NatureScot Research Report 1288 - Updated non-native species risk assessment of feral pigs in Scotland

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NatureScot commissioned the Animal and Plant Health Agency (APHA) to prepare a non-native species risk assessment as part of their feasibility study into options for controlling feral pigs in Scotland. This work was undertaken to inform the development of the Scottish Government's policy on feral pigs in Scotland. APHA completed the risk assessment in 2015. It was published in 2022 in Massei G. & Ward A. 2022. Preliminary Assessment of the Feasibility of Maintaining, Limiting or Eradicating Feral Pigs in Scotland.

The Scottish Government Centre of Expertise on Animal Disease Outbreaks (EPIC) peer-reviewed the risk assessment in 2016. NatureScot updated the risk assessment to reflect EPIC's comments, and added a summary sheet to highlight the key risks identified in the assessment. This is the updated non-native species risk assessment.

Contents

Risk assessment summary sheet

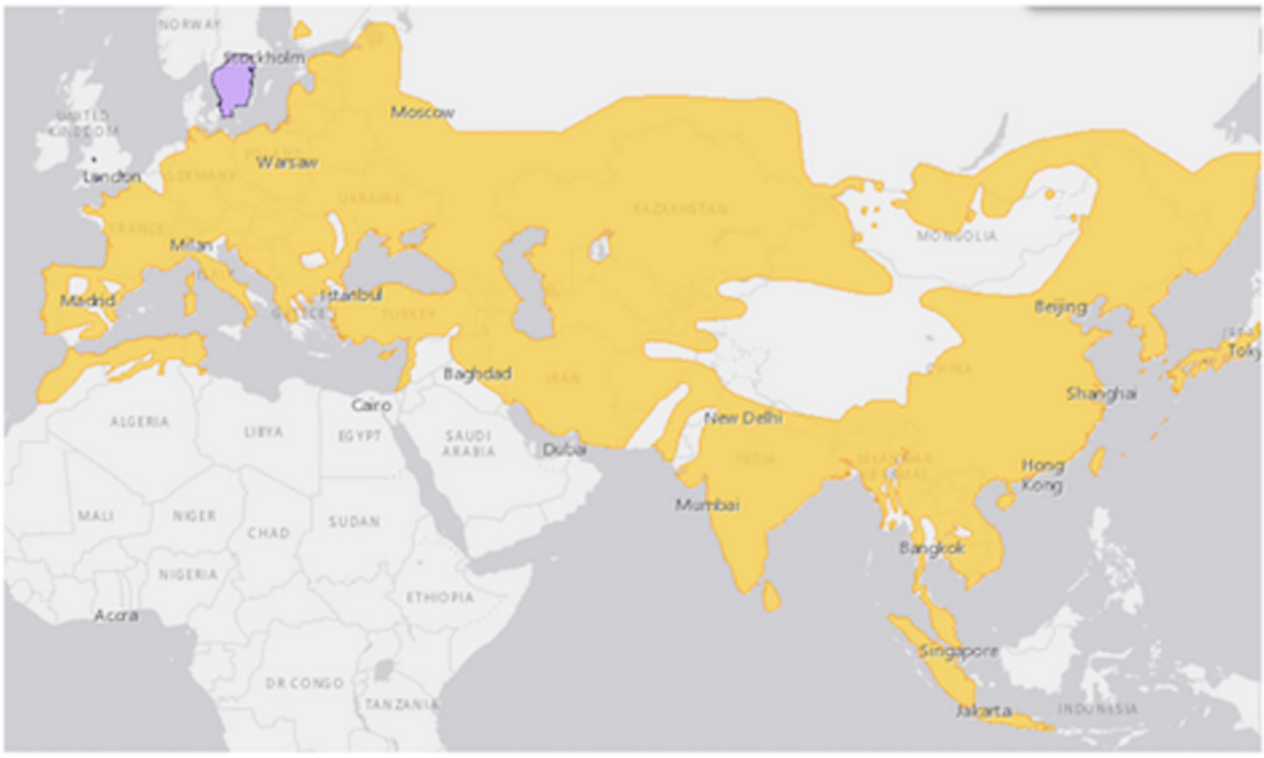
Feral pig (*Sus scrofa*)

- Wild boar are former natives, which means that it is an offence under the Wildlife and Countryside Act 1981 to release them or allow them to escape.
- Mostly farmed for their meat; some are kept in private animal collections, where they are sometimes used for hunting or habitat management.
- Breeding populations in Lochaber and Dumfries and Galloway, as a result of escapes from captivity and illegal releases.
- Both positive and negative impacts on plant and animal communities, on soil and nutrient cycling.
- Potentially serious impacts from disease transmission, crop damage, road traffic accidents and damage to property.

History in Scotland

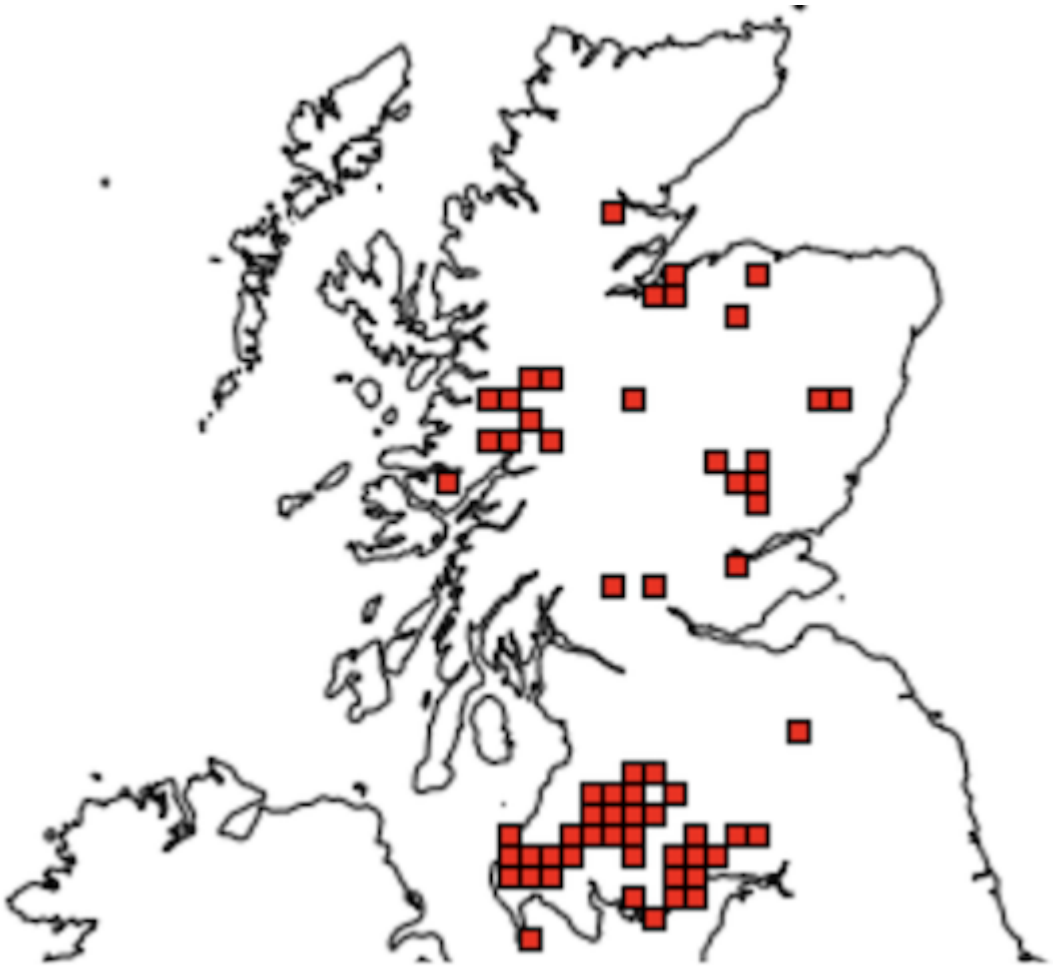
Wild boar are native to Scotland but they were hunted to extinction by 1300 AD. Captive animals were imported from continental Europe and kept under license in zoos, private collections and on farms. Farmers often crossed wild boar with domesticated pigs to increase their litter size. There have been numerous escapes from captivity, or deliberate releases, resulting in at least two breeding populations of feral pig in Scotland. The origin of these animals suggests that they are a mixture of wild boar, domesticated pigs and hybrids, as is the case in England.

