Animal & Plant Health Agency | Asiantaeth Iechyd Anifeiliaid a Phlanhigion

Wales Epidemiology Reporting

Annual Surveillance and Strategy Report

Bovine TB Epidemiology in Wales 2021

Authored by Wales TB Epidemiology Team, Department of Epidemiological Sciences APHA Weybridge & TB Policy Team, Office of the Chief Veterinary Officer for Wales

Contents

Executive Summary

Introduction

Compulsory measures for bovine tuberculosis (bTB) have been in place in Great Britain since the 1950s. Wales instated a new regionalised eradication strategy in 2017, based on Spatial Units which reside within the five TB Areas. The aim of this strategy is for Wales to be Officially TB-Free by 2041. To determine the level of progress towards the new eradication goal, Welsh Government has commissioned this new surveillance and strategy report, which supersedes two separate reporting streams (Wales Annual Surveillance Report, Animal and Plant Health Agency Weybridge 2022 and Annual Wales Eradication Target Review, Animal and Plant Health Agency Wales & OCVO 2021).

Surveillance

Surveillance testing for bTB covers routine, area, herd-risk, and check tests which occur on whole herds (with the exception of calves <42 days of age) that are Officially TB Free (OTF). In 2021, routine annual tests were the most common test type across all TB Areas except the High TB Area West (HTBW), where area risk tests were most common (Figure 4). Control testing which covers tests undertaken post disclosure of an incident has seen a slight increase from 2015-2021 at both herd and animal level, with the highest rise observed in the Intermediate TB Area North (ITBAN) and the Low TB Area (LTBA), consistent with an escalating disease situation in these areas. Several new policies were brought into areas with increased levels of disease in the ITBAN and LTBA in 2021 (Welsh Government, 2021), including one whereby purchased animals in clear testing unrestricted herds located in certain Spatial Units were subject to blood testing if they had a positive response to bovine tuberculin in the skin test. This surveillance tool disclosed a large percentage (>50% in Q3 and Q4 2021) of the new bTB incident total in the ITBAN and LTBA in 2021.

Incidence and Prevalence

Just over one in ten herds was in a bTB incident at any point (prevalence) and just over one in twenty herds suffered a new bTB incident (incidence) during 2021. After a continuous fall from 2016 to 2019 incidence and prevalence have plateaued across Wales. In 2021, annual incidence was 5.7% when including the North Wales blood tests, and 5.3% when excluding the North Wales blood tests. Annual prevalence for 2021 was 10.9% (10.6% without the North Wales blood tests). These trends have seen substantial variation between the different TB Areas with increases in incidence and prevalence in the ITBAN from 2017 and LTBA from 2020 whereas the High TB Area East (HTBE) has seen a general fall in both metrics since the peak in 2011 with the 2021 figures constituting a 16-year low.

Persistence and Recurrence

On 31 December 2021, 152 incidents were subject to Enhanced Measures for Persistent Breakdowns in Wales, an increase of eight (+6%) on the previous year. While the annual total of herds with incidents of 550 days or more has fallen slightly, the Enhanced Management criteria were widened to include herds with previous persistent incidents that had become recurrent within six months, as well as six-

month recurrent Officially TB Free – Withdrawn (OTFW) incidents in parts of the ITBAN. As a result, the number of herds under the persistent designation has increased. In all areas other than ITBAN and LTBA the number of closed persistent incidents has decreased in 2021.
Recurrent incidents in the HTBE and HTBW have been on a downward trend from 2009-2021. In contrast, for the LTBA which had always shown lower levels of recurrence than other TB Areas, there was a 100% increase post-2018 for one, two and three-year recurrence.

TB Clusters

The Welsh TB Cluster approach focused on eight defined areas or clusters in Wales selected because of their local variation in disease pattern and their distinct geographical boundaries. Each of the five TB Areas incorporates at least one TB Cluster. Substantial reductions in bTB incidence have been observed in three out of four clusters in the High TB Areas, particularly the Intensive Action Area (IAA) in Pembrokeshire and Ceredigion and the Mid Wales Cluster in Mid Powys. In contrast, the situation has escalated in the Denbigh/Conwy Cluster and there is newly emerging evidence that the problem has spread from there to Anglesey.

Culture results and WGS homeranges

Six whole genome sequencing (WGS) clade homeranges were at least partially contained within Wales, with the increasingly ubiquitous B6-11 accounting for 45.9% of the total, followed by B6-14 (32.3%, almost exclusively in HTBW) and more localised in Gwent & Powys (HTBE), B6-83 (16.2%).

Main factors determining risk of infection for cattle herds

Increased herd size, dairy production and recent bTB incidents significantly contributed to an increased rate of confirmed incidents in 2021.

Non-bovines

In 2021, new world camelids comprised all disclosed non-bovine reactors, just as they contributed the overwhelming majority of reactors from 2017-2020 (31/34, 91.2%). 293 usable badger carcasses were submitted with 15 culture positives (5.1%). Notable results include a positive sample from the Conwy section of the Denbigh/Conwy TB Cluster which represents the first positive submission from the LTBA since 2015.

Eradication target review

Of the five TB Areas, the HTBE has shown the largest progress with a 27% reduction in pooled annual incidence (2018-21) with notable improvements in Gwent, Mid and South Powys, compared with 2012-17. In the same period, incidence in the HTBW has fallen by 17%, and by 6% in the Intermediate TB Area Mid (I Mid). Improvements were especially notable in Glamorgan. In the last four years, incidence has increased in parts of the LTBA (most notably Denbigh/Conwy) and the ITBAN (especially Wrexham). On 1 November 2021, a revised TB regionalisation was introduced to account for the escalating situation across the Denbigh/Conwy area.

Introduction

Bovine tuberculosis (bTB) is caused by the bacterium Mycobacterium bovis which is capable of infecting cattle, humans, and other mammalian hosts (O'Reilly & Daborn, 1995). Control of bTB is associated with considerable financial costs for the testing, removal, and restriction of cattle. The impacts of bTB are wide ranging; from causing emotional and financial hardship to individual farming families and communities (Robinson, 2017) to placing constraints on international trade. For the above reasons it is currently considered to be the most significant animal health concern in Wales.

In many countries, wildlife reservoirs of bTB are a barrier to eradication (Fitzgerald, 2013; Nugent, 2011; Renwick, 2007; Wobeser, 2009). The Eurasian badger (Meles meles) has been reported to be a significant reservoir in some regions (Allen, 2018; Bouchez-Zacria, 2018; Campbell et al., 2019; Corner, 2011), including Great Britain (GB) and Ireland. Badgers are a protected species in England and Wales under The Badgers Act 1992 and schedule 6 of the Countryside and Wildlife Act 1981 (Trust, 2021).

bTB control began in GB in the 1950s primarily for human health and international trade reasons. Further statutory requirements were introduced when the UK entered the European Union in 1973. Northern Ireland and GB followed separate bTB control measures and such regionalisation only became more significant in 1999 with devolution when Scottish and Welsh administrations took responsibility for agriculture.

From 1998 to 2009, a continuous rise in bTB herd incidence was observed in England and Wales, with the 2001 surveillance gap caused by foot and mouth disease (FMD) entailing an even more rapid increase. A similar trend occurred in the numbers of cattle found to have bTB lesions or bacterial culture (Conlan et al., 2012). In 2008, a TB Health Check Wales was undertaken which involved testing all cattle herds in Wales for bTB. Subsequently, annual routine testing was introduced across Wales in 2010. Many other policy changes in bTB controls were introduced in the years from 2009 to 2014. In 2009, the target time for removal of reactor cattle was reduced to 10 working days to mitigate against intra-herd bTB transmission. In the same year, inconclusive reactor animals at standard interpretation were removed after a single retest rather than after two retests.

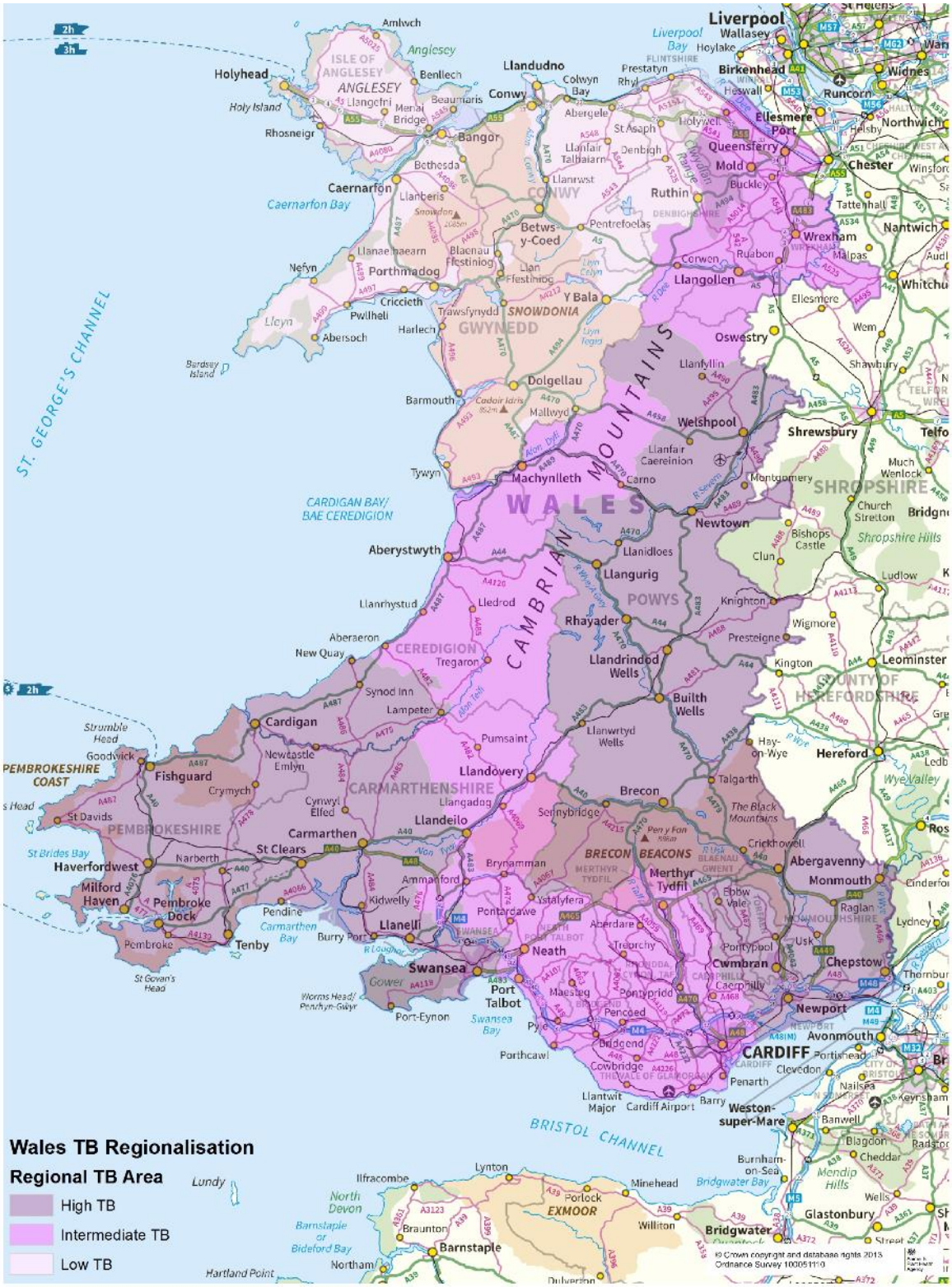
Epidemiological grounds other than confirmation of disease through culture or post-mortem examination became a reason to withdraw the Officially TB Free (OTF) status of a herd in 2011. This facilitated a reduction in spread between herds by extending the number of short interval tests required before restrictions were lifted, initiating testing of cattle herds neighbouring the incident as well as source and spread tracing.

To address endemic bTB in one of the worst affected areas in Wales, the Intensive Action Area was created in 2010. Six-monthly routine bTB cattle testing and further cattle controls were introduced; the former remains in effect today. Badger vaccination was deployed in the IAA from 2012 to 2015 with passive badger

surveillance also introduced and rolled out nationally (All Wales Badger Found Dead Survey (AWBFD)) from October 2014.

Specific polices to manage persistent bTB herds that have been under bTB restrictions for 550 days or more were introduced in 2014, and further extended in 2017. This entails targeted blood testing of potentially infected animals (gamma-interferon (IFN-γ) and IDEXX antibody (IAT) tests) as well as creation of a bespoke Action Plan to reduce the transmission of bTB within each individual cattle herd. This policy also provided powers to enforce biosecurity changes where required.

Figure 1: A map of Wales showing TB Regionalisation when first introduced in 2017



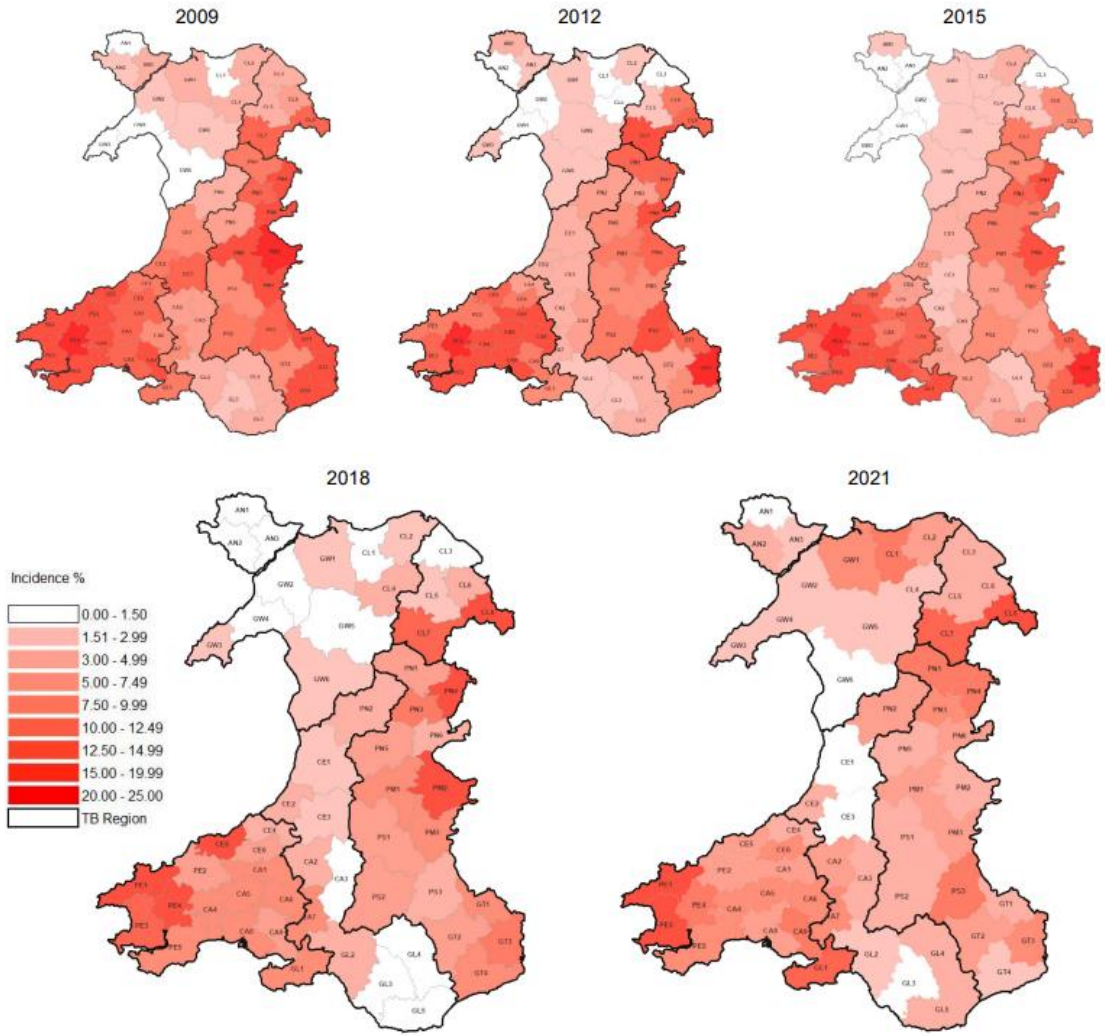
Description of Figure 1 - The map is colour coded to show different regions. The areas corresponding to the High TB Areas and associated policies are darkly shaded, areas corresponding to the Intermediate TB Areas have a purple shade while the Low TB Area is lightly shaded. The key in the bottom left corner of the map

provides a reference for the colour scheme used. The High TB Area West is made up of Pembrokeshire, Southwest Ceredigion, West Carmarthenshire, and the Gower while the High TB Area East is Gwent, South and Mid-Powys as well as the eastern part of North Powys. The intermediate TB Area North in 2017 consisted of Wrexham and Flintshire. The intermediate TB Area Mid is made up of Glamorgan (except the Gower), East and North Carmarthenshire and the western part of North Powys. The Low TB Area in 2017 consisted of Anglesey, the Ruthin Area, Gwynedd, Conwy Valley, and Denbighshire.

A new bTB eradication strategy (Wales Regionalised TB Eradication Strategy) was introduced at the end of 2017. This deviated from the previous approach of country-level measures, instead conceiving areas of High, Intermediate or Low bTB incidence and prevalence based on bTB epidemiology and geographical divisions, as well as bTB data from the period 2009-2015. Each TB Area consists of individual Spatial Units which comprise roughly 200-225 herds. Figure 1 illustrates the location of TB Areas across Wales at that time. Targets were set for each Spatial Unit with the aim of achieving TB free status in Wales by 2041. In accordance with their bTB status, each TB Area had tailor-made bTB controls implemented to enable realisation of these targets. Eradication milestones were placed at six-yearly intervals, though shorter review periods would be applied as required.

The targets for the initial six-year interval from 2018 to 2023 included a 50% reduction in herd incidence across all High and Intermediate TB Areas, as well as incidence below 0.1% in the Low TB Area (LTBA). Spatial Units CE4 and PN1 were to be transferred from High to Intermediate TB Areas. CL3 was to move from Intermediate TB Area North (ITBAN) to LTBA and the two Intermediate TB Areas were to merge.

Figure 2 – Five maps of Wales showing annual incidence at Spatial Unit level (top row) from left to right:2009, 2012, 2015; (bottom row) from left to right: 2018, 2021



Description of Figure 2 – The map is colour coded to show different levels of annual incidence. The areas with a high incidence of TB are marked in darker shades, while the areas with a lower incidence are depicted in lighter shades. The key in the top left corner of the map provides a reference for the colour scheme used. Spatial Units in the High TB Areas tend to have greater levels of incidence; however, incidence levels have generally fallen in certain Spatial Units in High TB Areas between 2009 and 2021. Incidence levels in certain spatial units in the Low TB Area and Intermediate TB Area North have increased.

As shown in Figure 2, certain Spatial Units in the LTBA have increased in incidence in recent years. In order to introduce increased controls (pre-movement testing) these Spatial Units were moved into the ITBAN from November 2021. For the purposes of this report, they were considered part of the LTBA for the whole of 2021. The ITBAN has consistently had incidence levels above the consideration threshold for an Intermediate TB Area since 2018, except CL3 which up to 2020, had been on track to move to the LTBA.

Several new policies were brought into areas with increased levels of disease in North Wales; these areas include the Wrexham portion of the ITBAN (Spatial Units CL7 and CL8) as well as the LTBA Spatial Units affected by the Denbigh-Conwy cluster (CL1, CL2, GW1). Policies 1-3 below were deployed in June 2021 while 4 and 5 were introduced in November 2021. Policy 3 was introduced across the entire ITBAN.

