Chief Veterinary Officer

Review of Bovine Tuberculosis in Northern Ireland

November 2024

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CVO statement

Following appointment as Chief Veterinary Officer (CVO) for Northern Ireland (NI) in April 2024, the Minister of Agriculture, Environment and Rural Affairs, Andrew Muir, MLA, tasked me with undertaking an overarching review of our approach to the control and eradication of bovine tuberculosis (bTB).

In advancing the review, I have met with a large and diverse range of colleagues, stakeholders and experts in the field of bTB. I am greatly appreciative of the time given by those groups and organisations to share their knowledge and views on one of the most enduring challenges facing our cattle farming industry.

Engaging with a wide range of those with an interest in, or affected by, bTB, I have assessed what potential additional steps are needed within our own bTB Programme if we are to finally set NI on the path to disease freedom. This includes close assessment of the experience and science available from other jurisdictions tackling the same or similar problems pertaining to bTB control.

This review also takes account of progress towards the actions contained within the 2022 Bovine TB Eradication Strategy for NI; acknowledges the challenges of delivering our bTB Programme within an extremely constrained resource environment, both financial and in terms of veterinary capacity; and examines the need to ensure our Programme fully meets our statutory obligations under both domestic and European legislation (namely the EU Animal Health Law).

This document is the outcome of that process.

To understand what the key challenges are to bTB eradication it has first been necessary to provide the NI context. This includes information on the history of, and most recent rises in, bTB spread here. In addition, detail on the particular make-up of our industry here and an analysis of those herds most impacted by bTB breakdowns.

Section One provides this introduction and also outlines why it is vitally important that a bTB Programme is in place - not just for the obvious public and animal health benefits - but to protect our internationally renowned export dependent trade in cattle and cattle products.

In Section Two I proceed to outline what I consider to be the key tasks and structural challenges to be addressed in order to effectively tackle bTB in NI.

Lastly, Section Three provides my assessment of what possible options may be implemented to address these identified barriers to progressing an effective bTB Programme.

I have grouped these proposals under a number of priority thematic headings, all requiring significant resource and commitment from both government and industry. These include actions aimed at changing culture; protecting uninfected herds from disease; detecting and removing infection effectively and efficiently; reducing transmission to other herds and wildlife; development of a wildlife intervention strategy; changes to compensation; proposals for further research and a new approach to regionalisation.

It must be made clear, however, that this document reflects a review undertaken by me as the CVO for NI. It does not reflect any final decision from the Minister at this juncture. A number of the elements, if advanced, will be subject to further policy development, financial and legislative assessment, and ultimate consideration by the Minister in the time ahead.

Engagement process

Over the course of the summer and autumn months, I met with a wide range of internal and external stakeholders to discuss matters relating to the control of bTB.

The purpose of this engagement was to seek views on how we set NI on a new bTB trajectory, to understand the wide-ranging policy positions of key stakeholders and hear first-hand their experiences and opinions. I am particularly grateful for the time given by external organisations and colleagues in AFBI, DAFM and Defra to share their knowledge and views.

It is clear that there remains a lot of goodwill and support towards taking new, and urgent, steps towards improving the disease picture in NI despite the frustrations that were frequently expressed throughout the engagement process.

Summary of Engagement undertaken:

- Former members of the TB Eradication Partnership
- Veterinary representatives- AVSPNI, NIVA, BVA
- Environmental stakeholders
    - USPCA, NI Badger Group
    - Ulster Wildlife
- Farming representatives
    - Ulster Farmers' Union
    - Northern Ireland Agricultural Producers' Association
    - Farmers for Action
- DAERA
- Agri-Food and Biosciences Institute
- Animal Health and Welfare NI
- Dairy Council
- Officials in neighbouring jurisdictions

SECTION ONE: Introduction

This section provides some historical context to the issue of bTB in NI including information on the bTB Eradication Strategy, the NI bTB Programme and our recent rises in disease incidence and associated government spend. It highlights why control of the disease is important and outlines some of the structural challenges we face in tackling bTB.

Northern Ireland Context

Bovine tuberculosis (bTB), caused mainly by *Mycobacterium bovis (M. bovis)*, is a complex and challenging zoonotic disease of cattle, endemic in many countries across the globe. Whilst primarily a disease of cattle, it also infects a broad range of farm and wild animals, further complicating attempts to control and eradicate the infection.

A national programme to eradicate bTB has been in place in NI since the late 1950s. In recent years there has been a significant deterioration in the bTB situation with substantial increases in both animal and herd incidence.

As of 31 October 2024, animal and herd incidence rate was 1.158% and 10.41% respectively, with significant increases having been seen over the past 5 years in particular. Herd incidence rates refer to the proportion of new reactor herds in NI disclosed with bTB infection over the past 12 months, with animal incidence rates indicating the proportion of reactor animals slaughtered under bTB control measures over this period. **Figure 1** below illustrates the annual animal and herd incidence since 1995.

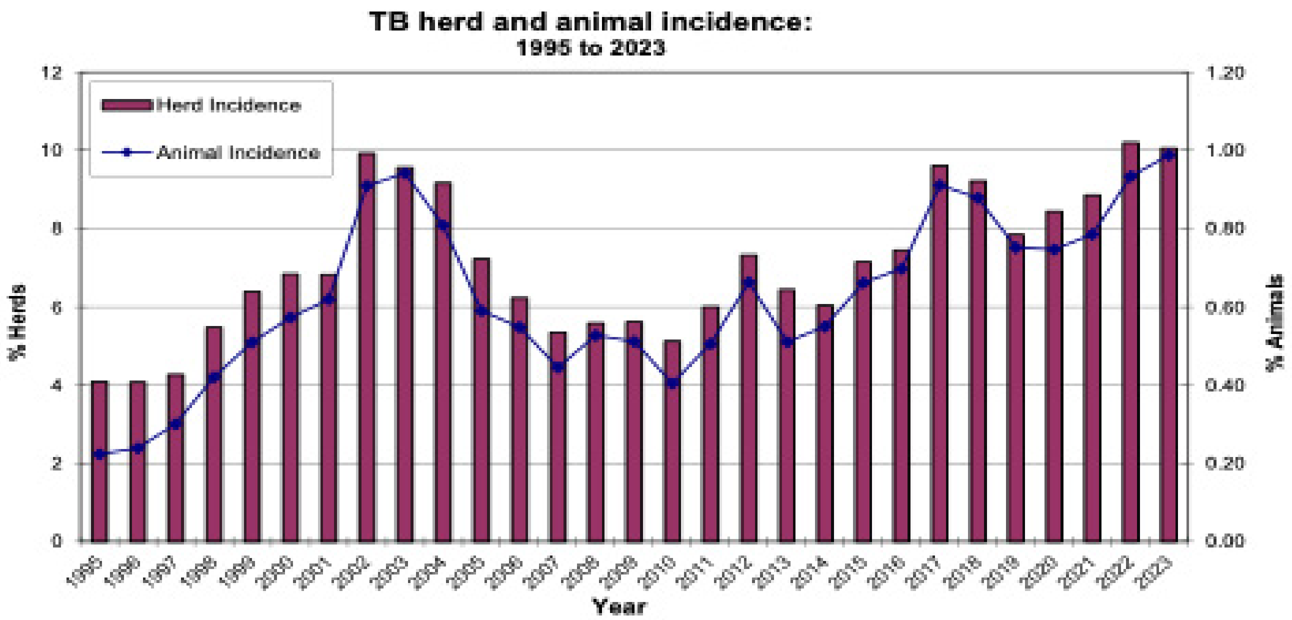

***Figure 1:** Annual herd and animal bTB incidence in Northern Ireland, 1995-2023.*

In the 12-month period to the end of October 2024, 20,619 skin test reactor animals were compulsorily slaughtered as part of the NI bTB eradication scheme. **Figure 2** below shows the annual total numbers of bTB animals slaughtered (incorporating skin test reactors, gamma-interferon reactors, negative in contacts, herd depopulations) as part of the NI bTB eradication scheme over the last nine years.

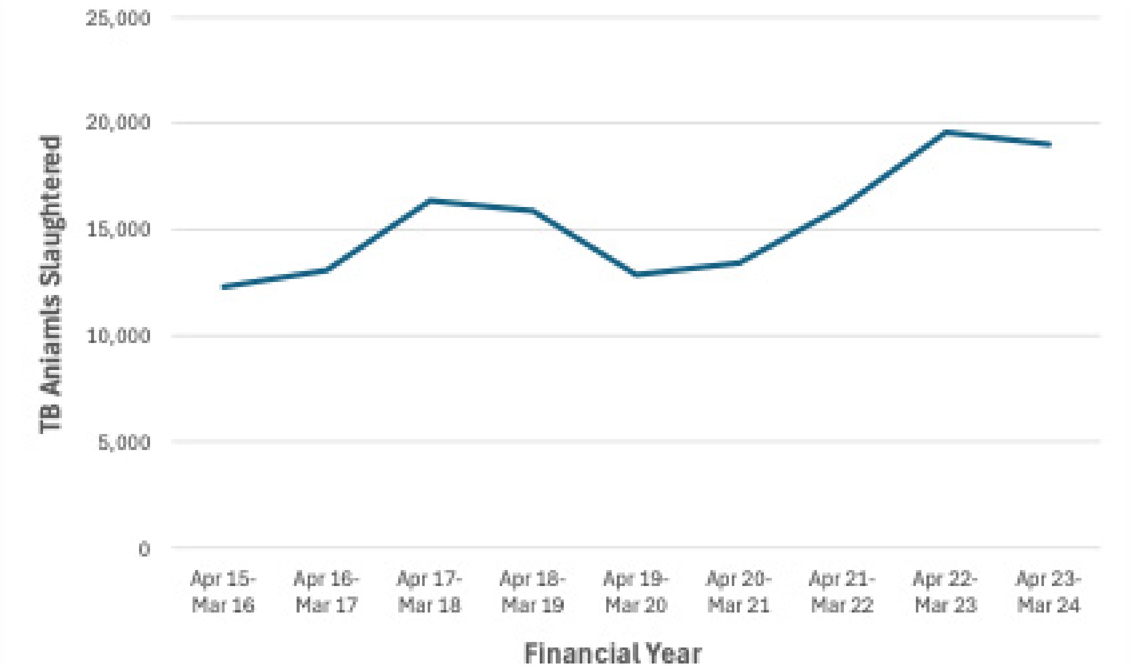

Figure 2: *Number of animals slaughtered due to bTB in NI by financial year, 2015/16 - 2023/24.*

Concurrently, with the deteriorating epidemiological disease situation, there has been a significant increase in total programme costs/expenditure. In the 2023/24 financial year, total departmental bTB Programme expenditure was £55.7m, a rise of 39% since 2020/21, with the rise in compensation costs (both numbers of animals and individual value) being the most substantial contributor to programme costs/expenditure.

Compensation payments for such animals was £36.5m for 2023/24. **Figure 3** displays the overall annual bTB Programme costs by cost category over the past 10 years.

To give a clearer sense of the magnitude of these costs, cumulative bTB Programme costs over the last 20 years were approximately £750m. Based on current disease trajectory, it could be anticipated that spend on the bTB Programme alone may be expected to exceed £1 billion over the next 15 years.

***Figure 3:** Annual financial costs of the NI bTB eradication programme by main cost area, 2014/15-2023/24.*

Premature culling of cattle due to bTB is also held to have an adverse impact on climate change, due in most part to a combination of reduced lifetime productivity and elevated stocking rates, however, there has been no studies to date analysing this in NI.

The costs of bTB are not confined to the direct financial costs to government as outlined above but also involve a significant financial burden on farmers and farming families. Not only is there a loss of income with the early removal of reactors from farms, but indirect costs are also substantial with loss of genetics and productivity, and the additional labour involved in facilitating bTB testing.

Furthermore, restrictions applied to bTB infected herds, and the removal of reactor animals, causes significant emotional and psychological distress to farming families across NI.

It should be noted that whilst herd incidence levels are 10.41% this does not represent the total number of herds across NI under restriction as a consequence of bTB. Approximately 12% of herds are currently under restriction for bTB, with these herds constituting 24% of the total bovine population reflecting the fact that bTB breakdowns are skewed towards the larger herds, also disproportionately impacting dairy enterprises.

It is within this deteriorating context that the Minister has asked me to assess our current approach and provide initial proposals for a new way forward to put us on the path to eradication of bTB.

NI bTB Eradication Programme

A bTB eradication programme for cattle is required under EU legislation, with Regulation (EU) 2016/429 (Animal Health Law) and its subordinate Commission Delegated Regulation (EU) 689/2020 setting out the particular requirements in relation to bTB. In NI, this is supported by domestic legislation - the Tuberculosis Control Order (Northern Ireland) 1999 (as amended) and the Tuberculosis (Examination and Testing) Scheme Order (Northern Ireland) 1999 (as amended), and is focused around the following pillars:

- Detection and removal of infected animals through routine annual testing with the comparative intradermal tuberculin test (CITT; 'the skin test');
- Abattoir surveillance;
- Application of movement restrictions on infected herds for a period (minimum 4 months) and further testing to enable further identification and removal of infected animals and limit onward spread of infection;
- Epidemiological investigation and supplementary testing for herds and individual animals considered at risk to bTB herd breakdowns.

Despite these efforts, the trends portray a worrying picture and highlight the importance of a critical review (and ongoing scrutiny) of the current approach to bTB in NI.

This requirement is further reflected in the recent increases in disclosure of bTB in animals disclosed at routine slaughter; termed bTB lesions at routine slaughter (LRS). The rise in proportion of confirmed LRS animals over recent years (**Figure 4**) paints a disturbing picture as regards more disease remaining undetected in the cattle population and overarching programme failings.

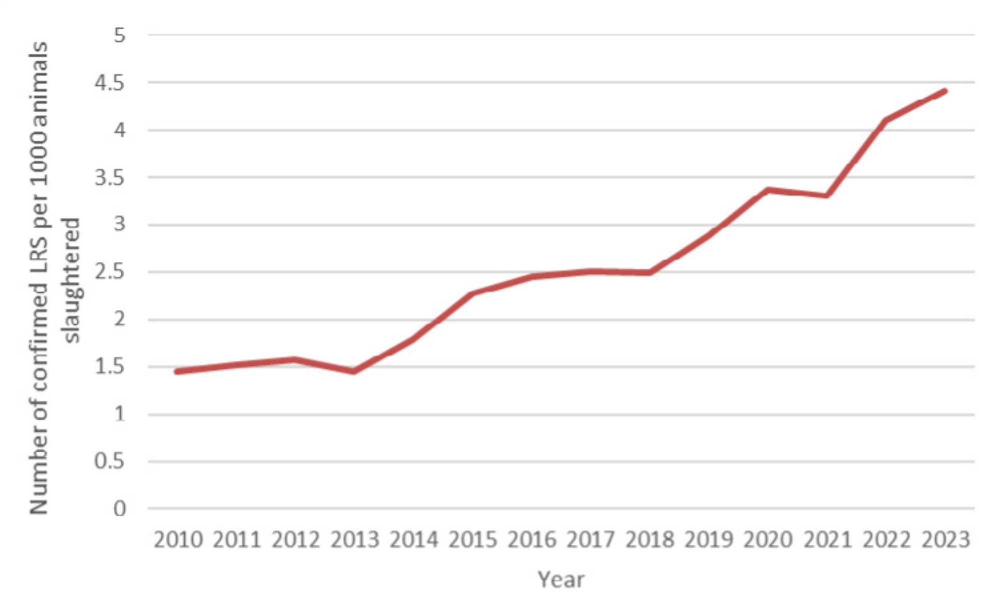

***Figure 4:** Number of animals with bTB confirmed lesions at routine slaughter (LRS) per 1000 animals slaughtered.*

In addition, over recent months, there has been a divergence between animal and herd incidence (**Figure 5**) with an increase in animal incidence (blue line) compared to fairly level herd incidence trend (red line), indicating an increase in the size of individual breakdowns and overall reactor numbers.

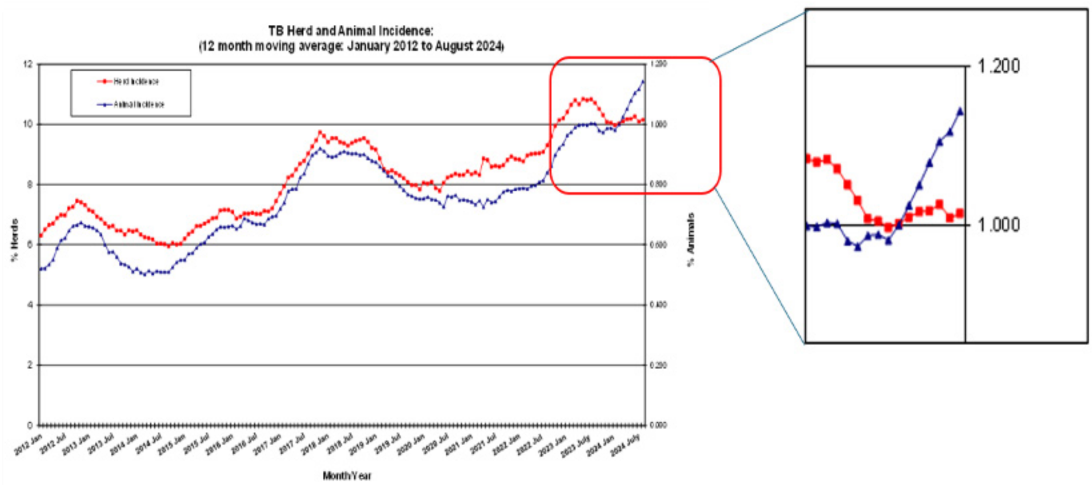

Figure 5: bTB herd and animal incidence since January 2012.

It should be noted that there now exists a substantial body of scientific knowledge from across the UK and the Republic of Ireland in relation to bTB epidemiology and control, and examples from countries where bTB eradication has been successful or is nearing completion; all information which must be taken into consideration when making proposals on the way forward.

Similar to the antimicrobial resistance and climate change debate, decisions taken now will have long term implications in terms of both the time taken to eradicate, and the cumulative costs (direct & indirect) of the bTB eradication programme, with obvious consequential impacts on future generations, including the future of NI farming, the rural economy and society in general.

NI Herd Profile

The NI Agricultural Census for 2023 reported a total of 20,341 cattle farms containing 1,673,345 cattle (DAERA, 2023). Of these cattle farms, 3,150 were dairy farms containing 319,346 dairy cows along with 13,810 beef farms containing 236,082 beef cows. The overall median cattle herd size has remained reasonably constant since 1995 (current median = 39 cattle) as has the median beef farm (current median = 11).

However, the median dairy farm size has more than doubled since 1995 (median increased from 37 to 79) which is a trend mirrored by the Republic of Ireland (CSO, 2020). Further trend details on the NI cattle demographics can be found in **Figures 6 - 8**.