Native distribution



Native distribution, Source: IUCN Redlist, 2016

Distribution in Scotland



Distribution in Scotland, Source: NBN, 2016

Impacts

Environmental (moderate)

- Rooting behaviour can modify ecosystems by affecting soil mineralisation, plant growth and abundance of invertebrates and small mammals. Impacts can be both positive and negative.
- Fragile ecosystems could be adversely affected by extensive rooting and rare ground nesting birds could be affected by predation of eggs.

Economic (major)

Feral pigs can cause significant damage to crops, spread diseases to livestock and people, cause vehicle collisions and damage to property.

Social (moderate)

Although feral pigs will attack dogs, most injuries to people are as a result of road traffic accidents or being thrown from startled horses.

Introduction Pathways

Escapes from farms – most likely route of entry, 1-2 escapes/ releases per year reported in England.

Illegal releases – in many instances it is not possible to separate escapes from illegal releases.

Spread Pathways

Natural – highly mobile; capable of rapid population growth in suitable habitats with a rich food supply.

Human – further escapes or releases may occur and heavy hunting pressure can encourage dispersal.

Summary

-	Risk	Confidence
Entry	Very likely	Very high
Establishment	Very likely	Very high
Spread	Intermediate	Medium
Impact	Major	High
Conclusion	High	High

Risk assessment of feral pigs in Scotland

GB non-native organism risk assessment scheme

Name of organism: Feral pig (*Sus scrofa*)
Author: Giovanna Massei
Risk Assessment Area: Scotland
Version 1: 10 September 2014
Updated: 2 August 2016

SECTION A – Organism Information and Screening

Stage 1. Organism Information	RESPONSE	COMMENT

Stage 1. Organism Information	**RESPONSE**	**COMMENT**
1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	Feral pig	Pigs, feral pigs and wild boar belong to the same species *Sus scrofa*. In areas where the species is not native, such as the USA or Australia, these animals are often referred to as feral or wild pigs, hogs or swine (Engeman *et al.,* 2001; Choquenot *et al.,* 1996). Genetic analysis has been often used to determine the degree of inbreeding between wild boar and domestic pig. Animals farmed in England are believed to have been imported from western European wild boar populations (Wilson, 2014), although some of these have wild boar/domestic pig ancestry (Frantz *et al.,* 2012). Throughout the Risk Assessment the species will be referred to as "wild boar" or "feral pigs" where appropriate.
2. If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)	Partially	Defra's Action Plan (2008) refers to animals escaped from farms in the UK as "feral wild boar". The Action Plan sets out the Government's position that free roaming wild boar are feral wild animals: as such they do not belong to anyone, and the responsibility for managing feral boar rests with the relevant landowner or land manager. Further information on legislation relating to feral wild boar can be found on the Deer Initiative's Best Practice Guide 'Wild Boar Legislation'. The SG and NatureScot refer to this species as "feral pigs". As a former native species, the wild boar is not included on the list of non-native species listed on the GB Non-Native Species Information Portal. In Scotland it is considered to be a Non-Native Species under the Wildlife and Countryside Act 1981 (Scottish version as amended by the Wildlife and Natural Environment (Scotland) Act 2011 because former natives are considered to be outwith their native range. According to section 14P (3) and also 3.8 and 3.12 of the Code of Practice on Non-Native Species "animals and plants that were once native in a location but have become extinct are considered to be "former natives". For the purposes of the 1981 Act former natives are considered to be outwith their native range and it is therefore an offence to release a former native without a licence".

Stage 1. Organism Information	RESPONSE	COMMENT
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	Yes	The first qualitative risk assessment (RA), commissioned by Defra (Goulding *et al.,* 1998) highlighted that there were two breeding populations of feral boar in England, one in Kent and East Sussex and one in Dorset. Based on an initial population of 100 animals, modelling suggested that the number of boar would increase to 169 in 5 years, with a minimum of 108 animals and a maximum of 326. A 15- year projection gave an average population size of 485; however, there are now significantly more feral boar in England than the model predicated (see question 4 below). The RA also mentioned that wild boar could be associated with different types of impact, ranging from crop damage to animal health and public safety. A subsequent RA, covering England and Wales was commissioned by Defra as part of the action plan for feral wild boar in England (2008). The RA was mainly focussed on likelihood and impacts of transmission of diseases between freer-ranging wild boar, humans and livestock in England. The RA concluded that the risk of exotic disease incursion was low; the impact should these incursions occur was medium and the likelihood of zoonotic diseases was low. The document also pointed out that population increase would affect these conclusions and modify the disease risk. The RA on the environmental and economic impact concluded that at moderate densities, environmental impact was likely to be minor, whilst economic impacts, such as agricultural damage, were likely to become significant in the longer term particularly if the populations spread and increased substantially.
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	Partially	Some conclusions of the risk assessment published as part of the 2008 Defra's Action Plan were based on much smaller numbers of feral wild boar and on very conservative predictions on population growth. It is possible these conclusions will be revised as in the last few years at least one wild boar population (in the Forest of Dean) has increased to circa 800 animals (Forest Research, 2014) and other breeding populations have appeared in Scotland.

Stage 1. Organism Information	RESPONSE	COMMENT
5. Where is the organism native?	Eurasia	The natural range of wild boar extends from Western Europe and the Mediterranean basin to Eastern Russia, Japan and Southeast Asia (Sjarmidi & Gerard, 1988). In Europe, wild boar recently recolonized Sweden, Finland, Estonia and Norway (Erkinaro *et al.,* 1982; Rosvold & Andersen, 2008; *Veeroja & Männil,* 2014). In Denmark the species has become re-established following farm escapes (Andersen & Holthe, 2010).
6. What is the global distribution of the organism (excluding Great Britain)?	Eurasia, USA, Australia, New Zealand, several countries in South America and Africa	Outside their native range, wild boar and feral pigs have been introduced to the US, South America, Australia, New Zealand and in many African countries where the species now occurs as wild boar, feral pig or as a mixture of wild boar and feral pig (Choquentot et al., 1996; Mayer & Brisbin, 2009).

