Bovine TB strategy review update

Submitted to Daniel Zeichner MP, Minister of State, Defra on August 1st, 2025.

Update to the Review submitted to Rt Hon Michael Gove MP, Secretary of State, Defra on October 2nd 2018

Professor Sir Charles Godfray CBE FRS (Chair)

Professor Glyn Hewinson CBE FLSW

Professor Sir Bernard Silverman FRS

Professor Michael Winter OBE

Professor James Wood OBE

Summary and Conclusions

1. **This is an update of the Summary and Conclusions from our 2018 Report[1]. Material unchanged (apart from minor wording) from 2018 is in black and new material is in purple bold. The main body of the report explains our thinking behind the updated sections.**

Introduction

2. Bovine TB is an infectious disease that spreads between cattle that is unlike any other endemic disease afflicting the livestock industry in England. The prevalence of the disease in parts of the country, coupled with the test and slaughter strategy that is the basis of disease control, makes the risk and consequences of infection one of the greatest factors affecting the livelihoods of numerous farmers. In writing this report we are acutely aware of the burden this disease places on the welfare and well-being of farmers and their families. We do think more can be done to control this disease, and hopefully eventually eradicate it, but we would be offering false hope if we pretended this will be other than a protracted campaign.

3. The disease is notable in that it also infects badgers, and there is transmission to and from badgers and cattle. Culling of badgers to reduce infection in cattle is seen as unconscionable by some sections of society **and the current administration has pledged to end culling during this Parliament (by 2029)**. The deeply held beliefs of people who cannot countenance culling badgers deserve respect, as do the beliefs of people who argue that sacrificing badgers is justified to reduce the burden of this disease on livestock and farmers. The decision whether or not to cull badgers must be informed by evidence which provides important information on likely outcomes. However, final decisions have to take into account the irreconcilable views of different stakeholders and so inevitably require judgements to be made by ministers.

4. Our interpretation of the evidence is that the presence of infected badgers does pose a threat to local cattle herds. This interpretation reflects the broad consensus amongst epidemiologists who have studied the disease **and has been supported by recent evidence using whole genome sequencing of strains of *Mycobacterium bovis*, the bacterium that causes bovine tuberculosis.** Reducing this threat from badgers, by culling or non-lethal intervention, will thus help lower the incidence of the disease in cattle. **As a decision has been made to phase out culling it is of great importance to develop effective non-lethal interventions to enable eradication, such as vaccination of badgers or reducing contact between badgers and cattle.**

5. An unfortunate consequence of the controversy around badger culling and the politicisation of the debate has been a deflection of focus from what can be done by the individual farmer and by the livestock industry to help control the

[1] Godfray *et. al.*, 2018, https://tinyurl.com/2018bTBReview

disease. In particular, the poor take up of on-farm biosecurity measures and the extent of trading in often high-risk cattle is severely hampering disease control measures. **There has been some progress,** but all the industry bodies we spoke to recognised this as an issue and saw the need for industry to take more ownership of the problem. Implementing better control measures on the livestock side will mean short- to medium-term costs to the industry to achieve the greater goal of bovine TB eradication. The degree to which the industry as opposed to the State bears these costs is a decision for ministers but it is wrong to over-emphasise the role of wildlife and so avoid other measures, even if these may incur short-term costs.

6. Bovine TB is a notifiable disease and exactly how it is monitored and controlled affects our ability to trade. The complex statutory underpinning of surveillance and control, involving both national and European legislation **(which is relevant as it affects our ability to trade)**, makes agile and adaptive management of the disease very difficult. This legal and administrative viscosity hampers better disease control.

7. **This update to our 2018 report has the same structure with Chapters 1 & 2 providing some background material and Chapters 3-9 exploring** a wide range of interventions that should be considered in attempts to control bovine TB in England. We have attempted to broaden the discussion of interventions from a narrow focus on epidemiology, and tried dispassionately to weigh their advantages and disadvantages. In many cases we do not recommend a specific course of actions. This is for a number of reasons including: (i) many decisions require ministerial judgement, for example those involving ethics or costs; (ii) further more detailed cost-benefit analysis and modelling is required than has been possible in this study; (iii) **and we report at a time of flux in trade policy (including around Sanitary and Phytosanitary measures) with final agreements affecting bovine TB policy**. Here we summarise our conclusions and highlight the factors that should be at the front of decision makers' minds when determining future policy.

Governance

8. **A 25-year plan to achieve Bovine TB free status for England by 2038 was announced in 2014. Next year will see the mid-way point of the plan which remains the Government's goal. There has been significant progress since 2014 with an encouraging drop in herd breakdowns since 2017. However, in our opinion there is only a small chance of meeting the target without a step change in the urgency with which the issue is treated and the resources devoted to eradication. There needs to be a mindset of defeating rather than managing the disease and performance indicators should focus much more on disease level outcomes.**

9. **We are mindful of the great current pressures on public finances. Nevertheless, we find that bovine TB control is suffering from lack of investment in Defra/APHA and in the local authorities that play a critical role in compliance. We suggest that investment now will save money in**

the future and agree with the comment in the recent National Audit Office (NAO) Report *Resilience to animal diseases*[2] that "Defra has struggled to quantify and monetise the benefits from investment to strengthen resilience to animal diseases".

10. **It is essential that the problem of bovine TB is co-owned by the government and the industry. We know that the industry would prefer to take the lead with few constraints on interventions (the "New Zealand model") but the reality is that this does not have a social licence in England and policy needs to be developed accordingly. This requires leadership and a willingness to move beyond long-held positions by government, the industry and wildlife NGOs.**

11. **On the government side, there are many dedicated officials working hard to control bovine TB at a time when emerging diseases are adding to their workload. However, we do not believe the disease is receiving the management attention required to achieve the target of eradication by 2038. Government should consider making leadership of the eradication strategy a more visible and public-facing role. The senior person taking on this role would own the government's contribution to eradication, working closely with the Bovine TB Partnership and all interested parties.**

12. **Government is currently working on England's Land Use Framework, a 25 Year Plan for Farming, a Food Strategy, updating the 25 Year Plan for the Environment, and preparing a response to the Climate Change Committee's proposed Seventh Carbon Budget (which discusses livestock). In developing these programmes, the opportunities to contribute positively to bovine TB controls (and avoiding negative effects) should be considered.**

13. An important part of farmers taking more ownership of the disease is ensuring that they receive the best advice (for example on safe trading practices, on-farm controls and biosecurity) from trusted sources. Existing information available on the web (TB Hub) is very good, though obviously farmers must be motivated to find and make use of it. The role of private veterinarians in providing advice is particularly important and should be supported, taking into account the true costs of its provision for veterinary businesses.

14. Consultation with industry and other stakeholders is an important part of bovine TB control and of achieving shared ownership of the problem. Nevertheless, we believe that the current frequency and granularity of consultation is cumbersome and counter-productive. Concern over 'consultation fatigue' was expressed to us by many stakeholders. We see advantages in consulting at a higher level on broad strategy and principles of adaptive management. This will enable operational decisions to be made more swiftly and more flexibly as circumstances change and new evidence emerges. **We understand from Defra that there have been moves to reduce the number of consultations and ensure they comply with best**

[2] NAO, 2025, https://www.nao.org.uk/reports/resilience-to-animal-diseases/

practice on consultation, but more could be done to reduce delays and ensure adaptative management of policy.

Surveillance and diagnostics

15. **We discussed in 2018 the growing evidence for substantial undiagnosed bovine TB infections in the national herd. Since then, the evidence has mounted, reinforcing the importance of testing and surveillance. Here we place great emphasis on facilitating farmers to manage out infections in their herds in ways that do not impose unmanageable business interruptions and financial burdens.**

16. Almost all tests involve a trade-off between sensitivity and specificity. If a test is not sensitive enough it will miss too many infected animals, while if it is not specific enough it will produce too many false positives. The test used in the United Kingdom (UK) and the Republic of Ireland (the Single Intradermal Comparative Cervical Tuberculin or SICCT test) has high specificity but lower sensitivity than that used in continental Europe (the Single Intradermal Cervical Tuberculin or SICT test). There is some evidence that the sensitivity of the SICCT test under operational field conditions is lower than that estimated in formal trials.

17. Policy makers need to balance the disadvantages of low specificity (more cattle sent to slaughter and herds placed under provisional restrictions) and low sensitivity (infections going unrecognised). We see a strong argument for moving to a more sensitive test (probably the SICT) for surveillance in the High Risk Area (HRA) and Edge Area (EA) to enable the detection of infections in these regions as early as possible. **Outside hotspots in** the Low Risk Area (LRA) the numbers of new infections detected would not justify the increased number of false positives. **There has been reluctance to move to SICT because of its perceived low specificity but we think this perception is not supported by relevant data and recommend that the specificity of the SICT should be determined in the context of its potential use in England to inform future options.**

18. **The Edge Area (EA) is divided into zones with six- or twelve-monthly testing. Disease prevalence is decreasing more in the former than the latter and we recommend that making the whole of the EA subject to six-monthly testing be considered.**

19. Were these changes to be made, the number of herd breakdowns would in the short term go up as more infections are revealed. It is very important that policy makers and all stakeholders understand this epidemiological reality and do not misinterpret it as a policy failure.

20. **The detection of infection after slaughter remains a critical element of disease surveillance, especially in the LRA where cattle are tested every four years. Slaughterhouse detections have dropped recently, which may reflect lower disease levels but possibly poorer rates of detection. We recommend this is investigated and if the latter is the explanation then better incentives for detection are introduced.**

21. **It is possible for individual farmers to obtain an APHA licence to conduct private tests on Officially TB Free (OTF) herds between statutory tests. This is seldom taken up as the detection of a positive animal can trigger a breakdown with major economic consequences. As part of empowering farmers to manage risk in their herds, regulations could be introduced to make voluntary OTF testing easier and involving less financial jeopardy.**

22. **Once infection is discovered in a herd it is important to identify all cattle infected with the bacterium. After 2018, the highly sensitive interferon gamma test was used much more widely after herd breakdowns, detecting many infections missed by the standard skin test (SICCT). The use of interferon gamma tests has fallen markedly in the last three years and we think there is a strong argument for its mandatory use in Official TB Free - Withdrawn (OTF-W) breakdown herds.**

23. **There are a number of informal initiatives in which groups of farmers work with veterinarians proactively to manage out high-risk animals after a herd breakdown. We explore how this might be encouraged and facilitated by (i) giving farmers and their advisors access to the maximum amount of information available to allow them to estimate the risk of infection for individual animals; (ii) enabling the use of additional testing beyond statutory requirements; (iii) allowing some possibly infected cattle (which have passed statutory tests but are deemed high risk) to remain on farm to reduce the financial costs of a breakdown (for example, lost milk production) without risking the spread of infection. The use of serological tests to detect infection from milk may also help in this process.**

24. The current SICCT, SICT and interferon gamma tests rely on tuberculin – essentially a cocktail of proteins derived from the bacterium that is difficult to standardise. We see a strong argument for investing in better tuberculin quality control. In the medium term, and requiring efficacy and safety tests, the aim should be to replace tuberculin by defined antigens. Such tests would also provide a DIVA (differentiating infected from vaccinated animals) function.

25. There is intensive research on TB testing and diagnostics in both the human and veterinary science worlds. A number of promising tests are in development. We see it as very important to make sure that an efficient pipeline is developed to assess the value of new innovations, to carry out field efficacy and safety tests, and where justified to deploy them rapidly. We realise, of course, that the administrative burden of changing test protocols, as well as any consequences for trade, must be taken into account.

26. **Since our last report, the use of Approved Tuberculin Testers (ATTs) has been scaled up in England and Wales, a move we very much welcome. We understand analysis of ATT performance in Wales will be published shortly and will be encouraging. Careful training, auditing and monitoring of ATTs is critical but we see their use as important in**

developing the most cost-effective methods of surveillance and diagnosis.

27. **We have been greatly encouraged by the widespread adoption of whole genome sequencing (WGS) since we last reported, and the new insights that it has enabled. Further integration of WGS data with epidemiological databases, and routinely and quickly making the data publicly available will maximise its value.**

Vaccination and genetic resistance in cattle

28. The BCG vaccine available for cattle provides some but not complete protection against bovine TB. However, vaccinated cattle often test positive for current tuberculin-based tests for the disease and the widespread use of BCG in cattle would compromise surveillance (and affect trade in live cattle and dairy products).

29. In our view, the goal should be to move to vaccination with DIVA (Differentiating Infected from Vaccinated Animals) tests. Once these are available, then the possible advantages of different models of vaccination deployment should be re-examined. This should involve a cost-benefit analysis that takes into account implications for international and UK trade and business.

30. **Considerable progress has been made since we reported in 2018 on better characterising the performance of the bovine BCG vaccine that would be used in England, as well as developing and testing a novel DIVA test. We are optimistic about vaccine deployment and fully support the current research programme but caution that the development of a successful BCG/DIVA product, is not yet guaranteed. A particular concern is the very high levels of DIVA specificity required to avoid cattle being wrongly classed as infected and we discuss alternative or supplementary approaches to determining the infection status of cattle in vaccinated herds.**

31. **Given the uncertainties and timescales around the licensing of the DIVA skin test and the clear benefits of BCG vaccination in reducing *M. bovis* transmission, there is merit in considering the use of BCG vaccination in recurrent and persistently infected dairy herds as soon as BCG is licensed for cattle.**

32. **The deployment of a full vaccination programme across the HRA and EA in England (as well as, potentially, in Wales) would be one of the largest livestock epidemiological interventions that the country has ever attempted. There is ongoing work on funding models, security of supply, workforce deployment, communication strategy and (critically) IT infrastructure. We recommend Government assures itself that this is occurring at scale and on time for planned deployment.**

33. **The process of obtaining marketing authorisation from the Veterinary Medicines Directorate is rightly detailed and careful to ensure animal**

and human health and welfare are not compromised. Nevertheless, the lessons of the Covid-19 pandemic are that regulatory approval for vaccines can be safely accelerated if all concerned act with urgency and if the required resources are found. Such an approach would be valuable here.

34. Progress has been made in understanding the genetic basis of bovine TB resistance in cattle enabling genetic selection for higher resistance. This sensible approach that will in the long term make a modest but valuable contribution to disease control should, we believe, be supported.

Cattle Movements and Risk-based Trading

35. **In 2018 we wrote** "We strongly emphasise the importance of the LIS **[now the Livestock Information Transformation Programme]** in providing the data backbone for improvements in incentivising risk-based trading and many other aspects of bovine TB control. We place the highest research and development priority on ensuring from the design stage that the system works to deliver these benefits for [bovine TB] disease control." **This is still our view, and we have been disappointed at the slow rate of progress (as was the NAO; see ¶9). Much more could have been done on disease control if LITP had been available when originally planned, and it is essential for meeting the 2038 eradication target.**

36. It is now routine to mark horses and pets with microchips and we believe further investigation of the feasibility of this for cattle is warranted. It would reduce the opportunities for fraud and improve traceability. We understand the need to avoid microchips entering the human food chain.

37. Relatively crude indices of the risk of infection of cattle have already been developed and LITP will enable more sophisticated measures. There is, we believe, a strong argument that these measures should mandatorily be available prior to purchase and at market ring-sides.

38. The number of cattle movements in England is very high and will inevitably be a risk for disease spread. We have not been able to do a full analysis of the regulatory and economic drivers of this level of trading with the time and resources available. We recommend such an analysis is carried out to discover whether there are perverse incentives for movement. **We are still transitioning from the CAP to ELM schemes and other means of supporting the farming industry outside the EU. These changes may affect the number and pattern of cattle movements, and disease control threats and opportunities should be considered in the design of these instruments.**

39. Farmers are currently compensated for slaughtered cattle (or might in the future take out insurance against the risk). We believe that there is a strong argument for disincentivising risky trading by reducing compensation (or insurance payments) to reflect trading behaviour. Such adjustments would need to be relatively large to change behaviour.

40. **Pre- and post-movement testing for animals moving from a higher risk area into the LRA picks up relatively few infected animals. Nevertheless, the major costs from new foci arising in the LRA are so great we think more stringent tests than the current interpretation of the SICCT test should be used. Specifically, we suggest the same SICCT interpretation as used before export to Europe should be used as a pre-movement test, and the interferon gamma or a serological test (which may pick up an infected animal missed by a skin test) be employed as a post-movement test.**

Disease in wildlife

41. **We conclude from our study of the evidence that badgers can transmit bovine TB to cattle and contribute to the persistence of the disease. It is very important to estimate the magnitude of this threat to judge the emphasis that must be placed on measures tackling the disease in wildlife (which due to government policy will increasingly need to be non-lethal). The polarisation of the debate about the role of badgers has not been helpful in estimating this risk.**

42. **There have been various analyses of the industry-led culls and the Randomised Badger Control Trial (RBCT). It is clear that the package of measures in operation during the industry-led culls has led to a reduction in herd breakdowns, but it is not possible statistically to separate the effects of culling from the other measures introduced at the same time (in particular, the much more frequent use of the sensitive interferon gamma test). In our view, especially in the light of other evidence showing badgers can transmit infection to cattle, it is reasonable to conclude culling made some positive contribution. Our review of analyses of the more historical RBCT indicates that it provides some evidence that culling as implemented in the experiment reduced the number of confirmed herd breakdowns but that the evidence is not as strong as initial analyses suggested.**

43. **Improvements in biosecurity and the use of the injectable BCG vaccine are currently the only viable options currently available that allow moving from lethal to non-lethal control of the disease in badgers. Important but limited field data supported by modelling shows that vaccination is a realistic way of controlling bovine TB in wild badger populations, though some estimates suggest this may take more than a decade to achieve using current approaches.**

44. **Experience in England and the Republic of Ireland has highlighted the significant challenges of running a successful badger vaccination campaign. A major issue is the costs and difficulties of catching sufficient badgers. Considerable effort will be required to scale-up vaccination so that it becomes a viable tool at scale. A better understanding of badger ecology and epidemiology is required to design vaccination campaigns, and economies of scale need to be realised to make vaccination financially viable. Expanding the use of trained and accredited lay vaccinators will likely be important here. A**

communication strategy is needed to address scepticism in parts of the farming community. To meet the eradication target, there is not time to conduct large-scale experiments so vaccination campaigns must be adaptively managed in the spirit of "learning by doing". Very valuable data on disease prevalence in badgers can be obtained by the routine testing of badgers found dead by the roadside and in other places.

45. **Test, vaccinate and remove (TVR) programmes are similar to vaccination programmes but badgers are tested in the field for bovine TB and infected individuals are killed. Euthanising infected individuals (whose welfare will suffer from the disease and who will possibly infect other badgers) will be seen by some (but not all) people otherwise opposed to culling as ethically acceptable. TVR is more complicated and expensive than vaccination, but has the advantage of removing infected animals from the population immediately (which might increase buy in from the industry). More data on the potential efficacy of TVR is needed but we recommend government explores with the industry and wildlife groups the possibility of the limited use of TVR (for example in emerging hotspots).**

46. The evidence does not suggest that other wild or feral animals (for example deer, fox, wild boar) pose a substantial national threat to cattle but any opportunity to increase our knowledge of disease prevalence in these species should be taken. **Recent evidence of increased prevalence suggests particular attention should be paid to deer.**

The disease in non-bovine managed animals

47. Bovine TB occurs in other farmed animals, though is less of a problem than in cattle. **There have been some recent changes to the regulations concerning these species which are sensible and proportionate.**

48. ***Mycobacterium tuberculosis* complex (including *M. bovis*) infections in pets are rare but there have been several recent outbreaks and cases where humans have also been infected. We note that the regulations related to feeding fallen stock to dogs have been tightened, but regulations on the use of game and other raw meat in pet food may need revision or better enforcement.**

Biosecurity, compensation, insurance

49. The evidence base about which biosecurity measures work is not strong because of the difficulties of carrying out formal experiments for each of multiple different options. **We support the redesign of Disease Report Forms to help address this though we are concerned that they are increasingly being completed remotely rather than during a site visit which provides more informed data.** Nevertheless, there are many relatively cheap things a farmer can do to separate cattle from badgers, cattle from other cattle on neighbouring holdings, and potentially infected from uninfected cattle. These are 'no regret' biosecurity options whose take up is disappointingly low. In our view, the issue here is not the availability of

information but motivation to discover what can be done and to implement the measures. Above we stress the importance of the industry taking greater ownership of the disease, and we hope this leads to greater uptake of biosecurity. We also underline the importance of farmers' trusted advisors, in particular private veterinarians, giving clear and unambiguous advice on biosecurity.

50. A number of accreditation schemes mandate biosecurity measures while supermarkets **and other major purchasers and processors of meat and dairy products** also lay down rules for their suppliers. **Greater engagement with these bodies and** unifying all these rules relevant to bovine TB in a single guidance set would, we believe, be helpful for farmers and stimulate uptake.

51. **Government is appointing a Commissioner to the Tenant Farming Sector and we advise explicitly including in the terms of reference for this position the improvement in the uptake of disease-control measures by tenant dairy and beef farmers.**

52. **We remain concerned that the system of Temporary Land Associations provides a means of local spread of bovine TB through cattle movements. More data is needed on the extent of this risk and, depending on the results of its analysis, consideration might be given to reducing the allowable 10-mile distance for TLAs involving cattle where the risk of bovine TB is high.**

53. Farmers are at present partly compensated for losses due to cattle slaughtered for reasons of disease control. In 2018 we examined the relative merits of compensation versus insurance and recommend further exploration of the latter. Because of the issues of adverse selection, Government would need to be involved in setting up an insurance programme (as, for example, it has been in flooding insurance) and in information provision. We envisage a compulsory insurance programme partially supported by Government (replacing compensation) with premiums and compensation designed to incentivise and reward behaviour that reduces the risk of disease.

54. **The risk of infection from slurry spread on pasture remains poorly characterised and until more data are available it is prudent to store slurry for six months and to restrict grazing for 60 days after its spread. Slurry spreading is also an issue in nutrient run-off from farmland and we advise that considering all slurry (and farmyard manure) issues together would be helpful in developing coherent policy.**

55. **Recent research since our 2018 Report has highlighted the impact of bovine TB on farmer mental health; the subject is receiving significant industry coverage. There are training opportunities available and it would be desirable if those dealing directly with farmers in a regulatory or advisory capacity, received basic mental health first aid and suicide awareness training.**

Research

56. There are many areas, some outlined in this review, where research has played a valuable role in the battle against bovine TB. The specific need for more research, such as in novel diagnostics, vaccines, genetic resistance and around farmer behaviour, is identified in this report. Research in this field is funded by a variety of bodies and occupies the whole spectrum from largely fundamental to highly strategic. This diversity is a strength. Nevertheless, we believe there would be a benefit from setting up a forum that would better link research funders with the needs of customers of the more applied research. This would ensure that the research had the highest possible impact and value for money.

57. **It is important to make available all research in this area as soon as possible. Where the work involves data analysis, this should include sufficient detail of the data and the analysis programs to allow the results to be reproduced. This has not always been the case. Material for publication should be posted before submission on pre-print servers (such as bioRxiv) and delays in the peer-review process (which can be lengthy) should not be allowed to delay making the research available. Government (and other funders) should consider making the rapid pre-publication dissemination of results a condition of receiving research funding.**

Concluding remark

58. **Bovine TB remains a major issue for England's livestock sector, affecting both animal (livestock and wildlife) health, farmer livelihoods and the public purse. The goal of eradicating the disease by 2038 is very challenging but achievable. To get there a systems approach is required, utilising all tools that ministers decide are in scope. While interventions on the farm are critical, equally important are the social and governance elements of eradication. Leadership and collaboration from government, the industry and all interested groups will be essential for success, as will finding short-term finance for disease control to save money in the long-term. Eradication will require a stepping up of urgency and attention and a relentless focus on reducing the prevalence of a disease that has blighted livestock farming in England and other home nations for far too long.**

Table of Contents

Chapter 1: Introduction

The 2018 Bovine TB Strategy Review

1.I In February 2018 the Rt Hon. Michael Gove, then Defra Secretary of State, commissioned a review of England's Bovine TB Strategy which was submitted in the October of that year. Its purpose was "To reflect on progress being made with implementation of the bTB Strategy and consider how to take the Strategy to the next phase. Advise on what further actions might be prioritised now to ensure we maintain progress towards our target of achieving Officially Free status for England by 2038." The full terms of reference requested a comprehensive review of all aspects of bovine TB epidemiology within the context of the economic, social and regulatory environment of farming in England, incorporating lessons from the Devolved Administrations and other countries.

1.II After two introductory chapters, the Review explored seven areas, each of which impinged on bovine TB control:

- Surveillance and Diagnostics in Cattle
- The Disease in Cattle: Vaccination and Resistance
- Cattle Movements and Risk-based Trading
- The Disease in Wildlife
- Non-bovine Farmed Animals
- Biosecurity, Compensation and Insurance
- Governance.

For each topic it set out the rationale for its inclusion and current policy in that area. It then listed different "Options for the Future" (which included continuing with the current policy unchanged) and the natural and social science evidence base that should be considered when deciding amongst these options. This structure reflected the purpose of the Review which was not to advocate for particular interventions but to assist ministers and officials in developing policy. The final section in each chapter summarised what the Panel considered Research and Development Priorities. In addition to the core of the Report, a Summary and Conclusions was provided along with a series of Annexes. The Report can be found here[3].

1.III The Government (at the time the Johnson administration) responded in March 2020 commenting "The Review has provided an opportunity to regroup and refocus the shared government and industry efforts on achieving OTF status for England by 2038. There are no easy answers but we do have a range of effective tools available. The Review is clear that the current bTB situation cannot be allowed to continue and that what is required is a new drive and

[3] Godfray *et. al.,* 2018, https://tinyurl.com/2018bTBReview

concentrated and concerted effort by all sectors involved." The Executive Summary and full response can be found here[4].

The Review Update

1.IV The incoming Labour administration announced on 30 August 2024 plans to carry out a comprehensive refresh of the strategy to achieve officially tuberculosis free status for cattle in England. It aimed to co-design with relevant stakeholders "a new bovine TB eradication strategy that would use a data-led and scientific approach to accelerate progress towards the goal of achieving officially TB free status in cattle herds by 2038". The Government also stated its commitment to end the culling of badgers for bovine TB control by the end of the parliament[5].

1.V On 19 December 2024, Daniel Zeichner MP, the Minister of State responsible for bovine TB policy, wrote to the 2018 Panel requesting them to revisit their Report "to highlight any substantial updates to the evidence base or studies that may have emerged since the [Report's] publication". "In particular, since the Strategy Review of 2018, have any relevant information or scientific studies come to light or been published in the field of bTB which change or expand on any of the 2018 review conclusions? If so, in which way does the new evidence alter those conclusions?" The full letter is at Annex 3.

1.VI The 2018 Panel was happy to accept this commission except that Professor Christl Donnelly requested to stand down. Her place as an expert statistician was taken by Professor Sir Bernard Silverman. The declarations of interest of the Panel members are given in Annex 2.

Structure of the Update

1.VII The 2018 Review contained substantial background material to assist people coming to the topic of bovine TB for the first time. It also set out in some detail the history and current status of different interventions and the relevant evidence bases. None of that material is repeated here unless new information has arisen since we reported. The current document (with the exception of the Summary) is thus not stand alone and should be read in conjunction with the 2018 Report. It is important to note that we consider our original findings and advice to stand unless we explicitly state otherwise.

1.VIII To facilitate comparison with the 2018 Report we maintain the same overall structure with nine chapters (Introduction, Background and then the seven chapters on the topics listed in ¶1.I). Within each of the evidence chapters (3-9) there is an Introduction and then sections on Recent Developments, Updates on Options for the Future and Research and Development Priorities. Paragraphs in the original Report were indexed X.Y (e.g., 2.23) where X refers to the chapter and Y to the paragraph which were numbered consecutively within each chapter. As we refer frequently to the 2018 Report, to avoid confusion we use

[4] Defra, 2020, https://tinyurl.com/2018bTBReviewGovResp
[5] Defra, 2024, https://tinyurl.com/GovbTBStrategy

the same indexing here except the numbering, Y, is in Roman rather Arabic numerals. A glossary of acronyms and terms used is provided at Annex 1.

How the Update was carried out

1.IX The Update was announced by Defra in late January 2025. The announcement included an invitation to any interested party that if they would like to alert the Panel to relevant natural or social science evidence that might not be picked up in standard literature searches, then they should send material to the panel via Defra. Twenty eight submissions were received by March 1st, 2025 and the names of contributors will be made public by Defra.

1.X The Panel met online roughly every two weeks and in person twice for extended meetings. Panel members also visited the Pembrokeshire Project in Wales. It used traditional and AI-assisted literature search to identify new bovine TB research findings, and also received a considerable body of evidence from Defra relating to the implementation of control strategies.

1.XI We would like to thank our Defra liaison, for tirelessly answering our many questions and requests for information. We discussed specific issues with Christine Middlemiss (CVO), Ele Brown (Deputy CVO) and Gideon Henderson (CSA until June 2025) and had valuable feedback on several issues from Defra, APHA & Natural England officials.

1.XII The Panel is grateful to the following people for discussion or answering questions: Damien Barrett, John Cross, Peter Diggle, Caroline Elmslie, Gareth Enticott, Nigel French, John Krebs, Helen McShane, NFU Officeholders and staff, Conor O'Halloran, Dick Sibley and Rebeca Wheeler. Michael Williams, Brendan Griffin, Rhiannon Lewis, Roger Lewis & Paul Rogers very kindly hosted us at Fagwrfran Farm and explained the Pembrokeshire Project. We thank the individuals and organisations that submitted evidence in writing.

Chapter 2: Background

Introduction

2.I Chapter 2 in the 2018 Report contained considerable background material on past bovine TB strategy and an introduction to bovine TB epidemiology, diagnostics and surveillance, and legislation. Much of this material is still germane today and is not repeated in this chapter which summarises what has changed in the last seven years.

Overview of current bovine TB strategy in England

2.II In 2014, Defra published its Strategy for achieving OTF status for England by 2038[6]. Since then, a number of changes have been made including those enacted in response to the 2018 Bovine TB strategy review[7]

2.III Bovine TB remains the most pressing animal health problem in the UK. The costs to the taxpayer of tackling bovine TB in England are estimated to be about £100 million a year[8] with costs to farmers probably running to a further £75 million[9].

2.IV England continues to be divided into three areas with different levels of bovine TB risk: High Risk Area (HRA), Edge Area (EA) and Low Risk Area. Figures (from APHA's epidemiological analysis[10]) on the following page show:

(i) Figure 2.1: The location of the three bovine TB areas (and their equivalents in Wales; Scotland is considered all low risk).

(ii) Figure 2.2: The density of cattle herds in Great Britain (2023); higher risk areas tend to be in areas of higher herd density.

(iii) Figure 2.3: The density of reactors in Great Britain (2023); 76%, 18% and 6% of new incidents were in the HRA, EA and LRA respectively.

(iv) Figure 2.4: A 2023 analysis illustrating areas where bovine TB infections are increasing or decreasing.

[6] Defra, 2014, https://tinyurl.com/2014bTBStrategy
[7] Defra, 2020, https://tinyurl.com/2018bTBReviewGovResp
[8] UK Parliament, 2022, https://tinyurl.com/bTBCosts
[9] Defra (accessed July 2025), https://tinyurl.com/BadgerControlCBA
[10] APHA, 2024, https://tinyurl.com/APHAEpiAnalysis2023

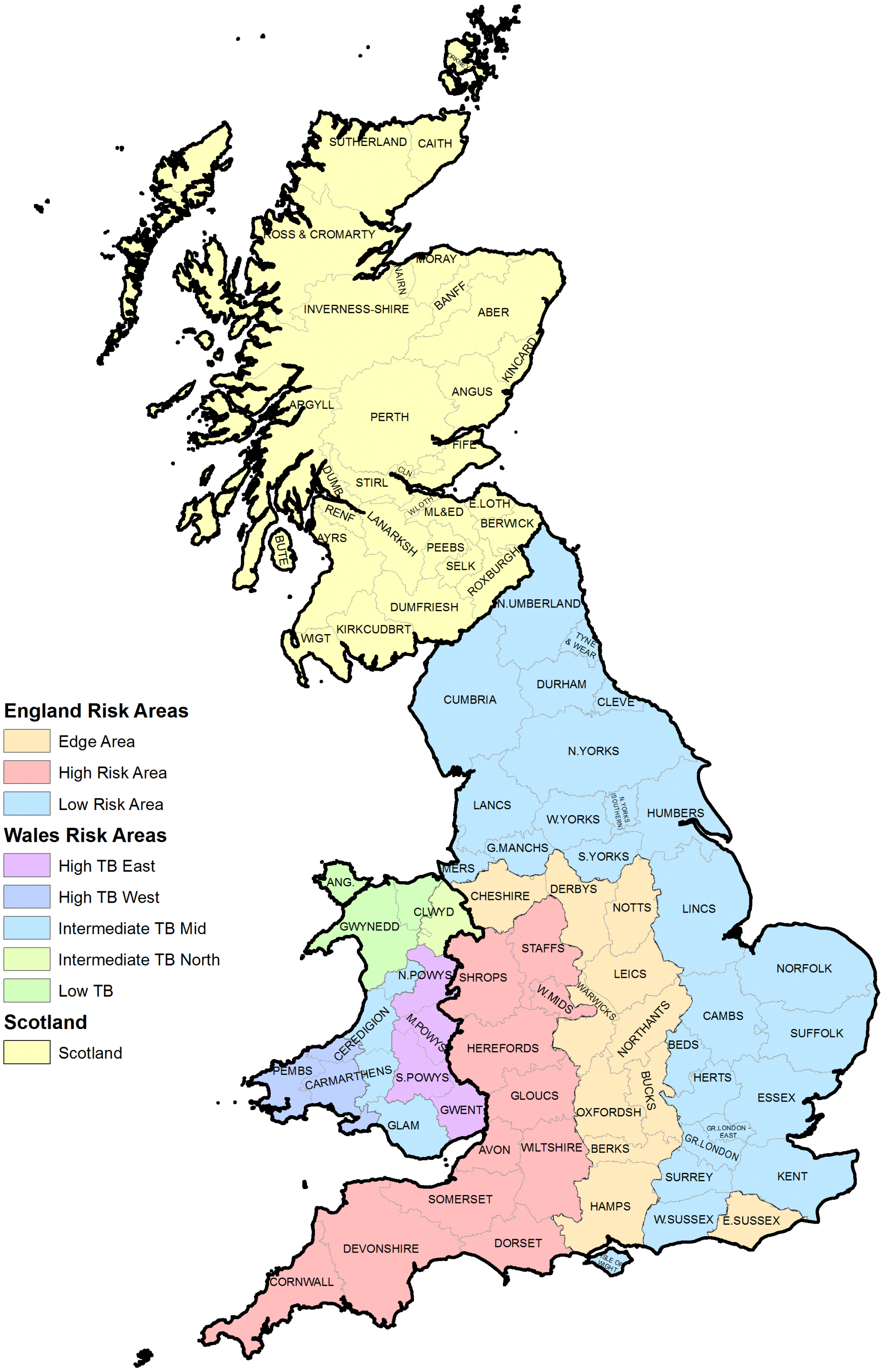


Figure 2.1. Geographic distribution of bovine TB risk areas across England, Wales, and Scotland, highlighting regional classification and disease management zones.

