Bovine tuberculosis in cattle from 1986 to 2012 in and around badger-culled areas of the RBCT

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In 2007 the Independent Scientific Group (ISG) reported to the UK government the impact on bovine tuberculosis (TB) in cattle of a trial where badgers were culled between 1998 and 2005. This trial, known as the Randomised Badger Culling Trial (RBCT), was performed across 100 km^2 (nominal) zones in the West of England. The results were based on a model of new herd incidence data. It was concluded that reactive culling generated overall detrimental effects, while proactive culling achieved very modest overall benefits at the cost of elevated incidence on neighbouring farms.

This work looks at more extensive RBCT data to examine if these findings hold true. Instead of presenting the results of a model, this work directly illustrates data supplied in March 2016 by the Animal and Plant Health Agency. Such data covers a greater number of years (1986 to 2012) and includes the prevalence of herd restrictions as well as herd incidence.

It appears that whilst cattle TB noticeably reduced in areas subjected to proactive culling, TB did not significantly increase in the surrounding areas. The more limited reactive culls were found to have no significant impact either positively or negatively. This applied to both the treated and surrounding areas.

The more extensive data also showed that culling badgers only reduced confirmed TB with no significant impact on unconfirmed TB. This was also found by the ISG in 2007 when using their model.

The delay before culling benefit became apparent was about 5 years after the first substantial cull. This has implications for the culls which started in South West England in 2013. If account is taken for the need to average the data, the number of years needed to see TB drop, and the reporting delay, it may not be until September 2023 before the impact of these culls become clear. Also, if culls stop after year four in each zone, this risks benefits falling short of those achieved in the RBCT.

INTRODUCTION

The Randomised Badger Culling Trial (RBCT) was a trial performed in the South West and West of England where badgers were culled between 1998 and 2005 to investigate the impact on bovine TB in cattle. Badgers were either culled proactively or reactively. Ten areas of 100 km^2 each (nominal) were designated to the proactive culls, ten such areas were designated to the reactive culls and ten such areas were designated as survey-only areas. In the proactive areas badgers were culled over the complete area whereas in the reactive areas badgers were only culled local to where infected cattle herds were detected. Reactive culling was undertaken by removing all social groups of badgers having access to the breakdown farm so were conducted on or near farmland where breakdown herds were detected. (Bourne, 2007)

The Animal and Plant Health Agency (APHA) at the Department for Environment, Food & Rural Affairs (DEFRA) made available for the first time raw, monthly, data for the RBCT on 15th March 2016. This article presents and discusses this data. The article finally reflects on implications for culls currently taking place. These current culls started in 2013.

DATA

In August 2015 the following request was submitted by www.bovinetb.info to APHA for raw data collected from 1986 to 2012 to cover years leading up to, during and after the trial.

Please email to me for each calendar month from 1986 to 2012 (i.e. 27 years, subject to availability) the following quantities

(a) the number of cattle herds,
(b) the number of confirmed new herd incidents,
(c) the number of unconfirmed new herd incidents,
(d) herds under restriction due to an OTF-W breakdown, and
(e) herds under restriction due to an OTF-S breakdown

in each of the following areas after the ten triplets are combined,

(1) proactive area,
(2) reactive area,
(3) survey area,
(4) 2km ring around the proactive area,
(5) 2km ring around the reactive areas,
(6) 2km ring around the survey area,
(7) high risk area of England.

Please note that I only need data for the total area (not for each triplet) for the area given in (1) to (6).

With help from the Information Commissioner's Office, APHA supplied the data on 15th March

2016 under the Environmental Information Regulations 2004 and Access to Information Reference Number ATIC0693. In this response APHA supplied data in an Excel spreadsheet shown in Data S1.

METHODS

Data smoothing

Data was smoothed by summing the monthly data in each year, dividing by 12 if an average is needed, and applying a Hann window over 5 years.

