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Wild boar *Sus scrofa* has been extinct in Britain for several centuries. Recently, however, some conservationists have argued that it should be reintroduced. Here, we report that two populations of free-living wild boar are already present in Britain, in the south of England, ranging over areas of approximately 15 km^2 in the county of Dorset and 175 km^2 in the counties of Kent and East Sussex. Presence of the animals was indicated initially by unsolicited reports to the Department of Environment Food and Rural Affairs, and was confirmed by searching the relevant areas for field signs such as tracks, faeces, nests and rooted areas. Six carcasses of road-killed or shot animals were available for inspection from the Kent/East Sussex area and had the morphological characteristics of wild boar. Breeding was confirmed in the Kent/East Sussex area and is suspected in the Dorset population. A simple population dynamics model, based on an estimated initial population of 100 animals, suggests a growth rate, r, of between 0.016 and 0.267 for the Kent/East Sussex population. We conclude that the Kent/East Sussex population is likely to prove viable unless actively persecuted, and discuss the social, agricultural, ecological and conservational implications.

Key words: conservation, reintroduction, Suidae, Sus scrofa, wild boar, wildlife management

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Wild boar *Sus scrofa* has been extinct in Britain since the 13th century (Yalden 1999), but remains widely distributed across Europe and North Africa to southeast Siberia, and eastwards to Sri Lanka, Java, Honshu, Taiwan and Korea (Lever 1994). The reintroduction of free-living wild boar into Britain has been advocated periodically on conservation grounds (e.g. Morris 1986, Yalden 1986, Howells & Edwards-Jones 1997) and a recent review has argued for the feasibility of reintroducing the species into Scotland (Leaper, Massei, Gorman & Aspinall 1999). The main argument in favour of reintroduction is the desirability, for moral and aesthetic reasons, of replacing an animal that was part of the native fauna of Britain until relatively recently, which became extinct as a direct consequence of human activity (Yalden 1986, Leaper et al. 1999). The main arguments against reintroduction involve the ability of wild boar to inflict agricultural and ecological damage (e.g. Mackin 1970, Singer, Swank & Clebsch 1984) and the possibility of disease transmission (e.g. Rutili, Ferrari, Maresca, De Mia & Ferraguzzi 1992); characteristics that have resulted in the species being regarded as a pest in some parts of its current range (Lever 1994).

Captive wild boar in Britain are kept in private or pub-

lic wildlife collections, in zoos and on farms. The original British wild boar farm stock was predominantly of French origin, but the industry expanded and from 1987, farmers have introduced animals of western and eastern European origin (Booth 1995). Wild boar have escaped from captivity on numerous occasions (Baker 1990), and the increase in the number of establishments housing wild boar has been accompanied by an increase in the frequency of escapes (Baker 1994).

In 1994, the government agency Department of Environment, Food and Rural Affairs (DEFRA), previously known as the Agriculture Development Advisory Service (ADAS), began to receive unsolicited reports of free-living wild boar sightings in the county of Kent, southern England. Reports of encounters with wild boar, or of agricultural damage attributed to them, also began to appear in the local and national press (Goulding & Roper 2002). Similar reports of free-living wild boar were received in 1997 from the National Farmers Union in Dorset, southern England. In view of the potential environmental, agricultural and social implications of these reports, the DEFRA agency, the Central Science Laboratory (CSL), sought to determine whether free-living wild boar really existed in Kent and Dorset, and, if so, how extensive the populations were, and whether they had the potential to increase and become naturalised. Here, we describe the results of this investigation. We provide the first formal confirmation of the existence of two separate free-living populations of wild boar in the south of England, and attempt to predict the potential for numerical growth of the larger of these populations.

Material and methods

Survey for evidence of wild boar presence

Information about the possible location of populations of wild boar was obtained in the first instance by searching two sources of data: a collection of press cuttings from local and national newspapers, accumulated by ADAS during the period 1994-1996, and an archive of unsolicited reports or complaints made to DEFRA by farmers or members of the public during the same period. Both collections of data were searched for relevant items, such as alleged sightings of wild boar or reports of agricultural damage attributed to them, from anywhere in England and Wales. All boar-related reports were investigated in the first instance by interviewing the individual who made the report, and subsequently by searching the relevant locality (parish) for evidence of wild boar activity ('ground-truthing'). Local offices of the National Farmers' Union (NFU) were also asked whether they had received reports of free-living wild boar and, as the investigation on the ground widened, further interviews were conducted with farmers, land owners and hunters who were identified by the original interviewees as having information about the presence of wild boar. These investigations were, in turn, followed up by further ground-truthing.

Ground-truthing was carried out from February to December 1997 and involved searching individual parishes for both direct and indirect evidence of wild boar activity. Direct evidence consisted of inspection of carcasses of animals either shot as game or killed by cars. Indirect evidence included instances of breached stock fencing, daytime nests, farrowing nests, faeces deposits, prints and tracks, rooting, tree rubbing and notching and wallows.

