimising badger-cattle interactions.

Direct transmission between cattle and badgers at pasture is highly improbable as badgers and cattle have been shown to avoid direct contact with each other [53, 263, 264]. More likely, transmission would occur through ingestion of bTB bacterium at badger latrine sites [265]. Cattle generally avoid areas of grass soiled with badger faeces and urine, but grazing on contaminated herbage is more likely when overgrazing occurs [265], and overgrazing is more likely to occur with overstocking. By managing grazing regimes and reducing stock density, the risk of cattle encountering potentially contaminated badger latrine sites is greatly reduced [19, 266, 267]. Where possible, allocating grazing fields away from badger setts can also prevent transmission of bTB to badgers [19, 266, 267].

Implementing these wildlife protection measures rather than lethal control, allows a potential risk pathway to be managed whilst ensuring wildlife is protected and farming practices sustainable.

10.1.7 Livestock grazing

Careful management of livestock grazing habits can reduce the risk of transmission between herds and wildlife. Cattle-cattle transmission is very likely when cattle come into direct or indirect contact, and overgrazing of land will increase the risk of cattle grazing in close proximity to faecal matter that may contain pathogens [19, 266, 267].

The bTB bacterium has been shown to persist on faeces left in pasture for at least six months in winter, or one to two months in summer [268]. Using shared community pasture, or leasing pasture can therefore indirectly expose livestock to bTB bacteria. By leaving time for the bacteria to biodegrade between moving cattle into a previously grazed area, stock keepers can minimise the risk of bTB transmission from bacterium persisting in the soil or faecal matter [269, 270].

Proximal contact between neighbouring herds, such as through fence lines or shared water courses, along lanes and gates, can allow direct aerosol contact between individuals. This can be avoided by preventing contiguous grazing, allowing a 3-metre gap, or large hedges or sheeted fencing to prevent contact. Farmers may not know the risk status of their neighbours' purchasing measures (these are generally confidential) so it is important to mitigate this between herds' transmission route.

10.1.8 Livestock Husbandry, Management, and Stress

The link between stress and increased susceptibility to disease due to immune system suppression is widely understood [271]. Animals under stress are more likely to suffer compromised immunity, becoming more susceptible to disease [271 - 273]. Stress responses can damage productivity and fertility, leading to reduced profits. Stress can also cause changes in behaviour, making animals more aggressive and dangerous, or affect within-herd sociality [274].

The delay between an animal becoming infected and becoming infectious is known as the latency period. Within this period, cattle may be infected but not test positive, or later, test positive but not yet be infectious [273]. For bTB, this delay can be a significant period of time and has been estimated to be around 20 months for cattle under regular testing [275]. However, heightened stress increases the risk of latent infections becoming reactive more quickly, increasing the risk of rapid cattle-cattle transmission within a herd prior to detection [275].

Animals subject to unfavourable environmental conditions, poor husbandry, inadequate nutrition or social distress will be more likely to suffer compromised immunity from heightened stress [271 - 273]. Poor hygiene and welfare standards also create ideal conditions for disease to thrive and rapidly spread.

By avoiding overcrowding, ensuring good ventilation, providing a good diet, maintaining hygiene standards, and reducing stress from management practices [276], animals are less likely to succumb to illness or disease (Text box 30), infections are less likely to spread rapidly, and latent infections are less likely to become active before detection [265, 272]. Ensuring good hygiene and conditions also reduces the risk of other diseases that affect productivity, such as lameness or bovine mastitis [277].

As already discussed (section 6.1) bTB causes considerable stress to farmers and stock owners, as well as their communities. Implementing cattle-based measures on farms can help farmers reduce stress by reducing bTB risk [208].

Text box 30: Cattle Welfare

"**Population density and housing animals in buildings with poor air circulation are important transmission factors.** Less important modes of transmission are ingestion of milk or feed heavily contaminated with *M.bovis*" [278]

Part IV Summary

- The current bovine tuberculosis control strategy costs an estimated £100 million per year to implement. Of this, an average of £30 million a year is issued as compensation to farmers when they suffer the loss of cattle from bTB herd breakdowns. On average, a herd breakdown costs the farmer £6,000. It costs the taxpayer £10,000.

- The financial costs of the current bovine tuberculosis control strategy implemented by DEFRA are, therefore, insufficient to cover the true costs involved in bTB management. Furthermore, as the current strategy is failing to bring the disease reduction benefits desired, the bill continues indefinitely.

- The badger cull has cost at least £58,776,156 from 2013-2022 according to official figures.