Calculation of 95% confidence interval limits

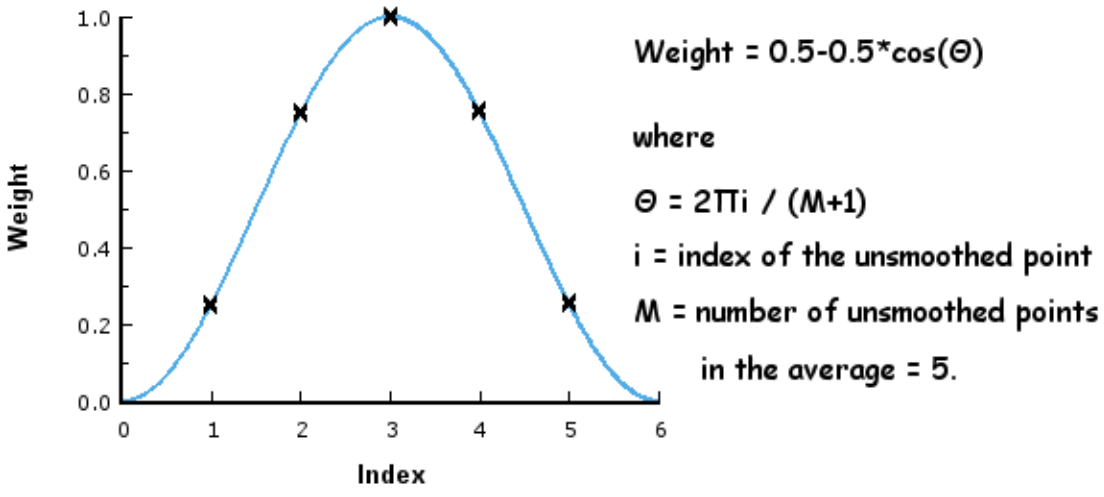
For quantities plotted without smoothing, 95% confidence intervals can be calculated as follows.

$$Confidence\ intervals = p \pm z\sqrt{\frac{p(1-p)}{n}}$$

where

$z = desired\ level\ of\ confidence\ (1.96\ for\ 95\%\ confidence\ intervals)$,
$p = x/n = proportion$,
$x = number\ of\ cases\ for\ which\ the\ condition\ applies, and$
$n = size\ of\ the\ sample\ in\ which\ those\ cases\ were\ found.$

However results were averaged to reduce sample error and give a Hann-smoothed graph line. This averaging would reduce the confidence interval at each smoothed point. These reduced intervals were calculated by replacing the values of x and n by the sum of x and sum of n respectively after applying the following Hann weight to each value.



The confidence intervals are now calculated as follows.

$$Confidence\ intervals\ =\ P\ \pm\ z\sqrt{\frac{P(1-P)}{N}}$$

where

$P\ =\ X/N,$
$X\ =\ \sum_w x\ =\ weighted\ sum\ of\ x, and$
$N\ =\ \sum_w n\ =\ weighted\ sum\ of\ n.$

Calculation of badgers culled per square kilometre

The number of badgers culled per square kilometer were calculated by dividing the number of badgers culled each year by the total treatment area summed across all triplets in which badgers were removed. These areas are given on Pages 205 to 209 of the RBCT Final Report (Bourne, 2007). No badgers were removed in Triplet J in the reactive area so the area of this triplet was not included when calculating the total area. Total treatment and accessible areas, after excluding triplet J when calculating reactive areas, are shown in the table below.

Cull type	Area type	Total area (km^2)
proactive	treatment	1132.4
proactive	accessible	796.6
reactive	treatment	1044.5
reactive	accessible	723.4

Table 1. Overall cull areas in the RBCT.

RESULTS

Proactive badger culling substantially reduced confirmed herd breakdowns without significantly increasing herd breakdowns in the 2km rings outside the treatment areas

Proactive culling led to substantially reduced confirmed incidence of cattle herd breakdowns in the treatment areas (see Figs. 1A and 1D) with no overall increase in the 2km rings surrounding these areas (see Figs. 1B and 1E). This is at odds with the conclusions reached in the RBCT Final Report (Bourne, 2007) which stated in Section 5.94 on Page 119 that proactive culling yielded only very moderate benefits at the expense of elevated TB incidence on neighbouring lands. However instead of showing the data (as are shown in the graphs below), the data were modelled and calculated values given by that model are shown. In addition to this that model incorporated large pre-cull adjustments in the 2km rings. Concerns regarding the size of these adjustments and what they are based on are outlined at www.bovinetb.info .

The graphs below show the data.