Since the purpose of ground-truthing was to determine the presence or absence of wild boar in a particular parish, and not to estimate the number of animals, surveying was discontinued when definitive evidence had been found. This is most relevant for the parish of Shadoxhurst (Kent), which was not surveyed for indirect evidence of wild boar since the discovery of a road-killed animal demonstrated their presence unambiguously. In practice, however, all other parishes were extensively surveyed for indirect evidence and in most, more than one type of evidence was recorded (see below).

Modelling population growth

In order to model population growth accurately, it is necessary to know the number of animals initially present, the annual rate of new escapes, and the rates of mortality, fecundity and dispersal. Since none of these variables has been directly measured for free-living wild boar in the UK, we have assumed a zero rate of new escapes and have estimated the other parameters using the best information available from other sources. The field survey (see the Results section) indicated the presence of two separate free-living populations of wild boar, in Dorset and Kent/East Sussex, respectively. However, direct evidence of breeding was only found in the Kent/East Sussex area. We therefore confined our modelling of population growth and expansion to the Kent/East Sussex population.

Minimum and maximum population sizes were estimated using the confirmed locations of wild boar as revealed by the field survey. To estimate minimum population size, we made the conservative assumption that a breeding group of wild boar occupies a range of about 25 km^2 (Boitani, Mattei, Nonis & Corsi 1994, Saunders & Kay 1996, Caley 1997), on the grounds that the agriculture-dominated English countryside was un-

likely to constitute an optimal habitat for wild boar (Howells & Edwards-Jones 1997). We then placed a 5 x 5 km grid over a map of confirmed wild boar locations in the Kent/East Sussex area and counted the number of occupied cells. Twelve cells were occupied, suggesting the presence of 12 breeding groups. This yielded a total minimum population estimate of 84 animals, assuming that each group consists of two adults and five young (Spitz, Janeau & Valet 1984, Spitz 1986). Maximum population size was estimated on the basis of the amount of woodland available to the population. We drew a line around all the confirmed Kent/East Sussex locations and measured the amount of woodland within this area. The resultant figure of 40 km^2 of woodland gave a maximum estimate of 120-160 animals, assuming a density of 3-4 individual wild boar per km^2 of woodland (Howells & Edwards-Jones 1997). Combining these minimum and maximum estimates gave an approximate mid-range figure of 100 animals, which we took as our estimate of starting population size for the model.

Two figures for annual fecundity rate were obtained from the literature, relating to populations of boar in the USA and Italy, respectively; 4.36 piglets per litter (Peine & Farmer 1990) and 4.95 piglets per litter (Boitani, Trapanese, Mattei & Nonis 1995). The USA population described by Peine & Farmer (1990) may contain wild boar x feral pig hybrid animals. However, the fecundity rate is relevant to our model because uncertainty exists over the purity of the British population (Goulding 2001). The most detailed mortality rates for wild boar are given by Jezierski (1977) for a Polish population, but it does not take account of animals alive at the end of the study, alive before emigrating or killed by hunting. We attempted to correct for these factors by entering the available figures into a 'fusion life table' (Smith 1995) in three different ways. One life table was corrected for animals alive at the end of Jezierski's study, one for animals present prior to their emigration from the study area, and one for all factors. This approach was taken since we did not have access to Jezierski's original data. For animals that were killed by hunting, we assumed that half of them were in their first year of life and half in their second year, since they were reported by Jezierski to have been mainly aged two years or less.

Table 1. Estimates of annual mortality rates of wild boar, as obtained from the three fusion life tables. For details of the assumptions underlying different estimates, see text.

	Age class (years)		
Estimate	1	2	>2
1	0.44	0.65	0.40
2	0.39	0.52	0.12
3	0.42	0.67	0.35

The three fusion life tables constructed in this way yielded three different estimates of annual mortality rates for animals in their first, second and subsequent years of life, all of which estimates lay within acceptable limits (Table 1). A simple model was produced in STELLA (High Performance Systems, Inc), incorporating these three age classes, and was run using the two different estimates of fecundity and the three different sets of mortality rates, so as to obtain six different projections of population growth.

Table 2. The 15 parishes in England in which various indirect or direct evidence of the presence of free-living wild boar was verified; + indicates that field sign was detected.

