



Department
for Environment
Food & Rural Affairs

Bovine TB: Setting the minimum and maximum numbers in licensed badger control areas in 2016

Advice to Natural England

August 2016



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Overview

1. Natural England is the competent authority for badger control licensing for the purpose of preventing the spread of bovine TB. It is a requirement of Defra's Guidance¹ to Natural England and the licences to set a minimum number in advance of each year's operation in an authorisation letter that is issued to each cull company once the licensing authority is satisfied that the cull company's preparations, planning and funding are sufficient to deliver a successful cull. The purpose of setting a minimum number under the current licence is to ensure that the cull company delivers the required level of population reduction in order to achieve the expected benefits in controlling bovine TB.
2. This advice to Natural England sets out the approach for estimating the badger population in the cull areas in 2016 and the minimum number of badgers to be removed.
3. The minimum number is intended to achieve a 70% reduction of the population relative to the initial starting population before the culls started. The culling objective is for no more than 30% of the starting population to remain on conclusion of the cull. The 70% target is derived from the Randomised Badger Control Trial (RBCT) where it was estimated that the culls achieved a mean of 70% control of the starting populations across the 10 areas², which resulted in disease reduction benefits for the cattle herds in those areas.
4. Culling also needs to "*not be detrimental to the survival of the population concerned*" within the meaning of Article 9 of the Bern Convention on the Conservation of European Wildlife and Natural Habitats. For that purpose Natural England set a maximum number of badgers to be removed from the licensed area.

¹ Guidance to Natural England: preventing spread of bovine TB. Updated January 2016
<https://www.gov.uk/government/publications/guidance-to-natural-england-preventing-spread-of-bovine-tb>

² Woodroffe, R., Gilks, P., Johnston, W. T., Le Fevre, A. M., Cox, D. R., Donnelly, C. A., Bourne, F. J., Cheeseman, C. L., Gettinby, G., McInerney, J. P. and Morrison, W. I. (2008), Effects of culling on badger abundance: implications for tuberculosis control. *Journal of Zoology*, 274: 28–37.
doi:10.1111/j.1469-7998.2007.00353.x

5. The approach to setting the minimum and maximum numbers for West Somerset and West Gloucestershire in Year 2 and 3 of the badger culls and year one in Dorset was published by Defra in August 2014 and August 2015 in advice to Natural England^{3 4 5}.
6. The estimate of population size must relate to the whole culling area, including any land within that area on which no culling is planned to take place. Any population estimate will have some degree of uncertainty which leads to an interval around the population estimate within which the true population is likely to lie. However, operating with uncertainty does not prevent an effective cull from being carried out, as shown during the RBCT culls, where no minimum numbers or targets were set.
7. This advice is divided into three sections.
 - Section A covers the areas in Somerset and Gloucestershire where culling began in 2013 and the Dorset area where culling began in 2015.
 - Section B covers the seven new areas where culling will begin in 2016.
 - Section C covers concluding remarks affecting all of the areas.
8. Given the number of new areas starting in 2016, cull areas will be named using a combination of a number and county. Areas will be ordered for numbering firstly by starting year, secondly by alphabetical order of the county⁶ and thirdly by decreasing area size. The existing three areas are therefore named as Area 1-Gloucestershire, Area 2-Somerset and Area 3-Dorset.

³ Setting the minimum and maximum numbers for Year 2 of the badger culls. Advice to Natural England. August 2014
<https://www.gov.uk/government/publications/advice-to-natural-england-on-setting-minimum-and-maximum-numbers-to-be-culled-in-year-2>

⁴ Setting the minimum and maximum numbers for Year 3 of the badger culls. Advice to Natural England. August 2015.
<https://www.gov.uk/government/publications/advice-to-natural-england-on-setting-minimum-and-maximum-numbers-of-badgers-to-be-culled-in-2015>

⁵ Setting the minimum and maximum numbers in Dorset for Year 1 of the badger cull. Advice to Natural England. August 2015.
<https://www.gov.uk/government/publications/advice-to-natural-england-on-setting-minimum-and-maximum-numbers-of-badgers-to-be-culled-in-2015>

⁶ Where an area spans county borders, the county comprising the highest proportion of an area will be used to name the area.