- Deployment of a successful cattle vaccine and testing protocol must be rolled out alongside additional animal movement identification and movement tracking, with mandatory biosecurity measures. This needs to be done alongside educational workshops for farmers and cattle buyers.

- Significantly increase resources into validating and approving more accurate tests such as the actiphage test and the Enferplex antibody test as soon as possible. These tests could be critical to better and earlier detection of infected animals.

- Cattle movements are not adequately controlled on a national scale to restrict disease spread. The National Cattle Tracing System, soon to be replaced with the Livestock Information System (LIS), needs to be better used to identify high risk farms and set strategic control measures accordingly. Currently, farmers are unable to determine the risk level per farm when making purchasing decisions.

- The LIS system could be linked up with the devolved nations so that there is a combined effort in bTB security strategy.

- Redirect costs from culling badgers to the implementation of annual combination testing and associated farmer support. The government could then better support farmers to protect their herds from the main cause of bTB transmission, cattle-to-cattle infection.

- Direct resources into developing a scalable, cost-effective badger BCG vaccine programme, that could be used to prevent reinfection to badgers, after the cattle transmission path is resolved.

- Effective biosecurity measures can reduce outbreaks and the impact of other diseases, including foot and mouth disease, bovine viral diarrhoea, leptospirosis, mastitis and infectious bovine rhinotracheitis.
- The recent outbreaks of Highly Pathogenic Avian Influenza (HAPI), African Swine Fever and Coronavirus (COVID-19) have highlighted the importance of biosecurity for public health, attracting growing public concern and scrutiny.
- Avoiding slurry spreading on pasture, and increasing storage duration from two to six months for manure and slurry, respectively, can reduce infection risk.
- The CHeCS Herd Accreditation and TB Entry Level Membership programmes are likely underutilised and could benefit from being taken up more widely by cattle farmers. The 'no regrets measures', as part of the entry-level scheme, focuses on the major risk factors of bTB to cattle herds. Developed with the BCVA, we welcome the proactive design of the course to improve input from private vets and encourage farmers and vets to have these infectious disease management conversations together.
- Good practices of biosecurity and maintenance of welfare standards are linked to reduced antimicrobial usage and the associated costs.
- Poor welfare standards create ideal conditions for bTB to thrive and rapidly spread between cattle. By avoiding overcrowding, ensuring good ventilation, providing a good diet and hygiene standards, and reducing stress, animals are less likely to succumb to illness or disease, and latent infections are less likely to become active and spread.
- We urge readers to remember that these measures will not only help prevent bTB but a host of other costly and preventative pathogens that affect the livelihoods and welfare of farmers, and their livestock.

11 Tackling bTB Effectively Together: Conclusions

Bovine TB is primarily a respiratory infection, and whilst some level of infection can remain in the environment, its main route of transmission is direct contact with an infected individual of the same species. For cattle, this main transmission route is the inhalation of affected aerosols from other cattle [5]. Bovine TB remains a persistent concern for British cattle farming, and cattle-cattle transmission has been recognised overwhelmingly as the primary driver of bTB outbreaks in cattle herds. All cattle movements are at risk from many different infectious diseases, bTB is one of these.

One of the UK's biggest selling points is its animal health and welfare standards, and since Brexit, it is important that we continue to maintain these standards. We must consider the UK as a single epidemiological unit and recognise that bTB is everybody's responsibility. We need to work collaboratively together, across the devolved nations, to empower and strengthen everyone involved in tackling this complex disease (Text box 31).

Throughout the report, we have highlighted that in order to bring about significant reductions in bTB in cattle, a variety of cattle measures are needed nationwide. We have highlighted many gaps in this report, both in the practices and in the ideology perpetuated around the primary transmission route and spread of bTB. Many of these top-down approaches need strong leadership to make a change. We hope, by highlighting these gaps and opportunities, to make a significant impact on the reduction of bTB in cattle, that we can focus on the primary transmission and risk pathways to cattle, and can immediately halt the end of the destructive, and ineffective cull of badgers. This includes the cattle-epidemiology-led culling of badgers, which as we have shown, will have no beneficial impact on reducing bTB in cattle.

Text box 31: Renewed opportunities for sustainable practices
With increased recognition of the interplay between animal, human, and planetary health, policymakers have a renewed opportunity within the current social and political climate to commit to **a One Health and One Welfare stewardship of British ecosystems**. To do so, policymakers need to better support British farmers to integrate bTB control measures into their animal welfare and environmental sustainability practices.