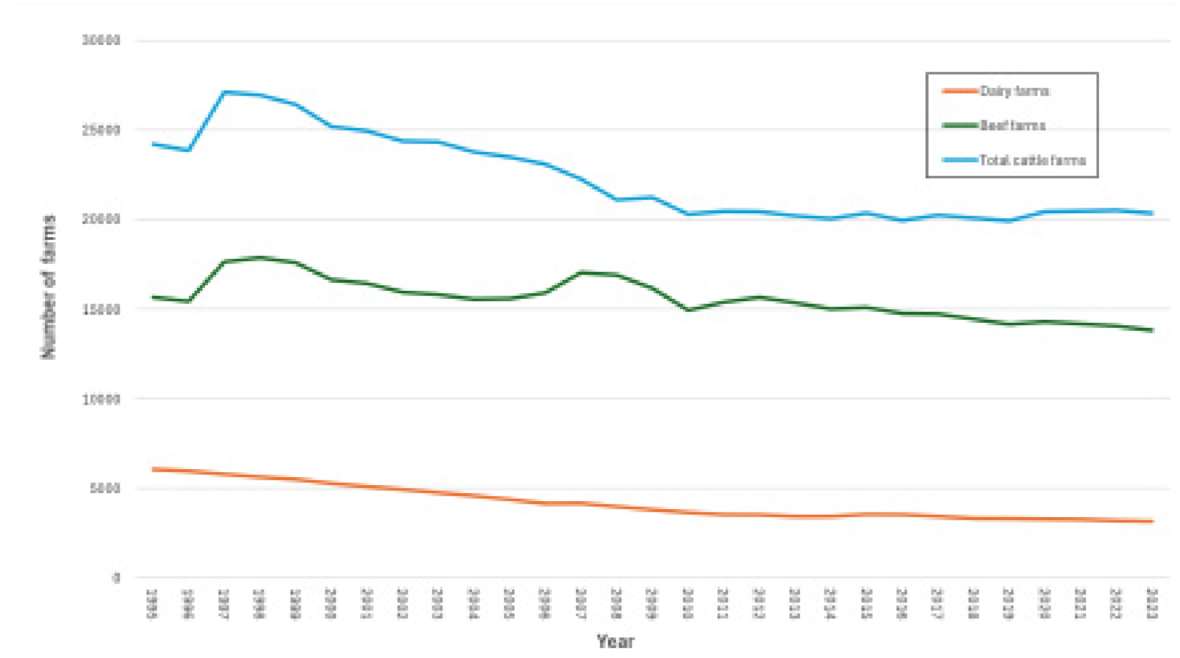

Figure 6: *Number of cattle farms by year and by type, 1995-2023.*

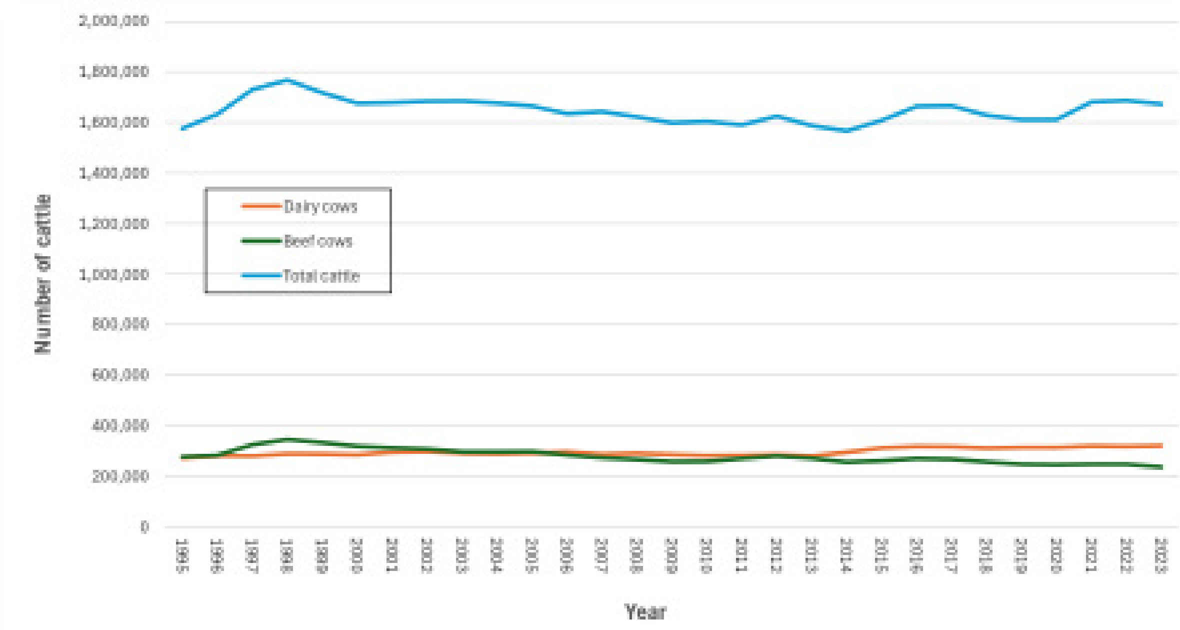

Figure 7: *Number of cattle by year and by type, 1995-2023.*

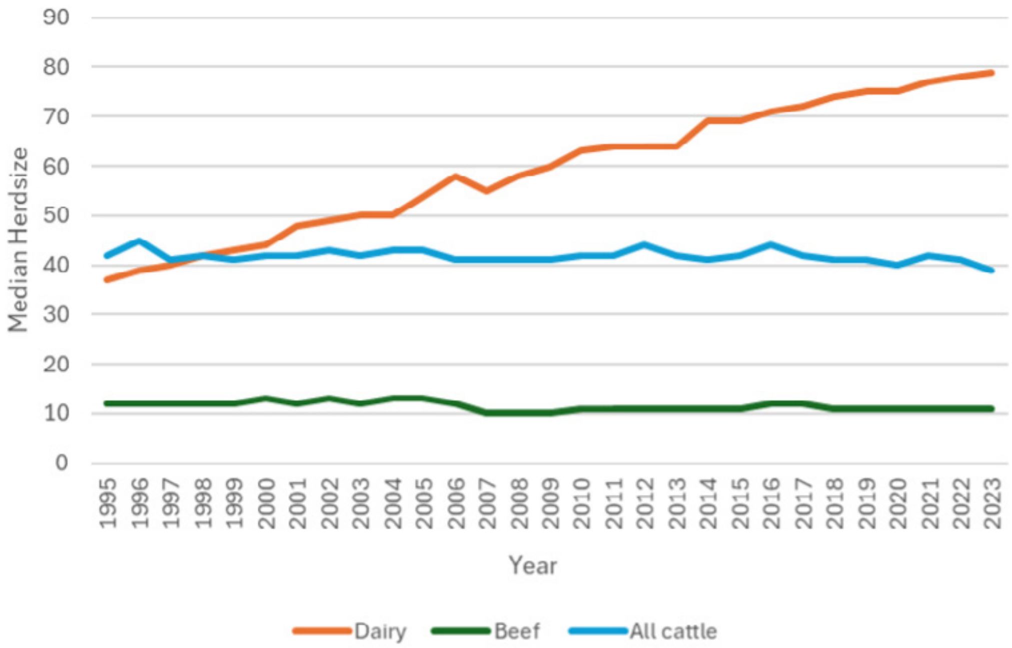

Figure 8: *Median cattle herd size by year and by type, 1995-2023.*

Bovine TB herd breakdowns

The length of bTB herd breakdowns in NI varies considerably (38 days to more than two years; **Table 1**) but the distribution has remained fairly constant when breakdowns starting in 2015 are compared to those that started in 2020. The median length of bTB herd breakdowns was also similar (191 days in 2015 cf. 205 days in 2020).

Breakdown length: Days (Years)	% 2015 breakdowns (Number)	% 2020 breakdowns (Number)
Under 120 (0.33)	7.5 (158)	5.6 (131)
120 to <180 (0.33-0.5)	36.2 (757)	33.8 (789)
180 to <365 (0.5-1)	41.5 (868)	43.3 (1,013)
365 to <730 (1-2)	10.7 (224)	13.4 (314)
>730 (more than 2)	4.2 (87)	3.9 (90)
Total	**100 (2,094)**	**100 (2,337)**

Table 1: *Distribution of bTB herd breakdown length for breakdown commencing in 2015 and 2020 (constructed using 2020 as the final year for analysis to allow for the majority of the breakdowns to be closed).*

Similarly, the number of reactors disclosed using the skin test during varying lengths of bTB herd breakdown has remained stable over the two time periods (breakdowns starting in 2015 and 2020; **Table 2**). Although the median number of skin test reactors per bTB herd breakdown was two for both time periods, there was a large range (0 to 663 reactors for breakdowns starting in 2015; 0 to 267 reactors for breakdowns starting in 2020). Note that the 2020 data may be affected by the switch of DAERA database from APHIS to the new NIFAIS platform.

Perhaps not surprisingly, prolonged bTB herd breakdowns do contribute to a disproportionately high number of skin test reactors with the top 2% contributing approximately one-quarter of the total skin test reactor numbers within those breakdowns presented in these datasets. **Tables 2 and 3** displaying that the majority (~80%) of breakdowns have less than 5 reactors; however, these breakdowns only contribute to ~20-25% of the total number of reactors.

Number of skin test reactors by breakdown	% 2015 breakdowns (Number)	% 2020 breakdowns (Number)
0^	13.3 (279)	11.9 (279)
1	34.6 (724)	35.8 (837)
2	13.1 (275)	13.2 (308)
3 to 5	17.0 (356)	17.3 (405)
6 to 10	9.3 (194)	9.8 (229)
11 to 50	11.2 (235)	11.0 (257)
51 to 100	0.9 (18)	0.8 (18)
>100	0.6 (13)	0.2 (4)

^ breakdown only involved bTB confirmed LRS animals.

Table 2: *Distribution of number of skin test reactors for bTB herd breakdowns commencing in 2015 and 2020.*

Number of skin test reactors by breakdown	% Total reactors from 2015 breakdowns (Number)	% Total reactors from 2020 breakdowns (Number)
0^	0.0 (0)	0.0 (0)
1	5.9 (724)	7.1 (837)
2	4.5 (550)	5.3 (616)
3 to 5	10.9 (1345)	13.1 (1539)
6 to 10	11.9 (1469)	14.8 (1734)
11 to 50	39.2 (4821)	43.7 (5121)
51 to 100	8.9 (1093)	10.4 (1214)
>100	18.7 (2297)	5.6 (660)

Table 3: *Distribution of total number of skin test reactors for bTB herd breakdowns commencing in 2015 and 2020.*

Dairy herds and bTB

There has been a steady intensification within the NI dairy sector (as elsewhere) over the years with dairy farms increasing in herd size but a decreasing number of registered dairy farms. This is reflected in the NI cattle demographics and in the bTB statistics.

Of the 21,889 cattle herds bTB tested during 2023, only 13% were dairy herds (n = 2,913 dairy herds). However, the dairy sector accounted for 43% of the cattle bTB tested during the year. This reflects the much larger dairy herd size compared to other cattle herds and herd size is a well-recognised risk factor for bTB (Skuce et al., 2012).

With respect to new bTB reactor herd breakdowns during 2023, 27% of all these breakdowns involved dairy herds (n = 602 dairy herds). Overall, 33% of all herds with bTB reactors during 2023 were dairy herds, which equated to over one-third of dairy herds (n = 1,016). These 1,016 dairy herds disclosed almost half of the bTB reactors declared during 2023 (8,939/18150 = 49%).

Further examination of these figures shows that 3% of dairy herds (n = 31) yielded 27% (n = 2,461 reactors) of the bTB reactors from dairy herds (or 14% of the total number of bTB reactors disclosed during 2023). This illustrates the disproportionate contribution being made to bTB Programme expenditure by some parts of this sector. More detailed analysis of the bTB chronic herds issue and proposals for addressing them are detailed further in this review.

NI bTB Strategy

In March 2022, DAERA launched the NI Bovine TB Eradication Strategy (TBES), consisting of a package of recommendations designed to achieve a sustained reduction and eventual eradication of bTB. The recommendations were based upon work undertaken by the NI TB Strategic Partnership Group (TBSPG). The TBES contained 21 recommendations in total and were grouped into six interrelated themes as outlined below:

- Management, Oversight and Governance
- Tools and Processes
- Herd Health Management
- Wildlife
- Finance
- Research

The recommendations across the 6 themes represented a fresh and integrated approach to enable eventual bTB eradication.

However, the majority of recommendations have not yet been fully implemented with obvious consequential impact on NI's bTB disease landscape. The proposals I have outlined further in this document, within Section Three specifically, for a new way forward will build upon these recommendations taking into account the current challenges faced to set us on a path to bTB freedom. My proposals will also consider the domestic and European legislative requirements placed upon the Department regarding bTB control and eradication efforts.

Trade in cattle and cattle products

From a trade in bovine agricultural products standpoint, NI is generally protected by being part of the EU internal market with an officially approved bTB eradication programme. However, given the current disease trajectory, there is a potential risk to continued access to international markets for NI dairy and beef products.

Trade in bovine products is valued at approaching £3 billion (£1,697 million beef/sheep products and £1,277 milk products) with the processing sector employing around 8,000 people across NI (5,700 in beef/sheep products and 2,300 involved in milk products). Approximately a quarter (21%) of NI milk is sent to the Republic of Ireland for processing (NISRA, 2023).

This risk has parallels with the situation experienced by Australia and New Zealand in the early 1970s, propelling a rethink in approach to bTB control to avoid the loss of key export markets and the resultant catastrophic social and economic consequences.

Conclusion

Taking into account the ever increasing bTB incidence and associated costs, our current trajectory is unsustainable. It is clear we have challenges; bTB is complex, and our herd profile and breakdown statistics do not lend themselves to easy eradication. However, the impact on government finances, on farming families too, and the need to ensure we protect trade means that maintaining the status quo is therefore not an option. This paper therefore plots my current position on what the way forward should be, taking into account engagement with the widest range of stakeholders, assessing and building upon the 2022 NI bTB Eradication Strategy and taking account of international best practice.

SECTION TWO: Factors Constraining bTB Eradication

This section outlines key structural issues which, in my opinion, we must - industry and government - collectively work to address if we are to effectively tackle bTB in NI. Section Three then moves on to what I believe are possible solutions, and next steps, required to meet those challenges.

Overview

Bovine Tuberculosis has a complex epidemiology which presents significant challenges in relation to the control and eradication (Allen et al., 2018; More, 2019; Milne et al., 2022). The reasons for the complexity are based on a range of factors, as outlined below, and further expanded on throughout this Section of the Review:

- Aspects of bTB in relation to anergy (a state in which the immune system is unable to mount a normal immune response against a specific antigen leading to infected animals not being picked up by the skin test) and latency (state where the bacteria lie dormant in the host without causing disease for long periods).
- The imperfect nature of the diagnostic tests available leading to residual infection in cattle herds, which indirectly incorporates the ability for *M. bovis* to evade the host immune system. This test imperfection can be further complicated by co-infections such as liver fluke (Byrne et al., 2019).
- The transmission of *M. bovis* to and from wildlife such as badgers and deer. A further complication is the fact that badgers are a legally protected species.
- The persistence of *M. bovis* in the environment with *M. bovis* remaining to be viable for up to 6 months in faeces.
- The movement of undisclosed infected cattle both between herds and within the herd.
- The fact that NI has one of the highest cattle densities in Europe (Strain et al., 2021).
- The high level of farmland fragmentation and the use of conacre.
- The difficulties around the fatigue shown towards the bTB Programme and lack of full stakeholder engagement/ownership brought on by the prolonged eradication timescale.
- The impact of bTB on trade and the need for minimal disruption from the bTB Programme in relation to cattle trading and management.

Given the complexity of bTB, a holistic multifaceted approach that effectively addresses all sources of infection, transmission pathways and factors that contribute to persistence of the disease in the environment, cattle and wildlife, will be critical to securing eradication. Of equal importance is effectively addressing the social science/human factors that contribute to bTB maintenance.

As previously noted, adequate information is now available from research and international experience to suggest the key measures needed if we wish to address NI's deteriorating situation. Ideally, these should focus on the following broad themes:

- **People measures - Culture, governance & stakeholder/industry engagement.**
- **Cattle measures - Addressing infection in cattle and Protecting herds that are bTB free.**
- **Wildlife measures - Preventing bTB risks from wildlife.**

Whilst cattle contribute significantly to new cattle bTB infections, the role of the badger in the disease epidemiology (bTB persistence and spread) has been elucidated based on several large-scale culling trials completed in England and the Republic of Ireland, with badger control subsequently added as an additional control measure in their eradication programmes.

In relation to the control and eradication of bTB in NI, it is widely accepted that co-existence of people, wildlife (badgers) and cattle is especially challenging with significant socio-cultural conflict as regards management approaches. This is discussed further below.

Whilst the main focus should be on the immediate control and subsequent eradication of bTB through the early and efficient detection of infection and prompt removal of infected animals in order to reduce onward transmission to other herds and wildlife, we also to need to consider shifting the bTB paradigm.

If we are to reach a successful outcome, we need to pivot towards also including a focus on protecting the majority of herds and animals free from bTB, driving positive biosecurity behavioural practices and improve the culture around bTB eradication.

This will involve intense and sustained effort, and commitment, from all stakeholders working in partnership. It will require complete commitment to shared objectives to remove bTB from all the reservoirs of infection in NI. It should be noted that there is a substantial difference between legislative-freedom and biological freedom (see Griffin et al. (2023) for more detail).

People Factors

Key principles of any bTB strategy are to detect and eliminate bTB rapidly and effectively, minimise the risk of spread, and protect herds free of bTB.

Arguably, one of the most important actions for enabling success are efforts relating to overall programme governance, structure and ownership.

International examples of success in achieving bTB eradication have been reliant on models of Programme governance, management and cost sharing that encourage high levels of stakeholder engagement and commitment (More, 2019), albeit, on such occasions, there was a ‘burning platform’ driving the necessity for these changes.

Many individuals and groups are directly involved in, or are impacted by, bTB. They would benefit greatly from disease eradication. Underpinning the development and delivery of a successful eradication strategy will be the advancement of an effective partnership between government, the farming and processing sector, veterinary profession, wildlife groups and other stakeholders - built on a shared ownership, a common understanding, and mutual respect for each other’s views.

Currently, bTB is widely regarded as a government problem, with some in industry (farmers) having very low perceived behavioural control with regards to bTB control and eradication. There is a sense of fatalism, i.e. they feel they can do nothing to prevent it (Robinson; 2017a; Robinson, 2017b; More, 2023).

More et al. (2015) concluded that in the successful eradication programme in Australia, ‘it is unlikely that TB eradication would have been achieved if TB had not been recognised as an industry problem’. In NI, many farmers have been disenfranchised from efforts to control the disease in cattle, almost accepting it (with resignation) as a part of everyday farming life which cannot be changed (Robinson, 2017a; Robinson, 2017b).

This “Government as the problem” idea is exacerbated by the perception that it has become resigned to controlling rather than eradicating the disease, further evidenced, from the farmers’ perspective, by the lack of any implemented policy to address bTB within wildlife populations.

Indeed, the controversy around wildlife intervention and politicisation of the debate on this particular element of the bTB eradication effort, has been a deflection of focus from what can be done by industry and government to help bring the disease under control. This is reflected, for example, in the poor uptake of on-farm biosecurity measures (O’Hagan et al., 2016a; O’Hagan et al., 2016b) and extent of trading of often high-risk cattle (Doyle et al., 2017).

Whilst good biosecurity will not on its own eradicate bTB, in combination with all other additional interventions, it is an integral part of any disease control or eradication strategy. There is a considerable amount of accessible and comprehensible information, advice and guidance available, however, too few herd keepers are acting on such guidance (O’Hagan et al., 2016a; O’Hagan et al., 2016b).

Many of the biosecurity measures and responsible actions are affordable, practical and achievable. Implementation of such measures will deliver much wider animal health and welfare, and ultimately economic, benefits across the farm business.

Managing the disease risks associated with the movement of cattle between and within herds is a standard and fundamental component of any effective programme. Responsible cattle movements are the first principle of good farm biosecurity and one the farmer has control over.

The bTB compensation regime currently helps to shield affected businesses from some of the financial impacts of the disease. However, it is accepted that the economic impacts go beyond the financial value of those animals compulsorily slaughtered, not to mention the significant emotional, societal and environmental impacts which are difficult to monetise.

On that basis, it is important that we ensure that any changes to compensation arrangements would not significantly impact farm sustainability. However, with this comes an inherent personal and moral responsibility. In fact, there is a very valid argument that those who put their own and other herds at risk by not meeting reasonable baseline standards and/or take risky decisions should not have the same compensation safety net and/or herd testing regime as those that do. In addition, having a bTB breakdown must never be seen as an option that offers the potential to make a profit through fraudulent activity.