	Indirect evidence								Direct evidence	
Parish	Prints/ tracks	Rooting	Fence damage	Faeces	Tree rubbing	Wallow	Day nest	Farrowing nest	Road kill	Shot animal
Kent/East Sussex										
Aldington	+	+	+	+	+	+	+	+		+
Appledore	+									
Beckley	+	+	+	+	+	+	+			
Bilsington	+	+								
Kenardington	+									
Lympne	+	+		+	+					+
Peasmarsh	+	+	+	+	+	+	+			+
Ruckinge	+	+	+							+
Shadoxhurst									+	
Stone-cum-Ebony	+									
Udimore	+	+	+							
Warehorne	+									
Wittersham	+	+								
Woodchurch	+									
Dorset										
Hooke	+	+								

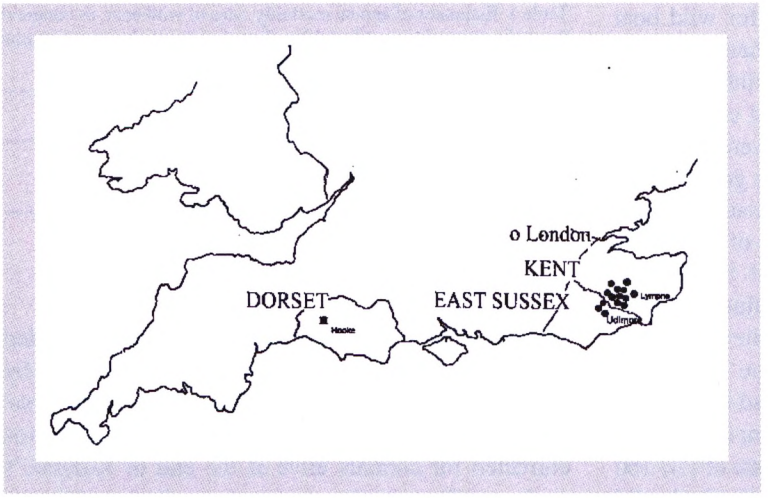

Figure 1. Known locations of free-living wild boar in southern England in 1997. The filled circles denote the parishes in Kent and East Sussex known to be inhabited by wild boar; the square denotes the parish in Dorset inhabited by wild boar.

Results

Evidence of presence of wild boar

Of the 21 parishes that were investigated, 15 yielded evidence of the presence of wild boar (Table 2). Of these, 14 comprised a single, more or less continuous area of about 175 km^2, stretching from Lympne in Kent to Udimore in East Sussex (a linear distance of 32 km), which we judged to contain a single population of animals (Fig. 1). The remaining parish, Hooke, covering an area of 15 km^2, was in Dorset, about 215 km from the other parishes. Since we found no evidence of boar between these two centres of activity, we infer that the Dorset area contained a second, separate population of animals.

Direct evidence of wild boar presence, in the form of carcasses (N = 6), was obtained from five parishes, all in the Kent/East Sussex area. All carcasses were of male animals, of which four possessed well-developed tusks and were estimated to be 2-3 years old, while the remaining two lacked tusks and were judged to be juveniles. All animals were in good bodily condition and had the phenotypic appearance of wild boar. Interviews with farmers and hunters suggest that at least 39 wild boar were killed in the Kent/East Sussex area in the five years preceding our investigation (31 shot, five live-trapped and slaughtered, three killed by road traffic), while four animals appear to have been killed in Dorset (three shot, one killed by traffic). However, in none of these cases carcasses were available for verification.

The most common type of indirect evidence was prints or tracks, which were found in all of the parishes where there was other positive evidence of wild boar. Rooting, either in woodland or on agricultural land, was also recorded in a majority of parishes. A farrowing nest and piglet prints were discovered in the Kent/East Sussex area, implying the presence of at least one breeding female. Interviewees in Dorset reported that a pregnant sow carrying six foetuses had been shot there in 1996, but no direct evidence remained to back up this report.

We investigated media reports of sightings of wild boar in several parts of England other than the Kent/East Sussex and Dorset areas described above. However, no farmer in any other area reported agricultural damage to DEFRA, and our visits and enquiries failed to find any evidence of wild boar in the parishes in question.

Predicted growth of the population

The six different combinations of fecundity and mortality rates that we used to model the population growth, based on a starting population of 100 animals, produced minimum, mean and maximum projected growth rates, r, of 0.016, 0.111 and 0.267, respectively, per year. These rates all predict positive growth of the population, but quickly lead to a very wide projected range of population sizes (Table 3). For example, the projected minimum, average and maximum population sizes after five years are 108, 169 and 326 animals, respectively, and after 15 years the corresponding estimates are 127, 485 and 3,481 animals.

Table 3. Predicted minimum, average and maximum population sizes, based on a starting population of 100 animals and on annual growth rates, r, of 0.016, 0.111 and 0.267, respectively.