In Part I of this report, we traced the management of the disease in Britain and showed that bTB was once effectively managed via cattle biosecurity. Through a review of the scientific and policy literature, we showed that previous badger culling trials were unsuccessful in reducing the rates of bTB in cattle. The results of the 1998-2005 Randomised Badger Control Trial led to the recommendation for cattle-based measures to be pursued instead of badger culling. However, despite this scientific advice, the government introduced badger culling in 2013, and it has continued to be implemented in greater levels of land coverage ever since. By 2022, over 210,000 badgers had been eradicated, yet there remains no evidence to support its contribution towards declining rates of bTB in cattle. Indeed, bTB rates were falling steadily before the introduction of badger culling, and a recent analysis of government figures revealed that badger culling was not causing reduced instances of bTB in cattle.

Throughout Part II we looked at the ethics of badger culling as a form of bTB control, and argued that badgers are not only essential for ecosystem health, but they are also iconic species that hold significant value for British natural and cultural heritage. We also explained how badgers are a species that have endured a long history of persecution, with rates of badger baiting so high as to warrant the introduction of the Protection of Badgers Act 1992.

Badger Trust argues, therefore, that the economic and ethical costs of the cull are disproportionate to the role badgers play in spreading bTB to cattle and the impact of disease reduction from culling.

The role of badgers in the transmission of bTB has been long debated and scientific advancements, including Whole Genome Sequencing, have shown that cattle-cattle transmission is the most common pathway through which bTB spreads.

We have specifically highlighted that badger culling contravenes several of Britain's nature protection commitments, including The Bern Convention, the UN Sustainability Goals, the Kunming-Montreal Global Biodiversity Framework, and the International Consensus for Ethical Wildlife Controls. Overall, throughout Part II of this report, we have demonstrated that badger culling is unscientific, ineffective and inhumane.

In Part III we considered the various attitudes towards bTB control from different stakeholders. We began by comparing bTB control strategies from the devolved nations of Britain and highlighted that England remains the only country in Great Britain to cull badgers. Scotland is largely bTB-free by restricting cattle movements into the country, and Wales has controlled bTB by focusing on mandated cattle biosecurity and testing measures. Both Scotland and Wales have healthy badger populations.

Specifically, we drew attention to the differences in cattle measures implemented by the English and Welsh governments. Namely, Welsh policy includes more rigorous testing of cattle (in terms of frequency of testing and application of combination tests), and the linkage of mandated policy, compensation eligibility, and pre-movement testing. We also showed that Wales effectively monitors disease in wildlife populations, and implements targeted measures such as badger vaccination to the populations where disease rates are evidenced. In England, cattle testing is less frequent and less rigorous, and wildlife disease is not routinely monitored. Neither is policy compliance related to compensation eligibility. We also highlighted a slight increase in rates in the LRAs of England and recommended that this needs to be addressed with mandated biosecurity and testing measures.

We also investigated the attitudes of farmers towards bTB disease and bTB eradication strategies. Our online survey revealed that farmers feel frustrated by the lack of progress made in bTB reduction, yet much blame for the disease is placed on badgers and their protected legal status. Most importantly for policymakers, our results indicate a common misconception amongst farmers regarding the epidemiology of bTB transmission. Overwhelmingly, participant farmers incorrectly ranked cattle movement and shared grazing as a lower disease risk than the risk posed by wildlife, and very few farmers implemented biosecurity at scale enough to prevent disease from spreading.

In Part III we also highlighted the important role that private vets can play in building positive farmer relationships and providing tailored biosecurity plans. Private vets can, however, feel frustrated and stressed by national regulations and there is a need for private vets to be allowed a stronger leadership role in managing bTB and to find solutions that enable more collaborative working with government vets.

Nature-based NGOs also have a role to play in the narrative and discourse used when discussing bTB policies. Using evidence-based, inclusive language, nature-based NGOs can work together with other stakeholders to find solutions to bTB that uphold non-lethal wildlife control and nature protection.

Alongside each of our findings, we have provided policy recommendations, such as support for enhanced testing and further uptake of on-farm biosecurity measures. We highly encourage the formation of a cross-disciplinary coalition of stakeholders, to ease the tensions currently surrounding the politicised nature of badger protection and to open communication channels between farmers, the veterinary sector, the public, policymakers, and animal welfare and environmental non-governmental organisations.

