Red fox (*Vulpes vulpes*)

Presence data for the red fox was obtained from the NBN gateway (https://data.nbn.org.uk/), where sighting records can be freely downloaded. DEFRA focused on records collected between 1960 and 2013.

Figure 1 shows the decade of the last red fox sighting record in each square of the Ordnance Survey 10km National Grid according to our dataset. The red fox is a common and widespread species and we expect it to have been sighted in most squares at least once in the last five decades, particularly in the South of England. However, there are many areas where the species has never been recorded since 1960, or has not been recorded for a long time. This map thus highlights areas where the data quality needs to be improved, and survey efforts should be focused in squares where the species has not been recorded recently.

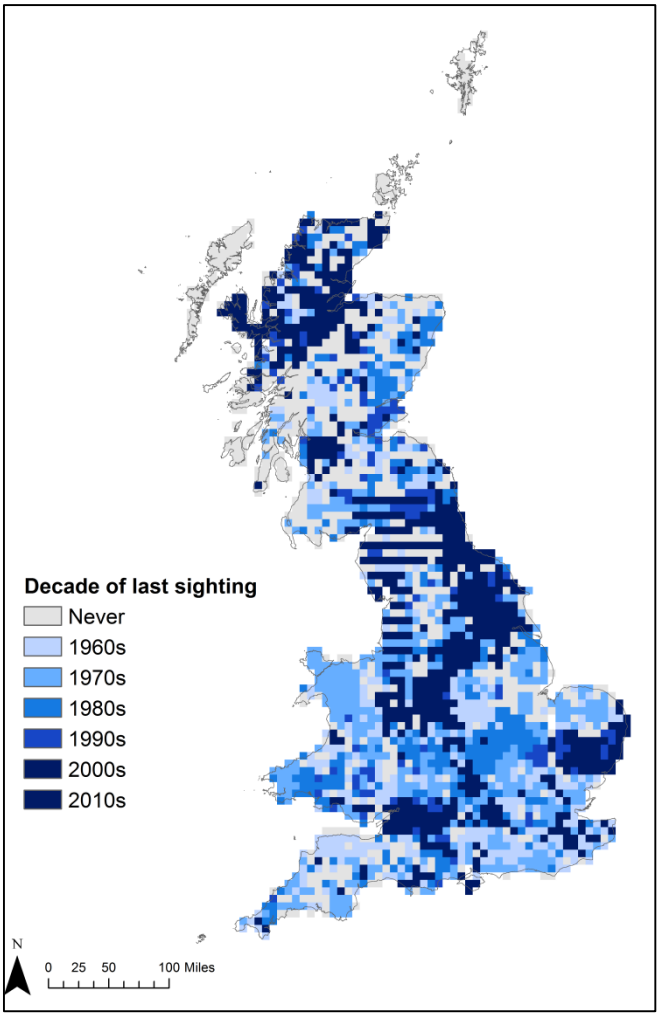

Figure 1: Decade of last sighting of the red fox in each squares of the Ordnance Survey 10 km National Grid.

The sighting record for the red fox in the UK (1960 – 2013) was then used to create a map of habitat suitable for the species using habitat suitability modelling. While several methods were tested and compared (including MaxEnt, GLM and BIOCLIM), the modelling technique

called Random Forest (Breiman 2001) yielded the best map of habitat suitability for the red fox. Figure 2 shows the predicted suitability of each square in the Ordnance Survey 10 km National Grid for the species.

The published literature was reviewed for geo-referenced estimates of density for the species. We found several studies which reported densities at the county level (Figure 2); they ranged between 0.025 fox per km^2 to more than 20.

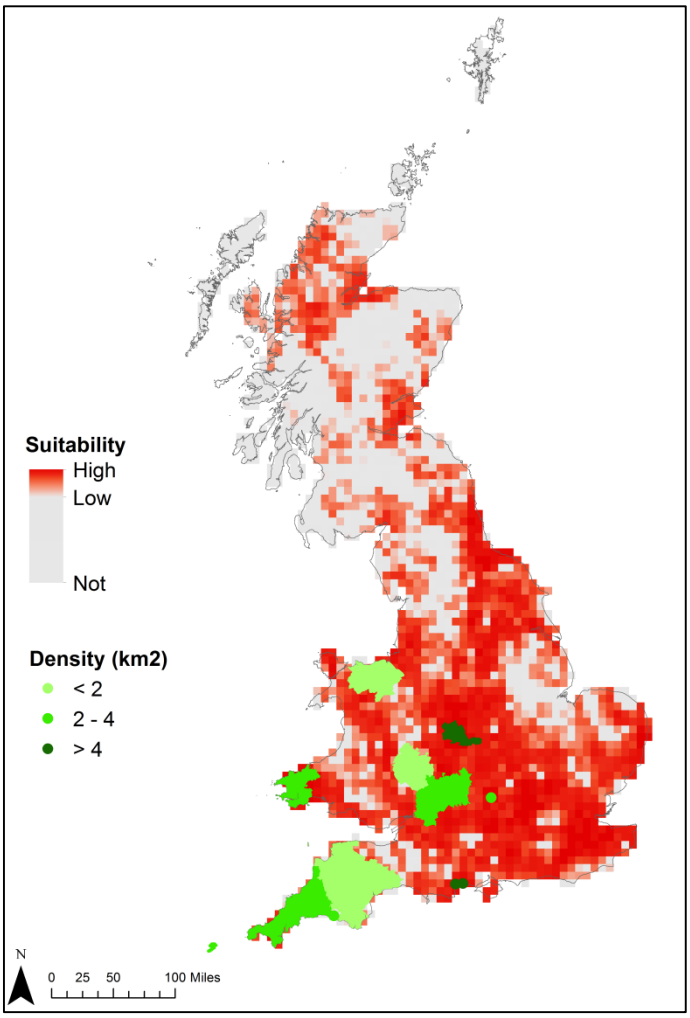

Figure 2: Suitability of each square of the Ordnance Survey 10 km National Grid for the red fox; grey squares are unsuitable; red squares represent suitable habitat with the darker the colour the more suitable for the species. Green areas show where geo-referenced estimates of red fox density were found in the literature.