Section A: Area 1 – Gloucestershire, Area 2 – Somerset and Area 3 - Dorset

9. Before the culls started in 2013, the population was estimated in Area 1- Gloucestershire and Area 2-Somerset by carrying out sett surveys and “hair trapping”. The cull-sample matching technique⁷, which can only be carried out after the cull to make a retrospective estimate of the starting population, was considered by the Independent Expert Panel to be the most reliable method for estimating the starting population in 2013⁸. The range of population estimates (lower and upper 95% confidence intervals and the mid-point) derived from cull-sample matching were published in the AHVLA report on the entire period of the first year of the cull⁹ and are set out in Table 1 in Annex A.
10. In subsequent years, up to date sett surveys were the preferred method to estimate the current population for both areas and are used again this year for Area 1-Gloucestershire and Area 2-Somerset.
11. The starting population for Area 3-Dorset in 2015 was estimated from the National Sett survey and the Social Group Size study, as set out in 2015 Advice to Natural England⁵.
12. As several hundred badgers were removed in 2015 from Area 3-Dorset the current population now needs to be estimated from sett surveys carried out this year rather than from the national level survey (which is based on an un-culled population).
13. In order to ensure that accurate assessments of sett activity were available to provide robust evidence to inform an estimate of the population and minimum

⁷ Appendix 1 - Monitoring the efficacy of badger population reduction by controlled shooting during the first six weeks of the pilots. Report to Defra. January 2014.

<https://www.gov.uk/government/publications/pilot-badger-culls-in-somerset-and-gloucestershire-report-by-the-independent-expert-panel>

⁸ Badger Culls in Somerset and Gloucestershire. Report by the Independent Expert Panel. March 2014

<https://www.gov.uk/government/publications/pilot-badger-culls-in-somerset-and-gloucestershire-report-by-the-independent-expert-panel>

⁹ The efficacy of badger population reduction by controlled shooting and cage trapping, and the change in badger activity following culling from 27/08/2013 to 28/11/2013. Report to Defra. February 2014.

<https://www.gov.uk/government/publications/pilot-badger-culls-in-somerset-and-gloucestershire-report-by-the-independent-expert-panel>

numbers, all three cull companies were instructed to carry out a thorough sett survey programme. The positions of all setts and their activity scores (in terms of numbers of active and inactive holes) on accessible land were collated and plotted on maps. APHA surveyors then carried out a Quality Assurance check in sample parcels across the whole of the cull areas, covering ~20% of the accessible area. The number of estimated active setts following this process is listed in Table 1 and Table 2 in Annex A.

14. As described in detail in the 2015 advice to Natural England, the population can be estimated by multiplying the number of active setts by the number of badgers per active sett.

$$P_n = S_n \cdot B_0 \cdot \alpha$$

15. Where P_n is the current population; S_n is the current number of active setts; B_0 is the average number of badgers per active sett before culling began and α is a factor to account for reductions in the numbers of badgers per active sett after culling.
16. The estimates for number of badgers per active sett before culling began are different for the three areas. The values for Area 1-Gloucestershire (2.53-3.28) and Area 2-Somerset (2.30-3.17) were estimated from the cull sample matching results obtained during the 2013 culls⁷. The estimate for Area 3-Dorset was assumed to be the average of the estimates from these two initial areas, giving an estimate of 2.42 to 3.04 badgers per active sett.
17. A discussion of the evidence and rationale for the α factor is set out in the 2015 Advice to Natural England⁴. Putting a quantifiable value on α is difficult, as each active sett in the culling area will be affected differently depending on numbers of badgers removed and how the population has recovered in different areas through net reproduction and net migration and how this affects sett use.
18. Sett surveys undertaken in 2016 in Area 1-Gloucestershire indicated that compared to 2015, a higher proportion of setts were partially active rather than fully active. Whilst it is possible to distinguish between partially active and fully active setts, reliable assumptions cannot be made about the numbers of badgers that are using them. Therefore we conservatively assume a value of α of 0.8 to approximate to the observed change from fully active to partially active setts after culling. This is the same value used in 2015 for Area 1-Gloucestershire and Area 2-Somerset and equates to a reduction of less than one badger per active sett.