In Part IV we analysed the economic and disease reduction benefits of cattle-based measures and the non-lethal control of wildlife. The financial costs of the current bovine tuberculosis control strategy implemented by DEFRA are insufficient to cover the true costs involved in bTB management. Furthermore, as the current strategy is failing to bring the disease reduction benefits desired, the bill continues indefinitely.

By drawing on a range of scientific studies, we demonstrated the importance of implementing policies that cover the entire farm network, and we theorised that the new Livestock Information System (to replace the cattle tracing system) must be used more effectively to identify farms acting as bTB ”hubs'' that could be targeted with additional disease prevention measures. We also want to see this system linked up with the devolved nations, so that there is a combined effort in bTB security strategy. We also recognised that infected cattle are a hidden reservoir of the disease without adequate testing measures in place, and discussed the advantages to be gained by the urgent need for the government to adopt new cattle testing technologies (namely the Actiphage and Enferplex tests), alongside the rollout of a cattle vaccine, and increased farm uptake of biosecurity on farms.

We support the notion that farmers can help to ‘control the controllable’, through on-farm biosecurity measures as highlighted by the BCVA and CHeCS programme when farmers are given the correct information and support. The results of our survey showed that some farmers believe that biosecurity measures are not overly effective and that wildlife is the main driver of bTB. Thus there was a key need for knowledge transfer between vets and farmers around bTB transmission pathways and mitigation methods. The CHeCS scheme supports this by offering accredited bTB training to vets so that the relationship between farmers and vets on the bTB narrative can be strengthened. We hope that this programme will reach scale enough to enable the majority of farmers to have access to this information and service across all areas, including those in the LRAs.

Overall, in Part IV we not only highlighted the strengths of a non-lethal wildlife control policy for solutions to bTB, but we emphasised the need for leadership by policymakers to make policy more consistently upheld and easier to follow.

We have attempted in this report to take a step into the needs and challenges of cattle farmers and the farming community, but we are not experts in this field nor do we have access to all of the information as to why certain farming practices and policies are not currently enacted. This is a first step for us in opening that dialogue between two often disconnected sides of the argument. Through empathy and respect, we want to support farmers in having a platform to work together with nature and conservation bodies in finding solutions to the bTB endemic together, with a government that supports that ambition. Only by working together, can England tackle bTB effectively, which can in turn only be achieved by protecting cattle, wildlife, and the environment sustainably.

Badger Trust advocates for a policy environment that supports farmers, vets, governments, and nature and conservation bodies to work together to create a sustainable future. We are committed to an open dialogue with the UK government, local and national policymakers, and politicians from all major parties.

12 Recommendations at a glance

In summary, effective bTB solutions require proficient government leadership via mandated measures that remove confusion for farmers, support private vets, provide an honest narrative of effective methods, and offer comprehensive support to eradicate bTB from cattle. All stakeholders involved have a role to play in depolarising the narrative around bTB and working towards open communication. Only by working together, can Britain tackle bTB effectively, which can in turn only be achieved by protecting cattle, wildlife, and the environment sustainably.

One of the UK's biggest selling points is its animal health and welfare standards, and since Brexit, it is important that we continue to maintain these standards. We must consider Britain as a single epidemiological unit, as disease does not respect political boundaries, and recognise that bTB is everybody's responsibility. By using a joined-up approach, we can work collaboratively together, across the devolved nations, to empower and strengthen everyone involved in tackling this complex disease.

Below, we make our stakeholder recommendations for consideration as we move forward in **tackling bTB together**.

Policymakers

- Policymakers need to make a unified effort to tackle bovine tuberculosis by **adopting a non-cull strategy towards badgers that is already being effectively implemented in neighbouring countries**. This needs to be combined with an honest and evidence-based narrative about the limited role of badgers and other wildlife in the spread of bTB in cattle.
- Urgently establish a **cross-sector coalition group** that includes vets, the farming industry, NGOs, and other relevant stakeholders to dispel inaccurate information regarding bTB risk pathways and the most effective best practice disease prevention strategies.
- Task the coalition group of stakeholders with **supporting a shift in the anti-badger rhetoric** towards a rhetoric of sustainable coexistence, in line with national and global biodiversity and sustainability goals. Resources need to be provided that support farmers and landowners to protect the health and welfare of both badgers and livestock and to assist in transparent communications between diverse groups such as the farming industry and nature-based NGOs.
- Invest in **educational outreach** efforts to better equip farmers with the knowledge of bTB epidemiology so that farmers are aware of **the significance of cattle-cattle transmission**.
- Provide sufficient funds to cover **appropriate farmer compensation schemes** for bTB testing and eradication, providing both **financial and mental health support**.
- **Compensation schemes** need to be linked to **biosecurity and husbandry**

measures in place on farms to reward best practices.