Stage 1. Organism Information	RESPONSE	COMMENT
7. What is the distribution of the organism in Great Britain?	Isolated, breeding populations occur in England, Wales, Scotland and N. Ireland	In the UK, wild boar are native but they were hunted to extinction by 1300 AD (Yalden, 1999). Since the 1990s, free-living feral pig populations have become established in several areas of the UK as a result of escapes from farms and of illegal introductions (Goulding *et al.,* 2003; Hartley, 2010; Wilson, 2005; Wilson, 2014). Using a suite of molecular markers, Frantz *et al.,* (2012) demonstrated that the 'wild boar' found in the Forest of Dean, in western England, were a genetic mixture of wild boar and domestic pigs. In Ireland wild boar sightings in the wild were first officially recorded in April 2009 on the Invasive Species Ireland website. By October 2012 there had been 27 recorded sightings of the species in Ireland (Figure S1; National Biodiversity Data Centre. Microsatellite analysis revealed that almost all the Irish individuals belonged to the domestic pig genetic cluster and only a few individuals were classified as hybrids between wild boar and domestic pig (McDevitt *et al.,* 2013). In Scotland, Campbell & Hartley (2010) suggested that at least 1,300 wild boar were kept in farms across 11 sites. Information provided in July 2014 (Campbell, personal communication) indicates that that there are at least two populations of feral pigs breeding in Scotland, one in Dumfries (originally two separate groups, one around New Abbey/Dalbeattie and one in Carsphairn Forest, about 40 miles from each other and likely now to be a single population) and another in Lochaber around Glen Dessary and Invergarry. Two other free-living populations have been recorded as possibly self-sustaining, one around Cawdor (SE of Inverness), and another near Blairgowrie (N of Perth). Many other sightings or reports of feral pigs shot have been collected across many parts of Scotland. The number of animals in each breeding population is estimated to be between 50 and 100 and the Lochaber population may exceed 100 (C. Lavin and S. Campbell, pers. comm.). Camera trap surveys estimated the density of feral pigs in Lochaber and Dumfries-shire to be less than one animal per square kilometre.

Stage 1. Organism Information	RESPONSE	COMMENT
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes	The IUCN (World Conservation Union) lists this species among the 100 worst alien invasives. The impact of feral pigs on conservation and economic interests includes spread of diseases to wildlife, livestock and people, vehicle collisions, damage to crops and amenities, predation on native species, reduction in plant and animal abundance and richness (e.g. Welander, 2000; Hone, 2002; Schley & Roper, 2003; Massei & Genov, 2004; Bueno *et al.,* 2010; Barrios-Garcia & Ballari, 2012).
Stage 2. Screening Questions	**-**	**-**
9. Has this risk assessment been requested by the GB Programme Board? (If uncertain check with the Non-native Species Secretariat)	Risk assessment requested by SNH If yes, go to section B (detailed assessment)	-

SECTION B – Detailed assessment

PROBABILITY OF ENTRY

QUESTION	RESPONSE	CONFIDENCE	COMMENT

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.1. How many active pathways are relevant to the potential entry of this organism?	few	high	Active pathways relevant to entry of feral pigs in Scotland are 1. Escapes from farms and 2. Illegal releases. These pathways have also caused the re-establishment of wild boar in several European countries where the species had become extinct in the last century (Sáez-Royuela & Tellería, 1986; Pfaff & Saint Andrieux, 2007; Apollonio *et al.,* 2010). The same pathways are mentioned for the US where the number of states reporting the presence of feral pigs rose from 23 in 1988, to 39 in 2004 (Hutton *et al.,* 2006; Centner & Shuman, 2014).
1.2. List relevant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.	Escapes from farms and illegal releases.	high	Several papers and reports on feral pigs in GB (e.g. (Goulding *et al.,* 2003; Defra, 2008; Hartley, 2010; Wilson, 2003; Wilson, 2005; McDevitt *et al.,* 2013; Wilson, 2014) as well as anecdotal evidence from rangers, hunters and groups operating in areas where feral pigs occur suggest the presence of this species in Scotland can be assigned to both pathways, although it is often difficult to establish whether the escape from farms is accidental or provoked.
Pathway name:	**Escapes from farms**	-	-

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)?	Mostly accidental	high	In Scotland, farmed wild boar can be kept in captivity under licence from Local Authority under the Dangerous Wild Animals Act 1976 (Modification) Scotland Order 2008. The Act specifies conditions in the licence to ensure the animals are confined in a way that prevents their escape. The requirement for a DWA licence applies to all *Suidae*, including farmed wild boar and hybrids where at least one parent is wild boar (SNH 2014). Feral pigs in Scotland are likely to have mixed wild boar and domestic pig ancestry and they are regarded as Non-Native Species under section 14C of the Wildlife and Countryside Act 1981. In Scotland, there is a presumption of 'no-release' for any species 'outwith their native range'. Section 14 of the Wildlife and Countryside 1981 Act makes it an offence to release an animal, allow it to escape, or cause it to be outwith the control of any person, at a place outwith its native range. Feral pigs are domesticated animals and are therefore outwith their native range. For the purposes of the 1981 Act former natives, like wild boar, are considered to be outwith their native range and the same offences, therefore, apply.
1.4. How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	unlikely	medium	By collating reports of escapes or releases of feral pigs and by assessing the presence of animals in the wild, Wilson (2014) concluded that between 1989 and 2009 an average of 1-2 escape/release per year occurred in England, involving from one to 140 individuals. Similar reports, in terms of a few animals sighted in the wild as a result of farm escapes or illegal releases, exist for Scotland (Campbell & Hartley, 2010).

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.5. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)?	very likely	very high	Feral pigs escaped from farms are likely to find food and shelter in the vicinity of the farm or in neighbouring woodlands where they can survive and reproduce.
1.6. How likely is the organism to survive existing management practices during passage along the pathway?	likely	high	The only significant factors affecting the mortality of feral pigs are hunting and vehicle collisions. Hunting aimed at eradicating pigs from an area might prevent these animals from establishing in that area, particularly if only a few pigs have recently been introduced. Vehicle collisions are more likely to occur following recent animal introductions into an area (Massei *et al.,* 2010). Current hunting levels appear to be insufficient to contain or eradicate feral pig populations in Scotland. Heavy hunting pressure can result in avoidance behaviour and dispersal (ESFA, 2014a); however, feral pigs have been successfully eradicated from over 56 islands, globally, and Oregon and Kansas have been successful at reducing feral pigs populations by rapidly responding to initial introductions (Keitt et al. 2011, Bevins *et al*. 2014).

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.7. How likely is the organism to enter Scotland undetected?	unlikely	medium	Recently escaped animals are less timid around humans and more likely to be attracted to easily available feedstuffs than pigs that have been feral for some time (Hartley, 2010). Sightings, characteristic rooting of ground vegetation and animals shot are the frequently reported records of feral pigs in England (Wilson, 2014). In Ireland it took several years to determine whether sightings represented an established population or isolated escapes (McDevitt et al., 2013).
1.8. How likely is the organism to arrive during the months of the year most appropriate for establishment?	very unlikely	very high	There isn't a time of year when feral pigs would find it impossible to establish in Scotland. They would find it harder in winter but even the hilly areas have woodlands that offer shelter. (Leaper *et al.*, 1999)
1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	likely	high	Wilson (2014) suggested that feral pigs are likely to escape from farms and establish breeding populations in the wild.
1.10. Estimate the overall likelihood of entry into Scotland based on this pathway?	very likely	very high	In Scotland, accidental escapes may occur from farms as well as from estates that offer wild boar hunting and that have poor animal containment facilities. Reports in England and Scotland (Campbell & Hartley, 2010; Wilson, 2014) suggest that in the last decades animals have regularly escaped from farms.
Pathway name:	**Illegal releases**	**-**	**-**

