Institution: University of Edinburgh and SRUC, Scotland's Rural College

Unit of Assessment: 6

Title of case study: Controlling bovine TB in the UK by controlling badger numbers.

1. Summary of the impact (indicative maximum 100 words)

Impact: Policy and public engagement: Formulation of the UK government's badger culling policy for the control of bovine tuberculosis that is currently being implemented. The underpinning research also had wider impact in terms of generating significant public debate and enhancing public engagement.

Significance: DEFRA has estimated the cost of TB control in England at £1 billion over the next 10 years without taking further action, and the cost of TB breakdown on a farm at £34,000

Beneficiaries: Livestock Industry (Cattle farms), Consumers, environment.

Attribution: Work performed by Professor Morrison (University of Edinburgh, UoE)

Reach: The immediate reach is the UK.

2. Underpinning research (indicative maximum 500 words)

Following the identification of infection with *M. bovis* in badgers in the 1970s, localised culling of badgers on TB-affected farms was deployed by Government as an additional measure to control tuberculosis in cattle. Despite these measures and continued intensive application of cattle herd testing for TB, the number of cattle herds infected with *M. bovis* has increased progressively over the last 25 years.

In 1997, the Krebs review [3.1] recommended that Defra conduct a badger culling trial to establish the contribution that badgers make to bovine tuberculosis and to determine the impact of different culling strategies on the incidence of TB in cattle. This led, in 1998, to the initiation of a National Badger Culling Trial and a series of associated research projects, to test the effects of different culling protocols on the incidence of cattle TB and on the transmission dynamics of infection in culled areas. The trial was initiated in 1998 and completed in 2006.

An Independent Scientific Group headed by Professor Morrison (Professor of Immunology and Group Leader, UoE employed 2002-onwards) oversaw the design and implementation of the trial and the analysis and interpretation of the results, which were published in a number of refereed publications [3.2-3.6] and in a final report (2007 [5.1]). Members of the independent scientific group were: John Bourne (retired – previous IAH director), Professor Sir David Cox (University of Oxford), Professor Christl Donnelley (Imperial College), Professor Rosie Woodroffe (University of California, Davis), Professor George Gettinby (University of Strathclyde) and Professor John McInerney (University of Exeter).

The results revealed the following ***key findings***:

- Results from proactively culled areas confirmed that badgers are a significant source of infection for cattle, which has not been demonstrated previously in a controlled manner.
- Culling of badgers only on farms affected with TB resulted in an increased incidence of infection in herds within the regions subjected to such culling.
- More extensive "proactive" culling on all farms across areas of approximately 100 km^2 significantly reduced the incidence of infection in cattle in the culled areas, but resulted in an increased incidence in immediately surrounding areas over the first three years, thus partially negating the overall impact of culling.
- Culling of badgers led to disruption of their territorial behaviour, resulting in more extensive movement into neighbouring territories.
- The residual disrupted badgers showed in increased incidence of infection compared to unperturbed populations.
- The perturbation of badger populations subjected to culling facilitates increased transmission

of infection both between the residual badgers and from badgers to cattle.
- Culling of badgers can only have a beneficial effect on cattle TB if applied intensively over large areas and sustained for prolonged periods of time.
- Previous badger culling policies are unlikely to have any beneficial effect and may have enhanced transmission of infection.

3. References to the research (indicative maximum of six references)

3.1 Krebs, J. R., Anderson, R., Clutton-Brock, T., Morrison, I., Young, D. and Donnelly, C. (1997). Bovine tuberculosis in cattle and badgers. Report by the Independent Scientific Review Group, MAFF Publications, London, pp. 1-191. http://www.bovinetb.info/docs/krebs.pdf

3.2 Donnelly, C. A., Woodroffe, R., Cox, D. R., Bourne, J, Gettinby, G., Le Fevre, A. M, McInerney, J. P. and Morrison W. I. (2003). Impact of localized badger culling on tuberculosis incidence in British cattle. Nature 426, 834-837. http://dx.doi.org/10.1038/nature02192

3.3 Donnelly, C.A., Woodroffe, R., Cox, D.R., Bourne, F.J., Cheeseman, C.L., Gao Wei, Gettinby, G., Gilks, P., Jenkins, H., Johnston, W.T., Le Fevre, A.M., McInerney, J.P. and Morrison, W.I. (2006). Positive and negative effects of widespread badger culling on tuberculosis in cattle. Nature 439, 843-846. http://dx.doi.org/10.1038/nature04454