There is a need to further develop and improve departmental case management and bTB advisory services (capability and capacity) to ensure that herd keepers receive effective, practical biosecurity/disease control information in a timely fashion. There are basic baseline biosecurity measures/controls that all herd keepers should take to mitigate risks but, given the complex epidemiology of the disease, what constitutes robust resilience will often differ from herd to herd with some herd keepers requiring additional tailored advice and support.

The veterinary profession and other farm advisory services are well placed to provide such information but not without the support/guidance of government vets to ensure quality assured advice is readily available (Lahuerta-Marin et al., 2018). Representative bodies for farm vets have expressed their willingness to continue to be involved in the provision of such information and there is a need to develop an affordable mechanism.

The need for social science is also pertinent. Controlling bTB is a complex issue involving a large range of stakeholders. The decisions made by these stakeholders may reflect long standing patterns of behaviours and cultures. In the cases where the decisions people take are contrary to the aims of disease control, social science can be helpful to understand and change these patterns (Enticott, 2023).

Existing programme governance arrangements in NI are inadequate with little evidence of partnership working. There is a need for fundamental change with a refresh of existing governance arrangements (both internal and external) required to consolidate and strengthen existing working relationships and structures, encourage ownership, improve coordination, agility, decision making and ultimately support a rejuvenated drive and resolute effort by all sectors to reduce bTB levels.

Making this a more pressing matter is the ending of the TB Eradication Partnership's (TBEP) tenure in December 2023. This means moves to strengthen our governance model will also need to take account of the findings of the Strategic Investment Board's review of the TBEP, completed in 2024. A collaborative governance model where interaction across all stakeholders is deliberative, respectful and resolution oriented and backed up with scientific research is the ambition (More, 2019; More, 2023).

Other jurisdictions have successfully progressed various models for industry and government partnership focusing on efforts to tackle bTB.

In England a Bovine TB Partnership was established in 2021. The Bovine TB Partnership contributes to setting strategic direction for the government's bTB eradication programme. It also plays a key role in co-designing new policies and communications. The aim of the bTB Partnership is to encourage shared ownership, coordination and direction setting, and act as a driving force for further progress towards disease eradication surrounding England's 25-year bTB eradication strategy.

In Wales, a TB Technical Advisory Group (TAG) was established in April 2024. The TAG will provide advice to Welsh Ministers through a forthcoming TB Programme Board.

In the Republic of Ireland, as part of the Government's commitment to eradicate bTB, a TB Stakeholder Forum was established and tasked with proposing policies to help achieve eradication. The forum provides a vehicle for the frequent exchange of policy information, scientific results, and stakeholder opinions and is supported by three working groups, including a dedicated scientific working group.

The structure of these partnership/advisory models will be an important consideration for NI when advising the Minister on possible ways forward. There will also be a need for a forum to provide independent scientific advice as we seek to advance, and regularly review and reform, our efforts towards disease eradication.

Further, mathematical modelling has proven to be an invaluable tool in the understanding of complex infectious disease systems such as bTB enabling the assessment of various intervention scenarios/strategies on disease transmission. This tool has previously been applied successfully in NI prior to starting the TVR project in County Down (Smith et al., 2016). Mathematical modelling has also been applied in relation to badger intervention strategies in England (Smith et al., 2016; Smith et al., 2021) and Republic of Ireland (Abdou et al., 2016;

Chang et al., 2023; Chang, 2024). This is something that should be further explored and developed for NI, potentially in conjunction with the Republic of Ireland.

Cattle Factors

In countries such as NI where bTB is endemic, it is not possible using the current available diagnostic tests to determine with 100% confidence whether a herd is bTB infected or not.

Herds with a (recent) history of bTB are at a greater bTB risk for an extended period after derestriction, depending on size of the initial breakdown, local bTB prevalence, movement history, herd size and type (Doyle et al., 2014). This extended bTB risk is a significant contributor to breakdown recurrence, local persistence and spread of bTB (Doyle et al., 2020; Doyle et al., 2022). On that basis, it is more appropriate to consider herds to be at differing levels of bTB risk.

There are two main drivers of persistent bTB risk which are; infection in the locality (contiguous herds/wildlife/environment), and infection in the herd (residual infection and cattle movements) (Doyle et al., 2016).

Residual Infection & Cattle Movements

Residual infection refers to the presence of undisclosed, infected animals within the herd. Some of these animals are undetectable using the available diagnostic tests either due to latency or anergy (Wiseman et al., 2024). Estimates of the sensitivity of the skin test range from 50-95% depending on its application (Nuñez-Garcia et al., 2018; O'Hagan et al., 2019).

This is particularly worrying at the time of bTB derestriction as such animals (especially breeding animals as they tend to live longer with more opportunity to be moved on to other herds) pose a risk to other animals within the herd, wildlife, contiguous herds or purchasing herds, a factor that is further exacerbated given the very high levels of cattle movements (intra and inter herd) in NI (Brown et al., 2019; Fielding et al., 2020; Tratalos et al., 2023).

For the 12 months to the start of September 2024, over 600,000 cattle movements were made to a new herd in NI. Within herds, or so-called intra-herd movements, would be a multiple of this figure especially given the level of farm fragmentation in NI. Such residual infection coupled with substantial animal movements results in a continuous recycling of infection within the NI cattle population, further constraining attempts to eradicate bTB.

Studies have highlighted the contribution of residual infection to bTB persistence in the herd and locality, with modelling estimates that up to 15- 24% of herds in the UK and the Republic of Ireland had residual infection in at least one animal when restrictions are removed (Conlan et al., 2012; White et al., 2013; Broughan et al., 2016).

Whilst the problem is theoretically a technical one associated with current diagnostic tests, it is aggravated/reinforced by existing legislation where previously restricted herds can be free to trade following two clear herd tests 60 days apart, potentially 4 months after removal of the last known infected animal. In effect, passing a herd test and being free of bTB are not necessarily the same thing.

Essentially, once bTB becomes established in a herd, it is very difficult to ensure its clearance, especially within large, intensive herds (Doyle at el., 2014; Doyle et al., 2016; Doyle et al., 2020).

It is estimated that the time taken to guarantee freedom from infection in a herd ranges between 5- and 10-years dependent on herd type, size, and nature of initial breakdown (**Figure 9**). For example, in the successful Australian eradication programme, all animals present during a breakdown were considered to be 'at risk' for life and infected herds required a minimum of 8 years to attain the lowest herd risk status (More et al., 2015).

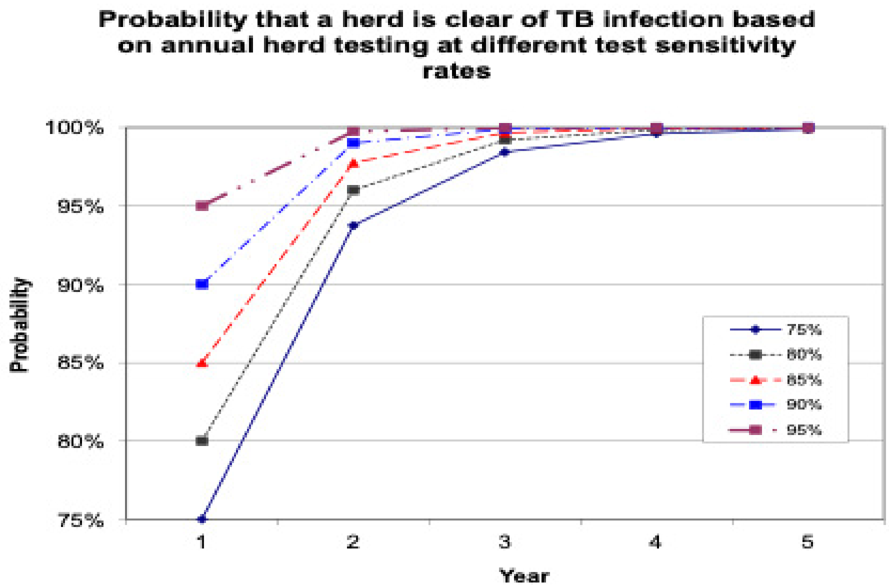

Figure 9: *Probability of a herd being clear of bTB infection based on annual herd testing at different test sensitivity rates.*

This theory is further corroborated when we consider NI bTB herd breakdown recurrence rates with 15% of herds disclosing bTB reactors at the 6-month post-derestriction test (Check Herd Test 1 - CH1). This compares with a lateral check test (LCT) herd breakdown rate of 8%, which arguably is a reasonable proxy for the background herd breakdown rate surrounding these breakdowns.

Residual infection and purchasing practices are the two main disease drivers behind the so called chronically bTB infected herds phenomenon, which is discussed in more detail below (see 'Chronic bTB herds' section).

The solution to the residual infection conundrum centres around two main pillars, the first pillar being application of a risk-based approach and a shift in thinking from a black and white perspective, i.e., infected or not infected, to a more nuanced 'shades of grey' perspective, with herds placed/categorised on a risk scale depending on likelihood of infection (Adkin et al., 2016a; Adkin et al., 2016b; Salvador et al., 2018).

Using this methodology, herds in the period following derestriction would still be considered high risk (particularly if a large breakdown), however, over time, with successive negative tests, assurance is accumulated that infection has been truly eliminated from the herd and it subsequently moves to medium and low risk.

Based on this understanding, farm businesses purchasing animals should be provided with real-time animal/herd disease risk information. This real time information can be used to support informed decision making and to mitigate against the risk of purchasing bTB infected animals. A natural evolution of this in the environment of a successful bTB programme would be the introduction of a risk-based approach to animal trade. With this risk-based trading system, animals would only be purchased from herds of equivalent or higher health status, thus limiting the potential that infection may be spread when animals are bought and sold (Adkin et al., 2016a; Adkin et al., 2016b).

Further future mitigations could include restricting high-risk cohorts (and animals previously in receipt of an inconclusive test result) (Clegg et al., 2011a; Clegg et al 2011b) to the herd for either a defined period, for example 3 years, or potentially until the end of their productive life and permitting moves to slaughter only for such animals.

The second pillar needing attention in order to address the issue of residual infection is the maximisation of diagnostic tests to ensure early identification of infected animals. This encompasses the application of additional/alternative testing strategies including maximising the sensitivity of the skin test, the use of severe interpretation, interferon-gamma (IFNg) testing and also machine learning (More, 2023), all of which will be discussed in more detail later in Section Three.

A useful analogy when considering residual infection and its impact on disease eradication is the BVD eradication programme and specifically the retention of persistently infected animals on farm (Graham et al., 2021).

Farm Fragmentation

The agricultural landscape in NI comprises highly fragmented farms distributed across spatially discontinuous land parcels. Indeed, 35% of cattle farms are comprised of five or more fragments - which is comparable to the Republic of Ireland - but much higher than GB, where only 7% of sampled farms have five or more constituent fragments (Milne et al., 2021).

This high level of farm fragmentation, as illustrated in **Figure 10** below, greatly facilitates disease spread and thwarts disease control efforts. Farm fragmentation and the increasing reliance on short term leases increasingly exposes herds to contiguous spread from infected neighbours and is a particularly important component of NI's bTB epidemiology. Tackling such means of transmission requires a deeper understanding of the patterns, drivers and characteristics of NI's conacre system - the key factor influencing land fragmentation (Milne et al., 2021).

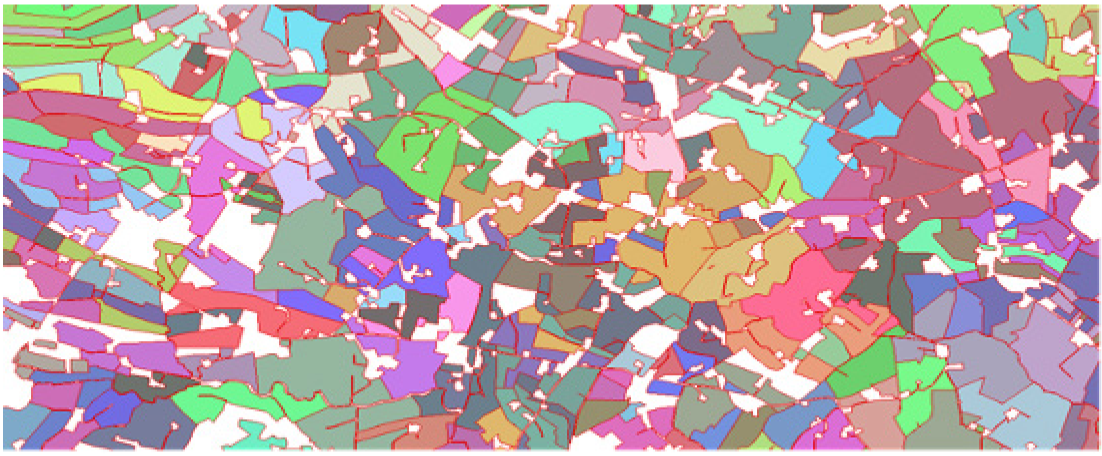

Figure 10: *Map of land parcels in an area of County Tyrone with each colour representing one farm business.*

Chronic bTB Herds

One area of particular relevance is how certain herds seem to have a greater propensity to develop prolonged and recurrent bTB breakdowns (Chronic herds).

Such herds have previously been defined in more recent research papers as those where the breakdown lasts in excess of twelve months ('prolonged') or those which have two further breakdowns within the two years following the initial breakdown which lasted less than one year ('recurrent') (Doyle et al., 2016; Doyle et al., 2020; Doyle et al., 2022). Alternative previous definitions used include having skin test reactors in three tests or more in a two-year period (Abernethy, 2005).

As previously highlighted, prolonged bTB herd breakdowns contribute to a disproportionately high number of skin reactors with the top 2% of bTB herd breakdowns contributing approximately one-quarter of the total skin reactor numbers (**Tables 2 & 3**).

Prolonged and recurrent breakdowns can have a major demotivating effect on herd keepers and vets (private and public). These chronic breakdowns have a desensitising effect whereby bTB becomes an accepted and perpetual hazard, with little hope of resolution. For some farmers, prolonged breakdowns bring despair and distress through overstocking and financial hardship, for others, there is an acceptance but frustration with the eradication regime. Ultimately, many develop a mind-set of resignation, and that the situation will never be any different, further constraining any eradication efforts.

Chronically infected herds present a significant barrier to bTB eradication and, in themselves, arguably provide enough disease output to maintain the endemic, hence the need for concentrating additional programme efforts on these particular herds.

The two main contributors to the phenomenon of chronic bTB herds are, firstly, the inability of disease control measures to completely remove infection and, secondly, repeated introduction of infection. Many factors can influence the effectiveness of these two contributing mechanisms (Doyle et al., 2016):

1. Herd size
2. Cattle movement
3. Wildlife
4. Inter-herd contiguous spread
5. Inability of control measures to effectively remove herd infection

In terms of contributing towards chronic bTB infection, herd size is a factor which can both influence the inability to remove infection, and allow more efficient repeat introduction of infection.

With respect to the impact of diagnostic test sensitivity (skin and IFNg tests), one of the most obvious issues for large herds are false negatives. False negatives contribute to both prolonged and recurrent bTB chronic herd breakdowns by allowing infected animals to remain in the herd, continuing the spread of infection.

Herd size has an impact on risk of repeated introduction of infection based on the increased epidemiological contact that large herds have with other herds and their direct environment. Indeed, a statistically significant interaction between herd size and source of infection in prolonged bTB herd breakdowns was detected with the most important factor being purchase of cattle (Doyle et al., 2020).

Exploring this further showed that prolonged bTB herd breakdowns, with purchase of cattle as a source, were mostly (75%) composed of beef fattening herds, demonstrating this factor as the primary driver of chronicity in these herds (Doyle et al., 2020).

Cattle movements in NI impact on disclosures of bTB herd breakdowns and showed that 6.4% of bTB herd breakdowns in NI were directly attributable to the movement of infected animals (Doyle et al., 2017). This result would tend to suggest movement of animals is not a major source in initiation of bTB herd breakdowns; however, that is not to say cattle movement does not provide a mechanism of repeat introduction of infection into some bTB chronically infected herds. In terms of risk source to herds, NI work has shown a strong association between beef fattening herds and purchase of cattle. Possibly more importantly, this work also showed that unlike cattle purchases, which was focused on beef fattening herds, badgers were a risk to all herd types (Doyle et al., 2020).

With respect to recurrent bTB herd breakdowns, these appeared to be strongly associated to carryover of infection from a previous bTB breakdown, with other sources such as badgers showing no statistically significant association (Doyle et al., 2022).

Another important result was that almost one-third (30%) of farms investigated with bTB herd breakdowns were recorded as having badger setts, but only 3% of these investigations reported farms where badger setts and/or latrines were fenced off (Doyle et al., 2020; Doyle et al., 2022). This result shows that on NI bTB breakdown farms there is relatively little biosecurity barrier for transfer of infection between badgers and cattle.

Looking at disease spread between neighbouring herds where prolonged bTB herd breakdowns were involved, it was found that either recent upgrading or complete installation of new boundary fences showed a significant negative association with the duration of bTB herd breakdowns (Doyle et al., 2020). This result provides circumstantial evidence that the application of better biosecurity measures in the form of adequate boundary fences to reduce cattle-to-cattle contiguous herd contact, could reduce the odds of a prolonged bTB herd breakdown.

Alongside processes which introduce infection into a herd, bTB can also be maintained due to the inadequacy of the diagnostic tests to remove infection fully from a herd. This inability of control measures to remove infection effectively was described as the main driver of recurrent bTB herd breakdowns (Doyle et al., 2022).

As diagnostic testing is a fundamental control measure to the NI bTB Programme, obvious failures in its effectiveness to remove infection are a serious demoralising factor for both the farmers and vets involved. This is reflected at a national level with a 15% bTB herd breakdown recurrence noted at the six-month post derestriction test (as previously mentioned).

Purchasing Policy in breakdown herds

In addition, cattle movements (including restocking) into and out of herds, especially in breakdowns with significant numbers of reactors, are an area of concern for the Department. EU legislative requirements make clear that restocking can only take place in bTB breakdowns following the completion of cleansing and disinfection (C&D). This legislation also states that, where necessary, to prevent the spread of disease, the movement of animals into and within the establishment should be restricted. At present, movements in are only prohibited in more severe bTB breakdowns and purchase into these herds under licence is considered on an individual basis subject to further risk assessment and consideration of mitigating measures.

Accepting the need to purchase animals to remain economically viable, it is important that added cattle do not effectively 'add fuel to the fire' of the existing disease problem. There needs to be an effective health management and business continuity plan to manage such risks and also to mitigate against further spread of infection.

Divergence between animal and herd incidence

As detailed above, over the past year, there has been a divergence between animal and herd incidence (**Figure 5**). Figure 5 shows this divergence as an upwards trajectory line for animal incidence (blue line) and a horizontal line (red line) for herd incidence. One possible explanation would be that interruption to bTB testing at the start of the COVID-19 pandemic and more recent resource constraints (financial and personnel).

These constraints resulted in the reduction of bTB herd risk testing surveillance which has delayed disclosure of infection in some herds enabling extended within-herd spread of infection before such herds are eventually tested and disclosed. The steady increase in the size of dairy herds (**Figure 8**) may also have a role to play here. This may have longer term detrimental effects on eradication given that it is much more difficult to eliminate bTB infection once it has become firmly established in a herd (particularly in large herds).

Prohibition on cattle vaccination

Under domestic and European legislation, the vaccination of cattle against bTB is not currently permitted. This is due to the skin test being unable to distinguish between vaccinated cattle and those infected with the disease. However, in recent years, Defra and APHA have been working on a major project to develop a new test that seeks to Differentiate Infected from Vaccinated Animals; a DIVA test.