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)? **If intentional, only answer questions 1.4, 1.9, 1.10,** 1.11	Intentional	high	Wilson (2014) suggested that between 1989 and 2009 an average of 1-2 escape/release per year occurred in England. Similar reports, in terms of a few animals sighted in the wild as a result of farm escapes or illegal releases, exist for Scotland (Campbell & Hartley, 2010). Although in many instances it is not possible to separate farm escapes from illegal releases, this pathway of entry is very common in other countries (e.g. Choquenot *et al.,* 1996, for Australia, Centner & Shuman, 2014 for the US).
1.4. How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	unlikely	medium	By collating reports of escapes or releases of feral pigs and by assessing the presence of animals in the wild, Wilson (2014) concluded that between 1989 and 2009 an average of 1-2 escape/release per year occurred in England, involving from one to 140 individuals. Similar reports, in terms of a few animals sighted in the wild as a result of farm escapes or illegal releases, exist for Scotland (Campbell & Hartley, 2010).
1.5. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)?	very likely	very high	No difference from escaped animals – see above

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.6. How likely is the organism to survive existing management practices during passage along the pathway?	likely	high	No difference from escaped animals – see above
1.7. How likely is the organism to enter Scotland undetected?	unlikely	medium	No difference from escaped animals – see above
1.8. How likely is the organism to arrive during the months of the year most appropriate for establishment?	very unlikely	very high	No difference from escaped animals – see above
1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	likely	high	Several studies (e.g. Choquenot *et al.,* 1996; Campbell & Hartley, 2010; Centner & Shuman, 2014; Wilson 2014) suggested that feral pigs are likely to be illegally released and establish breeding populations in the wild. Wild boar and wild pigs can adapt to a very wide spectrum of environmental conditions, which include woodlands, marshlands, agri-environment and suburban areas. Provided that high-energy food (such as acorns, crops, animal food), shelter and water for wallowing are available, feral pigs can live virtually everywhere (Schley & Roper, 2003; Massei & Genov, 2004; Rosvold & Andersen, 2008; Barrios-Garcia & Ballari 2012).

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.10. Estimate the overall likelihood of entry into Scotland based on this pathway?	very likely	very high	Experiences in the US and in continental Europe suggest that illegal releases of feral pigs are likely to increase in parallel with hunters' interest for a new game species (Centner & Shuman, 2014). In Scotland, releases might also occur as the result of lobby groups that advocate the return of wild boar as a former native species. Population modelling suggested that in Scotland a release of as few as five animals would be sufficient to establish a viable population of feral pigs (Leaper *et al.,* 1999). Experience of escape/release incidents and the establishment of feral populations in England tend to confirm the predictions of these models (Wilson, 2014).
End of pathway assessment, repeat as necessary.	-	-	-

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.11. Estimate the overall likelihood of entry into Scotland based on all pathways (comment on the key issues that lead to this conclusion).	very likely	high	Illegal releases and escape from farms are likely to continue. If the number of free-living populations increases it is likely that the number of illegal releases and escape from farms will increase. In Scotland, holding feral pigs in captivity without adequate containment is likely to lead to further escapes. Farmers are required by the Council Directive 2008/71/EC to identify pigs with an ear tag, tattoo or slap mark before animals are moved between holdings but not whilst pigs are held on the farm. The lack of permanent identification means it is more difficult to attribute escaped animals to a particular farm. At the time of writing, at least two sporting estates in Scotland were offering wild boar shooting and it is likely that recreational hunters had private arrangements with other land owners (Whitaker, pers comm.). This practice might lead to an increase of feral pigs in farms and to an increase of illegal releases, as already occurred in the US and in several other continental European countries such as Sweden and The Netherlands (Van Wieren & Groot-Bruinderink, 2010; Liberg *et al.,* 2010; USDA-APHIS, 2013).

PROBABILITY OF ESTABLISHMENT

Important instructions:

For organisms which are already well established in Scotland, **only completed questions 1.15 and 1.21** as recommended by the Non-native Species Secretariat.

QUESTION	RESPONSE	CONFIDENCE	COMMENT

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.12. How likely is it that the organism will be able to establish in Scotland based on the similarity between climatic conditions in Scotland and the organism's current distribution?	very likely	very high	Free-living, isolated populations of feral pigs already occur in Scotland (Campbell & Hartley, 2010). The widespread range of wild boar and feral pigs through different habitat types, latitudes and climatic regions shows that new free-living populations of this species can easily establish in Scotland. Wild boar and wild pigs can adapt to a very wide spectrum of environmental conditions, which include woodlands, marshlands, agri-environment and suburban areas. Provided that high-energy food (such as acorns, crops, animal food), shelter and water for wallowing are available, feral pigs can live virtually everywhere (Schley & Roper, 2003; Massei & Genov, 2004; Rosvold & Andersen, 2008; Barrios-Garcia & Ballari, 2012).

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.13. How likely is it that the organism will be able to establish in Scotland based on the similarity between other abiotic conditions in Scotland and the organism's current distribution?	very likely	very high	Two main factors limit the establishment of wild boar in an area: food availability and presence of snow cover for several consecutive weeks (Jędrzejewski *et al.,* 1992; Jędrzejewska *et al.,* 1997). Availability of high-energy food is crucial for this species as wild boar are unable to digest plants as efficiently as ruminants. Snow cover prevents wild boar from rooting for food and hampers their movements. However, wild boar populations are increasing in countries characterised by harsher winters than Scotland. Examples include Sweden, where widely spread supplementary feeding, used by hunters to increase local densities of wild boar and reduce crop damage, have increased the spread of this species (Thurfjell *et al.,* 2013). In Norway, wild boar that in the past were limited to the broad leaved deciduous forests have recently settled in areas with harsher climate, thanks to availability of crops and supplementary feeding that have allowed this species to find food throughout the year (Rosvold & Andersen, 2008). In Germany, wild boar originally restricted to large, deciduous forests, now occur also in poorer habitats like spruce forests and in areas characterised by snowy winters (Wotschikowsky, 2010).

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.14. How likely is it that the organism will become established in protected conditions (in which the environment is artificially maintained, such as wildlife parks, glasshouses, aquaculture facilities, terraria, zoological gardens) in Scotland?	very likely	high	Wild boar and their hybrids are successfully kept in captivity in Scotland for example Hilton farm, Perthshire has successfully kept them for more than 10 years. Campbell & Hartley (2010) reported that at least 1,300 wild boar or feral pigs were kept in farms across 11 sites in Scotland.
1.15. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Scotland?	moderately widespread	high	Wild boar and wild pigs can adapt to a very wide spectrum of environmental conditions (Massei and Genov, 2004). In Scotland, increased reforestation, particularly where focussed on deciduous trees, is likely to increase the habitat available for breeding populations of feral pigs (Leaper et al., 1999).