3.4 Woodroffe, R., Donnelly, C.A., Jenkins, H.E., Johnston, W.T., Cox, D.R., Bourne, F.J., Cheeseman, C.L., Delahay, R.J., Clifton-Hadley, R.S., Gettinby, G., Gilks, P. Hewinson, R.G. McInerney, J.P. and Morrison, W.I. (2006). Culling and cattle controls influence tuberculosis risk for badgers. Proceedings of the National Academy of Sciences USA 103, 14713-14717. http://dx.doi.org/10.1073/pnas.0606251103

3.5 Jenkins H. E., Woodroffe R., Donnelly C.A., Cox D.R., Johnston W.T., Bourne F.J., Cheeseman, C.L., Clifton-Hadley R.S., Gettinby, G., Gilks P., Hewinson R.G., McInerney J.P., Morrison, W.I. (2007). Effects of culling on spatial associations of *Mycobacterium bovis* infections in badgers and cattle. Journal of Applied Ecology 44, 897-908. http://dx.doi.org/10.1111/j.1365-2664.2007.01372.x

3.6 Jenkins H.E., Morrison W.I., Cox D.R., Donnelly C.A., Johnston W.T., Bourne F.J., Clifton-Hadley R.S., Gettinby, G., McInerney J.P., Watkins G.H., Woodroffe R. (2008). The prevalence, distribution and severity of detectable pathological lesions in badgers naturally infected with *Mycobacterium bovis.* Epidemiology and Infection 136, 1350-1361. http://dx.doi.org/10.1017/S0950268807009909

4. Details of the impact (indicative maximum 750 words)

The major impacts of this research are the influence on government policy and the impact on public debate. Based on the data from this research [5.1], the Government developed a new badger culling policy based on extensive culling of badgers in areas with a high incidence of bovine TB, which is now being implemented. This was developed in partnership with the farming community, which will bear most of the cost. Details of the implementation of the badger culling are available on the Defra web site [5.2].

While the research has allowed the design of culling policies that are predicted to have a beneficial effect on the bovine TB problem if properly implemented, it has also highlighted the shortcoming of this approach as a stand-alone option. Indeed, the evidence of the extent of culling that is required to produce any substantial impact has hardened opposition to culling by numerous community groups. An example is a recent decision to ban badger culling on Council land [5.3]. Equally, the research has had a major impact on public debate around badger culling [5.4-5.6]

The research and the intense public debate have subsequently influenced the UK government to redirect resources to alternative control measures. These include development of badger TB vaccination, which has received increased funding from Defra over the last 5-10 years, with plans in place to develop a bait-delivered vaccine that could be applied to large populations of badgers [5.7].

A second approach is based on the recent demonstration that resistance to TB in cattle is a

heritable trait (5.8). At its May 2013 board meeting, DairyCo agreed to fund genetic evaluation of dairy bulls in the UK for TB resistance [5.9].

5. Sources to corroborate the impact (indicative maximum of 10 references)

5.1 Bourne F.J., Cox D.R., Donnelly C.A., Gettinby G., McInerney J.P., Morrison W.I. and Woodroffe R. (2007). Bovine TB: The Scientific Evidence: A Science Base for a Sustainable Policy to Control TB in Cattle. Final Report of the Independent Scientific Group on Cattle TB. Defra Publications. Pp.1-289. http://tinyurl.com/qb4qxq7

5.2 Defra News, Bovine TB. http://tinyurl.com/ohhfjeq

5.3 Buxton Advertiser, "Council bans badger cull on county land" http://tinyurl.com/oktty9k

5.4 Farmers Guardian, "Farming hot topic : Bovine TB" http://tinyurl.com/nfhntz7

5.5 The Wildlife Trusts, "Badgers and bovine tuberculosis" http://tinyurl.com/om2pswv

5.6 UK Parliament, Opposition debate on the badger cull http://tinyurl.com/qcykpwq

5.7 Defra, Badger Vaccination http://tinyurl.com/q954hw7

5.8 Allen AR, Minozzi G, Glass EJ, Skuce RA, McDowell SW, Woolliams JA, Bishop SC. Bovine tuberculosis: the genetic basis of host susceptibility Proc Biol Sci. 2010 Sep 22;277(1695):2737-45. http://dx.doi.org/10.1098/rspb.2010.0830.

5.9 DairyCo Meeting Minutes May 2013 http://tinyurl.com/qjctkxq