APHA scientists have developed a candidate DIVA skin test and ongoing field trials began in England in 2021. The aim of these trials is to gather information to enable the candidate cattle vaccine (Cattle BCG) and the DIVA test to be authorised for use and recognised internationally. Should Defra succeed with this project and obtain the necessary international approvals, it could have significant implications for the control of bTB. DAERA continues to monitor the progress of this work, liaising with Defra officials on a regular basis.

Wildlife Factors

In NI, *M. bovis* is well established and maintained within the badger population with the badger being recognised as a reservoir host of the organism (Courcier et al., 2018; Griffin et al., 2005a; Griffin et al., 2005b).

While intra-species transmission (cattle-to-cattle, badger-to-badger) is considered much more common, interspecies transmission (cattle-to-badger, badger-to-cattle) is considered a rarer event. However, spill back from badgers to cattle still poses a significant risk as such seeding of infection in cattle may lead to further amplification taking place through cattle-to-cattle transmission (Griffin et al., 2023). Deer and other wildlife species have been shown to be infected with *M. bovis*, but such observations have been sporadic on the island of Ireland apart from in Co. Wicklow (Kelly et al., 2021).

Whole genome sequencing (WGS) provides some insights into transmission dynamics and relative contributions of the different sources of infection (Crispell et al., 2019; Crispell et al., 2020; Rossi et al., 2022; Akhmetova et al., 2023), which is fundamental in understanding the role that the badger plays in bTB epidemiology within different areas. The WGS information to date would suggest that transmission dynamics does vary across the different bTB hotspots that have been investigated.

Evidence of exchange of *M. bovis* infection between cattle and badgers necessitates a coordinated approach to disease control with infection needing to be controlled in all *M. bovis* reservoir hosts and the environment connected to an area/region (Birch et al., 2024). In NI, broadly speaking, we have a two-host system where infection oscillates between the two species.

Badger *M. bovis* prevalence is estimated at 20% based on recent DAERA road traffic accident survey with strain types similar to that identified in the local cattle population and prevalence levels positively associated with the local bTB prevalence (Courcier et al., 2018; DAERA, unpublished data). However, it has been hypothesised that the incidence of bTB in certain disease hotspot areas across NI may be significantly higher than what has been recorded in the RTA survey, potentially approaching 50% based on findings from Republic of Ireland field studies (Murphy et al., 2010; Corner et al., 2012).

As referenced earlier, bTB represents one of the most intractable challenges to human, wildlife (badger) and cattle co-existence. Therefore, subsequent agreement on wildlife management/control strategies, should that be a proactive cull, reactive cull, TVR (Test and Vaccinate or Remove), vaccination, or a combination thereof, is key in relation to overall disease control. The fact that badgers are a protected species under the Bern Convention, as well as NI legislation, makes control complicated.

Culling of badgers to reduce infection in cattle is considered unacceptable by some sections of society. Such deeply held beliefs deserve respect as do the beliefs of those who argue that the destruction of healthy badgers is justified/required to reduce the burden of disease on livestock and farmers.

Decisions on the way forward must be informed by evidence which provides information on likely outcomes; however, such decisions have to take into account the seemingly irreconcilable views of different stakeholders and so, inevitably, require final decisions to be made only by ministers. These decisions can only be based on the best science available, in consideration of the value for money presented by any proposal to progress intervention and be fully supported by all necessary impact assessments. In addition, any decision in this area must also be made within the context of all other statutory obligations placed on the Department with regards to wildlife protection.

Following a large-scale trial between 1997 and 2002 (Griffin et al., 2005a; Griffin 2005b), focused badger culling commenced in the Republic of Ireland in 2004 as an interim measure to limit badger-cattle transmission. This approach, along with enhanced cattle control measures, has had a significant impact on bTB incidence in Irish cattle herds with levels falling from 5.9% in 2004 to 3.3% by 2016, however this reduction has not been sustained (currently 5.62% bTB herd incidence to September 2024). Similar evidence exists in England where proactive culling (also along with additional cattle measures) has been practised with notable reductions in bTB cattle being observed (Brunton et al., 2017; Downs et al., 2019). Whilst such findings from the Republic of Ireland have not been challenged, it is acknowledged that there are analyses that dispute the claims relating to the English badger culls (Langton et al., 2022; Torgerson et al., 2024). All of this must be taken into account before any decision will be made on the future wildlife policy of the Department.

When considering the current evidence, proactive culling, although indiscriminate, will control *M. bovis* infection in the badger population in terms of directly reducing the infectious burden. There have been concerns in relation to the potential effect of a proactive culling strategy on badger behaviour, such as increased ranging distance (perturbation), which needs to be taken into account. However, the majority of previous studies have reported beneficial effects of culling strategies in both badger populations and cattle herds especially when rolled out alongside enhanced cattle-based measures.

More recently, substantial areas of the Republic of Ireland have changed to badger vaccination as the main control method (More, 2023) but with the option to revert to culling under license should bTB hotspots re-emerge. Vaccination aligns with the fact that badgers are a protected species under the Bern Convention and that therefore vaccination is the preferred long-term option to the control and eradication of bTB.

Research, both experimental and in the field, confirmed vaccination as a long-term viable control option providing it is part of a multifaceted approach (Chambers et al., 2011; Carter et al., 2012; Smith et al., 2016). A non-inferiority vaccination trial and modelling work in the Republic of Ireland has shown that badger vaccination was not inferior to targeted badger culling and its use can be effective in areas that have already been subjected to reactive badger culling (Aznar et al., 2018; Martin et al., 2020). These findings, however, should be noted with caution (More, 2023) given the significant increasing cattle bTB prevalence in some areas that have been turned over to badger vaccination, with a number of areas reverting to culling under license. It is crucial that ongoing monitoring and research will be conducted both of vaccine coverage and efficiency, and outcomes, of the intervention. This will also include the ecology and infection dynamics in vaccinated badger populations (More, 2023).

Whether these findings can be directly extrapolated/generalised to the NI context would need further consideration, given the varying historical approaches to bTB control and ecological landscape. The Republic of Ireland had transitioned from a decade of badger culling which had the effect of significantly reducing badger (and local cattle) bTB burden in advance (Smith et al., 2016) and we already know that vaccination of infected badgers is ineffective (Gormley et al., 2022).

For vaccination to be effective as a means of disease control in any population, a number of factors need to be considered. These include existing disease incidence, population dynamics/ecology, vaccination coverage and vaccine efficacy. Doctoral research, modelling the ongoing Irish vaccination effectiveness study, will enable evaluation of the badger vaccination programme and inform the need for any future research in this area (Chang, 2024).

Based on the evidence to date from research findings and infectious disease theory, and available published information, for vaccination to be most effective and meet our short, medium & long-term programme aspirations, it would need to be accompanied by a method of population control focused on removal of infected badgers. In addition, it would need to be conducted over an extended period with a high level of vaccine coverage (Smith et al., 2016; Smith and Budgey, 2021).

TVR uses a combination of selective culling and vaccination removing only test-positive badgers that are potentially infectious. It therefore reduces disease prevalence and the ongoing force of infection while vaccination of the residual population enhances protection against *M. bovis* infection (Menzies et al., 2021). This methodology leads to animal health and welfare benefits at population level.

Regardless of the approach applied, there will be an enduring need to limit the spill back of infection from badgers to cattle (and vice versa). This brings into question the best approach for the NI situation from a short-, medium- and long-term perspective, and the need to address all routes of transmission simultaneously.

Mathematical models play a crucial role in our understanding of complex infectious disease systems such as bTB as they enable assessment of the contribution of different transmission mechanisms, routes and hosts (e.g. Abdou et al., 2016, Smith et al., 2016; Smith and Budgey, 2021) without the costs and ethical considerations of large-scale field trials.

Several modelling studies (using Republic of Ireland datasets) have been used to determine whether badger vaccination and existing cattle controls would be effective in the control of bTB alone. Whilst they can reduce the levels of bTB, they cannot eradicate it unless being applied for several decades as the reproductive ratio (R_0) oscillates around 1 at best, further emphasising the need to address all transmission routes simultaneously (More, 2019; Chang et al., 2023).

Modelling outputs (supported by field trials in relation to culling) demonstrate that badger intervention, whether that be proactive culling, vaccination only or TVR can reduce bTB levels, with methods involving a lethal component (proactive or selective culling) providing a much faster bTB response than vaccination only. This is a point of particular relevance to NI considering the current epidemiological situation (Smith et al., 2016; Smith and Budgey, 2021). Mathematical modelling showed that with TVR, once the surrounding areas were considered, providing TVR did not cause perturbation (as was demonstrated previously in the NI TVR trial (O'Hagan et al., 2021)), it gave a significant reduction in the number of infected badgers (Arnold et al., 2021).

Critically, it should also be noted that whilst proactive culling in addition to existing cattle control measures will reduce bTB incidence, it will not lead to eradication (as has been shown in the Ireland) further emphasising the need for a holistic approach effectively addressing all transmission pathways and sources of persistence (More, 2023).

Indeed, for any intervention to succeed in the long term, bTB control measures in cattle need to be effective in preventing bTB re-introduction to an area as well limiting re-infection of badgers.

Concluding, there is considerable variation in the societal attitudes to the management of wildlife reflected in the apparent conflict between conservation, animal welfare and farm management. Badger interventions in particular are extremely challenging due to competing and conflicting stakeholder opinions and demand scientific evidence to inform any ministerial policy decision with, in my judgement, a 'one size fits all' policy for bTB being unlikely to succeed in NI.

Given this is a decision with wide reaching and long term strategic importance, it must be based on the best science available, have a sound economic basis and be fully supported by the necessary impact assessments. Further, it must consider any other statutory obligations, including our legal obligations regarding the protection of wildlife and take account of the legislative framework within which the Department operates.

SECTION THREE: Next Steps

This section outlines key structural issues which, in my opinion, we must - industry and government - collectively work to address if we are to effectively tackle bTB in NI. Section Three then moves on to what I believe are possible solutions, and next steps, required to meet those challenges.

1. People, Partnership and Science - Changing the Culture

(i) Governance & Partnership working

Eradication of bTB will only be achieved by simultaneously addressing all factors that meaningfully contribute to the persistence and spread of *M. bovis* in all infected animal populations through an integrated approach (More, 2023).

Whilst it is right that government takes the lead in setting the strategic direction for bTB control alongside the regulatory and economic framework for disease eradication, many individuals and groups play a direct role in the control of bTB. Existing arrangements in NI really only facilitate information exchange, with many stakeholders feeling disenfranchised with such arrangements.

It is vital that an effective partnership working model is established between government (including public health), farming and processing (beef/dairy) sectors, the veterinary profession, wildlife groups, auctioneers, retailers, accreditation schemes and other stakeholders. Essentially, all those who have an interest in, and are impacted by, this disease.

To achieve this, improvements on existing governance arrangements must be made, and consideration must be given to what is effective in other jurisdictions. From this it is proposed that DAERA work to develop a new bTB (eradication) partnership which will promote shared ownership, responsibility, coordination and direction setting. Ultimately creating the drive and concerted effort needed for progressing disease eradication. This recommendation will result in a new proposal to the Minister on the way forward and will draw upon the findings from the Strategic Investment Board (SIB) Review into the effectiveness of the former TB Eradication Partnership.

To date, the farming industry has not felt it had a significant role in influencing disease control strategies. The farming industry needs to feel a sense of shared ownership and be able to work effectively with government to advance new policies and interventions.

There is also a role for wildlife groups in addressing the spread of bTB at the cattle-badger and inter-species transmission interface.

The veterinary professions detailed local knowledge and experience in disease eradication and herd health, makes it ideally placed to protect clean herds, identify and remove disease rapidly and mitigate against further spread.

Markets, the processing sector, retailers and accreditation bodies can also play a key role as regards promoting responsible cattle movements, biosecurity and driving overall standards.

It is therefore my proposal that a new bTB partnership be established to bring together representatives from the aforementioned stakeholder groups working collaboratively with the following objectives:

- Setting direction and goals.
- Co-designing policies.
- Establishing standards and monitoring progress.
- Identifying priorities and areas for further research.
- Developing an effective communications strategy.

This is a new and radical form of bTB governance for NI and will be a unique coalition in terms of managing bTB. Bringing together such a diverse group of actors will most definitely bring challenges for all and particularly DAERA. However, it is important that government engages with this form of partnership working, embraces criticism constructively and enters dialogue openly with stakeholders adopting a solution focused mindset. Moreover, there are many good examples of similar arrangements across governments. It should be noted however, that ultimate responsibility for decision making in relation to policy resides with the DAERA Minister.

The bTB Eradication Strategy proposed that further tiers of governance be established to support the TBEP. Regional Eradication Partnerships would have a specific focus on bTB eradication in their particular geographical region and Disease Response Teams could be formed on an ad hoc basis in response to a serious outbreak, repeated breakdowns in an area, or to deal with particular disease issues. With the establishment of a new Eradication Partnership with a wider and more diverse representation of stakeholders, and taking into account the current disease picture, it is considered appropriate to pause work on these structures. The issue could be kept under review and further proposals on this matter submitted for consideration to the new Eradication Partnership, once established.

However, it is my view that if our Programme adapts as other countries have done and introduce controls via a regionalisation approach, then there is very real merit in seeking to establish more targeted local governance structures to assist in our ability for local stakeholder engagement and feedback on our efforts within a particular area.

(ii) Independent Science Advice

The quality of science is paramount to providing assurance to both stakeholders and the taxpayer that information underpinning policy decisions is both robust and informed. One way to ensure this is through the publication of DAERA commissioned works, and results of any scientific research, in international peer reviewed journals. This peer review process helps to provide assurance on the quality of science upon which policy is developed.

In relation to the subject matter, **I propose that the Department also needs to consider where independent science advice can be obtained** on an ongoing sustainable basis and in response to our own challenges within the NI context.

The purpose of this will be to assist the Department in shaping the bTB Programme as we set a new trajectory on our efforts to eradication, a pathway which will need continual expert review and amendment.

Another vital function of this asset will be its ability to respond to the ever-changing disease picture thus supporting programme agility and adaptability. An important point related to any infectious disease including bTB is that the island of Ireland is functionally one epidemiological unit, with a small pool of experts possessing the requisite knowledge to enable independent and effective advice to DAERA. This proposal should therefore also explore the potential for sharing this science resource with DAFM given our commonalities and the need to have a holistic all island approach to disease eradication.

(iii) Research

As highlighted previously, programme success will be dependent on timely, objective and independent scientific information and its use to inform future policy decisions.

Currently we have six bTB related Evidence and Innovation (E&I) projects underway. These are commissioned by DAERA and delivered by AFBI. They are as follows:

- **ELITE CLINIC: Exploring Livestock Trade through Cattle purchasing In Northern Ireland implications for bTB Control.**
  This project will investigate how network connectivity affects TB herd risks. Trade data will be used to construct networks from which a number of network statistics can be generated. These statistical networks will then be correlated with current and historic herd TB risk profiles.

- **Bovine TB: Analysis of strain types in NI.**
  There are approximately 9 years of data from all visibly lesioned cattle confirmed with *M. bovis* in NI. This has not, to present, been fully evaluated. Evaluation of that data is required to contribute to our capacity to understand and control infection at local and regional levels and contribute to policy development.

- **Detection and evaluation of confounders which may influence a positive Interferon Gamma test: the impact of Johne's disease on the bovine TB IFNg assay.**
  This project is an extension of recent AFBI projects on Interferon Gamma as a diagnostic tool. The overall objective of this project, therefore, is to investigate the potential impact of Johne's disease on the bovine TB IFNg test outcome.

- **Investigation of the Role of Passive Immunity in Wildlife bTB Vaccination and Evaluation of Dual-Path Platform (DPP) for cost effective field delivery.**
  This project is a further evaluation of the DPP test and the role of passive immunity which follows on from a previous ferret project. It is principally intended to address gaps in the current knowledge regarding the likely effectiveness of badger vaccination for bTB and how there might be indirect wildlife population level benefits of selected vaccination.

- **Development of the use of pathogen whole genome sequencing (WGS) as an epidemiological tool for bTB and to complement AMR studies.**
  This project will develop a platform to expand the use of WGS as an epidemiological investigative tool for bTB - ability to 'Track & Trace' infection and estimate the direction of disease transmission in well sampled case studies.

- **Relevance of genetic variability in the host/pathogen relationship**
  This project seeks to capitalise on our existing knowledge of host and pathogen genetics, and to begin to address how their interaction may affect bTB outcomes in the local industry.

There is also a current DAERA sponsored PhD studentship researching the application of machine learning to bTB control. This is another useful research avenue that has been, and will be, utilised to address key bTB strategic issues.

It is critical that scientific support is policy relevant, and this will be best achieved through close collaboration and ongoing interaction between scientists and policy makers throughout the programme lifecycle.

I propose that DAERA must continue to invest in research with the aim of advancing the ability to detect and eradicate disease. This will avail of the recently constituted science transformation programme as a vehicle for commissioning and delivering programme objectives. Also, research objectives must be taken forward through further collaboration and synergistic working with DAFM colleagues and exploring the potential for a shared DAFM/DAERA science forum.

The role of the current TB Stakeholder Working Group is also key in the identification of gaps in the evidence base to assist the Department in the commissioning of research, with this theme a standing item on the agenda for such meetings.

(iv) Intergovernmental Structures

There are a number of well-established forums for cross-UK and the Republic of Ireland engagement on our collective efforts to address bTB. Officials from both the Republic of Ireland and Northern Ireland meet twice a year for a TB Working Group established under the work of the North South Ministerial Council (Agriculture). This is not regularly attended by CVOs. Further, cross UK meetings take place quarterly in the form of the TB Liaison Group (TBLG). These are frequently attended by UK CVOs along with officials from DAFM.

Both forums are essential for cross collaboration on bTB eradication and sharing of updates and policy developments from the respective jurisdictions.

In my view, however, there needs to be a more formal level of engagement at the level of Chief Veterinary Officer or above. This would give the issue sufficient level of seniority to provide continual focus within the relevant competent authorities and enable further direction for those officials continuing to partake and engage in both the aforementioned forums.

I propose, therefore, that a CVO led North-South inter-governmental bTB eradication partnership is established to build on the existing collaborative working arrangements (make up to be confirmed) and advance disease control on an island wide basis; given that the same epidemiological threats are shared between jurisdictions. A further advancement of the above two arrangements and something worth future consideration would be the development of a North-South EPIC (Epidemiology, Population Health and Infectious Disease Control) type model similar to that developed by the Scottish Government (Centre of Expertise on Animal Disease Outbreaks I EPIC Scotland).

I propose that an ongoing review of the TBLG recommend a similar arrangement for our East-West engagement, that CVOs are required to attend, noting the seemingly more successful present efforts to control bTB specifically in Wales and the low-risk areas of England.

Subject to consideration by relevant Minister and CVO colleagues across the UK and Republic of Ireland, there is also potential that one overarching forum with representation from all jurisdictions at CVO level and below, across the British Isles, take place on a regular basis. Our challenges are all similar, and the fight to address bTB can only benefit from cross jurisdiction learning, engagement and collaboration.

The potential of these new structures will be the ability to adapt and develop in time to meet the changing demands of the bTB Programme throughout its lifecycle. Accompanying the establishment of the proposed partnership and science groups will be a review and refresh of the internal departmental programme governance structures to ensure they are agile, adaptable and resourced to meet the dynamic needs of the new programme.

(v) Culture/Ownership/Communications

Success in tackling bTB is predicated on a shared commitment, ownership and sense of purpose across all stakeholders that is built on a shared vision and a culture of understanding and respect.

As noted above, bTB can be perceived as a government problem, with the farming sector feeling a sense of despair, apathy, acceptance and fatalism - effectively no longer trying to proactively mitigate against disease spread.