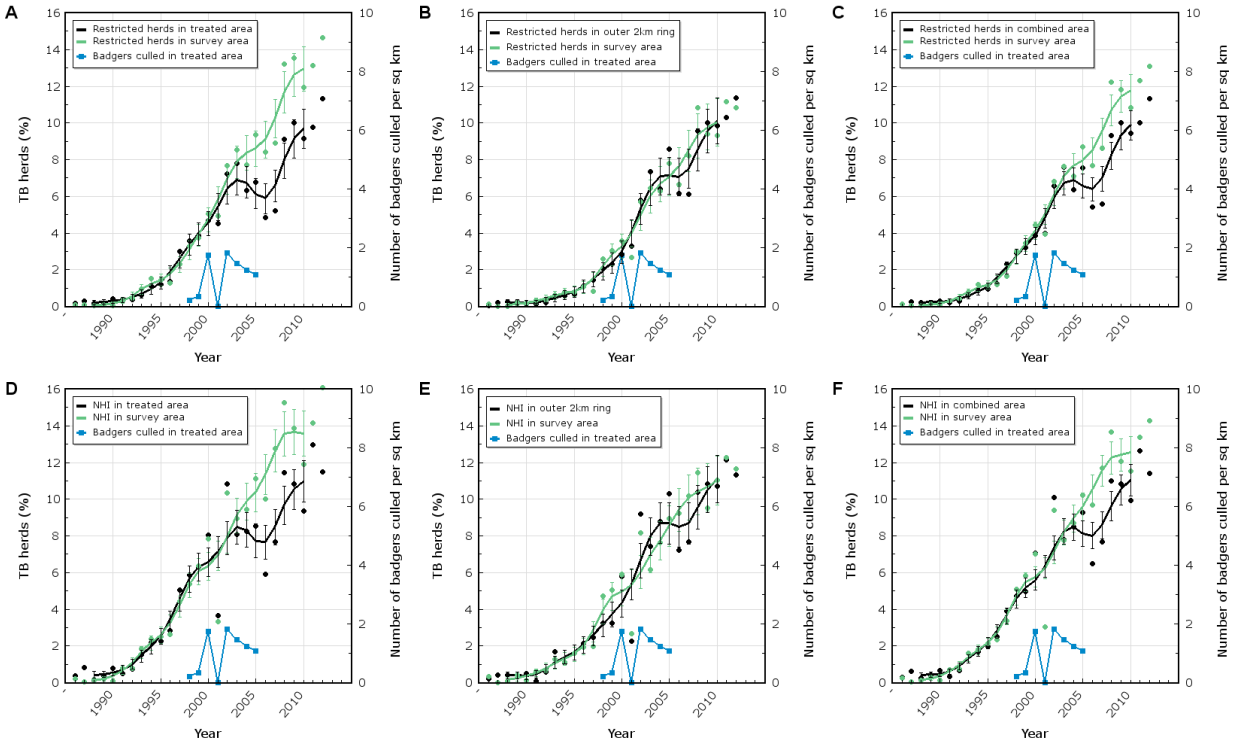


Figure 1. Impact of **proactive** culling on **confirmed** TB herds in terms of annual average percentage of restricted herds (A,B,C) and annual percentage of New Herd Incidents (D,E,F).

Badger culling did not significantly reduce unconfirmed cattle breakdowns

Although proactive badger culling may have slightly reduced the incidence of unconfirmed cattle breakdowns (Fig. 2F), such culling does not appear to have had any significant impact on the prevalence of unconfirmed breakdowns (Fig. 2C) . Culling clearly reduced the prevalence of confirmed breakdowns (Fig. 1C) so why did the culling not reduce the prevalence of unconfirmed breakdowns? This issue is intriguing and perhaps worth investigating.