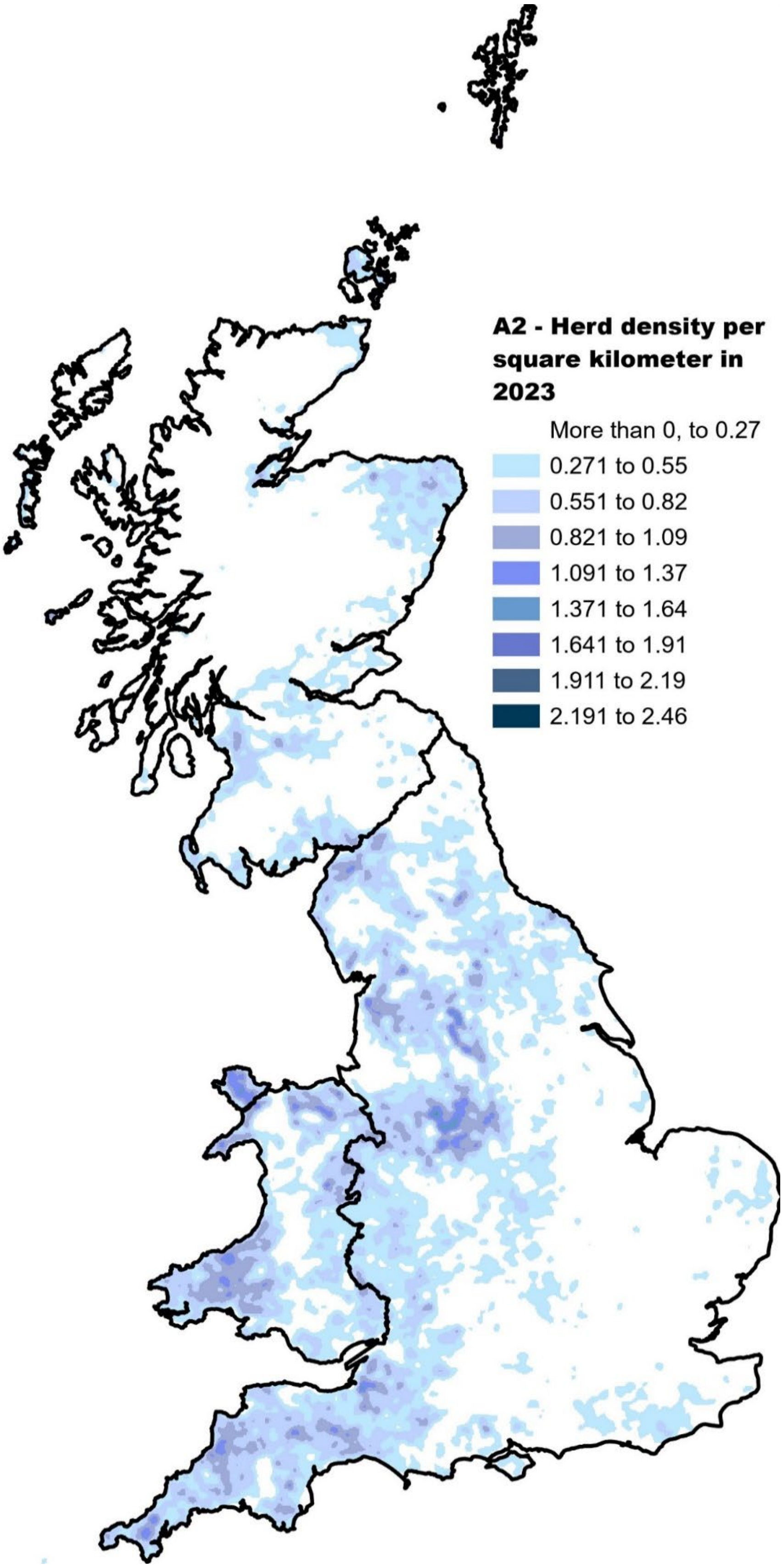


Figure 2.2. Distribution of cattle herd density across Great Britain

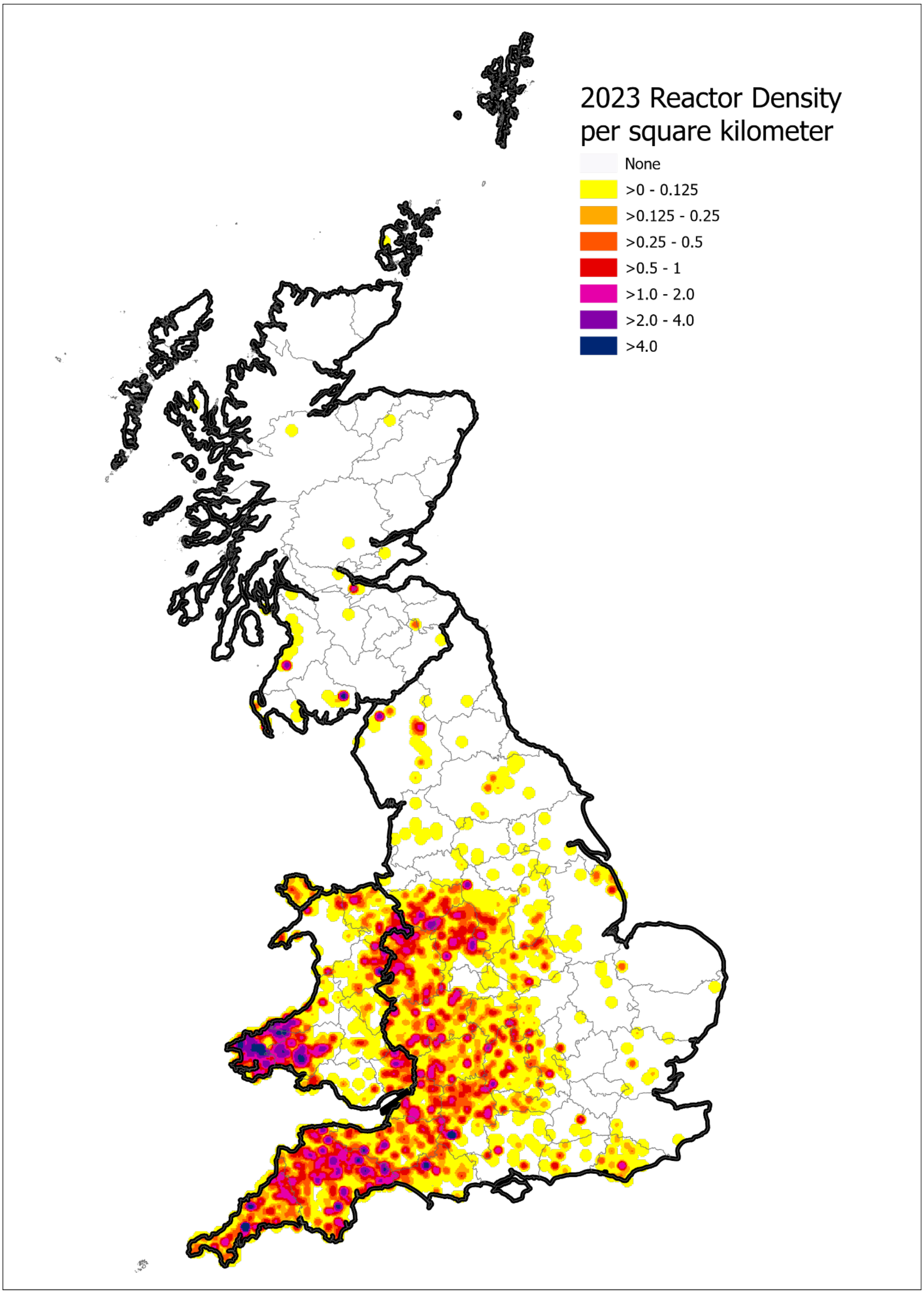


Figure 2.3. Spatial distribution of bovine TB reactor cases across Great Britain

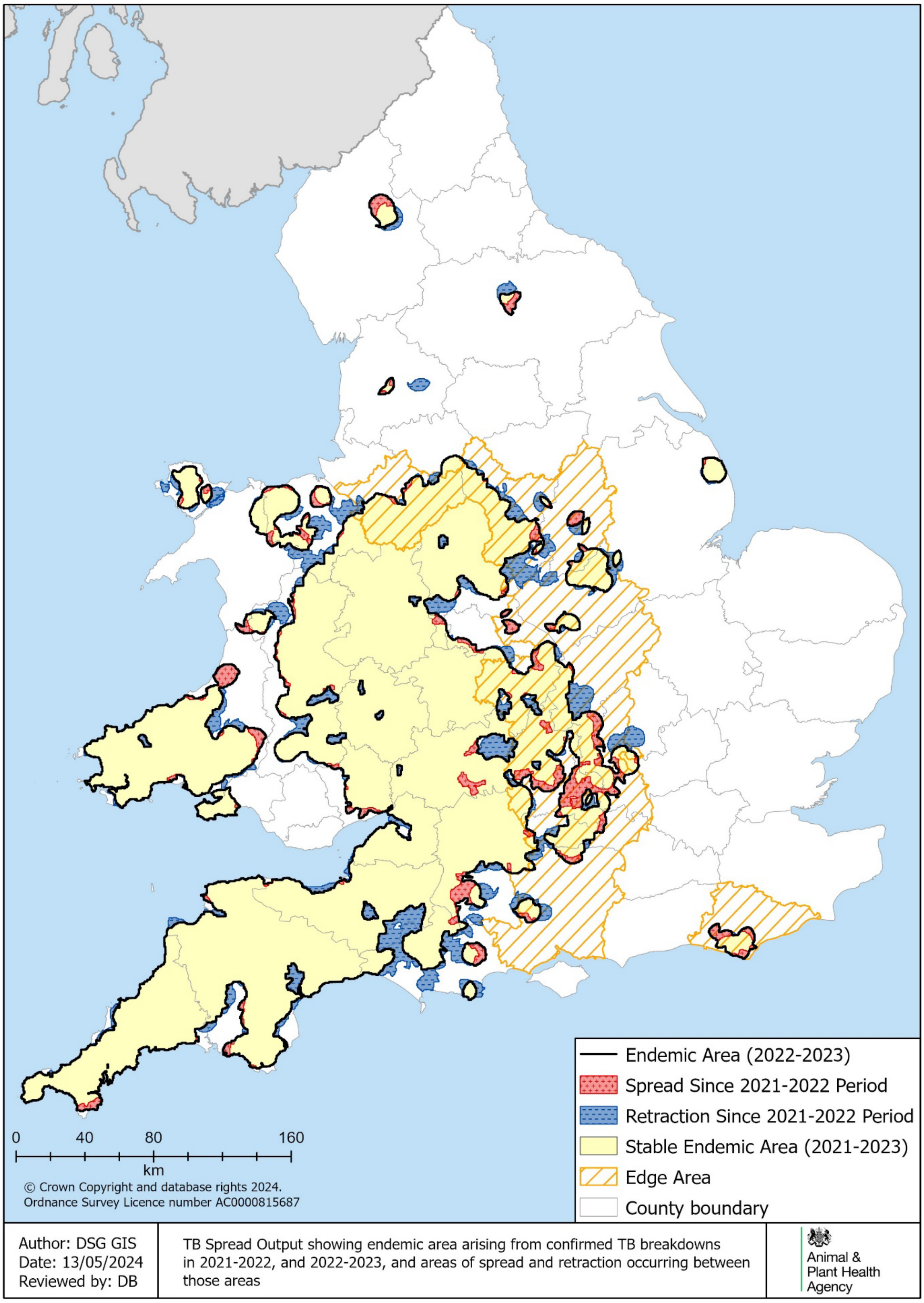


Figure 2.4. Geographic shifts in bovine TB endemic zones in England and Wales, highlighting areas of spread, retraction, and stability over the period 2022-2023.

2.V Figures 2.5 & 2.6 below show respectively trends in the incidence and prevalence of bovine TB in England (and separately in the HRA, EA & LRA), Wales and Scotland[11].

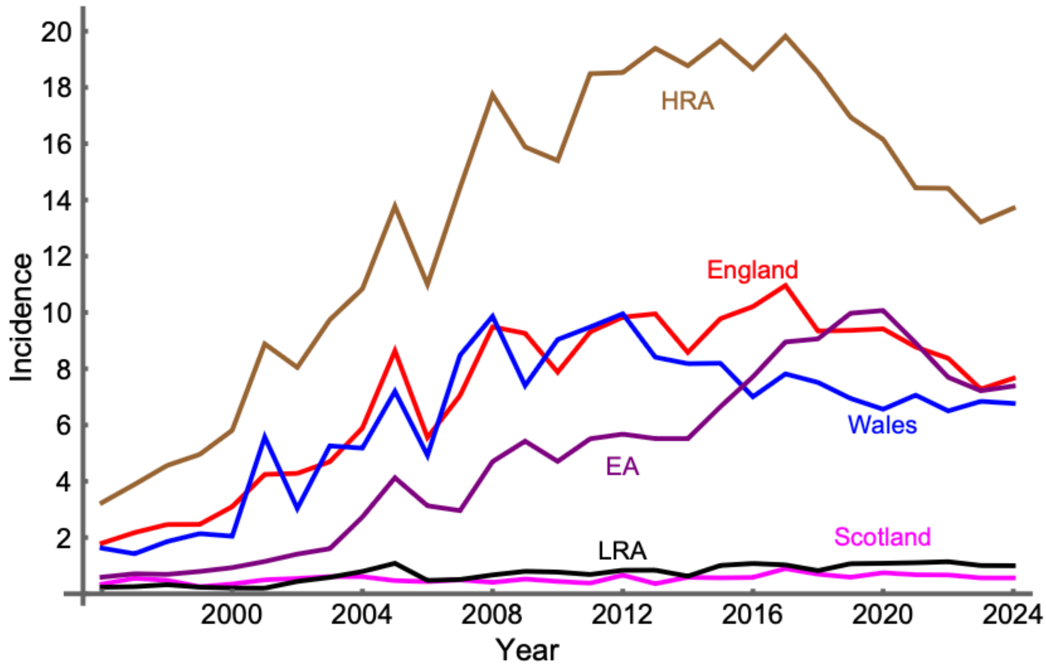


Figure 2.5. The incidence of bovine TB across nations and (in England) risk areas, 1996-2024.

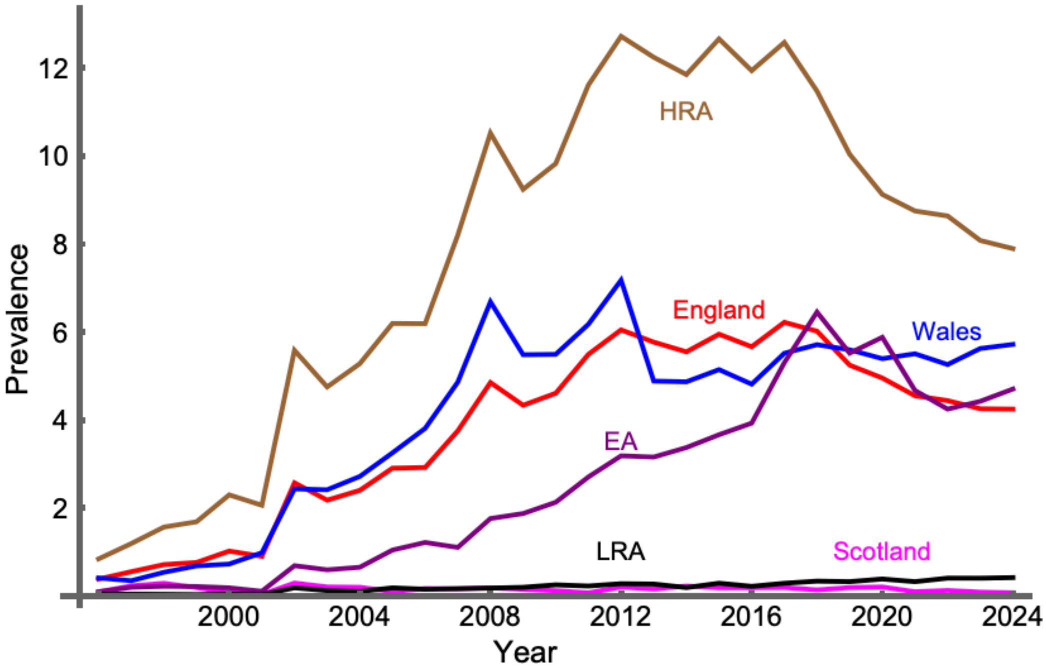


Figure 2.6. The prevalence of bovine TB across nations and (in England) risk areas, 1996-2024.

[11] Defra (accessed 2025), https://tinyurl.com/bTBStatsData2025

The incidence of the disease is defined as[11] “the number of new herd incidents per 100 herd years at risk over the time period. A herd is considered "at risk" for the length of time since its last negative herd test or since the end of its last breakdown. Thus this measure gives the average number of new incidents for every 100 unrestricted herds undergoing surveillance over the time period. The prevalence is the percentage of registered herds that were not officially TB-free at the end of the time period. The data show an encouraging drop in both measures in the HRA and to a lesser extent in the EA.

2.VI The incidence of bovine TB in the Republic of Ireland has increased (Figure 2.7[12]) in recent years. In part this is thought to be a result of a marked expansion of the dairy herd after the abolition of milk quotas in 2015.

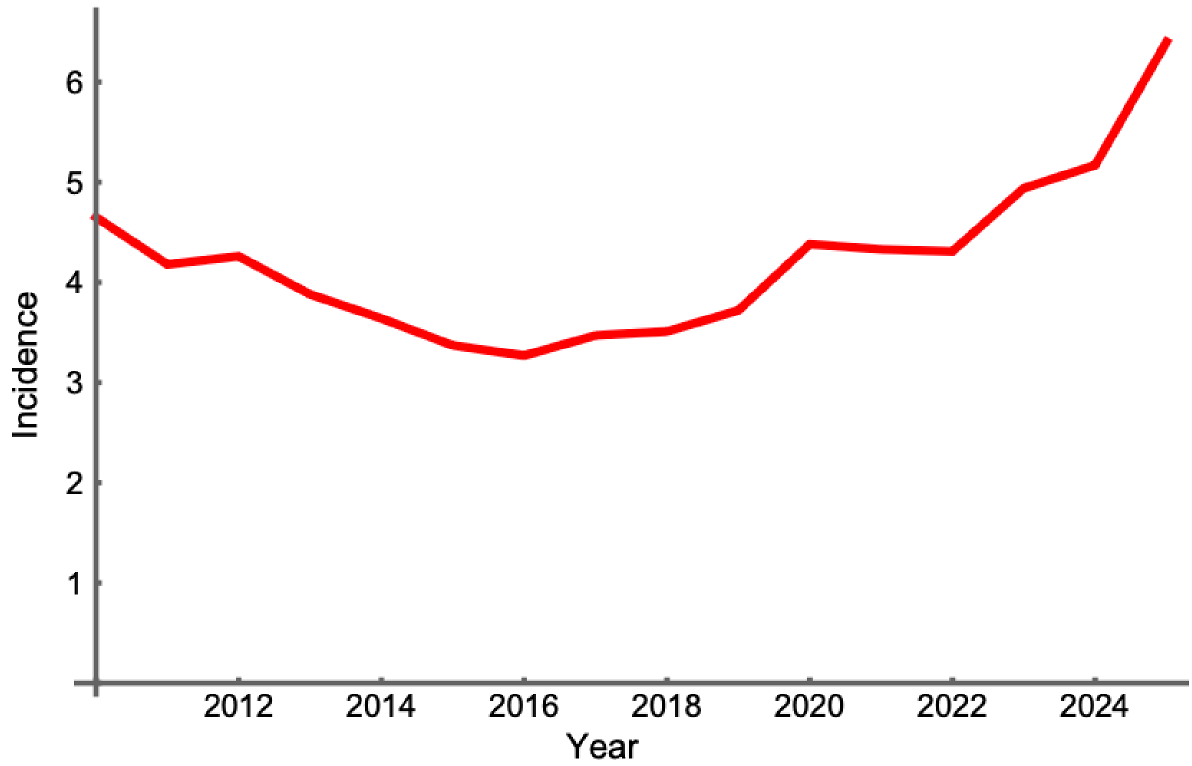


Figure 2.7. Incidence of bovine TB in the Republic of Ireland 2010-2024.

Recent developments

2.VII Recent developments in epidemiology, diagnostics and surveillance are described in the following chapters and are not repeated here.

2.VIII In Table 2.1 we update here the summary of legislation that we believe is relevant to bovine TB control.

[12] Central Statistics Office, Republic of Ireland, dataset DAA01, https://data.cso.ie/; Government of Ireland (accessed July 2025), https://tinyurl.com/RoIbTBStats

Table 2.1. Summary of recent legislation relevant to the control of bovine TB in England

Legislation	**Summary**
Council of Europe - Convention on the Conservation of European Wildlife and Natural Habitats (The Bern Convention) 1979	Conservation of wild fauna and their habitats. Defines the European badger as a protected species. The UK is a member of the Council of Europe (since 1949) and signatory to the Convention (1979) which will continue to apply in the UK post EU exit.
Domestic - The Animal Health Act 1981 c.22	Enables Ministers to make orders to prevent the spread of disease: cleansing and disinfection, biosecurity, animal movements, and imports and exports etc. Establishes a framework for government expenditure to control animal diseases and entitlements to compensation.
Domestic - Wildlife and Countryside Act 1981 c.69	Establishes offences relating to (among other things) the trapping and killing of wild animals including badgers, subject to licence.
Domestic - The Protection of Badgers Act 1992 c.51	Establishes that it is an offence to (or attempt to) kill, injure, or take a badger, or interfere with a badger sett, unless under licence. Sets out exceptions and conditions for granting a licence. Sets out enforcement and penalties for noncompliance.
Natural Environment and Rural Communities Act 2006 c.16	Establishes the framework under which badger control licensing functions have been delegated from Defra to Natural England, and guidance provided by the former.
Domestic - The Veterinary Surgery (Testing for Tuberculosis in Bovines) Order 2005 SI 2005/2015	Permits non-veterinarians to carry out tuberculin testing of cattle.
Domestic - The Veterinary Surgery (Vaccination of Badgers Against Tuberculosis) Order 2010, SI 2010/580	Permits non-veterinarians to vaccinate badgers by injection against tuberculosis, subject to certain specified conditions.
Tuberculosis (Non-bovine animals) Slaughter and Compensation (England) Order 2017, SI 2017/1254	Confers the power to slaughter bovines to control TB (as well as making other provision in relation to non-bovines).
Domestic - Cattle Compensation (England) Order, SI 2019/945 replaced SI 2012/1379 which expired on 1st July 2019	Sets out detailed arrangements for the payment of compensation to dairy and beef farmers where an animal has to be slaughtered under section 32(1) of the Animal Health Act 1981 for bovine TB.

Domestic - The Individual Ascertainment of Value (England) Order 2019 ,SI 2019/946 , replaced SI 2012/1380 which expired on 1st July 2019	Operates alongside SI 2019/945 and sets out arrangements for individual valuation when there is no table valuation figure provided for a specific category.
Domestic – The Tuberculosis in Animals (England) Order 2021, SI 2021/1001 as amended by SI 2023/867 and SI 2025/748. Replaced SI 2014/	Brought together statutory disease controls for bovine animals and non-bovine species into the same SI. Also included a new data sharing provision that allows the sharing of information on the TB histories of all cattle herds in England. Amended in 2023 to extend post movement testing to parts of the Edge Area. Amended in 2025 to allow sharing of TB information at animal level.

2.IX In Table 2.2 we update here the list of legal challenges (and attempts to bring about Judicial Review) relating to bovine TB policy in England, the majority of which have concerned badger control.

Table 2.2. Summary of recent legal challenges relating to bovine TB policy in England.

Date	**Claimant / Grounds**	**Outcome / To Note**
July 2018	Mr Langton: challenged the decision to publish guidance on licensing badger culls to prevent the spread of bovine TB, and the subsequent decision to grant two supplementary badger disease control licenses, arguing both were unlawful.	The challenge was dismissed. An appeal judgment also found in favour of the Secretary of State.
Aug 2018	Mr Langton: consultation on badger culling in the Low Risk Area was unlawful and the 2018 guidance falls outside the powers of the Protection of Badgers Act.	Claim discontinued.
2019	Mr Langton: challenged that the assessment of potential ecological impacts from badger cull licences within Sites of Special Scientific Interest (SSSIs) was fundamentally flawed.	Natural England took action required by the judgment.
Dec 2019	The NFU and another party: Challenged the decision by Defra to direct Natural England not to issue badger culling licences in Derbyshire.	The challenge was dismissed. An *ex gratia* payment was made to the Company to compensate it for the outlay in making the application.
2020	Mr Langton: Challenged that the government was bound but failed to consider its duty to conserve biodiversity under section 40 of the Natural Environment and Rural Communities Act 2006	The challenge was dismissed. An appeal judgment also found in favour of the Secretary of State.

Aug 2024	Badger Trust and Wild Justice: Challenging the lawfulness of Natural England's 2024 supplementary badger cull licensing decisions. Defra is an interested party	Permission for Judicial Review was initially refused, but following a renewal hearing, permission has now been granted.
Claims that did not proceed past the permission stage		
2020	Wild Justice: argued that Natural England failed to provide a clear benchmark for assessing humaneness and whether badgers are being killed humanely during licensed culls.	Permission for a Judicial Review was refused.
Nov 2023	Mr Akrill: argued that badger cull licences were unlawfully granted based on flawed scientific advice, materially mistaken in asserting badgers were spreading disease.	Permission for a Judicial Review was refused. Permission to appeal was also refused.
Jul 2024	Mr Langton: challenged the lawfulness of the consultation on the 'targeted badger intervention' policy, arguing that consultees lacked sufficient information to respond intelligently.	Claim discontinued.

Chapter 3: Surveillance and Diagnostics in Cattle

Introduction

3.I A cornerstone of bovine TB control policy in England (and in all other affected high-income countries) is surveillance and testing for the disease and the slaughter (or isolation) of infected animals. In the European Union, countries with bovine TB are required by law to have a test and slaughter programme as part of a TB eradication plan. While the United Kingdom is no longer subject to EU regulations, trading relations require us to maintain the confidence of key trading partners through strict adherence to this test and slaughter programme. Herds are regularly tested on the farm and may also be subjected to *ad hoc*, risk-based TB testing between routine tests. Cattle sent to slaughter are examined for the characteristic lesions made by the disease (as are all negative testing and untested cattle).

3.II The biology of *M. bovis* makes it very challenging to develop tests that have both high sensitivity (seldom miss an infected animal and hence produce few false negatives) and high specificity (seldom misidentify an uninfected animal as diseased and hence produce few false positives). Tests differ in their sensitivity and specificity and the optimum test to use and how it is deployed will depend on circumstances. For example, in the LRA where most animals are uninfected high specificity is particularly important to avoid large numbers of false positives.

3.III Most tests identify the presence of the disease by looking for an immune reaction to the presence of the bacterium. The most frequently used tests involve injecting into the cow's skin (typically the neck) a cocktail of proteins (tuberculin) derived from *M. bovis* and seeing whether the immune system responds by producing a "lump" approximately 72 hours later. In the Single Intradermal Cervical Tuberculin (SICT) test (the test used throughout most of continental Europe) the absolute size of the lump is measured. In the British Isles the Single Intradermal Comparative Cervical Tuberculin (SICCT) test is used where two injections are made, one of *M. bovis* tuberculin and the other of *Mycobacterium avium* tuberculin, and the two compared. SICCT is preferred in the British Isles over the SICT because of its higher specificity, although this comes at the expense of a drop in test sensitivity. The size of the lump that is deemed to indicate infection can be altered resulting in severe and standard interpretations of the test. Tests do not always give clear results and cattle can be classed as "inconclusive" pending further testing.

3.IV The World Organisation for Animal Health (WOAH) has designated the SICT and the SICCT, together with the Caudal Fold Test (similar to the SICT except the injection site is a fold of skin under the tail) as the prescribed tests to allow animals to be traded internationally[13]. The EU requires traded animals to be

[13] WOAH Bovine Tuberculosis, 2021, https://www.woah.org/app/uploads/2021/03/3-04-06-bovine-tb.pdf

negative for the SICT and also allows the use of the Interferon Gamma test[14]. To ensure that these tests are performed to their maximum potential, the WOAH has set standards for how the tests should be conducted and interpreted, as well as standards for the potency of the tuberculins used.

3.V Immunological tests can also be performed in the laboratory on blood samples taken from cattle. The interferon gamma release assay involves taking a blood sample from an animal and stimulating it in the laboratory with the bovine and avian tuberculins that are used for skin testing. The existence of an immune response is assessed by measuring the release of the cytokine interferon gamma which indicates prior exposure to *M. bovis.* This test has particularly high sensitivity, may detect animals at earlier stages of infection than the skin test, and can detect infected animals that have become desensitised to the tuberculin skin test due to multiple rounds of skin testing[15]. The presence of antibodies to *M. bovis* can be detected using serological tests; the IDEXX and Enferplex tests are both registered by the World Organisation for Animal Health (WOAH)[16] (but are not listed for use in the EU) and IDEXX is presently the most widely used.

3.VI Testing is used in three different contexts: (i) to monitor herds that are currently thought not to be infected; (ii) to help eliminate the disease from herds that have suffered a breakdown; and (iii) to reduce the risk of the movement of infected animals (this aspect we discuss in Chapter 5). At present, 50% of herds that are cleared of infection (regain their OTF status) suffer a further herd breakdown in the subsequent three years. We believe that in a large fraction of cases this is due to infected animals in the herd that are not detected. In our 2018 Report we emphasised the importance of designing a testing regime that efficiently identifies cattle infected with *M. bovis* in OTF herds.

Recent developments

Surveillance of Officially TB Free (OTF) herds

3.VII A risk-based approach is taken to the frequency of testing of OTF herds. The primary determinant is whether the farm is in the LRA (4 yearly testing), EA (divided into two based on prevalence with annual or 6 monthly testing) and the HRA (6 monthly testing). More frequent testing in the LRA and the annual testing section of the EA can occur on premises adjacent to those with a herd breakdown, in herds located within a TB hotspot declared by APHA, and in herds that regularly import cattle from higher risk areas of the UK or the Republic of Ireland, all of which are examples of the so-called 'Area and Herd Risk surveillance testing stream'. Farms in the HRA with little history of bovine

---

[14] EFSA Panel on Animal Health and Welfare, 2012, https://doi.org/10.2903/j.efsa.2012.2975

[15] Coad *et al.,* 2009, https://doi.org/10.1051/vetres/2009062; Lakew *et al.,* 2024, https://doi.org/10.1038/s41598-024-64884-x

[16] WOAH, The register of diagnostic kits (accessed July 2025), https://tinyurl.com/WOAHDiagnostics

TB can obtain "earned recognition" and move to annual testing. The definition of risk areas has remained the same since January 2018.

3.VIII APHA regularly provides reports on bovine TB surveillance[17]. In 2023 (the latest report[18]), over half (76%) of new TB herd incidents in England occurred in the High Risk Area and 18% in the Edge Area. Nearly 60% of those in the HRA occurred in herds that had experienced a TB incident in the preceding three years. In addition to location and history of infection, larger herds (>300 cattle) and dairy (as opposed to beef) herds were more likely to lose their OTF status.

3.IX It is very difficult to attribute changes in disease incidence in different areas to specific measures. However, we note that surveillance reports show a more rapid decline in Officially Tuberculosis Free Withdrawn (OTF-W) herds in the EA in areas that have undergone 6 monthly surveillance testing than in the lower incidence 12 monthly tested areas.

3.X Herd breakdowns occur sporadically in the LRA, mostly as a result of movement of infected cattle, and occasionally these turn into foci of infections with evidence of transmission to wildlife, so called 'hotspots' of infection. 54% of herd breakdowns in the LRA occur around sites that are designated hotspots or which are being monitored in case they become hotspots. We agree this additional testing is a critical defence against the establishment and spread of new foci in the LRA.

Removing infected animals from a herd

3.XI Over the last twenty years, increasing use has been made of the interferon gamma test to clear infections from herds because of its higher sensitivity. From 1 April 2017 until 12 July 2021 in England, mandatory interferon-gamma testing was used in conjunction with the skin test in OTF-W breakdown herds situated in parts of the HRA where at least two annual rounds of effective licensed badger culling have been completed. Its use was also mandatory in OTF-W breakdown herds in the HRA when the most likely route of infection was contact with infected cattle (e.g. via cattle movements, residual cattle infection from a previous TB breakdown, or contact with a contiguous infected herd). In the LRA and the Edge Area, mandatory interferon-gamma testing was applied to all herds sustaining a new OTF-W breakdown. Additionally, the supplementary blood test was deployed in persistent TB breakdown herds throughout England[19].

3.XII Since 2021 new rules have applied for interferon gamma testing[19]. In the HRA it is used when the breakdown has occurred within 18 months of the herd regaining OTF status following a previous breakdown with lesion and/or culture positive animals. Testing is also applied to chronic and persistent breakdowns with lesion and/or culture positive animals. In the six-monthly surveillance areas of the EA, the same rules apply. In the annual surveillance testing areas of the EA, interferon gamma testing is applied to all new breakdowns with lesion

[17] APHA (accessed July 2025), https://tinyurl.com/AphaSurv

[18] APHA, 2024, https://tinyurl.com/APHAEpiAnalysis2023

[19] TBHub (accessed July 2025), https://tinyurl.com/tbhubTestPolicy

and/or culture positive animals and to chronic and persistent breakdowns with lesion and/or culture positive animals. The policy remains the same for the LRA.

3.XIII Because of its greater sensitivity, the interferon gamma test identifies a high number of animals missed by skin testing. For example, in 2020, over 12,000 additional animals were identified as bovine TB positive by the interferon gamma test across Great Britain[20]. Between 2017 and 2021 (before the rule changes) approximately 339,000 interferon gamma tests were carried out with 19,580 cattle slaughtered[18]. This was in addition to 18,578 tuberculin-positive cattle detected by routine testing in the same period. These figures show both the value of the interferon gamma test and suggest that the use of the SICCT alone misses many infected individuals – diseased animals that can lead to recurrent herd breakdowns. Evidence from the same studies shows the use of the interferon gamma test during breakdown management significantly reduces the probability of a further breakdown in the next 18 months.

3.XIV In addition to the tuberculin skin and interferon gamma tests, the IDEXX ELISA test, which detects serum antibodies against *M. bovis*, is occasionally used as a further supplementary test, especially in herds anywhere in England experiencing TB breakdowns with large numbers of reactors (‘explosive breakdowns’) or persistent breakdowns that have not been resolved through other methods.

3.XV With the standard interpretation of the SICCT test, an animal is classified as a reactor if the lump resulting from the bovine tuberculin is more than 4mm larger than that from the avian tuberculin. If the difference is > 0mm and ≤ 4mm, then the individual is designated an “inconclusive reactor” (IR) and tested again after 60 days; if the re-test is negative the animal is judged a “resolved IR”, but if the result is positive or inconclusive again it becomes a reactor and is sent to slaughter. Resolved IRs are not permitted to move off the farm other than directly to slaughter or to an Approved Finishing Unit (though farmers can pay for additional interferon gamma tests which, if negative, can lift the lifetime restriction on resolved IRs). If TB lesions are detected in at least one of the slaughtered animals, the more severe interpretation of the SICCT test is applied where the cut-off point for a reactor is lowered (from a >4mm difference to a >2mm), so that only those animals with a difference <0mm and ≤ 2mm remain in the herd as IRs for re-testing.