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.16. If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in Scotland?	NA	NA	-
1.17. How likely is it that establishment will occur despite competition from existing species in Scotland?	very likely	very high	Wild pigs are omnivores that feed opportunistically on wild fruits (acorns, beech mast, berries, etc.), roots and tubers, vertebrates (including carcasses), invertebrates (including earthworms), eggs and crops (Schley & Roper, 2003; Massei & Genov, 2004). As the species' reproductive potential is higher than that of any other ungulate or medium- or large-size mammal occurring in Scotland, it is likely that feral pigs will outcompete any species with similar feeding habits. These include deer and ungulates feeding on beach mast and acorns as well as other generalists such as badgers.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.18. How likely is it that establishment will occur despite predators, parasites or pathogens already present in Scotland?	very likely	very high	In Europe, the only significant predator of wild boar is the wolf (*Canis lupus*) (Jędrzejewski *et al.,* 1992). This predator is not found in the wild in Scotland. Diseases and pathogens, such as for instance Classical Swine Fever or African Swine Fever could significantly affect mortality of feral pig populations (Defra 2008, Defra 2014) but they are unlikely to prevent establishment and also unlikely to be affecting simultaneously several isolated populations.
1.19. How likely is the organism to establish despite existing management practices in Scotland?	very likely	very high	Feral pigs are already established in some parts of Scotland. In Europe, hunting makes the greatest contribution to boar mortality (Nores *et al.,* 2008; Toigo *et al.,* 2008; Keuling *et al.,* 2013). Thus culling and trapping to achieve eradication are the only management options that may prevent establishment of new populations in Scotland. In a few instances, animals escaped from farms in Scotland and in England have been shot, thus preventing the establishment of a population in an area (Campbell & Hartley, 2010; Wilson, 2014). In the US, feral pig populations were prevented from becoming established only in those states that reacted swiftly to the presence of this species by making recreational hunting for pigs illegal, by promoting electronic identification of animals kept in captivity or by precluding import, transport or release of this animals (Centner & Shuman, 2014).

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.20. How likely are management practices in Scotland to facilitate establishment?	likely	medium	Woodland planting, particularly of broadleaves, is likely to increase the availability of suitable breeding habitat for feral pigs (Leaper et al., 1999). Growing high-energy crops and providing supplementary feeding for animals may also help pigs to become established (Thurfjell et al., 2013).
1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in Scotland?	unlikely	high	Successful eradication campaigns of isolated feral pig populations have occurred in the US (Cruz *et al.,* 2005; McCann & Garcelon, 2008; Massei *et al.,* 2011). As populations or feral pigs are still isolated in Scotland, the eradication of these populations should be possible through a combination of culling and trapping. Wild boar and feral pigs respond to intense hunting pressure by becoming more nocturnal and in some instances by moving away from the area for distances up to several tens of km (Andrzejewski & Jezierski, 1978; Bouldoire & Vassant, 1989). The species' high reproductive rate also means that eradication campaigns should be carried out in the shortest possible time, ideally in less than a year, to avoid the replacement of animals through recruitment.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.22. How likely are the biological characteristics of the organism to facilitate its establishment?	very high	high	Among ungulates, wild boar are characterised by the highest annual reproductive rate that may exceed 200% (Bieber & Ruf, 2005; Fonseca *et al.,* 2011; Keuling *et al.,* 2013). Females can reach sexual maturity in their first year of age (Gethoffer *et al.*, 2007) and produce one litter of 3-7 piglets, and occasionally two litters per year. The number of litters, the litter size and the proportion of females that reproduce in a year are strongly affected by the availability of energy-rich food such as acorns (e.g. Groot-Bruinderink *et al.,* 1994; Massei *et al.,* 1996; Nahlik & Sandor, 2003, Fonseca *et al.,* 2004).
1.23. How likely is the capacity to spread of the organism to facilitate its establishment?	very high	high	Wild boar can move over large distances. In the UK, the maximum distance tracked from site of capture was 20 Km (Moore, 2004). Radio-tracking studies found that in a single night, boars can travel between 2 and 15 km and that the direct distance between resting places varies between 0 and 7 km (Spitz, 1986). During seasonal migrations wild boar can move over longer distances, from 12 km to 250 km (Andrzejewski & Jezierski, 1978; Singer *et al.,* 1981). A French study showed that between 18 and 55% of wild boar trapped and ear-tagged in six areas where hunting occurred had been shot by hunters at more than 10 km from the initial trapping site (Cargnelutti *et al.,* 1992).

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.24. How likely is the adaptability of the organism to facilitate its establishment?	very high	high	Wild boar and wild pigs can adapt to a very wide spectrum of environmental conditions, which include woodlands, marshlands, agri-environment and suburban areas. Provided that high-energy food (such as acorns, crops, animal food), shelter and water for wallowing are available, feral pigs can live virtually everywhere (Schley & Roper, 2003; Massei & Genov, 2004; Rosvold & Andersen, 2008; Barrios-Garcia & Ballari, 2012).
1.25. How likely is it that the organism could establish despite low genetic diversity in the founder population?	very high	high	Several reports (Campbell & Hartley, 2010; Wilson, 2014) suggested feral pigs current populations derived from relatively few individuals. It is thus very likely that this species will establish irrespective of potentially low genetic variability.
1.26. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Scotland? (If possible, specify the instances in the comments box.)	very high	high	Feral pigs are already established in Scotland as escapes from farms or illegal releases.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.27. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	N/A	N/A	-
1.28. Estimate the overall likelihood of establishment (mention any key issues in the comment box).	very high	high	Feral pigs are already established in Scotland. Based on the history of invasion of this species in other countries (e.g. Erkinaro *et al.,* 1982; Andersen & Holthe, 2010; Centner & Shuman, 2014), establishment of new populations in Scotland is very likely.

PROBABILITY OF SPREAD

Important notes:

Spread is defined as the expansion of the geographical distribution of a pest within an area.

QUESTION	RESPONSE	CONFIDENCE	COMMENT

QUESTION	RESPONSE	CONFIDENCE	COMMENT
2.1. How important is the expected spread of this organism in Scotland by natural means? (Please list and comment on the mechanisms for natural spread.)	slow	low	Where local populations are present in confined areas of preferred habitat, dispersal may be slow until high densities occur (Leaper et al. 1999). Confidence is low because factors such as the availability of crops nearby and hunting pressure may give added incentive to disperse (Cargnelutti et al. 1992, Keuling et al, 2008). For instance, in the South of England, free-living populations of feral pigs subjected to relatively high hunting pressure have existed for about 20 years and experienced moderate levels of increase in range and spread (Wilson, 2014).
2.2. How important is the expected spread of this organism in Scotland by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	major	high	Deliberate releases or increase of local populations for sport hunting, and supplementary feeding provided by hunters are likely to increase the establishment and spread of feral pigs in Scotland. All these factors have played a significant role in the spread of wild boar and feral pigs in mainland Europe and in the US (Saez-Royuela & Telleria, 1986; Centner & Shuman, 2014; Massei *et al.*, 2014).

QUESTION	RESPONSE	CONFIDENCE	COMMENT
2.3. Within Scotland, how difficult would it be to contain the organism?	moderate	medium	As feral pig populations are still isolated, eradication or containment through sustained culling and trapping is still achievable. If populations expand, the cost of eradication is likely to increase dramatically, as shown in island eradications carried out in the US and summarized by McCann & Garcelon (2008). In the UK, an example of dramatic population growth is found in the Forest of Dean (Gloucestershire) where in early 2013 a comprehensive thermal imaging survey for feral wild boar carried out on the public forest estate indicated that 535 feral pigs occurred in the area. A follow-up survey in early 2014, estimated that 819 feral pigs occurred in the forest, despite a cull of circa 130 animals between 2013 and 2014, indicating a significant growth of the number of pigs in one year (Forest Research, 2014). For geographically isolated populations, McCann & Garcelon (2008) suggested that an intensive eradication program should be preferred to sustained control as only a high intensity program can achieve eradication in a short period. In addition, the high cost of a short but intensive eradication program is likely to be less than that of sustained control over a period of several years and a short, well-managed program is less likely to be exposed to factors that can undermine its success. These factors include reproduction that causes the pig population to increase, pigs learning to avoid control, public opposition, legal challenges arising in the course of the project, increased lack of staff motivation, and funders' fatigue which may result in lack of sustained funding to complete the program (Morrison *et al.*, 2007; Parkes *et al.,* 2010).