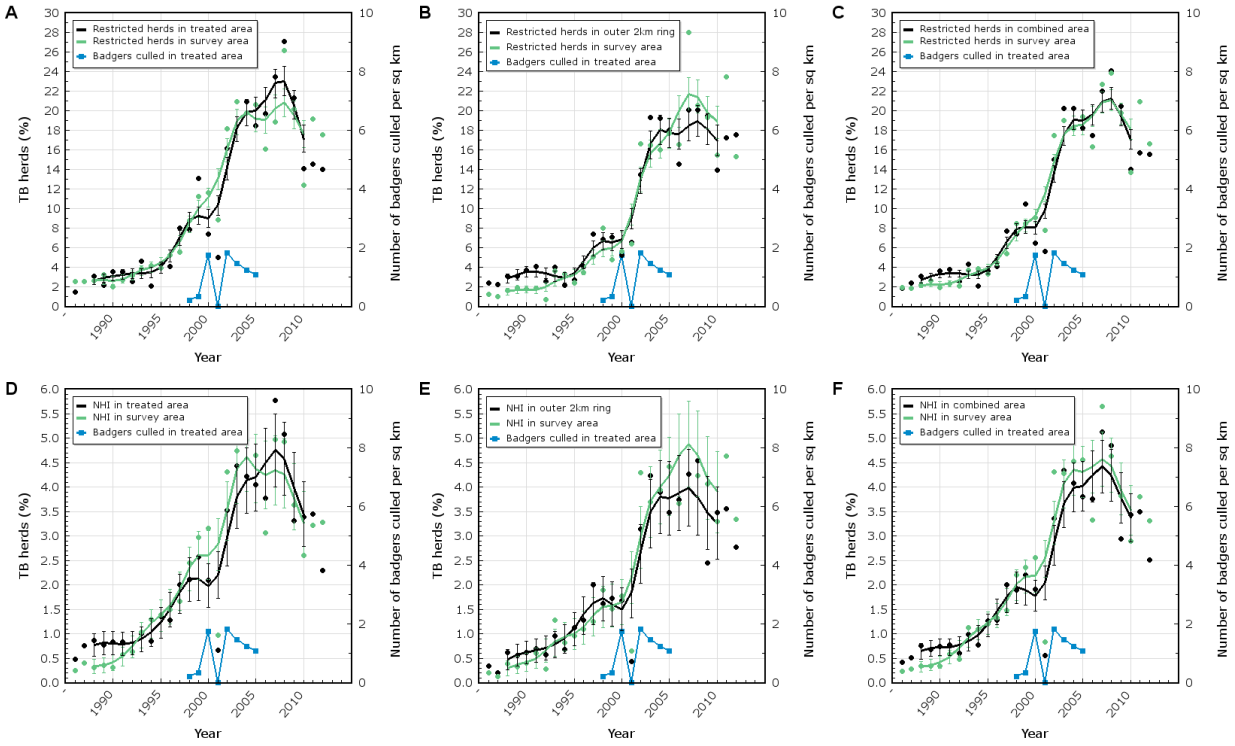


Figure 2. Impact of **proactive** culling on **unconfirmed** TB herds in terms of annual average percentage of restricted herds (A,B,C) and annual percentage of New Herd Incidents (D,E,F).

The limited reactive culls had no impact on cattle TB

Reactive culling was limited for the following reasons.

- It was only concentrated over 2 years.
- It only involved culling 2,067 badgers as opposed to the 8,892 badgers culled in the proactive culls.
- No reactive culling was performed in triplet J.

Figs. 3 and 4 show that reactive culling had no obvious impact on either confirmed or unconfirmed herd breakdowns. This appears to be at odds with conclusions in the RBCT Final Report (Bourne, 2007) which state that reactive culling generated overall detrimental effects. See Item 10.45 on Page 172.

The graph below shows the impact on confirmed breakdowns.