- Invest more resources into the more **rapid development and roll-out of a cattle vaccine and diva testing**. Lack of trust in the government's ability to develop and successfully implement a cattle vaccine is in need of urgent attention. Policymakers ought to be more transparent with the details of the cattle vaccination development. Only through a complete and comprehensive vaccination and testing programme will the entire farm network be protected from the devastating impacts of bTB in cattle.
- Significantly increase resources into **validating and approving more accurate tests such as the Actiphage test and the Enferplex tests** as soon as possible. These tests could be critical to better and earlier detection of infected animals.
- It is highly likely that improvements in cattle testing would create an initial rise in bTB cases as more infected cattle are positively identified. Thus, policymakers should prepare farmers for this likely outcome and **implement measures to assist farmers with the financial and psychological impact** of the testing and cattle removal process.
- **Better enforce timely bTB cattle tests** otherwise risking the movement of undetected cattle.
- Ensure an **effectively robust Livestock Information System to identify farms acting as bTB "hubs"** that could be targeted with additional disease prevention measures to protect the farm network. Ideally, this will be a combined effort in the bTB security strategy with the devolved nations.
- Better support British farmers to **integrate bTB control measures into their animal welfare and environmental sustainability practices and legislation**.
- **Direct resources into developing a viable badger vaccination programme that can be upscaled effectively** (either via injectable or oral BadgerBCG vaccine), to prevent reinfection to badgers after the cattle transmission path is resolved.
- Roll out **effective badger epidemiological surveillance** so that badger vaccination can be deployed in high risk areas.

Farming Industry

- **Write to their MPs and MSs requesting further investment in biosecurity support** and an effective cattle vaccine and testing protocol.
- Support and encourage participation in the **CHeCS Herd Accreditation scheme and the TB Entry Level Membership programmes**.
- **Enhance biosecurity measures** that are relevant to the scale and needs of each farm.
- **Consider if husbandry methods are appropriate for the scale of farming**, and reducing disease transmission and susceptibility.

Vets

- Provide **sector-wide support with the appropriate skills investment** to enable accurate veterinary support and advice to support the farming industry, regardless of the area of the country and bTB risk status, for example:
    - Encourage more vets to become Accredited TB Advisors to help improve farmer-vet relations and veterinary expertise in bTB, including those in LRAs.
- Ensure strengthened collaborative working between government vets and private vets, with **private vets taking more of a lead role in tackling bTB**.

Nature-based NGOs

- **Be proactive in using inclusive, evidence-based narratives** to openly engage with diverse groups of stakeholders.
- **Collaborate** with government agencies, farmers, veterinary professionals, and other NGOs to create integrated strategies for bTB management that are science-based and sustainable.
- **Invest in rural community development** to address the polarisation of opinions surrounding the protection of the badger.
- **Fund and encourage wildlife-proof measures on farms** that encourage best practices for biosecurity and disease management, such as using electric fencing and raised troughs.
- **Clearly identify their position on badger culling and bTB policy** to their members and supporters to open the dialogue between stakeholders.

We are not experts in farming practices and have based our recommendations on available research and recommendations made by others before us. We urge readers to remember that these measures will not only help prevent bTB but a host of other costly and preventative pathogens that negatively impact farmer livelihoods and welfare.

The cattle versus badger rhetoric has gone on for too long as a divisive distraction to the complex issues behind the disease and the lack of clear policies and leadership in place. Only by bridging the gap in narratives around bTB will we really be able to find solutions to **tackling bTB together**.