1. All incidents tested at severe interpretation for the duration of the incident and an exit strategy involving interferon-gamma (IFN-g) testing of severe IRs.
2. Supplementary IFN-g and IDEXX antibody (IAT) testing of animals with an out of herd ear tag and bovine increase to the skin test (+3mm) following a clear surveillance test in OTF herds.
3. Herds in a recurrent OTFW incident at or before the 6-month test to have an Action Plan, severe interpretation of all incident tests and blood testing of severe IRs.
4. CL1, CL2, GW1 moved into ITBAN from LTBA and consequently subject to pre-movement testing, two contiguous six-month tests, as well as Cymorth Keep It Out visits for herds contiguous to an incident. Post-movement testing no longer required.
5. Two contiguous six-month tests and Keep It Out visits introduced to the Pennal cluster.

To determine the level of progress towards the new eradication goal, the Welsh Government has commissioned this new surveillance and strategy report, which supersedes and replaces two separate reporting streams (Wales Annual Surveillance Report for 2020, APHA Weybridge 2022 and 2020 Annual Wales Eradication Target Review, APHA Wales & OCVO 2021) and which is based on the template provided in the report “Bovine tuberculosis trends in Wales, UK, 2010 – 2020” (Schroeder, Hewinson et al., in preparation).

Materials and methods

Data capture

Data in this report were initially captured by the Animal and Plant Health Agency work management system (Sam); the software used for the administration of bTB testing in GB. Data were collected within a calendar month of the end of each quarter. Data were cleansed initially by APHA Weybridge and latterly by APHA Wales at which point they were organised into herd and animal-level spreadsheets using appropriate software (Microsoft® Excel® for Microsoft 365 MSO (16.0.14326.20706) 64-bit 2018).

Data on likely risk factors for the introduction of bTB to cattle herds were collected from Disease Report Forms (DRFs) stored in Sam. The information in this form is gathered during the field epidemiology investigation which in 2021 was primarily by telephone questionnaire. This is executed by an assigned APHA veterinary surgeon and as such may be open to some bias or subjectivity. However, in-house auditing of DRFs reduces the potential for this to affect conclusions based on DRF data.

Detection of bTB

Several diagnostic tests are used to detect bTB in both live (single intradermal cervical comparative test (SICCT), IFN-g, IAT) and dead (post-mortem examination, bacterial culture, whole genome sequencing) animals. Defining a case of bTB can be challenging due to the range of surveillance measures in place across Wales. For the purposes of this report an incident of bTB is a cattle herd which is placed under movement restrictions following disclosure of a reactor after testing or a slaughterhouse case which subsequently tests positive on M. bovis bacterial culture.

Incidents triggered by skin or blood test reactors are considered ‘confirmed’ upon disclosure of bTB-like lesions on post-mortem examination, or positive bacterial culture results.

Disease metrics

In this report, annual herd incidence (number of new bTB incidents per 100 whole herd tests in cattle herds with Officially TB Free (OTF) status at the time of the test) and period prevalence (number of herds under TB restrictions at any point in the year per 100 live cattle herds at the end of the previous year) are used to summarise bTB disease patterns as detailed by Council Directive 64/432/EEC and 97/12/EEC. Interpretation of changes in incidence and prevalence over time is challenging due to the numerous developments in bTB policy over the last 12 years.

Persistent bTB incidents in Wales are defined as those which remain open for more than 550 days due to the continued disclosure of reactor or inconclusive reactor animals. In this report recurrent bTB incidents are those for which the interval between the closure of the previous incident and the start date of the new incident is 365 days, 730 days or 1,095 days in the case of one-, two- year or three-year recurrence, respectively. Persistent incidents which appear resolved only to recur at or before the six-month test are termed recurrent persistent incidents.

As described in section 1, the new Regionalised Bovine TB Eradiation Strategy in Wales was implemented in December 2017, with a devised geographical split for any TB reporting. The strategy is based on High, Intermediate and Low TB Areas, which in turn are comprised of Spatial Units. There are 58 Spatial Units across the whole of Wales, each currently composed of 157-249 cattle herds and typically covering an area of 350km^2.

Data analysis

Descriptive analysis was carried out in Microsoft® Excel® for Microsoft 365 MSO (16.0.14326.20782) 64-bit. Statistical analysis and production of graphs were performed in R Studio Version 1.3.1073 “Giant Goldenrod” for Windows 2020. R version 4.0.2 “Taking Off Again” © 2020 (R Core Team, 2020). Graphs were produced using the ggplot2 package (Wickham, 2016). Statistical significance was set at $p<0.05$. Multivariable Poisson regression was conducted using the ISLR package (James et al., 2021); confirmed incidents in 2021 were the outcome measure. Input variables included TB Area, herd type, herd size (category), whether animals had been purchased from herds with a risk score of 4-5 in 2019 or 2020, occurrence of resolved standard IRs in 2019 or 2020, bTB incidents in 2018 or 2019 and whether animals had been purchased from HTB Wales, HRA England, Edge Area England or the Republic of Ireland in 2019 or 2020.

WGS home ranges

Home range areas were produced using a Microsoft® Excel® dataset that included cattle bTB incidents, their map coordinates and WGS clades from the previous five years. The criteria for a home range area is the occurrence of three or more incidents of a certain WGS clade in at least two locations over three separate years within a five-year window and a 5km^2 area. Each home range area produced has a buffer of 10km from its centre placed around it. Where these areas overlap, they are amalgamated into one home range area or polygon. This data is then used to create the home range maps.

Surveillance and disease data

National herd demographic

Demographic data for the national herd are based on end-of-year figures for 2020 (Table 1). In comparison to the previous year (end of 2019 data), national herd shrinkage had occurred by 1.6%. This is consistent with the change in all TB Areas (1.6-1.8%) except for the LTBA which saw a smaller decrease (1.2%).

Table 1: Number and percentage of total herds by type at year end 2020 across different TB Areas

TB Area	Beef	Dairy	Other	Total
High TB Area East	2,362 (85.6%)	311 (11.3%)	87 (3.2%)	2,760 (23.8%)
High TB Area West	1,984 (63.4%)	1047 (33.5%)	97 (3.1%)	3,128 (27.0%)
Intermediate TB Area Mid	1,658 (82.7%)	288 (14.4%)	59 (2.9%)	2,005 (17.3%)

Intermediate TB Area North	612 (67.8%)	261 (28.9%)	30 (3.3%)	903 (7.8%)
Low TB Area	2,332 (83.5%)	341 (12.2%)	119 (4.3%)	2,792 (24.1%)
Total	8,948 (77.2%)	2,248 (19.4%)	392 (3.4%)	11,588 (100%)

Description of Table 1 – A table representing number of herds, and percentage of total, for each Welsh TB Area and for Beef, Dairy or Other types of herds. The table is organized with Welsh TB Areas listed in rows and Herd Types listed in each subsequent column. The intersection of each row and column contains data indicating the specific Herd Type present in the corresponding TB Area.

The percentage of beef and dairy herds remains constant, with beef operations comprising most herds in Wales (Table 1). The HTBW continues to have the greatest herd density, as well as the largest percentage of dairy herds (Table 1). 'Other' herds make up a low percentage of herds in any TB Area (Table 1). These herds comprise calf-rearers, dealers, Approved Finishing Units or holdings used for temporary gatherings.

Table 2: Median herd size and interquartile range, by herd type and TB Area

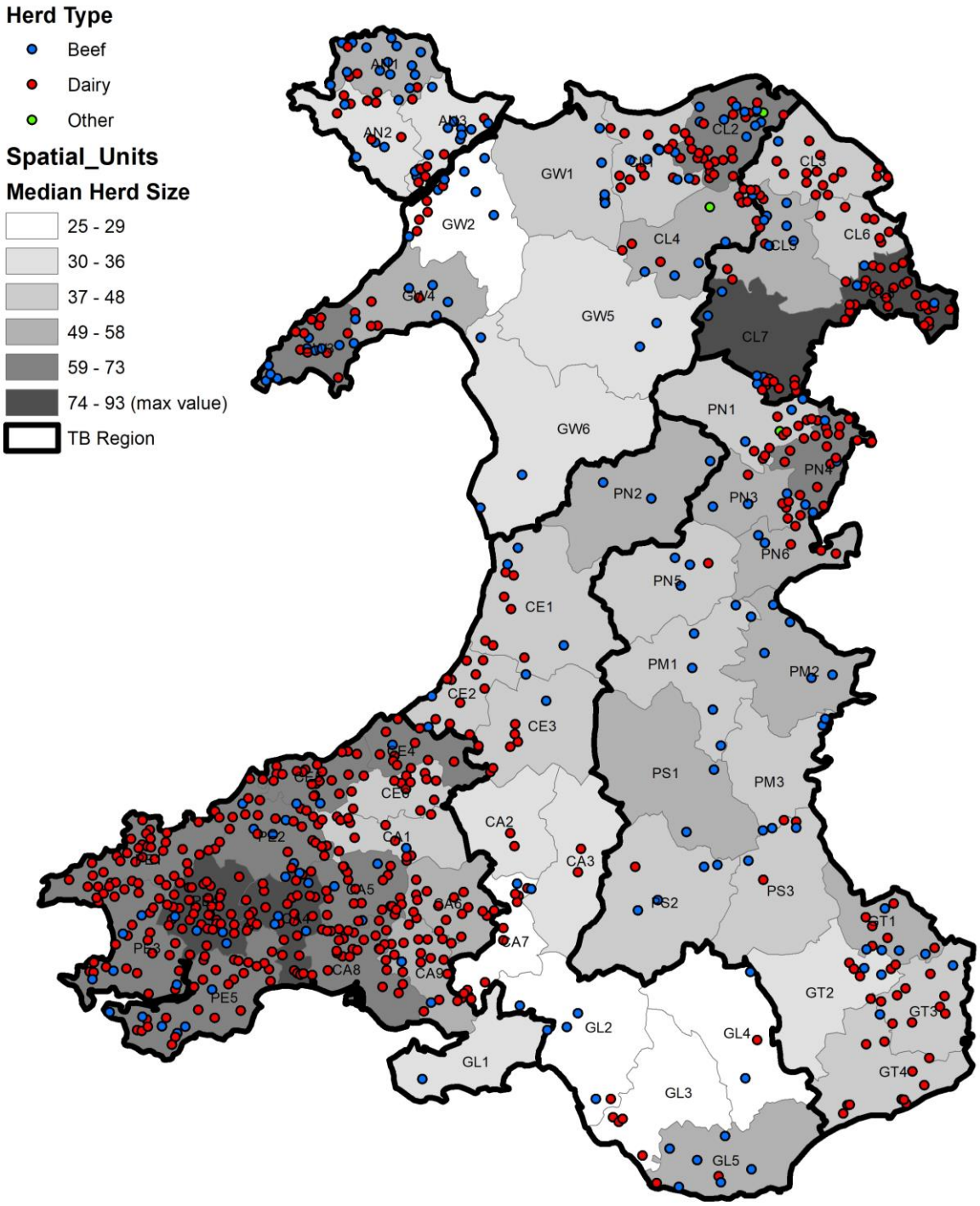
TB Area	Beef	Dairy	Other
High TB Area East	43.5 (17.3-88.0)	142.0 (52.0-288.5)	17.0 (6.0-51.0)
High TB Area West	36.0 (13.0-86.0)	177.0 (80.5-365.5)	10.0 (4.0-29.0)
Intermediate TB Area Mid	32.0 (11.0-67.8)	132.0 (62.8-236.3)	11.0 (6.0-25.0)
Intermediate TB Area North	37.0 (12.0-86.0)	189.0 (93.0-308.0)	10.0 (7.0-30.0)
Low TB Area	38.0 (14.0-89.5)	173.0 (77.0-316.0)	10.0 (3.0-35.0)
Total	38.0 (14.0-84.0)	168 (73.8-321.3)	11.0 (4.0-35.0)

Description of Table 2 – A table representing median herd size and interquartile range for each Welsh TB Area and for Beef, Dairy or Other types of herds. The table is organized with Welsh TB Areas listed in rows and Herd Types listed in each subsequent column. The intersection of each row and column contains data indicating the specific Herd Type present in the corresponding TB Area.

On average, dairy herds are over four-times larger than beef and 15-times larger than 'other' herds. Given the prevalence of dairy herds in the HTBW compared with other regions, it follows that this area has the highest median herd size across all herd types (61 cattle, IQR: 18-154), closely followed by ITBAN (57.0 cattle, IQR: 17.0-145.5). The I Mid TB Area has the lowest median herd size (37.0 cattle, IQR: 12.0-84.0).

The ITBAN has the largest median size of dairy herds, closely followed by the HTBW and LTBA (Table 2). The High TB East (HTBE) has the largest median size of beef herds (Table 2). The I Mid has the lowest median herd size across both beef and dairy herds (Table 2). Figure 3 illustrates the location of various herd types and sizes.

Figure 3: A map of Wales showing location and type of herds greater than 300 head of cattle at 1 January 2021, with median size per Spatial Unit. TB Region indicates boundaries of TB Areas



Description of Figure 3 – The map is colour coded to show different median herd sizes. The areas with a high median herd size of TB are marked in darker shades, while the areas with a lower median size are depicted in lighter shades. Beef herds are indicated by blue dots, dairy herds are indicated with red dots and other types of

herds are indicated with green dots. The key in the top left corner of the map provides a reference for the colour scheme used. The spatial units with highest median sized herds tend to be in the High TB Area West and spatial units CL7 and CL8 of the Intermediate TB Area North.

Across smaller herd sizes the number of beef herds far outweighed the number of dairy enterprises, reflecting the national herd demographics (Table 1). However, this pattern changes with greater herd sizes: for herds with 200 to 300 cattle, there are more dairy herds than beef in the HTBW, I Mid and ITBAN. For herds with over 300 cattle there are more dairy than beef herds in all TB Areas. This trend is most evident in the HTBW, with a dairy/beef ratio of almost 4:1 for herds with more than 300 animals.

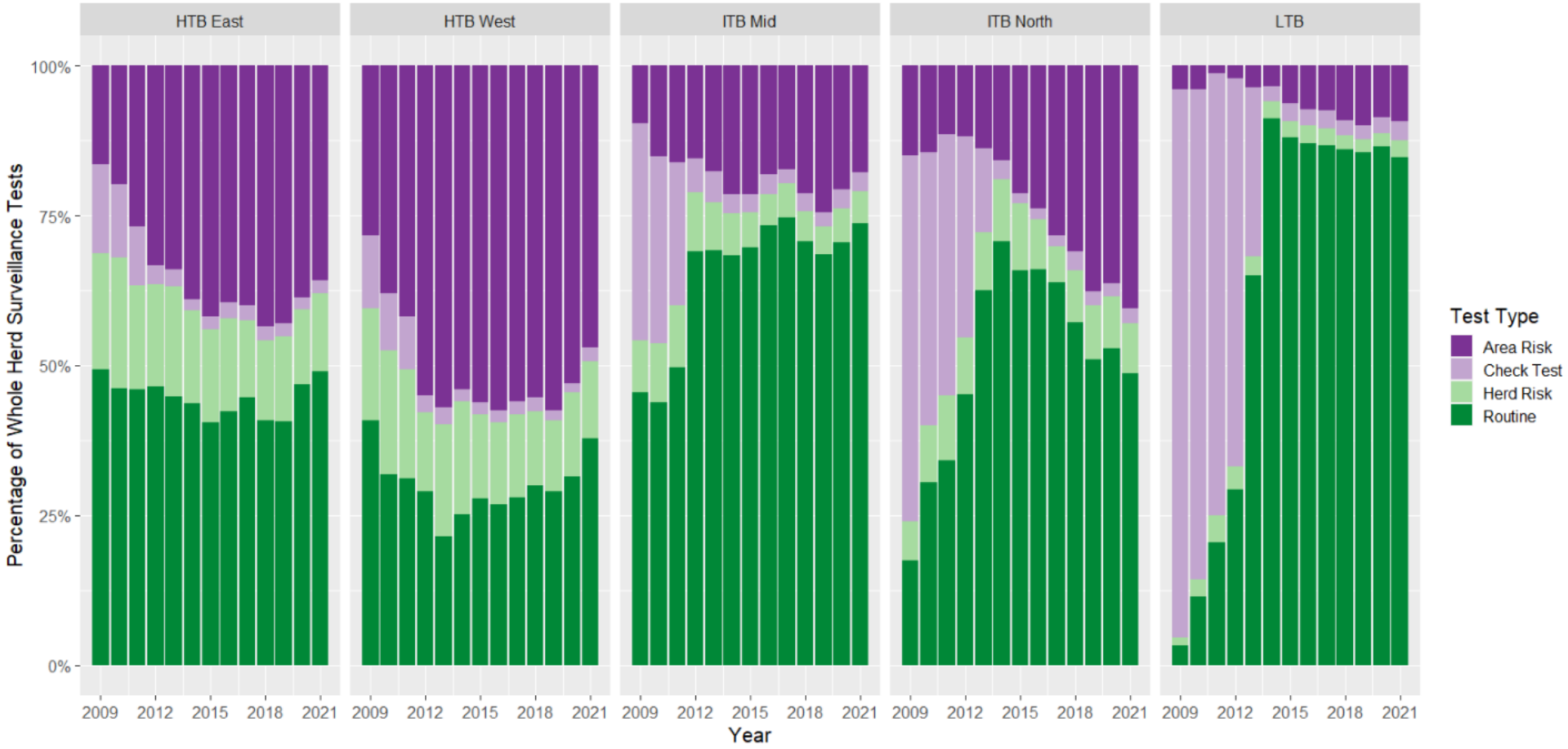
Surveillance Testing

The number of surveillance tests carried out in 2021 (10,527) was very similar to that of both 2019 (10,467) and 2020 (10,920) across Wales as a whole and individual TB regions. More tests were carried out in 2021 than 2020 for all parts of Wales except the HTBW. Given that there was a simultaneous decline in the number of herds in Wales, this indicates the impact of the Covid-19 pandemic on testing procedures in 2020 (with 158 overdue tests in October that year), and subsequent recovery in 2021 (APHA Wales, 2021).

In 2021, routine tests were the most common surveillance test type across all TB Areas except the HTBW, where area risk tests prevailed (Figure 4). This was the same in 2020. There are large differences in the proportion of test types across different TB Areas; in the LTBA and I Mid routine tests are the most common. This is consistent with the majority of herds in these arguably non-endemic areas not currently confined to a herd risk or area risk test window. On the other hand, in the HTBE and ITBAN the number of area risk tests is on a similar level as the number of routine tests.

Use of check tests (CT) has diminished over time across Wales from 2009 onwards. CT were very common at the start of the reporting period due to Heath Check Wales (HCW) which introduced annual testing across all herds in 2009. Following this exercise, annual testing has remained in place across Wales. The ITBAN had a similar test split in 2015 but in recent years this has been taken up by an increasing number of area risk tests (361/892, 40.5%), likely due to the deteriorating disease situation triggering additional contiguous tests. The numbers of routine tests have decreased consistently for the last six years in all areas other than the HTBW and HTBE, where numbers increased in 2021 compared with 2012, 2015 and 2018.

Figure 4: Five stacked bar plots showing the percentage of different whole herd surveillance test types performed on Officially TB Free herds in the five TB Areas in Wales for the years 2009 to 2021



Description of Figure 4 –The chart is colour coded to show different herd types. Dark green indicates the test type is routine, light green indicates the test was on a risky herd. Dark purple indicates the test was on a herd in a risky area while light purple indicates the test was a check test. The key in the right of the chart provides a reference for the colour scheme used. Between 2009 and

2021, the proportion of check tests in the Low TB Area, Intermediate Mid and Intermediate North has declined while the proportion of routine tests has increased, with particularly sharp increases for the Low TB Area between 2012 and 2014. In the Intermediate TB North, Area Risk tests have steadily increased since 2011 and by 2021 have almost become the predominate test type in the area.