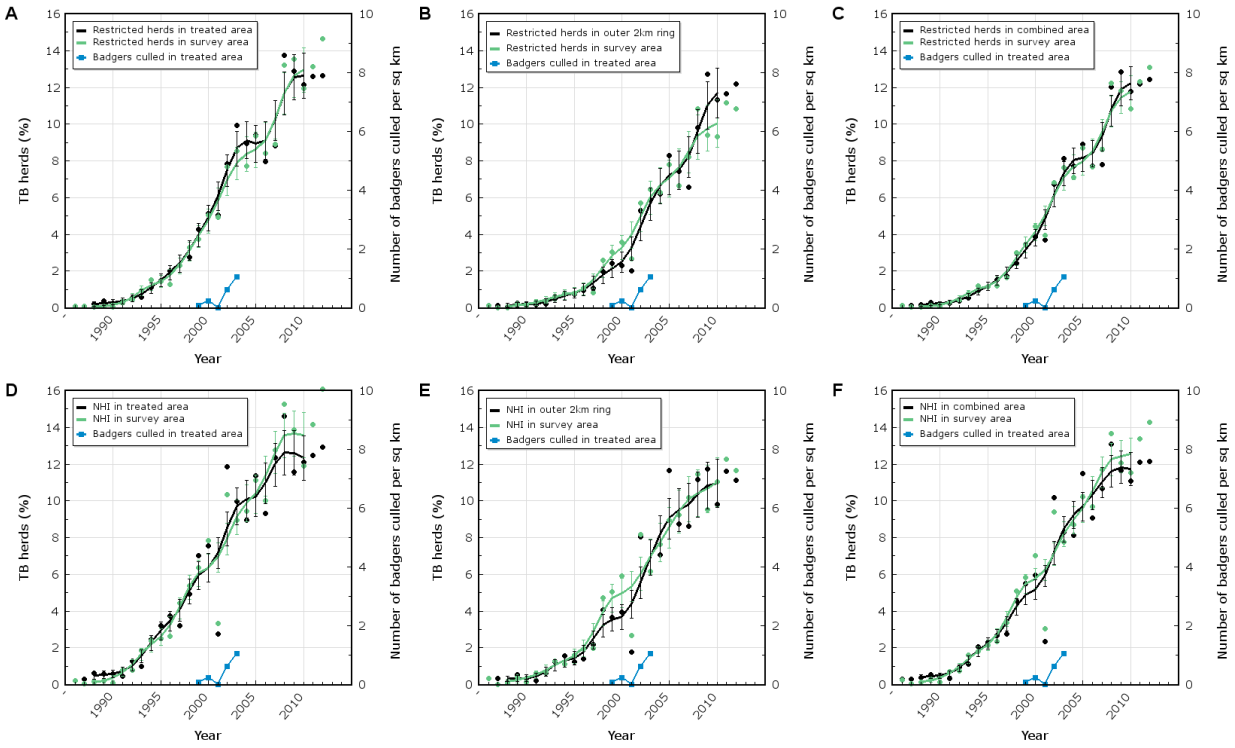


Figure 3. Impact of **reactive** culling on **confirmed** TB herds in terms of annual average percentage of restricted herds (A,B,C) and annual percentage of New Herd Incidents (D,E,F).

The graph below shows the impact on unconfirmed breakdowns.