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Appendices

Appendix 1. bTB rates in England and Wales

Table A1. Bovine TB incidence by herd and cattle level in England.*

Year	Cattle herds registered on Sam[4]	Herds not officially TB free at the end of the period due to a TB incident	New herd incidents	Herds under movement restrictions	Total cattle population	Cattle population slaughtered prematurely due to bTB
2012	53,610	3,242 **6.00%**	3,919 **7.30%**	5,026 **9.40%**	5,373,118	28,237 **0.50%**
2013	53,773	3,102 **5.80%**	3,890 **7.20%**	4,897 **9.10%**	5,363,810	26,592 **0.50%**
2014	51,808	2,874 **5.50%**	3,804 **7.30%**	4,133 **8.00%**	5,373,723	26,405 **0.50%**
2015	51,283	3,051 **5.90%**	3,973 **7.70%**	4,089 **8.00%**	5,384,753	28,031 **0.50%**
2016	51,168	2,898 **5.70%**	3,769 **7.40%**	4,176 **8.20%**	5,429,407	29,228 **0.50%**
2017	50,474	3,139 **6.20%**	3,825 **7.60%**	4,353 **8.60%**	5,417,967	33,239 **0.60%**
2018	40,258	2,964 **6.00%**	3,614 **7.30%**	4,358 **8.80%**	5,372,241	32,925 **0.60%**
2019	49,450	2,594 **5.20%**	3,303 **6.70%**	3,767 **7.60%**	5,279,566	31,215 **0.60%**
2020	49,635	2,458 **5.00%**	3,175 **6.40%**	4,110 **8.30%**	5,168,482	27,850 **0.50%**
2021	46,825	2,136 **4.60%**	2,866 **6.10%**	3,477 **7.40%**	5,070,989	27,577 **0.50%**
2022	46,719	2,078 **4.40%**	2,950 **6.30%**	3,605 **7.70%**	5,107,287	22,084 **0.40%**

[4]SAM is a wide ranging operational system that records registration of livestock species, work management and bovine tuberculosis (bTB) [279].

**data from [150]; number of cattle data [151]*

Table A2. Bovine TB incidence by herd and cattle level in Wales.*

Year	Cattle herds registered on Sam	Herds not officially TB free at the end of the period due to a TB incident	New herd incidents	Herds under movement restrictions at the end of the period	Total cattle population	Cattle population slaughtered prematurely due to bTB
2012	12,765	916 **7.20%**	1,111 **8.70%**	1,476 **11.60%**	1,113,141	9,286 **0.80%**
2013	12,699	620 **4.90%**	874 **6.90%**	1,018 **8.00%**	1,094,644	6,106 **0.60%**
2014	12,084	588 **4.90%**	858 **7.20%**	857 **7.10%**	1,102,768	6,371 **0.60%**
2015	11,685	601 **5.10%**	842 **7.20%**	724 **6.20%**	1,118,979	8,086 **0.70%**
2016	11,658	561 **4.80%**	706 **6.10%**	749 **6.40%**	1,134,341	9,889 **0.90%**
2017	11,984	661 **5.50%**	789 **6.60%**	915 **7.60%**	1,137,399	10,022 **0.90%**
2018	11,961	683 **5.70%**	745 **6.20%**	974 **8.10%**	1,134,137	11,238 **1.00%**
2019	11,781	659 5.60%	667 **5.70%**	915 **7.80%**	1,119,844	12,328 **1.10%**
2020	11,591	625 **5.40%**	613 **5.30%**	926 **8.00%**	1,122,369	10,488 **0.90%**
2021	11,551	636 **5.50%**	665 **5.80%**	908 **7.90%**	1,128,849	10,640 **0.90%**
2022	11,517	605 **5.30%**	601 **5.20%**	991 **8.60%**	1,131,811	9,516 **0.80%**

**data from [150]; number of cattle data [151]*

Appendix 2. HRA, LRA, and Edge Areas of England

Table A3. Bovine TB incidence by herd level in HRAs of England

Year	Number of cattle herds registered on Sam in HRA	% of national herds in an HRA	Herds in an HRA not officially bTB free at the end of the period due to a TB incident	% herds in an HRA not officially bTB free at the end of the period due to a bTB incident	New herd incidents in HRA herds	% new herd incidents in HRA herds	Herds under movement restrictions	% herds under movement restriction	National cattle population slaughtered to bTB	Cattle population slaughtered prematurely due to bTB in HRA	% of cattle slaughtered nationally from an HRA herd
2012	22,520	42.01	2,865	12.72	3,348	14.87	4,056	18.01	28,237	25,578	90.58
2013	22,237	41.35	2,723	12.25	3,267	14.69	3,809	17.13	26,592	23,162	87.1
2014	21,162	40.85	2,508	11.85	3,140	14.84	3,272	15.46	26,405	21,780	82.48
2015	20,888	40.73	2,645	12.66	3,279	15.7	3,295	15.77	28,031	23,700	84.55
2016	20,812	40.67	2,485	11.94	3,034	14.58	3,262	15.67	29,228	24,102	82.46
2017	20,624	40.86	2,595	12.58	3,042	14.75	3,340	16.19	33,239	26,415	79.47
2018	20,277	50.37	2,327	11.48	2,763	13.63	3,063	15.11	32,925	24,601	74.72
2019	20,309	41.07	2,039	10.04	2,509	12.35	2,648	13.04	31,215	23,175	74.24
2020	20,391	41.08	1,861	9.13	2,362	11.58	2,689	13.19	27,850	22,022	79.07
2021	19,209	41.02	1,688	8.79	2,162	11.26	2,347	12.22	27,577	21,845	79.21
2022	19,041	40.76	1,652	8.68	2,302	12.09	2,433	12.78	22,084	17,948	81.27