Over time farmers may have lost sight of bTB as an infectious zoonotic disease with concerns more focused on DAERA's bTB testing regime, lack of action on wildlife and the perception that government has become resigned to disease suppression as opposed to eradication.

Undoubtedly, there needs to be a fundamental shift in the culture and communications surrounding the NI bTB Programme. Changing a culture of resigned acceptance, weariness, apathy and misunderstanding of this chronic disease will require intense effort and persistence.

Shielded to a degree by the guarantee of full compensation for infected animals, and with approximately nine out of ten farmers free of the disease, there is little fear of stigma or awareness of the full cost to farmers when their herd becomes infected. Furthermore, this is hindering the active participation of farmers to prevent bTB coming into their herd.

Today's generation of farmers and vets have limited experience of clinical bTB (as bTB infected animals now rarely reach the advanced clinical stage). This lack of clinical signs further mitigates against taking the disease seriously. Farmers have a much greater awareness of other infectious diseases that can present as clinical cases such as BVD, Johne's and salmonellosis - with robust health and biosecurity plans developed to control them.

Bovine TB needs to be made visible again as the infectious, zoonotic, potentially fatal disease that it is with clear economic impacts. There also needs to be a fundamental change to our approach. To date this has always revolved around targeting infected herds and clearing them of disease. Whilst this is correct and essential for obvious reasons and must remain our focus, we should not forget about the approximately 90% of herds which are classified as Officially Tuberculosis Free status (OTF) and free to trade on the open market. We need to ensure this remains the position (or better) and this is of equal, if not of more, importance.

In conjunction with the new TB Eradication Partnership, **I propose that a vigorous and refreshed publicity and communications plan should be rolled out,** utilising appropriate modes of communication to engage as wide an audience as possible, including social media, websites, print media, posters, stands at agricultural shows and oral communications, emphasising key features of the disease, best practice, risk mitigations and the fact that the disease can and must be eliminated.

Supporting and underpinning this communications strategy would be the further development of the DAERA bTB portal and the creation of a dashboard similar to those used in GB and the Republic of Ireland, presenting clear and up to date information on progress to eradication, and the inclusion and monitoring of key performance indicators and associated trends.

How the Department engages with herd keepers during bTB herd breakdowns should also be reviewed, particularly the accessibility of the language used, and information provided in written and oral communications. In addition, the Department should review its internal communications systems to ensure the effective flow of up-to-date information within the organisation and to ensure consistency of messaging and accuracy of advice provided to herd keepers by all frontline DAERA staff.

(vi) Education and Knowledge Transfer

Education of stakeholders is paramount to ensure a greater understanding of the epidemiology of bTB and the eradication programme, keeping them informed of policy developments and to address common misconceptions. The new proposed Farm Sustainability Standards should include an element of education regarding disease control and the implementation of effective biosecurity measures on farm.

I propose that further practical training and knowledge transfer programmes on bTB and practical ways to mitigate against disease entry and transmission, through seminars, training courses and online information to support herd keepers, should be rolled out and tailored for a range of audiences. The knowledge transfer programmes should be reinforced with an extensive outreach programme in collaboration with members of a refreshed bTB Partnership across multiple agricultural fora, e.g. farmers meetings and discussion groups, processor groups, wildlife groups, auctioneers and breed associations.

(vii) Programme Measurements

It is essential that data collected, measurements used, and statistics displayed within the bTB Programme should provide insights into overall programme progress. More importantly and critically, they must also provide insights into the biological processes contributing to the persistence and spread of *M. bovis* in all infected animal populations, generating discussions and enabling informed decision making.

Extrapolating from international experience, there has been limited success in developing targets that realistically reflect eradication programme checkpoints. This is largely due to the complexity of infection in a multi-host system and multiple factors (many of which interact with each other and some of which are difficult to quantify) that influence the spread and persistence of *M. bovis*.

Despite this, there is a need to establish a trajectory (hopefully showing an exponentially decreasing trend) that would be expected in a successful eradication programme. Fundamental to charting timelines will be establishing a R_0 figure for the overall system once the eradication strategy is in place and functioning. As mentioned earlier computer/mathematical modelling is increasingly used as a way of representing complex infectious disease systems facilitating prediction of programme progress under various scenarios/interventions. **I propose that consideration should be given to the development of a disease model for NI in the medium-longer term.**

Whilst benchmarking across Divisional Veterinary Offices (DVOs) is currently in place across a range of programme parameters, **I propose that a review of what is being measured is required to ensure it meets the demands of the bTB Programme going forward.** We should also avail of the opportunities afforded through international benchmarking with the objective of assisting us to further identify strengths and weaknesses within our bTB Programme. More detailed performance measures such as breakdown recurrence, duration and severity should be considered as a starting point, particularly given the importance of chronic bTB herds within the NI cattle population.

2. Cattle Interventions

Bovine TB is primarily a disease of cattle, and infection is primarily sustained in cattle populations as a result of cattle-to-cattle transmission. As indicated above, cattle controls have been guided by relevant EU legislation. Proposed cattle interventions will be considered across a broad range of interventions focused on detection of the disease within a herd as soon as possible, effective control and eradication of the disease in affected herds, and possible actions for both industry and government focused on protecting the majority of herds which are currently bTB free.

Cattle measures contained within this review will be considered under the following headings:

- Disease surveillance/detection
- Management of infected herds
- Protection of other herds by preventing disease entry.

Disease Surveillance/Detection

(i) Field Surveillance - bTB Testing

I fully recognise the value of the Private Veterinary Practitioner (PVP) - herd keeper relationship. There should therefore be a much more inclusive and pivotal role for the PVP within the NI bTB Programme. This includes the management of bTB breakdowns given their local knowledge, epidemiological training and relationship/position within the local farming community (Lahuerta-

Marin et al., 2018). This is corroborated with evidence across GB where farmers have responded positively to such interventions.

To advocate for and support an increased role for PVPs in the management of bTB, actions must be progressed which will undoubtedly require the provision of continuing formal education to assist PVPs in keeping abreast of a complex and dynamic area of epidemiology.

I propose that DAERA should therefore ensure PVPs are well informed and confident in advising herd keepers in relation to the bTB Programme, the risk of bTB to their herd, and mitigating measures they can take.

Furthermore, whilst there exists a generally strong underlying framework of good relationships between PVPs and local DVOs, protocols will need developed and refined to ensure coordination, good communication, demarcation of roles and responsibilities in relation to bTB breakdown management between Veterinary Officers and PVPs. Building upon PVP and local DVO/Patch Vet relationships will only serve to enhance bTB breakdown case management and assist in our efforts to tackle this disease.

The governance of bTB testing and the provision of supervision of PVPs is a critical issue and a keystone of the bTB Programme, however the delivery of supervision has been reduced in recent years due to resource pressures.

DAERA has a legal obligation under the Animal Health Law (AHL) to ensure that bTB testing is performed correctly with the provision of testing and its associated services subject to a contractual agreement with PVPs. The aim of the contract is to maintain and improve the quality of skin testing to support ongoing disease control, to ensure that charges for testing reflect the cost of delivery, and to ensure that there is a process to address poor performance where it is found. Recognising the limitations of the skin test as regards sensitivity, it is fundamental that high quality testing is delivered to all our herd-keepers and there should not be, nor will there be, any toleration of substandard testing. Therefore, it is essential that appropriate monitoring/supervision of test quality is prioritised and conducted on a continuous basis.

Concerns over the quality of bTB testing by PVPs has arisen previously across the UK and a number of EU countries, with stricter enforcement rolled out by state authorities as a consequence.

Whilst many PVPs are opposed to such supervision (objecting on the basis that it brings their professionalism into question), this will be an integral part of the programme and a necessity for overall stewardship of the programme. **I propose that a review of the criteria used to monitor testing performance should be initiated ensuring learning and good practice is availed of from other competent authorities across the British Isles.**

(ii) Abattoir Surveillance

Over the last 12 months, there has been a notable increase in the frequency of tuberculous lesions (**Figure 4**) being detected during the routine slaughter of healthy animals highlighting the importance of this surveillance strategy (and indeed its current high-quality delivery), but also raising significant concerns around the background disease level and functioning of the programme in its current state, further emphasising the need for additional actions.

Objective monitoring systems are currently in place across all abattoirs, and I **propose that this will be supplemented with refresher training to all Veterinary Public Health Programme (VPHP) staff highlighting the significance and value of this surveillance method** and the need to ensure it is vigorously and uniformly applied.

(iii) Tuberculin

Tuberculin (protein purified tuberculin; PPD-A, PPD-B) is the antigen that is injected intradermally as part of the skin test that then elicits a delayed immune response in bTB infected animals. The processes by which current tuberculins are produced do result in large variability between tuberculin batches (Good and Duignan, 2011). Development of synthetic tuberculins is ongoing and field trials are actively underway (Middleton et al., 2021). While the focus has largely been on the development of tuberculins for use in BCG vaccinated cattle, work is also progressing for the future provision of a more stable and standardised product for more general use.

I propose that PVP and DAERA staff training includes enhanced awareness about, and the need for compliance with proper cold storage of tuberculin, particularly in the field (a simple but important practical issue required to maintain maximal efficacy for this biological product).

Management of infected herds

Eliminating disease from bTB infected herds, reflected by both the prolonged and recurrent nature of bTB in NI herds, is a key challenge to the eradication of bTB. The fundamental problem revolves around the phenomenon of residual infection arising from the limitations of the skin test to detect all infected animals within an infected herd. These animals are likely to be at different stages of infection, and going forward, pose a risk to cohorts, neighbouring herds, wildlife, and other herds they may subsequently move to following derestriction. The risk posed by such animals is magnified should such movements involve breeding animals.

In this context, and as previously discussed, large breeding herds and beef finishing herds contribute a substantial burden on the bTB eradication programme budget through the disclosure of skin test reactors. However, beef fattening/finishing herds may be considered as ‘collectors’ of skin test reactors through cattle purchases from numerous sources with the slaughterhouse being the primary destination for cattle from these herds. While there may well be spread of bTB infection within such herds, the threat of spread to neighbouring herds and local wildlife can be negated through the use of effective good biosecurity measures. It needs to be ensured though that these biosecurity measures are verifiable and are checked regularly. Spread within herd can also be mitigated through a shortened finishing period. In contrast, large breeding herds especially have the challenge of intra-herd spread and furthermore, they can also contribute to infection dispersal to other herds through the spread from the sale of infected cattle. Different strategic approaches may need to be developed to manage these differing epidemiological risks posed by the various cattle industry sectors.

The following tools are available to support the prompt identification and removal of infected animals.

(i) Consideration of the criteria for the suspension or withdrawal of Officially Tuberculosis Free (OTF) status

The threshold for the suspension (OTS) or withdrawal (OTW) of OTF status has very important implications for disease control. With the current NI bTB prevalence levels, there is a need to maximise control efforts in infected herds and to minimise the problems of residual infection and infection risk associated with animal movements.

We are already aware of the residual infection risk at time of derestriction and the fact it is exacerbated by current legislation where previously broken-down herds can effectively be open and clear to trade following two successive clear tests 60 days apart.

It is therefore critical that we do not inadvertently weaken our existing disease control regime by incorrectly classifying a herd as OTS. Current policy is that OTS herds are only required to have one clear herd test (under standard interpretation) before being derestricted and open to trade. This includes the scenario where a singleton skin test reactor has been detected at the disclosure test with no confirmatory post-mortem or laboratory findings. On the other hand, all OTW herds are subjected to a minimum of two herd tests under severe interpretation before being derestricted.

Given that the management of OTW and OTS herds differs (e.g. the number of clearance tests required, the type of interpretation and epidemiological investigation), a review of the qualifying criteria is required based on epidemiological research to ensure that adequate and proportionate disease control measures are being applied.

Future herd bTB risks are generally not associated with either detection of lesions at slaughter nor lesion confirmation but instead with the size/severity of the breakdown, herd type and previous history (Doyle et al., 2014; O’Hagan et al., 2018). It should be noted however that the risk persists for an extended period post derestriction. The specificity of the skin test should also be considered in such discussions.

On that basis, **I propose that OTS herd classification should only be considered for those herds that have an unconfirmed LRS or inconclusive skin reactors (ICs).** All herds which disclose reactors at skin test should automatically be classified as OTW as based on the high specificity of the skin test (Doyle et al., 2014; O'Hagan et al., 2019) the chances of false positives are rare.

There is conclusive evidence in infected herds that animals which are positive under severe interpretation, or inconclusive under standard interpretation pose a future infection risk as well as those testing positive to IFNg (Clegg et al., 2011a; Clegg et al., 2011b; Georgaki et al., 2022).

Following on from the above section, the classification of singleton reactor herds as OTW and the subsequent move to severe interpretation when one reactor has been disclosed at the test will improve sensitivity, facilitating the prompt removal of disease and mitigate against the possibility of residual infection in the herd. Whilst there may be a marginal drop in specificity, given current prevalence levels, enhancing test sensitivity is more of a priority and long-term benefit to disease eradication. In line with current policy all tests in OTW breakdown herds should be interpreted under severe interpretation and thus the above proposal will result in increased use of severe interpretation.

(ii) Inconclusive skin reactors (ICs)

As referenced above, the retention of previously inconclusive skin reactors (ICs) within a herd carries with it an increased disease risk. ICs identified at routine herd testing pose both a short- and long-term risk of bTB spread with ICs that were slaughtered before their next skin test being 100 times more likely to have bTB like lesions at post-mortem and those that were retested being 1.4 times more likely to be a reactor (Clegg et al., 2011a, Clegg et al., 2011b). Similar findings were found in GB (Brunton et al., 2018) and NI (Georgaki et al., 2022).

Despite these risks such animals are currently free to move subject to completion of a negative skin test 6 weeks post initial disclosure.

Given the enduring risk associated with such animals, **I propose the following measures:**

- **Restriction of all future resolved ICs to herd for life.**
- **Use of IFNg testing 2 weeks post disclosure of the inconclusive animal, as detailed below (IFNg testing section).**
- **Re-introduction of policy to remove any historical ICs disclosed in past breakdowns during any subsequent breakdowns in that herd, a policy that was suspended in 2023 in response to bTB Programme financial constraints.**
- **That all herd keepers with historic ICs in their herds should be made aware of the presence of such animals in their herds, and the associated risks, along with a recommendation that they should be culled at the earliest opportunity given their inherent disease risk.**

There is also an opportunity for machine learning and artificial intelligence (AI) to be applied across the bTB Programme to identify high risk herds/animals, which will be discussed in more detail later.

(iii) Compulsory parallel IFNg testing

Similar to above, animals that are positive to IFNg testing are at a much higher risk of subsequently going down at a skin test (Lahuerta-Marin et al., 2015).

Along with the skin test, IFNg is an EU accredited test for the purposes of bTB eradication. A benefit of IFNg is that it is more sensitive than the skin test (especially under standard interpretation), (Clegg et al., 2011c) enabling the identification of infection missed by the skin test. However, it is recognised that the specificity of the test is not as high as the skin test, and currently IFNg testing is focused on high-risk herds or high-risk groups within the herd to improve the positive predictive value of the test.

The use of IFNg testing has been central to eradication campaigns in the Republic of Ireland and GB playing a pivotal role in driving down disease incidence, enabling the quicker clearance of disease from infected herds and reducing the risk of recurrence through residual infection. Research conducted in NI indicated that animals which tested IFNg positive were 2.31 times (95% CI: 1.92-2.79; $P<0.001$) more likely to become a reactor compared with IFNg negative animals (Lahuerta-Marin et al., 2015). Removal of IFNg positive animals can therefore reduce residual burden of infection.

In response to the financial pressures in 2023, IFNg testing was reduced from a capacity of 3,000 tests per month to approximately 14,000 annually. In line with previous TBES eradication proposals, **I propose that IFNg testing is reinstated to target levels (36,000 in 2025/26, 45,000 in 2026/27) and also made compulsory when required** (following assessment) given that currently it is subject to herd keeper agreement (except in those cases when considered necessary in the investigation of atypical bTB breakdowns).

Additionally, as proposed above IFNg testing should be used on ICs following disclosure at routine herd tests similar to the policy used in the Republic of Ireland. Essentially all ICs are subjected to IFNg two weeks post disclosure with positive animals removed and negative animals subjected to a further skin test as currently takes place, albeit remaining restricted to herd for life.

The recent programme changes as detailed above, which had to be made in response to the financial constraints, and the necessity to live within budget over the past year, are likely to have paradoxically contributed to the increasing disease levels and associated costs that we are currently experiencing.

(iv) Full and Partial Depopulations

It is known that herd depopulation (full and partial) due to bTB outbreaks are effective in enabling herds to attain and retain bTB freedom following restocking (Good et al., 2011) and is a policy tool currently availed of to assist with the prompt removal of infection. Such action mitigates against the potential of residual infection establishing within a herd.

Use of partial and full herd depopulation should continue to be judiciously used following a full epidemiological investigation and consideration of key elements related to this intervention measure. Elements considered in decision making include the future risk of infection in the herd and the deliverability of effective measures to prevent re-introduction of bTB following partial/full depopulation.

Current policy dictates that a fallow period of 120 days must be observed before restocking is permitted. To support business continuity, **I propose that this time limited measure is replaced with a risk-based disease control assessment aligned with AHL.**

(v) Restocking after bTB Breakdown and Application of Severe Breakdown status

Prior to the introduction of AHL, EU legislation prohibited the movement of cattle onto confirmed bTB establishments until all remaining cattle in the herd had undergone one clear test. However, DAERA policy, in contravention of such legislation, has been to permit the unlimited introduction of animals except when a bTB breakdown is classified as a severe breakdown. This particular former non-compliance had been raised in previous FVO audits of the Department's bTB eradication policy.

Severe Breakdown Status and Purchasing Policy

Severe breakdown status is currently applied to those breakdown herds where the disease situation is assessed as 'not under control' with subsequent movements into the herd immediately prohibited.

Current DAERA policy is that a severe restriction should generally be applied in cases where any of the following criteria apply:

- There is a total of 10 or more reactors at a test;
- >25% of the herd are reactors at a test;
- The total number of reactors and subsequent LRS animals since day one of the last skin test is 10 or more;
- In herds with repeated numbers of reactors/LRS animals over a number of tests (e.g., on-going reactors or LRS animals over a period of 3 herd tests or more); or
- Prior to depopulation.

Severe restriction is also applied in the following circumstances:

- When an animal has clinical signs of bTB;
- For 120 days after full depopulation.

Existing policy also recognises that it may not be appropriate to apply the restriction in certain beef fattening herds despite meeting the criteria, and also that there may be other herds where it may be appropriate to apply the restriction when they do not meet the specific criteria. In such instances, any decisions taken are only done so following a comprehensive epidemiological risk assessment.

Presently, a severe restriction is usually only removed when a herd has had at least one clear restricted herd test (RH1) and has completed C&D, thereby providing an assurance that the disease situation has been brought under control.

However, there is provision for consideration of movement of animals into the herd under licence to maintain business viability. Such an arrangement is only permitted if it is assessed that there is a minimal risk of further disease transmission to the purchased animals.

I propose that a review of the criteria for application of a severe herd restriction is revised with consideration given to the inclusion of the role of cattle-to-cattle transmission.

Purchasing & Animal Health Law Implications

The AHL requires the completion of C&D prior to restocking of breakdown herds and, when considered necessary, DAERA must restrict the movement of animals into the establishment as opposed to the prescriptive nature of the preceding legislation which required a clear herd test in advance of such activity.

It would seem logical to limit if not prohibit the introduction of susceptible animals to a breakdown herd where such animals are at risk to exposure of *M. bovis*, until such times as the risk of infection within the breakdown herd has lowered. Furthermore, there is also the moral responsibility to not continue adding 'fuel to the fire' and expecting the risk to be covered by the public purse.