QUESTION	RESPONSE	CONFIDENCE	COMMENT
2.4. Based on the answers to questions on the potential for establishment and spread in Scotland, define the area endangered by the organism.	Throughout Scotland, mixed woodlands, pastures adjacent to woodlands (including conifer plantations) and/or crops	medium	The area endangered by feral pigs will depend, to an extent, on the density and distribution range of animals. The latter in turn will depend on whether local populations are supplemented with food, whether crops and natural food are available throughout the year to sustain high densities of feral pigs and whether hunting has a significant impact on population growth (Massei & Genov, 2004; Bieber & Ruf, 2005; Barrios-Garcia & Ballari, 2012). In Europe, increasing numbers of wild boar sightings were reported in urban and suburban areas, for instance in Berlin, Barcelona, Vilnius and Budapest (e.g. Náhlik in Massei *et al.,* 2014; Cahill *et al.,* 2003; Jansen *et al.,* 2007). It is also possible feral pigs in Scotland will colonise these areas.
2.5. What proportion (%) of the area/habitat suitable for establishment (i.e. those parts of Scotland were the species could establish), if any, has already been colonised by the organism?	0-10	medium	Likely to be less than 1%. Leaper *et al*. (1999) identified over 300 sites with habitats suitable to support populations of wild boar, covering around 5,000 km^2 or 6% of Scotland's land area. The model excluded areas of suitable habitat within 5km of arable land and urban settlements, accounting for most of the central and eastern lowlands. It is estimated that the confirmed populations of feral pigs shown on the SASA's distribution map (Campbell, 2014) occupy less than 1% of the potential area of suitable habitats within Scotland.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
2.6. What proportion (%) of the area/habitat suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)?	0-10	low	It is very difficult, at present, to answer this point. The answer is based on the population trends observed in the Forest of Dean in England, where feral boar occupy an area of circa 50 km^2. In the last four years this population increased from 200-250 feral boar estimated in 2010 to 500 in 2013 and up to 819 animals in 2014 but their spread to surrounding areas was not as conspicuous as their numerical increase (Forest Research, 2014). For other populations in mainland Europe, the spread per decade, in numbers and range, was more pronounced: for instance, in France in 1983-1986, 85% of the regional departments shot 1500-3000 wild boar, and only 15% of the departments shot > 3000 animals per year; in 1993-1996 45% of the departments shot 1500-3000 wild boar, and 55% shot > 3000 animals per year; in 2003-2006 14% of the departments shot 1500-3000 wild boar, and the remaining 86% shot > 3000 animals per year (Pfaff & Saint Andrieux,2007). In Sweden, the natural spread of wild boar since the species recolomised the country in the late ‘80s was calculated at 3-4 km/year but the expansion was speeded up by new illegal releases (Liberg *et al.,* 2010).

QUESTION	RESPONSE	CONFIDENCE	COMMENT
2.7. What other timeframe (in years) would be appropriate to estimate any significant further spread of the organism in Scotland? (Please comment on why this timeframe is chosen.)	10	medium	If a rapid increase in spread occurs, such as those recorded by Wilson (2014) in England, significant change could take place undetected for several years and this could limit the choice of management responses.
2.8. In this timeframe what proportion (%) of the endangered area/habitat (including any currently occupied areas/habitats) is likely to have been invaded by this organism?	10-20 %	low	Please see considerations at point 2.6. The confidence of this statement is low as spread is likely to depend on factors such as type of habitat where feral pigs already occur and surrounding habitat, population size and population management (including level of hunting pressure), new releases etc. that are difficult to quantify or predict with available information.
2.9. Estimate the overall potential for future spread for this organism in Scotland (using the comment box to indicate any key issues).	moderate	medium	Based on the information above, and on the fact that much of the woodland and agricultural land, as well as urban and suburban areas are suitable for establishment, feral pigs are likely to spread.

PROBABILITY OF IMPACT

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
2.10. How great is the economic loss caused by the organism within its existing geographic range **excluding** Scotland, including the cost of any current management?	major	very high	Wild boar and feral pigs cause major economic losses due to spread of diseases to livestock and people, vehicle collisions and damage to crops and amenities. As wild boar and pigs numbers increase, these losses grow (Massei *et al., 2014*). Examples include compensation for crop damage caused by wild boar in France rose from circa 2.5 million € in 1973 to 21 million € in 2005 and 32.5 million € in 2008 (Guibert *et al.,* 2008; Maillard *et al.,* 2010). In Luxembourg, compensation for crop damage caused by wild boar increased from circa 100,000 € in 1971 to 900,000 € in 2004 (Schley *et al.,* 2008) and in n Slovenia from 292,000 € in 2005 to 575,000 € in 2013 (ZGS, 2014, in Massei *et al.,* 2014). The number of wild boar-vehicle collisions in Sweden rose from about 50 per year in the early 2000 to *circa* 1000 in 2005 and over 4000 in 2012 (Liberg *et al.*, 2010). In the Netherlands this number rose from 142 in 1995 to 320 in 2003 (Van Wieren & Groot-Bruinderink, 2010), and in Switzerland, in the same period, this number increased from 212 to 412 (Imesh-Bebie' *et al.,* 2010). In Germany, out of the 227,000 traffic accidents with deer and wild boar in 2005, 13700 involved wild boar (Wotschikowsky, 2010). In Catalonia (North-eastern Spain) the number of accidents involving animals increased by 41.6% between 2007 and 2011, with wild boar responsible for 85% of the accidents (Rosell *et al.,* 2013). In the US feral pigs cause significant economic loss: in California pig damage to crops in 2006 was estimated at $ 1.2 million, whilst damage to natural areas in 2005-2007 was estimated at $ 11.3 million (Sweitzer 2007 in Christie *et al.,* 2014). In 2013, the USDA Wildlife Services estimated $ 28 million damage caused by feral pigs to crops, rangeland and developed land in

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
			California (Christie *et al.,* 2014). Throughout the US, feral pig damage to crops in 2002 was valued at $800 million per year (Pimentel *et al.,* 2002). This estimate did not consider livestock predation, disease transmission, or environmental impact. In Australia, annual crop damage by feral swine exceeded >$100 million (Choquenot *et al.*, 1996). PLEASE NOTE: the role of feral boar in disease transmission and its related economic loss is covered under point 2.24.
2.11. How great is the economic cost of the organism **currently** in Scotland **excluding management** costs?	minor	medium	Anecdotal evidence suggests that in Scotland the economic cost of feral pigs is still small, due to relatively low local densities of animals (Campbell & Hartley, 2010). Although the economic cost of this species in Scotland has not been quantified, impact so far include isolated incidents of disturbance to grasslands and woodlands through rooting activity, damage to gardens, vehicle collisions and pigs feeding from pheasant feeders (Campbell & Hartley, 2010). This cost must be in the order of £10,000s.

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
2.12. How great is the economic cost of the organism likely to be **in the future** in Scotland **excluding management** costs?	moderate	medium	If feral pigs increase in numbers and spread, following for example the trend observed in the Forest of Dean as well as in the US and mainland Europe, the economic cost will grow for Scotland. The growing population of feral boar in the Forest of Dean has led to significant impacts on the resident community and on visitors to the area. Impacts include rooting of amenity grasslands, woodlands and road side verges, perceived risks of attacks by walkers, attacks on dogs, road traffic accidents and several instances of horse riders thrown off their horse when scared by a feral pig encounter. Damage to grasslands in the villages includes play areas, caravan parks, sports pitches, golf courses and private gardens (Forest Research, 2014). In 2013, for the first time the number of road traffic accidents involving feral wild boar in the Forest of Dean has surpassed the number of deer-vehicle collisions (Forest Research, 2014). Social impact will also depend on perceived risks of feral pigs' attacks on humans and on risk of pig attacks on dogs. In Scotland, there have been reports of recently escaped feral pigs visiting gardens and rooting on a golf course near Aberfoyle, although there are no estimates for the financial value of this damage.
2.13. How great are the economic costs **associated with managing** this organism **currently** in Scotland?	minor	high	At present there are no reports on economic costs associated with the management of feral pigs in Scotland.