Table A4. Bovine TB incidence by herd level in LRAs of England

Year	Number of cattle herds registered on Sam in LRA	% of national herds in an LRA	Herds in an LRA not officially bTB free at the end of the period due to a TB incident	% herds in an LRA not officially bTB free at the end of the period due to a bTB incident	New herd incidents in LRA herds	% new herd incidents in LRA herds	Herds under movement restrictions	% herds under movement restriction	National cattle population slaughtered to bTB	Cattle population slaughtered prematurely due to bTB in LRA	% of cattle slaughtered nationally from an LRA herd
2012	21,064	39.29	58	0.28	103	0.49	274	1.3	28,237	211	0.75
2013	21,328	39.66	57	0.27	109	0.51	310	1.45	26,592	460	1.73
2014	20,943	40.42	39	0.19	109	0.52	284	1.36	26,405	683	2.59
2015	20,948	40.85	60	0.29	158	0.75	258	1.23	28,031	611	2.18
2016	20,981	41	45	0.21	134	0.64	286	1.36	29,228	601	2.06
2017	20,700	41.01	59	0.29	125	0.6	286	1.38	33,239	922	2.77
2018	20,145	50.04	67	0.33	130	0.65	396	1.97	32,925	722	2.19
2019	20,259	40.97	65	0.32	151	0.75	338	1.67	31,215	749	2.4
2020	20,414	41.13	78	0.38	139	0.68	453	2.22	27,850	348	1.25
2021	19,330	41.28	62	0.32	128	0.66	400	2.07	27,577	539	1.95
2022	19,414	41.55	77	0.4	153	0.79	457	2.35	22,084	429	1.94

Table A5. Bovine TB incidence by herd level in Edge areas of England

Year	Number of cattle herds registered on Sam in Edge areas	% of national herds in an Edge area	Herds in an Edge area not officially bTB free at the end of the period due to a TB incident	% herds in an Edge area not officially bTB free at the end of the period due to a bTB incident	New herd incidents in Edge area herds	% new herd incidents in Edge area herds	Herds under movement restrictions	% herds under movement restriction	National cattle population slaughtered to bTB	Cattle population slaughtered prematurely due to bTB in Edge areas	% of cattle slaughtered nationally from an Edge area herd
2012	10,026	18.7	319	3.18	468	4.67	696	6.94	28,237	2,448	8.67
2013	10,208	18.98	322	3.15	514	5.04	778	7.62	26,592	2,970	11.17
2014	9,703	18.73	327	3.37	555	5.72	577	5.95	26,405	3,942	14.93
2015	9,447	18.42	346	3.66	536	5.67	536	5.67	28,031	3,720	13.27
2016	9,375	18.32	368	3.93	601	6.41	628	6.7	29,228	4,525	15.48
2017	9,150	18.13	485	5.3	658	7.19	727	7.95	33,239	5,902	17.76
2018	8,836	21.95	570	6.45	721	8.16	899	10.17	32,925	7,602	23.09
2019	8,882	17.96	490	5.52	643	7.24	781	8.79	31,215	7,291	23.36
2020	8,830	17.79	519	5.88	674	7.63	968	10.96	27,850	5,480	19.68
2021	8,286	17.7	386	4.66	576	6.95	730	8.81	27,577	5,193	18.83
2022	8,264	17.69	349	4.22	495	5.99	715	8.65	22,084	3,707	16.79