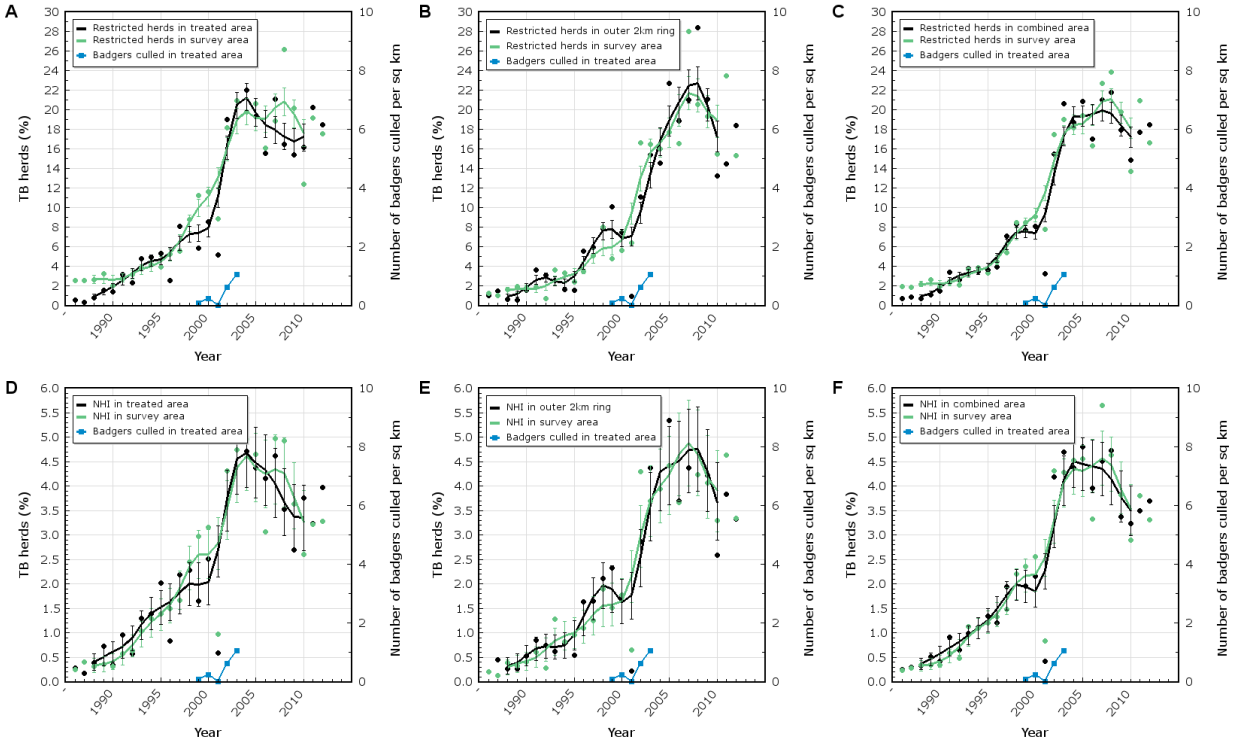


Figure 4. Impact of **reactive** culling on **unconfirmed** TB herds in terms of annual average percentage of restricted herds (A,B,C) and annual percentage of New Herd Incidents (D,E,F).

Incident herd breakdowns in proactive areas did not clearly reduce until 5 years after the first substantive cull

Although there was no culling of badgers in 2001 due to Foot and Mouth, the first year incident herd breakdowns due to proactive culling reduced in the treated and outer rings combined was 2005. See Fig. 1F above. The year 2000 was the first year in which a large number of badgers were removed. If the year 2001 is excluded, years 2000, 2002, 2003, 2004 and 2005 elapsed before incident breakdowns clearly reduced; another words, 5 years. However it should be noted that years were shifted in the analysis reported in the final RBCT report (Bourne, 2007). Indeed some areas were further advanced and others less advanced depending on when culling in those areas started. However 1998 will always remain the earliest year culling could have possibly started in any area and 2006 will be the last complete year data could have been included in that report's analysis.

According to file properties, the final RBCT report (Bourne, 2007) was created in June 2007 when it was also presented to the Secretary of State for Environment, Food and Rural Affairs. As such conclusions were drawn based on data only in years 2005 and 2006 of significant TB incidence reduction in the combined areas (Fig. 1F). That is 2 years.

DISCUSSION

Current badger culls and timescales

The fact that the RBCT only saw a clear TB reduction after 5 years may be worth bearing in mind when interpreting results from the current badger culls. In addition to this, extra years will be needed to see the full extent to which TB levels drop and a further 2 years will be needed to allow for 5-year averaging. This is illustrated in Fig. 5 below which shows how many years of data is needed to reveal this. Data will need to extend up to 2009 which, after excluding the year 2001, is 9 years worth of data starting at the first year of substantial culling.