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
2.14. How great are the economic costs **associated with managing** this organism likely to be **in the future** in Scotland?	moderate	medium	The cost associated with managing this species in Scotland will depend on the location, number, local densities and distribution range of feral pigs. The higher the number of feral pigs, local densities and species range, the higher the cost. In addition, the cost will depend on the efficacy of methods used to manage this species. Typically, both culling and trapping are relatively inexpensive (in terms of man hour per pig) when densities are high but become progressively more expensive when numbers of animals decline (Parkes *et al.*, 2010). Although it is not possible to establish a cost with current information, this could be moderate (between £ 100k and £ 1m) if feral pigs increase and must be quickly contained. In case of a sudden disease outbreak such as Classical Swine Fever or Foot-and Mouth Disease, the cost could exceed £1m.
2.15. How important is environmental harm caused by the organism within its existing geographic range **excluding** Scotland?	major	high	Wild boar are very opportunistic feeders that adapt their diet according to the season and to the relative availability of different food sources (Genov 1981, Massei *et al.,* 1996; Schley & Roper, 2003; Baubet *et al.,* 2003). The environmental impact can derive from direct consumption of native plants and animals and from disturbance to the ground that affects ground-dwelling vertebrates (Massei & Genov, 2004; Barrios-Garcia & Ballari, 2012). Wild boar feed on around 400 species of plants, animals and fungi in Western Europe (Schley & Roper, 2003). The bulk of the food consists of plant material such as mast, roots, tubers, wild fruits and crops. Energy-rich plant food, like acorns and beechmast or agricultural crops, is particularly important as wild boar are not ruminants like other ungulates (Andrzejewski & Jezierski, 1978; Groot Bruinderink *et al.,* 1994; Schley & Roper, 2003). Most crops are

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
			consumed when available (Genov, 1981; Schley & Roper, 2003). Animals are regular components in the diet of the wild boar but occur in relatively small quantity compared to plants (Schley & Roper, 2003). Insects and earthworms are the most important; however most small animals including birds, mice and invertebrates as well as carcasses of larger animals and eggs of ground-nesting birds are consumed opportunistically (Genov, 1981; Schley & Roper, 2003; Barrios-Garcia & Ballari, 2012). In addition, wild boar may exploit mast hoards collected by small mammals and stored underground (Focardi *et al.,* 2000). Contrasting results exist on the consequences of rooting on soil processes and cycling of minerals, with some studies suggesting wild boar and feral pigs have a significant impact on these processes, whilst other studies finding little evidence of impact (reviewed in Barrios-Garcia & Ballari, 2012). No effect of rooting on soil pH, organic matter, nitrogen content and regeneration of broadleaved and conifer species was observed in the Netherlands, with the exception of oak and beech regeneration that was negatively correlated with wild boar rooting (Groot Bruinderink & Hazebroek, 1996).
2.16. How important is the impact of the organism on biodiversity (e.g. decline in native species, changes in native species communities, hybridisation) **currently** in Scotland?	minimal	low	At present there are no reports on the impact of feral pigs on biodiversity in Scotland.

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
2.17. How important is the impact of the organism on biodiversity likely to be in the **future** in Scotland?	moderate	medium	Impact on biodiversity in Scotland will depend on feral pig local densities and location, proximity to fragile ecosystems that could be affected by extensive rooting, availability of food sources that might maintain high densities. As the species feed opportunistically, it is also possible that feral pigs will impact on eggs of ground-nesting birds such as grouse and other galliformes.
2.18. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions) caused by the organism **currently** in Scotland?	minimal	low	At present there are no reports on alteration of ecosystem function due to feral pigs in Scotland.
2.19. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions) caused by the organism likely to be in Scotland in the **future**?	moderate	medium	Wild boar are described as “ecosystem engineers” because their rooting behaviour has marked ecosystem-level effects. Rooting affects above- and belowground components of plant and animal communities but also indirectly affects other organisms by physically changing habitat characteristics and modifying resource availability. For instance, wild boar rooting affects soil mineralisation, plant growth and abundance of invertebrates and ground-dwelling mammals (reviewed in Massei & Genov, 2004; Barrios-Garcia & Ballari, 2012). It is likely that alteration of ecosystems will occur in Scotland if the density of feral pigs is relatively high.

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
2.20. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism **currently** in Scotland?	minimal	medium	At present there are no reports on decline in conservation status caused by feral pigs in Scotland.
2.21. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism likely to be in the **future** in Scotland?	moderate	medium	It is possible that feral pigs will have an impact on areas of conservation value such as Sites of Special Scientific Interest and Natura 2000 sites. The decline in conservation status of these areas will depend on local wild boar density and on measures taken to mitigate this impact.
2.22. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their economic, environmental or social effects more serious?	moderate	medium	If feral pigs come in contact with rare breeds of pigs held in outdoors farm, they are likely to interbreed, with potential loss of genetic traits in the rare breed. Accidental entry of wild boar in pig farms have occurred in England (Massei, pers. comm.). The most recent accident, recorded in January 2015 in England involved a wild boar that entered an outdoor farm and killed a Gloucester Old Spot pig

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
2.23. How important is social, human health or other harm (not directly included in economic and environmental categories) caused by the organism within its existing geographic range?	major	high	Wild boar and feral pigs have a significant impact on human economic interests and on conservation throughout their range. The main impacts are related to transmission of diseases, road traffic accidents, crop damage and effects on plant and animal communities. In addition, this species may cause damage to sites of archaeological importance: for instance in the US 42 % of these sites containing artefacts in a protected area of ~ 40000 ha showed signs of rooting by feral pigs
2.24. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	major	very high	Wild boar can act as reservoir or as vehicle for several pathogens that can be transmitted to other wildlife species, livestock and people (e.g. Meng *et al.,* 2009). A qualitative risk assessment of the role of the feral wild boar in the likelihood of incursion and on the impact of effective disease control of selected exotic diseases in England (Hartley, 2010) concluded that the greatest risks of exotic disease incursion into the UK were associated with disease entering through the consumption of infected pork meat or meat products by either wild boar or domestic swine. The diseases identified as highest risk were classic swine fever (CSF), African swine fever (ASF), foot and mouth disease (FMD), Aujeszky's disease, *Trichinella* sp and *Brucella suis*. ASF and CSF are of particular concern due to the potential impacts that infection of wild boar would have on effective disease control (Hartley, 2010, CSF rated high, ASF rated medium). This risk assessment was based on relatively low densities of feral wild boar (200 animals in Kent/East Sussex and 30-50 boar in the Forest of Dean). The assessment acknowledged that if populations did increase or if an outbreak of disease was not contained and entered wild

boar populations in England, there would be potential for a reservoir of disease to be established for CSF and FMD.