This is further highlighted by the fact that over the past 2 years, a total of 2,342 animals which had moved into herds during the course of a breakdown were subsequently compulsorily slaughtered during the same breakdown (2,242 reactors, 22 Negative in contacts & 78 IFNg positives).

Therefore, there needs to be balance struck between restocking for farm business viability and protecting 'bought-in' animals from unacceptable risk of bTB infection. Allowing the introduction of more animals into a high-risk environment early in a breakdown episode to allow them in turn to be infected is not a sound basis for disease elimination nor is it morally acceptable.

Breakdown Herds - Purchasing Proposal & Compensation

I propose that future purchasing policy in bTB breakdown herds aligns with AHL and its supplementary legislation, requiring both C&D and a proportionate risk assessment to mitigate against the further transmission of disease. Furthermore, I propose that all purchases/introductions during a breakdown including animals moved in under licence which are subsequently compulsorily slaughtered due to bTB during that breakdown are subject to a reduction in compensation. (e.g. other jurisdictions such as England pay 50% compensation). It should also be noted that the herd-keeper will have the alternative option, in such circumstances, of taking the positive animal to an abattoir, under license, on an “owner’s risk” basis.

Previously there have been instances when herd keepers have purchased animals in contravention of notices preventing the purchase of animals. In such cases, **I propose that compensation for these animals should be further reduced if they are subsequently required to be slaughtered due to bTB during that breakdown.**

Information on bTB compensation will be further illustrated in the finance section below.

The question may inevitably arise whereby it is hypothesised that infection was actually purchased, as opposed to obtained within the herd. In such instances it will be up to the farm business to source cattle responsibly, thereby mitigating such risk. To support responsible sourcing, it is proposed that the Department provide such information to all herds as suggested under the ‘Informed Purchasing & Risk-based trading’ section below.

(vi) Chronic herds

One area of particular importance to NI in relation to bTB is how certain herds seem to have a much greater propensity to develop prolonged and recurrent breakdowns; with the term “chronic bTB herd” applied to them (Doyle et al., 2016; Doyle et al., 2020; Doyle et al., 2022).

The problem with these herds is that they generate large numbers of infected animals and, thus present a significant financial burden to government in terms of compensation payments and an enhanced risk to any other herds epidemiologically linked to them.

This subject area has been debated for many years with an initial internal DAERA report (Abernethy, 2005) defining such herds as those which disclosed skin reactors in at least three tests within two calendar years.

Using this definition, it was shown that the number of chronic bTB herds was increasing (1996-2000 - 18% vs 2001-2003 - 27%) and that in the period 2001 to 2003, these 27% of herds contributed 56% of the total number of skin reactors.

Chronic bTB herds were also highlighted in the TB Strategic Partnership report as an area requiring focused research to provide possible solutions to this long-term problem (TBSPG, 2016).

Chronic bTB was formally investigated in the "Chronic bTB Herds Project' with the purpose of this study to use data in the national database APHIS (Animal and Public Health Information System) to perform an analysis of potential associations to prolonged and recurrent bTB herd breakdown periods.

These definitions (prolonged breakdowns; (with duration > 12 months) and recurrent breakdowns (those which have two further breakdowns within the two years following the initial breakdown which lasted less than one year)) demonstrated that 40% of all skin reactors were encompassed within these chronic breakdowns (Doyle et al., 2016).

One of the main reasons for these observations in NI cattle herds is internal infection spread directly between herd members. Indeed, work such as Conlan et al. (2012) demonstrated by mathematical modelling that the R_0 in herds of size 30 to 400 varied from 1.5 to 4.9 (where no controls were applied) and that up to 50% of recurrent bTB breakdowns in British herds could be attributed to infection missed by tuberculin testing.

A unique opportunity to study internal bTB transmission dynamics was presented in NI work carried out as part of the TVR (Test and Vaccinate or Remove) project. In this study genomic methods based on *M. bovis* isolates from the TVR area showed that transmission dynamics in this area appeared to be dominated by cattle associated transmission (35/37 direct transmission events) with only sporadic inter-species transitions (2/37 direct transmission events) and no badger-to-badger direct transmission events being observed (Akhmetova et al., 2023).

Given present levels of knowledge on the subject it is hard to challenge that a large proportion of the number of bTB reactors in NI are generated from cattle-to-cattle direct infection spread. This means that methods of internal biosecurity should be considered as a potential mechanism to reduce within herd R_0.

Given the high proportion of our bTB reactors being disclosed in such herds, **I propose the establishment of a chronic herd taskforce to deploy enhanced control measures to expedite the removal of infection from these herds.**

Actions required in addition to an in-depth epidemiological investigation will include a more aggressive intervention regime, deploying a range of measures as illustrated below, which are tailored to the individual needs of the farm business.

Recommendations to address chronic bTB herds include increasing farm biosecurity where measures need to be taken to reduce contact between badgers/badger setts/latrines and cattle, reducing potential for indirect spread of infection. Another area where repeat introduction of infection leads to mainly prolonged bTB herd breakdowns is the purchase of bTB infected animals. Recommendations to control this source could include information provision to purchasers about the risk posed by the animals they intend to buy or using more stringent surveillance to prevent the movement of infected animals.

The average size of herds in NI has continuously increased over time and results from this research on chronic bTB herds and elsewhere provide evidence for its role in both prolonged and recurrent bTB herd breakdowns. Thus, for large herds it may be necessary to introduce specifically tailored bespoke controls. These could include the routine use of more sensitive diagnostic testing and possibly more focus on concurrent endemic diseases in these herds (e.g. Johne's control programmes).

One important risk factor for bTB herd breakdowns is the number of disclosing skin reactors and its relationship to recurrence of future bTB herd breakdowns (Doyle et al., 2014; O'Hagan et al., 2018). In situations where there are large numbers of disclosing skin reactors, it may be the case that these herds require longer restricted periods and more herd tests to remove residual infection and limit their ability to trade with herds that are bTB free.

Expanding on the concept of internal herd biosecurity, there are well developed veterinary risk and management plans (VRAMPs) available to control other chronic bovine diseases such as Johne's, the causative agent *(Mycobacterium avium subsp. paratuberculosis (M. paratuberculosis))* which is closely related to *M. bovis* (Strain et al. 2021, Gavey et al., 2021).

Based on first disease control principles, consideration should be given to the application of Johne's infection control programmes in those herds dealing with the duality of chronic bTB and Johne's infection. The hypothesis to be tested in this case would be to disclose a group of herds in NI with both concurrent chronic bTB and Johne's disease (PCR faecal positive herd), apply Johne's controls in the form of VRAMPs, providing enhanced veterinary advice/assistance over several years and then monitor the level of Johne's and bTB on these farms in association with how well they apply biosecurity controls.

(vii) Whole Genome Sequencing

Molecular epidemiology is a well-established discipline with AFBI recognised as a world leader in the development and application of such technologies. It provides insights into the dynamics of infection from both a spatial (including inter and intra species) and temporal aspect providing valuable information on transmission pathways. Whole Genome Sequencing (WGS) is able to facilitate superior disease tracing by defining smaller core ranges compared to the established

Multiple-Locus Variable Number Tandem Repeat Analysis (VNTR). Furthermore, WGS enables the determination of how lineages are disseminated across the landscape, likely via cattle movement (Allen et al., 2024)

It is critical that utilisation of this technology is optimally advanced to ensure that the programme has available the full range of epidemiological information to make informed decisions on existing and future disease intervention strategies.

(viii) Use of private /alternative tests by herd keepers

Currently the only tests approved by the EU for bTB eradication programmes are the intradermal skin test and the IFNg test. The World Organisation for Animal Health (WOAH) have in addition added two further tests to the Register of Diagnostic Kits certified by WOAH as validated fit for purpose for use as supplemental tests for the diagnosis of bTB (WOAH, 2024a). The use of these tests, the Enferplex Bovine TB antibody test (Whelan et al., 2010; Griffin et al., 2011), and the IDEXX *M. bovis* antibody test requires the development of a policy to support those herd keepers who wish to go above statutory requirements by carrying out supplementary tests at their own expense. This policy would also include conditions for the private use of unvalidated tests such as Actiphage and faecal PCR testing (Griffin et al., 2021). The use of such tests must be subject to DAERA authorisation and feedback of results.

It is proposed that such a policy is developed to support herd keepers and PVPs in the private use of these tests similar to that in England. The policy would lay down conditions for the approval of private use of these tests, and also detail follow-up consequences for herds and animals in the event of positive results.

Trials are being carried out in GB on the use of the Enferplex test as a bulk milk screening test in dairy herds. This work is due to conclude in 2025, and if the findings of the trail are favourable, consideration will be given to introducing bulk milk sampling to the bTB Programme as an additional herd screening test. Use of new technologies may well enable the development of other bTB tests, which can be encompassed using the above approach.

(ix) Pembrokeshire project trial & Risk rate

The Welsh Pembrokeshire project is part of the Welsh five-year bTB delivery plan aimed at tackling the deep-seated levels of infection in parts of Pembrokeshire where bTB incidence and prevalence have worsened (Welsh Government, 2023).

The project works with a small sample of farms in Pembrokeshire, with the purpose of empowering vets and farmers to make informed decisions and show leadership in disease control. It develops and implements additional approaches to bTB control, over and above the statutory measures currently used in the area.

The project focuses on identifying residual disease risk in clear testing cattle and develops a pathway for reducing cattle-to-cattle transmission. This includes identification and management of high-risk animals to slaughter and veterinary oversight of biosecurity practices.

The project uses data from previous bTB tests to categorise the bTB risk of animals in conjunction with other herd health parameters. This information is then presented to the herd keeper to assist with decision making.

It is proposed that opportunities for displaying this information to PVPs for use as part of their routine herd health management programmes are explored and trials with interested parties are actively supported by the Department. This is discussed in further detail below under machine learning opportunities.

(x) Machine Learning

Utilisation of emerging technologies to minimise the potential for bTB transmission to herds, within herds and from herds is an active area of research and has the objective of maximising identification of bTB infected herds and animals through the use of existing data processed by machine learning (ML).

This approach has shown promise recently through its application to GB bTB data where a herd model has indicated that herd level sensitivity and specificity of predicting outbreaks would both be increased through its use (Stanski et al., 2021).

ML modelling refers to data driven techniques which detect patterns within data as opposed to process-driven models that rely on understanding system dynamics. Therefore, correlation patterns may be observed that are not obvious to a disease expert that can then be used by the model. Furthermore, inter-correlations within the input variables are also taken into account, all of which have the potential to provide a more sophisticated interpretation of the NI bTB data.

It is proposed initially to explore opportunities to build or adopt a ML model which would accurately predict herds and animals that were infected with bTB by incorporating data directly (e.g. skin test results) and indirectly related to the animal's bTB infection risk (e.g. cattle movements, location) (Stanski et al., 2021). The ability to include other extraneous variables will be explored (such as badger sett density and agricultural land classification) to investigate if they can increase the predictive ability of such models. The first steps into ML application in relation to bTB have been made in NI (McBride et al., 2023) and such research is ongoing.

The individual and herd level data along with other potentially useful data for this approach are reasonably readily available to DAERA, especially through databases already established within DAERA's Veterinary Epidemiology Unit (VEU). There is the added advantage that VEU epidemiologists have a thorough understanding of these data as well as of bTB epidemiology within NI.

The potential exists for the end product from this project to be used as a practical decision-making tool assisting in the disease controls process involved in the bTB control programme e.g. what additional animals should be targeted in a bTB breakdown for removal as having a higher probability of being infected with bTB and that have not been readily identified by diagnostic tests.

Protection of clear herds - reducing the risk to other herds

(i) Restrictions & Risk Based Trading

The current bTB eradication programme (as per EU regulations) requires two clear sequential intradermal tuberculin tests at herd level to be de-restricted and obtain freedom to trade animals with other cattle herds and doesn't consider such herds to be of any greater risk than non-infected herds.

There is conclusive evidence that herds with a recent history of infection are at a continuing risk of infection for an extended period (5 years +) after de-restriction with level of risk linked to type and severity of initial breakdown (Doyle et al., 2014; O'Hagan et al., 2018). It could be argued that EU legislation is at odds with scientific thinking.

Once bTB becomes established within a herd, it is very difficult to ensure its 100% clearance, especially so within the large intensively kept herds. **Figure 9** helps to illustrate this particular aspect of the disease highlighting the fact that we really need a minimum of 5 years clear herd tests to be sure a herd is actually clear of infection.

This is due to a combination of reasons but primarily as a result of residual undisclosed infection remaining on farm and also environmental persistence (from wildlife/infected animals) of *M. bovis* subsequently re-infecting animals. Subsequent purchases are also a contributor (Doyle et al., 2017).

Current policy does not impact on the free movement of animals once derestriction has occurred bringing with it the potential for onward spread of infection unknowingly to other herds. Compromises need to be sought to limit the disruption to farm businesses whilst also managing the heightened risk that can persist for an extended period following infection and subsequent de-restriction. To better address this immediate risk following derestriction and protect non diseased herds, **the following proposals are suggested:**

1) Extension of Restricted period

To offset part of the risk associated with the movement of undisclosed infected animals post de-restriction it is suggested that, if possible, under EU legislation, herd restrictions remain in place until the 6-month check herd test is completed. This is particularly relevant for those herds which have experienced a severe breakdown, and where the risk of residual infection is inherently higher.

2) Restriction of high-risk cohort animals

It is proposed that those animals identified as high-risk cohorts during the breakdown (i.e. those animals in the same batch as the reactors), and again, particularly in those severe breakdowns, should be restricted in the herd for a minimum number of years (ideally for life) with direct movements to slaughter only permitted. This is especially the case for breeding animals as opposed to young dry stock.

3) Informed Purchasing & Risk based trading

As mentioned earlier, the application of risk-based trading has been a key component of successful eradication schemes across the world, both from a need to address the residual disease issue but also to support a progressive disease eradication strategy on both a herd and regional basis (Adkin et al., 2016a; Adkin et al., 2016b; More et al., 2015).

Whilst consideration and respect need to be given to the commercial/economic importance of cattle trade to the NI farming sector/rural economy, there is an inherent moral responsibility that movements of high-risk animals are appropriately communicated and discouraged.

It is proposed that all herd keepers within NI receive a bTB herd classification rating denoting their number of years clear (+/- no of breakdowns they have had within the last 5 years).This information should be made available during all cattle trading, both private sales and those through the market so that the purchaser can make an informed decision given the potential future impact any such decision may have.

Years bTB free herd demographics

Herds with a recent history of bTB are known to be at higher risk of future bTB herd breakdowns (Skuce et al., 2012). Therefore, animals from herds that have been bTB free for an extended, consecutive period may be considered as posing less of a bTB risk. Arguably, herds with 5 or more years of freedom from bTB may be used as a reasonable proxy for herds using higher than average farm biosecurity management practices.

Using the NI bTB test results (2016-2023), an estimated national profile of the annual number of herds and animals that were be considered bTB free over the calendar years can be constructed based on the disclosure of skin test reactors (**Table 4**). In this table, the calendar year 2023 is represented by ‘0 years bTB free’ while being bTB free for 8 or more years are those herds that have not disclosed a skin test reactor since or before 2015. The table indicates that over 60% of herds were bTB free for five or more years with such herds containing 37% of the national herd (over half of NI cattle herds were bTB free of 8+ years and contained 28% of the national cattle population). These figures suggest that there may be an adequate capacity to enable informed purchasing to be utilised by herd keepers with respect to purchasing cattle from herds which have a similar or higher number of years of bTB freedom. However, certain sectors, such as the dairy sector, may have less capacity in this respect, given their larger herd sizes.

Years bTB free	Herds	Animals	% Herds	% Animals
0 or more	21,889	1,607,302	100.0%	100.0%
1 or more	18,782	1,099,438	85.8%	68.4%
2 or more	16,950	888,173	77.4%	55.3%
3 or more	15,683	763,474	71.6%	47.5%
4 or more	14,627	668,718	66.8%	41.6%
5 or more	13,752	596,669	62.8%	37.1%
6 or more	12,814	532,882	58.5%	33.2%
7 or more	11,935	476,039	54.5%	29.6%
8 or more	11,364	448,313	51.9%	27.9%

***Table 4:** Estimated number of NI cattle herds and their animal counts by years free of bTB based on having no skin test reactors (2016-2023 calendar years). Animal counts are based on 2023 data*

4) Pre-movement testing

The introduction of AHL brings with it the requirement for pre or post movement testing of all cattle over 6 weeks of age. There is a derogation whereby the movement test may not be required where the animal has received a clear bTB test within the previous 6 months and comes from a herd that has also had a clear bTB test in the last six months. There can be a perception that there is currently an increase in frequency of moves in advance of bTB herd testing with associated risk of the movement of undetected infected animals. Introduction of such pre-movement testing should take place as soon as possible to mitigate such risks and equally deliver compliance with legislative requirements.

Given the high level of bTB across NI at present, and subject to public consultation, consideration should also be given to not applying the derogation and therefore requiring a pre-movement test for all cattle moves (where the animal has not been tested in the last 30 days).

5) Post Movement Testing

Subject to arrangements regarding pre-movement testing, it is proposed that (in the interim and before the introduction of any risk-based trading regime be implemented in NI) consideration be given to the introduction of post movement testing for those animals that are moved from a high to a low-risk herd no later than 30-days post movement at the herd keeper's expense.

At this stage of the eradication programme, it would not be proposed that further measures are applied such as additional herd testing or a reduction in compensation for so called high risk moves. However, as progress to eradication continues this position should be reviewed and given consideration.

(ii) Movements out of bTB breakdown herds under certain conditions

We recognise that when a herd is restricted for an extended period, overstocking and cashflow difficulties can occur. Whilst movement restrictions are required by law and these laws exist to mitigate against disease spread, we do believe that where suitable destination herds are identified, moves of lower risk animals (excluding breeding animals) could be justified subject to risk assessment and stringent biosecurity measures

Alternative Control Herds (ACHs)

The aim of ACHs is to control bTB by containment rather than the removal of the disease. ACHs were to be permanently non-grazing herds operating under an agreed protocol including strict biosecurity conditions to prevent the spread of disease to other establishments. Strict controls on slurry were required, and as part of the original protocol for an ACH, bTB testing was not compulsory, but could be imposed in exceptional cases if deemed necessary.

There have never been any approved ACH herds in Northern Ireland, although there has been occasional interest, however, no producer has ever been able or willing to operate under the strict conditions required for an ACH, even with the option of not requiring testing for bTB.

The revised legislative rules, as set out in Regulation EU 2020/689 supplementing the AHL provides derogations from the restriction of movement of animals from infected establishments and lays down conditions for such movement, including that the animals are kept in a closed facility. The derogation also states that the animals shall only move from the receiving establishment directly to slaughter. However, there is no derogation which would permit the removal of the obligation for operators of such establishments to obtain and maintain disease free status, meaning that the existing requirement not to test in these premises would remain non-compliant with the AHL. On that basis ACH would be required to undergo annual testing. Under current domestic legislation this would require compensation to be paid for cattle subsequently removed for disease control.

A key change in the revised ACH criteria, which had been developed in conjunction with the TBEP, is a relaxation on the rules regarding the disposal of slurry. As this had been a key barrier to uptake previously, it is hoped that this will be sufficient to generate new interest in establishing ACHs by operators. While not explicit in the criteria, it may also be possible for an operator to have separate facilities for rearing and finishing cattle, provided that these are considered to be the one establishment. Another major change is that a selling disease restricted herd does not have to demonstrate severe welfare problems to move cattle to an ACH.

I would propose that the Department work with industry to facilitate the establishment of ACHs similar to the Controlled Finishing Unit model used in the Republic of Ireland, as the ACH criteria (with robust biosecurity) forms a reasonable basis for mitigating against the risk of onward spread of bTB to other herds.