Disease metrics: incidence and prevalence

Incidence across Wales has steadily decreased from 10.1% in 2009 to 6.3% in 2021 (Figure 5). This trend is seen in the HTBW, HTBE and I Mid regions with particularly marked reductions in the high TB Areas. Incidence has reduced from 14.2% and 14.4% to 6.8% and 9.0% in the HTBE and the HTBW, respectively. However, in the ITBAN the incidence rate has fluctuated since 2009. In 2021 it reached 9.0%, only previously seen in 2012.

The LTBA had a consistently low and mostly decreasing incidence year on year from 2009 to 2019 (Figure 5). In 2020 this trend reversed when incidence increased to 2.2%, the highest level observed since 2011. 2021 saw further deterioration with incidence rising to 3.6%.

Figure 5: Six small multiple line charts showing incidence and prevalence across Wales and TB Areas from 2009 to 2021

Description of Figure 5 – The top charts from left to right are Wales, High TB Area East, and High TB Area West. The bottom charts from left to right are Intermediate TB Area Mid, Intermediate TB Area North and Low TB Area. The chart is colour coded with red indicating incidence and turquoise indicating prevalence. The key to the right of the chart provides a reference for the colour scheme used. Between 2009 and 2021, prevalence and incidence for Wales has generally declined. This is due to decreases in incidence and prevalence in both High TB Areas. However, in recent

years, prevalence and incidence has been increasing in the Intermediate TB Area North and Low TB Area.

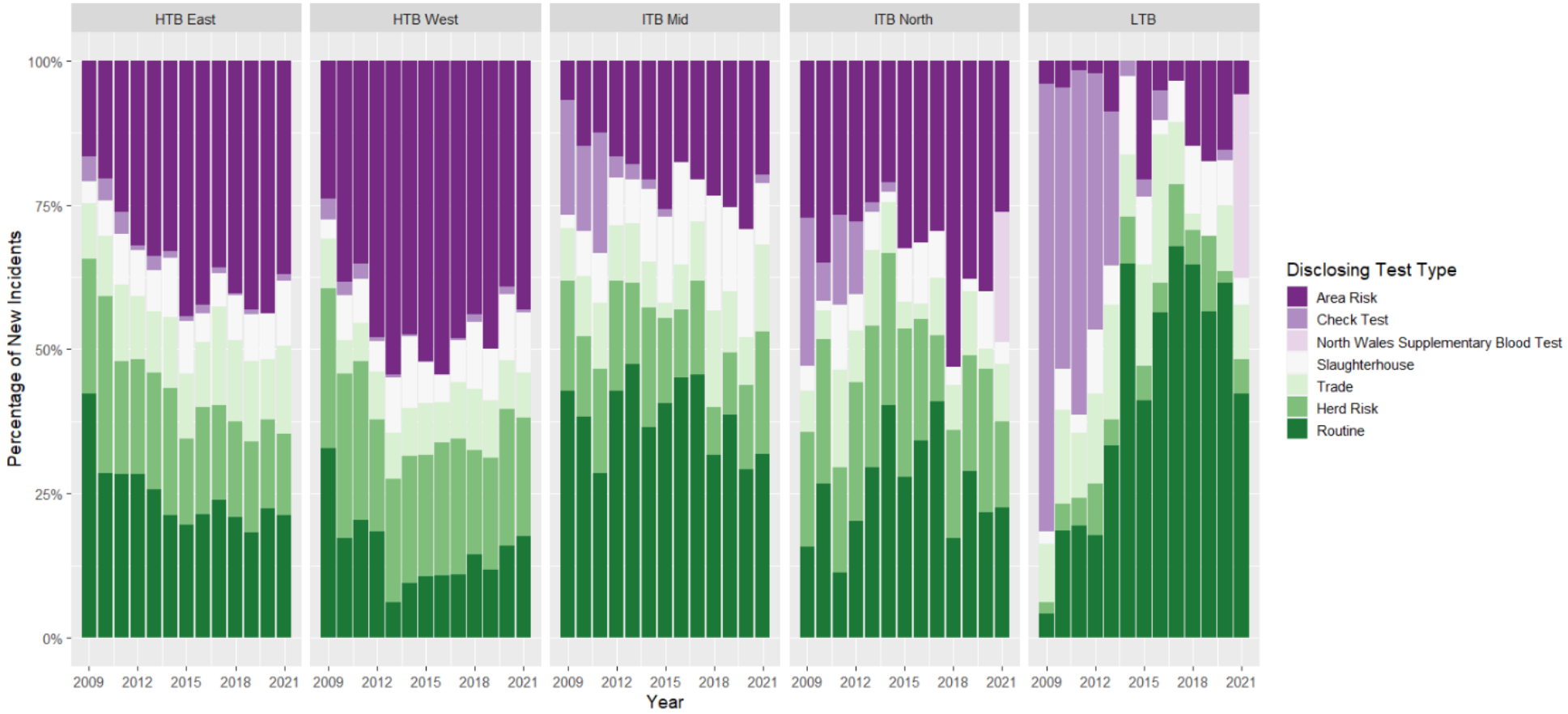
Annual prevalence of bTB fell across Wales from 15.9% in 2009 to the lowest figure of 10.7% in 2020 (Figure 5). There was a small increase in 2021 (11.1%). Despite fluctuations, the HTBE showed an overall downward trend, with a reduction in prevalence from 22.6% in 2009 to 12.3% in 2021. The HTBW and I Mid showed marked decreases from 2009 to 2014, after which this trend slowed. Both areas had a small increase in prevalence in 2021 compared with 2020. Despite a decrease from 2013 to 2016, prevalence in the ITBAN has increased over the reporting period from 9.1% in 2009 to 15.8% in 2021. In the LTBA, prevalence decreased over most of the reporting period, being consistently <2% from 2014 to 2019. However, 2020 and 2021 showed a reversal of that trend with an increase to 4.2% in 2021 (Figure 5).

The two metrics, incidence, and prevalence, follow a similar trend over time. From 2017 to 2021, ITBAN prevalence has increased at a steeper trajectory than incidence. During 2021, incidence remained below 10% while prevalence increased above 15%. This shows that even with comparatively low incidences, we are seeing an increasing backlog of restrictions which are taking longer to resolve.

New incidents: disclosing test type.

Figure 6 illustrates the percentage of new bTB incidents each year that are disclosed by different test types. The percentage of area and herd risk, check and routine tests largely reflect those shown in Figure 6. However, tests performed to mitigate movement risk are also responsible for disclosing 15% of new bTB incidents across the HTBE and I Mid in 2021, and 8-10% of new incidents in the HTBW, ITBAN and LTBA. In the ITBAN and LTBA, a new supplementary blood testing policy introduced to certain Spatial Units in June 2021 has proven to be an important means of identifying infected herds. This test disclosed 22.5% of new incidents in ITBAN and 31.8% in LTBA over the whole of 2021.

Figure 6: Five stacked bar graphs showing percentage of new incidents disclosed by different test types across all TB Areas of Wales, from 1 January 2009 to 31 December 2021

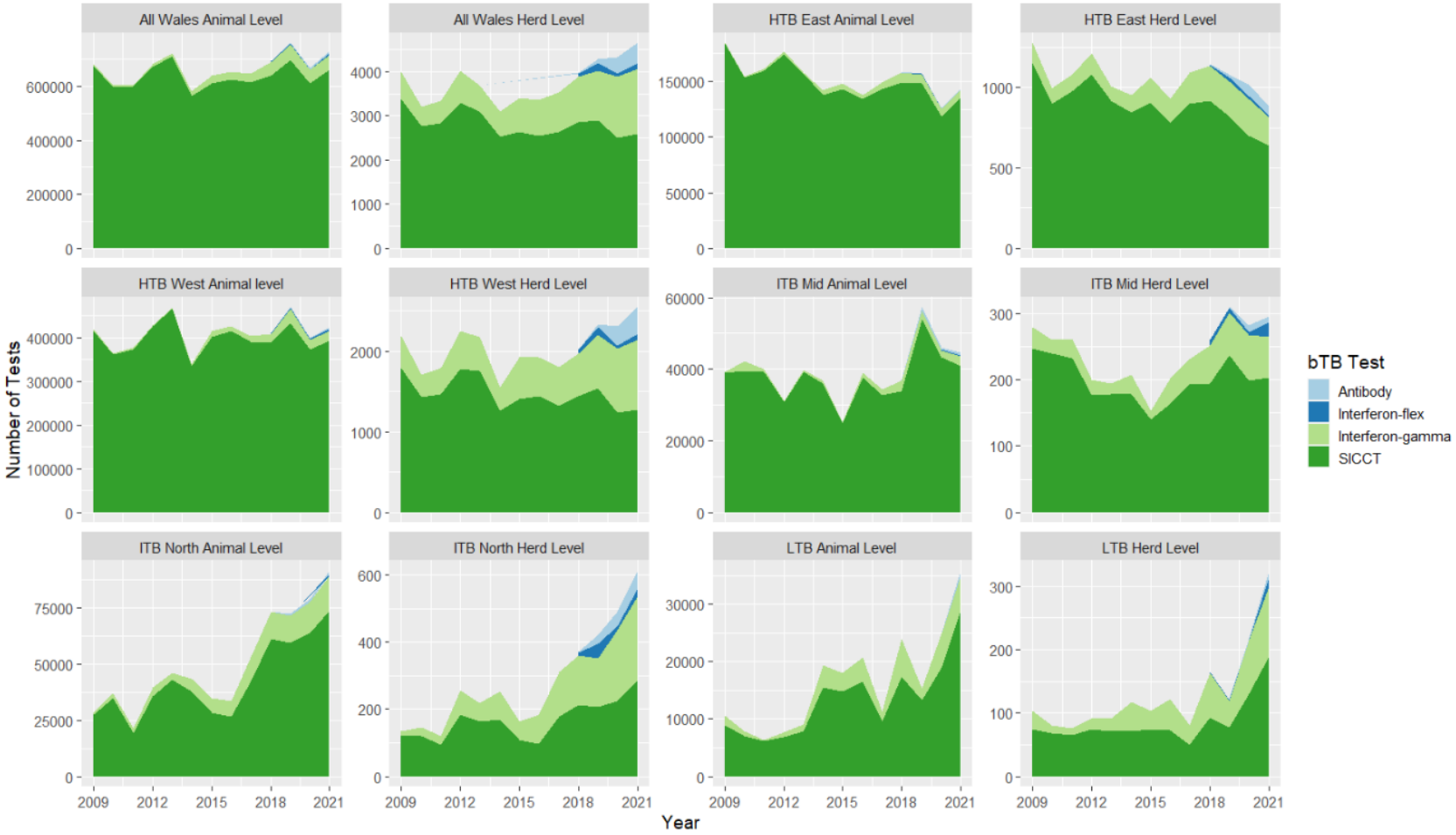


Description of Figure 6 – From left to right, the charts refer to the High TB Area East, High TB Area West, Intermediate TB Area Mid, Intermediate TB Area North and Low TB Area. The chart is colour coded to show different test types. Dark green indicates the disclosing test type is routine, medium shaded green indicates the disclosing test was on a risky herd while light green indicates the disclosing test type is related to trade. White indicates the incident was due to a slaughterhouse case. Dark purple indicates the disclosing test was due to additional tests to manage a herd in a risky area while medium shaded purple indicates the test was a

check test. Light purple indicates the disclosing test was from a North Wales supplementary blood test. The key in the right of the chart provides a reference for the colour scheme used.

The number of skin tests carried out in incident herds has decreased substantially from 2009 to 2021 in the two High TB Areas (Figure 7). The I Mid had around half the number of herd-level control skin tests in 2015 compared with 2009, but the numbers increased again up to a peak in 2019, before decreasing once more (Figure 7). The use of IFN-g testing has increased steadily increased from 2009 to 2021. The introduction in October 2017 and subsequent expansion in use of the flexible-extended interferon gamma test (IFN-flex) is notable (Figure 7). IFN-flex was used across all areas in 2018, as was the IAT test other than in the LTBA and I Mid where its use is only seen from 2019 onwards. In the ITBAN and LTBA, the number of skin tests and IFN-g tests in incident herds are on a similar trajectory, particularly since around 2016 when mandatory whole herd IFN-g testing for OTFW herds in these areas was introduced. The increase in both skin and IFN-g tests in these two areas also reflects the deteriorating disease situation of recent years.

Figure 7: 12 stacked area graphs demonstrating the numbers of different skin and blood tests used in incident herds from 1 January 2009 to 31 December 2021 across different Wales TB Areas at animal and herd level (SICCT = single intradermal comparative cervical test, Interferon-gamma = interferon gamma test, Interferon-flex = flexible extended interferon gamma test, Antibody = IDEXX antibody test

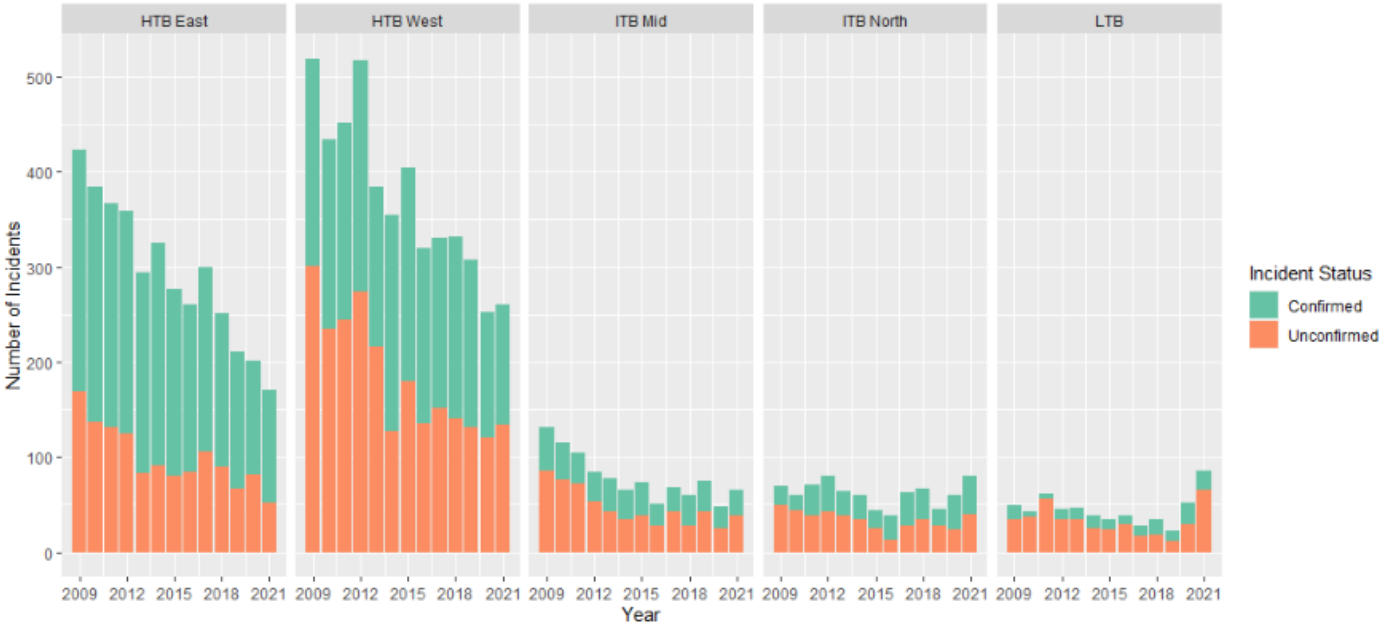


Description of Figure 7 – The top charts from left to right are All Wales Animal Level, All Wales Herd Level, High TB Area East Animal Level and High TB Area East Herd Level. The middle charts from left to right are High TB Area West Animal Level, High TB Area West Herd Level, Intermediate TB Area Mid Animal Level, and Intermediate TB Area Mid Herd Level. The bottom charts from left to right are Intermediate TB Area North Animal Level, Intermediate TB Area North Herd Level, Low TB Area Animal Level and Low TB Area Herd Level. The chart is colour coded with dark green indicating the number of single intradermal comparative cervical tests and light green indicates the number of Interferon-Gamma tests. Dark blue indicates the number of interferon-flex tests and light blue indicates the number of antibody tests. The key to the right of the chart provides a reference for the colour scheme used. Between 2009 and 2021, most tests for all TB areas is the single intradermal comparative cervical test. Noticeable numbers of antibody and interferon-flex tests can be observed from 2018.

Incident confirmation status

Incidents are confirmed either through detection of lesions typical of bTB at post-mortem examination or positive culture of samples obtained from potentially infected cattle. Figure 8 shows the numbers of incidents in each TB Area by confirmation status. In 2021, 70% of incidents in the HTBE were confirmed, largely unchanged from previous years. Less than half of all incidents in the HTBW were confirmed in 2021; a decrease to levels previously seen in 2013. The Intermediate Areas have around 50% of incidents confirmed, although this has fluctuated in the ITBAN in recent years, reaching 65.8% confirmed incidents in 2016. In the LTBA, the highest percentage of confirmed incidents was observed in 2019 (52.1%), decreasing in 2020 and 2021 to 23.3%.

Figure 8: Five stacked bar graphs showing the number of confirmed and unconfirmed bovine tuberculosis incidents across Wales TB Areas from 1 January 2009 to 31 December 2021

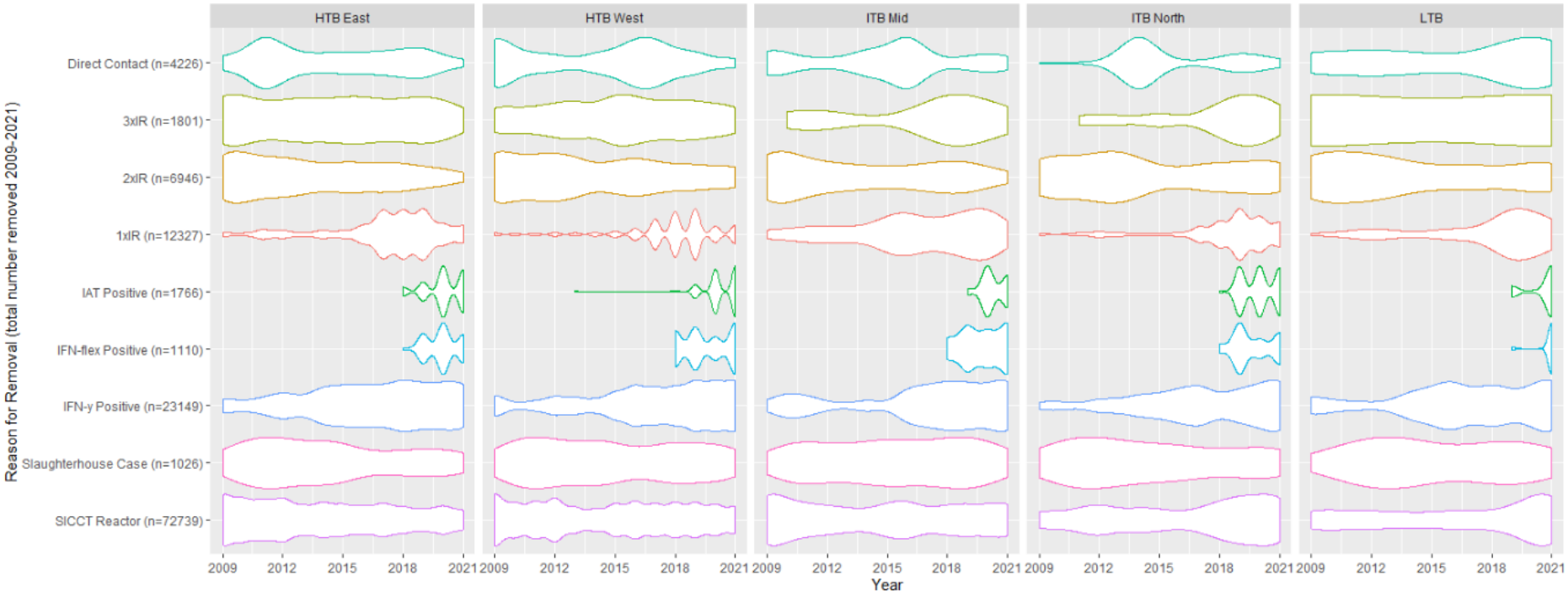


Description of Figure 8 – The chart is colour coded to show either confirmed or unconfirmed status. Green indicates confirmed incident status while orange indicates unconfirmed status. The key in the right of the chart provides a reference for the colour scheme used. Most confirmed and unconfirmed incidents occur in the High TB East and High TB West however incidents in the Low TB Area have been risen to a high point in 2021.