Appendix 3. High Risk and Intermediate Areas Wales

Table A3. Bovine TB incidence by herd level in HRAs of England

Year	Number of cattle herds registered on Sam in HRA East areas	% of national herds in an HRA East	Herds in an HRA East not officially bTB free at the end of the period due to a TB incident	% herds in an HRA East not officially bTB free at the end of the period due to a bTB incident	New herd incidents in HRA East herds	% new herd incidents in HRA East herds	Herds under movement restrictions	% herds under movement restriction	National cattle population slaughtered to bTB	Cattle population slaughtered prematurely due to bTB in HRA East	% of cattle slaughtered nationally from an HRA East herd
2012	3,209	25.14	293	9.13	363	11.31	450	14.02	9,286	2,610	28.11
2013	3,181	25.05	198	6.22	297	9.34	332	10.44	6,106	1,656	27.12
2014	2,954	24.45	219	7.41	332	11.24	298	10.09	6,371	2,199	34.52
2015	2,807	24.02	168	5.99	278	9.9	203	7.23	8,086	2,041	25.24
2016	2,776	23.81	175	6.3	262	9.44	219	7.89	9,889	1,924	19.46
2017	2,830	23.61	238	8.41	299	10.57	290	10.25	10,022	2,372	23.67
2018	2,868	23.98	209	7.29	250	8.72	264	9.21	11,238	2,206	19.63
2019	2,812	23.87	182	6.47	213	7.57	231	8.21	12,328	2,016	16.35
2020	2,759	23.8	170	6.16	201	7.29	240	8.7	10,488	2,146	20.46
2021	2,759	23.89	132	4.78	170	6.16	188	6.81	10,640	1,653	15.54
2022	2,747	23.85	154	5.61	196	7.14	244	8.88	9,516	1,540	16.18

Table A7. Bovine TB incidence by herd level in High Risk Area West, Wales

Year	Number of cattle herds registered on Sam in HRA West areas	% of national herds in an HRA West	Herds in an HRA West not officially bTB free at the end of the period due to a TB incident	% herds in an HRA West not officially bTB free at the end of the period due to a bTB incident	New herd incidents in HRA West herds	% new herd incidents in HRA West herds	Herds under movement restrictions	% herds under movement restriction	National cattle population slaughtered to bTB	Cattle population slaughtered prematurely due to bTB in HRA West	% of cattle slaughtered nationally from an HRA West herd
2012	3,533	27.68	512	14.49	538	15.23	701	19.84	9,286	5,707	61.46
2013	3,518	27.7	331	9.41	385	10.94	460	13.08	6,106	3,704	60.66
2014	3,363	27.83	298	8.86	359	10.67	395	11.75	6,371	3,115	48.89
2015	3,246	27.78	356	10.97	411	12.66	415	12.78	8,086	5,041	62.34
2016	3,239	27.78	304	9.39	321	9.91	395	12.2	9,889	6,463	65.36
2017	3,325	27.75	324	9.74	331	9.95	428	12.87	10,022	6,425	64.11
2018	3,254	27.21	355	10.91	334	10.26	470	14.44	11,238	7,521	66.92
2019	3,187	27.05	351	11.01	311	9.76	450	14.12	12,328	8,317	67.46
2020	3,130	27	323	10.32	252	8.05	436	13.93	10,488	6,314	60.2
2021	3,102	26.85	328	10.57	262	8.45	424	13.67	10,640	6,269	58.92
2022	3,079	26.73	270	8.77	186	6.04	396	12.86	9,516	5,593	58.77

Table A8. Bovine TB incidence by herd level in Intermediate areas, Wales

Year	Number of cattle herds registered on Sam in Intermediate areas	% of national herds in an Intermediate	Herds in an Intermediate not officially bTB free at the end of the period due to a TB incident	% herds in an Intermediate not officially bTB free at the end of the period due to a bTB incident	New herd incidents in Intermediate area herds	% new herd incidents in Intermediate area herds	Herds under movement restrictions	% herds under movement restriction	National cattle population slaughtered to bTB	Cattle population slaughtered prematurely due to bTB in Intermediate area	% of cattle slaughtered nationally from an Intermediate area herd
2012	2,173	17.02	51	2.35	83	3.82	169	7.78	9,286	388	4.18
2013	2,165	17.05	40	1.85	78	3.6	117	5.4	6,106	286	4.68
2014	2,063	17.07	28	1.36	68	3.3	70	3.39	6,371	331	5.2
2015	1,992	17.05	43	2.16	74	3.71	55	2.76	8,086	407	5.03
2016	1,989	17.06	37	1.86	53	2.66	59	2.97	9,889	727	7.35
2017	2,040	17.02	40	1.96	68	3.33	75	3.68	10,022	423	4.22
2018	2,046	17.11	44	2.15	60	2.93	87	4.25	11,238	588	5.23
2019	2,036	17.28	53	2.6	75	3.68	90	4.42	12,328	628	5.09
2020	2,006	17.31	39	1.94	48	2.39	81	4.04	10,488	550	5.24
2021	2,008	17.38	50	2.49	68	3.39	86	4.28	10,640	754	7.09
2022	2,005	17.41	41	2.04	55	2.74	96	4.79	9,516	401	4.21

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