Year	Numbers of animals		
	Minimum	Average	Maximum
1998	102	111	127
1999	103	123	161
2000	105	137	203
2001	107	152	258
2002	108	169	326
2003	110	188	414
2004	112	209	524
2005	114	232	664
2006	115	258	841
2007	117	287	1066
2008	119	318	1351
2009	121	354	1711
2010	123	393	2168
2011	125	437	2747
2012	127	485	3481

Discussion

The field survey suggests that in 1997, free-living wild boar ranged over a total of 15 parishes in the south of England: 14 in Kent/East Sussex and one in Dorset. Much of the evidence that was collected was indirect, consisting of field signs such as footprints, rooting and faeces deposits, but we also obtained direct evidence, in the form of carcasses, in five of the Kent/East Sussex parishes. In any case, field signs of the type that we report are unambiguous to an experienced observer and have been used successfully elsewhere to investigate wild boar population density and habitat use (e.g. Hone 1988, Abaigar, del Barrio & Vericad 1994). No domestic pigs were farmed, or had been seen or reported lost in the areas investigated (DEFRA, pers. comm.). We are therefore confident that wild boar were present in the parishes in question. However, we cannot be sure that these are the only populations of free-living wild boar in England.

Given the proximity of the 14 inhabited parishes in the Kent/East Sussex area, it is likely that these animals constitute a single population. Little is known about the possible origin of this population but, judging from the extent of its range and the frequency with which we encountered field signs, it is substantial in size. Anecdotal reports suggest that it initially resulted from at least two escape events, one directly from a wild-boar farm in the area and the other involving animals from a wildlife centre that were being transported to a slaughterhouse (Goulding 2001). Breeding in the Kent/East Sussex population was confirmed by sightings of a farrowing nest and piglet tracks.

The Dorset population, which is clearly separate from the one in Kent/East Sussex, is believed to have resulted from the escape of animals from a farm in the area of Toller Porcorum, in April 1996 (C.Wilson, pers. comm.). During investigations in the relevant parish (Hooke) in 1997, three animals were reported to have been shot and one to have been killed by traffic, but evidence subsequently collected by DEFRA suggests that 32 wild boar were killed in the area between 1996 and 1998, implying that the population contained at least a few dozen animals. DEFRA staff sighted a sow and five half-grown young in the parish of Hooke in October 1998 (C. Wilson, pers. comm.), which indicates that the Dorset population was breeding in the wild. However, this requires further confirmation. No evidence was found to suggest that the population had spread beyond the Parish of Hooke by 1997.

In attempting to model the growth of the Kent/East Sussex population, we were obliged to rely on information from other studies in order to estimate population density and rates of fecundity and mortality. Since the studies in question were conducted elsewhere in Europe or in the USA, there is no guarantee that the relevant data apply to wild boar in the UK. Because of this uncertainty, the model was intended to be conservative. However, it is notable that all versions of the model predicted some degree of population growth, from which we conclude that the Kent/East Sussex population is unlikely to go extinct unless attempts are made to control it. Similarly, when considering the re-introduction of wild boar into Scotland, both Howells & Edwards-Jones (1997) and Leaper et al. (1999) predict that a relatively small founding population would be viable. Subsequent events have confirmed these predictions, insofar as the Kent/East Sussex population is still in existence at the time of writing, despite mortality owing to hunting and road traffic deaths (M. Goulding, pers. obs.).

The existence of free-ranging wild boar in the south of England has important agricultural, ecological, conservational and health implications. Wild boar are capable of significant damage to agriculture, primarily through their rooting activities but also through predation and damage to fencing (for references see Leaper et al. 1999). They may also constitute a reservoir of infection for diseases of domestic swine and humans (e.g. Rutili et al. 1992, Greenblom, Martinsmith, Isaacs & Marshall 1997) and they cause traffic accidents (Groot Bruinderink & Hazebroek 1996). On the other hand, they are thought to have positive as well as negative effects on the natural environment (for references see Leaper et al. 1999), and they are a valued recreational resource for hunters. A recent review of British newspaper and magazine articles referring to the presence of free-living wild boar showed that press coverage was predominantly negative, focussing on issues of public safety, agricultural damage and transmission of livestock disease (Goulding & Roper 2002). However, there was also support for the animals' conservation on the grounds that they could be hunted for their meat.

From a conservational point of view, the existence of free-living populations of wild boar might appear welcome, given that there have been proposals to reintroduce the species deliberately to the UK (Yalden 1986, Howells & Edwards-Jones 1997, Leaper et al. 1999). However, there would only be a strong conservation case for allowing the existing populations to survive if the animals prove to be pure wild boar derived from European descent, as opposed to feral domestic swine or domestic/wild hybrids (Jefferies & Mitchell-Jones 1993, Goulding 2001). An investigation of the genetic sources of the two free-living wild boar populations, using available records, proved inconclusive (Goulding 2001).

Because the modelling exercise predicted an increase in the wild boars' population and range, further study of the animals is required. It is important to know more about the genetics of the animals, as well as about their population size, habitat use and environmental impact, to inform any future management strategy.

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