19. The minimum number also needs to take into account the badger population in the non-participating land within the cull area. Not all land in each cull area is accessible for culling or surveying. It is reasonable to assume that setts in the inaccessible area are likely to remain active during the cull.
20. For Area 1-Gloucestershire and Area 2-Somerset we have assumed that the number of active setts per square kilometre in the non-participating land is the same as the estimated number before the cull. The population estimates based on the numbers of active setts for participating and non-participating areas in Area 1-Gloucestershire and Area 2-Somerset are set out in Table 1 in Annex A.
21. For Area 3-Dorset we do not have information on sett density prior to the culls and therefore the following formula was used to calculate the population in the inaccessible area

$$P_{in} = P_0 \cdot I \cdot \alpha$$

22. Where P_{in} is the current population in the inaccessible area, P_0 is the pre-cull starting population, I is the proportion of the cull area that is accessible.
23. We have assumed that the density of badgers was the same in participating and non-participating areas before the cull. The population estimate based on the number of active setts for participating areas and pre-cull badger density for non-participating areas in Area 3-Dorset are set out in Table 2 in Annex A.
24. The assumptions used to determine the population in the non-participating areas are highly conservative but they are based on the original data used in estimating the pre-cull populations.
25. Taking into account the available evidence, and following a similar rationale to 2015, we use sett activity surveys as the basis for estimating the current population and to define the population size at the lower end of the range. Given the overall uncertainty associated with the methods and the range (lower to upper limits), we consider that it is still more prudent to manage the uncertainty this year (as happened last year) by defining a realistic minimum number that aims to achieve the desired level of population reduction to secure the anticipated disease control benefits. **Therefore, we conclude that the minimum number of badgers to be removed in Area 1-Gloucestershire in 2016 is 228. The minimum number of badgers to be removed in Area 2-Somerset is 75. The minimum number of badgers to be removed in Area 3-Dorset is 390.**

26. The licence also requires Natural England to define a maximum number, for the purposes of avoiding the removal of too many badgers. In the first year of the cull, NE defined the maximum reduction level at 95% of the initial starting population (as opposed to the 70% minimum number) to avoid local extinction in the area. Therefore all of the calculations for the minimum can be repeated for this purpose, simply altering the goal to leave 5% of the initial population rather than 30%. The calculations are shown in Table 1 and Table 2 in Annex A. **Therefore, the maximum number of badgers to be removed in Area 1-Gloucestershire in 2016 is 642. The maximum number of badgers to be removed in Area 2-Somerset is 544. The maximum number of badgers to be removed in Area 3-Dorset is 610.**
27. The minimum and maximum numbers for Area 2-Somerset are slightly higher than the figures for 2015. This is driven by the slightly higher number of estimated active setts in 2016; substantial population reduction is expected to increase immigration and reproduction rates of badgers. Field evidence suggests that badgers have immigrated from inaccessible land within the cull area and possibly across parts of the boundary from neighbouring areas. In addition the level of uncertainty around the active sett estimate is greater when a substantial proportion of the population has been removed, and this is expected to lead to year on year variation.