3.XVI Recently published research suggests IRs may pose a risk to future herd health. In the HRA and EA, the odds of a resolved IR becoming a subsequent reactor were seven (HRA) and nine (EA) times greater than for animals that tested negative[21]. At herd level, the time interval before a new TB breakdown in IR-only herds (those only with IRs and no reactors) in England and Wales was around half that of herds where all animals tested negative. Adjusted for confounding variables, the risk of a subsequent TB breakdown the following

[20] Duncan, 2025, Poster presented at The Society for Veterinary Epidemiology and Preventive Medicine meeting https://svepm.org.uk/conferences-posters-list/
[21] May *et al.*, 2019, https://doi.org/10.3390/vetsci6040097

year was 2.7 times greater for IR-only herds compared with all-negative herds[22]. Data from England in 2019 showed that overall 40% (HRA) or 33% (EA) of IR-only herds went on to have a TB incident (with lesion and/or culture positive animals) within the following 15 months. Data from the Republic of Ireland also suggest that IRs (from standard and severe interpretation of the SICCT test) are at greater risk of subsequently testing positive for the disease[23].

New tests

3.XVII Since we last reported the Enferplex Bovine TB Antibody Test for the detection of *M. bovis* antibodies in serum and milk has been registered by the WOAH[24]. We welcome new additional tests and encourage their evaluation in the specific epidemiological situations in which they are to be used. It will be particularly valuable to run them alongside and compare them with other tests already in widespread use in APHA's and other laboratories.

3.XVIII In other diseases, PCR detection of infection is often used as a primary diagnosis. For bovine TB, PCR is used to confirm the presence of infection in lesions from tissues of slaughtered animals but has not been recognised as an official test for evaluation of other samples, such as respiratory secretions and faeces. The sensitivity of different PCR approaches can vary widely and the official APHA test is reported to detect ~10^5 organisms /ml of faeces, which is not sensitive enough to detect low level excretion. We believe that a more sensitive and validated PCR could play a greater role in detection of low-level excretion.

Tuberculin quality

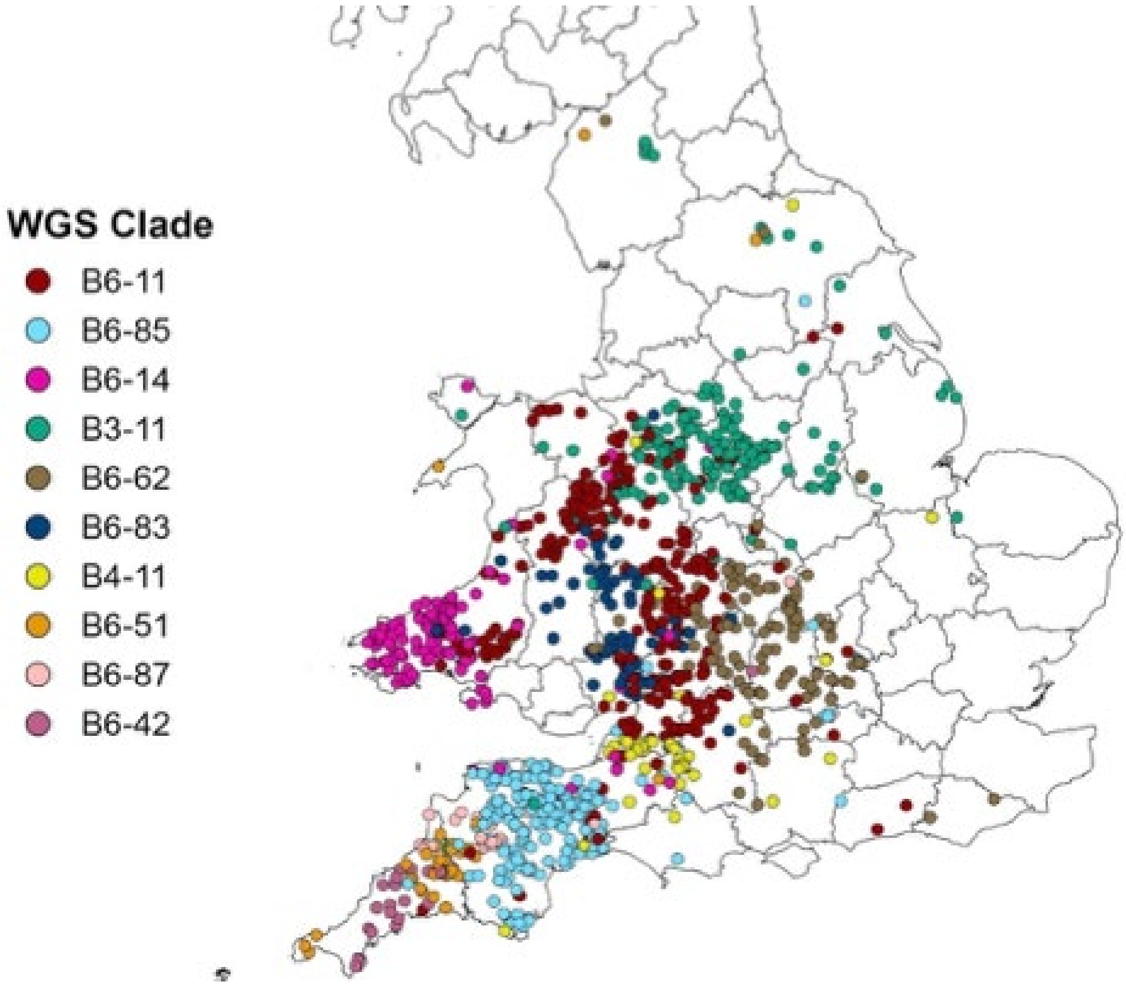
3.XIX Bovine tuberculin is a cocktail of proteins derived from live *M. bovis* bacteria. It is purified to obtain Purified Protein Derivative (PPD) tuberculin which is used in diagnostic tests. Its precise make up can depend on the bacterial strain used and how the tuberculin is prepared, and when used in a test this affects both its sensitivity and specificity. WOAH, through its network of reference laboratories, produces carefully prepared bovine and avian PPD tuberculin international standards that are used to assess the potency of batches of tuberculin to be used in diagnostic tests (typically by comparing responses in guinea pigs). However, there are known sub-potent tuberculins in circulation and being used worldwide[25].

Whole Genome Sequencing

3.XX Since our last review, whole genome sequencing (WGS) of *M. bovis* isolates has become employed routinely by APHA (and others[26]) to aid epidemiological

[22] Brunton *et al.*, 2018, https://doi.org/10.3389/fvets.2018.00228
[23] Byrne *et al.,* 2022, https://doi.org/10.1016/j.prevetmed.2022.105761
[24] WOAH, The register of diagnostic kits (accessed July 2025), https://tinyurl.com/WOAHDiagnostics
[25] Good *et al.,* 2018, https://doi.org/10.3389/fvets.2018.00059
[26] Price-Carter *et al.,* 2018, https://doi.org/10.3389/fvets.2018.00272; Michelet *et al.,* 2019, https://doi.org/10.3390/microorganisms7120687;

investigation and control. New insights into the comparative importance of cattle-cattle and wildlife-cattle transmission have been obtained (and see Figure 3.1). A study[27] using WGS of *M. bovis* isolates obtained from cattle and badgers during the Randomised Badger Culling Trial suggested that clusters of herd breakdowns in parts of South-West England were established by long-distance seeding events involving cattle movement and then maintained primarily by within-species transmission, with less frequent spill-over from badger to cattle or cattle to badger. WGS was used extensively to understand the dynamics of an outbreak in the LRA in Cumbria[28] (¶4.XXX). The outbreak was initiated by infected animals bought in from Northern Ireland and then passed through two phases, the first dominated by cattle-to-cattle transmission before becoming established in the local badger population. It should be noted that it will not be possible to isolate *M. bovis* strains from all breakdown herds as sometimes no lesions are found. Here, more traditional methods for source attribution such as movement and contact tracing will need to be employed.



Lorente-Leal *et al.,* 2025, https://doi.org/10.1016/j.prevetmed.2025.106519; Azami *et al.,* 2025, https://doi.org/10.1371/journal.pntd.0011982

[27] Van Tonder *et al.,* 2021, https://doi.org/10.1371/journal.ppat.1010075

[28] Rossi *et al.,* 2021, https://doi.org/10.1111/1365-2664.14046

Figure 3.1. Distribution of different *Mycobacterium bovis* clades (lineages) showing geographical structuring (from[29]).

3.XXI APHA have developed software tools to help maximise the benefit of WGS. ViewBovis is an APHA web application[30] that has been developed for use as a disease surveillance and breakdown investigation tool for bovine TB. It combines WGS data of *M. bovis* isolates with geographical locations of host animals to understand bovine TB transmission.

Updates on options for the future

3.XXII Policy makers have the difficult job of designing a testing regime in the absence of a perfect test. They must balance the epidemiological costs of false negatives (due to low sensitivity) against the economic (to state and industry) and farmer-welfare costs of false positives (due to low specificity). This balance will depend on local disease prevalence and whether the test is being used for general surveillance or herd breakdown management. Avoidance of near-term economic and social costs may trade-off against worst outcomes in the medium to long-term due to failure to control and eradicate the disease. Optimising testing using currently available tests, both to clear herds of animals carrying the disease and to ensure that the disease is controlled in areas where it is currently increasing, will have significant medium- to long-term benefits and indeed will be critical to achieving the goal of eradicating the disease by 2038.

3.XXIII Our 2018 report surveyed the evidence of the effectiveness of a range of policy options, and much of this discussion remains relevant today. Here we revisit those issues that will make the greatest contribution to bovine TB eradication.

Improving surveillance and detection of M. bovis *infected herds*

3.XXIV The standard test for bovine TB in the EU is the Single Intradermal Cervical (SICT) test in which only bovine TB tuberculin is injected into an animal's neck. The individual is deemed to be a reactor if a swelling of greater than 4mm results. The EU allowed the UK (and the Republic of Ireland) to continue its use of SICCT, but for any cattle exported to the Union movement is not allowed if the bovine only test measures 2mm or more or the presence of oedema (swelling caused by fluid build-up) is observed, 72 hours after tuberculin injection. The SICT has higher sensitivity than the SICCT and will detect more infected animals and herds. However, it has lower specificity and the UK has in the past been concerned by the number of false positives that might arise through cross-reactivity to other mycobacteria (including the causative agent of Johne's disease).

3.XXV A meta-analysis of published data suggested the specificity of the SICT was only 89% with wide confidence intervals[31] , a figure that has been influential in arguing against the use of SICT in England. We have concerns that this figure may underestimate the value of SICT. The metanalysis included studies using

[29] APHA (accessed July 2025), https://tinyurl.com/GBDataReport

[30] APHA (accessed July 2025), https://github.com/APHA-CSU/ViewBovis

[31] Nuñez-Garcia *et al.,* 2018, https://doi.org/10.1016/j.prevetmed.2017.02.017

different batches of tuberculin and involving cattle with different levels of exposure to environmental mycobacteria. None of the primary data was collected in the British Isles. Recent analysis of skin test data from England suggests that specificity of the SICT is between 98% and 99%[32]. The specificity of the SICT test should be determined in the context of its potential use in England so that policy makers can re-evaluate using it as a primary surveillance test, especially in high-risk situations in the HRA and EA, or hot spots in the LRA. In addition, it could be helpful in clearing persistent or recurrent herds and as a pre- or post-movement test in animals moving into the LRA.

3.XXVI Bovine TB surveillance using SICCT or SICT is highly reliant on the skill and care of the tester, so quality control is of great importance. Since our last report, the use of Approved Tuberculin Testers (ATTs) has been introduced in England. APHA assures the quality of delivery of TB skin testing by ATT's and Official Veterinarians through a combination of routine and targeted audits for individual TB testers. Audits are targeted based on intelligence and/or data that raises concerns about a tester's TB testing performance. We welcome this approach and recommend that performance data are frequently monitored and that training for those involved in the testing process is regularly reviewed in order to drive continual improvement. We are aware of and await with interest an analysis of ATT performance in Wales which will be published shortly.

3.XXVII We understand that although in most cases APHA will arrange for surveillance testing to be carried out, farmers have the option to choose a suitably qualified person to carry out tuberculin testing on their farm. In this case they may have to pay for the test. We are concerned that this has the potential to create a vulnerability in the current surveillance testing system and recommend that this option is reviewed with a view to closing this loophole.

3.XXVIII All cattle in British slaughterhouses are examined for gross lesions suggestive of TB and this continuous form of surveillance has historically been particularly important in the LRA given the 4-year interval between live animal testing. All detected lesions are investigated by PCR and/or culture to determine if they are caused by TB or other reasons. Approximately 11% of all new TB breakdowns declared in cattle herds between 2019 and 2022 were discovered by routine slaughterhouse surveillance, as opposed to tuberculin skin testing of live cattle on farms. When considered as a percentage of OTF-W breakdowns across all risk areas, the proportion in the last two reported years (2022-23) was 21%. The annual proportion of new TB incidents detected by slaughterhouse surveillance in England almost halved over 7 years (16% in 2015 compared to 9% in 2023)[33,34]. In the most recent year reported it was 9% in the HRA, 6% in annually tested EA, 10% in the six-monthly part of EA and 5% in the LRA. These changes are most striking in the LRA, where previously around 40% of all breakdowns were identified through this route.

[32] Unpublished data shown us by Defra

[33] APHA, 2024, https://tinyurl.com/CattleSlaughtered

[34] APHA, 2024, https://tinyurl.com/bTBSurveillance2023

3.XXIX APHA has suggested that the recently enhanced on-farm surveillance and control measures are detecting infected cattle at earlier stages of infection before they reach slaughter age explaining the drop of numbers. A test of this is to look at the frequency of lesions that are visually indistinguishable from those caused by bovine TB. If earlier detection of bovine TB is occurring one would expect them to increase in proportion over this time - and also expect them to be far higher in LRA slaughterhouses where TB is so rare. APHA reports that the proportion of bovine TB positive samples has indeed reduced over time. However, the number of slaughtered animals from the LRA with non-bovine TB lesions seems low in comparison to the HRA, and we have some concerns about lower rates of slaughterhouse detection. As recommended in our previous review, slaughterhouse surveillance could be enhanced further by raising awareness of its importance with slaughterhouse workers and by providing financial incentives for good practice.

3.XXX The use of modelling to explore residual variation in detection rates of TB slaughterhouses cases across cattle abattoirs in GB is now routinely used to provide quality assurance. The introduction of polymerase chain reaction (PCR) testing[35] of samples received from slaughterhouse cases from the end of March 2022 provides a much faster result compared to laboratory culture and is to be welcomed.

3.XXXI APHA have now established a system for the early identification of novel developing foci in the LRA. Once an area is designated as a hotspot, enhanced control measures are put in place around the developing focus, including surveillance in cattle and wildlife. There is encouraging evidence from the hotspot in East Cumbria that this approach can reduce the burden of bovine tuberculosis in both wildlife and cattle[36]. We believe maintaining this proactive approach to stopping foci developing in the LRA is important. Enhanced testing in LRA hotspots[17] has recently been highly effective in detecting a large number of breakdowns. Whether this is a reflection of more serious and larger foci or the better intelligence-led identification of high-risk farms is not clear. Whatever the reason we underline the importance of preventing hotspot foci from developing.

Voluntary testing in OTF herds

3.XXXII There is currently an APHA licencing system that allows OTF farms to use additional tests, typically ‘private’ interferon gamma tests, to identify infected cattle between statutory tests, although this is seldom taken up as a failure triggers breakdown restrictions and related costs. We argue that there is scope to allow farms to use serological tests when OTF, and that cattle that test positive should be treated in the same way as resolved inconclusive reactors (IRs) in OTF-W herd. The movement except to slaughter of these animals is prohibited and many farmers will separate these individuals from the rest of the herd. We recognise the potential for abuse and that farms may need some form of accreditation to take part. It will also require the data infrastructure to store and process the extra testing information. Such a scheme is likely to be particularly attractive to large dairy operations that are at relatively high risk of

[35] Morris *et al.,* 2023, https://doi.org/10.1093/jambio/lxad038
[36] APHA, 2025, https://tinyurl.com/TBHotspots

disease and which already use data such as the detailed results of skin tests to give risk scores to individual cattle to influence slaughter decisions. Such a programme could reduce the costs of compensation to the state and for farmers reduce business interruption and breakdown costs, and result in fewer peak lactation animals being sent slaughter.

Frequency of testing

3.XXXIII Herds are tested every six months in the HRA, every four years in the LRA, while different areas within the EA are tested either annually or every six months. There is evidence that more frequent testing has led to a falling incidence in the EA (¶3.IX). Maintaining six-monthly testing in the HRA and extending it to all of the EA would increase the numbers of herd breakdowns that are detected early before the disease spreads further and should be considered as an effective way to reduce disease incidence.

3.XXXIV While recognising the extent of risk-based testing that already exists, we discussed in 2018 the possibility of moving towards more herd-level risk-based testing were more comprehensive information to be available as part of the Livestock Information System. Progress on the latter's development has been much slower than we envisaged (see ¶¶5.XVIII-5.XX) but if it were to be deployed important new policy options around targeted herd-level testing would be opened up.

Increasing efforts to remove infections from herds

3.XXXV Once a herd has had its official bovine TB free status suspended (OTF-S), it is regularly tested until no more reactors are located on two successive visits. When recurrence in the herd is detected, the cause might be reinfection from other cattle or wildlife, or because the infection had not been eliminated. We wrote in 2018 that "Evidence has grown in recent years that the frequency of hidden or occult infections in OTF-W herds is higher than previously thought". This evidence has continued to mount and we argue that bovine TB policy needs to be developed on the premise that there is a substantial burden of undisclosed infection in the national cattle herd, especially in herds with a history of infection. These infected cattle pose risks both to the herds in which they are kept and, importantly, to the herds into which they can currently be sold.

3.XXXVI Increased testing is clearly part of the solution but will lead to more cattle being classified as infected with costs for the farmer and the state. More sensitive tests that can detect latent and occult infections will also generate more false positives. We discuss below ways that this burden could be reduced, for example to avoid cattle at peak lactation being immediately destroyed and to allow farmers more flexibility in managing infection out of their herds.

3.XXXVII There are several options to use statutory tests with greater sensitivity than the current SICCT test (with severe interpretation) which is the default test for restoring OTF status to OTS-S and OTF-W herds:

(i) The interferon gamma test has higher sensitivity but lower specificity than the SICCT (¶¶3.XI-3.XIII) and is already used as a major tool to rid OTF-W herds of infection. Its use is not currently mandated on a routine basis in every herd with an OTF-W breakdown and the numbers of animals being tested with it have fallen substantially over the last 3 years. Given the high numbers of infected cattle that have been identified by the interferon gamma (¶3.XIII) there is a strong argument for its mandatory use in all OTF-W herds.

(ii) Serological tests such as IDEXX ELISA or Enferplex Bovine TB Antibody Test detect some infected animals that are missed by other tests (¶3.XIV)[37]. Combining a skin test, the interferon gamma test and a serological test will maximise the sensitivity of detection. The costs of testing would increase but this combination would be particularly useful to help clear high risk or high impact herds, such as persistent and recurrent herds, post-cull and post-badger vaccination herds in the HRA and the EA and emerging hotspots in the LRA. These tests might also be more widely used in non-statutory settings (below). We are aware of ongoing studies[38] comparing the performance of the IDEXX and Enferplex tests that will help in the design of testing regimes and we encourage greater use of these additional tests.

(iii) The SICT test has a higher sensitivity but lower specificity than standard and severe interpretation of the SICCT. It would detect more infected animals in breakdown herds than using the severe interpretation of the SICCT. If there are situations when the interferon gamma test is not available, then we encourage the use of SICT to help clear infection in problematic herds.

3.XXXVIII Farmers can use discretionary tests including serological tests (IDEXX and Enferplex) during a breakdown, under licence from APHA, to identify high risk animals. Other tests may be available in the future. There are regulatory issues here, similar to those of allowing voluntary testing of OTF herds (¶3.XXXI). The IDEXX test is mandatorily used in certain circumstances in TB breakdowns in Wales.

3.XXXIX Instead of slaughtering animals that test positive to discretionary serological tests (as currently mandated at the farmer's expense), the test results could provide extra information to develop individual cattle risk scores to be used alongside existing data such as the quantitative readings from SICCT tests to allow farmers to manage out infection from their herd. One approach would be to keep more high-risk animals on farm but in isolation from the main herd. The animals would be sent to slaughter when low-risk replacements become available. This is particularly attractive for dairy herds as it makes it easier for the farmer to meet milk contracts without the emergency purchase of new cows (though in ¶5.XXII we argue for reform of how milk contracts operate). But in the absence of strict biosecurity measures the risk remains of further on-farm transmission. The compulsory slaughter of these animals may remove the

---

[37] Moens *et al.,* 2023, https://doi.org/10.1016/j.rvsc.2023.04.004;
O'Brien *et al.,* 2023, https://doi.org/10.1038/s41598-023-28410-9;
Defra (accessed July 2025), https://randd.defra.gov.uk/ProjectDetails?ProjectId=17264

[38] Defra (Accessed July 2025), https://randd.defra.gov.uk/ProjectDetails?ProjectId=21022

problem but is a huge disincentive for farmers wanting to use more tests to reduce the level of infection in their herds. Overall, we see value in exploring rules relating to discretionary tests that do not automatically lead to slaughter. Over time, as vaccination and other interventions reduce prevalence, the scale of these impacts should decrease.

3.XL It is possible to use the Enferplex test to detect bovine TB antibodies in bulk milk[39] or the milk of individual cows[40] The test is provisionally approved by WOAH for this purpose[41] and is currently undergoing a large-scale evaluation using bulk milk samples from dairy herds across Great Britain[42]. The test can be automated to allow continuous surveillance, something that is facilitated by modern automated and robotic milking parlours which already collect data on individual cows. Automated milk testing could be a valuable tool in helping farmers manage out infections. As above, milk-test positive animals should be separated from negative animals or sent to slaughter.

3.XLI In ¶3.XVI we discussed the extensive evidence that resolved IR cattle are associated with substantial residual risk. Farms focussed on managing out infection will usually regard these as the highest risk animals. We believe the evidence supports retaining policies that prohibit farmers moving resolved IR cattle from their herds (unless direct to slaughter, or via an approved TB dedicated sale/slaughter gathering or to an AFU), including if they have negative interferon gamma test (unless new evidence demonstrates that these animals do not pose a risk).

3.XLII Substantial information already exists to help farmers manage out infections after a breakdown (and indeed to prevent them in the first place), and we argue there is value in facilitating farmers to obtain further data. Several initiatives based around developing risk scores for all cattle in a herd exist, for example the Pembrokeshire Project (see ¶9.XV). For these to succeed, farmers and their veterinarians need to work closely together, and also to have good links with APHA vets. Data from statutory testing needs to be provided to both farmers and their vets quickly and in the most useable form. Examples of best practice and innovation should be advertised and celebrated, and their adoption by other groups of farmers and vets should be made as easy as possible.

3.XLIII In our last report we suggested that a more stringent criterion for herds to be declared OTF would be to require two tests, 60 days apart, for OTF-S to be removed and three or four tests for OTF-W to end, and this is the policy for most OTF-S herds in England. In the final stages of Australia's eradication programme four or five successive negative whole herd tests were required for disease-control measures to be removed. The general point here is that as controls become more successful, it will be important to increase the stringency

[39] Hayton *et al.,* 2025, https://doi.org/10.3168/jds.2024-25539
[40] O'Brien *et al.,* 2024, https://doi.org/10.1371/journal.pone.0301609
[41] WOAH, 2019, https://www.woah.org/app/uploads/2021/03/oie20abstract2026-07-19.pdf
[42] SRUC (accessed July 2025), https://pure.sruc.ac.uk/en/projects/can-bulk-milk-revolutionise-tb-testing

and frequency of testing, not to reduce them as occurred in the 1980s and 1990s.

3.XLIV There are several new tests under research or development. As we highlighted in our previous report, facilitating the validation of promising tests and designing testing regulations so that they can be utilised as soon as they have been validated and accredited remains important. However, we urge caution on the use of these tests until they are fully validated under the specific conditions of cattle farms in GB.

3.XLV Several times in the Update we express disappointment at the delayed delivery of a fully functional Livestock Information Transformation Programme (¶5.XVIII). If farmers are to be encouraged to expand testing to resolve breakdowns, then it will be important to have the IT infrastructure in place to record test results and ideally to assess an individual animal's risk score. This is important for both the individual farmer but also for APHA to obtain a clear epidemiological overview of the disease.

Ensuring continuing supply of high-quality tuberculin

3.XLVI There are concerns about the maintenance of supply of both high-quality PPD tuberculin and of the WOAH-accredited International Standards used in quality control (¶3.XIX). We know that both WOAH and APHA (a WOAH Reference Laboratory) are aware of these issues and we support the development of robust plans to ensure the maintenance of quality and supply (note that similar issues apply to vaccine reagents, ¶4.XX).

Whole Genome Sequencing and epidemiological intelligence

3.XLVII We believe further insights can be obtained from WGS, in particular if more *M. bovis* isolates are collected over long time periods from well-sampled local populations of cattle and wildlife. This is essential if the pattern of transmission between cattle and to and from wildlife is to be inferred. As is discussed in ¶6.V more data from wildlife isolates would be very valuable.

3.XLVIII Further integration of WGS data with epidemiological databases including cattle movement data, testing histories and data associated with local badger populations will be helpful, and sharing *M. bovis* genome sequence data with the national and international scientific community in a routine and timely way would maximise the opportunities for analysis and public good arising from the data.

Research & development priorities

3.XLIX The absence of a cattle test with both high specificity and sensitivity is probably the single greatest barrier to effective disease control. The last few years have seen new tests registered with the WOAH and others proposed which are currently in the early stages of development or commercialisation. There is also a fruitful read across from work on human TB diagnostics. Research and development to characterise the performance of novel tests and explore new options is, we believe, of high priority. Discussions and exploration of novel tests is also hampered by the lack of high-quality data on the true performance of currently available tests in cattle in different epidemiological situations relevant to England and filling this evidence gap is a high priority. Such data would facilitate the quantification of the likely costs and benefits of the different testing regimes we explore. For example, the use of serological tests needs to be carefully validated in herds that have had all skin test and interferon gamma test positive animals removed, as they are never likely to be used as standalone tests in GB.

3.L The establishment of a repository (biobank) of bovine material has already assisted the research, development and evaluation of new tests and we argue this should be continued.

3.LI Research to identify defined antigens for use in the skin test and for interferon gamma assay is ongoing. Although this is a slow and challenging process it is important and we think support should be continued. The use of specific antigen cocktails in place of tuberculin offers the possibility of improving the performance of the tuberculin skin test and the interferon gamma assay and replacing the cumbersome and highly variable production, quality control, standardisation and potency evaluation processes required for the current tuberculin products.

3.LII More research is required to understand the relative contribution of cattle movements and wildlife reservoirs to cattle herd breakdowns using WGS and other methodologies (see also ¶6.LXXI).

3.LIII *M. bovis* can be transmitted from a mother cow to her calf through respiratory infection, suckling and potentially in the womb. Given the potential importance of this route of infection for maintaining persistent infection within herds and the fact that cattle under 42 days old are exempt from pre-movement TB testing, we recommend that more research is carried out to understand the impact of this route of infection on within and between herd spread.

3.LIV Machine Learning and Artificial Intelligence will increasingly become important tools in epidemiological research. A recent study used machine learning to predict herd-level bovine TB breakdowns in Great Britain, achieved better predictive performance than previous research approaches[43]. This is a developing technology and not yet mature enough for deployment, though further research in this area should be encouraged.

[43] Stanski *et al.,* 2021, https://doi.org/10.1038/s41598-021-81716-4

Chapter 4: The Disease in Cattle: Vaccination and Resistance

Introduction

4.I The spread of bovine TB can be reduced by making cattle less susceptible to infection or by reducing the probability of infected cattle transmitting the disease – traits that together characterise how resistant an animal is to *M. bovis*. Two strategies to increase resistance are cattle vaccination and livestock breeding. As we describe in detail in our 2018 Report, one vaccine available for cattle is the BCG (Bacillus Calmette-Guérin) which is the same as that used in humans. Livestock breeding over centuries has resulted in substantial meat and dairy yield gains and in recent decades the selection of other traits has increasingly been targeted.

4.II The standard surveillance tests used in cattle cannot distinguish between vaccinated and infected animals. Because an animal may have been infected prior to vaccination or, as the vaccine is not perfect, after vaccination, there is a risk of these individuals going undetected. To avoid this a DIVA (Differentiating Infected from Vaccinated Animals) test is required. The BCG vaccine is prepared from an attenuated strain of *M. bovis* that lacks certain proteins (antigens) present in the strains of the bacterium circulating in farmland. A DIVA test involves seeing whether an animal has been previously exposed to these missing proteins which would indicate infection by the wild strain of *M. bovis.* The DIVA test can involve simply injecting these missing proteins into the skin and seeing whether there is a response (as in the standard skin tests). Alternatively, exposure to *M. bovis* can be assessed by taking a blood sample and in the laboratory seeing whether white blood cells respond to the presence of the missing proteins by producing the cytokine (a chemical that mediates immune responses) interferon gamma. DIVA tests based on interferon gamma release assays are used to detect TB infection in humans vaccinated with BCG. Note that blood- and skin-test DIVAs involve subtly different aspects of the immune response to infection. Encouraging results have also been reported for the use of Enferplex and IDEXX antibody tests as ancillary DIVA tests in BCG vaccinated cattle although transitory false positive reactions are observed after a tuberculin skin test[44]. Additional work is required to validate this approach.

4.III The main strategy to control bovine TB has been test and slaughter and because vaccination masks true infection, vaccination has been illegal under UK and EU law. Though test and slaughter has been successful in many countries, its lack of success in countries such as the UK and the Republic of Ireland with wildlife reservoirs, and in poorly-resourced low-income countries had led to increased interest in vaccination + DIVA interventions. In the UK, the

[44] Holder *et al.,* 2025, https://doi.org/10.3390/vaccines13060578

government elected in 2024 did so with a manifesto commitment to pursue a policy of using cattle vaccination with DIVA as a major plank of its bovine TB strategy. The WOAH[45] (World Organisation for Animal Health) have recently emphasised that this strategy can also be valuable in high prevalence settings in the global south.

4.IV Since our 2018 report, there has been substantial progress in providing breeding indices (based on both performance and genomics) for dairy breeds. TB Advantage scores are available for animals in several dairy breeds (including Holstein, Friesian, Ayrshire, Scandinavian Red, Jersey and Guernsey). The availability of the performance-based scoring for individual bulls is of course wider in the more common breeds. The indices, which are publicly available on an AHDB hosted website, are shown on a scale from -3% to +3%, where positive scores are desirable. For every +1 point in the index, 1% fewer daughters are expected to become infected during a TB breakdown[46]. Scores are given for many other important production parameters such as milk production and calf survival and the range of the score for bovine TB resistance fairly represents the positive but limited effect that breeding can have. While work on beef cattle is not so advanced, similar Advantage scores should be available soon, especially for the more common breeds.

Recent developments

Vaccination

4.V Evidence accumulates on the efficiency of the BCG vaccine to reduce infections. A systematic review and meta-analysis[47] in 2021 of studies where cattle were vaccinated and then experimentally challenged with the pathogen summarised 51 data sets from 24 publications and estimated an overall reduction in the likelihood of infection of 18% (95% CI: 11-24%). There is considerable variation across studies reflecting differences in the way the attenuated vaccine was prepared, the strain of BCG, the dose and the route of vaccination used as well as variation in the cattle, their exposure to environmental mycobacteria and the detailed experimental protocol.

4.VI The same study also summarised vaccine efficacy when the cattle were exposed to natural infection rather than experimental challenge. Higher efficacies (61%, 95% CI: 40-74%) were estimated which is to be expected as these studies capture both the direct protective effect of the vaccine as well as some of the consequences of reduced transmission within the herd. There is strong evidence that infected but vaccinated animals suffer a less severe form of the disease (for example with fewer lesions at post-mortem) compared to non-

---

45 WOAH, 2024, https://www.woah.org/app/uploads/2024/10/v6-guidelines-mtbc-181024.pdf

46 AHDB (accessed July 2025) https://breedingdairy.ahdb.org.uk/

47 Srinivasan *et al.,* 2021, https://doi.org/10.3389/fvets.2021.637580

vaccinated individuals[48]. Several recent studies in Ethiopia[49], New Zealand and Mexico have also reported encouraging efficacy against natural infection.

4.VII A particularly significant natural infection study in Ethiopia exposed disease-free vaccinated and non-vaccinated animals to infected stock and then assessed the degree to which the two classes became infected. These animals were then placed with disease-free vaccinated and unvaccinated cattle to assess onward transmission. Together, this experimental design estimates the total effect of vaccination, the quantity most relevant to disease control. The study reported a 74% reduction in bovine TB transmission [95% CI: 46-89%] in vaccinated as compared with unvaccinated animals. Overall, considering both direct and indirect effects of vaccination, in a fully vaccinated herd the total efficacy of BCG was estimated to be 89% (95% CI: 74 - 96%)[50]. These results along with modelling of within-herd transmission dynamics strongly suggest that cattle vaccination can be an important tool in controlling bovine TB.

4.VIII Studies performed to Good Laboratory Practice (GLP) in which calves and lactating cows were vaccinated with BCG have shown that the vaccine is well tolerated, has no detrimental effect on milk yields in lactating cattle and vaccinated animals do not shed BCG in milk, saliva or faeces[51].

4.IX Recent studies have shown that vaccination of calves with BCG results in a duration of immunity of at least 52 weeks indicating that annual vaccination will be required[52].

4.X The DIVA test currently being developed in the UK is a skin test involving three proteins (ESAT-6, CFP-10 & Rv3615c) that are absent or not secreted from the attenuated *M. bovis* strain from which the BCG vaccine is produced[53]. For ease of manufacturing and quality control, a fusion protein has been designed where the three proteins are combined in a way that still elicits their individual immune response when used in a cattle skin test (the construct is called DIVA Skin Test-Fusion or DST-F)[54]. An interferon gamma release assay using combinations of these antigens is also available, either as the fusion protein or as peptide cocktails, but still requires validation[55]. This DIVA test is less specific than the DIVA skin test and so would be unsuitable for widespread use, but its higher sensitivity may be of benefit where maximum test sensitivity is required.

4.XI APHA have conducted specificity and sensitivity studies of DST-F. Specificity is high: only 1 of 140 (vaccinated or unvaccinated) uninfected cattle were erroneously identified as infected. Studies evaluating DST-F sensitivity in

---

[48] Nugent *et al.,* 2018 https://doi.org/10.1016/j.vaccine.2018.10.025
[49] Bayissa *et al.,* 2021, https://doi.org/10.3389/fvets.2021.702402
[50] Fromsa *et al.,* 2024, https://www.science.org/doi/full/10.1126/science.adl3962
[51] Williams *et al.,* 2022, https://doi.org/10.1016/j.heliyon.2022.e12356
[52] Holder *et al.,* 2023, https://doi.org/10.1016/j.vaccine.2023.10.060
see also Ábalos *et al.,* 2022, https://doi.org/10.3390/ani12091083
[53] Srinivasan *et al.,* 2019, https://doi.org/10.1126/sciadv.aax4899
[54] Jones *et al.,* 2022, https://doi.org/10.1038/s41598-022-16092-8
[55] Holder *et al.,* 2023, https://doi.org/10.1016/j.vaccine.2023.10.060

naturally infected cattle (i.e. skin test reactors from TB breakdown farms) are ongoing and should provide data to estimate the relative sensitivity of the DIVA skin test in cattle.