The mean red fox density in each land cover type was calculated. Land cover classes were obtained from the UK Land Cover Map 2007 (LCM2007; Morton *et al.* 2011). Specifically, the 1km dominant target land class raster was used (Table 1).

Table 1: Mean red fox density per land cover class (LCM 2007). Shown is the number of records found in each class, as well as the year of the last density record in that class.

LCM2007 class number	Dominant LCM2007 class	Number of records	Year of last record	Average density (per km^2)
1	broadleaf	4	2006	1.94
2	coniferous	6	2006	1.57
3	arable	89	2006	2.41
4	improved grassland	110	2006	2.20
5	rough grassland	6	2006	2.31
6	neutral grassland	0	-	-
7	calcareous grassland	0	-	-
8	acid grassland	9	2006	1.63
9	fen, marsh, and swamp	0	-	-
10	heather	1	2006	0.98
11	heather grassland	2	2006	0.98
12	bog	2	2006	1.46
13	montane habitat	0	-	-
14	inland rock	0	-	-
15	saltwater	0	-	-
16	freshwater	0	-	-
17	supra-littoral rock	0	-	-
18	supra-littoral sediment	0	-	-
19	littoral rock	0	-	-
20	littoral sediment	1	2006	2.6
21	saltmarsh	0	-	-
22	urban	2	2006	1.79
23	suburban	15	2006	4.70

To calculate the total abundance of red fox in the UK, density was regressed as a function of the habitat suitability score in each cell where density records were present. This relationship was then used to predict red fox density in the cells where there are no published estimates of density (Figure 3). The predicted red fox abundance in the UK with this method is 430,515.

Today's predicted abundance is higher than the abundance reported in the Harris et al. (1995) report, which suggested that there were 240,000 red fox in the UK. The abundance figure from 1995 was qualified as somehow unreliable when it was published (reliability score of 4 on a 1-5 scale were 1 is reliable and 5 is not). Therefore, it is difficult to say whether today's predicted abundance is significantly different from the true red fox abundance in 1995 and thus represent an increase for the species.

Moreover, there is also uncertainty surrounding the estimate of 430,515 foxes. As shown in Figure 1, areas where foxes are expected to be do not contain recent sightings, which could

bias the resulting suitability map. The abundance estimate could also be improved with more refined geo-referenced density data.

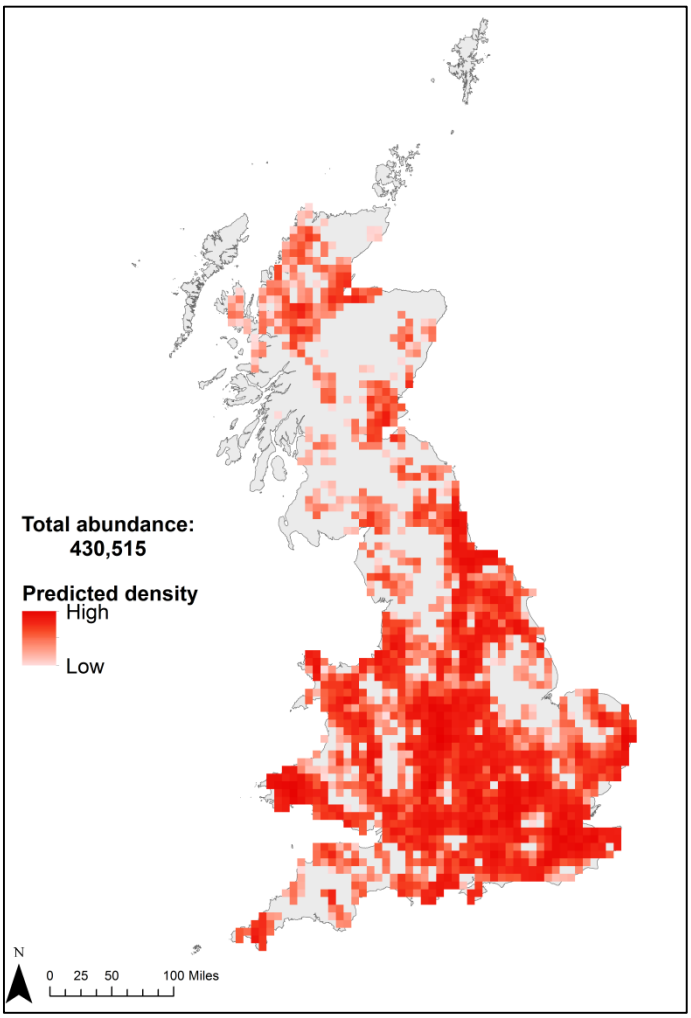

Figure 3: Predicted density and total abundance of red fox in the UK.

Breiman, L. (2001) Random forests. *Machine learning,* **45,** 5-32.

Harris, S., Morris, P., Wray, S. & Yalden, D. (1995) *A review of British mammals: population estimates and conservation status of British mammals other than cetaceans*. Joint Nature Conservation Committee, Peterborough.

Morton, D., Rowland, C., Wood, C., Meek, L., Marston, C., Smith, G., Wadsworth, R. & Simpson, I. (2011) Final Report for LCM2007-the new UK land cover map. Countryside Survey Technical Report No 11/07.