Section B: Seven new areas for 2016

28. As with Area 3-Dorset in 2015, data from the National Sett Survey were used to estimate the population for the seven new areas. The National Sett Survey¹⁰, which estimated the number of main setts across different land class groups, was combined with the Social Group Size study¹¹, which used hair-trapping and subsequent DNA analysis to estimate the range of social group sizes across different landscape types, to provide an estimate of the population. In both the sett survey and the social group size estimation project, data were collected according to landscape type. The landscape types were grouped into seven broad categories, known as Land Class Groups (LCG) for analysis.
29. The National Sett Survey and the Social Group Size estimation projects produced estimates of the mean number of social groups and numbers of badgers per social group respectively per LCG in England and Wales.
30. In order to allow the potential for the number of main setts and individuals in a social group to vary to a greater extent than simply using the averages produced by the two national surveys, a Monte Carlo resampling procedure, using the raw data from the Badger Settle Survey and Social Groups Size project, was carried out to produce the estimates of population size. Ten thousand iterations of random selections of one kilometre squares and social group sizes were performed to produce the mean population size along with the 95% confidence intervals for each area.
31. Taking into account the available evidence and following a similar rationale to setting the minimum and maximum numbers as used for Area 3-Dorset last year, **we use the national sett survey method for estimating the population and define the population size at the lower end of the range.** This is a precautionary approach and assumes that this method is the most reliable one available.
32. Given the overall uncertainty associated with the methods and the range (lower to upper limits), we consider that it is still more prudent to manage the

¹⁰ Judge, J., Wilson, G.J., Macarthur, R., Delahay, R.J. & McDonald R. A. (2014) Density and abundance of badger social groups in England and Wales in 2011–2013. *Sci. Rep.* **4**, 809; DOI:10.1038/srep03809

¹¹ Judge, J., Wilson, G.J., Macarthur, R. & Delahay, R.J. (*submitted for publication*) Estimates of badger social group sizes in England and Wales.

uncertainty this year by defining a realistic minimum number that can be revised in the light of new data, than to define it too high, with a risk of removing too many badgers.

33. The licence also requires Natural England to define a maximum number, for the purposes of avoiding the removal of too many badgers. In the first year of the cull, NE defined the maximum reduction level at 95% of the initial starting population (as opposed to the 70% minimum number) to avoid local extinction in the area. Therefore all of the calculations for the minimum can be repeated for this purpose, simply altering the goal to leave 5% of the initial population rather than 30%. The calculations are shown in Table 3 in Annex A. This is identical methodology to that used for Area 3-Dorset in 2015.

Section C: Conclusions

34. A summary of the minimum and maximum numbers for all areas is in Table 4 in Annex A.
35. In the first year of the cull in Areas 1-Gloucestershire and 2-Somerset we learned that we were dealing with more uncertainty than we anticipated, and therefore in defining minimum numbers in subsequent years we needed to avoid false levels of confidence. As with last year, we need to consider two realistic scenarios:
- a) that during the cull, there is accumulating evidence that the number of badgers in the cull area is low, and that the number of badgers removed, despite a high level of contractor effort sustained across the whole cull area, is towards the lower end of our estimates. In this scenario, if the minimum and maximum numbers were set too high, Natural England would need to consider adjusting the numbers down to bring them in line with the actual circumstances being observed in the cull, so as to manage the risk of too many badgers being removed; OR
 - b) that during the cull, there is accumulating evidence that the number of badgers is higher than the minimum and maximum numbers suggest, either because the cull company quickly exceeds the minimum number, or because feedback from observations suggests there is a higher level of activity observed than expected. In these circumstances, Natural England would need to consider the need to compel the cull company to continue the cull by revising the minimum and maximum numbers upwards to ensure that the optimum disease benefits can be secured.
36. Daily data collected through the course of the cull about the level of effort being applied across the cull area, and locations of badgers removed, will enable Natural England to build an assessment of progress towards the cull total. This will allow Natural England to assess whether the estimated population was a reasonable reflection of the true population.
37. The Badger Control Deed of Agreement will allow Natural England to adjust the minimum number during the cull, if required. If the evidence suggests that there are more badgers than the estimates indicated (e.g. because the number of badgers killed per unit effort is relatively high) Natural England will have the ability to revise the number upwards at an appropriate point, to ensure that the cull company is required to carry on the cull in order to achieve effective disease control.