4.XII Studies are currently underway to assess the performance of DST-F under field conditions. A recent study in Ethiopia[56], not using DST-F but a peptide cocktail of its three component proteins, showed worryingly low sensitivity, identifying less than 50% of infections in vaccinated cattle when assessed against animals testing positive for *M. bovis* by culture PCR. Getting better estimates of specificity will be very important because modelling studies[57] project large number of incorrect herd breakdowns occurring if vaccination/DIVA was implemented at scale with less than very high specificity (if a very large number of herds are tested in low-risk areas the majority of positive tests are false positives). This burden is reduced but not eliminated if implementation is restricted to high risk-areas. Encouragingly, a recent study in India reported very high specificity in recently revaccinated calves (though sample size was small and a peptide cocktail of the antigens comprising the DST-F rather than the recombinant proteins used in the DST-F skin test being evaluated in the field trials in England and Wales was used)[58].

4.XIII A pathway for bringing cattle BCG vaccine to market, along with a DIVA test, was reported to industry through an APHA technical document in 2021[59] which we summarise in Figure 4.1 incorporating some updates from APHA (our interpretation rather than an official position).

[56] Fromsa *et al.,* 2025, https://doi.org/10.1038/s41598-025-85389-1
[57] Conlan *et al.,* 2015, https://doi.org/10.1371/journal.pcbi.1004038
[58] Subramanian *et al.,* 2022, https://doi.org/10.3389/fvets.2022.814227
[59] OIE Reference Laboratory for Bovine Tuberculosis, 2021, https://tinyurl.com/bTBVaccinationGlobal

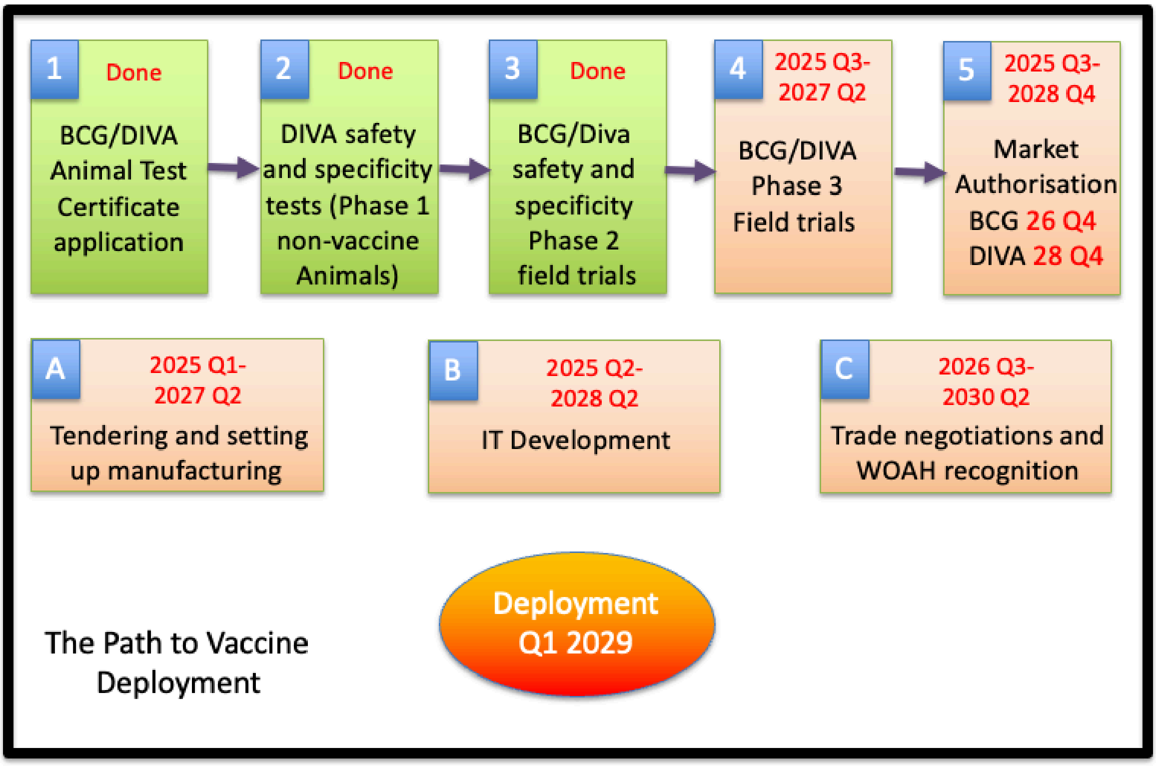


Figure 4.1. Putative pathway for BCG vaccine and DIVA development and deployment.

4.XIV "Phase 1" and "Phase 2" trials have been completed and work is underway[60] on "Phase 3" trials. These aim to measure vaccine safety and DIVA safety and specificity in field settings. A dossier for the market authorisation of the cattle BCG vaccine is about to be submitted to the Veterinary Medicines Directory with the expectation that approval will take 18 months. The dossier for the DST-F test is planned to be submitted mid-2027 with approval after 18 months. Parallel work is required to i) ensure a commercial and affordable supply of the BCG vaccine and DST-F, ii) set up the IT systems needed to support vaccination at scale, iii) negotiate with retailers to ensure vaccination will create no barriers to international trade and iv) to seek recognition of vaccination and the DIVA test for inclusion in the WOAH Manual and Terrestrial Code.

Resistance

4.XV Breeding for resistance is now possible through farmers choosing semen that comes from bulls who pass demonstrable, if small, advantages onto their progeny[61]. It has now also become clear that TB Advantage indices are somewhat correlated with general production traits currently in the UK breeding indexes (¶4.IV); thus, selecting bulls with positive TB Advantage should, on average, have no detrimental effect on any other traits. Further, as we noted in 2018, selection for other traits should therefore lead to some improvements in TB resistance.

4.XVI Unpublished analyses that we have seen suggest that in dairy breeds at least, average bovine TB resistance has increased slightly over the last 20 years, of

[60] APHA, 2025, https://tinyurl.com/VaccineTrialAnnouncement
[61] Tsairidou *et al.*, 2018, https://doi.org/10.3389/fvets.2018.00310

the order of 2% in bulls and 1% in cows. While these % changes are small, they translate into the potential for thousands fewer reactors during breakdowns at the national level and so are genuinely encouraging.

Updates on options for the future

Vaccination

4.XVII In our 2018 report we considered a series of vaccination policy options

- Working to obtain approval for a BCG vaccine under EU rules without deployment (¶4.21)
- Deployment of a BCG vaccine (¶¶4.24-4.29)
- Deployment of a BCG vaccine with a DIVA[7] test (¶¶4.30-4.32)
- Targeted vaccine deployment (at critical areas of infection) (¶¶4.33-4.34)

The different strategies have different national and international regulatory implications, which we discussed, and that have not substantially changed since then. For what we believe are good reasons, Government policy has focussed on the development of a BCG vaccine with a DIVA test, which we concentrate on here.

4.XVIII Considerable progress has been made since we reported in 2018 on better characterising the performance of the bovine BCG vaccine that would be used in England, as well as developing and testing the novel DIVA, the DST-F test. New findings in Europe have been supplemented by work in low-income countries where the sadly high prevalence of bovine TB facilitates the collection of data that despite difference in cattle breed and the farmed environment, are highly relevant to the UK (and of course progress on vaccines in England is highly relevant to countries where test and slaughter is impractical).

4.XIX Though we are optimistic about vaccine deployment and fully support the current research programme, the development of a successful BCG/DIVA product is not yet guaranteed. A particular concern is the very high levels of DIVA specificity (avoidance of false positives) required to avoid herds being wrongly classed as infected, something that would severely undermine confidence in vaccination in the farming community. We believe careful consideration should be given to alternative or supplementary approaches to determining the infection status of cattle in vaccinated herds. The best approach would depend on the exact properties of the DST-F test as will be determined by the Phase 3 trials but could include one or more of the below:

- Restricting routine use of the DIVA skin test to animals vaccinated at least six months previously (when any cross reaction may have subsided, assuming that it has a similar immunological trajectory as SICCT reactions following BCG usage).
- The use of additional tests in animals that in skin tests are positive with DST-F, for example the 'high specificity interferon gamma test for cattle from OTF herds'[62]. This test includes an additional peptide cocktail of

[62] APHA (accessed July 2025), https://tinyurl.com/HighSpecIFNg

DIVA antigens ESAT-6 and CFP10 (see ¶4.X) alongside the standard test, which must also be positive in order for the test to be passed. Currently this test is available for private testing and may be used for movement, sales, IRs pending retest, resolved IRs in non-breakdown herds and additional surveillance following negative routine skin test. This test could be simply included in the Phase 3 trials with little additional cost, along with a DIVA interferon gamma test based on the DST-F fusion protein and/or a peptide cocktail of these antigens.

- Given the reduced transmission that has been demonstrated in fully vaccinated herds, the Government might consider alternatives to herds losing OTF status when only low numbers of cattle (1 or 2) are identified in a DIVA test.

We would encourage continued research on the formulation of potential DIVA tests in both skin test and interferon gamma formats as this is such a fundamental issue.

4.XX The deployment of a full vaccination programme across the whole of England (or even just across the HRA and EA) would be one of the largest livestock epidemiological interventions that the country has ever attempted. There would be a series of major challenges including: (i) ensuring a secure supply of high-quality cattle BCG and DST-F at affordable prices; (ii) mobilising the workforce that would be required for implementation; (iii) agreeing how the programme would be funded by Government and industry; (iv) a clear communication and engagement strategy across multiple stakeholders including the farmers and vets (see ref[63] for valuable suggestions). These challenges are of course understood but the amount of work required, and the advantages of early planning, should not be underestimated.

4.XXI To allow the commercial use of cattle BCG, electronic identification and tracking of individual vaccinated cattle will be important. We understand that current IT capability would not allow such tracking and the development of the necessary software tools is included in the vaccine deployment map (see figure at ¶4.XIII). In our 2018 Report we expressed enthusiasm for the development of the Livestock Information System (LIS) that would bring together existing electronic information with the capacity for extension to serve the IT needs of a vaccination programme. In ¶¶5.XVIII-5.XX we discuss more fully the advantages of LIS (LITP) and the disappointingly slow progress that has been made in its development.

4.XXII Negotiating with our trading partners and obtaining WOAH recognition is acknowledged as important and is also included in the vaccine deployment map (see figure at ¶4.XIII)). The timescale for approval is likely to be long and outside Defra's control and is of course complicated by current uncertainty about future trading relationships. We support Defra's stated intention of gaining WOAH registration for the test as soon as is practical and note that it will be important for bovine TB issues to be clearly understood by the parts of Government negotiating future trade agreements.

---

[63] Maye *et al.*, 2022, https://tinyurl.com/FarmerAttitudesCattVacc

4.XXIII If all goes according to plan vaccine deployment will begin in 2029 and will be a major plank in achieving the Government's goal of eradicating bovine TB by 2038. This is a very challenging goal. There are many factors that influence the speed with which the vaccine can be deployed including the time taken for regulatory approval. The process of obtaining marketing authorisation from the Veterinary Medicines Authority is rightly detailed and careful to ensure animal and human welfare is not compromised. Nevertheless, the lessons of the Covid-19 pandemic are that regulatory approval for vaccines can be safely accelerated if all concerned act with urgency and if the required resources are found. The fact that BCG was first used in cattle in 1911 and that both the vaccine and DIVA tests employ well understood technologies should facilitate this. We return in ¶9.XXVIII to the issue of accelerating progress which we think is essential if the 2038 target is to be hit.

4.XXIV Given the uncertainties and timescales around the licensing of the DIVA skin test and the clear benefits of BCG vaccination in reducing *M. bovis* transmission, we believe there is merit in considering the rollout of BCG vaccination in recurrent and persistently infected dairy herds as soon as BCG is licensed for cattle. In these herds, within-herd TB prevalence is high and so maximum test sensitivity is required to detect all infected animals within the herd. Here the use of an interferon gamma DIVA test rather than the DIVA skin test would be appropriate either as a stand-alone test or as a serial test for animals that test positive to the tuberculin skin test 9 months after vaccination. Alternatively, the 'high specificity interferon gamma test for cattle from OTF herds' (see ¶4.XIX) could be trialled. This approach would allow BCG vaccination to be used in high prevalence situations in advance of any wide-scale vaccine roll out or licencing of the DIVA skin test.

Resistance

4.XXV Making genetic and performance-based indices available for major beef breeds would be advantageous, and we note that AHDB states that 'implementation is underway'[64].

Research & development priorities

4.XXVI We would encourage continued research on the formulation of potential DIVA tests as this is such a fundamental issue (¶4.XIX).

4.XXVII BCG is globally the most widely used tuberculosis vaccine in humans, although it is known to be imperfect. Substantial investment in R&D has not brought anything better to market, although research is ongoing. Even after BCG and the DIVA test are licensed and internationally recognised, there are strong arguments for continuing research in this area[65] and building, where opportunities allow, on any progress made in the human field.

[64] AHDB, 2020, https://ahdb.org.uk/btb-evaluations-in-beef-cattle
[65] Smith *et al.,* 2020, https://doi.org/10.1016/j.tube.2020.101979

4.XXVIII A recent experiment in which non-human primates received the BCG vaccine and were then challenged by *Mycobacterium tuberculosis*[66] demonstrated greater levels of protection when BCG was delivered intravenously compared to intradermal or aerosol delivery. This suggests that the delivery route may influence BCG efficacy and merits further research to explore ways to improve BCG efficacy against *M. bovis* infection in cattle.

4.XXIX Although currently gene editing of farm animals is not currently allowed in UK law, it is possible that in the future gene editing approaches could play a valuable additional role in the control of the disease. Further research in this area would likely prove advantageous.

[66] Darrah *et al.,* 2020, https://doi.org/10.1038/s41586-019-1817-8

Chapter 5: Cattle Movements and Risk-based Trading

Introduction

5.I England's livestock industry is nationally integrated and structured around the frequent movement of cattle amongst premises as well as to specialist units that concentrate on rearing calves or heifers, or exclusively take cattle and fatten them for slaughter (finishing units). Many movements occur when livestock are sold with traditional cattle auctions still as important as direct trading between farmers[67]. Cattle movements carry the risk of spreading bovine TB to previously uninfected premises, and also of creating new foci of infections including in the Low Risk Area (LRA). The risks can be reduced by testing cattle for the disease before and after movement, and by interventions such as those to promote risk-based trading that lower the chance that transported animals are infected. Cattle can also be moved between non-contiguous parts of a single holding, or land held under a TLA (Temporary Land Association), an issue we discuss under biosecurity (¶¶8.XXIII & 8.XXXVI).

5.II The potential importance of cattle movement is demonstrated by the scale of cattle movement in England (Figure 5.1). Between 1.7 and 2.0 M cattle movements occur per year, excluding cattle sent to slaughter and movements between non-contiguous parts of a single business. These numbers are approximately the same as those we gave for 2016 in our previous Report. An animation that graphically shows the magnitude of cattle movement in the Republic of Ireland (in 2016) has been created by the Centre for Veterinary Epidemiology and Risk Analysis (University College Dublin)[68].

5.III ibTB (information bovine TB) is an important source of information, mapping all cattle herds that have suffered a breakdown in the last decade. It is an online interactive tool that can be used to make informed decisions about the risk of buying cattle from different holdings. When we reported in 2018, there were ambitious plans to develop what we then referred to as the Livestock Information System (LIS) that would host a large amount of data on multiple farm animal species and which would revolutionise the information available for targeted bovine TB interventions. This initiative became the Livestock Information Programme and then the Livestock Information Transformation Programme (LITP), the latter name we use below.

---

67 Defra, 2019, https://tinyurl.com/CattleFarmPractices

68 https://www.youtube.com/watch?v=PTCdPMnenBw

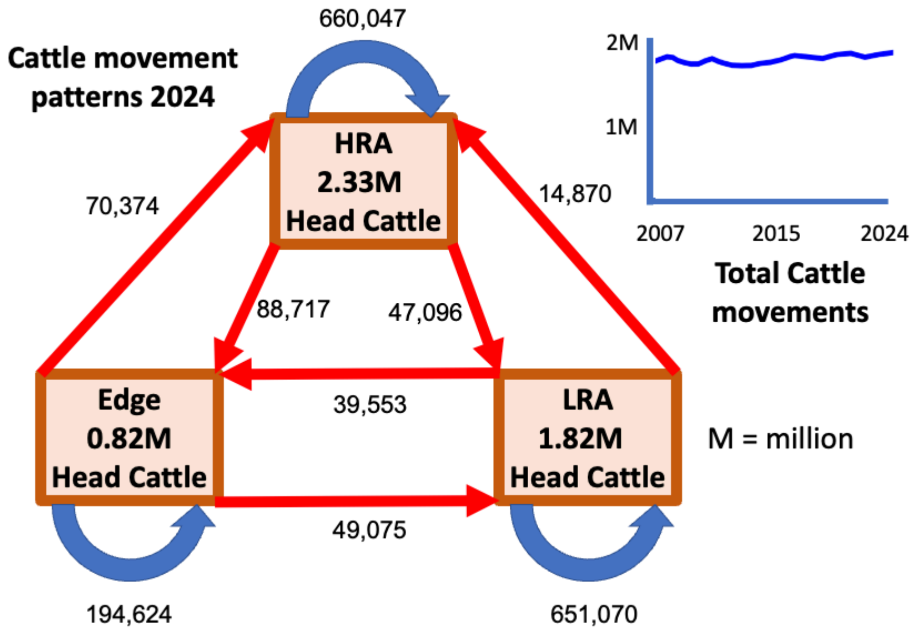


Figure 5.1. Cattle movements within and between different bovine TB risk areas in England in 2024 with (inset) total cattle movements 2007-2024 (data supplied to us by Defra).

Recent developments

Structure of the industry

5.IV Much of the motivation for moving cattle is economic and factors that change the structure of England's livestock industry may increase or decrease the amount of movement. Since the UK left the European Union and the Common Agricultural Policy in 2020, England has switched its chief pillar of support for the agricultural sector from the Basic Payment Scheme (BPS; essentially a cash transfer with modest environmental cross-compliance conditions) to payments, under the Environmental Land Management (ELM) schemes, which seeks to use public money to support the provision of public goods (in the economic sense). The BPS was retained for a period following Brexit subject to annual reductions from 2021 and was replaced in 2024 by payments that were no longer linked to the requirement to produce food. These will be phased out by 2027 with the maximum payment to any farm in 2025 capped at £7,200.

5.V The current most important component of the ELM scheme is the Sustainable Farming Incentive (SFI)[69]. Under this, farmers receive payments for implementing measures from a long menu of actions designed to enhance different aspects of the environment. All these actions (unlike the BPS) require linked investment of time or money by recipients. As of July 2025, there were 39,000 active SFI agreements in England out of a total of 102,000 registered holdings of which 63,000 are over 20 hectares. The scheme stopped accepting

[69] Defra (accessed July 2025), https://tinyurl.com/TransitionPln

new applicants in March 2025 as its budget was used up and Defra will announce details of a revised SFI scheme in summer 2025.

5.VI These changes to the economics and political economy of farming in England are both radical and complex and it is very difficult to predict how they might affect cattle movements. Two possibilities that have been discussed are as follows. First, many of the farms that most relied on the BPS are beef and sheep producers or dairy farms in the north and west of the country. Faced with a reduction in income, some farmers may be more willing to rent out land for grazing or forage production to larger-scale beef or dairy farmers leading to an expansion of some farms and consequently more cattle movement. However, some farmers may exit livestock production, especially perhaps in the HRA where bovine TB limits profitability. Second, there is already considerable movement of cattle from the west to the east of the country where many finishing units are located (near to the arable land where grain for feed is produced). One SFI option for arable land in East England involves the planting of herbal leys which improves soil health and can be used as forage which may encourage more movement of cattle from west to east (and place them in an environment where they are more likely to infect wildlife than in a finishing unit). We do not yet know whether these (or other) changes will occur, but these examples illustrate possible alterations to movement patterns that may affect the spatial dynamics of bovine TB.

5.VII Many dairy contracts require farmers to supply a fixed quantity of milk, with price reductions per litre if that quantity is not met. This can give rise to real difficulties if a farmer has a bovine TB breakdown and loses a significant number of animals. In such circumstances farmers may need to buy in additional cows in order to satisfy their contractual commitments, and there is a danger that this may lead to risky purchasing driven by the need to act fast to avoid breaking the contract or because of financial pressures.

Whole genome sequencing and cattle movement

5.VIII The use of whole genome sequencing (WGS) has expanded greatly since we last reported, and from 2021 APHA has routinely sequenced all isolates from slaughtered cattle. WGS can be used forensically to help identify the source of a breakdown, and cases where cattle movement was responsible have been found, for example:

4.XXX WGS of isolates from an outbreak in Cumbria (LRA) showed it to be of a type unknown in England but circulating in Northern Ireland from where purchased cattle had been moved, with the strain then moving from cattle into the local badger population[70].

(i) An area of the East Midlands (parts of Lincolnshire, Nottinghamshire and Leicestershire) straddling the EA and LRA has been designated a bovine

[70] APHA, 2024, https://tinyurl.com/TBHotspots

TB hotspot. WGS provided strong evidence that this was seeded from cattle bought in from Cheshire (Edge Area) or Staffordshire (HRA)[71].

(ii) A major WGS study of isolates collected during the RBCT from across South-West England discovered distinct genetic clusters of *M. bovis* that most likely represented separate origins of the disease from imported cattle (probably during a period of rapid bovine TB expansion in the 1980s), rather than the gradual spread of the disease from farm to farm across the country[72].

Pre- and post-movement testing

5.IX Movements of cattle are estimated to account for between a quarter and a fifth of all new TB herd breakdowns in the LRA each year and 1 in 6 in the Edge Area)[73].

5.X Pre-movement testing has been required since 2006 for animals 42 days or older originating in areas with annual or more frequent testing (2005 for Scotland). There are exemptions such as movement to slaughter or approved finishing units, though the number of these have been reduced over the years. An SICCT test must be conducted up to 60 days before movement; pre-movement tests are normally paid for by the farmer, but the results of a government funded routine surveillance test can also be used if the timing is right[74]; additional tests are paid for by the farmer and the results of statutory tests can also be used. Figure 5.2 shows the number of pre-movement tests and the percentage positive over the last 12 years.

[71] APHA, 2024, https://tinyurl.com/TBHotspots

[72] Van Tonder *et al.,* 2021, https://doi.org/10.1371/journal.ppat.1010075

[73] Defra (accessed July 2025), https://tinyurl.com/PrePostMoveTesting ; APHA, 2024, https://tinyurl.com/APHAEpiAnalysis2023

[74] APHA (accessed July 2025), https://tinyurl.com/PrePostMoveGuidance

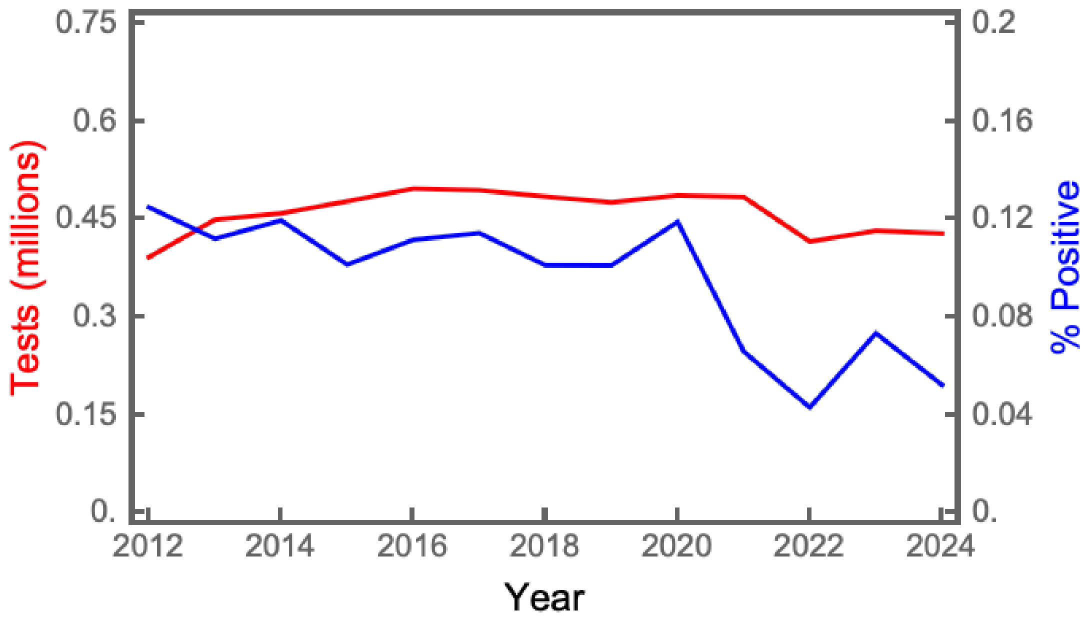


Figure 5.2. A little under half a million specific cattle tests are undertaken per year (red [upper] line)[75]. Until recently about 1 in 1000 animals tested positive (either at first attempt or when retested as an inconclusive reactor) with an indication of a reduction in the last four years (blue [lower] line).

5.XI Wales has similar rules for premovement testing. In 2017, it exempted cattle moved from the lowest of its three risk areas though the exemption was reversed in 2024 because of concerns about the spread of the disease. Scotland which is officially bovine TB free has more stringent rules and requires pre-movement tests from all areas in England and Wales up to 30 days before movement (with some exceptions) and does not allow the clearing skin test for a herd under restriction to be used as a qualifying pre-movement test[76].

5.XII Post-movement testing of cattle was introduced in 2016 for cattle moved into the LRA from the HRA, Edge Area and Wales. Post-movement testing in Scotland has discouraged the purchase of cattle from other parts of the United Kingdom. In 2023, the requirement for post-movement testing was extended to the annual surveillance parts of the Edge Area for cattle moved from higher risk areas. A SICCT test is conducted 60-120 days after movement, 60 days to allow any desensitisation from the pre-movement test to dissipate, and 120 days to allow farmers some time to send cattle to slaughter. Figure 5.3 shows the number of post-movement tests and the percentage positive over the last seven years.

[75] Defra (accessed July 2025), https://tinyurl.com/PrePostMoveStats
[76] Scottish Government (accessed July 2025), https://tinyurl.com/ScotbTBStats

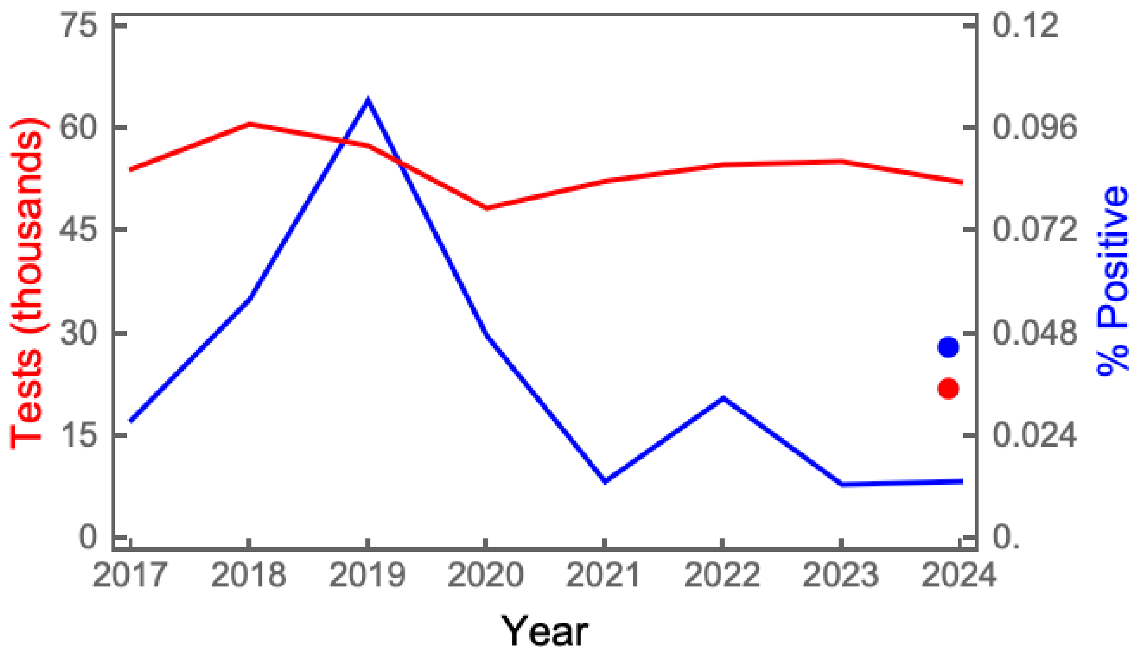


Figure 5.3. About 50 thousand post-movement tests are conducted in the LRA (red [upper] line) each year and 22 thousand in the first year in the annual-testing Edge Area (red [lower] point). In recent years only ~2 in 10,000 LRA tests have been positive (at first attempt or inconclusive reactor retest) (blue [lower] line) with a higher figure for the one year of data from the Edge Area (blue [upper] point) [77].

5.XIII The rules for post-movement testing in Wales & Scotland are similar (and include cattle purchased from Northern Ireland). Like England, Wales has recently expanded post-movement testing to include movements into the Welsh Intermediate Risk Zone from High Risk Areas.

Risk-based trading

5.XIV In January 2022, an enhancement was made to ibTB to provide more information of use to farmers in assessing trading risks. ibTB now displays the number of consecutive years herds in England and Wales have been officially TB free (OTF). This enhancement means that all cattle herds in England and Wales are potentially viewable, including those that have never had a TB breakdown, which was not the case before. In January 2023, an Approved Finishing Unit (AFU) finder was added to ibTB, allowing users to locate their five nearest AFUs. Potentially this could help farmers to reduce distances transported though it might equally be used by farmers to secure the best deal on price.

[77] Defra (accessed July 2025), https://tinyurl.com/PrePostMoveStats

5.XV In its 2024 Bovine TB Consultation[78], Defra proposed further enhancements to ibTB including providing information on the bovine TB status of the herds from which a farm has bought in stock (their location and the length of time they have been TB free). Defra has informed us that they hope that will be implemented in the summer of 2025 and that in addition ibTB will be extended to include animal level data. The Consultation listed the new data to be made available as follows:

(i) Date and type of the animal's most recent pre-movement TB test, if applicable (i.e. if pre-movement testing was required, was this a bespoke test, or is the animal moving off the back of a government-funded TB herd test such as a releasing short-interval herd test at the end of a TB breakdown).

(ii) Date and type of the most recent TB test completed in the herd of origin of that animal.

(iii) Number of years that the animal has been in the herd from which it is being sold.

(iv) Number of years that the herd of origin of the animal has been bovine TB free, and risk information on supplier herds". The Tuberculosis in Animals (England) Order 2021[79] allows Defra to publish TB risk information at herd level, and recent secondary legislation has extended this provision to animal level data[80].

5.XVI Since its inception, ibTB has been accessed 1 million times by 200 thousand unique users. To minimise disincentives to its use, registration is not required, though this makes it hard to analyse who exactly is accessing and using the data. There had been concerns that farmers might object to the amount of information made available through ibTB but a recent review reported less than ten complaints and concluded the public benefits outweighed the relatively minor privacy infringements[81].

5.XVII In 2018 we reported that social science research to understand better cattle purchasing behaviour would be valuable, and we are pleased that Defra has commissioned what we consider important research[82]. This work, led by Gareth Enticott, used a variety of techniques including structured interviews with farmers, focus groups with farmers, vets, auctioneers and advisors, and online purchasing simulators. It found that the major determinant of purchasing decision was the "fit" to the farm, both in terms of cattle breed as well to the farm's husbandry model. The apparent standing and trustworthiness of the

---

[78] Defra (accessed July 2025), https://consult.defra.gov.uk/bovine-tb/bovine-tb-consultation-wildlife-cattle/
[79] UK Government (accessed July 2025), https://www.legislation.gov.uk/uksi/2021/1001/contents
[80] UK Government (accessed July 2025), https://www.legislation.gov.uk/uksi/2025/748/contents/made
[81] Mitchell *et al.*, 2023, https://doi.org/10.20506/rst.42.3350
[82] Enticott & Little, 2022, https://doi.org/10.1016/j.jrurstud.2022.04.008

seller was also important, as well as the general appearance of the animal as appraised by “the stockman’s eye”. The possibility of disease infection was not a major factor, and diseases such as Johne’s and BVD (bovine viral diarrhoea) appeared more salient than bovine TB, possibly because the farmers took more ownership of protecting against the former. Providing information about the infection status of the source herds of potential purchases had a minor influence on buying decisions, sometimes helping to arbitrate between otherwise similar animals, and being more heeded when the farmer was aware of major local outbreaks.

Updates on options for the future

Information systems

5.XVIII In 2018 we wrote (¶5.49): “We strongly emphasise the importance of the LIS in providing the data backbone for improvements in incentivising risk-based trading and many other aspects of bovine TB control. We place the highest research and development priority on ensuring from the design stage that the system works to deliver these benefits for [bovine TB] disease control.” This is still our view.

5.XIX Progress since 2018 has been disappointing, as highlighted by a recent (June 2025) report from the National Audit Office (NAO) *Resilience to animal disease*[83]. To quote from paragraph 18 of their summary: “Defra and APHA lack a comprehensive livestock movement tracing system. Tracing animal movements quickly once an infection is detected is crucial to responding quickly and effectively to contain an outbreak. Current systems are fragmented, with different platforms for different species and in each of the devolved nations in the UK. Some also run on outdated legacy systems, such as the Cattle Tracing System which was set up in 1998 and has significant reliability issues. Defra’s Livestock Information Transformation Programme is intended to deliver an upgraded, multi-species digital tracing system, but has suffered from delays and cost increases as the scope of the programme has changed substantially from the original Livestock Information Programme. The estimated whole-life cost of the programme is now £563 million. Defra currently rates deliverability as ‘amber-red’ due to increased costs and funding constraints, and it has fallen behind the timescales planned in its 2023 outline business case. Defra had spent £181 million on the programme up to March 2025.”

5.XX The NAO report was considering all livestock diseases, epidemic and endemic. Our concern here is specifically for the infrastructure required to support bovine TB control. Defra’s 2023 outline business case expected to deliver the cattle service in October 2024, but this is not now expected until summer 2026. We advise that further delays in delivering the cattle component of the LITP (or a modern functional alternative) will be a major impediment to achieving disease-free status by 2038.

[83] NAO, 2025, https://www.nao.org.uk/reports/resilience-to-animal-diseases/

Structure of the industry

5.XXI The pace of change in England's livestock industry is unprecedented and likely to continue as we further adjust to life outside the EU alongside increasing environmental and geopolitical shocks. We have mentioned ways that near-term changes might affect the frequency and pattern of cattle movements, in ways that could be positive or negative for disease control, though the overall picture is far from clear. Using future and foresight techniques to anticipate changes and avoid unexpected negative outcomes will be helpful in achieving the 2038 disease-free target.