(iii) Genetics

Scientific research has demonstrated that there is a genetic component to the susceptibility of cattle to bTB with recent advances in genome mapping identifying that it is possible to breed for bTB resistance (Bermingham et al., 2014; Richardson et al., 2014; Ring et al., 2019) with the heritability assessed to be around 6-18% (Banos, 2023).

It has been demonstrated that bTB reactors are 26% more prevalent in cattle with the worst genetic merit for bTB resistance compared with the best genetic merit. Selection for bTB resistance should be an essential component of a holistic eradication strategy. Genetic indices have been determined for a range of breeds and particularly within the dairy sector. It is critical that industry and particularly the dairy sector promote the use of sexed semen from bulls with favourable bTB resistance figures.

It should be noted that genetics advances are permanent and cumulative and breeding for bTB will increase sustainability and profitability across all sectors

Furthermore, the recent launch of the Sustainable Ruminant Genetics (SRG) programme for Northern Ireland, as part of the future farm sustainability programme, provides the platform for DAERA to promote and both directly and indirectly incentivise the use of bulls with the relevant breeding indices.

Future opportunities afforded through an integrated genetics programme include identifying higher risk animals within herds and assisting decision making with purchases and repopulation.

(iv) Herd Health Management and Biosecurity

In relation to herd health and bTB disease control, biosecurity is defined as the strategy of management practices to prevent the introduction of *M. bovis* to the herd and also the control of spread of bTB within the herd.

Biosecurity can also be viewed as 'bioexclusion' which relates to the preventative measures designed to avoid the introduction of *M. bovis* and 'biocontainment' which relates to the measures to limit within farm transmission and onwards spread to other farms.

Biosecurity is a critical aspect of good farming practice and fundamental to protecting a herd from the spread of a broad range of infectious agents. Despite this it is largely a voluntary activity across Great Britain and Northern Ireland particularly in the cattle sector.

Farm biosecurity is generally regarded as poor in NI (O'Hagan et al. 2016a; O'Hagan et al., 2016b), in part due to farm fragmentation and animal movement. This is further reflected in the need for national eradication programmes as opposed to voluntary farm-by-farm control, e.g. BVD.

As regards bTB, the risk factors are increasingly understood, many of which relate to biosecurity risks. At its broadest level, there are two key biosecurity related risks

- Contact (direct & indirect) with undisclosed infected cattle either via animal movements or contiguous contact
- Contact (direct and indirect) with infected wildlife

In relation to 'contact with undisclosed infected cattle', risk mitigation measures are well understood and reasonably robust. Such strategies revolve around:

Control of cattle Movements - Maintaining a closed herd, minimising number of purchases and when necessary, ensuring responsible sourcing from high health herds, obtaining previous testing history at herd and individual animal level, along with pre-movement testing.

Contiguous spread - Attention to boundary fencing to prevent nose-to-nose contact and minimising farm fragmentation risk, where possible.

Considerable empirical evidence exists highlighting the impact of good biosecurity on infection risk, both for bTB and other transmissible diseases, e.g. Johne's and BVD. In relation to contact with infected wildlife the situation is more problematical giving the shared environment that both species occupy. However, despite this there are a number of actions that can mitigate against the risk of disease spread between species. These include addressing risks at both pasture and housing.

Infected cattle or wildlife may shed *M. bovis* in their faeces, urine or saliva, which can contaminate the farm environment. Experimental studies have shown that cattle can become infected with *M. bovis* by consuming feed and using troughs contaminated by infected wildlife (Palmer et al., 2004). Research also suggests that *M. bovis* can survive in stored slurry for up to 6 months (Scanlon and Quinn, 2000) and on pasture can survive in cattle faeces for up to

2 months in warm summer conditions and up to 5-6 months in cold winter conditions (Williams et al., 1930). Slurry spreading can produce aerosols containing *M. bovis* and studies have shown that there is an increased risk of bTB infection for cattle grazing land on which slurry was spread in the preceding 2 months (Griffin et al., 1993). The longer manure and slurry can be stored, and the longer land where it is spread is not grazed, the lower the risk. Herd biosecurity considerations should therefore be comprehensive, and not overlook the risk from specific practices on farm such as the handling, storing and spreading of slurry and manure.

DAERA had previously rolled out completion of a herd biosecurity questionnaire as part of the 2016 PVP TB testing contract. However following review, it was deemed that the existing process was not fit for purpose as the biosecurity information was not available to DAERA to assist with epidemiological investigations. Therefore, the requirement to complete the questionnaire ceased in April 2023.

I would propose that the Department explore a number of options related to the provisions of biosecurity advice guidance and engagement with farmers and wider industry.

Firstly, **a biosecurity assessment protocol should be refreshed and, subject to PVP engagement, reinstated ensuring that the process is 'fit for purpose' and delivering on agreed objectives.**

Secondly, **consideration needs to be given to ensuring any future DAERA financial support schemes including the future farm sustainability payments are aligned with animal health and welfare and disease eradication requirements.**

This could take the form of supporting the inclusion of basic biosecurity tools and processes as part of the new farm sustainability funding package (identification and fencing off badger setts/latrines), any future farm business investment schemes (badger proofing farmyards) and environmental programmes (e.g. double fencing) for the installation of physical biosecurity measures.

Thirdly, **consideration should also be given to linking compensation to good biosecurity, with the benefits focused on those farm business who implement proportionate biosecurity practices as outlined above.**

Fourth, **additional work is required in relation to advancing the use of 'Improvement notices' and formal enforcement in the event of deliberate biosecurity breaches** which pose an unacceptable risk to both the host herd and others.

Lastly, there is also an opportunity for knowledge transfer and best practice demonstrations in this area using a combination of Department advisors, accreditation bodies, processors, private vets, retailers, best practice farms and social scientists, all supported through a vigorous communications campaign.

This may also be supplemented with specific one-to-one biosecurity engagement, when resources permit, taking lessons learned from deployment of such initiatives in England though the TB Advisory Service and the Animal Health and Welfare Pathway. Implementation of such also builds on the recognised need for specific engagement on the matter of biosecurity, as detailed within the TBES which recommended that DAERA work with the TBEP, industry, PVPs and the College of Agriculture, Food and Rural Enterprise (CAFRE) to develop an integrated approach to improve herd health management on farms, and at marts and agricultural shows.

(v) Farm Fragmentation

Farm fragmentation has been identified as a significant risk factor in the epidemiology/spread of bTB, largely due to the increasing risk of contact (direct and indirect) with undetected infected cattle and infected wildlife. It has often been described as one of NI farming sector's biggest weakness

In NI, approximately 30% of farmland is rented as conacre. Despite the obvious disease risks, there are a number of underlying and understandable reasons why cattle farmers are limited in what they can do to reduce farm fragmentation. Firstly, the availability (turnover) of land coming on the market in NI has been historically lower than average in comparison with other countries/GB. Coupling this with the production pressures associated with a global marketplace and historical EU common agricultural policies has established a pent-up demand, accentuating the extent of fragmentation.

The majority of farmers dislike having to conduct their operations over multiple land parcels but feel constrained with no viable alternatives available. Whilst there has been an increasing trend towards intensification and particularly zero-grazing in the dairy sector with less cattle being grazed, this has not been associated with a reduction in fragmentation.

Currently bTB infected herds are not prohibited from making intra-herd moves and using conacre or land parcels distinct from their main holding. Furthermore, there are no records of such moves officially documented.

Whilst acknowledging the underlying reasons behind farm fragmentation, there is also **a need to balance such farm business arrangements with good disease control principles and give serious consideration to the application of 'restricted grazing' notices.** Similar measures were used successfully during the Brucellosis eradication scheme and are measures which could and should be successfully extrapolated over to the bTB eradication scheme.

3. Wildlife

Current scientific knowledge reveals unequivocally that badgers play a key role and are an important contributor in the epidemiology of bTB in cattle with the same strain types isolated from both cattle and badger populations sharing the same environment (Courcier at al., 2018; Byrne et al., 2024).

Badgers are an important maintenance hosts for *M. bovis* acting as a reservoir of infection with spillover of infection to cattle on the island of Ireland, in Great Britain and likely in other parts of Europe as well.

As detailed at the outset, in complex disease systems such as *M. bovis* infection in animal populations, eradication will only be possible if all factors contributing to its spread and persistence are addressed. How to reduce the prevalence of *M. bovis* in the badger population has been subject to much scientific and public debate with often polarised views between farmers, vets, scientists, environmentalists, policy makers, politicians and the general public. For example, many environmental groups in NI and GB refute the need for any wildlife control at all (even vaccination), a position opposed by many in the agriculture industry who argue that only the intensive culling of infected wildlife will result in a change to the disease picture here.

Comparatively, in a New Zealand context, possum control as part of the bTB eradication programme has been contested by the public because of the method of control, but the necessity of wildlife control has been generally accepted.

This has been a key lesson taken from the experiences of successful eradication schemes in other countries, with the presence of an infected wildlife reservoir being recognised as a key constraint to bTB control and eradication.

It is generally accepted that badgers can seed the infection into the cattle population where it is subsequently multiplied through cattle to cattle transmission (Griffin et al., 2023). Modelling of data from England indicated that around 6% of bTB herd breakdowns were directly due to badger-to-cattle transmission but the overall contribution (when onward cattle-to-cattle transmission was taken into account) was approximately half of all bTB herd breakdowns (Donnelly and Nouvellet, 2015).

Several large-scale culling projects have demonstrated substantial and sustained reduction in the bTB risk of associated cattle herds, with the impact noticeably greater in the Republic of Ireland (four area trial; Griffin et al., 2005a; Griffin et al., 2005b) than Great Britain (randomised badger culling trial; current industry-led culling projects).

Utilising basic epidemic disease theory and the concept of the R_0 (the expected number of secondary cases caused by a single infectious individual) in a multi-host system the number is influenced by both within and between species transfer. In order to get the R_0 below one (i.e. infection under control), it is necessary to address all causes of spread and persistence (O'Hare et al., 2014).

Consistent with such theory, options to limit transmission from badgers to cattle (mainly indirect transmission via contamination of the shared environment) the following options are available:

- Reduction of infected load in the badger population through either culling or vaccination or a combination of both.
- Improved biosecurity to limit both direct and indirect contact. These issues have been discussed under the biosecurity chapter.

As regards wildlife/badger intervention, only two options are available (or combinations thereof)

- Reducing the population of susceptible individuals through badger vaccination.
- Badger culling using either non-selective or selective methods

(i) Vaccination

Modelling has demonstrated that vaccination will be effective in reducing the prevalence of bTB in badgers (Aznar et al., 2018; Smith and Budgey, 2021), with apparent success in those field trials conducted in areas that had been subjected to culling interventions previously which had the impact of greatly reducing the infective load and disease dynamics in advance of vaccination roll-out (More, 2023). However, based on experiences in the Republic of Ireland, the introduction of badger vaccination in addition to other control strategies only marginally reduced the overall R_0 for the cattle-badger system below 1 (that is, R_0 = 0.93-0.97) (More, 2019). Vaccination post-cull, appears to be particularly effective, compared to vaccination only (Smith and Budgey, 2021).

Similar findings were reported in GB where vaccination was also found to be effective in high density populations provided annual deployment of a vaccine with an efficacy of 80%, however the effectiveness of this strategy was reduced by the presence of external sources of infection (Hardstaff et al., 2013). Vaccination was reported to be likely to be most effective as part of an integrated disease management strategy incorporating a number of different approaches across the entire host community.

Pseudo-vertical transmission (from adult to young) is believed to be an important feature of *M. bovis* infection in badgers and may be a key factor in maintaining infection within local populations. In infected setts it is therefore plausible that cubs may be infected with *M. bovis* whilst young and logically the force of infection will be greater in high compared with low prevalence badger populations.

The DAERA RTA badger survey, which has been in place since 1998, estimates the badger bTB prevalence to be 21.3% (95% Confidence Interval 17.4% - 25.1%) based on 2023 figures. However, in the Republic of Ireland, levels in excess of 40-50% have been detected in certain hot spot areas (Gormley et al., 2022). Furthermore, in undisturbed badger populations, infected animals are long lived and therefore an ongoing source of infection.

Collectively this raises very significant concerns as to whether badger vaccination alone will be sufficient to limit transmission in the longer term and definitely not in the short-medium term, initially between badgers and then from badgers to cattle, given the force of infection within the badger population.

(ii) Culling

In the Republic of Ireland, a significant reduction in the prevalence of *M. bovis* infection over time has been observed in the proactive culling areas. In GB, an increase was noted where landscape features allowed badgers from neighbouring areas to recolonise culled areas.

Given this background and particular the evidence base from this island and the non-inferiority trial, the current thinking is that culling (selective or non-selective) will be required in areas of high bTB prevalence in advance of mass vaccination, specifically to reduce the prevalence of bTB in the re-emergent badger population, and maximise the opportunities afforded by vaccination through population penetration.

Furthermore, modelling has demonstrated that cattle herd breakdowns and bTB prevalence were most effectively reduced by first introducing a proactive element (such as proactive culling) followed by vaccination or culling (Smith and Budgey, 2021). If this proactive element was avoided, the impact of vaccination alone on bTB prevalence in badgers took many more years to achieve. This idea has been echoed by experiences in the Republic of Ireland, where the introduction of badger vaccination alone in addition to other control strategies only marginally reduced the overall R_0 for the cattle-badger system below 1 (that is, $R_0 = 0.93\text{-}0.97$) (More, 2019), which would mean that an effective vaccination strategy would need to be rolled out for a long time period before having a significant effect.

Whilst a vaccination strategy is our long-term aim, taking into consideration the diverse scientific evidence base and experiences from other countries and given NI's bTB prevalence, the evidence demonstrates that for a vaccination campaign to be successful in the short, medium and long term, population control by either selective or non-selective lethal intervention in order to remove infected badgers is a necessary prerequisite in advance of such activity (Smith and Budgey, 2021).

(iii) Test, Vaccinate or Remove (TVR)

TVR should minimise concerns associated with an indiscriminate cull policy through the selective removal of *M. bovis* test-positive and potentially infectious badgers, thereby reducing disease prevalence and the ongoing force of infection on the residual population, which would already be partially protected through parallel vaccination of test-negative badgers, thereby maximising chances of vaccination only success.

Regardless of approach applied, there will be an enduring need to limit the spill back of infection from badgers to cattle. This brings into question the best approach for the NI situation from a short-, medium- and long-term perspective, and the need to address all routes of transmission simultaneously.

(iv) Alternative Next Steps

Culling of badgers is regarded as unconscionable and unacceptable to certain sections of society. The deeply held beliefs of such people deserve respect as do the beliefs of those who argue that culling of badgers is necessary to reduce the burden of disease on livestock and farmers. The decision as to whether or not to use lethal or non-lethal intervention must be informed by science along with a range of other legislative, economic and social factors. Final decisions have to take into account the irreconcilable differences of different stakeholders and so inevitably requires judgment to be made by Ministers.

If a decision is made not to cull, and should non-lethal interventions prove less effective (as the evidence would point to, Smith et al., 2016; Smith and Budgey, 2021), then progress towards eliminating the disease will be slower and complete elimination may be difficult.

A potential novel wildlife intervention scenario worth giving consideration to is:

From the NI TVR project, we know there can be heterogeneity in both badger density and DPP test-positive badger density (Menzies et al., 2021). The DPP test is now validated as a trap side test for *M. bovis* infection in badgers (median sensitivity of 69%; median specificity of 98% using whole blood; Arnold et al., 2021). This facilitates consideration of using the DPP test within an area to estimate the apparent *M. bovis* prevalence and the density of DPP test-positive badgers.

Therefore, if a TVR approach was undertaken during the first year of a badger intervention, the data obtained would enable the possibility of applying an adaptive management approach, which may vary across different sub-areas of the intervention area.

For example, in some sub-areas, proactive culling or continuation of a TVR approach may be considered the best option due to the relatively high density of DPP test-positive badgers while in other sub-areas it may be considered that vaccination only would be employed.

Annual reviews of the situation can be undertaken to assess whether the approach requires modification e.g. extension of vaccination to cull/TVR areas or vice versa. The added value of having completed a TVR approach in the first year would be the burden of *M. bovis* infection would be reduced through removal of test-positive badgers while a proportion of remaining badgers would be protected against *M. bovis* infection through vaccination hence providing some potential amelioration of any adverse effects of introducing sub-area proactive culling if it was considered necessary.

This proposed intervention programme is seeking to balance competing objectives, namely the requirement for a low prevalence population in which to successfully roll out a badger vaccination programme and mitigate any concerns that a perturbation effect may occur following badger removal.

This approach should signal that government is prepared and committed to implement a radical change in eradication policy. This must be matched by equal engagement and determination from industry stakeholders and a commitment to eradicate bTB in a public private partnership.

(v) Badger Road Traffic Survey

Concerns exist in relation to the validity and precision of results from the badger RTA survey and significant biases (convenience sample) that are inherently present. Validity characterises the quality of conclusions reached relative to the population under survey and the potential to extrapolate this to other populations. Study precision corresponds to a reduction in random error and adequacy to allow moderate variations in infection prevalence spatially and temporally to be detected.

I propose that the Department should continue to develop and implement strategies to at least partly address such concerns including reporting, regional quotas and proactive searching.

(vi) Badger App

DAERA has recently developed a new Application (the App) to enable the recording of badger sett locations across NI. Currently the App is used by DAERA officials to gather epidemiological information as part of bTB breakdown visits.

It is proposed that this App is further developed and adapted to enable farmers and the public to record the location of badger setts across the NI landscape. The provision of such information will support the Department in building its knowledge of the range and location of badger activity throughout the country, facilitating implementation of any future wildlife intervention programme and assisting with any biosecurity advice in relation to wildlife.

(vii) Role of Deer

In some countries, there is evidence that wild deer act as a maintenance host, playing an important role in the epidemiology of bTB. In most areas of the Republic of Ireland, there is no evidence in support of deer acting as a maintenance host for *M. bovis*. However, in certain hot spot areas of Co. Wicklow, the epidemiological role played by deer is uncertain with isolates from cattle, badgers and deer in this area being very closely related, indicating transmission within and between species (Crispell et al., 2020; Ryan et al., 2023).

Whilst high bTB prevalence has been observed in deer in Co. Wicklow, this does not provide conclusive evidence that bTB is self-sustaining in the local deer population, nor, if it is, of the relative contribution of infected deer to local bTB epidemiology (More, 2019)

Currently, there is limited knowledge of the role of other wildlife species, and particularly deer in the epidemiology of bTB in NI, with further ecological and epidemiological research required to assess whether intervention is warranted. In the meantime, **it is proposed that in those geographical areas of concern, deer should be managed to minimise those risk factors that are known to facilitate the establishment and perpetuation of deer as a maintenance host.**

4. Finance

Presently there is a structural mismatch between responsibility, costs and benefits across key programme partners. Essentially the government carries all the responsibility of bTB eradication, is the sole funder but the minor beneficiary. In contrast farmers carry little responsibility for the national programme and are the main beneficiary (market access etc.).

The primary programme beneficiaries have been in long term conflict around the programme and particularly the perceived lack of strategic direction. The government also takes most of (if not all) the criticism for failure to advance bTB eradication.

As outlined in detail above there are a number of difficult but critical decisions that will need to be taken should a path towards eradication be achieved, with one of these being the continued financing of the programme.

In countries where eradication campaigns have been successful, funding models have been critical to progress. In fact, it is this approach which has provided the burning platform required to drive the change and secure ongoing industry commitment. Involvement of industry in both funding (levy on primary producers) and policy development has contributed to such commitment and through peer pressure, of individual farmers to the programme (More, 2023).