Since Hartley (2010) carried out the qualitative risk assessment for England, there has been an extensive outbreak of African Swine Fever (ASF) in Europe, with cases particularly occurring in wild boar (Cwynar *et al.* 2019) and with wild boar appearing to play a relevant role in the spread of ASF into new areas of the EU (Bosch *et al.* 2017). Although gaps remain in our understanding of the transmission mechanisms of ASF from wild boar to domestic pig, ASF can be spread by wild boar and can persist in wild boar populations even at very low population densities (EFSA AHAW panel, 2018). The likelihood of an incursion of ASF into GB is considered to be medium (Defra, 2020). It is suggested that the impact of an ASF outbreak in wild boar in GB is revised to ‘high’.

Outbreaks of these notifiable diseases would incur significant costs due to disease control and the effects on international trade. The Defra (2008) Action Plan reports that a CSF outbreak in GB in 2000 cost more than £20 million. In 2008 an outbreak of Aujeszky’s disease, on a single farm cost at least £500K. If spread occurs this figure could possibly reach £1 million. The 2001 outbreak of FMD cost the UK over £8 billion (Anderson, 2008). Severe outbreaks of FMD in Scotland have been estimated to cost, on average, £950 million (Porphyre *et al.* 2018; Barratt *et al.* 2019).

It is theoretically possible for wild boar to act as a reservoir for Bovine Tuberculosis (bTB, caused by *Mycobacterium bovis*) (Defra 2005). For instance, at the high densities experienced in southern Spain, epidemiological, pathological and microbiological evidence is consistent

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
			with wild boar perpetuating TB infection independently within their populations, and thus posing transmission risks to other species, including livestock (Naranjo *et al.* (2008). However, evidence from other countries is conflicting (Machackova *et al*., 2003; Corner, 2006). In England, *M. bovis* was first isolated in free-living wild boar in 2010 (Foyle *et al.,* 2010). While Scotland remains bTB free, there is considerable uncertainty about the role feral pigs might play in introducing or perpetuating the disease in Scotland. A particularly virulent strain of Porcine Epidemic Diarrhoea (PED) caused high rates of mortality in piglets in Asia and the USA in 2013 and 2014. There have been no reports of PED in wild pigs ESFA, 2014b). but there is uncertainty about the role feral pigs might play in introducing or perpetuating the disease in Scotland.
2.25. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	N/A	N/A	-

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
2.26. How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in Scotland?	major	high	A recent review on wild boar population trends in Europe (Massei *et al.*, 2014) showed that wild boar numbers are growing significantly. This trend was first reported in the 1980s (Saez-Royuela & Tellería, 1986). The review by Massei *et al.,* (2014) suggested that natural mortality, such as predation, is not sufficient to reduce population growth and that predators have a very modest impact on wild boar mortality. Conversely, recreational hunting, which is the most important cause of mortality of wild boar throughout Europe, has declined. In localised areas, wild boar numbers can decrease due to diseases but in these instances human intervention usually ensures the disease is eradicated, particularly when the pathogen can be transmitted to livestock. At present there are no predators or pathogens in Scotland that could reduce the impact of feral pigs.
2.27. Indicate any parts of Scotland where economic, environmental and social impacts are particularly likely to occur	Any area where feral pigs occur or are encouraged to increase	medium	The highest economic, environmental and social impacts will occur where feral pig populations exist in or near fragile ecosystems that could be affected by extensive rooting, in areas where wild boar could prey on ground-nesting birds or prevent plant regeneration. Social impact will also occur if feral pigs live in proximity of villages and towns or in areas with frequent visitors (such as camping sites, forests where pigs may encounter dog walkers, golf courses etc.). Disease outbreak will have major economic impact in areas where other wild ungulates and livestock occur.

RISK SUMMARIES

-	RESPONSE	CONFIDENCE	COMMENT
Summarise Entry	very likely	very high	Entry here is regarded as “additional entry” as free-living populations of feral pigs are already present in Scotland. It is very likely that illegal releases and escapes from farms will continue, thus increasing the spread of feral pigs across Scotland.
Summarise Establishment	very likely	very high	Feral pigs can adapt to live in many environments and are increasingly occurring in urban and suburban areas across Europe. Establishment could derive from a few founder animals. The high annual reproductive rate of feral pigs, which may exceed 200% is another important factor that promotes the fast growth of small populations.
Summarise Spread	moderate	medium	Spread will depend on hunting pressure (culling and trapping to eradicate), numbers of animals released, improvement of controls and implementation of containment and tagging of farmed pigs.
Summarise Impact	major	high	The environmental, social and economic impact of feral pigs ranges from the ecological impact on plant and animal communities, on soil and cycling of nutrients through to disease transmission, crop damage, road traffic accidents and damage to properties, infrastructures and attacks on dogs and potentially some livestock.
Conclusion of the risk assessment	high	high	The main conclusions are based on trends in impact and population numbers of feral pigs and wild boar in Europe, USA and Australia. The feral pigs already present in Scotland are likely to increase in numbers and spread. In parallel, their economic, social and environmental impact will grow unless measures are taken to control entry, establishment and spread of this species in the wild.

ADDITIONAL QUESTIONS - CLIMATE CHANGE

-	RESPONSE	CONFIDENCE	COMMENT
3.1. What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	Milder winters	medium	Milder winters will decrease winter mortality due to lack of food. More food available will increase breeding success and decrease the mortality of juveniles thus increasing recruitment of new animals in a population.
3.2. What is the likely timeframe for such changes?	5-10 years	medium	Changes are likely to occur and be detected within a 5 to 10 year timeframe.
3.3. What aspects of the risk assessment are most likely to change as a result of climate change?	Probability of establishment and impact	medium	Higher breeding success and local densities as well as increased probability of establishment might increase local impact of feral pigs.

ADDITIONAL QUESTIONS - RESEARCH

-	RESPONSE	CONFIDENCE	COMMENT
4.1. If there is any research that would significantly strengthen confidence in the risk assessment please summarise this here.	yes	high	To strengthen the conclusions of the RA, particularly in areas where the confidence in the assessment is medium or low, research should focus on the following areas: • quantify population trends, relative density and distribution of free-living populations of feral pigs in Scotland. In parallel, monitor reproduction rate and mortality of feral pigs in isolated populations. This would strengthen predictions concerning both the probability of spread and the timeframe in which spread and population growth will occur.

- assess the ecological, economic and social costs of feral pig presence in Scotland, with particular emphasis on disease transmission, crop damage, ecological impact on conservation areas with vulnerable plant and animal communities, risks of road traffic accidents and damage to infrastructures and amenities. This would support current estimates derived from other European countries on the level of risks derived from the impact of this species.

The research recommended above would give stakeholders a sound basis for managing the risks derived from the presence of feral pigs in Scotland. To manage these risks, research should focus on the following areas:

- evaluate methods to assess presence of feral pigs in new areas. This would provide stakeholders with tools for early detection of feral pigs in new areas, so that control actions can be implemented quickly. Detection of feral pigs could also be used at the end of an eradication campaign, to ensure eradication has been successful.
- establish costs, feasibility and timing of controlling numbers of feral pigs or of eradicating local feral pig populations, based on data collected in Scotland on free-living population as well on populations occurring in estates where pig densities are likely to be relatively high. This would offer estimates of effort required to eradicate feral pigs or to reduce their numbers.

-	RESPONSE	CONFIDENCE	COMMENT
			• map livestock in Scotland that could be affected by disease outbreaks in feral pigs and assess risks of disease outbreaks in feral pig populations based on knowledge of numbers, distribution and predicted population growth. This would provide the Scottish Government with a basis for contingency planning for disease outbreaks.

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