5.XXII We believe there is a strong case for contracts between farmers and milk purchasers (processors or retailers) to contain get-out clauses in cases of compulsory slaughter in order to reduce the possibility of risky trading and to allow time for business adjustments to be made.

Pre- and post-movement testing

5.XXIII As the figures in ¶5.X and ¶5.XII illustrate, the number of pre-movement tests in England have been broadly level since 2017, with the number of reactors identified by pre-movement tests showing a substantial reduction since 2020[84]. However, evidence from WGS is increasingly revealing that long-distance movement of infected cattle has been responsible for much of the spread of bovine TB (¶5.VIII). This suggests that maintaining and possibly reinforcing pre- and post-movement testing regimes will be an important plank of the bovine TB eradication strategy.

5.XXIV The current pre-movement test used is the SICCT which has very high specificity but comparatively low sensitivity (it misses at least 20% of infected individuals and probably a greater proportion of early infected animals). Moving to a more sensitive test (SICCT severe interpretation, SICT or the interferon gamma test) would reduce the risk of the movement of an infected animal seeding an outbreak in a lower risk area. These tests have lower specificity and would produce more false positives and there has been reasonable concern over this triggering the loss of bovine TB free status for the originating herd.

5.XXV When the SICCT is used prior to possible export to the EU, movement is not allowed if the bovine only test measures 2mm or more or the presence of oedema (swelling caused by fluid build-up) is observed 72 hours after tuberculin injection. The avian reaction is then taken into account using the standard interpretation of the SICCT to assess whether any restrictions under national requirements are necessary. We argue there is a strong argument for mandating this test interpretation for movements into the LRA. There is no increased testing cost, we believe only a few animals will be affected, and the great risk of initiating a new LRA hotspot will be reduced.

5.XXVI The same process could be applied to pre-movement tests within Great Britain. Given the great costs of new outbreaks in lower risk areas we think a careful cost-benefit analysis of this option is warranted.

---

[84] Defra (accessed July 2025), https://tinyurl.com/PrePostMoveTesting

5.XXVII The SICCT is also used for post-movement testing. Some infected cattle do not produce a strong immune response of the type detected by the SICCT (hence its relatively low sensitivity) and so are more likely to pass *both* the pre- and post-movement tests. We see a strong argument to replace the SICCT with a supplementary test such as the interferon gamma test or a serological test.

5.XXVIII Whether an individual animal is subject to pre- or post-movement testing depends on a complex set of rules based on the risk areas (LRA, EA, HRA, equivalents in Wales etc.) of both the originating and destination farms. Below (¶5.XXXII) we discuss the desirability of having an IT infrastructure that enables a more granular assignment of risk to the individual farm or even the individual animal. Such a risk score could guide a more targeted approach to movement testing.

5.XXIX While the present regulations based on risk area are in operation it is important to make certain that they reflect the current geographical status of the disease and be revised if necessary. It is also important that when a hotspot is detected in the LRA, movement regulations are introduced quickly, especially as there may then be incentives to trade cattle.

5.XXX Though not possible on all farms, it is highly desirable to segregate bought in cattle from the rest of the herd until after their post-movement tests.

Risk-based trading

5.XXXI Interventions to reduce the movement of infected cattle include mandatory regulations and the provision of information to help farmers make informed decisions about the risks of purchasing different animals. While voluntary measures are to be preferred the new research described above warns that "in the heat of the moment" farmers place relatively little emphasis on bovine TB risk information. While providing point of sale information can never be a bad thing, we advise that too much reliance should not be placed on it and more attention should be paid to regulation.

5.XXXII In our 2018 Report (¶5.11) we referred to the Cattle Tracing System (CTS) database maintained by the British Cattle Movement Service (BCMS) which has information on every individual bovine animal in the country. We suggested that it would be feasible to derive a risk-score for individual animals incorporating their complete history of movement and testing (such a score would also be calculable from the LITP once operational). Parts of the industry already use risk scores that include prior movement data as well as more detailed information from testing (for example the size of reaction to the bovine arm of the SICCT). There are of course issues of privacy in making movement and other data publicly available, but we think this would be acceptable to the industry if it facilitated risk-based trading and herd management. There is a strong argument for mandating all movement (and testing) data to be made available in an accessible form, both raw data and the data summarised as an individual animal risk index.

5.XXXIII We appreciate the challenges faced by dairy farmers who lose cattle to slaughter because of bovine TB and face cash-flow challenges and the risk of breaking milk-supply contracts. We discuss elsewhere how milk contracts might be reformed (¶5.XXII) and note that rearing replacements on farm, or taking out insurance can help address this issue, though these will not be financially viable in many circumstances. Buying in cattle rapidly may be the only solution and helping farmers minimise the risk of purchasing high risk animals is very important.

Research & development priorities

5.XXXIV Further research on diagnostic tests as described in ¶3.XLIX will be valuable in improving pre- and post-movement testing regimes.

5.XXXV The fiscal and regulatory environment under which the livestock industry operates is going through a period of rapid change. Monitoring this change and understanding the response of farmers and other agents will be important in anticipating future patterns of cattle movement and trading and its implications for bovine TB epidemiology.

Chapter 6: The Disease in Wildlife

Introduction

6.I *Mycobacterium bovis*, can infect a broad range of hosts including many species of wildlife. In the United Kingdom and the Republic of Ireland (and possibly elsewhere[85]) the chief wildlife host is the badger though it is also recorded from deer, fox and feral boar. Transmission from both badger to cattle and cattle to badger has been demonstrated. We do not currently know definitively whether the disease is self-sustaining in badgers in the absence of reinfection from cattle, though as we discussed in our 2018 Report the weight of evidence suggests that it is.

6.II Badger culling was first used as a bovine TB control strategy between 1975 and 1997. A major review of bovine TB control in 1997, chaired by John (now Lord) Krebs, recommended a large-scale, replicated experiment to determine whether badgers were a source of infection for cattle and whether culling reduced the incidence of the disease[86]. The Randomised Badger Control Trial (RBCT) ran from 1998-2005 and reported that proactive culling of badgers reduced confirmed (OTF-W) herd breakdowns inside culling areas but increased them among herds within a 2 km belt outside these areas[87]. Overall, it concluded, culling had a relatively small but positive effect in reducing disease incidence.

6.III The administration in office when the RBCT reported decided not to implement badger culling. The new government elected in 2010 declared its intention "to introduce a carefully managed and science-led policy of badger control in areas with high and persistent levels of bovine tuberculosis."[88] It instituted industry-led culls that began in 2013 and continue today. In 2020 it committed to no new culls and an eventual cessation of culling.

6.IV The new administration elected in 2024 announced its intention to end badger culling by the end of the current Parliament (before 2029)[89]. It has indicated that a greater emphasis is likely to be put on badger vaccination as part of its revised bovine TB control strategy.

---

[85] Vásquez *et al.,* 2021, https://doi.org/10.3390/ani11051294
[86] Krebs *et al.,* 1997, https://www.pure.ed.ac.uk/ws/portalfiles/portal/10845557/KrebsReport.pdf
[87] Independent Scientific Group on Cattle TB, 2007, https://tinyurl.com/ISGFinalReport
[88] HM Government, 2010, https://tinyurl.com/CoalitionProg
[89] Defra in the media https://deframedia.blog.gov.uk/2024/09/02/government-announces-tb-eradication-strategy-to-end-the-badger-cull/

Recent developments

Epidemiology of M. bovis *in badgers: whole genome sequencing*

6.V Different forms of genotyping to explore interspecific transmission have been employed for many years with the first use of whole genome sequencing (WGS) to explore interspecific transmission in 2012 in Northern Ireland[90]. Bacterial isolates from cattle and badgers in a spatiotemporally linked cluster of cases were sequenced and were found to be very similar indicating recent cross-species transmission. WGS is now used more widely; since 2021 APHA sequences all suspect *M. bovis* isolates detected via slaughterhouse surveillance, and at least one isolate per TB incident detected via active surveillance of cattle herds. In 2018 we were enthusiastic about the use and likely impact of WGS and are very pleased to see this promise realised.

6.VI WGS data collected as part of a long-term ecological study of badgers and bovine TB at Woodchester Park, Gloucestershire, was used to quantify the rates and directionality of transmission in a high-density, endemic bovine TB area[91]. Cross-species transmission in both directions was found, with that from badgers to cattle approximately 10 times more frequent than from cattle to badgers. Within-species transmission occurred at much higher rates than between-species transmission.

6.VII The largest study to date analysed 1442 *M. bovis* genomes from cattle and badgers collected during the Randomised Badger Culling Trial (RBCT) in South West England[92]. It found that clusters in different trial areas had been seeded from initial infections (chiefly through cattle movement) some years previously during the period when disease prevalence was rapidly rising in England (¶5.VIII(ii)). Cross-species transmission was identified with badger to cattle infection occurring at about twice the frequency of the reverse. Within-species transmission was considerably higher than between-species.

6.VIII A study conducted as part of the Test, Vaccinate or Remove (¶6.XXVI) research project in Northern Ireland sequenced 600 bacterial isolates[93]. At this site, cattle to cattle transmission was the dominant form of transmission, with cattle to badger transmission being considerably more common than from badgers to cattle. Badger-to-badger transmission was not detected. This would suggest that in this location badgers are acting as a "spillover" host rather than a self-sustaining reservoir.

6.IX These studies demonstrate the power of WGS to uncover epidemiological patterns that would otherwise be difficult or impossible to characterise[94]. Though the number of published studies is still small the results to date suggest that the magnitude of different transmission routes is likely to depend on local

[90] Biek *et al.,* 2012, https://doi.org/10.1371/journal.ppat.1003008
[91] Crispell *et al.,* 2021, https://doi.org/10.7554/eLife.45833
[92] Van Tonder *et al.*, 2021, https://doi.org/10.1371/journal.ppat.1010075
[93] Ashmetova *et al.,* 2023, https://doi.org/10.1099/mgen.0.001023
[94] Sandhu *et al.,* 2025, https://doi.org/10.3389/fmicb.2025.1515906;
Wood *et al.,* 2024, https://doi.org/10.1016/j.epidem.2024.100787

farming practices and the farmed environment. Inferring transmission rates from WGS data is at the cutting edge of molecular epidemiology and requires a careful appraisal of possible sampling biases and the assumptions behind the models employed. We encourage all data to be made quickly available to allow multiple analyses using different techniques.

Badger culling

6.X Since 2013, England has implemented an industry-led badger culling policy aimed at controlling bovine TB in cattle. The licensing and execution of this policy have followed a structured, yet expanding, framework.

6.XI The legal authority for culling a protected species rests with Natural England (NE), which issues licenses to farmer-led groups under the Protection of Badgers Act 1992. Applications must meet specific criteria, including a minimum area size (initially 150km², later reduced to 100km²) and a high percentage of accessible land for culling operations. Three main types of licenses have been used:

(i) *Intensive Culling Licence:* The standard four-year licence for High Risk and Edge Areas, aiming for sustained population reduction.

(ii) *Supplementary Culling Licence:* Introduced in 2017, these licenses prolong culling in areas that have completed a four-year intensive cull, with the stated goal of preventing badger populations from recovering.

(iii) *Low Risk Area (LRA) Licence:* Introduced after consultation in 2018 and used to tackle specific bovine TB hotspots in areas of the country otherwise considered low risk.

6.XII The culls are carried out by trained contractors using two approved methods: cage trapping followed by shooting, and controlled (free) shooting of badgers at night. Over time, free-shooting has become the dominant method, accounting for over 77% of badgers killed by 2020. The operational objective is for no more than 30% of the starting population to remain on conclusion of the cull. Intensive culls typically take place over a continuous six-week period, usually starting in late summer, though extensions have been granted.

6.XIII The policy began with two pilot culls in West Gloucestershire and West Somerset in 2013 to test the methods' effectiveness and humaneness. Following these pilots, the government initiated a systematic expansion. The culls were extended to Dorset in 2015, followed by seven new areas in 2016, and eleven new areas in both 2017 and 2018.

6.XIV In total, 73 culling licences have been granted, covering almost all the HRA and worst affected parts of the Edge Area, as well as in 3 areas in the LRA (see next paragraph), a total extent of almost 33,000 km^2. The total number of badgers culled under the policy is 246,772[95].

[95] Figures provided by Defra, July 2025.

6.XV An LRA culling licence may be granted when APHA declares a hotspot: an area where *M. bovis* of the same WGS clade (genetic lineage) has been confirmed in both cattle and badgers. APHA strategy is to reduce badger density by culling and then switch to vaccination. Culling has occurred in three hotspots (which have been given hotspot numbers, e.g. HS21)[96]:

(i) Cumbria, south of Penrith (HS21). WGS showed that the hotspot arose from a novel Northern Irish *M. bovis* strain identified in 2014 and since then there have been 59 herd breakdowns. Intensive culling was initiated in 2018 when 11.1% of the 369 badgers culled were culture-positive. By 2020 measured prevalence in badgers fell to zero and vaccination was initiated (224 badgers were vaccinated in 2024). The area remains under review but has now entered annual testing and is on track for hotspot closure after five years with no reports in wildlife.

(ii) SW Lincolnshire, Nottinghamshire and NE Leicestershire borders (HS23). Culling began in 2020 when 24.5% of the 139 badgers culled tested positive. By 2024 ~500 animals had been culled but only 4.3% of the 46 badgers removed in 2024 were positive. However, cattle incidence (measured over a wider area than where culling took place) remains elevated with 163 breakdowns since 2018 and the area was placed under six-monthly herd testing in September 2024 with an "enhanced surveillance area" buffer. Infections in cattle in OTF-W breakdown herds were monitored with the more sensitive interferon gamma test. The hope is badger prevalence will continue to fall to a point when vaccination will be introduced.

6.XVI Cumbria, north-east of Penrith (HS29). Fifty six herd breakdowns have occurred since 2014 and the area is under six-monthly testing. Bovine TB positive badgers were detected in 2023 and a culling licence was obtained in 2024. 5.1% of ~450 badgers culled in the first year were disease positive. Two more years of culling are planned before vaccination is introduced.

In all these areas culling has been accompanied by enhanced cattle surveillance and testing and it is not statistically possible to distinguish the role of these types of intervention in reducing incidence.

6.XVII In Louth (east Lincolnshire; HS28) a hotspot was declared in 2020 and the disease detected in badgers in 2023 and 2024. Rather than culling, APHA has deployed badger vaccination, with a sample undergoing serological testing. 12% of the 40 badgers tested have been bovine TB positive. The situation is being monitored and the area has just entered 6-monthly testing. A fifth hotspot in the Aylesbury Vale (Hertfordshire and Buckinghamshire; HS30) has been declared though no wildlife infection has been reported.

[96] APHA (accessed July 2025) https://tinyurl.com/TBHotspots

Badger vaccination

6.XVIII Much of this section is derived from a recent and comprehensive review[97] of the state of our knowledge about badger vaccination in the British Isles which should be consulted for further details and references. Highly relevant is work in the Republic of Ireland where a mixed policy of culling and vaccination has been implemented at scale (Figure 6.1).

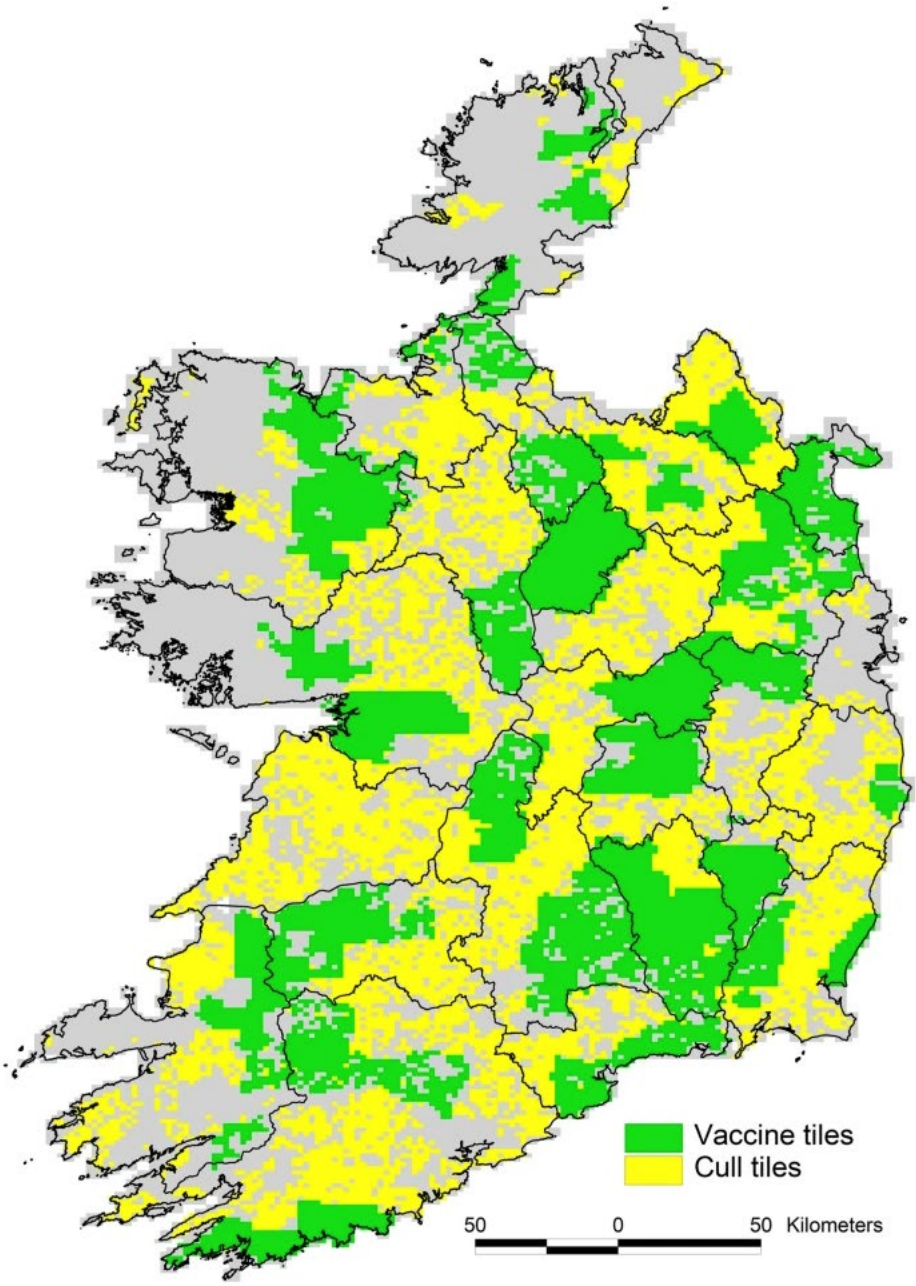


Figure 6.1. Areas where badger vaccination (green) or culling (yellow) were carried out in Ireland[98] in 2021.

[97] Robertson *et al.,* 2025, https://doi.org/10.1016/j.prevetmed.2025.106464
[98] Ryan *et al.,* 2023, https://doi.org/10.1186/s13620-023-00255-8

6.XIX Multiple experimental trials on captive badgers (17 listed in ref[97]) have consistently shown that BCG vaccination provides protection against *M. bovis*. While protection is often incomplete (vaccinated animals may still get infected), the vaccine significantly reduces the severity and progression of the disease, the number of lesions, and the excretion of *M. bovis* bacteria. The vaccine is not excreted, and vaccination does not cause changes in badger ranging behaviour and a "perturbation effect" that might lead to disease spread.

6.XX The currently licensed method is intramuscular injection of the BadgerBCG vaccine. Trials have shown this method is safe, causing only mild, temporary reactions at the injection site and no adverse effects on badger behaviour or body weight. There has been research on oral vaccines but because of problems with getting enough badgers to ingest them and in delivering a reproducible dose of vaccine that affords protection, an injectable BCG is currently preferred.

6.XXI Two major field trials have demonstrated the protective effects of BCG in wild, free-living badgers:

(i) Badger Vaccine Study (BVS) in England[99]: This study found that vaccinated badgers were 76% less likely to test positive for TB infection compared to unvaccinated ones. It also provided evidence of "herd immunity", where vaccinating at least a third of adult badgers in a social group reduced the infection risk for unvaccinated cubs in the same group by 79%.

(ii) Kilkenny Trial in the Republic of Ireland[100]: This trial, using an oral vaccine, found that vaccination reduced a badger's likelihood of becoming infected by 59%. Post-mortem examinations at the end of the trial confirmed that TB prevalence was significantly lower in the fully vaccinated area (24%) compared to the placebo area (52%).

6.XXII Mathematical and simulation models consistently predict that a sustained badger vaccination programme will lead to a decline in TB prevalence within badger populations. Models estimate that achieving a vaccine coverage of 30–40% could be sufficient to reduce the disease's reproductive ratio (R_0) to below 1, leading to the eventual eradication of TB from the badger population, although this could take 20–30 years of annual vaccination[101].

6.XXIII Models generally predict that culling is more effective than vaccination at reducing the numbers of infected badgers quickly in high-density populations. One study predicted an 11% reduction in cattle herd breakdowns from vaccination over ten years, compared to 18% for culling. However, vaccination

[99] Chambers *et al.,* 2011, https://doi.org/10.1098/rspb.2010.1953;
Carter *et al.,* 2012, https://doi.org/10.1371/journal.pone.0049833

[100] Aznar *et al.,* 2018, https://doi.org/10.1016/j.prevetmed.2017.10.010;
Gormley *et al.,* 2021, https://doi.org/10.1111/tbed.14254

[101] Wilkinson *et al.,* 2004, https://doi.org/10.1111/j.0021-8901.2004.00898.x;
Aznar *et al.,* 2018, https://doi.org/10.1016/j.prevetmed.2017.10.010

results in a gradual, consistent reduction in TB prevalence across both the core area and the surrounding buffer zone[102].

6.XXIV There have been few studies that have assessed the effect of badger vaccination on bovine TB incidence in cattle.

(i) To date, the only large-scale field trial designed to investigate this took place in the Republic of Ireland from 2011–2017 (The Irish "Non-Inferiority" Study)[103]. It compared areas transitioning to vaccination with areas continuing targeted culling. The study concluded that in five of the seven counties, vaccination was "not inferior" to culling at controlling bovine TB in cattle.

(ii) In the UK, projects like the Badger Vaccine Deployment Project (BVDP)[104] in Gloucestershire and the Intensive Action Area (IAA)[105] in Wales were not designed as formal trials to measure the effect on cattle. While bovine TB incidence in cattle did fall in these areas during vaccination, it also fell in comparison areas, making it difficult to attribute the decline specifically to badger vaccination.

6.XXV There are strong, polarised views on badger vaccination. The general public is largely supportive of vaccination (and opposed to culling) while farmers are generally negative or sceptical[106]. Surveys show many believe it is less effective and less practical than culling. This view is driven by concerns about its effectiveness, the belief that badger populations need to be controlled, and the limited evidence of its direct impact on cattle TB. However, a small-scale project in Cornwall supported by the National Farmers Union and the Zoological Society of London provides a good example of how different stakeholders can be brought together to support badger vaccination[107].

6.XXVI Between 2014 and 2018, a 100km^2 trial was conducted in County Down, Northern Ireland, to explore a Trap, Vaccinate and Remove (TVR) intervention[108]. Badgers were caught using baited traps and tested in the field for bovine TB infection. The test used was a lateral-flow serological test (DPP VetTB) that has high specificity (~97%; few false positives) and a sensitivity of ~70% (significant numbers of false negatives) (see also ref[109]). Animals that tested positive were removed and euthanised by veterinarians while the remainder were vaccinated. During the course of the study the prevalence of infection in badgers declined from 14 to 2%, roughly in line with model predictions. The effect on the frequency of herd breakdowns was less clear,

---

[102] Smith *et al.,* 2012, https://doi.org/10.1371/journal.pone.0039250
[103] Martin *et al.,* 2020, https://doi.org/10.1016/j.prevetmed.2020.105004
[104] APHA (accessed July 2025), https://tinyurl.com/APHABVDP
[105] APHA (accessed July 2025), https://tinyurl.com/APHAIAA
[106] Chivers *et al.,* 2022, https://tinyurl.com/FarmerAttitudesBadgVacc
[107] Woodroffe *et al.,* 2024, https://doi.org/10.1002/pan3.10691
[108] Menzies *et al.,* 2021, https://doi.org/10.1002/vetr.248;
Arnold *et al.,* 2021, https://doi.org/10.1371/journal.pone.0246141
[109] Jinks *et al.,* 2025 https://doi.org/10.1371/journal.pone.0313825

though this was probably because most were due to cattle-to-cattle transmission. Issues occurring with the supply of badger vaccine necessitated a switch in supplier mid-way through. The programme cost £1M-£1.5M per year.

The disease in deer and other wildlife

6.XXVII Deer, both wild and farmed (discussed in ¶7.IV), are known to be infected by bovine TB. Wild White-tailed Deer in Michigan were identified as the primary wildlife reservoir of bovine TB and a successful campaign against the disease involved targeting infections in this host. Infections in deer in the British Isles (and France[110]) have been known for some time but have appeared to be at low frequency. In 2018 we wrote "The evidence does not suggest that … wild … deer … pose a substantial national threat to cattle but any opportunity to increase our knowledge of disease prevalence in these species should be taken." Recent data from the Republic of Ireland and the United Kingdom suggest deer may need greater attention.

6.XXVIII Sika Deer were introduced to the British Isles in the 1880s where they interbreed with the native Red Deer. In the Republic of Ireland, they have increased rapidly in abundance and this is correlated with an increased risk of herd breakdown. A modelling study suggested that a doubling in deer density led to a 14% increase in herd breakdowns. The greatest density of deer is in the Wicklow region where WGS showed that deer and cattle carried similar isolates indicating cross-species transmission[111]. Significantly, genetic diversity was higher in the deer than in the cattle which the authors suggested might indicate that the deer are acting as a reservoir for the disease.

6.XXIX A recent study of deer on Exmoor[112] tested 432 blood samples from culled wild deer during the 2023/24 season. Using serological tests, they estimated a *M. bovis* prevalence of 29% (95% C.I. 21–39%). Prevalence did not differ by sex or species (though red deer made up all but a few of the animals sampled). Calves under one year showed the lowest apparent prevalence, suggesting cumulative exposure with age. The authors caution that serology detects exposure, not active shedding, but argue the figures justify incorporating deer into local risk assessments and carcass sampling schemes.

6.XXX A study of 522 culled deer in Northern Ireland found just 13 to be infected with *M. bovis*[113]. WGS of these and isolates obtained from cattle in the same area indicated recent inter-species transmission but suggested deer were a spillover species rather than a wildlife reservoir.

6.XXXI Wild boar can be a reservoir for bovine TB in parts of southern Europe. There are a few naturalised populations in England, the largest being in the Forest of Dean (Gloucestershire). The location and abundance of wild boar in England is receiving more attention because of the possibility they may spread African Swine Fever (ASF) should it reach the country. There is no evidence that wild

---

110 Michelet *et al.,* 2019, https://doi.org/10.3390/microorganisms7120687

111 Crispell *et al.,* 2020, https://doi.org/10.1099/mgen.0.000388

112 Jinks *et al.,* 2024, https://doi.org/10.1101/2024.10.03.613747

113 Allen *et al.,* 2025, https://doi.org/10.1016/j.meegid.2025.105721

boar play a role in bovine TB epidemiology in England, but this species has been little studied and any information gained as a by-product of work on ASF would be valuable.

Updates on options for the future

Culling and the polarisation of the debate of the role of badgers

6.XXXII It is unsurprising that opponents of culling tend to highlight evidence that suggests transmission from badgers to cattle is less important and that the positive effects of culling are small or absent, while proponents focus on the evidence that suggests the opposite. While understandable, the resulting polarisation is unfortunate and damaging to the development of a coherent wildlife strand to bovine TB control and eradication.

6.XXXIII Analyses and reanalyses of data from the Industry-led Culls and the RBCT have sometimes come to different conclusions from the same data, and the arguments are complex and highly technical. In a separate section (starting ¶6.L) we provide an overview of these debates.

6.XXXIV An aspect of this polarisation has been that our 2018 Report is sometimes misunderstood or misrepresented. Our task was to analyse and summarise the evidence base for a range of policy options which included different forms of culling. We explicitly did not make a recommendation on culling or not culling because that can only be made by ministers considering all the epidemiological and non-epidemiological issues in the round – our job, there and here, was to summarise the science evidence to inform this process. It is wrong to characterise the 2018 Report as either for or against culling and we repeat our headline conclusion here which we believe is still relevant today:

(i) "The evidence shows that badgers do transmit bovine TB to cattle and contribute to the persistence of the disease. Ministers have to decide whether the real but circumscribed benefits of culling to the farming industry outweigh the animal welfare and environmental concerns of other stakeholders. This decision must be informed by scientific evidence but inescapably involves a judgement call by ministers."

6.XXXV Since 2018 the evidence base has evolved, but in our view the broad conclusion about possible infection pathways has not changed. Evidence (both the statistical analysis of culling reviewed below, and new findings from whole genome sequencing) continues to support the hypothesis that badgers do infect cattle with bovine TB. In our opinion the weight of the evidence continues to point to some limited benefits of culling in reducing herd breakdowns. What has changed is that ministers have now decided to phase out culling with a timetable.

6.XXXVI We stress that evidence that badgers transmit bovine TB to cattle does not automatically validate or justify a policy of culling; decisions on culling policy are rightly influenced by many factors. As culling is wound down the denial of any role of badgers in infecting cattle, or its exaggeration, is unhelpful as it is important to know the risk posed by this species to assess the investment required in non-lethal interventions such as vaccination and badger-biosecurity measures. This is critical both to reduce herd breakdowns but also to lessen the welfare toll of bovine TB on badgers. Media coverage tends to focus on the question of badger culling[114] rather than the wider set of issues related to tackling the disease, which is also not helpful to furthering informed public debate on the wider context of control and eradication.

Badger culling

6.XXXVII In our 2018 Report we summarised the evidence for different types of culling strategies based on our conclusion of "real but circumscribed benefits". We believe these epidemiological arguments are still applicable, though their policy relevance is much reduced given the current administration's intention to phase out culling in the next few years (and note that the policy of the previous administration was also to end culling).

6.XXXVIII The circumstances where culling as an intervention is likely to be most missed is when a hotspot is identified in the LRA. Here there is a premium on acting swiftly to extinguish an outbreak before it becomes established. In the absence of culling it will be even more important to swiftly implement the full tranche of other interventions (enhanced testing and other cattle measures, badger vaccination and biosecurity).

Badger vaccination

6.XXXIX In the absence of culling we believe that the non-lethal control of the disease in the wildlife reservoir must be part of the portfolio of interventions required to achieve bovine-TB free status. At the moment the only viable option is vaccination using intramuscular BCG which requires catching badgers. Important but limited field data supported by modelling shows this is a viable way of controlling bovine TB in wild badger populations, though some estimates suggest this may take more than a decade to achieve using current approaches.

6.XL Work in England but especially from the Republic of Ireland has highlighted the challenges of running a successful vaccination campaign. Catching badgers is difficult and requires pre-baiting and for personnel to be in the field over several weeks. There is evidence that some ("trap shy") badgers never enter traps, and locating all setts in an area is not always straightforward. Ensuring a reliable supply of vaccine has proved challenging in some campaigns. Finally, there is scepticism in some but not in all the farming community about whether vaccination actually works and is a viable replacement for lethal control.

6.XLI Work on badger vaccination needs to be stepped up considerably for it to become an epidemiologically and financially viable intervention tool. For the former, better data on the efficacy of the vaccine and trapping strategies need to be collected at scale as part of much larger vaccination campaigns than have been undertaken so far in England. These campaigns should be designed both to make a real contribution to bovine TB control but also to provide the information to continuously improve the intervention in the spirit of adaptive management. Better data is also required about the density and distribution of

[114] Stanyer., 2021, https://doi.org/10.1016/j.jrurstud.2020.11.011

badgers, and their rates of infection (¶6.XLVII). We note the successful roll out in the Republic of Ireland of a "Badger Activity" app to record badger setts and associated information[115].

6.XLII A second major area of attention should be the costs of vaccinating badgers which currently are a brake on its deployment at scale. There needs to be a focus on economies of scale of wider deployment, and how costs might be reduced. For example, timely training and accrediting of lay vaccinators at scale is important to build a cost-effective work force, and there is also the possibility of using volunteers for some aspects of the work. Government and the industry also need to agree a funding model for badger vaccination campaigns that will need to run over multiple years.

6.XLIII A concerted effort will be needed to persuade the farming community that vaccination is a viable alternative to culling. Better data and demonstration projects will be important tools to do this. Misconceptions such as the need to vaccinate every badger will need to be dispelled: for a relatively slowly transmissible disease like bovine TB in badgers, not every animal needs to be immunised in order for a vaccination programme to be effective.

6.XLIV A successful oral vaccine could significantly reduce costs, but current products are not approved for use because of poor efficacy. Were new ideas to emerge we would support further research in this area but advise that policy should not be developed on the assumption that a deployable oral vaccine can be developed.

Test, vaccinate & remove (TVR)

6.XLV TVR involves the killing of some badgers but many fewer than in a culling programme. The badgers that are euthanised carry the disease which would impact their own welfare as well as that of other badgers in the sett who they might infect. Some groups would view the positive effects on net animal welfare as an ethical justification for limited culling, though others would not. Vaccination with destruction of infected animals may lead to greater buy-in by the farming industry compared to a vaccination-only programme.

6.XLVI TVR will be more expensive than vaccination alone due to the costs of the field diagnostic test, but especially because taking blood from badgers has at present to be done by a licenced operative. Were TVR to be pursued, economies of scale should drive down the cost of diagnostics. It might also be possible to extend the role of licenced lay operatives to test, vaccinate and euthanise badgers, though the effect this would have on recruitment and on animal welfare would need careful consideration.

Badger disease surveillance

6.XLVII Understanding disease prevalence in badgers is important in all areas but especially around developing bovine TB hotspots. In addition to targeted surveillance much useful information can be obtained from badgers found dead,

---

[115] DAFM (Irish Government) (accessed July 2025), https://tinyurl.com/BadgerActivityApp

in particular those killed on the roads[116]. There is a strong argument for the routine testing of "found-dead" badgers throughout bovine TB areas.

The disease in deer and other wildlife

6.XLVIII Since we last reported, evidence has been found that bovine TB may be more prevalent in wild deer in the British Isles than previously assumed. In our view this warrants more surveying of bovine TB prevalence in deer, and whole genome sequencing of any isolates to help understand transmission pathways. Deer are shot for sport and meat but also to control populations as they have no natural predators and high numbers can damage fragile ecosystems. It should be made as easy as possible for infections in these deer to be reported to provide surveillance data as cost effectively as possible (a bounty might be considered to compensate for the time involved and in some cases for the loss of sales of venison).

6.XLIX Wild boar are not thought to be a wildlife reservoir but as a precautionary measure any cost-effective opportunity to obtain more information about this species (for example as part of ASF-related work) should be taken.

Statistical analyses of culling

6.L Data from both the Industry-led Culls and the RBCT have been subject to multiple statistical analyses that have sometimes come to different conclusions. These often arise from quite subtle differences in statistical assumptions or interpretation, making it difficult for the non-specialist to get a clear overview of the evidence. Here we review these different analyses.