Animal-level slaughter data

Animals may be removed for a number of reasons relating to bTB. Figure 9 illustrates the distribution of the various removal types across different TB Areas from 2009 to 2021. In terms of volume, skin reactors are by far the most common, followed by IFN-γ reactors and first time IRs (1xIRs). Figure 9 also shows a reduction in skin reactors over time in HTBE, HTBW and I Mid, whilst in ITBAN and LTBA this has increased. Reactors to the IFN-g test have increased over time. IAT and IFN-flex reactor removals have only commenced in 2018 and as a relatively new adjunct surveillance tool, are still subject to fluctuation. 1xIRs have seen an increase across Wales after 2015.

Figure 9 – Five violin plots showing the distribution of animals slaughtered in all TB Areas of Wales following various test results from beginning of from 1 January 2009 to end of 31 December 2021.



Description of figure 9 – From left to right, the violin plots correspond to the High TB Area East, High TB Area West, Intermediate TB Area Mid, Intermediate TB Area North and Low TB Area. The maximum width of the plots is the same for every category of test result, the total number of bovine animals removed in each category is shown in brackets. SICCT reactor describes an animal which was disclosed as a reactor to the single intradermal comparative cervical test at either standard or severe interpretation; IFN-γ positive describes an animal that tested positive to the interferon-gamma test, IFN-flex positive describes an animal that tested positive to the flexible extended interferon-gamma test, IAT positive describes an animal that tested positive to the IDEXX antibody test; 1x, 2x and 3xIRs are animals found to be inconclusive reactors at the single intradermal comparative cervical test at either standard or severe interpretation, one, two or three times respectively; slaughterhouse case refers to an animal that had not tested

positive to a statutory TB test but lesions were detected in its carcass during post-mortem examination; direct contact is an animal voluntarily removed due to its suspected high risk of being an infected animal. Of the animals removed for bTB, the vast majority had no detected lesions, (DLs), regardless of year and TB Area (Annex, Table 1*A*). The highest rate of detected lesions (7671/28816, 26.6%) was observed in the HTBE over the 12-year period. The percentage of DLs in the HTBW was almost half compared to the HTBE (10812/76850, 14.1%), whilst the LTBA had the lowest rate of DLs (279/2690, 10.3%). Culture results for animals removed for purposes of bTB control are shown in Annex, Figure 1*A*. Just under one-third of animals slaughtered for bTB purposes had samples cultured (40,081/125,090, 32.0%) in the reporting period. Over three-quarters of cultures from 2009 to 2021 yielded negative results (30,329/40,081, 75.6%). At 43.7% (4,152/9,500) HTBE had the largest percentage of samples culture positive for Mycobacterium bovis (Annex, Figure 1*A*). In all TB Areas other than the LTBA, the percentage of animals which had a Mycobacterium bovis culture decreased over time (Annex, Figure 1A).

Persistent incidents

Incidents become persistent when they have been under restrictions for 550 days or more, or if a resolved persistent incident is closed only for restrictions to be reimposed within the first (six-month) herd risk window. From 2014 in Wales the Enhanced Management of Persistent Breakdowns (EMPB) policy was introduced. Previously persistent incidents were treated as any other bTB incident. From 2017, this policy was amended to increase the sensitivity of skin testing in these herds by using severe interpretation until the end of the incident and compulsorily removing IRs at standard interpretation. In 2020, the policy was updated again to include blood testing of severe IRs. Prior to January 2020, IRs at both standard and severe interpretation were compulsorily removed. Additionally, all herds must have an Action Plan agreed between the farmer and APHA which details actions to prevent prolongation of the incident such as biosecurity measures and additional blood testing. All persistent herds must have a statutory herd blood test, and this may be repeated annually if the incident persists.

On 31 December 2021, there were 152 incidents subject to EMPB in Wales, an increase of 8 (6%) on the previous year. Other than ongoing incidents of at least 550 days' duration, this also included seven herds which had persistent incidents conclude and which suffered another incident within six months, as well as six recurrent OTFW incidents in Spatial Units CL7 and CL8.

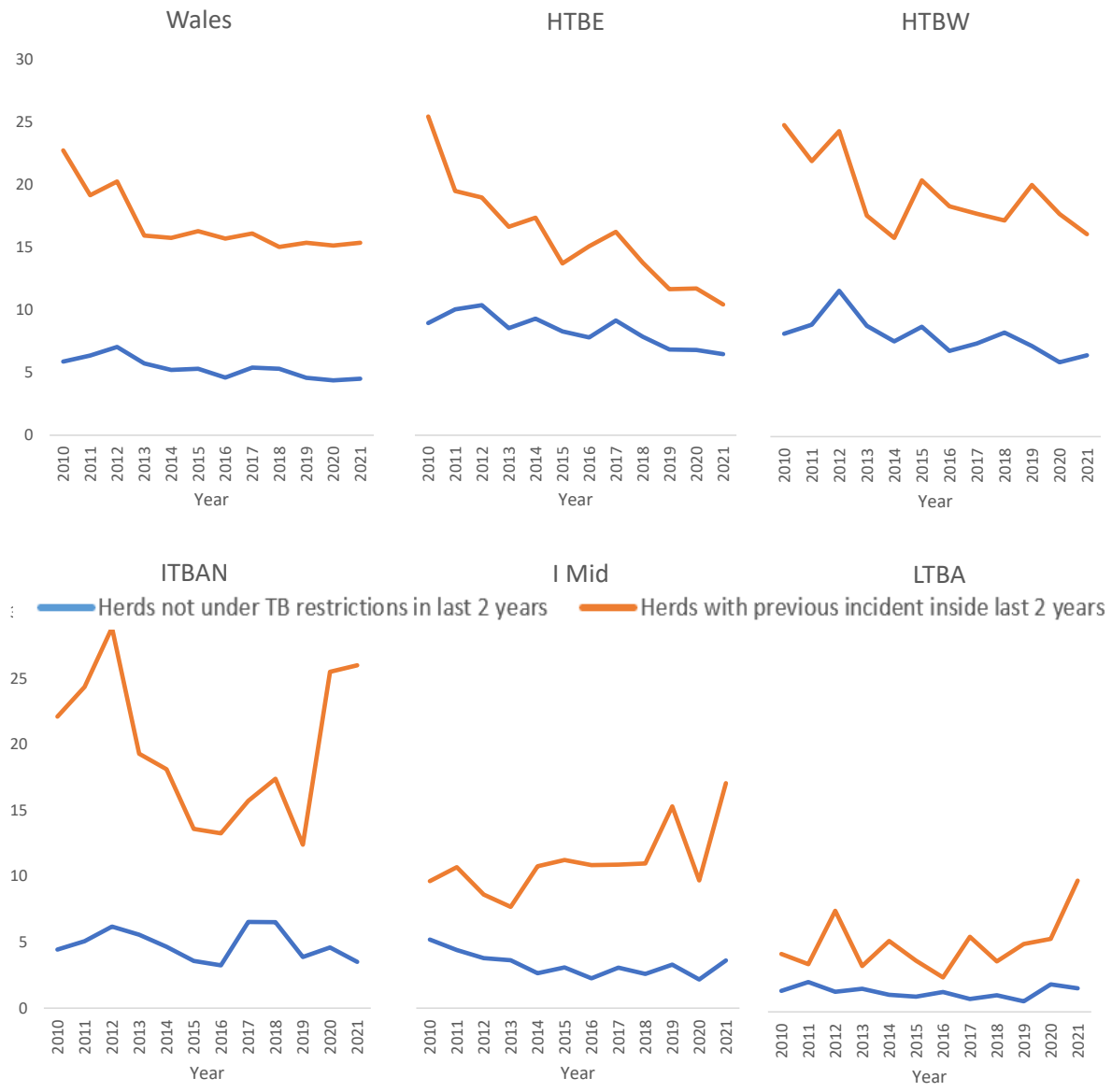
The trends for the number of persistent herds in the period from 2009 to 2021 is shown in Annex, Figure 2A. In all areas other than ITBAN and LTBA, the number of closed persistent incidents has decreased in this time. This may in part be due to the change in policy in 2017 which introduced a higher sensitivity of skin testing and therefore an increased likelihood of detecting infected animals in persistent incidents, resulting in longer total time under restrictions. In these same areas the number of existing and newly persistent herds each year is also decreasing, except for I Mid where there has been an increase in herds entering persistence.

In the LTBA and ITBAN, an upward trajectory can be seen for all three persistent parameters; both show the highest numbers for existing and newly persistent herds from 2018 to 2021 (Annex, Figure 2A).

Recurrent incidents

Recurrent incidents (herds with new incidents within two years of a previous resolved one) in the HTBE and HTBW have been on a downward trend from 2009 to 2021 (Figure 10). There was a sustained increase in recurrent incidents in the I Mid from 2014 onwards, 2021 brought this increase to a new high. Recurrence in the ITBAN has been fluctuating since 2014 but showed a sharp increase in 2020 and in 2021 it increased further. The LTBA has shown lower levels of recurrence than other TB Areas, the trend has been undulating for most of the time but increased by around two-fold post-2018 for one (Appendix 4, Figure 1), two and three-year (Appendix 4, Figure 2) recurrence.

Figure 10: Six small multiple line charts showing annual TB incidence in cattle herds with and without a resolved TB incident in the last 730 days from 2010 to 2021



Description of figure 10 – The top charts from left to right are Wales, High TB Area East, and High TB Area West. The bottom charts from left to right are Intermediate TB Area North, Intermediate TB Area Mid and Low TB Area. The chart is colour coded with orange indicating herds with previous incident inside two years and blue indicating herds that have not had an incident in last two years. The key in the centre provides a reference for the colour scheme used. Between 2010 and 2021, recurrence has steadily decreased in Wales driven by decreases in the High TB Area East and West, however, in recent years recurrence has increased in Intermediate TB Area North and Low TB Area.

Main factors determining risk of infection for cattle herds.

A Poisson multivariate regression analysis was conducted to analyse factors affecting the rate of confirmed incidents across Wales in 2021. Susceptible herds were those that had OTF status in 2020. Table 3 shows the output of the analysis; greater herd size, a previous bTB incident within three years and dairy herds were the most important factors affecting the rate of incidents. Herds that had resolved standard IRs in 2019 or 2020 and herds that had purchased from herds with a risk score of 4 or 5 increased the rate of confirmed incidents but this increase was not statistically significant (Table 3). Herds located in the I Mid or LTBA were significantly less likely to have a confirmed incident in 2021 than the reference TB Area (HTBE).

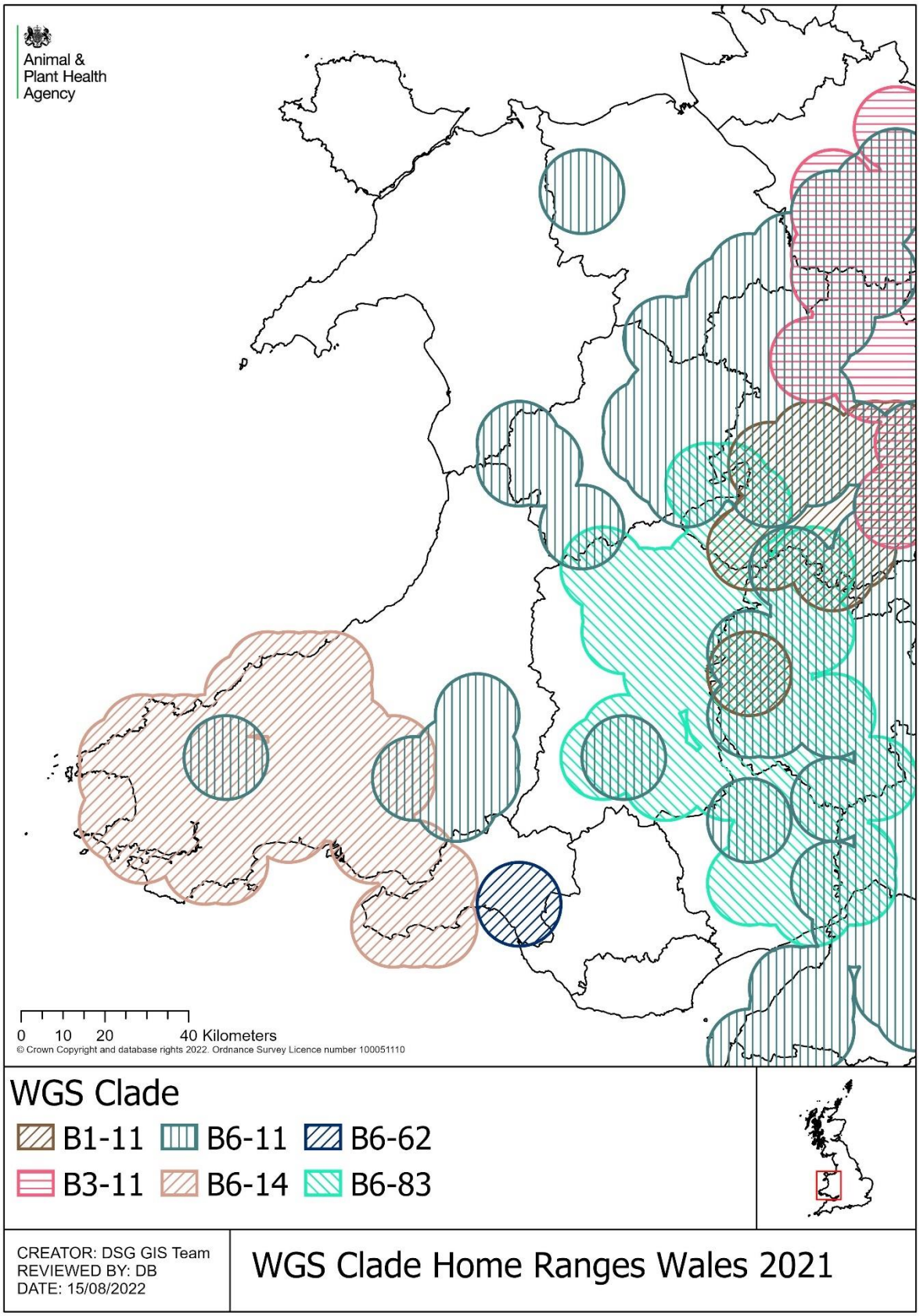
Table 3 – Output of Poisson regression analysis to determine key risk factors influencing the rate of confirmed bovine tuberculosis incidents across Wales in 2021. 95% CI = 95% confidence intervals, p = alpha value, bTB = bovine tuberculosis

Predictors	Incidence Rate Ratio	95% CI	p
(Intercept)	(0.01)	(0.01-0.01)	(<0.001)
Herd bTB Incident in 2018 or 2019 (Reference: no bTB incident in 2018 or 2019)	1.99	1.62-2.42	<0.001
Resolved IRs 2019-2020 (Reference: no history of resolved IRs)	1.18	0.94-1.48	0.150
Purchase from Herd Risk Score 4 or 5 2019-2020 (Reference: no history of Herd Risk Score 4 or 5)	1.19	0.99-1.44	0.070
Dairy Herd (Reference: beef herd)	1.78	1.45-2.18	<0.001
TB Area High TB West (Reference: High TB East)	0.97	0.78-1.22	0.816
TB Area Intermediate TB Mid (Reference: High TB East)	0.11	0.05-0.18	<0.001
TB Area Intermediate TB North (Reference: High TB East)	1.09	0.83-1.44	0.539
TB Area Low TB Area (reference: High TB East)	0.23	0.15-0.35	<0.001
Herd Size 101-300 cattle (Reference: ≤100 cattle)	2.72	2.19-3.38	<0.001
Herd size >300 cattle (Reference: ≤100 cattle)	3.25	2.44-4.31	<0.001

Description of table 3 - A table representing the output of a Poisson regression analysis. The table is organized with the predictors listed in rows and statistical measures in columns. Statistical measures include the Incidence Rate Ratio, 95% confidence interval and probability value. The intersection of each row and column contains data indicating the statistical result for each predictor.

WGS and genotyping

Figure 11: A map of Wales showing Whole Genome Sequencing (WGS) homeranges in 2021 (APHA Weybridge, 2022)



Description of figure 11 – Areas of the map are colour and symbolically coded to show different Whole Genome Sequencing home ranges. Brown with diagonal stripes indicates the B1-11 homerange. Dark green with vertical stripes indicates the B6-11 homerange. Dark blue with diagonal stripes indicates the B6-62 homerange. Red with horizontal stripes indicates the B3-11 homerange. Orange with diagonal stripes indicates the B6-14 homerange. Turquoise with diagonal stripes indicates the B6-83 homerange. The key at the bottom of the map provides a reference for the colour and symbol scheme used.

In 2021, six whole genome sequencing (WGS) clade homeranges were at least partially contained within Wales (Figure 11), with the increasingly ubiquitous B6-11 accounting for 45.9% of the total, followed by B6-14 (32.3%, almost exclusively in the HTBW) and more localised in Gwent & Powys (HTBE), B6-83 (16.2%) as well as B3-11 (2.4%). There were multiple submissions of B6-85, B6-62, B1-11 and B6-81 in 2021 (APHA Weybridge, 2022). Compared to previous years, B6-11 is getting more frequent, having overtaken B6-14 in 2020. A small B6-62 homerange in the Neath-Port Talbot Area (I Mid) constitutes a new addition of a previously out-of-range clade, which is more common in Gloucestershire, Worcestershire, Warwickshire and Oxfordshire in England. It is worth noting that the inclusion of this homerange is based on the minimum sample threshold required (please refer to materials & methods) and the decision to retain it here was driven by the existence of a B6-62 badger isolate, found in Neath, in 2016.

Non-bovine Surveillance

Domestic species

Systematic recording of non-bovine testing did not begin until 2017, hence results are presented from that year onwards (Table 4). A drop in the number of completed tests was seen in 2020, which was due to the impact of the Covid-19 pandemic. Apart from a few exceptions, goats were the most common species requiring TB testing (Table 4), closely followed by New World camelids. Pigs and deer also feature, usually in low numbers with sheep even lower again.