(i) Compensation

In 2023/24, £35.7 million was paid out in compensation with general programme administration (testing and administration etc.) incurring a further £20m expenditure. Acknowledging that the costs of bTB to individual farmers, and particularly those experiencing chronic or severe breakdowns, goes well beyond what compensation provides for, the key issue is whether 100% compensation for reactors discourages farmers from taking proactive steps to mitigate the risk of bTB entering and spreading within the herd.

Compensation for diseased animals removed compulsorily by the state is used as a policy instrument to encourage compliance with disease control and eradication (Wolf, 2013).

It has often been stated that 100% compensation contributes to lax attitudes to biosecurity and lack of concerted effort to manage risks (Barnes et al., 2015; Robinson, 2016) a fact that has been corroborated during the 2015 FVO and 2009 PAC audits. This is further reflected with the fact that over the past two years, 2,342 cattle which had been introduced into breakdown herds were subsequently compulsorily slaughtered and compensated for at 100% during that breakdown event.

Creating further moral hazard is the widely held perception that DAERA value animals in excess of current market value, with historical empirical evidence available to substantiate such claims (Abernethy, 2008). There is also the real risk that the current compensation level could distort market signals given current NI bTB incidence levels.

The issue of compensation was noted in the TB strategic partnership report as an area needing reform in order to encourage a shift in culture and attitudes. It was recommended that a cap be introduced without delay followed later with a percentage reduction in compensation paid.

To date, any recommendations to reduce compensation levels from 100% have been strenuously rejected by industry, citing that there will be no acceptance of changes until the issue of bTB in wildlife is addressed through a wildlife intervention scheme.

The main impact of reduced compensation would be on herds affected by severe breakdowns and in chronic breakdowns with repeat disclosure of reactors. There may also be a disproportionate effect on pedigree herds with high value animals, where a cap on compensation may mean a substantial loss on reactor animals.

However, there is a precedent here with the brucellosis programme where compensation was capped and set at 75% for reactors. Application of such an approach across the bTB eradication programme would be expected to act as a driver to change farmer behaviour around biosecurity in its widest context, placing the onus on the herd keeper to protect the health status of his/her herd.

On that basis and as part of a holistic package of measures addressing all aspects of bTB transmission and persistence, consideration should therefore be given to reviewing the compensation package in a graduated manner with regular reviews aimed at influencing and modifying the behaviours of herd keepers in mitigating bTB related risks.

Potential options which should be given immediate consideration include:

- Introduction of table valuation.
- Cap on both pedigree and non-pedigree animals.
- A possible reduction in compensation for animals that are bought into herds during a breakdown or herds which have been restricted for other disease control purposes, and which subsequently are compulsorily slaughtered for disease control reasons during that breakdown.
- Removal or reduction of compensation for contravention of legislative requirements or programme obligations.

In the medium-longer term consideration should be given to the introduction of a flat rate reduction, similar to the recommendation introduced by TBSPG.

Additionally, some recent work has shown that the Department may be overcompensating herd keepers for animals based on erroneous pregnancy data supplied by herd keepers at the time of valuation.

Currently, a DAERA Livestock Valuation Officer (LVO) determines the ‘market value’ for animals removed under the current bTB Programme. It is important to ensure that the ‘market value’ is, as required by legislation, a true reflection of the price which might reasonably have been attained for the animal from a purchaser in the market if it had been free from disease, and that all relevant factors determining that value are considered. This assessment takes all factors into account, such as but not limited to, pedigree, conformation, age, weight, milk recording data, and pregnancy. The pregnancy status is supplied by the herd keeper to the LVO.

The Department does assess and record the pregnancy status of all female animals post slaughter. This data was compared to the pregnancy status supplied by herd keepers for two random days in 2024 (**Table 5**).

It can be seen that between 70% and 77% of female animals were determined to have had their pregnancy status correctly declared (within 1 month of true gestational length) by the herd keeper at the time of valuation. However, between 21% and 26% of the female animals had their pregnancy status overestimated by the herd keeper by between 2 and 6+ months. Some of these animals were barren and not in calf and some had their stage of pregnancy overestimated by the herd keeper. For example, an animal would have been determined to be overestimated by 2-3 months if it was declared as 3 months pregnant and found to be barren. Similarly, an animal would have been determined to be overestimated by 2-3 months if it was declared as 7 months pregnant and found to be only 5 months pregnant at slaughter.

When the above is compared to the number of animals that had their pregnancy status underestimated by the herd keeper, a stark difference is noted. Only between 3% and 4% of female animals had their pregnancy status underestimated by between 2 and 6+ months by the herd keeper.

Stage of pregnancy	Kill of 18 April 2024	Kill of 23 May 2024
Accurate to within 1 month	158 (76.96%)	117 (70.06%)
Pregnancy status on farm overestimated by 2-3 months	36 (17.31%)	24 (14.37%)
Pregnancy status on farm overestimated by 4-5 months	7 (3.37%)	12 (7.19%)
Pregnancy status on farm overestimated by 6+ months	1 (0.48%)	7 (4.19%)
Pregnancy status on farm underestimated by 2-3 months	3 (1.44%)	6 (3.59%)
Pregnancy status on farm underestimated by 4-5 months	1 (0.48%)	1 (0.60%)
Pregnancy status on farm underestimated by 6+ months	2 (0.96%)	0 (0%)
Total	**208**	**167**

Table 5: *Pregnancy status (actual against on farm estimate) of bTB skin reactors at slaughter on 18 April and 23 May 2024.*

Animals that had their pregnancy status overestimated would have attracted a premium payment from the Department due to their incorrectly ascribed pregnancy status.

It is therefore proposed that if herd keepers wish to claim a premium in compensation due to pregnancy status, they must produce evidence of the official pregnancy status of the animal concerned. No animal should have a premium paid for pregnancy if it is not confirmed as being pregnant.

Finally, as disease eradication progresses, further changes around finance and compensation should be considered to drive behavioral change around those risks associated with poor biosecurity and purchasing practices.

(ii) Fraud

Quality control and robust governance processes must be an integral part of any national disease eradication program. Ensuring that all animals presented as reactors are truly so must be a central component of the quality control system.

Fraud risks to the bTB Scheme arise from:

a. false representation of the tuberculin reaction in cattle;

b. false representation of the identity of reactor and/or non-reactor cattle; and

c. false representation of the value of reactor cattle.

Attempts to interfere with the test or corrupt the detection and removal of diseased animals compromises the efficacy of the programme. In addition to the impact on the public purse, fraud distorts veterinary epidemiology and research findings; fuels organised criminality; harms animal health and welfare and it also has a demoralising effect on all stakeholders who are committed to eradication.

Unequivocally, this is one area all stakeholders agree on and are keen to see countermeasures advanced and enforcement action taken on those who tarnish the reputation of the NI agri-food sector through either neglect or deliberate actions.

The Department has a zero tolerance approach to fraud and implements a number of ongoing bTB Programme controls and fraud prevention measures.

I propose that existing control measures are reviewed to ensure that all available tools and enforcement activities are being fully utilised to deter and mitigate the risk of any fraudulent activity within the NI bTB Programme.

5. Regionalisation

(i) Applying a regionalised approach to bTB disease control/eradication in NI

As we are all too well aware, establishing and maintaining a disease-free status in the entire territory of a country can be difficult to achieve. However, subpopulations with distinct herd health status can be established within a country for the purposes of disease prevention and control, and international trade. These subpopulations can be established using either:

- Zoning/Regionalisation - Use of geographical boundaries
- Compartmentalisation - Application of defined management and biosecurity practices

The principle of regionalisation/zoning and compartmentalisation are outlined in the Terrestrial

Animal Health Code of the World Organisation for Animal Health (WOAH, 2024b). In disease eradication programmes, regionalisation is used to create 'risk boundaries' thereby enabling disease control and surveillance to be applied based on risk, to prioritise resource allocation and protect lower risk areas.

Considering the lack of progress over recent years, and as outlined above, new approaches must be considered in relation to the eradication of bTB. Internationally, it has proved challenging to roll out eradication programmes on a national 'one size fits all' methodology.

One potential option to advance a disease control and eradication programme is through the application of a regionalised approach. This would entail selecting a region of the country and applying all the necessary measures (cattle, wildlife, people) to remove infection from herds. It would also involve applying the necessary interventions to prevent re-infection of herds from wildlife and other sources within the selected area and from sources of *M. bovis* outside the area.

Regionalisation has been central to national bTB control/eradication programmes in all countries where eradication has been achieved or is progressing (New Zealand, Australia, Spain, Chile, GB).

Regionalisation involves establishing subpopulations of animals with defined health statuses within distinct geographical areas of a country for the purposes of disease prevention or control and trade.

In disease eradication programmes, regionalisation is used to create risk boundaries, thereby allowing disease control and surveillance to be differentiated based on risk, to prioritise resource allocation and to protect lower risk areas. Collectively, the regionalisation approach provides the forward momentum towards an improving disease situation.

From a NI perspective, there are several reasons why a regional approach would be beneficial. Firstly, it would provide a 'Proof of Concept' with respect to the feasibility and impact of deploying a holistic package of measures (wildlife, cattle, people) to achieve eradication of bTB.

It would allow the trialing of some of the programme measures, considered novel or not yet implemented on a country wide basis, in a region. Following demonstration of programme effectiveness, it would provide a template for achieving eradication across the rest of the country, providing the necessary impetus towards disease eradication.

The initiative would enable planning for the evolution of a regional approach as part of a broader strategic perspective as part of a stepwise/graduated approach maximising the effective and efficient utilisation of resources.

Such an approach should result in greater overall stakeholder engagement as the benefits become evident, resulting in enhanced stakeholder commitment.

More importantly it would allow a national programme to be put in place with a high level of confidence that bTB eradication could finally be achieved.

Successful implementation of a regionalised programme approach will bring many benefits to stakeholders. Broadly, it will result in a significant reduction in costs to both DAERA and industry, reduced disruption due to bTB testing and breakdowns and greater trading opportunities for farmers within the region.

However, there are a number of challenges associated with applying a successful regionalised approach. These include:

- Managing the inward movement of *M. bovis* infection into the selected area through the inward movement of infected cattle between farms, the inward movement of infected cattle between fragments of the same farm, or the inward movement via wildlife or other infected species.
- Effectively addressing all infection sources within the region, including transmission of infection between cattle, transmission of infection from wildlife to cattle and environmental transmission of infection.
- Securing effective stakeholder/farmer commitment and buy-in.

Fundamental prerequisites when establishing and rolling out a regionalised approach include:

- Regionalisation proposal is part of a broader strategic approach to bTB eradication.
- External biosecurity measures are in place to prevent/minimise inward infection into the region.
- Internal biosecurity within the region is developed to effectively address sources of infection and persistence within the region and as illustrated through on the trinity of measures above.
- Allocation of resources towards the regionalised approach does not have a detrimental impact on disease suppression nationally.
- Governance and management structures are developed to facilitate a very high level of industry and farmer commitment towards the effective implementation of all relevant eradication measures.
- Ongoing monitoring and evaluation of progress through the use of SMART targets and adapting the programme in line with epidemiological findings as required.

Criteria requiring consideration when selecting a geographical area in NI for a regional approach include the following:

- Factors relating to the inward movement of *M. bovis* into the region:
    - Inward cattle movements
    - Trade flows
    - Geographical boundaries
    - Land fragmentation.
- Factors relating to effectively addressing all infection sources within the region
    - Stakeholder commitment
    - Effective wildlife programme
    - bTB levels at herd and cattle level
    - Administration of the region.

It should be reiterated that all countries that have progressed towards or achieved bTB eradication have all applied a regional approach within their national bTB eradication programme. For it to be effective it must be implemented in its entirety, indeed, the effectiveness of a regional approach will fall rapidly should the risk boundary become increasingly permeable to inward movements of infection.

The tools and processes required to implement a successful regional approach have been outlined in detail above and are summarised below.

Cattle Measures

The main purpose of cattle measures is to resolve existing infection in herds within the region and prevent the ingress of further infection through the introduction of improved diagnostic, cattle trading/movement and biosecurity regimes.

Wildlife Measures

The main purpose is to limit within and between species transmission of infection within the region and prevent the ingress of infection into the region through the effective deployment and maintenance of an appropriate wildlife intervention regime.

People Measures

Effective stakeholder engagement and co-operation is an essential requirement to achieve and maintain freedom from infection. International experience has highlighted the critical link between programme governance and stakeholder collaboration. Key areas of farmer collaboration include testing of animals, identification of badger setts, and willingness to adopt additional cattle and biosecurity measures. Engagement of PVPs is essential to ensure testing is delivered to an optimal/elevated standard and farmers are advised of the most appropriate biosecurity measures for their business model e.g. development of customised herd health plans.

In addition to the above, a commitment to adequately resourcing the programme at all stages is a fundamental requirement/dependency.

To maintain freedom in the long term requires the maintenance of aforementioned existing measures and particularly those factors mitigating against ingress of infection with strict procedures needing to be established to identify and handle any herd infection that may arise. Wildlife species would need to be monitored, and any necessary actions taken to prevent spillover of infection to cattle.

Concluding Remarks

This review has provided a stark picture of the particular challenges we face in the fight to control bTB, challenges which must be overcome if we are to finally set NI on a path to eradication.

The urgency with which this now must be addressed is a direct response to the significant deterioration in the national bTB situation in NI, with a concurrent increase in expenditure. Spiralling costs of a programme that are unsustainable for government but have - for too many farmers suffering the financial, emotional and physical impacts of a breakdown - gone on for much too long.

Adequate information is available, both from research and international experience, to suggest what measures are now required to ensure NI is adequately addressing these challenges. The proposals I have outlined therefore focus on bTB risks from wildlife, risk-based cattle controls, industry commitment and improved programme governance.

Failure to address the key structural challenges, along with the current disease trajectory, pose the real risk that infection will further spread within the cattle population and may also establish in additional wildlife maintenance hosts beyond badgers with eradication potentially unattainable should such an event materialise

In the current agri-political environment, it can be challenging to make difficult or unpopular decisions. This is particularly so given the existing costs and disease trajectory along with the fact that such policy decisions will inevitably lead to an initial worsening of the disease picture and expenditure landscape, certainly in the short term, with only a limited positive impact on the current generation of NI farmers.

However, actions taken now will have long term benefits for future generations, including both the general public and future NI farmers. This is because the proposals outlined in this review, with industry and government working together, will directly reduce the ‘time to eradication’ and overall programme costs for both the Department and the wider agri-food industry when compared to the status quo.

Quite simply, a number of critical and difficult decisions need to be taken urgently. In this report I have clearly outlined what I think they should be - specifically detailing the scope and the intensity of control measures to be applied, the commitment of resources (both financial and people), with a crucial underpinning to success being engagement and responsibility sharing from all those with an interest in, or affected by, bTB.

These proposals are, I hope, the start of a new journey on our path to control and eradicate this disease from NI. While some represent a recommitment of the key measures contained within the current TBES, many others will now require industry buy-in and Ministerial decisions for progression. This is in addition to the relevant costings, policy development and assessments necessary for any new government, or government-industry, initiative.

Glossary

ACH	Alternative Control Herd
AFBI	Agri-Food Biosciences Institute
AHL	Animal Health Law
AHWNI	Animal Health and Welfare Northern Ireland
AI	Artificial intelligence
AMR	Antimicrobial Resistance
APHIS	Animal Public Health Information System
AVSPNI	Association of Veterinary Surgeons Practicing in Northern Ireland
BCG	Bacillus Calmette-Guérin
bTB	Bovine Tuberculosis
BVA	British Veterinary Association
BVD	Bovine Viral Diarrhoea
C&D	Cleansing and Disinfection
CAFRE	College of Agriculture, Food and Rural Enterprise
CITT	Comparative Intradermal Tuberculin Test
CHT 1	Check Herd Test 1
COVID-19	coronavirus disease
CVO	Chief Veterinary Officer
DAERA	Department of Agriculture, Environment and Rural Affairs
DAFM	Department of Agriculture, Food and Marine
Defra	Department of Environment, Food and Rural Affairs
DIVA	Differentiate Infected from Vaccinated Animals
DPP	Dual-Path Platform
DVO	Divisional Veterinary Officer
E&I	Evidence and Innovation
EPIC	Epidemiology, Population Health and Infectious Disease Control
EU	European Union
FVO	Food and Veterinary Office

GB	Great Britain
IC	Inconclusive skin reactor
IDEXX	IDEXX laboratories
IFNg	Interferon Gamma
LCT	Lateral Check Test
LRS	Lesion at Routine Slaughter
LVO	Livestock Valuation Officer
M. bovis	*Mycobacterium bovis*
M. paratuberculosis	*Mycobacterium avium subsp. paratuberculosis*
ML	Machine learning
MLA	Member of the Legislative Assembly
NI	Northern Ireland
NIFAIS	Northern Ireland Food Animal Information System
NIVA	North of Ireland Veterinary Association
OTF	Officially Tuberculosis Free Status
OTS	Officially Tuberculosis Free Status Suspended
OTW	Officially Tuberculosis Free Status Withdrawn
PAC	Public Accounts Committee
PCR	Polymerase Chain Reaction
PPD	Purified Protein Derivative
PVP	Private Veterinary Practitioner
R_0	Reproductive Ratio
RH1	Reactor Herd Test 1
ROI	Republic of Ireland
RTA	Road Traffic Accident
SIB	Strategic Investment Board
SMART	Specific, Measurable, Achievable, Relevant, Time-bound
SRG	Sustainable Ruminant Genetics
TAG	Technical Advisory Group
TB	Tuberculosis

TBAS	Tuberculosis Advisory Service
TBES	Tuberculosis Eradication Strategy
TBLG	Tuberculosis Liaison Group
TBSPG	Tuberculosis Strategic Partnership Group
TVR	Test and Vaccinate or Remove
UK	United Kingdom
USPCA	Ulster Society for the Prevention of Cruelty to Animals
VEU	Veterinary Epidemiology Unit
VNTR	Multiple-Locus Variable Number Tandem Repeat Analysis
VO	Veterinary Officer
VPHP	Veterinary Public Health Programme
VRAMPs	Veterinary Risk And Management Plans
WGS	Whole Genome Sequencing
WOAH	World Organisation for Animal Health

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Annex A Table of Proposals

People, Partnership & Science - Changing the Culture
Establishment of a TB Eradication Partnership Body
Commissioning of Independent Science Advice
Investment in Research
Establishment of Inter-Governmental Structures - North/South & East/West
Refresh of DAERA Programme Governance
Development of Communications & Engagement Plan
Rollout of Education & Knowledge Transfer Programme
Review of Programme Measurements & Indicators

Cattle Interventions
Disease Surveillance & Detection
Private Veterinary Practitioner Engagement & Training
TB testing Quality Control Programme
Abattoir Surveillance
Tuberculin Quality Control
Management of Infected Herds
Criteria for Suspension & Withdrawal of Official Tuberculosis Free Status
Management of Inconclusive Skin Reactors
Compulsory Interferon Gamma Testing
Depopulation Strategy - Full and Partial
Application of Severe Breakdown Status
Breakdown Herds and Purchasing Policy
Establishment of Chronic Herd Taskforce
Whole Genome Sequencing Roll-out
Alternative Tests Policy development
Development & Application of Machine Learning Models
DAERA approach to Breakdown Case Management

Cattle Interventions
Protecting Clear Herds - Reducing the Risk to Others
Extension of Restriction Period
Restriction of high-risk cohort animals
Informed Purchasing & Risk Based Trading
Pre & Post Movement Testing
Alternative Control Herds & Movements from Breakdown Herds
Genetics Programme
Herd Health Management & Biosecurity
Farm Fragmentation & Restricted Grazing Notices

Wildlife Interventions
Wildlife Intervention Strategy
Wildlife surveillance

Finance
Compensation Reform
Fraud Policy

Regionalisation
NI ‘Proof of Concept’ regionalised approach

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