6.LI Data from the industry-led culls give an indication of the effect that culling (combined with other interventions implemented at the same time) has had on herd breakdowns in recent practice. The RBCT, initiated nearly thirty years ago, aimed to provide evidence on whether badgers are a source of infection to cattle, and on whether culling, as implemented in the Trial, might reduce the frequency of herd breakdowns. It is important to note that the way culling was carried out in the RBCT would not be the same as in an industry-led intervention at scale, restricting the practical inferences that can be drawn.

6.LII In our discussion, we quantify the estimated effects of interventions by the corresponding percentage reduction in herd breakdowns. So, the larger the percentage reduction the more effective the intervention. Uncertainty in the estimate is described by giving a 95% confidence interval (CI), the standard statistical margin of error.

[116] Barron *et al.,* 2018, https://doi.org/10.1038/s41598-018-35652-5;
Schroeder *et al.,* 2020, https://doi.org/10.1038/s41598-020-72297-9;
Swift *et al.,* 2021, https://doi.org/10.1038/s41598-021-00473-6;
Corbetta *et al.,* 2024, https://doi.org/10.1007/s10344-024-01866-4;
Powell *et al.,* 2025, https://doi.org/10.1038/s41598-025-86930-y

Industry-led culls

6.LIII In the period since 2013 progressively more areas have been brought into culling and today culling occurs over most of the HRA with the cumulative number of badgers killed is over 240,000. Data collected in association with the culls have been subject to various analyses. In our discussion we refer to data both on OTF-W incidents and on total incidents, which include both OTF-W and OTF-S (see Glossary, p.105, for definitions).

6.LIV During the course of the industry-led culls, other measures targeting the disease in both wildlife and cattle were introduced. A particularly important intervention in the culled areas, from 2017 onwards, was the mandatory use of interferon gamma testing in OTF-W breakdown herds; the test was used in a more discretionary manner in other areas. In the period 2017 to 2021, this involved around 339,000 individual tests, with an estimated 19,580 interferon gamma-positive cattle slaughtered, in addition to 18,578 tuberculin-positive cattle detected by routine testing in the same period. As we discuss in Chapter 3, we view the use of this test as a very important tool in reducing disease spread and herd breakdowns.

6.LV Industry-led culling took place in Somerset and Gloucestershire starting in 2013, and in Dorset from 2015 onwards. An analysis of the results from all three counties was published in 2019[117]. Bovine TB incidence within culled areas was compared with incidence in herds in unculled areas chosen to have a similar spectrum of bovine TB risk factors. Breakdowns were monitored in surrounding buffer areas to explore any perturbation or related effects that might lead to local disease spread.

6.LVI In Gloucestershire and Somerset, data were available for four years after the start of culling. Considering total breakdowns in the culled zones, culling and its accompanying measures were associated with substantial reductions in herd breakdowns: Gloucestershire (CI: 51% to 62%) and Somerset (CI 26% to 36%). If OTF-W incidents only are considered, the effects are stronger. In the buffer zones, there was a significant reduction in Gloucestershire but no significant effect either way in Somerset.

6.LVII Data for all three counties after two years of culling were also analysed. In Gloucestershire and Somerset, there were no significant effects if total events are considered; the effects for OTF-W alone were found to be significant but not as strong as after four years. Comparisons with the four-year data indicate that the interventions take some years to take full effect. In Dorset, the results are inconclusive: in the culled zones, there was an increase for total incidents but not for OTF-W alone; in buffer zones there was a reduction in OTF-W breakdowns.

---

[117] Downs *et al.,* 2019, https://doi.org/10.1038/s41598-019-49957-6. This superseded an earlier analysis covering a smaller number of areas in Gloucestershire and Somerset for a shorter period (Brunton *et al.,* 2017, https://doi.org/10.1002/ece3.3254)

6.LVIII A study published in 2022[118] compared disease prevalence in parts of the High Risk Area that had and had not been culled. For each year in the period 2013 to 2019, the analysis compared the overall incidences in the portion of the HRA where culling was already taking place with the residual unculled portion, which includes both the areas where culling started later and those which were never culled in the period. Over this period, the culled area became larger and the unculled smaller. Their key conclusion was that their comparisons did not demonstrate any significant effect of culling.

6.LIX There has been considerable debate and discussion of this paper[119] and see particularly ref[120]. A major issue is that the study treats all culled areas as a single group. As noted above, the effects of the culling interventions build up over time. In most years considered, the culled group is dominated by areas in the first and second years of culling, and so any longer-term effects are diluted by taking the average over all the areas. Furthermore, culling is likely to be implemented in areas of higher incidence of bovine TB. Introducing a new high-incidence area to the culled group would initially increase the average incidence in the culled group and reduce it in the unculled group. For both these reasons the failure of the study to find a significant effect of culling is not a convincing demonstration of the inefficacy of the culling interventions.

6.LX The second part of the 2022 study[118] presents graphs of OTF-W incidence rates for ten counties in which there have been a range of levels of culling during the period. It argues on an informal basis that all show similar overall patterns of reductions in herd breakdowns, regardless of the level or timing of culling, and suggests that overall reductions in incidence since the mid 2010's are attributable to cattle measures rather than to badger culling. However, the data is complex and variable and a more formal approach would be needed to confirm the validity or otherwise of this conclusion.

6.LXI A comprehensive analysis[121], considering all 52 areas issued with Badger Disease Control Licences up to 2020, was published in 2024. Culling occurred as part of a suite of interventions, referred to as a badger control policy (BCP), which started in different years in different areas. The data were analysed using the well-established statistical approach known as "difference in differences". In its simplest form, where a treatment occurs on a number of units at a specific time, the method chooses a time before and after the treatment and compares the before-after differences in treated units with those in untreated units. The

---

[118] Langton *et al.,* 2022, https://doi.org/10.1002/vetr.1384

[119] Middlemiss, 2022, https://tinyurl.com/MiddlemissBlog (see also following discussion);
Middlemiss & Henderson, 2022, https://doi.org/10.1002/vetr.1605;
Langton *et al.,* 2022, https://doi.org/10.1002/vetr.1655;
Gibbens, 2022 & Langton *et al.* response, https://doi.org/10.1002/vetr.1709;
Middlemiss & Henderson, 2022, Correction to Figure 1,
https://doi.org/10.1002/vetr.1823;
Langton *et al.,* 2022, https://doi.org/10.1002/vetr.1822

[120] Robertson, 2025, https://doi.org/10.1101/2025.07.10.664183

[121] Birch *et al.,* 2024, https://doi.org/10.1038/s41598-024-54062-4

authors use a modification to account for the fact that the BCP interventions start at staggered times and continue once put in place.

6.LXII The analysis concluded that the percentage reduction in OTF-W herd breakdowns in BCP areas was 56% (CI 41% to 69%), an approximate halving. The greatest declines were in the second and third years after the start of culling and did not fall further beyond the fourth year. As the authors recognise, other interventions (particularly the adoption of compulsory interferon gamma testing) may well have contributed to the reduction in herd breakdowns.

6.LXIII The authors of the analysis express some scepticism about including OTF-S incidents in the analysis, on the grounds that variations in the numbers of OTF-S incidents could be due more to changes to surveillance rather than the true burden of infection. Nevertheless, their method still indicates a reduction of over 40% if total incidents are considered. The issue of when to analyse all incidents or just OTF-W breakdowns would benefit from further research (¶6.LXXIII)

6.LXIV Taking all the statistical evidence on the industry-led culls together, the panel's overall conclusion is that there is clear evidence that the package of intervention measures including culling has the effect of reducing bovine TB in cattle. It is not possible statistically to separate quantitatively the individual contributions of different components of the package and the possible interactions between them. Given other evidence of badger to cattle transmission, and the reduction in herd breakdowns observed before interferon gamma testing in OTF-W breakdown herds became mandatory, it is reasonable to posit that culling itself has had some reduction effect on herd breakdowns.

The RBCT

6.LXV The RBCT consisted of ten "triplets" each comprising three test areas. Within each triplet, in one area badgers were culled over a four-year period (proactive treatment), in another culling was only initiated when disease was detected locally (reactive treatment) while no culling was carried out in the last area (control treatment). Initial results suggested reactive culling increased herd breakdowns and this arm of the experiment was stopped and so all subsequent analyses were comparisons of the proactive and control treatments. The full implementation of the experiment was delayed by the Foot and Mouth epidemic of 2001 and culling in different triplets started at different times.

6.LXVI Most of the discussion and analysis of the RBCT has been in terms of "confirmed breakdowns" and we focus on these. The original analysis[122] concluded that the relative frequency of confirmed herd breakdowns in the proactive sites compared to the control sites declined during the period of culling and remained lower for two to three years after the cessation of culling. However, there was an increase in herd breakdowns in the areas surrounding the cull in the first two years, hypothesised to be due to a perturbation effect. The estimated reduction in herd breakdowns in the proactive areas due to

[122] Donnelly *et al.,* 2006, https://doi.org/10.1038/nature04454;
see also Mills *et al.,* 2024a, https://doi.org/10.1098/rsos.240385;
Mills *et al.,* 2024b, https://doi.org/10.1098/rsos.240386.

culling was estimated to be 19% (CI: 6% to 29%) over the four-year experimental period.

6.LXVII A recent analysis[123] of the RBCT disputes this conclusion. The new analysis accounts in a different way for the variation in the numbers of herds across test areas. If herd breakdowns were random then you would expect more breakdowns in areas with larger numbers of herds. Fitting a "triplet effect" is tantamount to comparing the difference in frequency of breakdowns between culling and control areas within the same triplet. But this does not control for all effects of herd numbers; while in some triplets the numbers of herds in the treatment and control areas are fairly close, in others they differ in one direction or the other.

6.LXVIII The original analysis allowed for this by estimating the effect of herd numbers on breakdowns as well as estimating the influence of culling versus non-culling. The new analysis took a different approach: it explicitly assumes that, all other things being equal, the number of breakdowns will be proportional to the number of herds, so the effect of herd numbers is constrained rather than estimated. It then estimates the additional influence of culling. This is roughly equivalent to using incidence rates rather than incidence numbers as the primary focus of attention.

6.LXIX We accept the argument that working with incidence rates is the more natural approach. But then it would also be more appropriate to model the odds of a herd breakdown rather than the number that occur. Technically this implies fitting a binomial log-odds, rather than a Poisson log-linear, regression model, in both cases with adjustment for overdispersion. In Annex 4 we present such an analysis, which has been independently refereed. It estimated the reduction of confirmed breakdowns as 17% (CI: 3% to 30%) and found that the reduction is significant at the standard 5% statistical level (the original analysis estimated a reduction of 19% [CI: 6% to 29%] and found it significant at the 0.5% level).

6.LXX Thus, our conclusion is that the analysis of confirmed incidents in the RBCT provides weaker evidence for a positive effect of culling than its first analyses suggested. We make two further points. First, reasonable people can disagree about the best way to analyse complex data such as these. Second, there are likely diminishing returns from further analysis of a now thirty-year old experiment. We note that the RBCT was set up for two reasons, to assess the role of badgers as a source of infection for cattle, and to test whether culling reduces herd breakdown. As we discuss elsewhere (¶5.VIII), recently introduced techniques, especially WGS, have provided valuable new information about the risk of infection from badgers, consistent with, but significantly extending, the original inference from the RBCT that badgers do present some risk to cattle. Finally, culling as an intervention at scale has been implemented in a very different way from how it was carried out in the RBCT. Government policy is to end culling but even were it to continue the RBCT now provides

---

[123] Torgerson *et al.,* 2024, https://doi.org/10.1038/s41598-024-67160-0; Torgerson *et al.,* 2025, https://doi.org/10.1098/rsos.241609

limited (if any) insights into the design and likely value of including culling in a control programme.

Research & development priorities

6.LXXI The continued and expanded use of whole genome sequencing to provide quantitative insights into disease prevalence in wildlife and the extent of wildlife-cattle and cattle-wildlife transmission will be key to tailoring geographical specific control strategies. This will entail increased surveillance for bovine TB badgers, for example in schemes that test badgers found dead by the roadside (¶6.XLVII).

6.LXXII There is some evidence about the optimal deployment of badger vaccination but more information is highly desirable. Because of the imperative of bringing in vaccination at scale as a non-lethal control measure we recommend these data are collected as part of a carefully designed implementation programme with the[124] results of the data analysis feeding back into the adaptive management of the programme. Examples of areas where better information would be beneficial include measures of the duration of immunity conferred by the vaccine, investigation of the effectiveness of trapping and vaccinating in post-cull landscapes, and more accurate knowledge of badger density and demography, particularly in post-cull landscapes. Building on existing modelling[125] will also be required to integrate this information and provide guidance to programme design.

6.LXXIII A long-standing question is whether it is statistically preferable to use total incidents (OTF-W + OTF-S) or just OTF-W to assess the efficacy of interventions[126]. Because the aim is to reduce actual infection, this choice would depend on a complex calculation involving the probabilities of false positives and false negatives under varying surveillance regimes and underlying prior probabilities of infection. A related issue is the degree to which OTF-S herds should be treated as OTF-W herds which would involve a cost-benefit analysis in addition. Detailed research is needed to allow these questions to be addressed systematically in ways that achieve a consensus among the various stakeholders.

6.LXXIV Further research on the drivers behind the negative attitudes of many farmers to the deployment of badger vaccination, and how it may be allayed, would be valuable.

---

[124] Benton *et al.,* 2023 https://doi.org/10.1002/2688-8319.12208
[125] Ketwaroo *et al.,* 2025, https://doi.org/10.1002/env.2888;
Chang *et al.,* 2025, https://doi.org/10.1016/j.prevetmed.2024.106386;
Smith *at al.*, 2022, https://doi.org/10.1016/j.prevetmed.2022.105635;
Prentice *et al.,* 2019, http://dx.doi.org/10.1098/rsif.2018.0901;
Smith & Delahey, 2018, https://doi.org/10.1098/rsif.2018.0901
[126] E.g. APHA (accessed July 2025), https://tinyurl.com/APHABadgerCont;
Birch *et al.,* 2024, https://doi.org/10.1038/s41598-024-54062-4;
Langton & Torgerson, 2025, https://doi.org/10.1002/vetr.5089

Chapter 7: Non-bovine Farmed Animals and Pets

Introduction

7.I Non-bovine farmed species, including deer, goats, South American camelids (SACs: alpacas, llamas, guanacos and vicuñas), pigs and sheep, are susceptible to *M. bovis* infection to varying degrees. There is no statutory bovine TB surveillance programme in place for these species, though testing may be initiated if risks are identified, for example a cattle herd breakdown on the same farm. The suspicion of TB in both a live specified animal and/or the carcass of such an animal is notifiable under Article 5 of the Tuberculosis in Animals (England) Order 2021 (the 'TB Order')[127] and requires isolation of potentially infected live animals.

7.II Domestic pets can also be infected, for example through eating meat from infected animals. It is a legal requirement to notify APHA if TB is suspected during a post-mortem examination or if *M. bovis* is identified in animal tissue or excreta (notification of clinical suspicion of bovine TB in a living pet is advised but not mandated)[128]. In our 2018 Report we discussed pets very briefly but several recent outbreaks suggest they might warrant more attention.

7.III Current consensus continues to be that infections in non-bovine farmed animals and pets are spillovers from the disease in cattle and wildlife, though unbiased estimates of prevalence are hampered by lack of data.

Recent developments

7.IV Figure 7.1 updates the data in ¶7.12 on the number of TB-positive, non-bovines slaughtered each year. It is one of several measures of prevalence available at ref[129] (for comparison, 21,864 cattle were slaughtered in the 12 months to September 2024[130]). It shows goats, SACs and deer to be the most commonly affected species. Numbers are relatively low and too variable to identify temporal trends, and there has not been a recent example of a large-scale outbreak in goats as has happened in the past. There has been a substantial increase in the numbers of deer tested since 2018, but the numbers of animals or premises surveyed remains very small compared to cattle and cattle farms.

[127] UK Government (accessed July 2025) https://www.legislation.gov.uk/uksi/2021/1001/contents

[128] APHA (accessed July 2025) https://tinyurl.com/bTBPetTest

[129] Defra (July 2025) https://www.gov.uk/government/statistical-data-sets/other-tb-statistics

[130] APHA (accessed July 2025) https://tinyurl.com/mrypdw6c

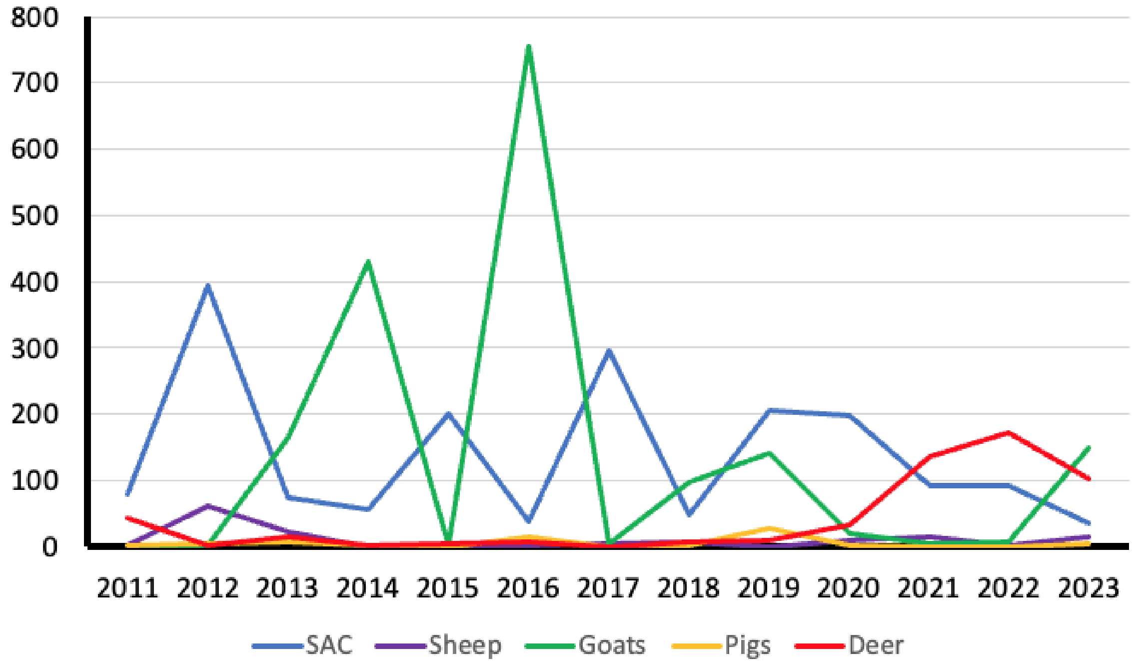


Figure 7.1. Numbers of non-bovine farmed animals slaughtered each year between 2011 and 2023. SAC are South American camelids (alpacas and relatives).

7.V At least two notable outbreaks of disease have occurred in domestic cats in the United Kingdom since we last reported[131] (see also an outbreak in the Netherlands[132]). In one outbreak, 47 clinical and 83 asymptomatic cases were detected in England and Scotland in cats that had all been fed the same diet containing raw venison. It was concluded there was 'compelling evidence' that the diet was responsible for the cats' infection. In addition, four cat owners and one veterinary surgeon were diagnosed with suspected latent TB, potentially due to exposure to infected cats with purulent lesions and/or their contaminated feed.

7.VI In the second outbreak, 11 young cats with similar symptoms were reported to be infected by members of the *Mycobacterium tuberculosis* complex (a further 5 cats have since been implicated in the outbreak[133]). Genetic analysis identified the bacterium in six animals as *Mycobacterium caprae,* an organism usually absent from the UK. Whole genome sequencing found that five of these isolates were nearly identical, indicating they were infected from a common source. All 11 cats were fed, at least in part, the same raw-meat diet.

7.VII The safety of game entering the food chain is governed by The Wild Game Meat (Hygiene and Inspection) Regulations 1995[134] which sets out detailed

[131] O'Halloran *et al*., 2020, https://doi.org/10.1111/tbed.13889 ;
O'Halloran *et al*., 2024, https://doi.org/10.1002/vetr.4625
[132] Commandeur *et al.,* 2025, https://doi.org/10.3168/jds.2024-25539
[133] Conor O'Halloran, pers. comm. July 2025.
[134] UK Government (accessed July 2025)
https://www.legislation.gov.uk/uksi/1995/2148/contents/made

requirements for carcass inspection and handling. Generally, raw meat for animals needs to be passed as fit to be eaten by humans. The Food Standards Agency (FSA) recalled the implicated product in the first outbreak because "the ingredients were not inspected in line with EU requirements."[135]

7.VIII Since we reported, several previously unreported cases of mycobacterial disease in dogs have been described[136]. Cases were caused by *Mycobacterium tuberculosis* (1 case), *Mycobacterium bovis* (12) and *Mycobacterium microti* (2). The sources were not identified clearly, although four of the dogs with *M. bovis* were from endemic areas and one of these was a farm dog. In 2018, a large outbreak in a foxhound kennel (97 out of 180 dogs) was reported[137]. As a result, DEFRA introduced tighter restrictions on the collection and feeding of fallen stock to hounds in registered kennels[138]. The UK Health Security Agency has also considered the exposure risks[139].

7.IX Although we are unaware of cases in the UK, we note that ferrets have been commonly infected in the wild in New Zealand[140]; there is increasing interest in their use as experimental animals for mycobacterial research[141], confirming their susceptibility to *M. bovis*[142]. The species is of growing importance as a pet and care needs to be taken that infection is not overlooked[143], given the close contact of ferrets with their owners.

Updates on options for the future

7.X The possible options for the future we considered in 2018 were:

- Continue with the current regime
- Consolidation of legal provisions
- Targeted measures where there is a risk of human infection
- Introduce stricter controls on movements of non-bovines
- Introduce stricter measures for bovine TB breakdowns in non-bovines
- Applying to non-bovine species the full range of bovine TB controls that currently apply to cattle

Our appraisals of the advantages and disadvantages of the different options are still largely applicable today, though with a few additions and modifications.

7.XI There is no evidence for increased prevalence of bovine TB in non-bovine farm animals though sampling intensity is low (and appears to be reducing for SACs) with the risk that outbreaks may be overlooked. APHA has protocols for dealing

[135] FSA, 2018, https://data.food.gov.uk/food-alerts/id/FSA-PRIN-65-2018.html
[136] O'Halloran *et al.*, 2024, https://doi.org/10.1016/j.tvjl.2024.106089
[137] O'Halloran *et al.*, 2018, https://doi.org/10.1136/vr.k3955
[138] APHA (accessed July 2025), https://www.gov.uk/guidance/fallen-stock
[139] Phipps *et al.*, 2018, https://doi.org/10.1017/S0950268818002753
[140] De Lisle *et al.*, 2008, https://doi.org/10.1016/j.vetmic.2008.05.022
[141] Gupta *et al.,* 2022, https://doi.org/10.3389/fcimb.2022.873416
[142] Lauterkorn, 2023, https://doi.org/10.3389/fcimb.2022.873416
[143] Barth *et al.,* 2020, https://doi.org/10.1055/a-1069-6630

with serious outbreaks of TB in non-bovine farmed animals. A general increase in infection in one of these species might justify the introduction of mandatory testing and stricter movement restrictions. We believe that the Livestock Information System could facilitate implementation of such measures and that that this is another reason for its development (see ¶5.XVIII).

7.XII *Mycobacterium* infections in pets are rare but there have been several outbreaks and a case where humans have also been infected. We note that the regulations related to feeding fallen stock to dogs have been tightened, but regulations on the use of game and other raw meat in pet food may need revision or better enforcement. The FSA Report quoted above (¶7.VII) noted potential loopholes in these regulations, which could allow infected venison meat into the food chain. We note that post-mortem suspicion of *M. bovis* in pet mammals must be notified to APHA, as should the identification of *M. bovis* in a laboratory test. It is important that the veterinary profession continues to be reminded of this in order to allow timely intervention.

7.XIII We emphasise the value of whole genome sequencing in understanding the epidemiology of the outbreaks mentioned above. This is a further argument for its widespread use.

Research & development priorities

7.XIV In our previous report we noted that testing protocols were understandably less well developed for non-bovine as compared to bovine animals. Research on better tests (and the continued transfer of technology from cattle to other species) would still be valuable.

Chapter 8: Biosecurity, Compensation and Insurance

Introduction

8.I This chapter examines a series of issues concerning bovine TB and farmers. These include the implementation of on-farm biosecurity to reduce transmission between cattle[144], cattle to wildlife and from wildlife to cattle, how farmers are compensated for a herd breakdown, and how the structure of the farming industry may incentivise or disincentivise disease control measures.

8.II Because there are many different aspects to biosecurity, large scale experiments to test individual measures are logistically and economically infeasible. However, there are a number of case-control and retrospective cohort observational studies that provide helpful information, and some measures are relatively cheap and can be thought of as "no regret" options. Uptake of biosecurity measures across farm premises is patchy (¶8.VIII) and understanding farmers' attitudes to their implementation is important.

8.III Farmers' decisions about implementing biosecurity and other disease avoidance measures are influenced by both financial and non-financial considerations. Amongst the former is the amount of compensation for cattle statutorily removed for TB control purposes during a herd breakdown, the degree to which compensation is linked to farmers' efforts to reduce disease risk, and the likely "return on investment". Return on investment is linked to security of tenure: an owner-occupying farmer is more likely to invest in long-term measures compared to a tenant farmer, especially one with a short lease. The structure of the farming industry thus influences the extent to which disease-control measures are put in place. In our 2018 Report we also explored whether insurance might be a better way of supporting farmers than compensation.

Recent developments

Biosecurity principles and their implementation

8.IV In 2015 Defra published a biosecurity strategy for bovine TB[145] based around five principles:

(i) Restrict contact between badgers and cattle

(ii) Manage cattle feed and water

(iii) Stop infected cattle entering the herd (discussed in Chapter 5)

(iv) Reduce risk from neighbouring herds

(v) Minimise infection from cattle manure

---

[144] Aspects of cattle to cattle transmission related to cattle movements and trading are covered in Chapter 5.

[145] TBhub (accessed July 2025), https://tinyurl.com/TBHubProtectHerd

The TBhub website contains more information on the specific measures that can be taken to implement each of these principles and fact sheets have been produced by the TB Advisory Service (TBAS) established in 2017.

8.V The strategy also sets out the policy to investigate possible reasons for herd breakdown. For all breakdowns in the LRA and EA, epidemiological investigations with farmers are carried out with the completion of a Disease Report Form (DRF). In the HRA, a random sample of 30% breakdowns are selected for a DRF and approximately 25-30% additional breakdowns are allocated a DRF investigation through a process which identifies explosive breakdowns (large numbers of reactors), those with a public health component, and herds which have not had a breakdown in the previous 5 years. In the past, information was largely gathered during a site visit and inspection but since 2020 an increasing number of investigations have been done remotely due to pressures on APHA staff from the Covid-19 pandemic and more recently Highly Pathogenic Avian Influenza and Blue Tongue Virus. Resourcing pressures (particularly during exotic notifiable disease outbreaks) have also meant that there is not always full completion of DRFs for all selected breakdowns.

8.VI A prioritisation system is in place to ensure outbreaks of the highest priority are investigated. In addition to DRF completion, the source of infection for all breakdowns in England is now assessed through the automated cattle movement algorithm and local infection indicator. This uses a variety of data (including whole genome sequencing) to assess the likelihood that cattle movements or local transmission are the source of infection. Recent research[146] suggests that the usefulness of DRF data has declined over time and that farmers' expectations that DRF data might be utilised to refine prescriptions around biosecurity are not being met.

8.VII An important metanalysis of all work up to 2024 investigating the efficacy of biosecurity measures was recently published[147]. An extensive literature review and sifting process resulted in the identification of 33 studies for further analysis. The evidence in support of principles (i), (ii) and (v) was found to be weak and sometimes inconsistent, though in part this is likely due to the complexities of getting the data and the amount of background variability. Evidence for the benefits of reducing the likelihood of introducing infected cattle into the herd (iii see Chapter 5) and preventing infection from neighbouring herds (iv) was stronger.

8.VIII The authors also looked at the take-up of biosecurity measures on farms that had suffered a breakdown using a sample of 4074 DRFs completed in 2018 and 2019. Overall, the presence of biosecurity measures was low, as shown in Table 8.1.

[146] Enticott & Ward, 2019, https://doi.org/10.1111/geoj.12341
[147] Voller et al., 2025, https://doi.org/10.1002/vetr.4912

Table 8.1 Take up of biosecurity measures, assessed by Disease Reporting Forms (DRFs) completed after a herd breakdown (from ref[146]).

Question on DRF	Number of DRFs with a response	% yes
Can badgers access cattle housing?	4074	97.9
Full wildlife proofing not in place?	4055	90.9
Feed troughs accessible to badgers?	4065	79.6
Cattle have high or very high risk of contact with badger excreta?	4046	55.1
Minerals accessible to badgers?	4051	51.1
Supplements accessible to badgers?	4039	40.6
Badgers can access feed store?	4062	37.9
Contact with other herds possible?	4059	23.1

8.IX Rather more encouraging results were found in Defra's 2019 survey of Cattle Farm Practices (based on a sample survey of 1,363 farmers)[148] although unfortunately the categories used are not the same as in the DRF so comparison is not straightforward (Figure 8.1).

8.X TBAS (the TB Advisory Service) was set up in 2017 in part to improve on-farm biosecurity. TBAS advisors visit farms seeking to develop trust and offering bespoke advice, typically recommending 4 key actions out of a menu of over a 100. TBAS's own internal evaluation of its work[149], based on a large sample of 2,280 farms visited between 2017 and 2021, is positive about the uptake of its advice, showing that after six months 43% of farmers had completed 3 out of the 4 recommended actions and 52.9% 2 out of the 4. 90% of the farmers surveyed said the TBAS service was excellent (a further 6% said it was acceptable) and 98% of farmers said the recommendations were very useful (92%) or useful.

8.XI Defra commissioned the consultancy ICF to conduct an evaluation of TBAS[150] which reported in spring 2025. It was based on interviews with 47 farmers (39 who used TBAS and 8 who did not) as well as interviews with 20 advisors and other stakeholders. The results were broadly in line with TBAS's own earlier evaluation: the percentage of farmers implementing between 0 and 4 of the recommendations were: 4 (12%), 3 (24%), 2 (29%), 1(23%), 0(12%).

8.XII Another study[151], found an even lower take-up of recommendations, with farmers viewing the interventions as time consuming, costly and not always feasible. The interviewees suggested uptake would be facilitated by the co-

[148] Defra, 2019, https://tinyurl.com/CattleFarmPractices
[149] TBAS, (accessed July 2025), https://tinyurl.com/TBASReport
[150] ICF (May 2025) Evaluation of the Bovine Tuberculosis Advisory Service (TBAS): Qualitative element, Report to Defra. Unpublished (July 2025).
[151] Collinson *et al.,* 2025, https://doi.org/10.31220/agriRxiv.2025.00319

design of the disease reduction programme. However, this work was based on just 13 semi-structured interviews (6 farmers and 7 TBAS advisors).

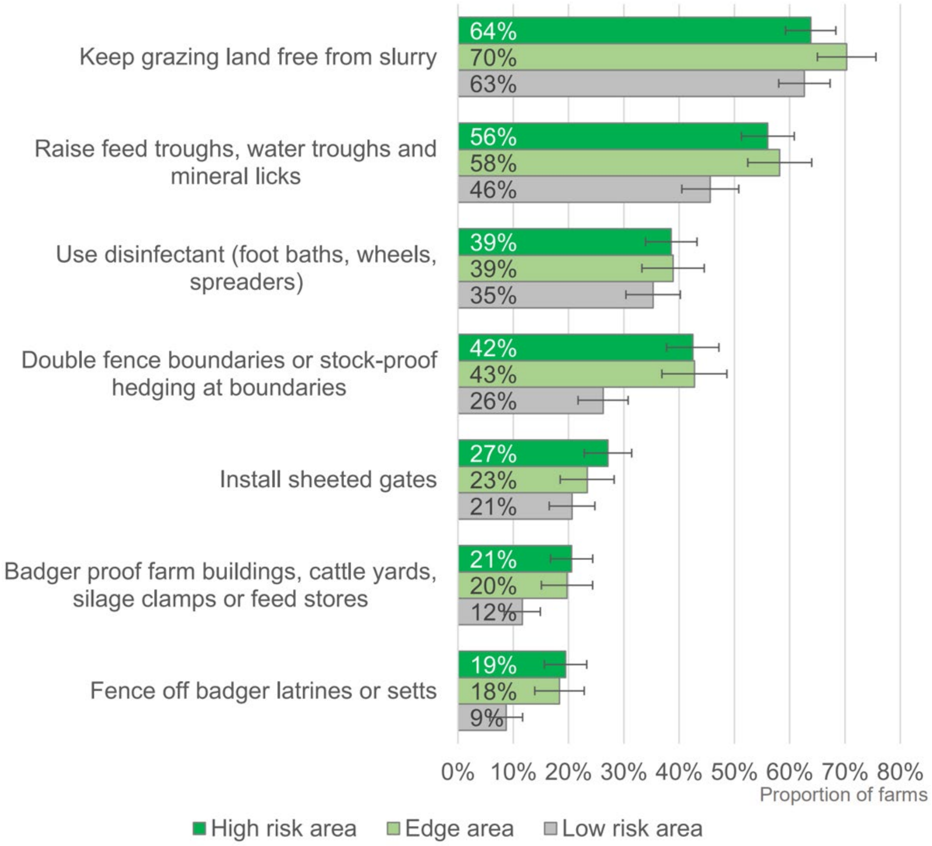


Figure 8.1 The uptake of different interventions in different bovine TB risk areas (after ref[147]).

8.XIII Implementation of biosecurity measures is a condition of obtaining a badger cull licence from Natural England who check compliance using farm visits. We have seen some raw data from these visits which appears to show imperfect implementation of biosecurity. However, there has been as yet no formal analysis of these data making quantitative inference difficult.

Cattle and badger behavioural studies

8.XIV Since our last report new data has become available on the fine scale movements of cattle and badgers in the farmed landscape. Technological developments in proximity loggers and the use of Global Positioning Systems (GPS) has allowed the continuous monitoring of cattle and badger locations and an assessment of how they interact at a high degree of precision[152].

8.XV An important study[153], conducted in a high-density badger population in south-west England, fitted proximity loggers to both cattle and badgers to detect interactions within a 1.4-metre radius – a distance considered biologically relevant for aerosol transmission. Over the course of the study, which recorded

[152] Ferreira *et al.,* 2023, https://doi.org/10.1111/mam.12324
[153] Drew *et al.,* 2013, https://doi.org/10.1017/S0950268813000691

more than 500,000 animal-to-animal contacts, only four were confirmed as direct interspecies interactions between a badger and a cow at pasture. This finding, demonstrating the rarity of direct contact despite ample opportunity for it to occur, has been corroborated by other tracking studies[154]. The implication is that direct aerosol transmission, while theoretically possible, is unlikely to be a significant contributor to the overall incidence of bovine TB in cattle herds.