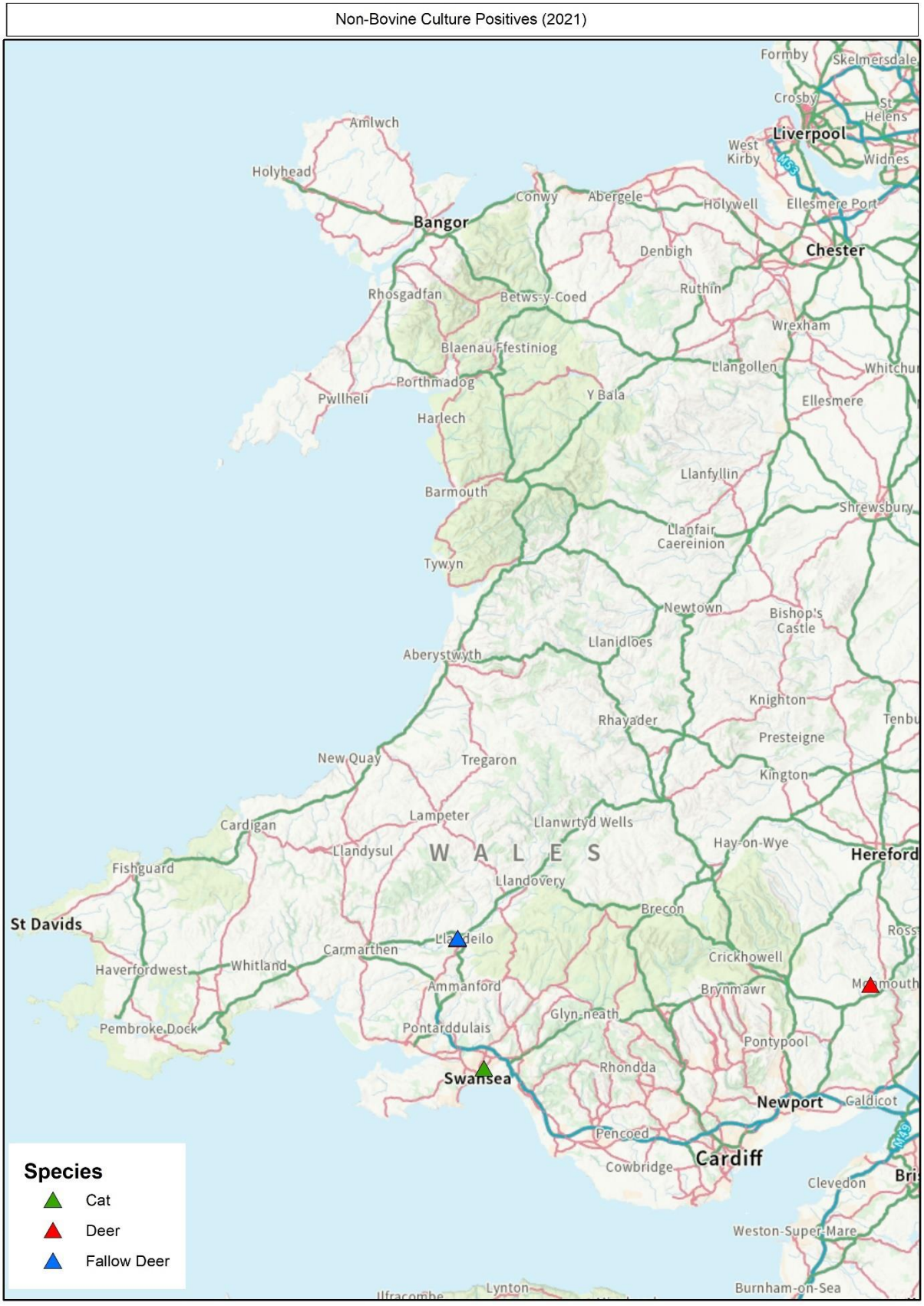
Table 4: Number of herd level non-bovine tests carried out and reactors disclosed per year from 2017 to 2021 by species group.

Year	Deer	South American Camelids	Goats	Sheep	Pigs	Other	Total
2017	4 (0)	58 (0)	61 (0)	2 (0)	7 (0)	2 (0)	134 (0)
2018	3 (0)	57 (22)	65 (0)	2 (0)	10 (1)	0 (0)	137 (23)
2019	5 (0)	92 (3)	86 (2)	1 (0)	9 (0)	2 (0)	195 (5)
2020	0 (0)	51 (6)	61 (0)	0 (0)	4 (0)	0 (0)	116 (6)
2021	14 (0)	73 (5)	67 (0)	0 (0)	1 (0)	0 (0)	155 (5)

Description of Table 4 – A table representing number of herd level non-bovine tests and reactors disclosed for each year from 2017 to 2021. The table is organized with years listed in rows and non-bovine species listed in each subsequent column. Non-bovine species included from left to right are Deer, South American Camelids, Goats, Sheep, Pigs and Other species. The intersection of each row and column contains data indicating the specific number of non-bovine species in the corresponding year.

Recording of samples to be cultured for M. bovis from non-bovine species began in 2012, in a separate process from that of non-bovine bTB testing. The distribution of culture positive samples in 2021 is shown in Figure 12; these consist of two samples from deer and one from a cat. Clinical suspicion of bTB in a living pet is not notifiable, however where bTB is suspected in the carcase of a cat or dog APHA must be notified. Similarly, if a private laboratory were to identify M. bovis by culture in the tissues, secretions or excretions of a live cat or dog, or the carcase of a cat or dog, the laboratory must notify APHA (APHA, 2022). Collection of samples from deer is either at sites where deer are co-located to a cattle incident, or through voluntary submission as part of the Deer Survey. In the latter initiative, samples are submitted primarily by Natural Resources Wales staff who regulate deer populations in forestry they manage, with some from deer stalkers who have completed the Deer Stalking Course level one (Harris, D; Morris, J, Personal Communication, 13 October 2022). The distribution of historical culture positive samples for 2012, 2015 and 2018 is shown in the Annex, Figures 3A-5A.

Figure 12: A map of Wales showing location of samples from non-bovine domestic species which were culture positive for Mycobacterium bovis in 2021



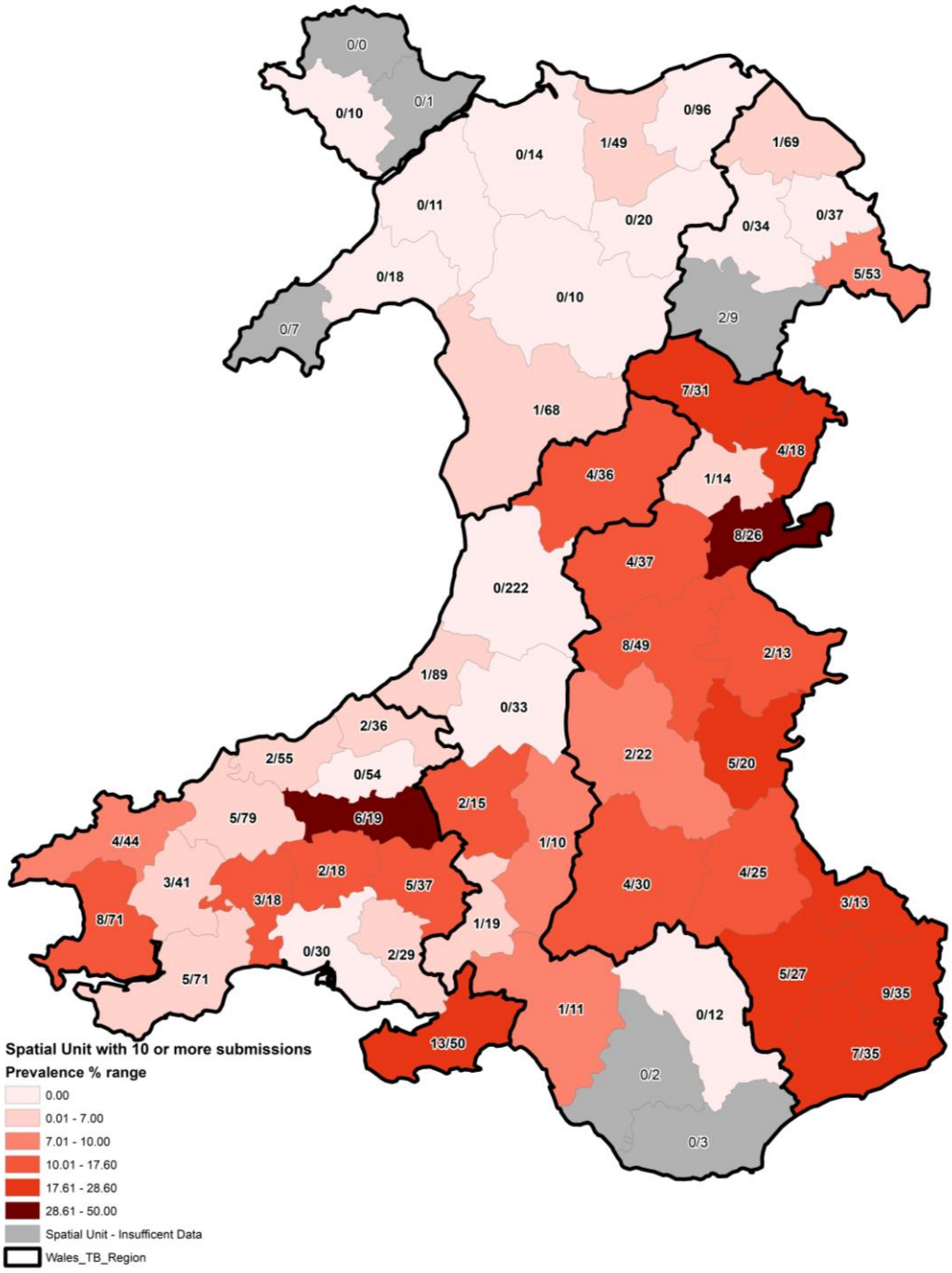
Description of figure 12 – Areas of the map are colour coded to show location of culture positive samples from non-bovine domestic species. A green triangle indicates the location of a sample from a cat. A red triangle indicates the location of a sample from Deer. A blue triangle indicates the location of a sample from Fallow Deer. The key at the bottom of the map provides a reference for the colour and symbol scheme used.

Passive badger surveillance

An all-Wales dead-badger submission scheme began in 2014 to determine how the geographical associations between the genotype of bovine tuberculosis in badgers and in cattle herds has developed since the previous survey conducted in 2005-2006. The results were reported at the level of the newly introduced Wales TB Regionalisation (Schroeder, Hopkins et al. 2020). Based on post-mortem examination and culture, a prevalence estimate was calculated for each TB Area and, where appropriate, individual Spatial Unit (provided at least 10 submissions were received for post-mortem and culture) (Figure 13). Between 2014 and 2021, 2,065 usable badger carcases were submitted and M. bovis was isolated from 165 (8.0%), compared to 12.0 % in the 2005-2006 survey. The highest prevalence estimate was observed for the HTBE (18.8%) followed by the HTBW (9.8%). The LTBA had the lowest percentage of carcases with bTB isolated (1.4%), followed by the two Intermediate TB Areas (2.5%). In the latter part of the survey, there is evidence of an increasing prevalence of M. bovis infection in badgers in the ITBAN while the percentage of infected badgers in the HTBE, which shares its border with England, has remained high throughout.

In 2021, 293 usable badger carcasses were submitted, with 15 culture positives (5.1%). Notable results include a positive sample from the Conwy section of the Denbigh/Conwy TB Cluster (LTBA until 31 October 2021; ITBAN since 1 November 2021) which represents the first positive submission in the LTBA since 2015 and yielded a B6-11 WGS clade isolate (consistent with the B6-11 homerange in Denbigh/Conwy).

Figure 13: A map of Wales showing prevalence estimates for TB infection in badgers based on 2014-2021 badger found dead submission scheme, with TB Area boundaries (n=2065 submitted badger carcasses)



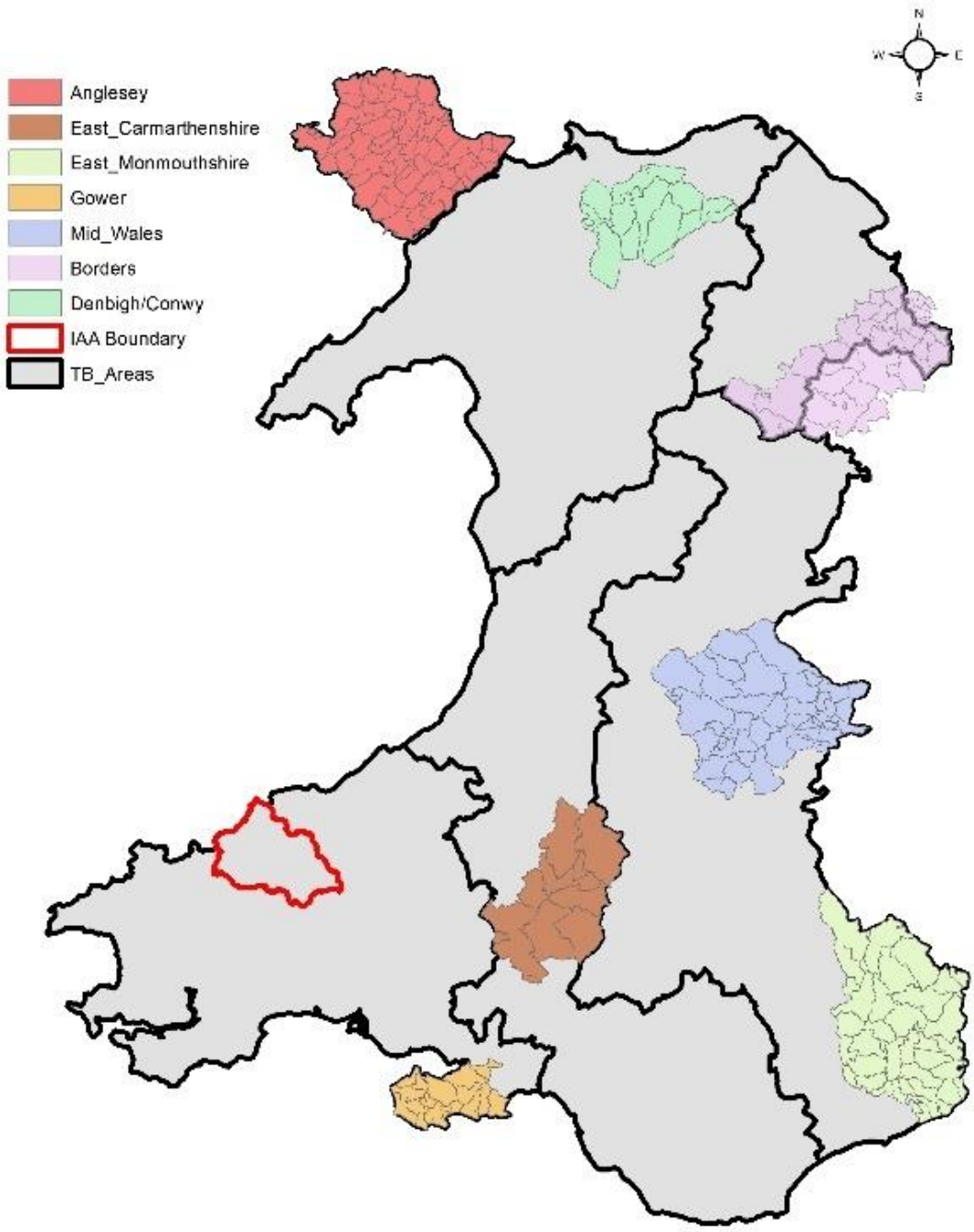
Description of figure 13 - Areas of the map are colour coded to show prevalence estimates for TB infection in badgers. The areas with a higher estimated prevalence are marked in darker shades, while the areas with a lower estimated prevalence are depicted in lighter shades. Grey shading indicates there is insufficient data to estimate prevalence in that spatial unit. The key in the bottom left corner of the map

provides a reference for the colour scheme used. The spatial units with highest prevalence estimates tend to be in the High TB Area East and West.

TB Clusters

The TB Cluster pilot commenced in April 2013, aiming to support the Welsh Bovine TB Eradication strategy by better integrating the use of field epidemiology in the control of bTB. The initial pilot focused on six defined areas or clusters in Wales selected based on their local variation in disease pattern and their distinct geographical boundaries (Anglesey, Wrexham, IAA, East Carmarthenshire, Gower and East Monmouthshire). Each of the five TB Areas incorporates at least one TB Cluster. Two additional clusters were added in 2016 (Mid Wales Cluster) and 2021 (Denbigh/Conwy Cluster) respectively while in 2018 Wrexham was superseded by the Wales Border Cluster (Figure 14).

Figure 14: A map of Wales showing TB Cluster Areas from 2012 to 2021



Description of figure 14 - Areas of the map are colour coded to show TB Cluster areas from 2012 to 2021. The Anglesey cluster is shaded in red. The Denbigh and Conwy cluster is shaded green. The border cluster is shaded pink and crosses into England. The Mid Wales cluster is shaded blue. The IAA boundary is grey with a red border. East Carmarthenshire is shaded brown. East Monmouthshire is shaded green, and the Gower is shaded gold. The key in the top left corner of the map provides a reference for the colour scheme used.

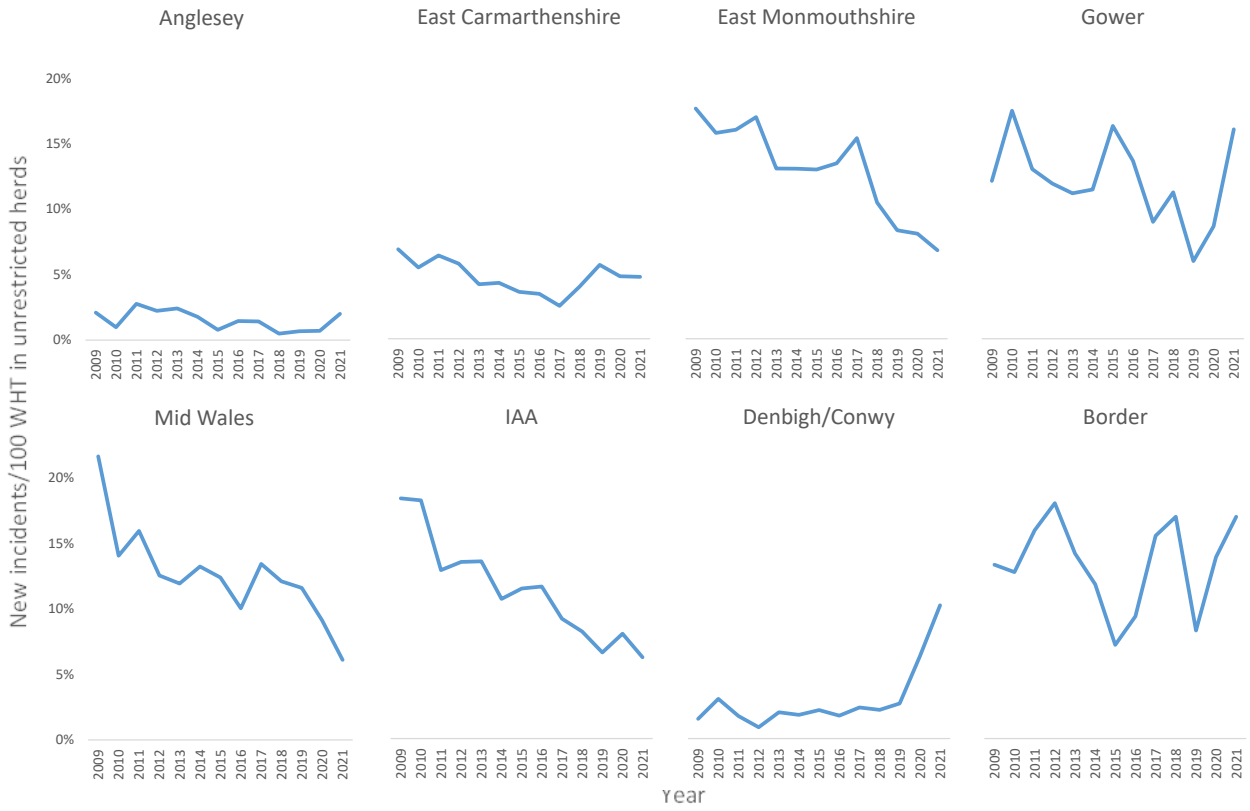
Several clusters have seen a range of interventions and controls imposed on them over time: in 2010 an Intensive Action Area (IAA) was established in the region

which had the highest density of herds with bTB in Wales. This area was subjected to a combination of enhanced cattle controls and Bacillus Calmette-Guerin (BCG) badger vaccination (2012-2015) as well as passive badger surveillance and six-monthly TB testing (Schroeder et al. 2020). For the Gower, almost exclusively an area of beef production, movement restrictions to and from common grazing were introduced in 2015. Subsequently registered numbers of cattle common graziers dropped from 21 in 2012 to 3 in 2018. The same area has also been the focus of a farmer-led badger vaccination pilot (since 2018). Additional bespoke policies recently (June 2021) introduced in the Wrexham portion of the Border Cluster and the Denbigh/Conwy Cluster include blood testing of all non-homebred animals which tested clear at the SICCT but showed positive skin reactions to the purified protein derivative from M. bovis (PPDB) antigen.