38. Conversely, if the estimates are too high there will be a risk of removing too many badgers. In these circumstances, Natural England could, on the basis of careful consideration of the evidence and provided that the level of effort applied by the cull company has been sufficient, adjust the maximum number downwards at an appropriate point.

Annex A

Table 1: Areas 1-Gloucestershire and 2-Somerset 2016 sett survey results and calculations of minimum and maximum numbers

	Area 2-Somerset			Area 1-Gloucestershire		
	Inaccessible land	Accessible land	Total	Inaccessible land	Accessible land	Total
Cull area size (km ²)	60	196	256	93.3	217.7	311
Area surveyed in 2016 (km ²)	N/A	180		N/A	217.7	
Estimated total active setts 2016	192.4	154.1	346.5	196.5	161.8	358.4
Estimated active setts pre-cull 2012	192.4	622.4	814.7	196.5	458	654.8
Active setts in 2016 relative to 2012 pre-cull survey			42.5%			54.7%

	Lower level	Mid-point	Upper level	Lower level	Mid-point	Upper level
Population estimate from CSM 2013	1876	2225	2584	1658	1904	2151
Badgers per sett -pre cull (CSM 2013)	2.30	2.73	3.17	2.53	2.91	3.28
Badgers per sett -adjusted for culling	1.84	2.18	2.54	2.02	2.33	2.62
Estimated population 2016	638	757	879	725	834	940
30% pre-cull population level	563	668	775	497	571	645
Minimum number	75	89	104	228	263	295
5% pre-cull population level	94	111	129	83	95	108
Maximum number	544	646	750	642	739	833

Table 2: Area 3-Dorset sett survey results and calculations of minimum and maximum numbers

Cull area size (km ²)				223
Estimated active setts in accessible land 2016				243
		Lower level	Mid-point	Upper level
Population estimate pre-cull	879	1187	1547	
Estimated badgers per sett pre-cull	2.42	2.82	3.23	
Estimated badgers per sett -adjusted for culling	1.93	2.26	2.58	
Accessible area population 2016	469	548	627	
Inaccessible area population 2016	184	249	325	
Estimated population 2016	654	797	952	
30% pre-cull population level	264	356	464	
Minimum number	390	441	488	
5% pre-cull population level	44	59	77	
Maximum number	610	738	874	

Table 3: The estimates of the population and the minimum and maximum numbers for the seven new areas in 2016

	Area size range (km ²)	Population estimates			Minimum and maximum numbers based on lower level of the population estimate	
		Lower level	Mid-point	Upper level	Minimum number	Maximum number
Area 4-Cornwall	300-400	1856	2154	2457	1299	1763
Area 5-Cornwall	200-300	1249	1495	1761	874	1187
Area 6-Devon	500-600	2746	3107	3491	1922	2609
Area 7-Devon	400-500	2052	2364	2686	1436	1949
Area 8-Dorset	400-500	1832	2255	2725	1282	1740
Area 9-Gloucestershire	600-700	2090	2639	3251	1463	1986
Area 10-Herefordshire	200-300	1245	1527	1868	872	1183

Where an area spans county borders the county with the highest proportion of an area is used to designate the area.

Table 4: Summary of minimum and maximum numbers for all cull areas in 2016

	Minimum number	Maximum number
Area 1-Gloucestershire	228	642
Area 2-Somerset	75	544
Area 3-Dorset	390	610
Area 4-Cornwall	1299	1763
Area 5-Cornwall	874	1187
Area 6-Devon	1922	2609
Area 7-Devon	1436	1949
Area 8-Dorset	1282	1740
Area 9-Gloucestershire	1463	1986
Area 10-Herefordshire	872	1183