8.XVI Pastures where cattle graze and badgers forage offer many opportunities for indirect contact. Badger latrines—communal sites consisting of clusters of shallow pits used for defecation and urination—are identified as key potential sources of infection (badger urine can contain exceptionally high bacterial loads of up to 250,000 colony-forming units per millilitre, and badger faeces up to 400,000 per gram). The same proximity logger study that found direct contact to be rare also monitored animal visits to latrines located on cattle pasture. It found that indirect interactions at these sites were two orders of magnitude more frequent than direct contacts, with 1700 visits by cattle and 400 visits by badgers recorded[153]. Cattle frequently investigate and spend time in the exact locations where badgers deposit potentially infectious material. Their behaviour, such as sniffing or nuzzling badger faeces to access grass underneath, further increases the risk of ingesting or inhaling the pathogen.

8.XVII Farm buildings and yards provide another critical arena for indirect transmission. Badgers are frequently attracted to farmyards by the availability of highly palatable and high-energy cattle feed, such as concentrates, maize, and silage, as well as water troughs[155]. Numerous studies using motion-triggered infrared cameras have documented widespread and frequent badger visits to farm buildings, with feed storage areas being a particular focus of activity. These studies have provided direct visual evidence of badgers defecating, urinating, and grooming in and around cattle feed, sometimes in feed troughs themselves, creating a clear and direct mechanism for contamination of resources consumed by cattle.

8.XVIII If infected cattle shed bacteria in their faeces, and slurry derived from this waste is spread onto pasture, there is a risk of forward infection. The extent of this risk is unclear, but *M. bovis* can survive in slurry for up to six months[156]. Government advice is now to store slurry for six months before spreading (it had previously been four months)[157]. Farmers are advised not to graze cattle on pastures to which slurry has been applied for a minimum of 60 days[158]. An alternative to spraying slurry on pasture is to inject it beneath the soil surface which reduces the likelihood of transmission and has the added benefit of lowering nitrogenous run-off. Cattle manure (farmyard manure or FYM) can also be used to fertilise pastures but if well composted the heat generated is thought to kill *M. bovis* reducing the risk of infection. Defra's 2019 survey of cattle farm practices found that 61% of specialist dairy farms spread slurry on both arable

[154] Chang *et al.,* 2023, https://doi.org/10.3389/fvets.2023.1233173
[155] TTBhub (accessed July 2025), https://tinyurl.com/TBHubProtectHerd
[156] Scanlon & Quinn (2000), Irish Vet. J. 53, 412-415.
[157] Defra (accessed July 2025), https://tinyurl.com/SlurryStrorage
[158] TBHub (accessed July 2025), https://tinyurl.com/PersistentBreakdown

and grazing land, 31% on grazing land only and 3% on arable land only[159]. The survey also found that farms with cattle in Edge Areas were more likely to store slurry for six months before spreading (48%) compared to 34% in the HRA and 24% in the LRA.

8.XIX A recent study[160] of naturally and experimentally infected cattle attempted to culture *M. bovis* from faeces and to see whether it could be detected using PCR. From a total of 84 animals, a culture was obtained from one *M. bovis* experimentally infected individual, and a PCR test was positive in a second naturally infected animal (the latter does not necessarily imply the presence of live bacteria). This is encouraging, but is a single study, and shedding is likely to be intermittent, vary from cow to cow and dependent on cattle condition and husbandry. Both culturing from environmental samples and environmental PCR are complex procedures and results can depend on the details of the protocols employed (¶3.XVIII). A number of earlier studies (reviewed in ref[161]) report much higher success rates for culturing. There is also evidence[162] of faecal shedding from infected cattle in developing country settings, though poorer cattle condition and a higher likelihood of other infections may increase its frequency.

Structure of the industry

8.XX In our 2018 Report we stressed that disease control will only be successful if it takes account of the physical, social and economic structure of the livestock industry in England: for example, how farm businesses are spatially constructed, the distribution of farm sizes, the ratio of owner to tenant farmers, and the socio-economic drivers of investment in, among other things, disease control measures. We continue to believe this is an important and understudied aspect of bovine TB control.

8.XXI As we have already noted in the context of factors affecting cattle movement (¶5.IV *et seq.*), the farming industry is going through a period of unprecedented change, largely driven by the restructuring of farming support consequent on our leaving the European Union. The move from the Basic Payment Scheme to the Environmental Land Management schemes will affect many land-use and investment decisions that may influence bovine TB epidemiology. These changes, as well as alterations to Inheritance Tax relief, will also affect decisions famers make up about remaining in or leaving the industry.

8.XXII Obtaining accurate data on the detailed structure of farm holdings is very complex. There are different types of tenancy agreements and land occupancy arrangements (Full Agricultural Tenancy, Farm Business Tenancy, informal, seasonal and share and contract farming agreements), some of which are of short duration. The average length of a Farm Business Tenancy, for example, is 3.8 years with over a half being for two years or less[163]. Tenant farmers

---

[159] Defra, 2019, https://tinyurl.com/CattleFarmPractices
[160] Palmer *et al*,. 2022, https://doi.org/10.1111/jam.15677
[161] Allen *et al.,* 2021, https://doi.org/10.1155/2021/8812898
[162] Holder *et al.,* 2024, https://doi.org/10.1038/s41598-024-52314-x
[163] Central Association of Agricultural Valuers (2024), https://tinyurl.com/CAAVSurveys

manage a third of England's farmland and are a critical part of England's agricultural industry but the annual Defra June survey of agricultural holdings does not capture the full complexity of tenure relationships. There is evidence that analysis of its headline figure underestimates increasingly complex patterns of land occupancy with a trend towards increased concentration in the livestock sector leading to fewer businesses operating at a larger scale using rented land or with more frequent share and contract farm agreements[164]. We do not know of any studies that have sought to explore whether these trends affect investment in bovine TB control measures. Defra's 2019 survey of cattle farm practices found that 34% of cattle farmers had rented grazing land, rising to 50% for farms with more than 150 cattle[165]. The incidence is also higher among specialist dairy farmers (51%) than livestock farmers (31% in LFA and 32% in lowlands). No information is available on the type of tenancy arrangement.

8.XXIII Some evidence of the incidence of short-term grazing arrangements is to be found in data from Temporary Land Associations (TLAs) which allow a farmer to use land they rent within a 10-mile radius of their registered holding as if it was any other part of their farm (technically they share the same County/Parish/ Holding [CPH] code for the duration of the TLA). Currently there are 5,828 cattle farmers with TLAs on rented land in England covering 74,224 active TLAs with the number of TLAs per holding ranging from 1 to 351. TLAs are issued on a field-by-field basis, hence there are usually more than one per holding. A TLA licence for cattle grazing is only permitted if the land is in the same bovine TB risk area. Movements to a TLA from other land in the permanent CPH do not need to be recorded or reported and are not subject to the six-day standstill rule before they can be moved again. All land covered by a single CPH, whether permanently or temporarily, is treated as a single unit from a disease testing and restriction perspective. TLAs are attractive to farmers in part because they are associated with a lower movement reporting burden.

8.XXIV In 2023 the Rock Review[166] documented the challenges facing tenant farmers and made a series of recommendations about how they might be supported. Amongst its recommendations are:

(i) Defra needs to examine ways to incentivise investment into renewing and upgrading infrastructure.

(ii) Defra and HMT should create appropriate incentives throughout the agricultural transition period to bring tenanted holdings into an improved state.

(iii) Defra and HMT should carry out a robust analysis on a strategic package of measures to incentivise landlords to let more land for longer.

Longer tenancies and incentives for investment may both encourage spending on disease control measures.

---

164 Winter *et al.,* 2024, https://doi.org/10.1016/j.jrurstud.2024.10341

165 Defra, 2019, https://tinyurl.com/CattleFarmPractices

166 Defra, 2023, https://tinyurl.com/DefraRockReview

8.XXV Another factor that may influence farmer uptake of biosecurity measures is the finance available to them to make the necessary investments. The gearing ratio is one way to measure this and refers to the size of a farm's liabilities as a percentage of its net assets. A higher ratio indicates less resources to invest in measures such as biosecurity. Figure 8.2 updates the numbers given in our 2018 Report (¶8.22). The relative gearing of different sectors (and of tenanted versus owner-occupied farms) remains largely the same. Of note here, the dairy sector has relatively high ratios with 10% of dairy farms having a gearing ratio value of over 40% (Figure 8.2). Tenanted farms have a gearing ratio higher than owner-occupied farms.

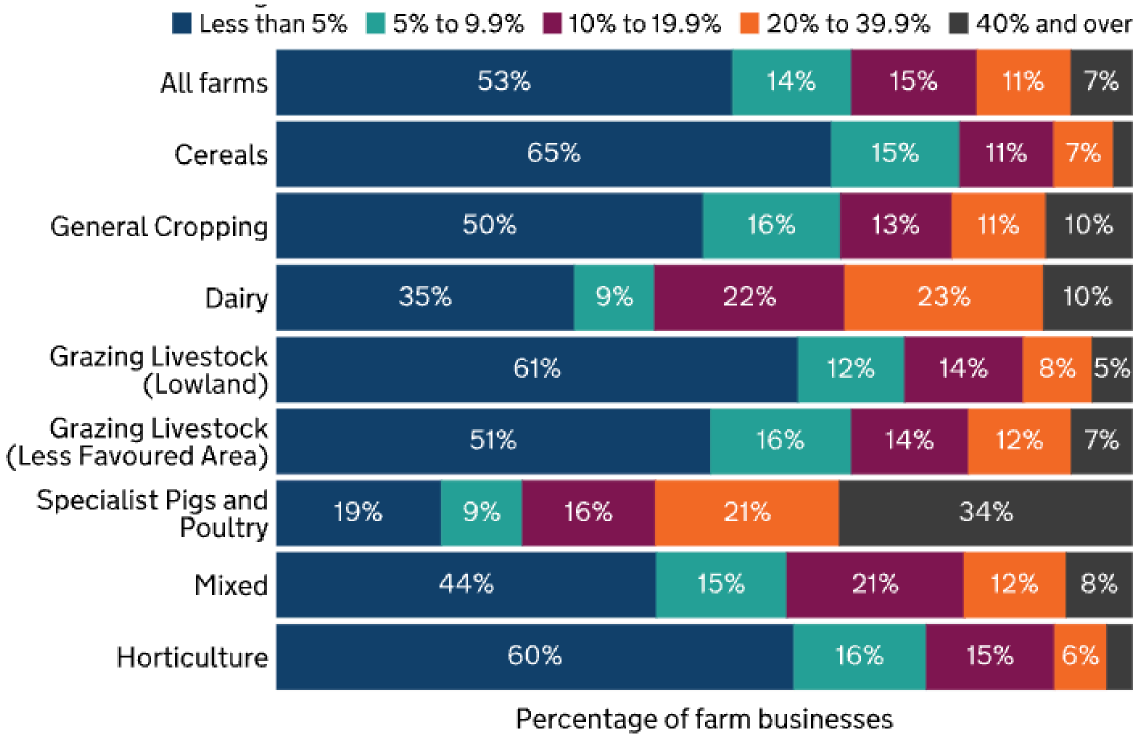


Figure 8.2. Distribution of farms by gearing ratio (the size of a farm's liabilities as a percentage of its net assets) and farm type in England, 2023/24 (from ref[167])

8.XXVI Even farmers with a low gearing ratio may, of course, struggle to find the necessary cash for investments in biosecurity. And here the direct impact of a bovine TB breakdown is of significance. In 2018 we quoted an analysis by Clothier and Betts that showed no difference in income between farms that had or had not had a breakdown. This was an internal Defra paper, based on Farm Business Survey data, that is not in the public realm. It seems counterintuitive, as previous published studies have reported on the financial challenges to farm businesses although usually based on cost impacts rather than income per se.

8.XXVII Since our 2018 report, there has been one examination[168] of farm economic costs of bovine TB outbreaks, based on a sample of 1,604 farmers located in the High Risk and Edge areas of England and the High (HTBA) and

[167] Defra (accessed July 2025), https://tinyurl.com/GearingRatio
[168] Barnes *et al.*, 2020, https://tinyurl.com/bTBEconCost

Intermediate (ITBA) TB areas of Wales. It found that the total costs of a breakdown across all farms in the survey had a median value of c.£6,600 with an interquartile range of c.£20,800 indicating a highly right-skewed distribution. Costs increase with herd size, breakdown duration, and breakdown severity (number of animals slaughtered). Testing, movement restrictions and output losses account, on average, for almost two-thirds of total costs. As the total cost of a breakdown increases the most important component costs switches from testing to movement restrictions and output loss (Figure 8.3).

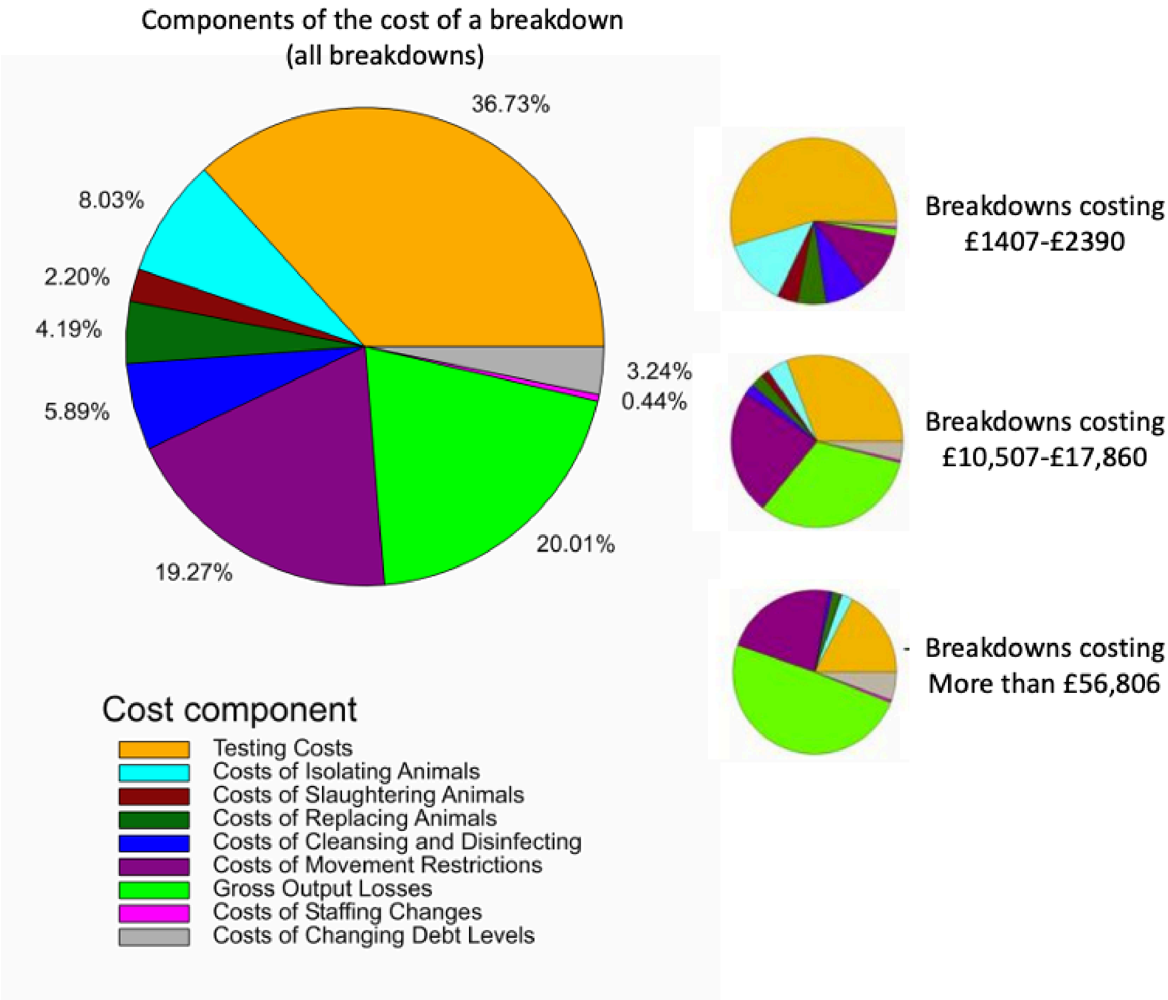


Figure 8.3. The components that contribute to the cost of a breakdown. The main figure shows the costs across all breakdowns while the three smaller figures show the proportions for breakdowns with different total costs (from ref[167]).

8.XXVIII We wrote in 2018 of the stress caused by herd breakdowns. Since then, several studies have tried to quantify this issue. One approach uses postal surveys to ask farmers to self-report different dimensions of well-being. Farmers in general report higher levels of anxiety and depression compared with the general population[169]. Against this background a postal survey of 582 farmers found no overall significant differences in well-being between farms with and without bovine TB. However, farmers in the high-risk area (HRA) with a history of bovine

[169] Wheeler & Lobley, 2022, https://doi.org/10.1186/s12889-022-13790-w

TB reported lower measures of two out of three measures of subjective well-being ($p < 0.05$)[170].

8.XXIX There are known limitations to postal surveys and consequently the Farming Community Network (FCN) in 2023 undertook in-depth interviews with 195 farmers who had experienced a herd breakdown[171]. Farmers reported a wide range of mental health symptoms from fear and depression, sleepless nights and persistent anger, to a deep sense of loss of control over their personal lives and their farm business, which may lead to a sense of "worthlessness." Consequently, the impact of bovine TB contributes to famers feeling disengaged from the policies to manage and eradicate bovine TB with scepticism about both the underlying science and the capacity of policies to achieve eradication. It should not be assumed that the mental health issues associated with the regulatory framework are necessarily 'solved' if more 'ownership' is given to farmers. Recent research[172] has examined the impact of passing 'ownership' of disease control policy to farmers, using the example of those involved in farmer badger culling companies. Through interviews and workshops cull directors and farmers involved in culling were found to be emotionally and physically tired of the work involved. The researchers reported that for some farmers "these activities had taken over their lives affecting their work and family lives". Signing up farmers in each cull area, collecting payments and culling badgers all involved significant physical and emotional costs. Cull directors reported suffering sleepless nights as a consequence of the work. The FCN has developed training provision for those interacting with members of the farming community[173].

Updates on options for the future

8.XXX The Disease Report Form (DRF) provides critical information about possible causes of a herd breakdown that will be of value to affected farmers but also to the broader farming community. Recent pressures on APHA have meant fewer site visits and more remote collection of information. Some information on a DRF is entered using codes that are easy to extract, while other information is free text and much more difficult to parse. There is some useful information, for example around use of slurry as fertiliser and cattle purchasing behaviour, not currently captured. It would be helpful for the next iteration of DRFs to include currently missing useful data and to explore how AI might be used to extract and summarise heterogeneous data that cannot easily be coded.

8.XXXI Much of the emphasis on completing DRFs and in the advice given by TBAS is on measures related to badgers. Whilst this is important, and understandable in terms of the way the biosecurity issue is often framed, it risks downplaying other aspects of biosecurity related to cattle to cattle transmission. In addition to biosecurity measures around cattle movement discussed in Chapter 5, we underline the importance of these other measures including limiting herd-herd

[170] Crimes & Enticott, 2019, https://doi.org/10.3389/fvets.2019.00342
[171] Smith *et al.,* 2025, https://tinyurl.com/bTBHumanCost
[172] Chivers *et al.,* 2025, https://doi.org/10.1016/j.geoforum.2024.104145
[173] Farm Community Network (accessed July 2025) https://fcn.org.uk/training/

contact and taking care with the storage and spreading of farmyard manure and slurry. Some farmers and vets also highlight the importance of taking deadstock to the farm perimeter for collection rather than having lorries come on to the farm (a precaution to cover a range of disease transmission risks) and limiting the risk of mother-calf transmission (for example by snatch calving or using pasteurised or artificial colostrum).

8.XXXII The use of biosecurity measures, even those requiring few resources or time, appears to be poor with a failure to persuade all members of the farming community to adopt even "no regret" interventions and we believe there needs to be a new approach. There are a variety of frameworks that have been developed within the social sciences to help understand and promote behavioural change that may be helpful in this context[174]. details of each approach may vary but they all tend to have in common the need to combine the personal characteristics of farmers (attitudes, values, education, etc) with wider constraints or opportunities (such as family context, farm business characteristic, finances, policy, etc). The Pembrokeshire Project (see ¶9.XV) seeks to integrate biosecurity alongside other measures with farmers and vets taking control of the problem through collaborative working. The Project's approach has valuable lesson for disease control in England. Of course, the adoption of biosecurity measures is only one component of an overarching bovine TB programme and in Chapter 9 we discuss the broader issues of co-design and co-development and how trust between different stakeholders and interest groups can be increased.

8.XXXIII The risk of infection from slurry spread on pasture remains poorly characterised and until more data are available it would seem prudent to minimise contact between cattle and recently spread slurry. Slurry spreading is also an issue in nutrient run-off from farmland. A Nutrient Management Group set up by Defra produced a report in May 2024 which focussed on issues of agricultural production and the risks of air and water pollution. Biosecurity and animal health issues were not addressed, and we advise that considering all slurry (and farmyard manure) issues together would be helpful in developing coherent policy.

8.XXXIV In 2018 we called for biosecurity advice to be made more consistent, particularly across different assurance schemes, and that farm assurance and compliance inspections be more joined up. We do not think there has been substantial progress here (and note the recommendations of the Stacey review were not implemented). We reiterate these calls here.

8.XXXV We noted above the Rock Review on Tenant Farming and that implementation of some its recommendations could incentivise investment in bovine TB control measures. In response to the Review the Government have advertised to appoint a Commissioner to the Tenant Farming Sector[175]. Government should consider explicitly including in the terms of reference for this position the

[174] For an overview see: AHDB (accessed July 2025), https://tinyurl.com/AHDBFarmerBehaviour

[175] Defra, 2024, https://tinyurl.com/TenantFarmerCommissioner

improvement in the uptake of disease-control measures by tenant dairy and beef farmers.

8.XXXVI We remain concerned that the system of TLAs provides a means of local spread of bovine TB through cattle movements. We think it is a priority to get more information to assess the spread and would like to see some way of recording cattle movements amongst TLAs under the same CPH. The forensic use of WGS to understand the cause of breakdowns involving TLAs may also be helpful (though are aware that WGS has limitations for very fine scale investigations). Based on these results consideration might be given to reducing the allowable 10-mile distance for TLAs involving cattle where the risk of bovine TB is high.

8.XXXVII Recent research since our 2018 Report has highlighted the issue of bovine TB and farmer mental health, and the issue is also receiving significant industry coverage. There are now training opportunities available and it would be desirable if those dealing directly with farmers in a regulatory or advisory capacity received basic mental health first aid and suicide awareness training.

8.XXXVIII In 2018 (¶¶8.59-8.63) we explored the arguments for and against moving from a regime where farmers were compensated for bovine TB losses to one of insurance. Current state spending on compensation could be used to support the insurance markets, reducing costs for farmers. Premiums would be made dependent on the extent to which farmers avoided risky behaviour and implemented biosecurity measures, providing an incentive pro-actively to adopt disease-control interventions. We understand that this would be a significant change with concomitant administrative costs but continue to think it deserves consideration.

Research & development priorities

8.XXXIX Getting better evidence about the efficacy of different biosecurity measures is very important, both to know how to interrupt disease transmission but also to demonstrate to the farming community their value, especially those that are costly to implement. Thought should be given to ensure that DRFs return appropriate and sufficient information to allow for both the monitoring and evaluation of biosecurity interventions and for the broader understanding of the surrounding context of disease incidence. It would be helpful if the Cattle Farm Practices Survey last held in 2019 was repeated every 3-4 years to chart progress with uptake of biosecurity measures.

8.XL Our understanding of the risk posed by slurry and the persistence of *M. bovis* in the environment is still poor. Further research in this area would materially assist the design of biosecurity measures. Recent years have seen great advances in the field of environmental DNA and the deployment of “next generation” sequencing which should help improve the evidence base.

8.XLI The detailed social science work on cattle purchasing which we commended in Chapter 3 is not matched by equally robust work on the uptake of biosecurity measures, despite the useful insights from the 2019 cattle practices survey. The evidence in the literature of farmer ‘fatalism’ and low take-up of biosecurity measure tends to be based on very small samples with little by way of examination of causal mechanisms for different levels of adoption within the farming community. There is a need for robust interview and focus group research, along the same lines as the cattle purchasing research, to enable a segmentation of the farming community around their willingness to adopt particular biosecurity measures, thereby improving the targeting of information and advice.

Chapter 9: Governance

Introduction

9.I Control of bovine TB in England is a scientific and epidemiological challenge but one that is situated in the broader context of the structure, socioeconomics, and political economy of the farming industry and how it relates to multiple interest groups and stakeholders of which the government is particularly important. For a campaign to eradicate bovine TB to be successful, the influence of these external factors must be understood and considered: the problem is not purely scientific and technical.

9.II The 2018 Report made a case for looking at bovine TB in this broader context, especially as the UK's departure from the EU would necessitate major changes to agriculture and land use. Seven years later some things are clearer, but the intervening period has seen the pandemic and a period of domestic political volatility, and more recently pronounced geopolitical unpredictability. These are macro-level processes but impact on resourcing and implementing a successful disease control programme. The near and medium-term future is more than normally opaque.

9.III We believe much of the governance analysis in the 2018 Report is still relevant today and have not sought to repeat it here. We also acknowledge that Government reacted positively to our analysis as can be seen in their formal response to our Report and in several new measures introduced in recent years. Here we update our analysis in the light of progress and events since 2018 and take the opportunity of looking at the bigger picture and the prospects of achieving the goal of eradicating bovine TB by 2038.

Recent developments

Developing bovine TB policy in a time of change

9.IV As has already been mentioned several times in this Update, the economics of farming in England and the broader UK is undergoing a period of change unprecedented since the Second World War. The Basic Payment Scheme (BPS), the cornerstone of farming support under the CAP, is being replaced in part by the Environmental Land Management (ELM) schemes with a much greater focus on using public money to procure public goods that are of benefit to society but under-supplied by the market. Changes to Agricultural Property Relief (APR) and Business Property Relief (BPR) within the UK's Inheritance Tax (IHT) framework were announced in October 2024, effective from 6 April 2026. Recently signed and possible future trade deals may affect the economics of producing different farm products.

9.V It is unclear how these changes may affect bovine TB epidemiology, and there may be both positive and negative consequences. Many small beef and dairy farms, especially in the west of England, have low profitability without the

BPS[176], and its phasing out may lead to fewer herds in the HRA, or possibly to larger herds managed in different ways. It may also lead to a higher proportion of farmers diversifying or seeking work off the farm. As discussed in ¶5.X, measures introduced under ELM schemes may incentivise new patterns of cattle movement, including from the HRA to the LRA. Changes to farm economics may encourage more (or less) renting out of pasture which will influence the amount and pattern of animal movements.

9.VI Government is currently working on England's Land Use Framework, a 25 Year Plan for Farming, a Food Strategy, updating the 25 Year Plan for the Environment, and preparing a response to the Climate Change Committee's proposed Seventh Carbon Budget (which was published in February 2025 and discusses livestock numbers and land use). Control of bovine TB is an important component of UK farming policy, and touches on all these plans and strategies, but it will never, and cannot, be the primary determinant of policy across all these areas. Some policies will need to be implemented that may have negative effects on disease prevalence, though hopefully the reverse will be more common. Our advice is that there is value in conducting futures and foresight studies of how farming and farming policy will evolve in the coming decades, and that these studies should consider impacts on livestock diseases. For bovine TB, this will help decision makers develop joined-up policy that avoid detrimental effects on disease control and identify potential win-win synergies.

9.VII England and the UK currently and at least for the next few years face a very tight fiscal environment. Government will have less money and likely more calls on its funds. While obviously challenging, this squeeze should be used as an opportunity to question established practices around bovine TB control and find out whether they might be done more efficiently and cost-effectively. The possibilities of increasing efficiency using AI and related technologies should be grasped. But equally, it would be counter-productive if short term funding constraints stood in the way of making investments that save money in the medium and long terms.

Creating partnerships and co-ownership

9.VIII In Figure 9.1 we have attempted to summarise the governance structure around bovine TB control in England (though the choice of exactly what to include or exclude is to some extent arbitrary). It is undoubtedly complex, reflecting the underlying complexity of the epidemiological, socioeconomic and legal aspects of the problem. Below we explore how it might evolve and support bovine TB eradication at a time of stretched finances.

9.IX In our 2018 Report we placed great emphasis on the importance of co-ownership of the problem and co-design of disease control measures. As part of the response to our Report, the Government set up the Bovine TB Partnership (building on the previous bovine TB Eradication Advisory Group) to bring a greater number of stakeholders to the table[177]. The Partnership has been expertly led by John Cross and we believe has generally improved

[176] Defra (accessed July 2025), https://tinyurl.com/FarmBusinessIncome
[177] Disclosure: one of our panel (JW) sits on the Partnership board

interactions across multiple stakeholders. However, Partnership members in conversation with us have expressed frustration at the amount of influence they have and their ability to get things to happen quickly on the ground.

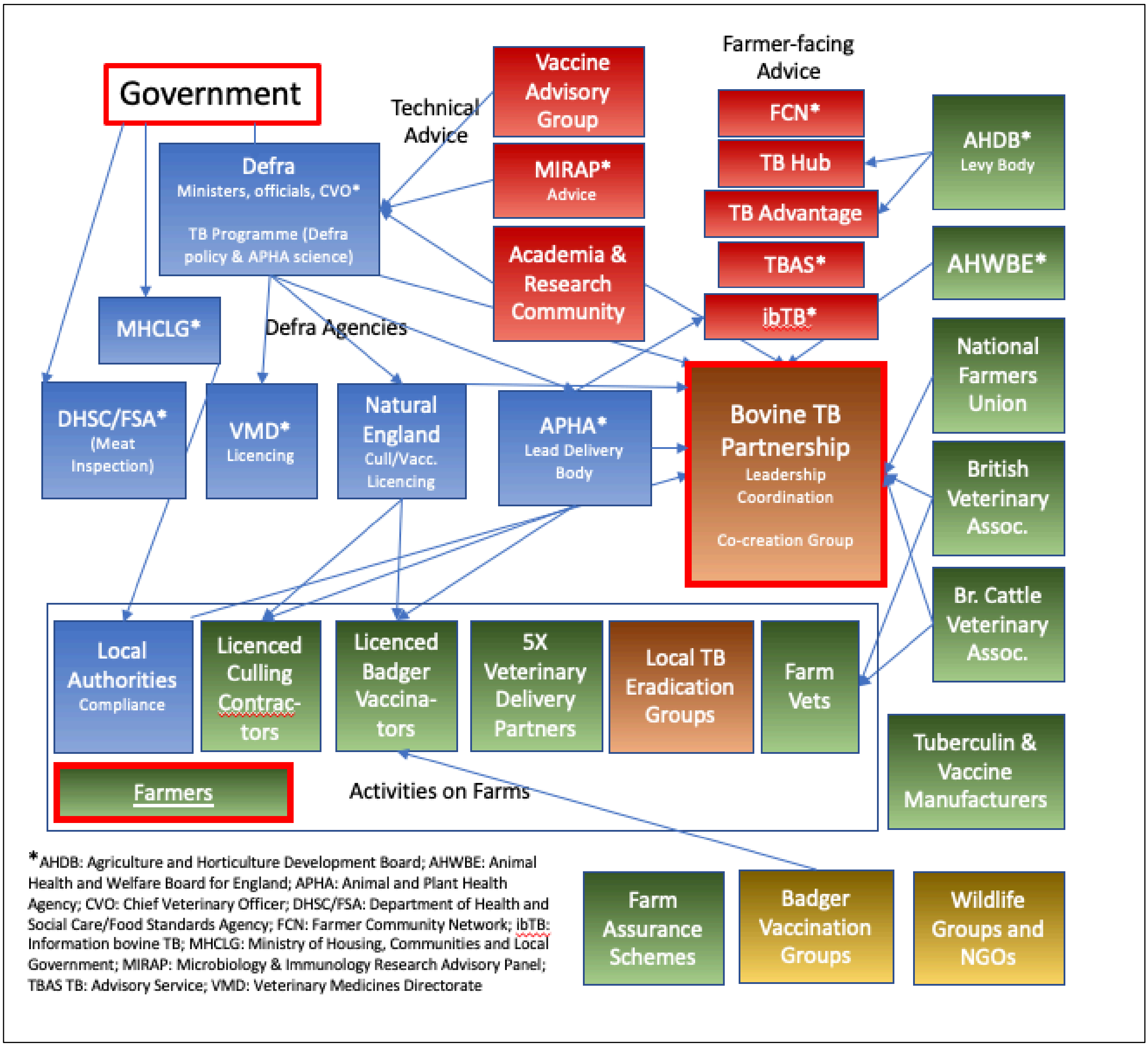


Figure 9.1. An approximation of the governance structure around bovine TB control in England (noting that a diagram such as this could be drawn in different ways).

9.X What makes policymaking so difficult for this disease is the presence of a wildlife reservoir and the question of whether culling badgers should be an element of disease control. As we set out in Chapter 6, we think the evidence shows that badgers can transmit bovine TB to cattle, but that a coherent disease control strategy can be formulated that either includes or does not include badger culling. If the latter, other measure to address the wildlife reservoir will be required, for example badger vaccination. Ministers have the very difficult task of deciding which to pursue, a decision that is informed by science but must be made in the round considering social and economic factors as well as the often-conflicting interests and viewpoints of different stakeholders. The current administration has clearly said badger culling will come to end in this Parliament. We believe a more detailed road map of how culling will be phased out will be helpful for all stakeholders.

9.XI We fully appreciate the very strong views held by different stakeholders around the issue of badger culling and understand how the debate has become so polarised. The issue can only be decided by ministers, but given a decision has been made we urge all interested parties to come together to develop and co-own bovine TB control, including the parts that relate to the wildlife reservoir. We are under no illusions that this will be easy and realise that it will require great leadership from senior figures in the industry and wildlife organisations. We are encouraged by local initiatives where this coming together is occurring. The current focus of so much of the debate around bovine TB control on badger culling, and its politicisation, is distracting and a major impediment to achieving bovine TB eradication.

9.XII Chapter 8 explores the different ways farmers and the veterinarians respond on the farm to bovine TB control measures. There are wonderful examples of individuals and groups coming together with a “disease-control mind-set” to reduce the risk of infection and to eliminate it after a breakdown. Yet there are also examples of farmers that feel disempowered when confronting bovine TB, are fatalistic about outcomes, and have a “regulatory” rather than a disease-control mind-set.

9.XIII We believe that further empowering farmers and vets to take control of the disease on their own farms will be critical for bovine TB eradication and in this Report have made a series of suggestions about how this might be facilitated. A key component of this is helping farmers and their advisors manage their herds to reduce the risk of a breakdown and to rapidly manage out the infection after a breakdown occurs. To do this they need access to all available data, and to be facilitated to get further relevant information about the animals in their herd. We note that the Welsh TB Engagement Task & Finish Group has recently made similar recommendations for greater farmer empowerment and for a closer partnership between farmers, private veterinarians and their official and APHA counterparts[178].