East Carmarthenshire incorporates the narrowest section of the I Mid, positioned between converging sections of HTB East and West, and has been the site of overlapping homeranges of 9:b (WGS clade B6-14, usually associated with the HTBW) and 17:a (WGS clade B6-11, more common in the HTBE). This cluster is also characterised by a strong beef focus and has consistently been the part of Wales with the highest proportion of slaughterhouse cases. The East Monmouthshire Cluster was long defined by its prominent dairy focus, with comparatively small milking herds and an emphasis on farms rearing their own replacements, as well as being part of (what was assumed to be) a small and well-defined 22:a genotype homerange. This conception has now been superseded by an understanding that this presumed genotype is part of a much larger (B6-83) WGS clade which also contains many isolates previously given the 9:c genotype. More recently this cluster has seen a decline in both the number and overall proportion of cattle operations still committed to dairy farming. The Mid Wales Cluster is largely congruent with the Mid Powys Spatial Units PM1 and PM2 and as such is almost exclusively made up of small and medium size beef herds, with strong links to local cattle markets such as Ludlow and Knighton.

Finally, Anglesey has long been the cluster with the strongest claim for OTF designation, with its geographic isolation and, until recently, relative absence of badgers. Moreover, after field and molecular epidemiological investigation the few bTB incidents which did occur were almost invariably attributed to purchased disease.

Figure 15: 8 small multiple charts of incidence in Welsh TB Clusters from 2009 to 2021



Description of figure 15 – The top charts from left to right are Anglesey, East Carmarthenshire, East Monmouthshire, and the Gower. The bottom charts from left to right are Mid Wales cluster, Intensive Action Area, the Denbigh and Conwy cluster and the Border cluster.

The strongest improvements were recorded for three clusters in the High TB Area, with the Mid Wales Cluster leading the way having seen a drop in cattle TB incidence from 22% in 2009 to just over 6% in 2021, constituting a reduction of 75%. Incidence in both the IAA and East Monmouthshire had fallen by more than 60% over the same period (Figure 15). The fourth cluster in the High TB Area, Gower, has seen no sustained long-term trend although incidence has increased over the last two years.

Disease levels in East Carmarthenshire Cluster have remained on a moderate plateau for the last three years. The Border Cluster has seen several peaks and troughs of bTB incidence over the last four years with recent levels very close to the all-time high; this pattern contrasts with the pronounced upward trajectory in the Denbigh/Conwy Cluster where incidence has increased by a factor of 10 since 2012.

Four-year review of Wales TB eradication targets

Background

The Wales eradication target and milestones policy statement (Welsh Government 2017) was released in December 2017 and set out the overall target for reaching TB

free status for Wales by 2041[1] as well as several regional (TB Area) milestones towards TB eradication (Table 5). These milestones were divided into four, six-year intervals with chronologically staggered eradication or incidence reduction milestones. The first annual review of the Wales TB eradication targets was carried out in March 2019 and from thereon, revisited on an annual basis. This section reviews the first four years of the initial six-year period (2017-2023) or first quartile of the overall 24-year eradication timeframe.

Table 5: Wales TB eradication timeframe from published policy statement (1), revised to include period prevalence in run-up to OTF status

Six-year interval	Low TB Area	Intermediate TB Area North	Intermediate TB Area Mid	High TB Area East	High TB Area West
2018-2023	**OTF**	50% fall in incidence. CL3 to Low TB area.	50% fall in incidence.	50% fall in incidence. PN1 to Intermediate TB Area.	50% fall in incidence. CE4 to Intermediate TB Area.
2024-2029	**OTF**	Achieve and maintain less than 0.1% incidence and prevalence.	Achieve and maintain less than 0.1% incidence and prevalence.	40% fall in incidence.	40% fall in incidence.
2030-2035	**OTF**	**OTF**	**OTF**	Achieve and maintain less than 0.1% incidence and prevalence.	Achieve and maintain less than 0.1% incidence and prevalence.
2036-2041	**OTF**	**OTF**	**OTF**	**OTF**	**OTF**

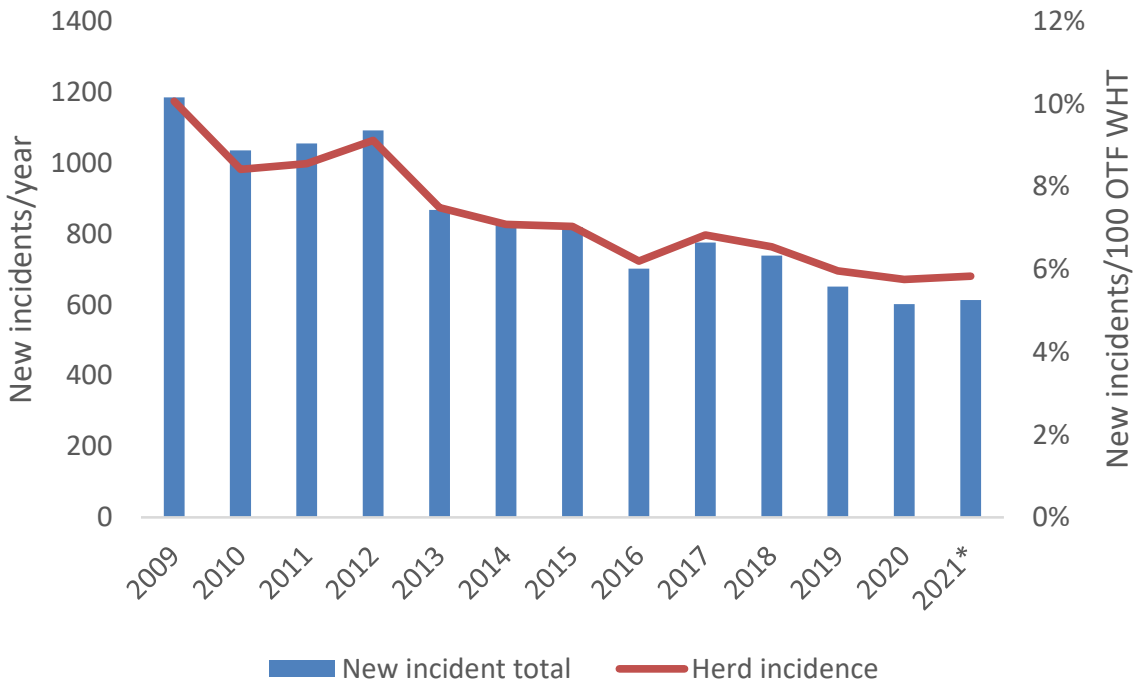
Description of table 5 – The table visually shows Welsh Governments eradication target and milestone statement as originally conceived. The rows indicate the timeframe by which Welsh Government hopes to achieve eradication targets for each TB Area in six-year intervals by descending chronological order. Each column refers to a TB Area. The intersection of each row and column contains information on the targeted level of prevalence and incidence for each specific six-year interval. Welsh Government aims to achieve OTF status for the Low TB Area while reducing incidence

[1] The definition for Officially TB Free (OTF) status is set out in Council Directive 64/432/EEC and in more detail, 97/12/EEC, which specifies that Member States or areas within Member States may be declared OTF if the percentage of bovine herds confirmed as infected with tuberculosis (not including incidents where disease brought in from higher TB Areas) has not exceeded 0.1% per year of all herds for six consecutive years. In addition, at least 99.9 % of herds need to have achieved OTF status each year for six consecutive years (based on situation at 31 December in each year). In the original briefing note presented to Welsh Government in November 2017, the 2041 target featured as “best case scenario”. It was then chosen as preferred option by the Cabinet Secretary. To achieve this goal, annual incidence needs to fall below 0.1% by 2036 and stay below this threshold until the target year 2041.

by 50% in each of the other areas by 2023. Furthermore, PN1 and CE4 are targeted for transfer to the Intermediate TB Area and CL3 to the Low TB Area. By 2029, Welsh Government aims to achieve and maintain less than 0.1% incidence and prevalence in both Intermediate TB Areas and see a 40% reduction in High TB Areas. By 2035, Welsh Government aims to achieve OTF status in the intermediate TB Areas, while achieving and maintain less than 0.1% incidence and prevalence in the High TB Areas. Finally, by 2041, Welsh Government aims to achieve OTF status for all of Wales.

Regional eradication progress

Figure 16: Vertical bar and line chart of new bTB incidents and annual herd incidence in Wales from 2009 to 2021; *Excludes OTFS incidents triggered by North Wales Supplementary Blood Test policy

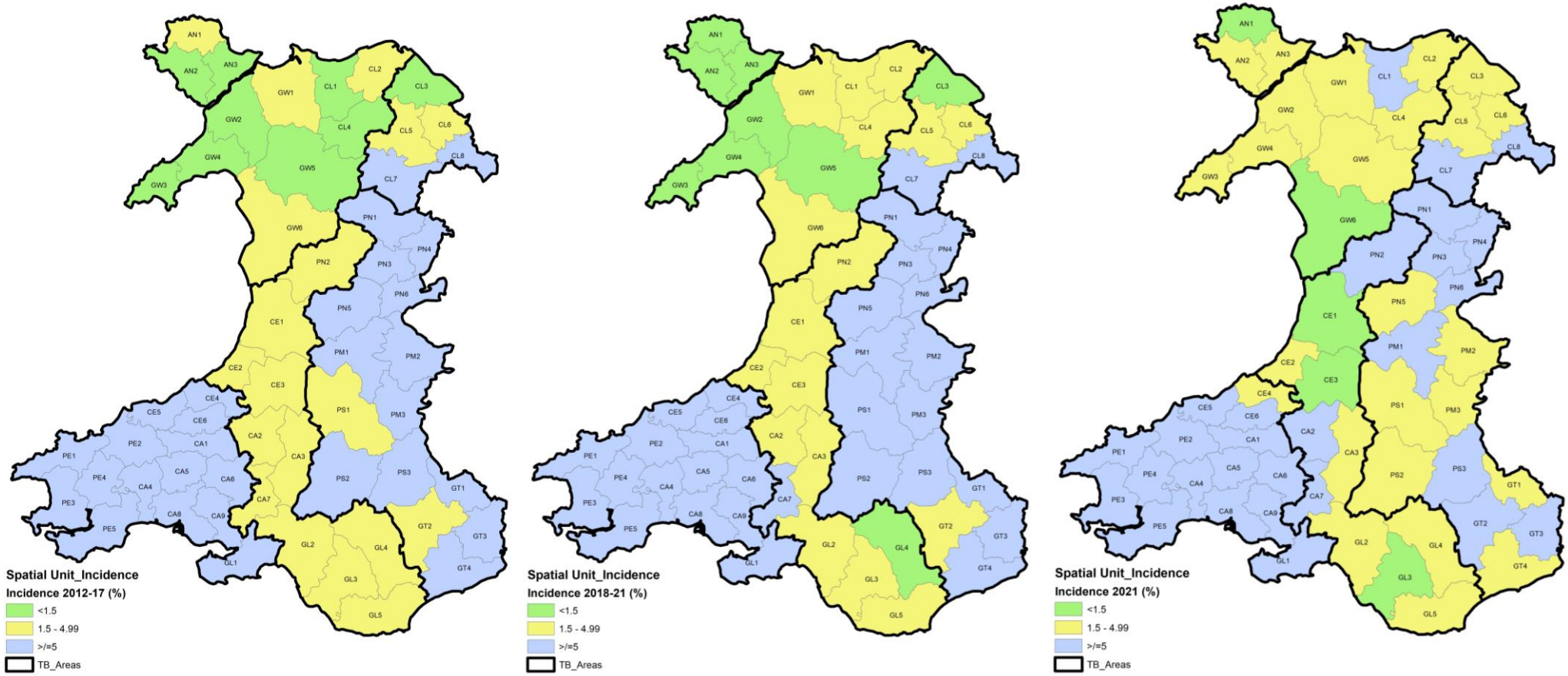


Description of figure 16 - The blue vertical bars indicate the number of new incidents per year and corresponds to the left Y-axis while the red line indicates annual herd incidence percentage and corresponds to the right Y-axis. The key on the bottom of the chart provides a reference.

Nationally, bTB incidence has fallen between 2012 and 2021 by over 40% (Figure 16). Between 2017 and 2021 a decrease of almost 19.8% was recorded (Figure 16). The official Wales bTB eradication milestones for the first six years included a halving of annual TB incidence, in relation to the 2012 to 2017 observation period. Of the five TB Areas, HTBE has shown the largest progress with a 26.9% reduction in pooled annual incidence for 2018-21 with notable improvements in Gwent, Mid and South Powys, compared with pooled incidence for 2012-17. In the same period HTBW incidence has fallen by 17.1%, and by 6.2% in the I Mid (with improvements especially notable in

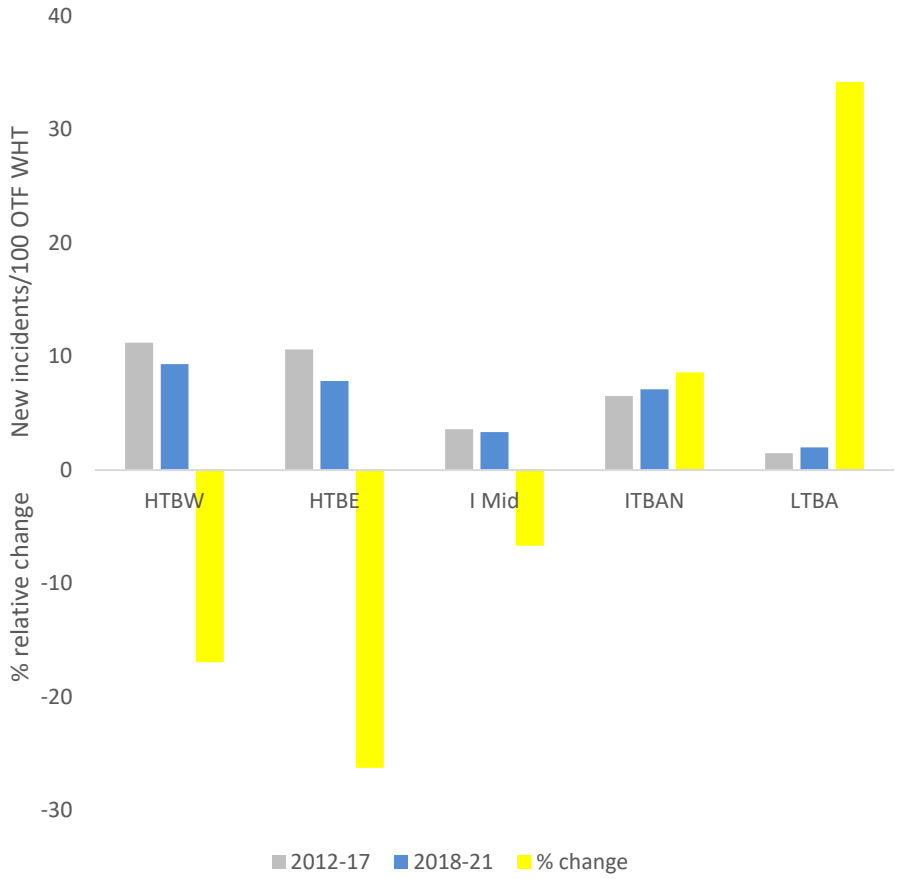
Glamorgan). In the last four years incidence has increased in parts of the LTBA (most notably CL1, CL2 and CL4) and ITBAN (especially CL8).

Figure 17: Three maps of Wales showing pooled incidence (all new incidents in year/100 OTF WHT) by Spatial Unit; pooled 2012-17 (left), pooled 2018-21 (centre) and 2021 (right)



Description of figure 17 - Areas of the map are colour coded to show consideration thresholds for each TB Area. Spatial units with an incidence level less than 1.5% are shaded green and are consistent with expected levels for the Low TB Area. Spatial units with an incidence level between 1.5% and 4.99% are shaded yellow and are consistent with expected levels for the Intermediate TB Areas. Spatial units with an incidence level at 5% or more are shaded blue and are consistent with expected levels for the High TB Areas. The key in the bottom left corner of each map provides a reference for the colour scheme used.

Figure 18: Bar chart showing pooled incidence for 2012-17 in each TB Area compared with 2018-21



Description of Figure 18 – From left to right, the bar chart refers to High TB Area West, High TB Area East, Intermediate TB Area Mid, Intermediate TB Area North and Low TB Area. The bar chart is colour coded with grey indicating pooled incidence in 2012-17 and blue indicating pooled incidence in 2018-21. The yellow bar indicates the relative percentage change between 2012-17 pooled incidence and pooled incidence 2018-21. The key at the bottom of the chart provides a reference for the colour scheme used. The Y-axis has two separate meanings depending on which bar we are using. For the grey and blue bars, the Y-axis indicates new incidents divided by number of OTF WHT tests multiplied by 100. For the yellow bar, the Y-Axis indicate the relative percentage change between pooled incidence in 2012-17 and 2018-21.

Spatial Unit reallocation

Looking at the longer-term disease trajectories and the thresholds detailed in the 2017 policy document[2], Spatial Units PS1 & PS2 (South Powys, incidence 2018-21 just above 5% consideration threshold but recent trend has shown improvement, Figure 17) could be targeted for transfer from HTBE to I Mid. Not all Spatial Units originally conceived for transfer to areas with a lower risk designation are on a trajectory consistent with this objective, this is especially true for PN1 (HTBE) which has exceeded the threshold for Intermediate TB areas over the last 10 years. CE4 (HTBW) has been intermittently consistent with transfer to the I Mid since 2017 while CL3 (ITBAN) has continued to meet the threshold which would support incorporation into the LTBA had it not been for a considerable surge in incidence in 2021.