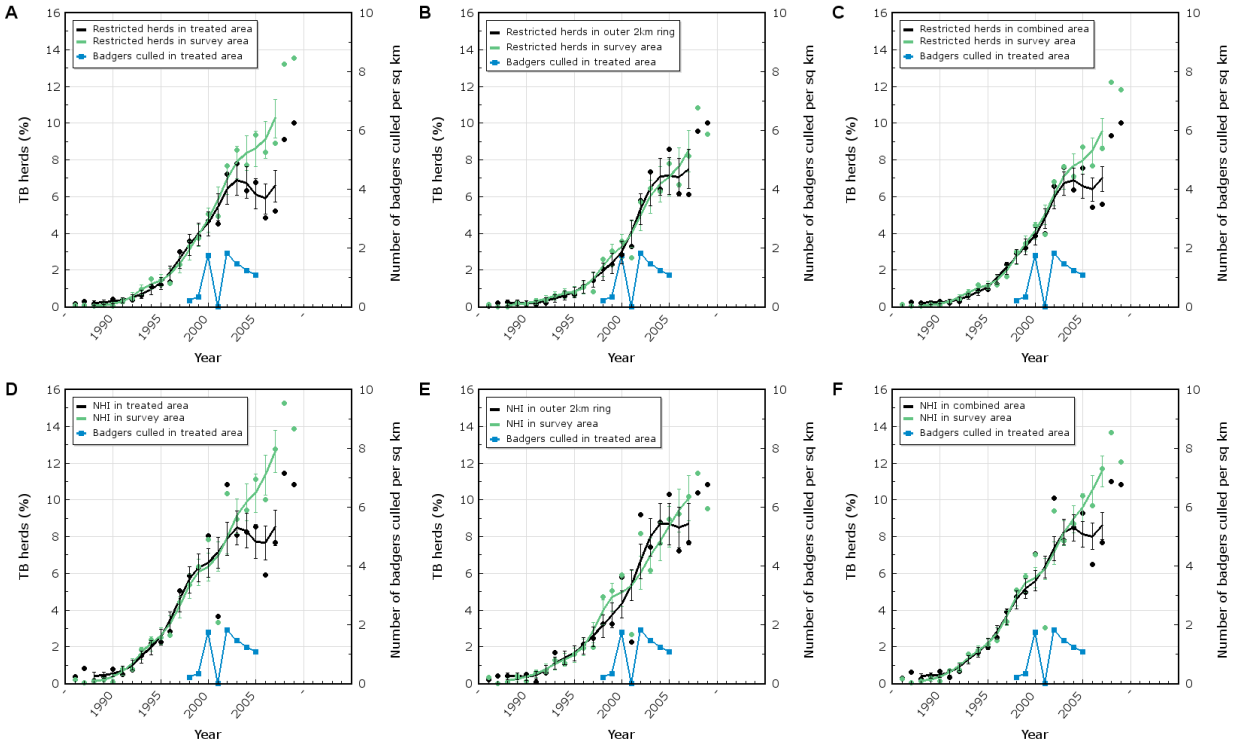


Figure 5. Impact of proactive culling on confirmed TB herds when data is shown for a limited number of years.

Badger culls currently taking place in the South West of England started in the counties of Gloucester and Somerset in 2013. If results are published every year at the same time as last year (i.e. 5th September), this will incur a 20-month delay beyond the last year of data shown in the results. It follows that the date on which 9 years worth of data will be published, for data in years 2013 to 2021, may be September 2023. However all this assumes that the results in Gloucestershire and Somerset over 9 years carry the same significance as the results did over this same length of time in the RBCT. In fact the significance will be less because the zones in South West England cover less total area. This will extend the need for time. The treatment area is 256 km^2 in Somerset and 311 km^2 in Gloucestershire (DEFRA, 2015a). This is exactly half the total proactive treatment area in the RBCT shown in Table 1. In addition to this, for culls starting in 2013, there are only two zones as opposed to ten in the RBCT. This increases the risk that overall TB dropped in the zones for reasons other than culling. However, an extra zone (in Dorset) was added in 2015 and additional zones are expected to be added in 2016.

Current badger culls and effectiveness

DEFRA are stipulating that the culls are only carried out for 4 years minimum. (DEFRA, 2015b). If culling stops after 4 years, no culling will take place in 2017 in Gloucestershire and Somerset where culling started in 2013. Culling in the RBCT was carried out in seven out of the ten proactive areas for at least 5 years, i.e. for an extra year, as shown in Table 4.8. See Bourne, 2007. It was not until during that fifth year in the RBCT, in which culling was taking place in those seven areas, that a clear reduction was seen. In terms of the number of badgers removed per square kilometre, cull rate each year in the current culls when averaged across the first 3 years (www.bovinetb.info) has been comparable to that in the RBCT. If culls stop after Year 4 in each cull zone in the current culls, this may reduce the extent to which TB drops and lasts in the current culls and as such increase the risk that results fall short of what was achieved in the RBCT.

REFERENCES

- **Bourne FJ. 2007**. Bovine TB: the scientific evidence. Final report of the Independent Scientific Group on Cattle TB. London: Department for Environment, Food and Rural Affairs. •
- **DEFRA. 2015a.** Setting the minimum and maximum numbers in West Gloucestershire and West Somerset for Year 3 of the badger cull. Advice to Natural England. August 2015.
- **DEFRA. 2015b.** 2010 to 2015 government policy: bovine tuberculosis (bovine TB). Policy Paper. Updated 8 May 2015.