9.XIV There is much information relevant to assessing the disease risk of individual animals that would be of use for disease avoidance and management. This includes the detailed results of statutory tests (not just whether it is a reactor or not) and other tests, the animal’s pedigree, and for a traded animal, the time it has spent on farms with active, recent, or not yet disclosed breakdowns. Some of this data is held by APHA and making sure it is available to farmers and their veterinary advisors in a more usable form than at present is important. We have expressed disappointment at the slow progress made on LITP since 2018 and note that current data systems cannot support all information relevant to

[178] Welsh TB Engagement Task & Finish Group, 2022, https://tinyurl.com/WalesFarmerComms

assessing an individual animal's risk. This reinforces the importance of investing in data infrastructure.

9.XV Farmers can obtain more information by using tests outside the statutory framework. This is a difficult issue as there is the risk of abuse and of undermining regular testing, and from the farmer's perspective, the additional risk of triggering a herd breakdown. In Chapter 3 we explore some specific options for allowing farmers to identify animals in OTF herds that are of high risk of disease, and for better managing out the disease during a herd breakdown. There are some excellent examples of initiatives using data to manage herd risk and infection (see Box for a description of the Pembrokeshire Project[179]) and there are lessons from these for scaling up this approach more widely.

The Pembrokeshire Project (2023-28)

Funded by Welsh Government and delivered by Iechyd Da and Aberystwyth University.

It seeks to take a new approach to tackling bovine TB at a local level through farmers and vets working together. There are three main strands to the approach:

- Using data analysis from existing bovine TB skin test results to identify high risk animals.
- Voluntary culling of high-risk animals.
- Enhanced biosecurity on farms.

At the heart of the project is the production of a herd management plan. Farmers and private vets receive skin test results (including historical test data) and the results are converted into a "Risk Rate' traffic lights system based on an algorithm that takes into account the bovine only interpretation (trade test), severe and super severe interpretations of their skin test data and factors in the change in these parameters over time. Farmers participating in the project agree not to move red rated animals but make management decisions on what to do with red and amber animals using the traffic lights system (a similar approach is used for managing Johne's disease) such as:

- Sending high risk animals to slaughter after lactation,
- Not breeding from high-risk animals.

The farmers and vets are provided with information on badgers found dead within 6 km of the farm and receive advice and training on the science around bovine TB and biosecurity more generally. A weighted risk score for each biosecurity risk is produced using the Herdsafe App which gives a:

- Total Risk Score for the Farm
- Biosecurity Star Rating

The project has a strong social science element with a focus on facilitating farmers and vets to work together thereby empowering farmers and vets to take action reversing the fatalism that was apparent in an area of high levels of infection (of the 13,034 animals slaughtered in Wales in 2024, nearly 40% were in Pembrokeshire).

[179] Iechyd Da (accessed July 2025), https://tinyurl.com/PembsProj

9.XVI The way that different stakeholder and interest groups have come together to provide farmers with information and advice about bovine TB control is impressive. A wealth of valuable information is available on the TB Hub and famers can seek advice from TBAS. Purchasing decisions can be informed through ibTB and farmer's breeding plans through TB Advantage. These resources serve well those farmers who are motivated to seek information. We have seen evidence[180] that the information does not penetrate as far as it might and encourage further marketing and dissemination of the value of these information sources.

9.XVII APHA holds a large amount of information about bovine TB only part of which is available to external users. We read with interest an article[181] by APHA scientists and their colleagues exploring how more non-personal and non-confidential data might be made available through the development of an Application Programming Interface (API) to allow third-party apps (e.g., cattle trading apps) to more readily utilise data. Some development has already started, and we agree that the creation of such an online portal could be valuable for both the farming and research communities. We recognise of course that these initiatives would require funding.

Updates on options for the future: Accelerating to eradication

9.XVIII A 25-year plan to achieve Bovine TB free status for England by 2038 was announced in 2014 with the publication by Defra of "A strategy for achieving Officially Bovine Tuberculosis Free status for England". Next year will see the mid-way point of the plan which remains the Government's goal.

9.XIX There has been significant progress since 2014 with an encouraging drop in herd breakdowns since 2018 (¶2.V). However, we advise that there is only a small chance of meeting this target without a step change in the urgency with which the issue is treated and the resources devoted to eradication. Although many people and groups working on bovine TB show enormous dedication and energy, this is not universal and the mindset of managing rather than defeating the disease persists along with, in some quarters, scepticism about the strategy's eventual success. Often the focus is too much on operational performance indicators (for example metrics around testing) rather than outcomes involving levels of the disease.

9.XX Accelerating efforts to control the disease requires multiple actions across all aspects of bovine TB policy, including many beyond the remit of this Report Update. We make no pretence at having a fully-worked solution but in the remainder of this section highlight different areas that we believe need attention to achieve the 2038 goal.

---

[180] Hamilton *et al.,* 2019, https://doi.org/10.1136/vr.104995

[181] Mitchell *et al.,* 2023, https://doi.org/10.20506/rst.42.3350

9.XXI The recent NAO Report *Resilience to animal disease*[182] highlights the pressures that APHA are under at a time when Government budgets are severely constrained and the country is facing new livestock disease threats such as Highly Pathogenic Avian Influenza and bluetongue Virus. These acute threats divert resources and management attention away from endemic diseases. The situation is made worse by APHA's current difficulties in recruiting veterinarians (~20% of posts are unfilled). The NAO wrote "We have observed that many of Defra and APHA's animal disease activities are reactive rather than part of a proactive, coherent plan". This view is shared by many bovine TB stakeholders outside Government.

9.XXII To achieve the 2038 target will require greater resources to be devoted to bovine TB than at present, either from Government or the industry. In a broader context the NAO wrote "Defra has struggled to quantify and monetise the benefits from investment to strengthen resilience to animal diseases" and we believe this comment applies more narrowly to bovine TB where eradicating the disease would result in substantial economic savings for both Government and industry. Balancing short-term expenditure against medium to long-term gains that are uncertain and not easily quantified is difficult, but such an exercise would ground ambitious targets in economic reality and make clear the immediate resourcing challenges.

9.XXIII In addition to Defra/APHA, local authorities play a critical role in compliance with Bovine TB regulation and enforcement of disease control mechanisms (for example concerning biosecurity measures, cattle movement restrictions, and testing requirements). However, these and other animal disease responsibilities are competing with other statutory duties and priorities at a time of very tight budgets. Achieving the 2038 target will require local authorities to appropriately prioritise bovine TB, and to have the resources to allow them to carry out their duties.

9.XXIV Defra is the lead Government Department in delivering eradication working with multiple stakeholders through the Bovine TB Partnership and other bodies. It has a critical leadership role in setting the pace and urgency with which eradication is pursued. The last seven years has seen huge pressures on the Department due to the pandemic and Brexit, as well as the incursions of the new livestock diseases described above. It is understandable and should not be seen as a criticism of the many dedicated civil servants in Defra if bovine TB control does not get the management attention we believe is required to accelerate progress to eradication. Government might consider how this could be addressed, possibly by making leadership of the eradication strategy a more visible and public-facing role. A person taking on this role would own the Government's contribution to eradication, working closely with the Partnership and all interested parties.

9.XXV In other parts of the Update we discuss how testing and cattle vaccination will play a critical role in achieving eradication. Advancing improved testing and rolling out vaccination will entail a larger programme of on-farm activities than

[182] NAO, 2025, https://www.nao.org.uk/reports/resilience-to-animal-diseases/

has ever been attempted before. This needs to be supported by well-designed IT infrastructure. We discuss in ¶¶5.XVII-5.XIX our disappointment at the slow progress that has been made on the LITP since 2018. We appreciate that this issue is understood by Defra/APHA but stress our view that this must be addressed rapidly for 2038 to remain achievable.

9.XXVI Upscaling testing and vaccination (of cattle and badgers) requires an expanded, trained workforce. We are encouraged by the roll out of the scheme to use approved tuberculin testers (ATTs) in the delivery of official TB tests in cattle in England and Wales and encourage greater use of them. For ATTs, there is experiential training in veterinary practices and more specific teaching and assessment/certification by APHA. While recognising the regulatory and certification issues around their use (involving both the RCVS, as they are licenced to conduct specific acts of veterinary surgery, and Defra), we see no reason why cattle vaccination and testing cannot be delivered by such a competent and high-quality team in a cost effective and scalable manner. Badger vaccination training is now available[183] though its provision would need to be markedly increased if badger vaccination was to be scaled up.

9.XXVII Introducing a new cattle vaccine (plus a DIVA) rightly requires a series of regulatory hurdles to be crossed to assure that both animal health and welfare and human health is not compromised (¶4.XXIII). This process, chiefly overseen by the VMD, can take a long time and we point to the pandemic as an example of the acceleration of regulatory approval (for vaccines and other interventions) without compromising safety. The same urgency will be needed to meet the 2038 eradication goal.

9.XXVIII Testing and vaccination at scale requires the production of specific products (such as tuberculin, BCG and DST-F) by the private sector. This is a small and specialist market with relatively few players, some not in the UK. There is a risk of one company dominating the market with consequences for prices, as well as a risk of a single-point failure were a critical company to collapse or exit the market. We believe it is important to anticipate these issues (which we know are appreciated by Defra/APHA) and to stress-test the supply chain of the products that will be essential for successful eradication.

9.XXIX In our 2018 Report we said we were concerned at the frequency of time-consuming consultations and how they slowed the introduction of new interventions, while acknowledging their role in ensuring stakeholder buy-in. We suggested consulting about batches of proposed and possible interventions. Government responded positively to this suggestion and pointed to its code of practice for consultation. Given the relatively little time remaining to achieve the 2038 eradication goal we believe it important to optimise consultation to achieve valuable input and buy-in with the least possible delays. The Bovine TB Partnership has an important role to play here in coordinating input.

9.XXX Scientific research underpins the bovine TB eradication strategy and it is important to publish all details of any research as soon as possible. Where the

---

[183] Defra *et al.* (accessed July 2025), https://www.gov.uk/guidance/bovine-tb-badger-vaccination-training

work involves statistical analysis, this should include sufficient detail of the data and the analysis programs to allow reproducibility of results. The traditional process is that research is conducted, analysed, written-up and then submitted for peer-reviewed publication. This can be a lengthy process, the time needed for peer review alone often being a year or more, with papers often submitted to more than one journal before eventual acceptance. In addition, the principle of providing full and sufficient information for all analyses to be reproducible is not yet ubiquitous. Several times in preparing this update we were frustrated by studies not yet being available because they were undergoing peer-review.

9.XXXI We would encourage prompt publication (or, in the case of work intended for peer-review journal consideration, pre-publication) on archives such as BioRxiv to allow work to be scrutinized in detail. This should be routine for all Defra science. We note that journals such as *Nature* explicitly support the posting of preprints and state that "unrefereed web preprints do not compromise novelty". Making data freely available, faster, to allow alternative analyses can only be helpful. As Government funds the majority of bovine TB research we suggest it considers mandating the rapid and detailed dissemination of any research that it funds in this area, and we make the same recommendation to other funders.

9.XXXII If we are to meet the 2038 eradication target, then novel interventions need to be implemented without delay and their success monitored and fed back to allow a process of adaptive management. This implies a need for the better co-ordination of research and implementation within government organisations, and for the integration of contributions from the broader research community. We note that this appears to work particularly well in the Republic of Ireland. Incentivising data sharing and research cooperation, and avoiding research protectiveness and silos, is important to ensure science makes the fullest contribution to bovine TB eradication.

Annex 1: Acronyms and Definitions

95% CI - 95% Confidence Interval
AFU – Approved Finishing Unit used to channel cattle from bovine TB restricted herds to slaughter
AHVLA - Animal Health and Veterinary Laboratories Agency, an executive agency of Defra
AHWBE – Animal Health and Welfare Board for England
APHA – Animal and Plant Health Agency
ARAMS - Animal Movement and Reporting Service
AHDB - Agriculture & Horticulture Development Board
AIM - Animal Identification and Movement database (Republic of Ireland)
BCG – Bacillius Calmette- Guérin, which is used to manufacture tuberculosis vaccines
Biosecurity – Security from transmission of infectious diseases
Bovine Tuberculosis – An infectious disease in cattle caused by *Mycobacterium bovis (M. bovis)*
Breakdown – Detection of exposure to *M. bovis* infection in a herd (e.g detection of a bovine TB reactor or signs of possible bovine TB at post mortem). This is followed by breakdown control procedures; the duration of a breakdown depends on the successfulness of the breakdown measures to clear the infection from the herd
BVA – British Veterinary Association
BCVA – British Cattle Veterinary Association
BEVS - Badger Edge Vaccination Scheme
BPS – Basic Payment Scheme (administered by Rural Payments Agency)
CAP – Common Agricultural Policy
CFT test - Caudal Fold Tuberculin Test
CVO – Chief Veterinary Officer
CTS – Cattle Trading System
CPH - Country-Parish-Herd
CHeCS - Cattle Health Certification Standards
DA – Devolved Administration (Wales, Scotland. Northern Ireland)
Defra – Department of Environment, Food and Rural Affairs
DIVA – A test used to **d**ifferentiate **i**nfected from **v**accinated **a**nimals
DP – Regional Veterinary Delivery Partner
EA – see Edge Area
Edge Area – The edge of the HRA where the disease is not yet considered to be endemic and disease prevalence is lower than in the HRA but there is a great likelihood of further geographical spread of bovine TB out of the HRA.
Endemic disease – A disease which is continuously present in a specific population
Epidemiology – A study of the distribution and dynamics disease in a population
EU – European Union

FSA – Food Standards Agency
FYM – Farm Yard Manure
GB – Great Britain, comprising England, Wales and Scotland
Genotype – a genetically distinct strain of a specimen or species
Herd Prevalence – This statistic can be expressed in different ways but depicts the proportion of herds that are affected by a disease/condition in a specific population
High Risk Area for bovine TB – An area defined geographically in which cattle herds have a greater likelihood of experiencing a bovine TB breakdown. It includes geographical areas in which there is a relatively high herd prevalence of bovine TB
Home range – the specific geographic area where a specific animal or pathogen (for example, a genotype of *M. bovis*) is typically detected
Host – animals which can routinely become infected with a pathogen (for example, *M. bovis*) if exposed
HRA - see High Risk Area
IAA – Intensive Action Area (South West Wales)
ibTB – Interactive map showing the locations of bovine TB breakdowns
Incidence – This statistic reflects the number of cases of infection or disease in a population as a rate per time unit.
Inconclusive reactor – an animal which gives an inconclusive reaction to the tuberculin skin test as defined in Council Directive 64/432/EEC
Index infection (or case) – the first infection (or case) in a herd or area
Interferon Gamma Assay – a rapid (24-hour) whole blood in-vitro assay to detect immune response to *M. bovis* infection for the diagnosis of bovine TB
IFNγ - Interferon Gamma test
IR – see Inconclusive reactor
Lesions – Characteristic tubercles or larger abscess-like structures typically found in lymph nodes and organs such as the lungs, liver and spleen.
LIS – Livestock Information Service
Low Risk Area – an area defined geographically in which cattle herds have a lower likelihood of experiencing a bovine TB breakdown. It includes geographic areas with very low herd prevalence of bovine TB and where the disease is not believed to be maintained by badgers and is primarily caused by cattle movements
LRA – see Low Risk Area
Mycobacteria – a family of bacteria which includes *Mycobacterium bovis*
Mycobacterium bovis (M. bovis) – one of the bacteria which causes tuberculosis in cattle. It can also infect other mammals including humans and wildlife.
Mycobacterium tuberculosis (M. tuberculosis) – one of the bacteria which causes tuberculosis in humans
Natural England – an executive non-departmental public body responsible to Defra, which administers applications for licences under the Badger Protection Act 1992

NPV - Negative predictive value, the proportion of negative diagnostic test results that are true negative results.

OIE – World Organisation for Animal Health

OTF – "Officially Bovine Tuberculosis Free" as defined in Council Directive 64/432/EEC. OTF status may apply to herds, regions or Member States

OTF-S – Officially Bovine Tuberculosis Free status of herd suspended as defined in Council Directive 64/432/EEC. This status is used when one or more skin test reactors or interferon gamma positive animals are detected in a herd, but no lesions typical of TB are found at post mortem inspection, and the culture results are negative for the bovine TB bacterium (*M. bovis*). See also OTF-W.

OTF-S 2 – a small subset of OTF-S herds considered at greater epidemiological risk

OTF-W – Officially Bovine Tuberculosis Free status of herd withdrawn as defined in Council Directive 64/432/EEC. This status is used for those cattle and herds where any of the following apply:

- One or more skin test reactors or interferon gamma positive animals are detected with typical lesions of TB at postmortem inspection
- There is a positive culture result for *M. bovis* during a TB breakdown
- The herd has one or more slaughterhouse cases of TB with a PCR test or culture result positive for *M. bovis*

See also OTF-S

OV – Official Veterinarian, a private veterinarian permitted to undertake official controls such as tuberculin skin testing

PCR – see Polymerase Chain Reaction

Perturbation – disruption of badger social organisation or structure which causes badgers to range more widely than they would normally and come in contact more often with other animals (including both cattle and other badgers).

Polymerase Chain Reaction – technology to amplify a single of a few copies of a piece of DNA in order to allow easier detection of a particular pathogen by its DNA

Post Movement Test – a tuberculin skin test applied to an animal after it has moved between premises

PPD-B - Purified Protein Derivative, extract of *Mycobacterium bovis*; tuberculin.

PPV - Positive Predictive Value, the proportion of positive diagnostic test results that are true positive results.

Pre Movement Test – a tuberculin skin test applied to an animal before it has moved between premises

Prevalence – see Herd Prevalence

R&D – Research and Development

RBCT – Randomised Badger Culling Trial, a scientific study carried about from 1998 – 2005 to quantify the impact of two forms of culling badgers on TB incidence in cattle

RPA – Rural Payments Agency

Reactor –an animal which gives a positive reaction to the tuberculin skin test as defined in Council Directive 64/432/EEC

Reservoir Host Population – A population in which the pathogen is endemic and from which infection is transmitted to a particular target population.

Routine herd testing – the programme of routine surveillance testing of breeding cattle in herds using the tuberculin skin test in line with Council Directive 64/432/EEC. Routine herd testing is applied to four-yearly tested herds

SAC – South American Camelids, for example alpacas and llamas

Sensitivity (of a test) – the percentage of true positives (a test with 95% sensitivity will correctly identify infected individuals as positive 95% of the time). See also specificity.

Severe Interpretation – a more rigorous interpretation of the tuberculin skin test (than the "standard interpretation") in line with Council Directive 64/432/EEC.

Short Interval test – the intensive testing of all cattle in breakdown herds using the tuberculin skin test in line with Council Directive 64/432/EEC

Specificity (of a test) – the percentage of true negatives (a test with 95% specificity will correctly identify uninfected individuals as negative 95% of the time). See also sensitivity.

Standard Interpretation – the routine interpretation of the tuberculin skin test in line with the Council Directive 64/432/EEC

SICT – single intradermal cervical test. See tuberculin skin test

SICCT – single intradermal comparative cervical test. See tuberculin skin test

Spillover Host Population – A population which can become infected with the pathogen but from which the infection is not transmitted to a particular target population.

Surveillance – the collection of health data to detect disease in a population by using diagnostic or clinical methods. For bovine TB in England, formal surveillance is carried out with frequent, whole or routine herd testing, by pre-movement testing of all cattle of 42 days of age, leaving premises in the HRA and by inspecting all cattle carcases slaughtered commercially for post mortem signs of bovine TB

TB – Tuberculosis

TBAS – Tuberculosis Advisory Service

TBEAG – Bovine Tuberculosis Eradication Advisory Group for England, a sub-group of AHWBE

Test Interval – the period of time between routine or whole-herd tuberculin tests

Therapeutics – pharmaceutical agents (drugs) licensed for use in treating human or animal diseases

TLA – Temporary Land Association

Tuberculin – mycobacterial proteins used in tests to detect bovine tuberculosis

Tuberculin skin test – A diagnostic test measuring an animal's reaction to injection(s) of tuberculin carried out in line with Council Directive 64/432/EEC.

UK – United Kingdom, comprising Great Britain and Northern Ireland

VMD – Veterinary Medicines Directorate, an agency of Defra

Whole herd testing – the testing of all cattle in herds using the tuberculin skin test in line with Council Directive 64/432/EEC. Whole herd testing is applied routinely to annually tested herds and to breakdown herds

WGS – Whole genome sequencing (of the *Mycobacterium*)

Annex 2 – Register of interests

This register records declarations of interests relevant to the remit of the bovine TB Strategy Review.

Professor Sir Charles Godfray CBE FRS (Chair)

- Director of the Oxford Martin School, University of Oxford (current employer)
- Fellow & Trustee, Balliol College Oxford
- Trustee, Lawes Trust
- Trustee Director, UK Centre for Ecology & Hydrology
- Member, Advisory Board, Collegium Helveticum, Zurich
- Member, Boards of Directors, International Consortium for the Barcode of Life (iBOL) & Centre for Biodiversity Genomics, Guelph, Canada
- Chair, UKRI Land-use for Net Zero (LUNZ) Programme Executive Board
- Member, Science & Technology Advisory Council, Nestlé S.A.
- Climate & Sustainability Advisor, Compass UK&I PLC
- Research in group currently funded by National Environment Research Council (NERC), the Foundations of the National Institute of Health (USA), Bill & Melinda Gates Foundation, and the Open Philanthropy Foundation
- Current and recent committee service for Royal Society, Food Standards Agency, NERC, BBSRC, UKRI, Soil Association, Co-Centre for Sustainable Food Systems.

Professor Glyn Hewinson CBE FLSW

- Sêr Cymru Chair and Head of the Sêr Cymru Centre of Excellence for Bovine Tuberculosis, Aberystwyth University (current employer)
- Chair of the Bovine TB Technical Advisory Group for Wales
- Member of the Bovine TB Eradication Programme Board for Wales
- Member of the APHA Science Advisory Board
- *Ad hoc* advisor to World Organisation for Animal Health (WOAH)
- Member of Defra's bTB Microbiology & Immunology Research Advisory Panel (MIRAP)
- Academic lead for the Welsh Government funded Pembrokeshire Project and the North Wales Bovine TB Project
- Research in group currently funded by Welsh Government and UKRI.

Professor Sir Bernard Silverman FRS

- Chief Scientific Adviser, Home Office, 2010-17 (last full-time employer); role included oversight of the Animals in Science Committee and advice to the Minister responsible for licensing animal experiments
- Emeritus Professor of Statistics, Universities of Oxford and Bristol
- Chair of Methodological Assurance Review Panel, Office for National Statistics
- Advisory Board member, Parliamentary Office for Science and Technology
- Trustee, UK-China Transparency

- Council Member, Economic and Social Research Council, 2020-25
- Chair, Geospatial Commission, 2021-24; Technology Advisory Panel, Investigatory Powers Commission, 2018-22.

Professor Michael Winter OBE

- University of Exeter (current employer)
- Board member, Natural England (2016-23)
- Board member, Rothamsted Research (2015-2024)
- Board member, UK Joint Nature Conservation Committee (2018-23)
- Member, Natural England Science Advisory Committee (2016-July 25)
- Chair, Devon Local Nature Partnership
- Current or recent research (last 5 years) funded by Defra, ESRC , Devon County Council.

Professor James Wood OBE

- University of Cambridge (current employer)
- Wolfson College, Cambridge, Fellow & Council Member / Trustee
- Chair, National sub-panel 6, REF 2029
- Honorary Research Associate, Zoological Society of London
- Vice Chair, Royal College of Veterinary Surgeons Fellowship Board
- Director and charity trustee, British Equine Veterinary Association Ltd
- Director, Equine Veterinary Journal Ltd
- Charity trustee (chair), Survival International
- Fleming Fund Technical Advisory Group Member
- EUFMD Standing Technical Committee Member
- Member, Defra Bovine TB Partnership and Strategy Refresh Group
- Research currently (or recently) funded by Alborada Trust, Wellcome Trust, BBSRC, NERC (CINUK Programme), Zoonoses and Emerging Livestock Systems (NERC, BBSRC, ESRC, DfID, MRC), UKRI, European Food Safety Agency (registered expert), Defra – directly and through BBSRC.

Annex 3 Request to Update Report

Department
for Environment
Food & Rural Affairs

Daniel Zeichner MP
Minister of State

Seacole Building
2 Marsham Street
London
SW1P 4DF

T: +44 (0) 3459 335577
E: correspondence.section@defra.gov.uk
W: gov.uk/defra

19 December 2024

Dear Professor Sir Charles Godfray,

Review of bTB eradication strategy

As you are no doubt aware, on 30 August 2024 the Government announced plans to carry out a comprehensive refresh of the strategy to achieve officially tuberculosis free status for cattle in England.

For the first time in over a decade, the Government will work with farmers, vets, scientists and conservationists to co-design a new bovine tuberculosis (bTB) eradication strategy, marking a significant step-change in our approach to tackle this devastating disease. We will use a data-led and scientific approach to accelerate progress towards the goal of achieving officially TB free status in cattle herds by 2038. The Government has also signalled its intention to end the culling of badgers for bTB control purposes by the end of this parliament.

The Government is committed to ensuring that the refreshed strategy considers all available scientific evidence. I would be very grateful if you, with the support of the 2018 review panel, would be able to highlight any substantial updates to the evidence base or studies that may have emerged since the publication of the independent review of the bTB strategy for England that you led in 2018[1].. In particular, since the Strategy Review of 2018, have any relevant information or scientific studies come to light or been published in the field of bTB which change or expand on any of the 2018 review conclusions? If so, in which way does the new evidence alter those conclusions?

The co-design Steering Group will begin work to design the refreshed bTB strategy in January next year, with co-design Working Groups developing recommendations from early spring to late autumn. Your advice within the early stages of this period will be helpful in ensuring the refreshed strategy is informed by all available scientific evidence. Your brief reactions to my request ahead of those early scoping and planning meetings would be most useful.

Yours sincerely,

DANIEL ZEICHNER MP

[1] A strategy for achieving Bovine Tuberculosis Free Status for England: 2018 review. https://assets.publishing.service.gov.uk/media/5beed433e5274a2af111f622/tb-review-final-report-corrected.pdf

Annex 4 - A binomial analysis of the RBCT data

The results of the 1998−2005 Randomised Badger Culling Trial (RBCT) have been analysed in a number of ways right up to the present. The original analysis was carried out by Donnelly et al. (2006)[184]. This note concentrates on the data of confirmed incidents in whole trial areas since the initial proactive cull, based on VETNET location data, available in the supplementary material of Donnelly et al. (2006) and given in the table.

Triplet	Treat-ment	Incidence	Herds	Historic	Treat-ment	Incidence	Herds	Historic
A	Control	52	86	32	Culled	37	71	33
B	Control	61	132	27	Culled	87	152	42
C	Control	84	174	27	Culled	29	105	15
D	Control	40	106	30	Culled	36	97	28
E	Control	56	97	28	Culled	36	116	26
F	Control	61	191	35	Culled	15	138	12
G	Control	40	131	16	Culled	72	245	26
H	Control	27	130	22	Culled	31	63	23
I	Control	21	98	19	Culled	27	100	29
J	Control	36	123	18	Culled	34	114	25

Donnelly et al. (2006) fitted a Poisson log-linear regression model, depending on triplet, the log of baseline herd numbers, and the log of the number of confirmed breakdowns over a three-year period before RBCT culling. Within this regression, culling had a statistically highly significant effect in reducing incidence ($p = 0.005$).

The analysis was disputed by Torgerson et al. (2024)[185], henceforth [T]. Denote by θ_B the coefficient of the log of baseline herd numbers in the model. The estimated value of θ_B in the model fitted by [D] is 0.05 with a standard error of 0.25. [T] argue on biological grounds that this model is implausible, and that θ_B should be fixed at 1, by coding the log baseline as an offset variable. This would correspond to assuming that, all other things being equal, the number of herd breakdowns in a region would be proportional to the number of herds. It would focus attention on incidence rates rather than absolute incidence numbers. If this is done, and a quasi-Poisson model fitted to allow for overdispersion, the treatment effect is no longer significantly different from zero. [T] also fit several groups of models and within each group define the most parsimonious model as the one with lowest AICc. In each case the most parsimonious model does not include the treatment effect.

A more natural approach to incidence rates is to consider the number of breakdowns in each region to have a binomial distribution where the number of "trials" is the baseline

[184] Donnelly *et al.,* 2006, https://doi.org/10.1038/nature04454
[185] Torgerson *et al.,* 2024, https://doi.org/10.1038/s41598-024-67160-0

number of herds, and a "success" is a herd having a confirmed breakdown. The standard approach is then to model the log odds of "success" as the response variable.

The standard R function `glm` was used to fit various binomial models; see the R scripts below. The explanatory variables considered were the triplet effect and the log odds of historical breakdowns, as well as the treatment effect itself (proactive culling vs control). When calculating the log odds of historical breakdowns, the number of herds was taken to be fixed over the historical three-year period to be its "baseline" value; the actual number in each year is not known but this seems a reasonable approximation.

The parameter for the historical breakdowns can either be fitted from the data or can be constrained to be equal to 1, and the treatment effect can either be omitted or included; this gives four combinations. Using [T]'s AICc definition of parsimony, the most parsimonious model was the one which fixed the parameter and, in contrast to [T]'s groups of models, *included* the treatment effect. Fixing the parameter is intuitive because it means one is modelling the log odds ratio between the observed breakdown rate and the historical breakdown rate.

The point estimate of the treatment effect on the log odds of breakdown is then −0.29. This would mean that culling multiplies the odds of infection by exp(−0.29) = 0.75. How that translates into a reduction in infection rates depends on the initial infection probability. The proportion of breakdowns in control herds in the RBCT is 0.377, breakdown odds of 0.605. Multiplying these odds by 0.75 would yield a breakdown probability of 0.311, a percentage reduction of about 17.5%. This compares with the point estimate of 18.7% from the 2006 analysis and [T]'s figure of 13.5%.

The significance of the effect depends on the consideration of possible overdispersion. With no overdispersion correction, then the conclusion that culling reduces incidence is highly significant (p = 0.001). The fitted model has a residual deviance of 17.6 on 9 degrees of freedom. This is within the central 95% of the χ^2_9 distribution though at the "overdispersed" end. The confidence intervals are (−0.47, −0.12) for the log odds parameter, leading by the same calculation as above to (7.4%, 27.2%) for the percentage reduction.

However, to accept the binomial model without correcting for overdispersion is counter-intuitive biologically because it would suggest no dependence between herds. One of [T]'s concerns about the 2006 model was that it was underdispersed, so we can take some comfort from the slight overdispersion displayed by the binomial model.

The simplest way of accounting for overdispersion is to fit a quasi-binomial model, analogous to the quasi-Poisson model fitted by [T]. If this is done, then the treatment effect is significant at the standard 5% level. The estimate of the treatment effect log odds parameter is −0.29 with 95% confidence interval (−0.53, −0.05). With a baseline proportion of 0.377 as above, this gives an estimate of 17.5% for the reduction in herd breakdowns, with a confidence interval of (3.1%, 30.3%). As an aside, these conclusions are only marginally affected if the parameter for historical breakdowns is estimated rather than fixed; in that case the coefficient for the historical log odds is not significantly different from 1, and the significance and the confidence interval for the treatment effect are very similar to the model with historical log odds as an offset.

In conclusion, Torgerson et al. (2024) make a strong argument for focusing on incidence rates, but they fit a quasi-Poisson with the log of herd numbers as an offset, rather than following through to the more logical conclusion of using a quasi-binomial. Under a quasi-binomial model, culling has a significant effect on herd breakdowns in the RBCT data, but only at the 5% level, rather than the much higher level of significance obtained in the original analysis.

Peer Review

This note was independently peer reviewed by Professors Peter Diggle (Lancaster University) and Nigel French (Massey University).

R scripts

```
library(AICcmodavg, glmmTMB)
RBCT = read.csv("RBCT.csv", stringsAsFactors = T)
RBCT$Triplet = relevel(RBCT$Triplet, ref="J")

#   set up for fitting of binomial model
Incidence.bin = cbind(RBCT$Incidence, RBCT$Herds-RBCT$Incidence)
Historic.logodds = log(RBCT$Historic/(RBCT$Herds-RBCT$Historic))

# fit models including and not including Treatment, and treating
#  Historic.logodds as either an offset variable or not.
model1 = glm(Incidence.bin~ Treatment + Triplet + Historic.logodds,
      family=binomial, data=RBCT)
model2 = glm(Incidence.bin~ Triplet + Historic.logodds, family=binomial,
      data=RBCT)
model3 = glm(Incidence.bin~ Treatment + Triplet, offset=Historic.logodds,
      family=binomial, data=RBCT)
model4 = glm(Incidence.bin~ Triplet, offset=Historic.logodds,
      family=binomial, data=RBCT)

#    demonstration that model3 has lowest AICc
unlist(lapply(list(model1, model2, model3, model4), AICc))

##      [1] 151.7044 161.4883 151.5346 159.3868

summary(model3)

##   glm(formula = Incidence.bin ~ Treatment + Triplet, family = binomial,
##       data = RBCT, offset = Historic.logodds)
##
##  Coefficients:
##                  Estimate Std. Error z value Pr(>|z|)
##  (Intercept)      0.79480    0.14932   5.323 1.02e-07 ***
##  TreatmentCulled -0.29175    0.08871  -3.289 0.001007 **
##  TripletA        -0.04318    0.21516  -0.201 0.840938
##  TripletB         0.59250    0.18559   3.193 0.001410 **
##  TripletC         0.65793    0.18836   3.493 0.000478 ***
##  TripletD        -0.25472    0.20359  -1.251 0.210871
##  TripletE         0.17070    0.19982   0.854 0.392943
##  TripletF        -0.10789    0.19670  -0.549 0.583339
##  TripletG         0.60452    0.18237   3.315 0.000917 ***
```

```
## TripletH        -0.31503    0.21393  -1.473 0.140862
## TripletI        -0.63301    0.21885  -2.892 0.003823 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 119.367  on 19  degrees of freedom
## Residual deviance:  17.593  on  9  degrees of freedom
## AIC: 140.58

round(confint(model3, "TreatmentCulled"),2)
##   2.5 % 97.5 %
## -0.47  -0.12
#
# switch to quasibinomial to allow for overdispersion
#
model5 = glm(Incidence.bin~ Treatment + Triplet, offset=Historic.logodds,
      family=quasibinomial, data=RBCT)
summary(model5)

## glm(formula = Incidence.bin ~ Treatment + Triplet,
##     family = quasibinomial, data = RBCT, offset = Historic.logodds)
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.79480    0.20779   3.825  0.00406 **
## TreatmentCulled -0.29175    0.12345  -2.363  0.04237 *
## TripletA        -0.04318    0.29940  -0.144  0.88850
## TripletB         0.59250    0.25826   2.294  0.04745 *
## TripletC         0.65793    0.26211   2.510  0.03331 *
## TripletD        -0.25472    0.28330  -0.899  0.39201
## TripletE         0.17070    0.27805   0.614  0.55447
## TripletF        -0.10789    0.27372  -0.394  0.70263
## TripletG         0.60452    0.25377   2.382  0.04109 *
## TripletH        -0.31503    0.29769  -1.058  0.31752
## TripletI        -0.63301    0.30455  -2.079  0.06742 .
## ---
## (Dispersion parameter for quasibinomial family taken to be 1.936396)
##
##     Null deviance: 119.367  on 19  degrees of freedom
## Residual deviance:  17.593  on  9  degrees of freedom
##
round(confint(model5, "TreatmentCulled"),2)
##     2.5%  97.5%
##    -0.53  -0.05
```