Regionalisation changes

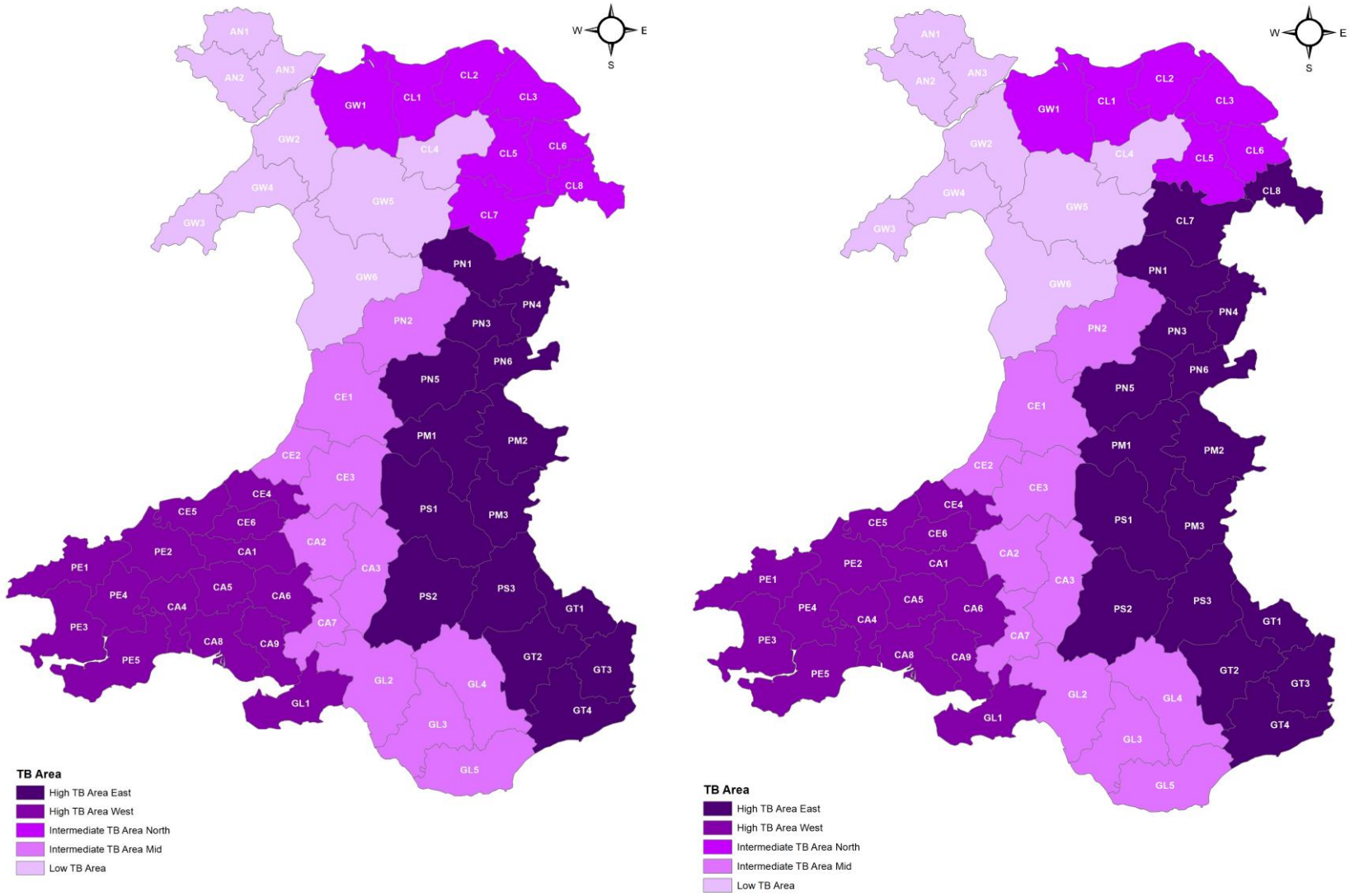
As stated in the Eradication Target policy note published in December 2017, any Spatial Unit transfers to areas with lower risk designation and more stringent TB controls are limited to the interquartile window (the period between each six-year quartile of the overall 24-year eradication timeframe), provided the conditions set out in Table 5 are met. The alternative approach where such a re-allocation is instigated as soon as a Spatial Unit has met the consideration threshold for at least six reporting years, either consecutively or based on pooled cases, would have to be phased in after the completion of the first quartile. This assumes that stakeholders may require due preparation time for the additional cattle controls incurred following transfer to an area with a lower risk designation. Conversely, if Spatial Units were to be earmarked for transfer from a lower risk area to an area with a higher risk designation, based on an escalating TB situation, ostensibly there would be no reason for any delays. Such a change has now been implemented to account for the escalating situation across the Denbigh/Conwy area with the transfer of CL1, CL2 and GW1 to the ITBAN on 1 November 2021 (Figure 19). This enabled the introduction of pre-movement testing in these areas.

Finally, the Wrexham Spatial Units (CL7 and CL8) have long been incorporated into a risk category lower than their current disease trajectory would suggest. This was done to (i) prevent any further fragmentation of the already very small ITBAN and (ii) to allow additional cattle controls in an area where disease is usually attributed to local cattle movements while there is scant evidence of bTB in badgers. However, such discretion can also be detrimental for Spatial Units in the Intermediate TB Area with lower incidence and prevalence as they may be more exposed to movement threats from higher-incidence locations /which share the same risk designation. With fragmentation not an immediate concern due to the move of CL1, CL2 and GW1 to

[2] To be considered for transfer to Intermediate TB Area, High TB Area Spatial Units should have annual crude herd incidence of 1.5% - 5%; form a continuous area with other Spatial Units of the Intermediate TB Area; show no significant levels of endemic disease (as established through badger found dead surveys and other field epidemiological investigations). To be considered for transfer to the Low TB Area, Intermediate TB Area spatial units should; have annual crude herd incidence of <1.5%; form a continuous area with the rest of the Low TB Area; show no significant level of endemic disease (as established through badger found dead surveys and other field epidemiological investigations).

ITBAN, an alternative regionalisation, accounting for the endemic situation in the Wrexham area is proposed below.

Figure 19: (left) Wales TB Regionalisation as of 1st November 2021; (right) alternative regionalisation accounting for both the long-term trend in Wrexham (Spatial Units CL7 & 8)



Description of figure 19 - Areas of the maps are colour coded to show the current and proposed TB Area boundaries. The darkest shade of purple indicates the High TB Area East and West. The medium shades are the Intermediate TB Area North and Mid. The lightest shade of purple indicates the Low TB Area. A key at the bottom left of each map provides a reference for the colours used. The proposed new TB Areas boundaries include transfer of the Wrexham spatial units CL7 and CL8 from the Intermediate TB Area North into the High TB Area East.

Bibliography

Allen, A. R., Skuce, R. A. & Byrne, A. W. (2018). Bovine tuberculosis in Britain and Ireland—a perfect storm? The confluence of potential ecological and epidemiological impediments to controlling a chronic infectious disease. Front. Vet. Sci., 5, 109.

APHA (2022). OV Instructions Retrieved 23/11/2022 from http://apha.defra.gov.uk//External_OV_Instructions/index.htm

Badger Trust (2021). What is the law? Retrieved 24/12/2021 from https://www.badgertrust.org.uk/

Bouchez-Zacria, M., Courcoul, A. & Durand, B. (2018). The distribution of bovine tuberculosis in cattle farms is linked to cattle trade and badger-mediated contact networks in south-western France. Front. Vet. Sci., 6, 2007-2015. https://doi.org/https:// doi. org/ 10. 3389/ fvets. 2018. 00173

Campbell, E. L., Byrne, A. W., Menzies, F. D., McBride, K. R., McCormick, C. M., Scantlebury, M., & Reid, N. (2019). Interspecific visitation of cattle and badgers to fomites: A transmission risk for bovine tuberculosis? Ecology and Evolution, 9, 8479–8489. https://doi.org/DOI: 10.1002/ece3.5282

Conlan, A., McKinley, T., Karolemeas, K., Brooks-Pollock, E., Goodchild, A., & AP, M. (2012). Estimating the Hidden Burden of Bovine Tuberculosis in Great Britain. PLoS Comput Biol, 8(10). https://doi.org/ https://doi.org/10.1371/journal.pcbi.1002730

Corner, L. A., Murphy, D. & Gormley, E. (2011). Mycobacterium bovis infection in the Eurasian badger (Meles meles): The disease, pathogenesis, epidemiology and control. Journal of Comparative Pathology, 144, 1-24. https://doi.org/https:// doi. org/ 10. 1016/j. jcpa. 2010. 10. 003

Fitzgerald, S. D. a. K., J.B. (2013). Wildlife reservoirs of bovine tuberculosis worldwide: hosts, pathology, surveillance, and control. Veterinary Pathology, 50(3), pp.488-499.

More, S.J., Houtsma, E., Doyle, L., McGrath, G., Clegg, T.A., de la Rua-Domenech, R., Duignan, A., Blissitt, M.J., Dunlop, M., Schroeder, P.G., Pike, R., Upton, P. (2018). Further description of bovine tuberculosis trends in the United Kingdom and the Republic of Ireland, 2003-2015. Veterinary Record, 183 (23), pp. 717. doi: 10.1136/vr.104718. Epub 2018 Nov 28. PMID: 30487295; PMCID: PMC6312888.

Nugent, G. (2011). Maintenance, spillover and spillback transmission of bovine tuberculosis in multi-host wildlife complexes: a New Zealand case study. Veterinary microbiology, 151(1-2), pp.34-42.

O'Reilly, L. M., & Daborn, C. J. (1995). The epidemiology of Mycobacterium bovis infections in animals and man: a review. . Tubercle and Lung disease, 76, 1-46.

Renwick, A. R., White, P.C.L. and Bengis, R.G. (2007). Bovine tuberculosis in southern African wildlife: a multi-species host–pathogen system. Epidemiology & Infection, 135(4), pp.529-540.

Robinson, P. A. (2017). Farmers and bovine tuberculosis: Contextualising statutory disease control within everyday farming lives. Journal of Rural Studies, 55, pp.168-180.

Schroeder, P., Hopkins, B. J., Jones, J., Galloway, T., Pike, R., Rolfe, S., & Hewinson, G. (2020). Temporal and spatial Mycobacterium bovis prevalence patterns as evidenced in the All Wales Badgers Found Dead (AWBFD) survey of infection 2014–2016. Nature Scientific Reports, 10, 15214.

Welsh Government (2021). Low TB Area: frequently asked questions. Retrieved 14/12/2022 from https://gov.wales/low-tb-area-frequently-asked-questions

Wobeser, G. (2009). Bovine tuberculosis in Canadian wildlife: an updated histor. The Canadian veterinary journal, 50(11), p.1169.

Annex

Table 1A - Results of post-mortem examination for each TB Area in Wales by year

Description of Table 1A – A table representing the number and percentage of post-mortem with and without detected lesions for each TB Area from 2009 to 2021. The table is organized with years and TB Area listed in rows in the first two columns. From left to right, the subsequent columns show the number of post-mortem results without any detected lesions, the percentage of total with no detected lesions, the number with detected lesions, the percentage of total with detected lesions and the total number of samples. The intersection of each row and column contains post-mortem data for the corresponding year and TB Area.

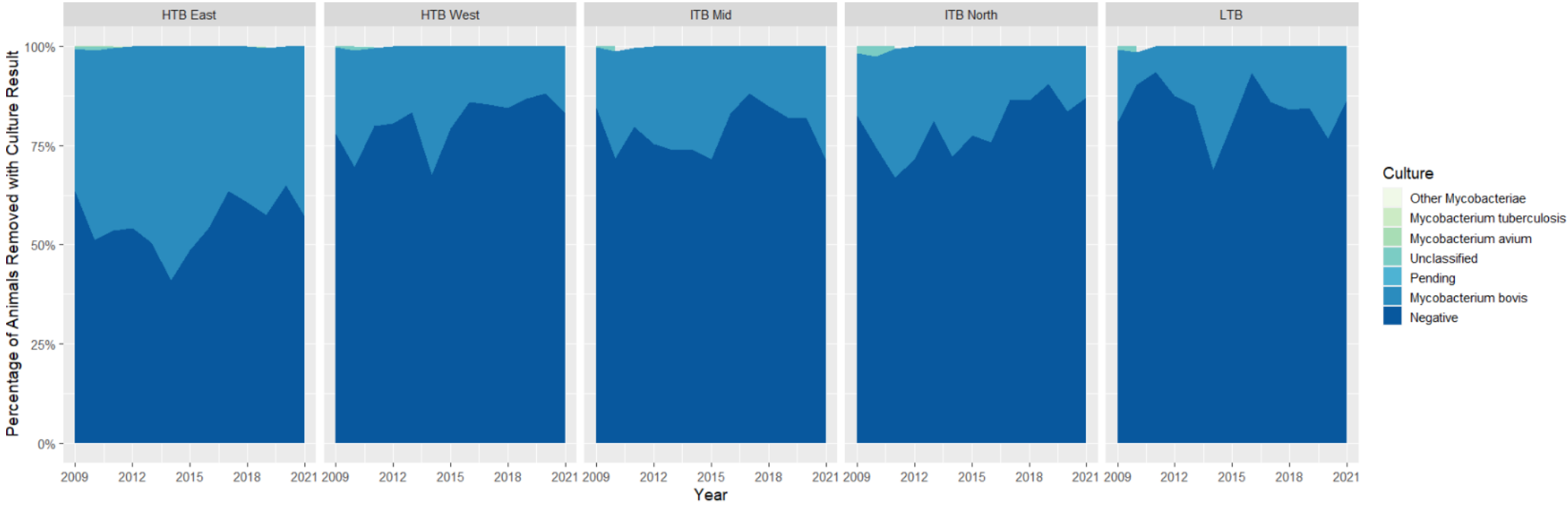
Year	TB Area	Number of samples without lesions	% of samples without lesions	Number of samples with lesions	% of samples with lesions	Total
2009	High TB Area East	2,028	70.8	838	29.2	2,866
2009	High TB Area West	5,679	77.9	1,611	22.1	7,290
2009	Intermediate TB Area Mid	697	84.1	132	15.9	829
2009	Intermediate TB Area North	253	86.1	41	13.9	294
2009	Low TB Area	162	83.9	31	16.1	193
2010	High TB Area East	1,549	68.5	712	31.5	2,261
2010	High TB Area West	3,275	77.1	970	22.9	4,245
2010	Intermediate TB Area Mid	433	71.6	172	28.4	605
2010	Intermediate TB Area North	206	88.8	26	11.2	232
2010	Low TB Area	86	94.5	5	5.5	91
2011	High TB Area East	1,793	73.2	657	26.8	2,450
2011	High TB Area West	3,931	82.6	830	17.4	4,761
2011	Intermediate TB Area Mid	387	83.2	78	16.8	465
2011	Intermediate TB Area North	213	78	60	22	273
2011	Low TB Area	115	96.6	4	3.4	119
2012	High TB Area East	1,912	72.1	740	27.9	2,652

2012	High TB Area West	4,696	80	1,172	20	5,868
2012	Intermediate TB Area Mid	324	81.4	74	18.6	398
2012	Intermediate TB Area North	386	79.3	101	20.7	487
2012	Low TB Area	100	89.3	12	10.7	112
2013	High TB Area East	1,209	71.8	476	28.2	1,685
2013	High TB Area West	3,187	83.1	646	16.9	3,833
2013	Intermediate TB Area Mid	251	83.7	49	16.3	300
2013	Intermediate TB Area North	322	85.9	53	14.1	375
2013	Low TB Area	85	87.6	12	12.4	97
2014	High TB Area East	1,507	67	743	33	2,250
2014	High TB Area West	2,375	73.1	872	26.9	3,247
2014	Intermediate TB Area Mid	274	82.3	59	17.7	333
2014	Intermediate TB Area North	455	78.9	122	21.1	577
2014	Low TB Area	146	88.5	19	11.5	165
2015	High TB Area East	1,465	70.1	625	29.9	2,090
2015	High TB Area West	4,339	83.9	831	16.1	5,170
2015	Intermediate TB Area Mid	329	76.5	101	23.5	430
2015	Intermediate TB Area North	415	87.4	60	12.6	476
2015	Low TB Area	118	88.7	15	11.3	133
2016	High TB Area East	1,481	76.4	457	23.6	1,939
2016	High TB Area West	5,779	87.6	815	12.4	6,594
2016	Intermediate TB Area Mid	616	83.1	125	16.9	741
2016	Intermediate TB Area North	475	91.3	45	8.7	520
2016	Low TB Area	278	96.5	10	3.5	288
2017	High TB Area East	1,839	75.2	607	24.8	2,446
2017	High TB Area West	6,015	90	667	10	6,682
2017	Intermediate TB Area Mid	382	88.4	50	11.6	432

2017	Intermediate TB Area North	681	93	51	7	732
2017	Low TB Area	85	87.6	12	12.4	97
2018	High TB Area East	1,749	77.9	497	22.1	2,246
2018	High TB Area West	6,938	90	767	10	7,705
2018	Intermediate TB Area Mid	512	83.1	104	16.9	616
2018	Intermediate TB Area North	641	90.5	67	9.5	708
2018	Low TB Area	236	91.8	21	8.2	257
2019	High TB Area East	1,657	80.2	410	19.8	2,067
2019	High TB Area West	7,887	92.5	639	7.5	8,526
2019	Intermediate TB Area Mid	565	86.5	88	13.5	653
2019	Intermediate TB Area North	1,130	94	72	6	1,202
2019	Low TB Area	182	92.4	15	7.6	197
2020	High TB Area East	1,653	75.7	530	24.3	2,183
2020	High TB Area West	5,951	92.3	494	7.7	6,445
2020	Intermediate TB Area Mid	480	83.5	95	16.5	575
2020	Intermediate TB Area North	1,061	88.6	137	11.4	1,198
2020	Low TB Area	266	82.1	58	17.9	324
2021	High TB Area East	1,300	77.4	379	22.6	1,679
2021	High TB Area West	5,984	92.3	498	7.7	6,482
2021	Intermediate TB Area Mid	635	82.9	131	17.1	766
2021	Intermediate TB Area North	1,269	93	95	7	1,364
2021	Low TB Area	552	89.5	65	10.5	617

Bacterial culture outcome

Figure 1A: Five stacked area plot showing the outcome of bacterial culture on samples collected from cattle removed from farms due to suspicion of infection with Mycobacterium bovis, from 1 January 2009 to 31 December 2021.

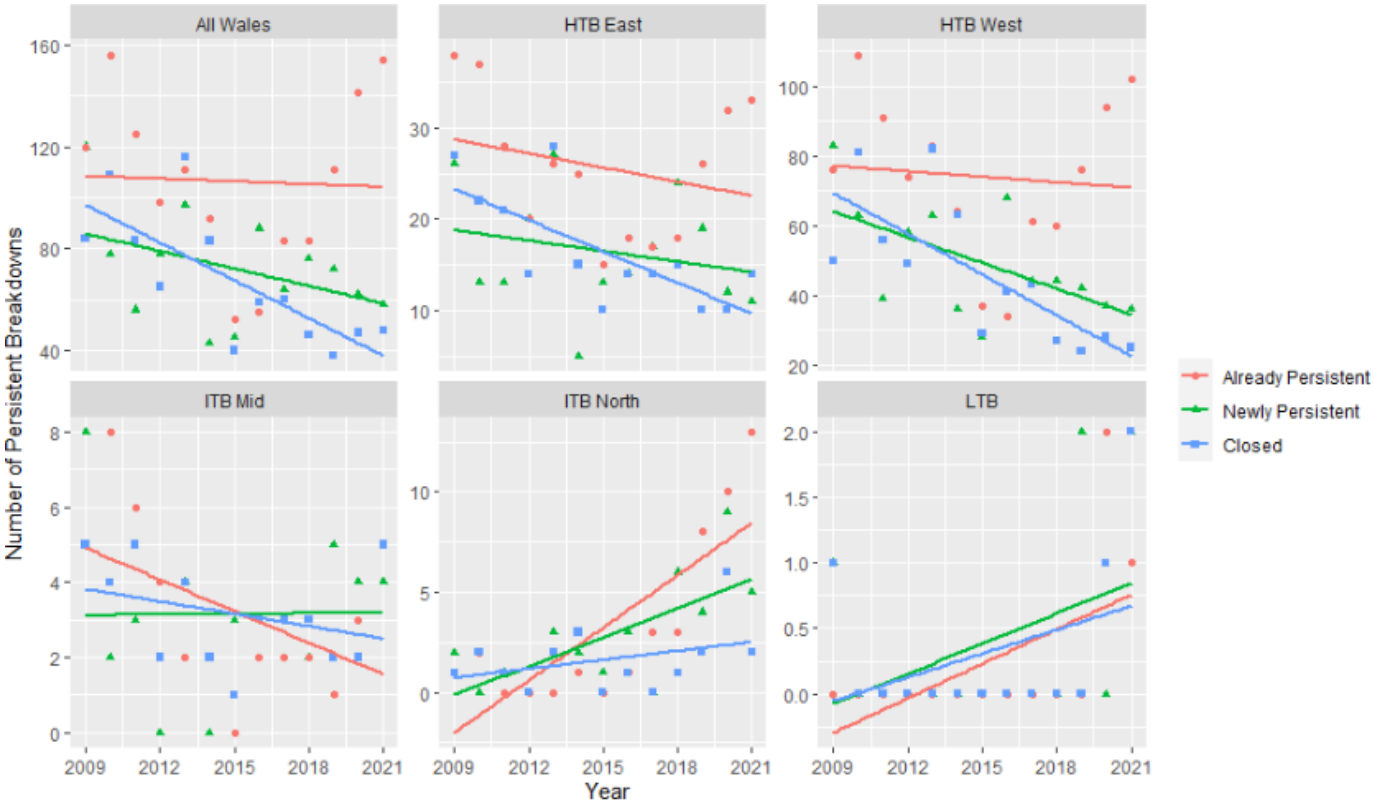


Description of Figure 1 – From left to right, the stacked area plots represent the High TB Area East, High TB Area West, Intermediate TB Area Mid, Intermediate TB Area North and Low TB Area. The chart is colour coded with the darkest blue indicating the percentage of negative samples. The medium shaded blue indicates the percentage of samples with detected Mycobacterium bovis. Cyan indicates the percentage of pending samples. Turquoise indicates the percentage of unclassified samples. The darker green indicates the percentage of Mycobacterium avium samples. The medium shaded green indicates the percentage of Mycobacterium tuberculosis, and the light green indicates the percentage of Other Mycobacteriae samples. The key to the right of

the chart provides a reference for the colour scheme used. Most samples are negative however the High TB East has a higher percentage of detected Mycobacterium bovis samples.

Persistent breakdowns from 2009 to 2021

Figure 2A: Six small multiple scatterplots showing incidents that were already persistent, that became persistent and closed persistent incidents each year from 2009 to 2021, across the Wales TB Areas and the whole of Wales. A linear regression line is fitted to show the trend over time



Description of Figure 2A - The top charts from left to right are Wales, High TB Area East, and High TB Area West. The bottom charts from left to right are Intermediate TB Area Mid, Intermediate TB Area North and Low TB Area. The chart is colour coded with the red line and red dots indicating the number of already persistent breakdowns, the green line and green triangles indicate newly persistent breakdowns, and the blue line and blue squares indicate closed persistent breakdowns. The key to the right of the chart provides a reference for the colour scheme used. Between 2009 and 2021, the number of newly persistent breakdowns has decreased across Wales however the number closed has also decreased while the number already persistent has remained similar.

Non-bovine species

Figure 3A: Map showing location of culture positive M. bovis samples from non-bovine species in 2012

Description of figure 3A - Areas of the map are colour coded to show location of culture positive samples from non-bovine domestic species. A green triangle indicates the location of a sample from a cat. A pink triangle indicates the location of a sample from Llama. An orange triangle indicates the location of a sample from a pig. A brown triangle indicates the location of a sample from a sheep. The key at the bottom left of the map provides a reference for the colour and symbol scheme used.

Figure 4A: Map showing location of culture positive M. bovis samples from non-bovine species in 2015

Description of figure 4A: Areas of the map are colour coded to show location of culture positive samples from non-bovine domestic species. A green triangle indicates the location of a sample from a cat. A red triangle indicates the location of a sample from Deer. A blue triangle indicates the location of a sample from Fallow Deer. A brown triangle indicates the location of a sample from a sheep. The key at the bottom of the map provides a reference for the colour and symbol scheme used.

Figure 5A: Map of Wales showing location of culture positive M. bovis samples from non-bovine species in 2018

Areas of the map are colour coded to show location of culture positive samples from non-bovine domestic species. An orange triangle indicates the location of a sample from an Alpaca. A green triangle indicates the location of a sample from a cat. A red triangle indicates the location of a sample from Deer. A blue triangle indicates the location of a sample from Fallow Deer. A pink triangle indicates the location of a sample from Red deer. A yellow triangle indicates the location of a sample from a Guanaco. The key at the bottom of the map provides a reference for the colour and symbol scheme used.

Glossary of terms table

Description of Glossary of terms table- A table showing the glossary of technical terms with their abbreviation and definition or description. From left to right, the first column is the Abbreviation column, the second column, labelled 'Detail', shows the full technical term and the third provides a definition or description. If there is not a relevant abbreviation for the technical term this is indicated by a [-] symbol.

Abbreviation	**Detail**	**Definition or description**
-	Area Risk Test	Active surveillance (VE-CON, VE-CON6, VE-CON12) single intradermal comparative cervical skin test on entire OTF herd except animals <42do. Scheduled after OTFW incident in directly adjacent (contiguous) whole herd unless another herd test carried out within 60 days either side of incident.
bTB	Bovine Tuberculosis	Infection caused by **bacterial** infection with Mycobacterium bovis (M. bovis)
-	Breakdown	This term is used synonymously with Incidence. It refers to a herd which has evidence of bTB either during testing (reactors or 2 x IRs) or by slaughterhouse surveillance resulting in movement restrictions being imposed. A herd may have multiple incidents in a single year.
-	Chronic herd	Chronicity relates to either recurrence or persistence of TB
-	Confirmed	When there is evidence of M. bovis infection detected at post-mortem examination and/or by laboratory culture.
-	Control test	Skin, IFN γ or antibody test in breakdown herd
-	Contiguous herd	A herd that has a common boundary with the herd of interest, but includes herds separated only by a short distance e.g. across a road or river, or where an epidemiological assessment indicates they are likely to be at risk of exposure to infection.

CTS	Cattle Tracing System	The Rural Payments Agency (RPA), through the British Cattle Movement Service (BCMS) runs Great Britain's Cattle Tracing System (CTS) database on behalf of the English, Scottish and Welsh Ministers. Information, held in the Cattle Tracing System (CTS), is required by European legislation to ensure there is a complete movement history from birth to death for every cattle.
DC	Dangerous Contact	Animals in an OTF-W herd whilst not reactors are at such high risk of being infected that slaughter is justified, usually for the reason of contact with infected cattle.
DL	Detected Lesions	Lesions typical of bovine TB detected in the carcass of a SICCT or IFN-g test reactor at post-mortem examination or during routine slaughterhouse inspection of cattle.
-	Disclosing Test	The test that triggers the start of a new bTB incident.
DRF	Disease Report Form	Form used at the disease investigation visit which acts as a record of case management actions taken and enables capture of TB breakdown data and epidemiological information for subsequent analysis.
-	Genotype	Genotype, previously used for the molecular epidemiology of bTB in GB (and therefore Wales) is a combination of spoligotype and VNTR type. Now superseded by Whole Genome Sequencing (WGS) Clade.
HCW	Health Check Wales	A surveillance initiative operating between 1st October 2008 and 31st December 2009 during which all herds in Wales were tested. Annual testing of all herds has continued thereafter in Wales.
-	Herd	Bovine herds are defined as those which are 'live or active' in SAM (i.e. not archived) for at least 183 days in any one year. This definition varies from the Cattle Tracing System (CTS) and Agricultural Census resulting in different values. The advantage of using SAM is the availability of separate data for every herd within a holding, which is maintained continuously for all herds including very small herds. However, delays in reflecting changes in herd size and type since it was recorded on SAM at the previous test effects the accuracy of estimates.
-	Herd Risk Test	Active surveillance (VE-6M, VE-12M) single intradermal comparative cervical skin test on entire OTF herd except animals <42do. Scheduled six and 18 months after resolved incident.

-	Herd Size	For a bTB incident, herd size is the largest number entered in SAM at any time during the incident. For officially bTB free herds, herd size is generally that recorded at the most recent whole herd test. However, veterinarians performing tests do not always record numbers of animals not tested (e.g. in herds where only breeding bulls, cows that had calved and animals purchased since the previous test were tested) and therefore herd size may be underestimated in some lower-risk herds and areas.
-	Herd Types	'Beef' includes Beef, Finishing, Suckler, Beef Heifer Rearer, Beef Bull Hirer and Stores herds. 'Dairy' includes Dairy, Dairy Dealer, Dairy Bull Hirer, Dairy Producer, Dairy Heifer Rearer and Domestic herds; 'Other' includes Calf Rearer, unspecified Dealer Herds, AI, and herds described on SAM as 'Other herds'.
-	Homerange	The geographical area in which a Whole Genome Sequencing clade is most frequently recovered.
IAT	IDEXX antibody test	The IDEXX M. bovis antibody ELISA (IDEXX Laboratories, Maine, USA) is the diagnostic kit used by APHA for official government-funded TB antibody testing of cattle. This test is an antibody detection assay that uses a combination of two M. bovis recombinant antigens (MPB83 and MPB70). The test is a laboratory blood test used to improve detection of infected cattle in chronic or explosive TB breakdowns.
-	Incidence	For the purposes of this report, incidence – expressed as ratio or percentage – is the quotient between the number of bTB incidents detected ("disclosed") and a denominator for the population, which is the number of whole herd tests in 100 unrestricted ("Officially TB Free OTF") "live or active" herds ("susceptibles"). With no available data on active herds from 2008 to 2011 we have taken as proxy the number of "active" herds in 2012.
-	Incident	This term is used synonymously with breakdowns. It refers to a herd which has evidence of bTB either during testing (reactors or 2 x IRs) or by slaughterhouse surveillance resulting in movement restrictions being imposed. A herd may have multiple incidents in a single year.

IQR	Inter-quartile range	The inter-quartile range is a measure of spread that reports the 25th percentile (meaning that 25% of observations are below the value) and the 75th percentile (meaning that 75% of observations are above the value).
IR	Inconclusive reactor	An animal showing a particular pattern of reactions to a comparative intradermal tuberculin test that uses bovine and avian reagents, where the difference in size of reactions to bovine and avian tuberculin is not large enough to cause it to be described as a reactor. In Wales, both standard and severe interpretation inconclusive reactors are recognised.
IAA	Intensive Action Area	An area with high bTB prevalence in North Pembrokeshire, adjacent to Ceredigion, in which additional control measures (including twice-yearly routine testing and enhanced testing for OTF-S incidents) have been applied since May 2010.
IFN-flex	Flexible extended interferon-gamma test	A flexible extended version of the interferon-gamma test using the synthetic peptide antigens ESAT6 and CFP10. This test was made available for use from 1st October 2017. It is most often used to increase the sensitivity of testing in chronic or persistent TB breakdowns.
IFN-y	Interferon-gamma test	Laboratory-based blood test used in parallel with the tuberculin skin test to improve the sensitivity of the testing regimen. The in vitro gamma-interferon (IFN-g) assay is only approved as an **ancillary** diagnostic tool and measures the release of γ-IFN in whole blood cultures stimulated with tuberculin. Most frequently used to enhance the sensitivity of testing in OTF-withdrawn herds.
-	Length of bTB Breakdown	A bTB incident is considered to have started the date infection with M. bovis was suspected or identified (issue of TB2 notice) and to end the date movement restrictions (following disease control measures) are lifted (issue of TB10 notice). Therefore, the length of bTB breakdown is defined as the time elapsed between TB2 and TB10.
M. avium	Mycobacterium avium	The causative organism of avian tuberculosis, which occasionally infects cattle.
M. bovis	Mycobacterium bovis	The causative organism of bovine tuberculosis.

-	Mean	The mean is a measure of centrality calculated by dividing the sum of all observations by the total number of observations.
-	Median	The median is a measure of centrality that reports the midpoint in a frequency distribution meaning that there is an equal probability of being above or below the median.
-	Mode	The mode is a measure of centrality reporting the most common observation.
-	Movement restriction(s)	Prohibitions on the free movement of animals into and out of a herd. Movement restrictions may be imposed on a herd because of the presence, or the suspicion of the presence, of M. bovis infection or because statutory tests are overdue.
-	New TB Incident	A herd previously OTF in which at least one test reactor, IR taken as a reactor, or a culture-positive slaughterhouse case has been found. To qualify as being “new”, the incident must have been disclosed in the period specified.
NDL	No detected lesions	No lesions typical of bovine TB detected in the carcass of an animal removed for TB control reasons at post-mortem examination or during routine slaughterhouse inspection of cattle.
OTF	Officially bovine tuberculosis free	For the purpose of this report, this term refers to the status of a herd not under movement restrictions and giving negative results at routine TB surveillance testing.
OTFW	Officially bovine tuberculosis free status withdrawn	For the purpose of this report, this term refers to a herd with a bTB incident in which additional evidence of M. bovis infection has been identified in at least one slaughtered bovine animal, i.e. M. bovis identified in a cultured tissue sample and/or lesions detected in the carcass of a reactor. It does also include breakdowns upgraded to OTFW for epidemiological reasons.
OTFS	Officially bovine tuberculosis free status suspended	For the purpose of this report, this term refers to the status of a herd with a bTB incident where there is a suspicion of infection being present or the TB status is unknown because a routine tuberculin test is overdue.
-	Persistent breakdown	Ongoing TB incident which has lasted 550 days or more, or herd with resolved persistent TB incident with recurrence at the first herd risk skin test. Subject to enhanced management with mandatory Action Plan. In Spatial Units CL7 and CL8 (ITBAN) all six-month recurrent OTFW incidents are also subject to enhanced

		management./
PME	Post-mortem examination	Examination (to various extents) of the carcass and organs of slaughtered cattle for suspected lesions of bovine TB. Such post-mortem examinations included those undertaken at an APHA Regional Laboratory, those undertaken at the slaughterhouse following in vivo suspicion of infection (e.g. reactors, IRs and DCs), and those undertaken as part of routine meat inspection.
-	Prevalence	For the purposes of this report, prevalence is the proportion of herds under movement restrictions on a given date due to a bTB incident, and excludes herds restricted due to an overdue test.
R	Reactor	An animal showing a particular pattern of reactions to the SICCT, or to IFN-g, IAT or IFN-flex assays. An animal first suspected to have bTB at the slaughterhouse would not be considered a reactor. A SICCT inconclusive reactor (IR) will be treated as a reactor if a retest yields a second inconclusive result.
-	Recurrent breakdown	Herd with resolved TB incident which suffers new breakdown within defined timeframe; one year recurrence captures first herd-risk post-breakdown test; two-year recurrence captures both herd-risk tests. Three-year recurrence covers all post-breakdown enhanced controls, including whole-herd restrictions on disclosure of an Inconclusive Reactor.
-	Routine Test	Active surveillance single intradermal comparative cervical skin test on entire OTF herd except animals <42do, and not currently subject to herd- or area risk testing. Scheduled annually or every six months (Intensive Action Area).
Sam	Sam Database	APHA's bTB control and surveillance system, which records details of herds, bTB tests, bTB breakdowns and the details of any slaughtered (reactors, slaughterhouse cases and direct contacts) and inconclusive reactor cattle.
Se	Sensitivity of test	The proportion of truly infected individuals in the screened population who are identified as infected by the test.
-	Severe Interpretation	Using this interpretation of the comparative intradermal tuberculin test, animals showing either i) a positive bovine reaction and negative avian reaction or ii) a positive bovine reaction more than 2mm greater than a positive avian reaction are deemed reactors.

SICCT	Single Intradermal Comparative Cervical Test	Also commonly referred to as the 'skin test' or 'tuberculin skin test'. The testing procedure involves the simultaneous injection of a small amount of M. bovis and M. avium tuberculin (purified protein derivative (PPD); a crude extract of bacterial cell wall antigens), into two sites of the skin of the animal's neck, followed by a comparative measurement of any swelling (delayed-type hypersensitivity reaction) which develops at the two injection sites after 72 hours.
SLH	Slaughterhouse case	This refers to a breakdown that is identified when an animal routinely slaughtered (i.e. not as a reactor or 2xIR) from an officially Tb free herd has lesions typical of bTB infection. These breakdowns are classified as OTFS unless culture positive, or epidemiological evidence of bTB, in which case they are classified as OTFW.
Sp	Specificity (of a test)	The proportion of truly uninfected individuals in the screened population who are identified as uninfected by the test.
-	Spoligotype	The result of one form of genomic typing of organisms of the Mycobacterium tuberculosis group described as Spacer Oligonucleotide typing.
SD	Standard deviation	The standard deviation measures the spread of the data around the mean value. It is useful in comparing sets of data which may have the same mean but a different range of raw values.
-	Standard Interpretation	Using this interpretation of the comparative intradermal tuberculin test, animals showing a positive bovine reaction more than 4mm greater than a negative or positive avian reaction are deemed reactors.
-	TB2	The legal notice issued at the start of a bTB incident to impose restrictions on cattle movements onto and off the holding.
-	TB10	The legal notice issued at the end of a bTB incident to lift the restrictions imposed on cattle movements onto and off the holding.
-	Unconfirmed	When there is no evidence of M. bovis infection detected either at post mortem or by laboratory culture.
Vetnet	Vetnet Database	Vetnet is the predecessor of SAM, APHA's bTB control and surveillance system, which records details of herds, bTB tests, bTB breakdowns and the details of any slaughtered (reactors, slaughterhouse cases and direct contacts) and inconclusive reactor cattle.

VNTR	VNTR type	The result of a form of genomic typing based on repeated sequences of genomic DNA described as Variable Number Tandem Repeat typing.
WGS	Whole Genome Sequencing	WGS provides information on the entire genome of M. bovis compared to genotyping which targets only a small proportion of the genome. WGS therefore achieves higher resolution of M. bovis strains compared to conventional genotyping as it allows for finer-scale differences in the DNA sequence to be identified. Specifically, WGS examines variation caused by mutations across the entire DNA sequence of the M. bovis genome (4.4 million nucleotide positions), while spoligotyping and VNTR-typing measure variation in only one and six small regions of the genome, respectively, which contain repetitive sequences. WGS therefore offers higher discriminatory power compared to conventional genotyping for differentiation of M. bovis strains.
WGS-C	Whole Genome Sequencing Clade	Six major groups (B1-B6) were identified from phylogenetic analysis of M. bovis genomes and then further subdivided into a total of 30 WGS clades. The nomenclature of the WGS clades was designed to reflect genetic similarity in a hierarchical manner. The WGS clade names consist of the letter ‘B’ for M. bovis followed by a number (i.e. B4, B6 etc.) that indicates which major group the isolate belongs to. Further numbers complete the clade name (e.g. B6-13, B6-42), indicating the subgroup within the major group to which the isolate is assigned. For instance, B6-42 is more closely related to B6-41 than it is to B6-13; and B6-41, B6-42 and B6-13 are more closely related to each other than to B3-11.